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FIELD STUDIES ON WATER SANITATION AND HEALTH EDUCATION IN RELATION TO HEALTH STATUS IN CENTRAL AMERICA

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The "Food Wastage/Sanitation Cost-Benefit Methodology Project" was conceived as one type of policy research. Policy research is usually predicated on the use of the skills and methods of diverse disciplines to provide insight into the multiple variables and linkages that characterize real-world problems and solutions. Under ideal conditions, policy research should offer the techniques that can make the assumptions explicit and the tests for establishing the validity of the assumptions. The Agency for International Development. sponsored this policy research project on the relationship of water-related diseases and health benefits. The study was conducted in rural lowland Guatemala by the University of North Carolina at Chapel Hill and the Institute of Nutrition of Central America and Panama in Guatemala.

A conceptual scheme for pathways and linkages between water supply improvement, health behavior and economic change is shown in Fig. 1. The scheme is somewhat illusionary in terms of measurement potential, but it is helpful in understanding the hypotheses for the study. These hypotheses were:

A. A population living under unsanitary conditions will have an increased prevalence of diarrheal morbidity. Improvements in sanitation (with emphasis on water supply) will diminish diarrheal morbidity.

This hypothesis was tested through the provision of a piped water supply to each house in the experimental village. At a later stage of the project, educational and community development programs were introduced to encourage the sanitation-related use of water and to promote improved sanitation behavior patterns. The objective of these inputs was to improve water quality, availability, convenience and utilization by the village population. A control village, where no inputs were introduced, was used for comparison. Florida Aceituno was the control village and Guanagazapa was the test village.

B. A population with a high prevalence of diarrheal morbidity may waste increased amounts of food as compared to a population with a lower prevalence of diarrheal morbidity. The food wastage is a consequence of repeated incidents of diarrheal disease which eventually traumatize the intestinal tract and results in malabsorption. There is reduced absorption during the diarrheal incident, however, this acute loss is considered separately from the losses due to chronic malabsorption.

Food ingested and then lost through intestinal malabsorption may constitute an economic loss and may be assessed in terms of wasted energy, non-utilized nutrients, direct food costs and losses in agricultural production.

The verification of these hypotheses required the assessment of inter-relationships and the measurement of a large number of variables. These variables included health status, dietary and nutritional status, anthropometry, intestinal efficiency, health behavior and other biomedical, economic, social and demographic characteristics of the village populations.

Policy research, because of its requirement for application to existing problem situations, is tied to the perception of these problem situations at a given time. Kuhn (1) proposes that scientific research at any given period is carried on within an instrumental and conceptual framework accepted by an entire scientific community. The resultant mode of scientific inquiry then leads to a point where current problems cannot be resolved within the accepted framework. The scientific community then proceeds to a new conceptual structure or paradigm to govern the search for new facts.

It may be useful to explore the changes in the "paradigm" for water supply/health benefits research from the 1960's to the present. The victories for disease prevention in the industrial countries based on treated water supplies led to the conviction that this pattern

