WATER AND SANITATION FOR HEALTH PROJECT

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RELATING IMPROVEMENTS IN WATER SUPPLY AND SANITATION TO NUTRITIONAL STATUS

WASH TECHNICAL REPORT NO. 16

OCTOBER 1982

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Office of Health
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Prepared for the Office of Health,
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1. INTRODUCTION

This paper assumes a causal relationship, although poorly discerned and incompletely described, between certain improvements in water supply and sanitation and the nutritional status of older infants and young children (age eight months to four years). Since the debate surrounding this relationship bears not so much on its existence as on its implications for field programs, the paper will be limited to addressing the strengths of the relationship as revealed in studies and the question of whether or not nutritional status can and should be used as an evaluation measure for water supply and sanitation programs. Other issues include the research needed for further clarification of this complex relationship and the implications of current knowledge for policy and program planning. First the importance of the water/sanitation-nutrition relationship, and a conceptual model of this relationship, and then some of the existing evidence will be reviewed. At the close, questions needing further debate will be summarized.

2. IMPORTANCE OF ESTABLISHING THE RELATIONSHIP

The interest in elucidating the relationship between water supply and sanitation improvements and nutritional status is more than an esoteric one. The International Drinking Water Supply and Sanitation Decade of the United Nations and the water supply and sanitation plank of the Alma Ata platform on "Health for All" are predicated on the assumption that investments in water supply and sanitation will improve the health of the populations served. Detractors of this view point to the scarcity of evidence to support the assumption. The World Bank in preparing for the Decade chose to avoid the question altogether by declaring that research on the subject to be adequate would cost more than anyone would care to invest (World Bank 1976).

Yet program managers in this decade of water and sanitation need to evaluate their programs. Numbers of pumps installed, even numbers of functioning pumps, do not suffice. Investors and policy makers demand evidence of health and other benefits as a justification for continued investment. Health benefits are among the first sought.

Among potential measures of the health status of populations subjected to improvements in water supply and sanitation, nutrition status measures (primarily anthropometry) present a relatively easily managed objective and potentialy sensitive reflector of improvements, on condition that the relationship to these improvements can be theoretically established. When contrasted with measures of specific diseases, including prevalent conditions such as dysentery and gastroenteritis, anthropometric measures present distinct advantages (Struba and Isely, 1982). Thus the potential of using anthropometry in field evaluations of water supply and sanitation projects is the first point to make.

Clarifying the relationship would also have a salutary effect on research in the field. Those of us who have worked in the field have long realized the complexity of the relationships of nutritional status to disease incidence and prevalence, to behavior, and to environmental conditions. Influences flow in

both directions along most of the links among variables. Each group of variables can be dissociated into hundreds of factors. There is need for more knowledge on how these mechanisms interact and interrelate.

Lastly and perhaps most importantly, a confirmed and better understood relationship is probably essential for planning at both policy and field levels within programs in several sectors. Water supply and sanitation improvements could be a part of nutrition policy and strategy. Domestic use of irrigation water is a fact of life in most areas (Annis and Cole, 1982). Low cost simple adaptations of irrigation systems to address this reality could be an important adjunct to food production.

An improved understanding of this relationship could lead to training in water supply and sanitation technology for field nutrition workers, and water and sanitation could be included in nutrition education programs and materials as suggested by Latham (1978) and others.

Realizing those implications depends on how we address the relationship now. What is our present understanding? What evidence can be brought forth to support the various links in the chain of causation and correlation? What can we recommend now to evaluators, researchers, and program managers?

3. A CONCEPTUAL MODEL OF THE RELATIONSHIP

A tentative model for understanding one pathway in the relationship between water supply and sanitation improvements and nutritional status is found in Figure 1 (Isely, ed. 1982). The model depicts a two-step quasi-causal or correlative relationship with diarrheal morbidity intervening between the two. Intermediate between the improvements and diarrheal morbidity is a series of behavioral variables related to how facilities are accepted, used, and maintained. These later are in turn influenced by the degree and type of community participation. Impinging on the link between diarrheal morbidity and nutritional status is the occasional use of oral rehydration therapy, said by some to mitigate the nutritional effects of diarrheal disease (Hirschhorn, 1975). Moderating the response of nutritional status are food availability represented by income and feeding behavior. Each of the elements in the diagram merits a brief discussion.

