WATER AND SANITATION FOR HEALTH PROJECT

Operated by
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Sponsored by the U.S. Agency for International Development

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The WASH Project is managed by Camp Dresser & McKee International Inc. Principal cooperating institutions and subcontractors are: Associates in Rural Development, Inc.; International Science and Technology Institute, Inc.; Research Triangle Institute; Training Resources Group; University of North Carolina at Chapel Hill.

THE CHOICE OF HEALTH STATUS INDICATORS TO EVALUATE WATER AND SANITATION PROJECTS IN NORTH CAMEROON:

A Synthesis of Available Information

WASH TECHNICAL REPORT NO. 5

OCTOBER 1981

Prepared For:

USAID Mission To The United Republic Of Cameroon

C – Task 49

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CAMEROON

THE CHOICE OF HEALTH STATUS INDICATORS TO EVALUATE WATER AND SANITATION PROJECTS IN NORTH CAMEROON: A SYNTHESIS OF AVAILABLE INFORMATION

Prepared for USAID Mission to the
United Republic of Cameroon
under C-Task 49

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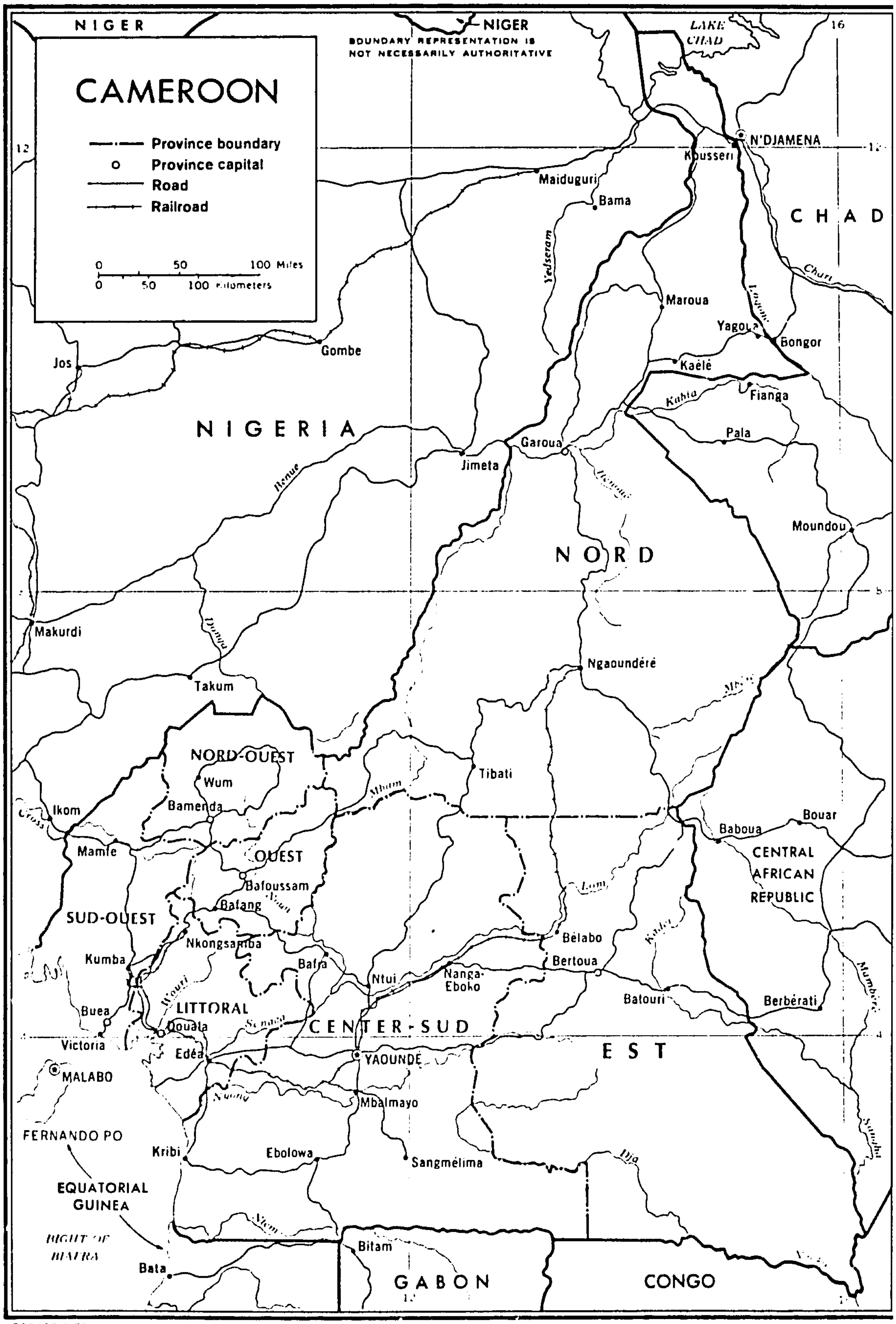
October 1981

Contract No. AID/DSPE-C-0080
Project No. 931-1176

TABLE OF CONTENTS

FIGURES


CAMEROON
Province boundary
Province capital
Road
Railroad
0 50 100 Miles
0 50 100 Kilometers
BOUNDARY REPRESENTATION IS NOT NECESSARILY AUTHORITATIVE
NIGER
NIGER
LAKE CHAD
N'DJAMENA
Kousseri
Maiduguri
Bama
CHAD
Maroua
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NORD-OUEST
Wum
Bamenda
Tibati
Ikom
Mamfe
OUEST
Bafoussam
Bafang
SUD-OUEST
Nkongsamba
Kumba
Bafia
Ntui
Nanga-Eboko
Bélabo
Bertoua
Batouri
Baboua
Bouar
CENTRAL AFRICAN REPUBLIC
Berbérati
Buea
LITTORAL
Douala
Victoria
Edéa
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Chapter 1

BACKGROUND

Upon its completion, the Mandara Mountains Water Resources project will consist of 35 gravity over-spill, water catchment dams in the semi-arid Mandara Mountains region of North Cameroon. Ten additional such structures will be supported by the World Bank, and a complementary CARE project will upgrade 92 wells. The undertaking is beginning with several pilot projects and is to be completed over a period of five years. These projects contain an important self-help component in that unskilled construction labor will be provided by people in the area to be served by each dam. The purpose of the project is to make drinking water more available year round and especially during the nine month long dry season when local surface water supplies and wells dry up. The project should reduce the distances (7 to 10 km) that women have normally had to walk to collect water for their families' needs.