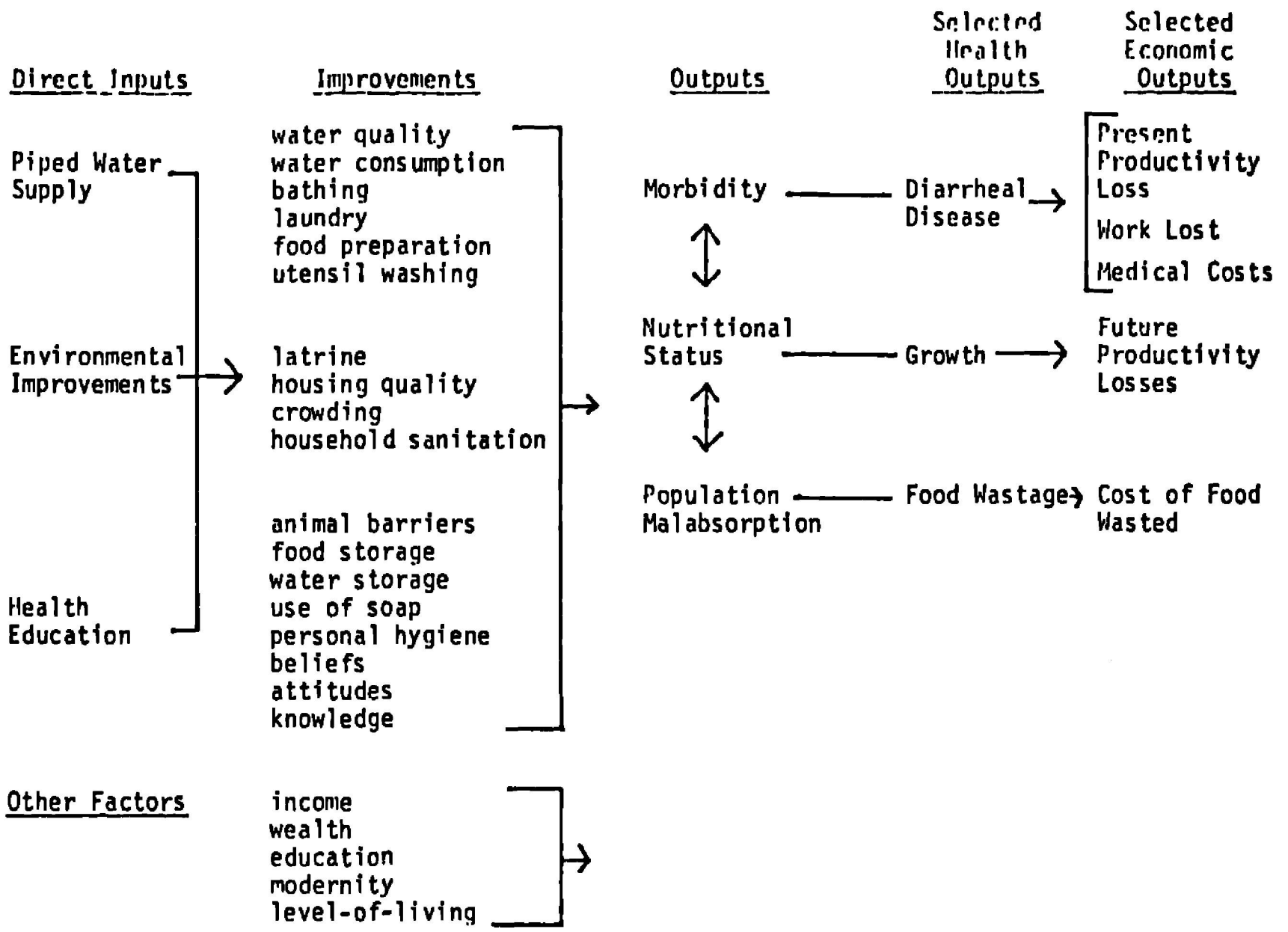

FIG. 1. Conceptual Scheme for Linkage Between Environmental Improvement, Health and Economic Change.

could be duplicated in the less developed countires through the introduction of piped water supplies of high quality. This view is still expressed with confidence and is historically demonstrable for the industrialized countries, however the demonstration must include all the other changes in housing, nutrition, and economics that also occurred in the industrialized countries during the same period. In any event, the experimental verification of the water supply/disease link has not been clearly demonstrated for the warm, poor, rural areas of the world. Confidence in establishing the project-impact link is lessened by difficulties in establishing the etiology of diarrheal disease and other "fuzzy" variables in the proposed equation.

The "classic" water supply project-impact was further questioned on the basis of economic justification for water supply projects. The UNC/INCAP project is a lineal discendent of several project-impact studies initiated by the economists' request for criteria for allocation of resources between water supplies and other sectors. The public health virtue of water supply investment was not considered sufficient for decision-making and investments in water supply were to be considered in the framework of economic analysis. During the late 1960's there were already doubts appearing in the literature about the feasibility of evaluating health, social or productivity outputs in terms of economic units. The emphasis on "food wastage" attributed to a diminished intestinal absorptive capacity seemed to offer a readily measurable system of inputs and outputs, definable in terms of energy and chemical constituents, which were calculable in terms of economic units.

RESULTS OF THE STUDY ON SANITATION, HEALTH EDUCATION AND MORBIDITY

The results of the study are presented with reference to individual variables and their relationships.