3.1 Improved Water Supply and Sanitation

One must assume that systems, however simple, are correctly installed. Without such an assumption further discussion of these relationships would be futile. Another assumption is that systems produce water in sufficient quantity and quality and are reasonably convenient and reliable. The World Health Organization (1976) has established standards for quality and for convenience of water. Hughes (1980), in reviewing 43 studies of varying quality, has concluded that projects which emphasized increased quantities of water were more frequently able to demonstrate improvements in diarrheal morbidity than those that emphasized only improved water quality. An accepted minimum per capita figure necessary for health benefits appears to be 20-30 liters a day (Hughes, 1980).

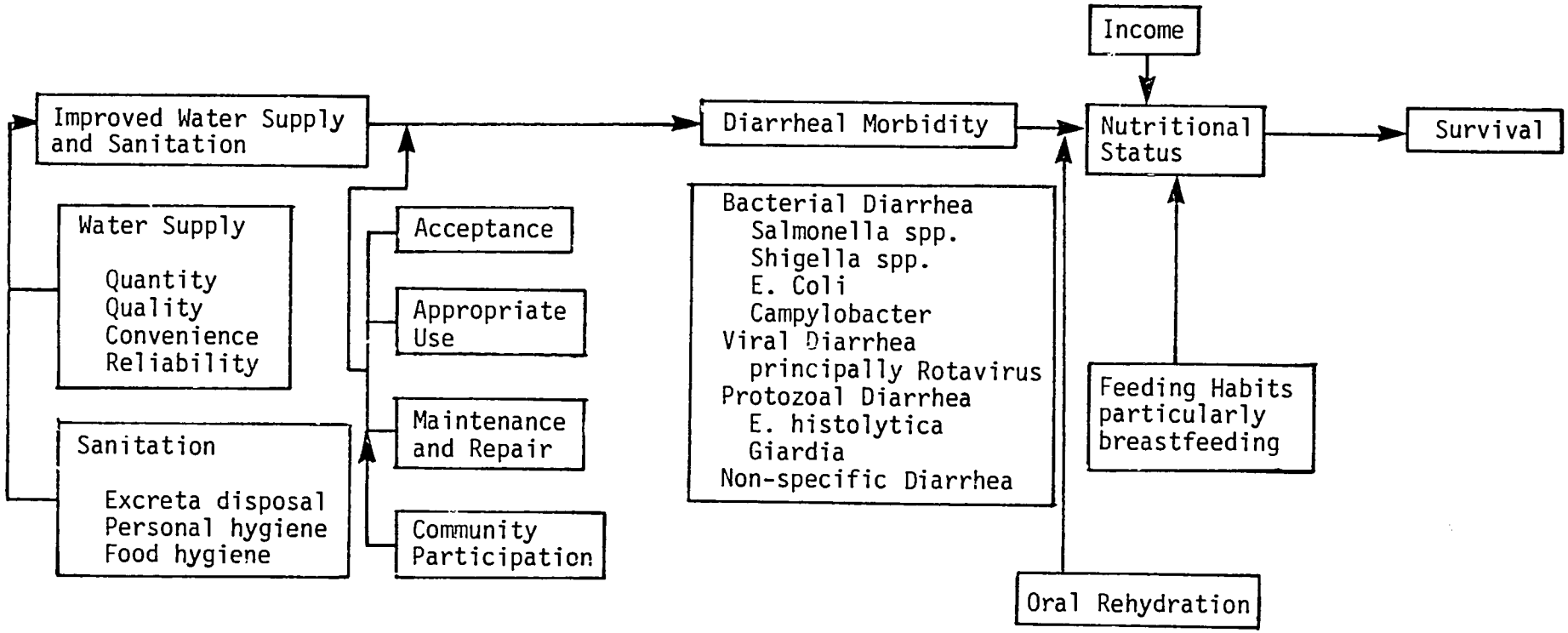


Fig. 1 Relationships among improved water supply and sanitation, diarrheal morbidity, and nutritional status (adapted from Isely, R.B. ed., 1982).