The project is expected to bring about changes* in other respects, including economic conditions, social welfare, agriculture and health. The impacts of the project on these factors are to be evaluated. Indeed, project plans already exist for health and nutritional surveillance within the project area in order to help assess the health impact of the planned water, sanitation and health education interventions. A number of health status indicators (HSI) are potentially available for this purpose. These range from relatively simple measures, such as change in weight and height in young children, to rather sophisticated laboratory work on samples of blood, urine and stool. In this paper, the relative merits of these HSI are discussed. Particular emphasis is placed on those diseases and health conditions which are endemic in the project area and are most likely to be affected by improvements in water and sanitation.

*It should be kept in mind that the impacts of such water and sanitation hygiene interventions are not always beneficial (Reference 1).

Chapter 2

AN OVERVIEW OF EVALUATION METHODS APPLIED TO WATER SUPPLY AND SANITATION PROJECTS

Before discussing the various HSI, several related underlying concepts of project evaluation are presented for purposes of clarification. An overview of the evaluation process itself* is provided in order to focus on key concepts.

A paradigm for project evaluation is presented in Figure 1. The evaluation process is divided into three components; these components may also be referred to as levels of evaluation measures (Efficiency, Effectiveness and Impact Levels). Operational (efficiency or functional) measures focus on the physical system and its engineering aspects. Performance measures (also called intermediate or effectiveness measures) deal with the use of the water system by members of the commmunity where it is located. These first two components are the most immediately accessible although frequently the most difficult to interpret. Impact measures refer to the actual and perceived effects of the project on users and the community where it is located.

Impacts, such as changes in health or social functioning, are often difficult to define, less accessible, and difficult to measure, even if an evaluation study design is well conceived and designed. Consequently, many questions which would be better answered with impact measures are often evaluated using process measures. For example, it may be quite difficult to measure the loss in productivity caused by water gatherers' travelling long distances to obtain water. By using baseline and follow-up measure one can, however, easily measure the savings in time and distance travelled. These savings can then be assumed to become available for more productive tasks.

In a similar fashion, some health impact measures are easier to study than others, and practical substitutions are often necessary. For example, it is quite difficult to measure infant diarrheal morbidity. However, we do know that a large portion (perhaps one third) of infant mortality is related to diarrheal diseases. Similarly weight-faltering in infancy may be due in large part to diarrheal morbidity. Therefore, if a given water and sanitation improvement scheme can be shown to lead to lower mortality rate (and an increase in infant growth rates, also relatively easy to measure), and other factors have not changed (such as other disease rates, food availability, etc.), one is in a better position to assume that diarrheal morbidity has decreased. Thus we have an example

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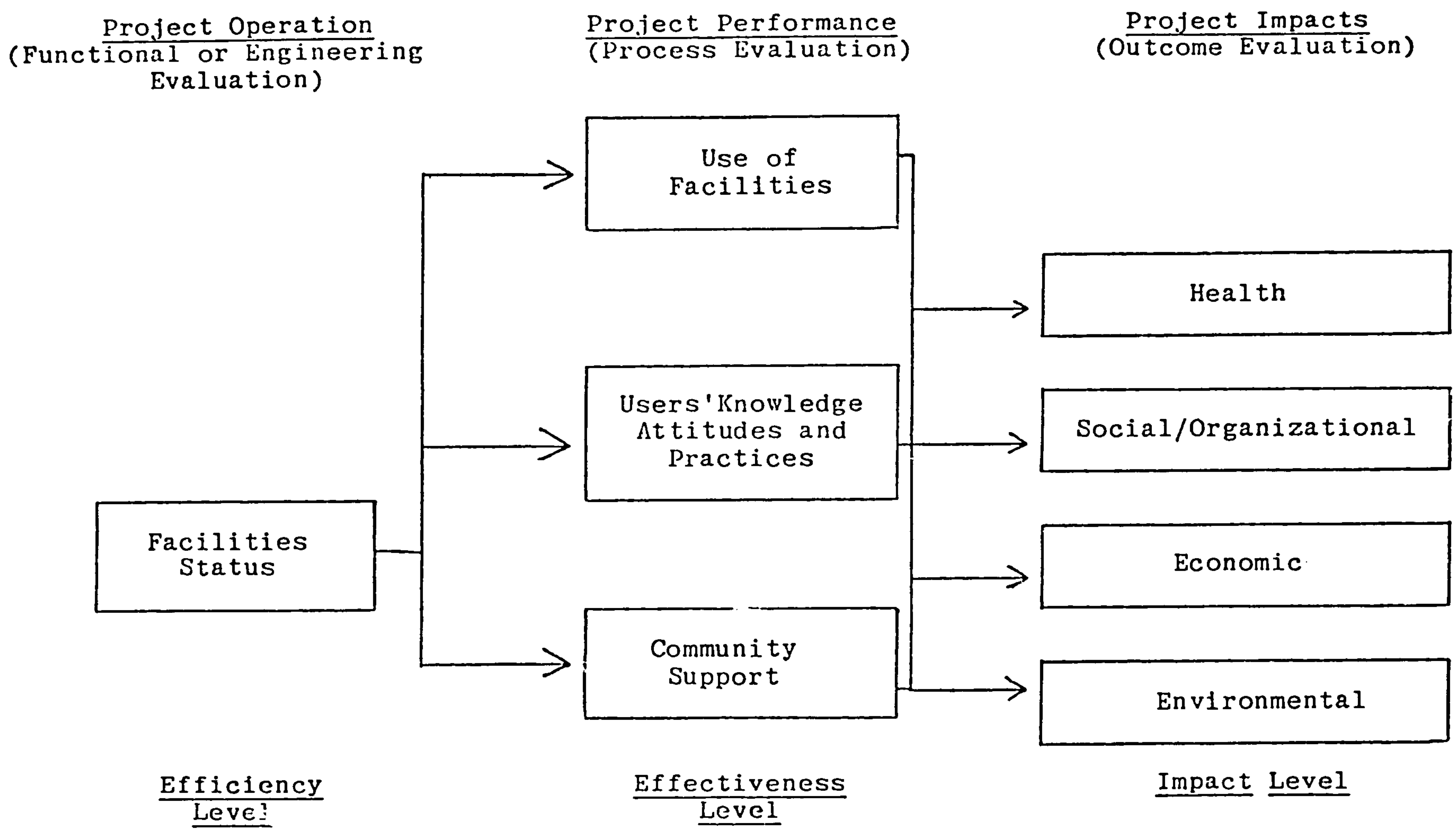
*For detailed discussion of evaluation methods for water and sanitation projects, see References 2 through 9.