Demography

The objectives of the demography studies were to establish the comparability of the test and control villages. The villages were comparable in respect to their population sizes, age and sex distribution and family structure. Both villages showed a high degree of mobility. Villagers moved because of seasonal occupational requirements, however, there was also an extensive long term in and out migration. This finding is of some consequence since the usual perception of rural village populations is that they are static. A highly mobile population raises additional questions of time and concentration in respect to inputs. How long and for which periods were migrants exposed to the "beneficial" inputs; and obversely, what was the exposure outside of the "improved" village?

The population of each village in August 1976 was 1097 in Guanagazapa and 1006 in Florida. The populations under study were too small for any significance to be attached to the crude birth and death rates, infant mortality or vital index rates. However, the villages were comparable for demographic and other vital statistics and for morbidity and mortality. There were differences in family income, employment opportunities and land ownership.

An advanced technology water treatment and distribution system was installed to supply a rural village in the lowlands of Guatemala. This system consisted of a protected source (spring), chlorination facilities, adequate storage and water mains with faucets in the yards of 164 homes. It was designed for health and environmental appropriateness but not for functional appropriateness as defined by Pacey (2). This system provided high quality water (chemical and bacteriological), of unlimited quantity (but at a small cost), which was convenient and did not adversely affect the environment (breeding of vectors). However, it will be difficult for this village to adequately maintain this system without outside assistance in the future.

The primary purpose for installing this water system was to study the relationship of water to health, more specifically, to diarrheal morbidity and intestinal malabsorption. Functional appropriateness and cost were secondary considerations. The design and operation of the system met all the criteria for interrupting and/or reducing water-borne diseases (typhoid, cholera, amoebic and bacillary dysentery, gastroenteritis) and water-washed diseases (skin infections, otitis, conjunctivitis).

During the three year period after the installation of the water system, September 1973 to August 1976, the total morbidity of the population in this village was intensively investigated through monthly household surveys and a record of visits to the health post. Total as well as selected causes of morbidity were compared over seven periods of six-months each. The six-month periods were chosen to coincide with the rainy and dry seasons. Morbidity from all causes was not significantly different in the two villages, although there was more total illness in the control village during the last eighteen months of the study. No significant changes in morbidity were observed in the test village (Table I).

TABLE I. Selected Annual Morbidity Rates in Guanagazapa

Disease	Incidence Per 1000 Population* 1973	1976
Total morbidity	123	124
Diarrhea	39.7	39.5
Respiratory disease	53.7	52.7
Skin infections	12.5	9.1
Conjunctivitis & Otitis	3.5	4.3

*Incidence computed on two-weeks recall experience in each month. The true incidence will be higher than this for an entire month.

Diarrhea, respiratory disease, skin infections, otitis and conjunctivitis were analyzed by age, sex, season (dry and rainy), water usage, and family size. Monthly family morbidity rates were preponderantly zero. Only family size was correlated with any of these diseases and large families (more than five persons) had a disproportionately high morbidity rate. No attempt was made to isolate the agent(s) of diarrhea, thus the prevalence of salmonella and shigella in the village population could not be estimated. Stool cultures were collected on a small sample of the population in 1973, 1974 and 1975. Approximately 5% of the cultures were positive for salmonella and/or shigella. Children who were between one and two years old had more diarrheal disease than any other age group in the study. Children who were seven years of age and younger accounted for more than 80% of all diarrheal morbidity.

Diarrheal illness in the adult was low (<20/1000/fortnight) and was probably under-reported, especially for mild episodes. However, on the basis of study data, it can be stated that diarrheal illness was not a significant cause of disability in these adult populations. The relationship between season and illness is ambiguous when observed on a continuum. However, the rates for diarrheal morbidity were higher for the rainy seasons ($p < .05$) when differences in sanitation and family size were controlled for.

A review of the data on diarrheal morbidity leads to the conclusion that the introduction of water and the attempts to improve sanitation did not significantly affect diarrheal disease. Such a conclusion should not go unquestioned nor unchallenged. However, this conclusion is supported by the study data and criticism must be directed to study methods.

Improvements in Water Supply and Sanitation

Diarrheal morbidity leaves something to be desired as a criteria for the outcome of environmental improvements, however, it is "the only game in town." On the other side of the equation, water supply cannot be considered as a single point of reference but as a part of a delivery chain. In fact, this chain for the delivery of water of high quality was difficult to maintain.