Regarding sanitation, the World Health Organization (1976) has not ventured further than declaring that facilities must be "adequate." Kalbermatten, et al (1980) have published a series of standards for various latrine constructions. In practice, however, these models have proven to be more costly than originally ascertained. The simple pit-latrine which the Bank publication eschews may still be an "adequate" option.

Standards for personal and food hygiene are obviously difficult to set in rural or periurban areas of developing countries. Even in urban areas application of food hygiene standards is spotty at best.

We are thus left with the dilemma of defining what is meant by "improved" water supply and sanitation. Since there is no simple way out of the dilemma one must assume a certain level of improvements either meeting standards already set or those that appear adequate to reap the health benefits we are seeking.

3.2 Acceptance, Appropriate Use, Maintenance and Repairs

Acceptance of new water supply technologies appears to depend chiefly on convenience and reliability (White et al, 1872). Appropriate and careful use of facilities can be assured by user education, dependent in turn on community involvement in collective behavioral change (Isely and Parker, 1982). Maintenance and repair of water supplies are likewise dependent on community participation but conditioned strongly by the availability of technical assistance and spare parts.

The acceptance, use, and maintenance of sanitation installations sufficient to assure health effects appear to have collectively a higher response threshold to efforts at user education. Community participation is probably more essential. Shuval et al (1981) in fact contend that this response threshold probably cannot be overcome in the absence of a certain level of socio-economic development. Their model ignores, however, the possiblity that a sanitation user education program could be sufficiently intensive.

3.3 Diarrheal Morbidity

Diarrheal morbidity has proved extremely difficult to define. Frequency of diarrheal episodes is an elusive concept, especially in circumstances where diarrhea tends to be a chronic continuing phenomenon. Rowland et al (1977) (see also Rowland and McCollum, 1977), for example, estimated that the average rural Gambian infant spends 20.4% of the rainy season with diarrhea. In such circumstances the boundary between one episode of diarrhea and the next tends to be blurred. This problem confounded the evaluation of the Guatemala rural water supply project as reported first by Schneider et al (1978) and later by Dworkin and Dworkin (1980). Diarrheal episodes in the latter reworking of the data were treated as discrete variables whereas they were probably on a continuum.

Frequency of stools of a diarrheal type represents a second way to measure diarrheal morbidity, but problems of a definitional nature tend to render data gathering unreliable. Rahaman (1980) in Bangladesh is using pictorial presentations of diarrheal stools in interviewing mothers to overcome some of these problems.

As indicated in the diagram diarrhea is not a single entity; rather it is a syndrome composed of conditions with multiple etiologies. Rahaman and Wahed (1981) have demonstrated differential degrees of protein and caloric loss for the various etiologic agents associated with diarrheal disease. It appears that Shigella species, Rotavirus and perhaps E. coli are the chief offenders. The key factor appears to be the ability of the organism to penetrate the epitheliel layer of the gut (Formal et al, 1969).

Bacteriologic or virologic diagnosis as a basis for assessing diarrheal morbidity is not, however, very promising under most field conditions. Neither can one ingore the possibility that a group of infants and children would have diarrhea of many etiologies in a given time frame. A more reliable and more feasible indicator is needed.

Chen (1980) suggests nutritional status as that alternative outcome indicator. His model (Figure 2) depicts the influence of improved water supply and sanitation as mediated through not only diarrheal morbidity but also through savings in maternal time and energy and improved agricultural production which are passed on to the infant. The energy savings may be most critical to the breastfeeding woman (Isely, 1981; Vis, 1981). In other circumstances diarrheal morbidity is probably the most important intermediate. In fact there is evidence that diarrheal disease through intestinal losses, increased catabolism, and anorexia may be the chief cause of growth failure.