FIGURE 1

A PARADIGM FOR THE EVALUATION OF WATER SUPPLY
AND
SANITATION PROJECTS IN DEVELOPING COUNTRIES



SOURCE: Warner and Dajani (Ref. 8)

of an indirect health status estimate using measures more concrete than those attached to the direct outcome (diarrheal morbidity).

Figure 2 shows a brief topical overview of the logical sequence of events in the entire project evaluation process. The process is divided into three phases. Each phase culminates in a product which can be the starting point for the next phase (indicated by double arrows, ==>). Within each phase, the series of events leading to these end products are themselves also sequenced (indicated by curved arrows, ↷). However, there is considerable interaction among events within each phase, and it is necessary that this suggested sequenced be rigidly adhered to. What is important is that each event be given consideration.

At first glance, it would appear that the subject of HSI would fall neatly under the topics "Evaluation Measures" and "Evaluation Criteria" in phase 2 of the Scheme. On closer examination, however, it becomes clear that the choice of HSI relates to many other aspects of project evaluation. For example, choosing HSI which are costly to collect or measure will clearly have an impact on the scope and purpose (phase 1) of an evaluation. Similarly, sampling and analytic procedures (phase 2) and the collection of the data (phase 3) also are dependent on the choice of HSI. The salient features of these interrelationships are discussed more fully in the next sections.

Figure 2

DEVELOPMENT OF AN EVALUATION PROCESS

Phase I Specification of the Evaluation Topic	Phase II Design and Selection of the Evaluation Procedures	Phase III Implementation of the Evaluation
Specify the following: - Subject Evaluation - Type of Evaluation - Scope of Evaluation - Purpose of Evaluation - Decision Options ==> Finalize the Evaluation Topic	Select the following: - Organizational Plan - Study Design - Study Populations(s) - Evaluation Criteria - Evaluation Measures - Analysis Procedures - Sampling Procedures - Data Collection Procedures - Data Reporting Procedures ==>Finalized the Evaluation Design	Check the Feasibility of the Evaluation Designate the Organization of the Evaluation Pretest and Refine the Evaluation Procedures Collect, Analyze, and Report the Results Evaluate the Evaluation ==> Complete the Findings and Recommendations

SOURCE: Modified after Freeman et al. (Ref. 3).

Chapter 3

HEALTH STATUS AND DISEASE INDICATORS IN THE EVALUATION OF IMPROVED WATER SUPPLY AND SANITATION PROJECTS

3.1 General Considerations

From the above discussion it is clear that there are levels of study variables (including HSI) to measure and that the selection of HSI impinges on many other aspects of a project evaluation. The type of HSI employed will also be guided by certain other concerns, including the scientific requirements of statistical appropriateness and measurement validity, as well as more practical aspects such as cost and feasiblity.

The statistical implications of a given HSI are quite important, especially in terms of subsequent options for statistical analyses. HSI are often thought of simply as rates, such as the infant mortality rate (defined below). However, the issue is more complex* since HSI actually include ratios and proportions as well as rates. For present purposes, a ratio can be defined as the result of dividing one number by another. A proportion is a type of ratio, in which the numerator is included in the denominator; a proportion is therefore a dimensionless quantity and ranges in value between 0 and 1. A rate (technically) is a measure of change in one quantity per unit change in another quantity (usually time) on which the first quantity depends. The HSI listed in Figure 3 are therefore, all technically ratios and proportions, although the proportions are usually loosely called rates.** For example, what is commonly called the fetal death "rate" is really a ratio, since the denominator (all live births) does not include the events counted in the numerator (fetal deaths). Likewise, the infant mortality "rate" is really a proportion, but it is often called a rate.

The distinctions here are more than purely semantic or academic, since they relate to the statistical appropriateness of a given HSI. Specifically, methods of sample size estimation, hypothesis testing and statistical analysis depend heavily upon the type of HSI used; for these purposes, proportions are generally more desirable. More fundamental is the fact that only proportions (called "rates" in Figure 3) are statements of probability; simple ratios are not probability statements

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*For more complete discussion of this topic, see References 10 through 12.

**This discussion ignores the distinction between average and instantaneous rates. The distinction is not important here, since most HSI that are rates are calculated as average rates. For more details see Reference 10.