It was apparent that "final-use" bacteriological water quality was inferior to source quality in both of the study villages. Even though 97% of the water samples collected from the distribution system in Guanagazapa were free of coliforms, only 65% of the samples collected from home water containers were satisfactory. Water samples from shallow wells in Florida Aceituno were contaminated 52% of the time while home water containers were contaminated 59% of the time. These results have implications for future studies which attempt to correlate water quality with morbidity and they also indicate the increased risk to a population from contaminated water containers. Assuming that final-use quality (consumption, bathing, handwashing, dishwashing) is the same as source quality (distribution system or well) could lead to erroneous conclusions.

There were some expected results. The installation of a convenient and plentiful water supply system did promote water usage. When the study concluded, the families in the test village were using two and a half times the water per person (69 liters/person/day) than were the residents of the control village. How this additional water usage translates into maintaining a sanitary home environment is discussed later. The maintenance of a clean home environment was difficult under the conditions that existed in the villages and the homes. Water supply is not an isolated change and some of the problems in assuring desirable outcomes from water inputs may result if sanitation improvements and the modification of health behavior are neglected.

Home Sanitation

Surveys were made throughout the period of the study to evaluate sanitary conditions in the home. It was assumed that the diarrheal diseases which were being recorded in the morbidity survey were mainly water-washed infections.

House construction and sixteen variables, indicative of sanitary behavior, were selected and monitored as indices of environmental quality. House construction and maintenance were surveyed annually and the sixteen environmental variables were monitored monthly. This array of variables is not exhaustive since it did not include information on food preparation practices, dishwashing, handwashing, infant feeding, the presence of insect vectors, and environmental quality outside the home (workplace, school, etc.). These latter variables are difficult and costly to quantify.

Crowding in the home is often felt to contribute to morbidity. Continuous measurements of total home crowding and number of persons occupying each bedroom were made. The mean and standard deviation of respiratory illness and diarrheal disease rates were plotted against crowding in bedrooms and for total home area for both the villages. Morbidity rates did not increase with more persons per bedroom or more persons per household area.

Health Education

The provision of a piped water supply to the test village was supplemented by a program for community health development. The objective of the health education program was to reduce fecal contamination in the home and surrounding areas and to promote the use of the piped water supply. In specific terms, this component of the study was directed to:

1. persuading the villagers to reduce human and fecal wastes in the home and the surrounding areas.

2. installing barriers to keep domestic animals out of the kitchen.

3. promoting the installation and sanitary maintenance of latrines.

4. improving food and water handling.

5. increasing water consumption for hygienic purposes; particularly for home and kitchen cleanliness, food preparation, and handwashing.

The community health development approach used in this study was found to be practical and useful, particularly for small communities. Since the comprehensive health education program was in effect for only one year, it is difficult to evaluate the potential impact which it might have had if it had been continued.

A health education scale was used to measure changes in attitude and perception after the initiation of the health education program. It was concluded that the program did influence the attitudes of the population relating to sanitation changes. Whether these changes in attitude are permanent is not known.

Several interesting observations were documented which have implications for future studies. Even with increased water availability and health education, the residents of Guanagazapa did not bathe more frequently nor did they wear clean clothing more often. However, they did report washing their hands more-frequently. Handwashing and bathing practices were evaluated by questioning the female head-of-household and the validity of this data cannot be confirmed.

Improvement was documented in five environmental categories: removal of human and animal fecal matter from the home environment, protection of stored water, cleanliness of the yard, installation of latrines, and the exclusion of domestic animals from the kitchen and dining areas. These improvements, however, did not result in a decline in diarrheal or other morbidity during the study period.

Level-of-Living Indexes

A modification of Belcher's level-of-living index was used to evaluate socio-economic and socio-cultural variables and their relationship to morbidity. The Belcher scale contains fourteen household functions: construction of walls, floor, roof; water storage; water source; lighting; food preservation; eating utensils; sewage disposal; type of transportation; cooking facilities; floor cleaning equipment; and dishwashing facilities. These items are based on household functions and scaled according to the technological means employed in the accomplishment of the household function. Many of the functions represent sanitation facilities in the household.

The conclusion, based on this analysis, was that morbidity is associated with level-of-living [environmental quality as defined by Belcher (3)] but the association is weak and the level-of-living index is not a good predictor of the morbidity experience of a household.