3.4 Nutritional Status

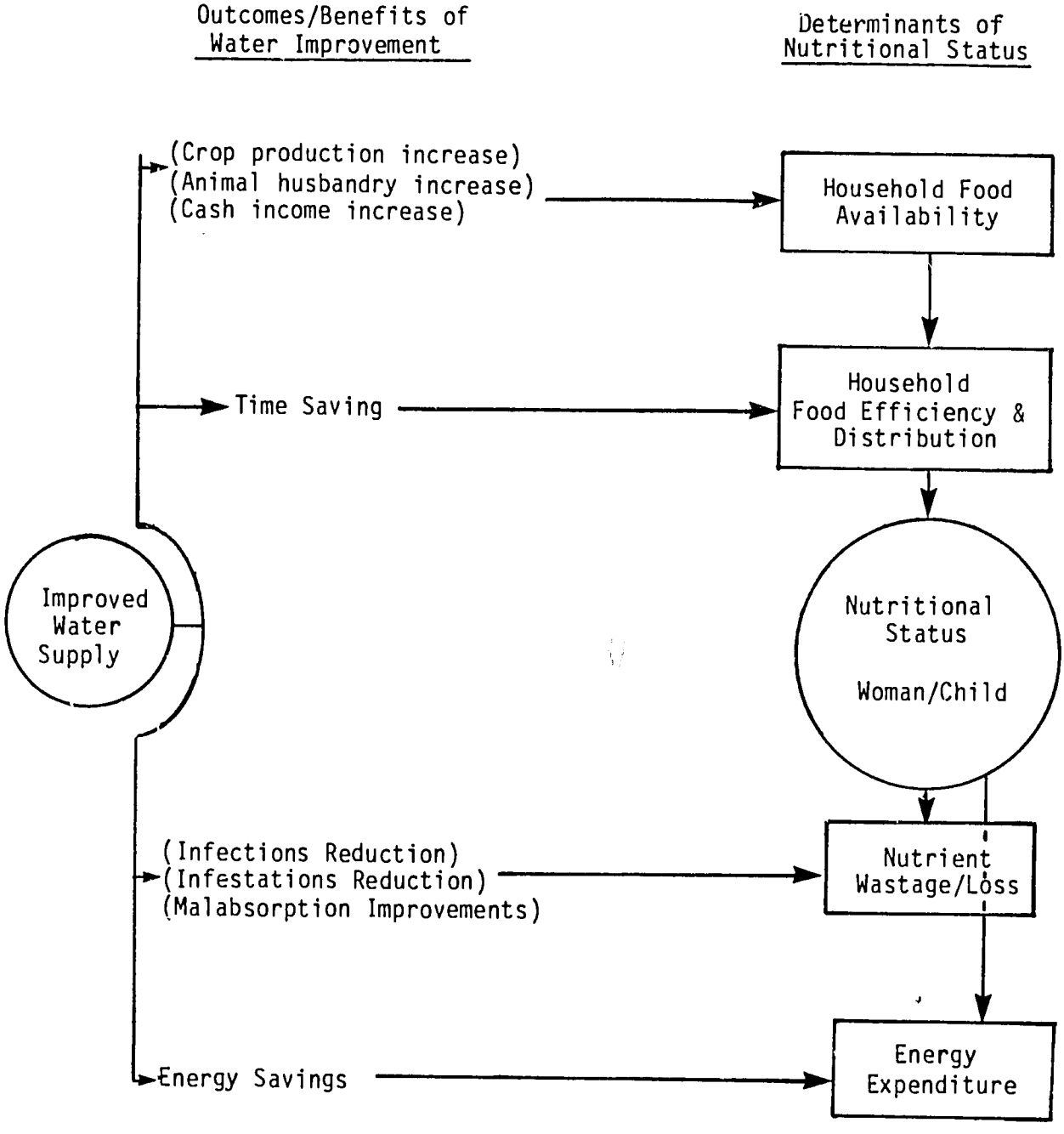
Measuring growth has the advantage of relative ease of administration by personnel with minimal training and reliability under various conditions in the field. Interpretation of growth data is aided by the existence of standard scales for height for age, weight for age, weight for height, and arm circumference. Each measure has advantages and disadvantages that are well known (Habicht et al, 1982).

3.5 Mediating Variables: Oral Rehydration, Feeding Habits, and Income

Among the most salient objections to the use of nutritional status as an outcome measure for water supply and sanitation programs are the possible influence and/or interference of oral rehydration, feeding habits, income and other mediating variables.

The ability of oral rehydration therapy to reverse any or all of the nutritional effects of diarrheal disease is uncertain. Hirschhorn (1975) reports that Apache children experiencing a rapid restoration of body fluids through the use of an oral glucose-electrolyte solution tolerate oral feedings within sometimes hours of restoring equilibrium. Those children who received oral feedings were discharged with significantly higher median weights than those who did not.