MAJOR MEASURES OF MORBIDITY AND MORTALITY

Rates	Usual Factor
Rates Whose Denominators Are the Total Population	
Crude birth rate = $\frac{\text{number of live births during the year}}{\text{average (midyear) population}}$	per 1,000 population
Crude death rate = $\frac{\text{number of deaths during the year}}{\text{average (midyear) population}}$	per 1,000 population
Age-specific death rate = $\frac{\text{number of deaths among persons of an age group in a year}}{\text{average (midyear) population in specific age group}}$	per 100,000 population
Cause-specific death rate = $\frac{\text{number of deaths from a stated cause in a year}}{\text{average (midyear) population}}$	per 100,000 population
Rates and Ratios Whose Denominators Are Live Births	
Pre-school mortality rate = $\frac{\text{number of deaths in a year of children 1 through 4 years of age}}{\text{number of live births in same year}}$	
Infant mortality rate = $\frac{\text{number of deaths in a year of children less than 1 year of age}}{\text{number of live births in same year}}$	per 1,000 live births
Neonatal mortality rate = $\frac{\text{number of deaths in a year of children less than 28 days of age}}{\text{number of live births in same year}}$	per 1,000 live births
Fetal death ratio = $\frac{\text{number of fetal deaths* during year}}{\text{number of live births in same year}}$	per 1,000 live births
Maternal (puerperal) mortality rate = $\frac{\text{number of deaths from puerperal causes in a year}}{\text{number of live births in same year}}$	per 100,000 (or 10,000) live births

*Includes only fetal deaths for which period of gestation was 20 weeks or more or was not stated.

FIGURE 3 (Cont'd.)

Rates	Usual Factor
Rates Whose Denominators Are Live Births and Fetal Deaths	
Fetal death rate = $\frac{\text{number of fetal deaths** during year}}{\text{number of live births and fetal deaths during same year}}$	per 1,000 live births and fetal deaths
Perinatal mortality rate*** = $\frac{\text{number of fetal deaths at 28 weeks or more of gestation and infant deaths under 7 days of age}}{\text{number of live births and fetal deaths 28 weeks or more during the same year}}$	per 1,000 live births and fetal deaths

SOURCE: From National Center for Health Statistics: Vital Statistics of the United States. Vol. I and II. U.S. Govt. Printing Office, Washington, D.C., 1974.

**This rate is for Perinatal Period I (page 194 and Figure 9-1).
***Monthly Vital Statistics Report 22:12, U.S. Govt. Printing Office, Washington, D.C., 1974.

and are less useful for public health purposes. Proportions, then, make the most desirable HSI and should be used whenever possible.

3.1.1 Measurement Validity

Measurement "validity" should also enter into the discussion on choice of a HSI. Certain HSI are more valid (i.e. more representative of what they purport to measure) than others. (This matter is discussed more in the next section.) Validity is typically directly related to the cost of obtaining the measure and inversely related to the feasibility of using a given HSI. (However, exceptions do occur - see below.) As discussed above, practical exigencies of field work (particularly in developing countries) often necessitate the substitution of one HSI for another (i.e. an intermediate measure for an impact measure or an indirect one for a direct measure). A guiding principle here is that validity should be retained as much as is practically possible. When one HSI is substituted for a more valid one, the validity of the new measure should be carefully examined. Fortunately, for work in developing countries certain relatively valid HSI can be used that are still relatively inexpensive to measure. These options are discussed more completely in the following sections.

3.1.2 Measurement Reliability

Unlike validity, measurement "reliability" refers to the degree of agreement among repeated measures taken on the same study unit by using a given instrument (or observer). It is also possible to speak of the relative measurement reliability of various instruments (or of observers). Whereas validity is assessed by comparing a given measurement with the value for that measurement obtained by using a "standard" or accepted set of criteria, reliability simply refers to the degree of comparability of repeated measurements. The concept of validity therefore refers to <u>accuracy</u> of measurement; reliability is often characterized in terms of <u>precision</u> of measurement.

As with validity, care should be taken to insure that the reliability of a given HSI is as high as possible. There are a number of statistical procedures for doing so (Reference 42). Reliability is also typically directly related to cost and inversely related to the feasibility of using a given HSI, but exceptions do occur. In general, HSI which directly measure biological end points or variables (i.e. mortality, anthropometry) tend to be more reliable than those using intermediate or subjective measures. As with validity, the reliability of an HSI should be considered before using it as a substitute for another HSI. As indicated, a number of relatively inexpensive yet valid and reliable HSI exist for use in developing countries.

3.2 Health Status and Disease Indicators

HSI are defined here as measures which describe quantitatively and qualitatively the physical, emotional and social well being of human populations. Four general types of HSI are considered:

- measures of morbidity and mortality
- measures of laboratory values
- anthropometric measures
- summary indices of health

These categories of HSI are described and discussed in this section. In the following section, recommendations are made for the use of HSI in the evaluation of the Mandara Mountains Water Supply Project.

3.2.1 Measures of Morbidity and Mortality

These measures are the more traditional and widely used HSI. Figure 3 displays the most important of these HSI. The distinction between rates and proportions in these measures, discussed above some, is illustrated here. Several other points require clarification in this regard. First is the distinction between prevalence and incidence measures. Both take into account the estimated population at risk and are measures of the frequency of a disease in that population. However, incidence refers only to new cases arising in the population, and is therefore a statement of the probability of new disease occurring there. Incidence, therefore, can be used to study etiologic factors of a disease and in the evaluation of preventive measures. Prevalence, on the other hand, is a measure combining new and old active cases of disease in the population. Prevalence is a function of both the etiology and duration of disease among old cases and better care could actually increase the prevalence of a chronic disease by increasing survival of those afflicted. Therefore, prevalence measures are more useful for administrative purposes, such as in research on the efficacy of medical care, rehabilitation and social welfare programs. (See also Reference 11.)

Crude measures should also be distinguished from various adjusted and specific measures. Crude measures are calculated for the whole population, irrespective of various subcomponents of this population. The crude mortality rate of a generally older population, for example, will tend to be lower than that of a very young population since small children are generally at higher risk of mortality from all causes. This phenomenon can occur even if a particular etiologic agent is more frequent among the older group in the population. For this reason, crude rates should be adjusted for various characteristics of the population in which they are measured. Adjustment tends to remove the effects of large population differences and thus facilitates comparisons of rates between widely different groups. Adjustment is usually done for differences in age since this factor is often the most important. However, adjustment can be done for any variable* (e.g. sex, race).

Unlike crude measures, rates can also be expressed as specific for a particular disease in a particular subgroup in the community or for some other population variable. Thus there can be age-specific and disease-specific rates. An example of the former would be the total (crude) mortality rate among children under five years of age; an example of a disease specific rate would be the death rate for measles. It is of course possible to combine both concepts, i.e. the mortality rate of measles among children under five years of age.