Households were also characterized according to relative wealth status, occupational status of the head of the family, and levels of education and literacy of family members. House-

holds were also described in terms of attitudinal modernity, cosmopoliteness, religion, and family size. Only family size was shown to be correlated with morbidity.

Observations

The data for census, morbidity and sanitation were examined extensively through the use of general linear and categorical models in order to determine if there were significant relationships between the four selected types of morbidity (diarrhea, respiratory diseases, skin infections and other infectious diseases) and water and sanitation. The data were adjusted for age, sex, size of family, season and village. In this way, sanitation effects on morbidity could be estimated without being influenced by these other factors, which also influence morbidity.

The results of these comprehensive analyses are disappointing in respect to policy research but do emphasize that answers to the water/sanitation/health question are still not resolvable through field studies. The variables which were "controlled for" did have discernable effects on morbidity. In contrast, there was no single sanitation variable which had a measurable effect on the morbidity rate. This statement is striking since the results also show no significant relationship between water supply and the morbidity rates. Of course, the measurements were taken over a study period of less than four years; a relatively short period for change to occur.

It is not reasonable to conclude from these results that there is no association between sanitation and morbidity. After all, diarrheal disease and death, especially in children, are clearly a problem in the Less Developed Countries. This issue will only be resolvable when reliable and pertinent measurement instruments are available.

We feel that future studies into the water/health relationship must be able to measure and deal with these multiple variables and to separate out the significant from the superfluous.

SUMMARY OF RESULTS OF THE STUDY FOR FOOD WASTAGE

An important objective of the study was to design and test a methodology through which the relationship between the improved water supply and food wastage could be examined and described in economic terms. The linkages between water supply/diarrheal disease/malabsorption were not known at the initiation of the study.

The choice of intestinal malabsorption as a measure of the health benefits of water supply was based on the assumption that it would provide a convenient economic measure of the benefits in terms of the reduced costs of food wastage. However, there were major difficulties in dealing with intestinal malabsorption as a variable in this study. This syndrome had been previously investigated only in the clinical setting. This study dealt with this condition on a population basis using community samples rather than individuals who were in a clinic setting. Further the use of accepted clinical standards for defining malabsorption was shown to be untenable for population studies and the concept of relative malabsorption for a given population was developed.

The role of malabsorption in diarrheal disease has been of interest in the last few years. Rosenberg, Solomons and Levin (4) have reviewed the combined effects of nutrition and infection on the diarrheal diseases. The need for field studies on intestinal malabsorption was reinforced by their observation that,

"In some populations, 20-25 percent of the presumed healthy adult population demonstrated some defect in intestinal absorption when tested and although there are far fewer studies in children, there is growing evidence that tropical enteropathy is seen in the first few years of life. The true quantitative implications of this phenomenon in terms of nutrient and food wastage by malabsorption are still uncertain. However, the possibility that a large proportion of the population in less developed countries, who are already on marginal nutrient intake, are failing to derive nutritional benefit from that intake because of a chronic malabsorption problem underscores the difficulty of projecting nutrient requirements based on research under sheltered ward conditions in developed countries."

Malabsorption

A basic objective of the study was to develop a methodology for assessing the extent of malabsorption in the village populations. This objective was based assessing long term losses in the adult and did not include food wastage due to diarrheal episodes. The adult malabsorption syndrome may result from a continued trauma to the intestinal tract as a consequence of multiple bouts of diarrheal disease, particularly during the early lifetime of the individual. Thus, measurements were designed to determine "subtle" rather than overt clinical changes. The subtle changes were then compared with a "normal" value which was derived from the study of a similar population who were free from repeated diarrheal disease

for a sufficient period to allow for improvement in gastrointestinal tract efficiency.

The cycle of studies involved:

1. establishment of the absorption test methods, including the selection of the rural metabolic diet and metabolic ward procedures, laboratory procedures and the choice of the longitudinal sample.

2. determining the digestibility of the diet.

3. conducting the intestinal absorption study (balance studies).

4. food cost. Surveys were done in each month of the study to determine the cost of foods most commonly eaten by the village populations. The price information was based on the local markets in the communities.