In general, measures of morbidity and mortality are preferred HSI for all types of and evaluation research aimed at elucidating etiologic relationships. They can be defined as specifically as necessary to give an acceptable indication of the health of a population and they lend themselves to both simple and sophisticated statistical analyses (Reference 12). However, they are costly to collect on an <u>ad hoc</u> basis and are therefore most practical if they have already been collected and can be accessed. Since baseline mortality and morbidity data have been collected in the Mandara Mountains Project area, and since part of the project protocol calls for periodic continued collection of these data, such measures can be used in the evaluation of the impacts of the project. Specific applications to the project are discussed in the next section.

3.2.2 Laboratory Measurements

This group of HSI, as the name implies, are obtained through quantitative and/or qualitative, chemical or biological determinations done in the laboratory on specimens of tissue or body fluids (usually blood, urine or stools) taken from individuals. They represent a type of morbidity measure since they are used in estimating incidence and prevalence rates. The measures are often highly specific i.e., <u>Schistosoma</u> egg counts or other quantitative estimate of parasite burden. Because there are literally thousands of such laboratory measurements, a listing of every one is not possible here.** Measures specific for the diseases endemic in the Mandara Mountains project area are discussed in the next section.

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*See Refs. 13, 14 and 18 for a more complete discussion of adjustment and the use of various measures of morbidity and mortality.

**For details the reader is referred to texts on laboratory medicine such as Spereer, H., <u>Tropical Pathology</u>, Springer-Verlag, 1973, 765 p.

There are very real advantages to using HSI derived from laboratory measurement. They lend themselves to high degrees of validity and precision. They can be expressed as rates (crude, adjusted or specific) and lend themselves to all levels of statistical analysis. The problems with such measures, however, include cost, and the logistics of transporting field samples to a central laboratory. Furthermore, for purposes of comparison, all laboratory determinations must be performed according to uniform standards, a problem if more than one laboratory is involved. Finally, laboratory measurements are often difficult for a non-specialist to interpret and, thus, less than optimal for presentation to policy makers.

3.2.3 Anthropometric Measures

Anthropometry, the practice of measuring and determining the proportions of parts of the human body, encompasses a wide variety of techniques for leading to an almost limitless number of indices. Each user of anthropometric measures in fact has a particular list of indices considered essential. The most frequently used measures of anthropometry are displayed in Figure 4.

Anthropometry represents a practical and effective HSI for use in developing countries. It is simple to perform and can yield very accurate results. Since anthropometric values are expressed as continuous variables (i.e. without fixed intervals on a scale) they lend themselves to a variety of statistical analyses. Furthermore, they are easy for non-specialists to understand.

Anthropometry, as an index of nutritional status, is an important measure of health status as well. It will probably see increased use in health impact evaluations of various development interventions in developing countries. Infants and young children are the appropriate age group for study. The specific anthropometric measures recommended for use in the health impact evaluation of the Mandara Mountains Project are discussed in the next section.

3.2.4 Summary Indices of Health

This concept is a relatively new one in which the general well-being (physical, emotional and social) of an individual can be summarized into a single variable. One recent approach treats the health of each individual as a continuous (without fixed intervals) variable from zero to one (Reference 16). The value is obtained by summing various dimensions of physical and psychosocial health, each statistically weighted according to defined criteria of the importance or "desirability" of that particular aspect of health. The data could come from health records and personal health interviews, or from

FIGURE 4

LIST OF FREQUENTLY USED ANTHROPOMETRIC MEASURES

Weight
Stature
Head circumference
Biceps circumference, relaxed

Source: Adapted from Stroudt, H.W. et al. 1970 (Reference 15) other sources, such as physical examinations or surveys. Such a scale for individuals could be summarized as a value for the whole population, also ranging from zero to one.

There are many conceptual and practical problems with developing such an index. However, the idea of summarizing the health status of an individual (or a population) in one number has considerable appeal, because of its simplicity. This research area is, however, in its embryonic stages, and much research remains to be done before it can be applied on a large scale. It is not presently useful as a valid HSI.

Chapter 4

SUGGESTED APPLICATIONS OF HEALTH STATUS INDICATORS (HSI) TO THE NORTH CAMEROON

Both the USAID Mission in Yaounde and the World Bank have funded missions of environmental health teams to assess the current health status of the population in the North Cameroon as it relates to the project and to determine the likely health impacts of small dam construction (Reference 17). The group visited the project area in 1977 and 1978, once during the dry season and again during the wet season.

The teams concluded that certain health problems could be accentuated as a result of planned interventions, but that these problems would be insignificant in comparison with the potential economic and social benefits gained. Suggestions to minimize potentially adverse health effects were also made and incorporated into the project design. Finally, in consideration of environmental factors influencing the major water and excreta related diseases in the area, a list of diseases most likely to be affected by the project was prepared. These diseases include malaria, bacillary and amebic dysenteries, diarrheal diseases, intestinal and urinary schistosmiasis, onchocerciasis and dracunculiasis.

Any recommendations for the use of HSI to study these diseases should consider what health monitoring activities are already underway in the region. The project calls for routine monitoring of health statistics in the 23 hospitals and dispensaries of the Mandara Mountains Region. This monitoring was begun as part of the health assessment described above and is to continue throughout the development of the project. The statistics foreseen include morbidity and mortality rates specific to the important diseases listed above.

The project also provides for semi-annual visits by staff of the Ministry of Health and the University Center for Health Sciences (CUSS) to inspect health facilities and investigate health status (presumably by physical examination) of people living in the area.

Finally, the project provides for nutritional surveillance of a (presumably stratified random) sample of 1,000 to 2,000 children under five years of age. Arm circumference anthropometry and a simple measure of acute infection are planned during the project by community development agents and Peace Corps personnel. These data will provide measurements for comparison with those obtained earlier in a national nutrition survey. In this regard it is useful to note the availability of baseline data on nutritional status from the UCLA study of 1977-78 (Reference 19).

This impressive list of health monitoring activities already includes the most recommended HSI for project health impact evaluation. In the following discussion, suggestions are made for the coordinated use of these and other HSI. Each important disease listed above is treated separately.

4.1 Mortality Rates

The infant mortality rate appears to be a particularly useful measure of the impact of improved water and sanitation facilities. The burden of diarrheal disease (including shigellosis or bacillary dysentery) and the associated mortality from dehydration falls disproportionately upon infants and very young children, who, because of their physiologic state are particularly prone to dehydration. It has been estimated in Sahelian Africa that diarrhea and dehydration may account for as much as one third of the infant mortality (Reference 20). If such be the case, then any significant diminution in fecal pathogens in the environment brought about through improved access to water or reduced contamination by excreta should affect infant mortality. This relationship of course assumes that other causes of infant mortality (prematurity, neonatal tetanus, malnutrition, bronchopneumonia, measles, and malaria) remain constant.

Within the mortality rate for ages 1-4, only the mortality from ages 1 to 2 may be potentially responsive to improved water and sanitation (Anderson, 1981). With both rates it is necessary to have a large enough population sample (live births) in order to obtain statisticially significant changes in the number of deaths and therefore the number of deaths due to diarrhea and dehydration. A practical suggestion then would be to treat large populations, comparing cross-sectionally, for example, groups of villages with improved and protected water supplies, with those without improvements, rather than treating small populations village by village. Cost considerations may mitigate this possibility however.

4.2 Morbidity or Disease Incidence and/or Prevalence Rates - Laboratory Measures

4.2.1 Malaria

The validity of laboratory (thick smears of blood) or physical (splenomegaly) measures of malaria incidence and prevalence depends to a large extent upon whether or not one can assume that the improvements in water supply and sanitation alone are sufficient to achieve a diminution in malaria incidence. Since malaria carrying mosquitoes, especially A. gambiae, tend to breed in reservoirs such as those planned for this project but selectively within a few feet from the edge, it is safe to assume that removal of aquatic vegetation from reservoirs, and periodic drawdown of water levels in the reservoir, should be a part of an effective control program. In addition, draining and filling small bodies of water, overturning small receptacles, and, most importantly, administration of both prophylactic and therapeutic antimalarials, would be necessary to achieve desired changes. If these measures are a part of the program then the use of thick smears of blood to measure incidence and prevalence of malaria, and splenomegaly counts to measure prevalence are recommended. If not, the cost of training and supplying field workers to keep up malaria surveillance is probably not worth the effort.

4.2.2 Dysenteries: Bacillary and Amebic

These two entities are probably responsible for no more than three to five percent of all diarrheas in infants and small children (Reference 21). The proportion due to amebic infection is so small as to be useless as an outcome indicator. Shigella, the causative agent of bacillary dysentery and other milder diarrheas, are highly infectious organisms which are difficult to control in unhygienic surroundings. The infection may be partially waterborne, but the more frequent route of infection is through fecal contamination of fingers and food. By having sufficient quantities of available water handwashing before handling food and after defecation and thorough cleansing of foods and kitchen utensils are facilitated and control of infection enhanced. But water is only a part of the solution. M.U. Khan and co-workers (Reference 22) have shown that handwashing with soap is essential to control Shigella.

Thus the selection of an outcome HSI is again dependent on whether or not the program is sufficient to achieve a desired effect. Unless water in sufficient quantity and of some minimally acceptable quality is available and accessible to households and is used for washing hands, food and utensils, Shigella transmission will be difficult to control and it will probably not be useful to measure incidence of shigellosis as an indicator of program effectiveness. Even if it were decided that Shigella incidence should be measured, the difficulties of specimen collection and preservation and laboratory analysis could mitigate against its practical utilization. It is therefore not recommended for use as an HSI in North Cameroon.

4.2.3 Other Diarrheal Diseases

Included in this group are diarrheas secondary to E. Coli, Salmonella, V. cholerae, Yersinia, Campylobacter, Giardia and Rotavirus infections. Together these agents probably account for no more than 50 percent of all diarrheas, Rotavirus itself being associated with 40 percent in some areas (Reference 23).

With the exception of *V. cholerae*, *S. typhi* and *Giardia*, one is again dealing with infections that are mainly transmitted via fecal contamination of fingers and food and only secondarily spread through contaminated water. In addition, only one type of infection is responsible for more than a small fraction of the diarrhea in infants and children, that being Rotavirus infection. The diagnosis of Rotavirus infection, however, is possible only under well managed field conditions, rendering routine surveillance difficult. Thus none of the other diarrheas may be suitable as an HSI.

4.2.4 Schistosomiasis

In areas heavily endemic for urinary schistosomiasis infection with *Schistosoma haematobium* the disease may infect from 70 to 95 percent of the school age population. Usually the prevalence is higher in boys than in girls. The majority of these infections are mild with only five to ten percent having signs of morbidity such as hepato-splenomegaly, gross hematuria, or cachexia. *S. mansoni* infections are associated with higher morbidity but lower prevalence rates. In fact a large proportion of infected individuals of both types may be asymptomatic (Reference 24).

The only definitive criterion for diagnosis is to find a viable egg of any species of schistosome in urine, stool, or rectal biopsy (Reference 25). Twenty percent of individuals with the infection, however, may not pass eggs, particularly in a single specimen. For diagnostic purposes repeated specimens or a rectal biopsy may be necessary, supplemented by clinical examination, history, skin tests and serology. These procedures are, however, too unwieldy for epidemiologic investigations so that a single specimen plus a physical examination may be all that is feasible. Urine specimens should be collected near midday whenever possible. Stool specimens can be centrifuged in water; urine specimens should be fixed in formalin.

Assessing the intensity of infection, which is necessary in monitoring the effects of interventions, must rest on egg counts of urine or stool. Egg counts can be performed easily in the field by use of the Ritchie formol-ether concentration technique (Reference 26) for stools and the method of Peters, et al. (Reference 27) for urine.