The balance studies were performed over four years (1973-76) and participants were chosen from a pool (longitudinal sample) of adult males (15 years and older). Sixty participants from each village (120 a year) were subjected to the balance tests once each year for a period of at least six days. The tests were performed in a specially designed facility located midway between the two villages. The longitudinal sample was relatively stable in that 45 men from Guanagazapa and 37 men from Florida Aceituno particpated in all four years of the study. Replacements for dropouts came from an original pool of 97 men from Guanagazapa and 98 men from Florida. The data from these studies is voluminous (40,000 laboratory analyses alone) and cannot be dealt with in any detail in this paper.

The calculation of population malabsorption was based on the differences between the two population means (reference and village). The amount of calories, nitrogen, and fat lost in the stools was calculated from the difference between the average percentage absorption of individuals in the village longitudinal sample and the average percentage absorption of the reference group of soldiers. The extent of food wastage was assumed to be the difference between the stool loss of the average villager and an average soldier from the reference group. This average percentage loss (per person per day) was then applied to the daily food intake to derive the amount of food lost (per person per day).

The meaning of a "reference population" needs to be explained. The extent of malabsorption in a given population must be defined relative to a reference point. The reference population for this study was a group of soldiers who were born in the Pacific lowlands of Guatemala and who had been living during the previous 18 to 24 months in a military installation near Guatemala City. The level of sanitation in the military barrack was better and the diet quantitatively superior to that available to the rural population in the test and control villages. Therefore, this population was chosen and the absorptive capacity of a sample of this reference poulation was measured Malabsorption in the test and control villages was defined relative to this reference population. This reference population is an appropriate choice because they represent an absorption efficiency associated with a level of sanitation and nutrition which might be aspired to by the rural village populations.

The project investigators agree that the study data do not indicate that there was a real change in intestinal efficiency in Guanagazapa that could be interpreted as significant for the economic calculation of food wastage. There are a number of reasons:

1. The four year period was not sufficient time for improvement to occur.

2. There was significant and unpredictable variability within the same individualfrom year to year.

3. This study has expanded the understanding of some of the biological linkages between diarrheal morbidity and malabsorption, however, the primary linkages were not clarified.

Hypothesis A. Repeated diarrheal disease in childhood leads to enteropathy which in turn results in chronic population malabsorption and food wastage. There was not enough time to test this hypothesis. All that can be said is that there were no striking decreases in infant and childhood morbidity.

Hypothesis B. The enteropathy discussed in A above is reversible through improved water supply, sanitation and personal hygiene. The length of the intervention was not long, ranging from four years for water supply to one year for hygienic behavior modification. The observed changes in improved intestinal efficiency were in the right direction although there were no significant changes in diarrheal morbidity. The results do not fulfill the needs of policy research in providing a clear basis for planning, and particularly, for resource allocation. There is, however, sufficient reason to believe that the phenomenon of a small food wastage through population malabsorption is real when evaluated by reference

to a comparable population living under improved sanitation conditions. In sum, these results do contribute to the scientific understanding of intestinal absorption and food wastage.

IMPLICATIONS FOR FUTURE STUDIES

The results of this study indicate: a) much must still be learned about the water supply/diarrheal disease/malabsorption linkage and b) losses from malabsorptive food wastage in a population does not lead to the loss of large amounts of food. However, scientific research in malabsorption, diarrheal morbidity and health status should be continued so that future policy research will be based on refined methods, information and knowledge. At present, policy research in this area is limited by difficulties in quantifying the economic variables, defining "normality" for food wastage in a population and explaining the biological variability in individuals in respect to malabsorption. Further constraints relate to the measurement of morbidity and sanitation.

The contributions of the study have not been to define the exact quantification of health benefits. The accomplishments have been in the developing and testing of methods, the development of indicators, and in results which provide an information base for further studies in policy and scientific research.

The field study, over the limited period of four years, did not demonstrate that a safe and available water supply leads to a decrease in diarrheal morbidity. This negative finding may be among the most significant of the study. Epidemiologists now have reservations about the usefulness of these field studies because of the difficulties in isolating the numerous variables involved. This study has helped in delineating the operational details of these difficulties and has led to new concepts, strategies, experimental designs and methods which may be used in future studies Limited studies are needed now to refine methods, information and data bases. Also needed are studies to add to the current knowledge of disease etiology and health benefits quantification. These are required before any further large-scale policy research is undertaken.

The complete study has been presented in a report to the United States Agency for International Development in three volumes I Methodology, II Results, III Assessment and Policy Implications.

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