Schistosomiasis thus satisfies two of the three criteria for HSI. It is a prevalent infection, and relatively easy to diagnose in the field. With regard to the third criterion, that is its ability to reflect sensitively the effects of water and sanitation improvements, it leaves some doubt. In order to achieve a positive effect on the prevalence/intensity of Schistosoma infection through improved water and sanitation, a nearly complete separation of a human population from contaminated water must be accomplished (Reference 28). Such a separation can be achieved only through:

- Establishing separate washing and bathing facilities.
- Erecting foot bridges over contaminated streams and ponds.
- Providing alternative uncontaminated swimming facilities.
- Influencing children not to urinate/defecate in streams and ponds
- Promoting latrine use for urination and defecation.

Depending upon local exposure and behavioral patterns, most of these inputs must be a part of the program in order, to influence Schistosoma prevalence. The selection of schistosomiasis prevalence as an HSI will depend on the probability that project inputs will include them.

4.2.5 Onchocerciasis

This infection, an endemic disease, can be eliminated entirely as a potential HSI because of the difficulty of linking changes in its prevalence to improvements in water and sanitation alone. The effects are only indirect. If alternative sources of water to the fast moving streams that serve as breeding sites for Similium damnosum can be found, then affected populations may have less reason to frequent stream banks. This effect, however, supposes that such alternative sources can completely eliminate the need to visit the streams, that is for bathing, washing, drinking, and fishing. It also ignores the range of flight of S. damnosum from stream banks to village and field locations.

To these epidemiologic considerations one must also add the difficulty of surveillance involving skin scrapings and biopsies of nodules.

4.2.6 Dracunculosis (Guinea worm)

This infestation offers a potential among diseases as an HSI in the early evaluation of water supply improvements. It is prevalent in many parts of West Africa among the productive population of adult men and women. It is relatively easy to diagnose when females are mature. It is the cause of a significant morbidity and loss of economic productivity (Reference 29) Unique among the diseases discussed here, prevalence reponds to the provision of an adequately designed source of water (closed springbox, gravity fed tap, closed well, or open well with a wide margin, an apron and a high wall) sufficient to prevent the contamination of the water and, thus, the intermediate host by eggs excreted from the lesions on hands and feet. Guinea worm prevalence can be expected to fall in endemic areas within a year after definitive improvements in water supply. This disease is therefore suggested as an HSI to monitor early effects of improved water supply in areas where it is endemic.

4.3 Anthropometry

Anthropometric measurements (height or length, weight, and mid-arm circumference) in infants and small children may potentially be the health status indicators most useful for estimating the impact of improved water supply and sanitation. These measurements offer three distinct advantages corresponding to the criteria used earlier to evaluate other candidate HSI.

1. The measures themselves require a minimum of equipment for field use, can be readily applied by persons with minimum of training and give reasonably reliable results.

2. Undernutrition, most frequently manifested as deficient weight for height, is prevalent among infants and young children in rural areas of developing countries and in North Cameroon in particular (Reference 19). Thus it satisfies the requirement of measuring a prevalent rather than an esoteric health condition.

3. The validity of anthropometric measures as indirect estimators of reduced diarrheal morbidity is strongly suggested by studies reported in the literature.

These advantages suggest criteria for field application of anthropometry. In turn will be discussed: the measures themselves and their use in the field, the computation and reporting of results and the interpretation of results with respect to the evaluaton of water and sanitation improvements.

4.3.1 Application of Anthropometric Measures in the Field

The reader is referred to King et al. (Reference 30), Jelliffe (Reference 31) and Zerfas (Reference 32) for a more complete discussion of methodology. These authors and many others agree that two simple anthropometric measures, height (or length) and weight form the essence of what is needed for an adequate field assessment of overall nutritional status. Mid-arm circumference gives an additional insight into the degree of soft-tissue wasting, but the same can be deduced from weight/height ratios.

Height or length should be taken by using a locally manufactured measuring board following specifications obtainable from the Center for Disease Control (CDC) (Reference 33). The infant is measured in the recumbent position, the young child standing with the measuring board against a flat surface.

Weight is estimated using any standard scale. Great practical use has been made of suspended spring balances to which a harness for the infant or child is attached (Reference 34). Mid-arm circumference should be measured using fiberglass or laminated tapes with clear numerals printed along the long axis of the tape. The mid-point of the left upper arm is identified and the circumference measured with the arm hanging loosely. It is important to maintain a correct tension on the tape so that it remains closely applied to the skin.

All of these measurements can be taken by field staff with minimal training. A brief period of technical training followed by continuous supervision and quality control will usually suffice.

4.3.2 Computation and Reporting of Results

Weight and height are computed in absolute terms and then expressed individually on a percentile scale in which each is compared with a reference population (Reference 35). However, it is more helpful, to compute and plot the weight/height ratio on a standard reference scale. This ratio is generally more useful than plotting weight against age, since it permits a comparison of somatic (weight) to linear growth, whereas weight/age permits only a comparison of weight with expected weight for a given age. Weight is, in fact, less of a function of age than is height. An additional ratio comparing height with age is sometimes used. This ratio permits one to compare the progress of linear growth, dependent as it is on influences of genetic, hormonal, and antecendent nutritional factors with expected height at a given age. All these ratios are usually expressed in the aggregate as the percent of the childhood population falling over or under certain percentiles.

Arm circumference is reported in centimeters and compared with a table like that in Figure 5.

Weight/height ratios are plotted on a percentile scale with the percent over a certain level (60 percent) reported. This measure, supplemented by mid arm circumferences, offers the most potential in evaluating. The rationale for this recommendation becomes apparent in the next section.

FIGURE 5

Mid-Upper Arm Circumference
(3rd to 5th percentile)*

Age	Centimeters
0 months	9
3 months	10
6 months	11.5
9 months	12
12 months	13
2 years	13
4 years	13.5
5 years	13.5

*Less than this value suggests undernutrition.

Source: adaption of Zerfas (Reference 32)

Of note is the relative constancy of the lower limit from 1-4 years of age.

4.3.3 Interpreting Results

The assumption that improved water and sanitation leads to corresponding improvement in nutrition status as expressed by weight/height ratios is based on a three-step cause and effect relationship, illustrated simply in Figure 6.

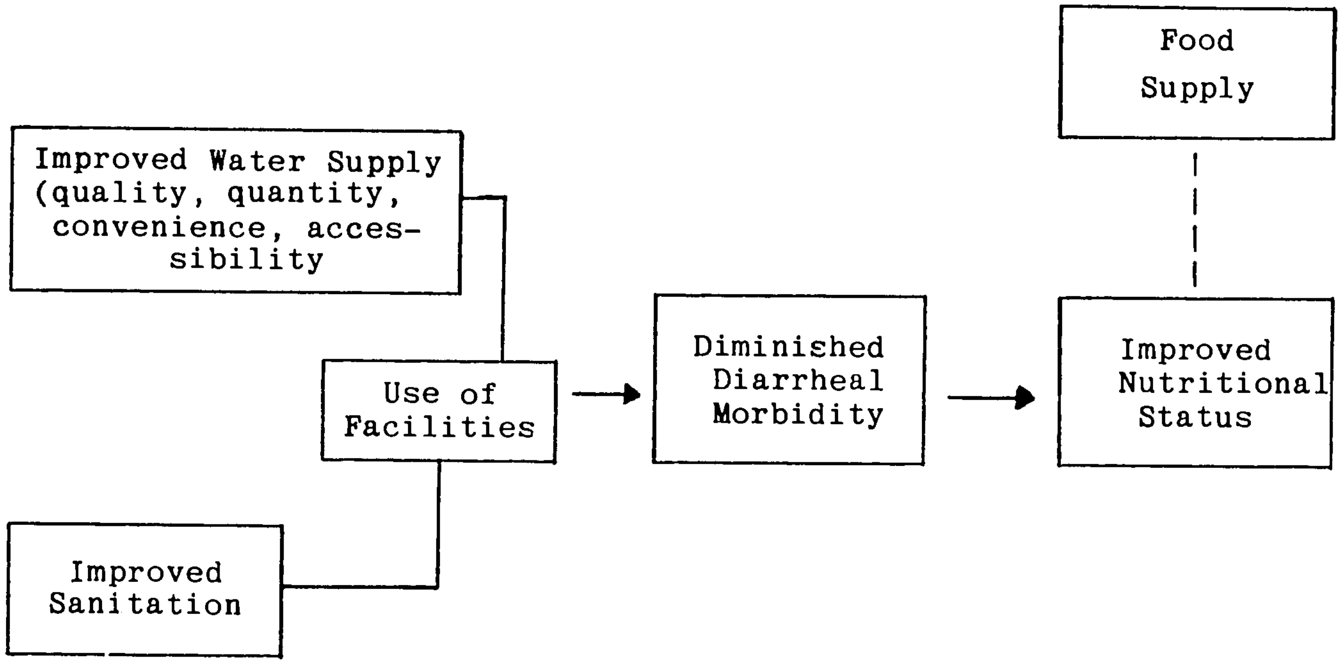

FIGURE 6: Improved water and sanitation as related to nutritional status.

The third step of the relationship has been rather firmly verified (References 36 through 38). Studies in the Gambia in particular, a region not unlike the North Cameroon in climate, have revealed a striking effect of infection, especially diarrheal disease, on the weights of young children (Reference 39). During the prolonged drought (1974-78) a surprising diminution in both mortality and seasonal weight-faltering occurred. Whereas the rainy (growing season) had usually been associated with a precipitous fall in aggregate weight-for-height and a rise in child mortality, both these seasonal curves were considerably flattened during the drought. Despite a general lack of food, a reduction in diarrheal disease and malaria had resulted in an overall improvement in nutrition status.[1] The effect of diarrheal morbidity on nutritional status is therefore considerable. The relationship of infection to nutrition is, of course, reciprocal (Reference 40). Well known are the ravages of measles, tuberculosis and shigellosis in the undernourished child.

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[1]McGregor, I.A., personal communication, 1978.

Support for the first two steps in the equation are less firm. Because diarrheal morbidity is difficult to measure and interpret, as we have seen earlier, attempts have been made instead to use nutrition status because of its strong causal relationship to infection as a substitute for a direct measure of disease incidence. It stands to reason that if diarrhea contributes heavily to under-nutrition, then any improvement in nutrition status correlated with improved water supply and sanitation may be attributed indirectly to a reduced diarrheal incidence. A study in Northern Nigeria has recently shed light on this assumption (Reference 41). Tomkins et al demonstrated better weights for height among young children using a protected copious source of water than among those served by a scanty unprotected source. The differences were significant ($p<0.01$).

Chapter 5

CONCLUSION

Among the array of possible health status indicators to use in evaluating improved water supply and sanitation in the context of the Mandara Mountains Region, three stand out as the most feasible:

1. Infant and, possibly, child mortality rates.

2. Infant and child weight-for-height ratios expressed as percents above or below the 60th percentile.

3. Prevalence of dracunculosis in older children and adults as an initial indicator of project success.

To each are attached certain methodologic and conceptual constraints, but on balance they should all serve well as HSIs under rigorous field conditions. All the other measures fail to qualify whether by reason of logistical problems, failure to measure a prevalent condition, or lack of a valid relationship to project inputs. In the long run the use of these few valid and reliable measures, simple to apply, but in fact profound in their implications will serve the project evaluation better than a large repertoire of doubtful criteria.

The next step, therefore, would be to determine whether data are already available locally or whether primary collection will be necessary. Birth and death records, for example, may be a source of information for calculating infant and child mortality rates.

If primary collection of data is necessary, then community level health workers should be trained to:

1. Record births and deaths of infants and children under five years of age.

2. Weigh and measure infants and children.

3. Estimate ages of infants and children.

4. Observe and record cases of dracunculosis

If these skills can be taught to these workers, then the recommended measures will be feasible.

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