Figure 2



Taken from Chen, L. (1980)

In a similar study of Philippine children Hirschhorn and an International Study group (1981) report a salutary effect on weight gain in children over one year of age receiving an oral glucose electrolyte solution and continuous feeding. Weight gains were significantly different from those of controls for an episode one month after an episode and seven months after an episode. Rowland and Cole (1980), however, in a controlled study could not demonstrate any significant effect.

Since any changes in infant and child feeding habits or household income during the period in which water supply and sanitation installations were being evaluated might significantly affect the nutritional status of the infant and child population and thereby lead to a confused interpretation of results, these factors need to be controlled for when programs are being evaluated. Feeding habits might be expected to change in the presence of an intensive nutrition education program. Income, a proxy for food availability, might rise if programs of rural credit, irrigation, fertilizers, or new high yield varieties of food were successful.

The foregoing section has presented a model depicting the relationships among improved water supply and sanitation, diarrheal morbidity, and nutritional status. Each of the variables has been characterized, and moderating variables have been described. Now the evidence for the linkages among them will be examined as a prelude to some concluding recommendations.

4. SUPPORTING EVIDENCE

4.1 Evidence Supporting the Linkage of Improved Water Supply and Sanitation to Diarrheal Morbidity

This linkage is somewhat better supported that one might suppose. The weaknesses in many studies are probably related to the difficulties alluded to earlier of measuring diarrheal morbidity in the field and to problems associated with the use of installed facilities (Curlin et al, 1977, and Briscoe, 1978). Hughes (1981), McJunkin (1982) and Esrey (1982) have recently reviewed the evidence supporting a positive influence of improved water supply on diarrheal morbidity. As indicated earlier Hughes in reviewing some 43 studies, concluded that there is more evidence than one might expect for a positive influence. Of interest is his observation that an increased quantity of water is more beneficial than increased quality of water to achieving a diminution in diarrheal morbidity. Unfortunately the studies reviewed were not all of the same quality. Some in fact were poorly designed and/or executed. Hughes admitted studies to the review if indicators of diarrheal disease in populations exposed to different levels of water supply and/or sanitation were quantified. All studies had to contain data for at least one study and one control group. Excluded were epidemic investigations, case-control studies, studies where the different water supply and/or excreta disposal groups were not discrete, or studies where results were presented as linear regressions or correlations without adequate data to permit calculations of indicator rates in study and control populations.

McJunkin has recently reviewed several hundred studies relating water supply and sanitation improvements to health indicators, the majority of the latter indicators of enteric disease. He concludes that there is a health impact, especially where water is readily accessible in adequate quantities. Other things being equal health impacts improve with increasing levels of service and with complimentary activities in excreta disposal and health education. Soap appears essential. Interestingly in this review the studies that were unclear or negative tended to occur in situations of the greatest poverty and underdevelopment.

The studies reviewed by Esrey nearly all suffered from major defects although the criteria for admission to his review were more stringent than those of Hughes and McJunkin. He could conclude little from his review.

The first major linkage in the model is thus supported by the weight of evidence both historical and contemporary.

4.2 Evidence Supporting the Linkage of Diarrheal Morbidity to Nutritional Status

This relationship is probably the best supported of the three (see Scrimshaw et al, 1968, and Latham, 1970). There is little need to review individual studies. Table 1 summarizes several of the more important of the past several years.

As the table indicates the relationship of diarrheal morbidity to physical growth is stronger than for any other disease, and probably operates with shortages of food to keep growth rates below standard for the majority of poor children despite medical and nutrition interventions.

Other factors too seem to condition the response of growth rates to diarrheal disease: sex, the parity of the mother, caste, and the timing of birth and weaning in relation to season.

4.3 Evidence Supporting the Linkage of Improved Water Supply and Sanitation to Nutritional Status

Whether through diminished morbidity, through savings in maternal time and energy, or through improved food production, a number of studies are beginning to suggest nutritional benefits from improvements in water supply and/or sanitation. Although there is great variation in the quality of these investigations, results are encouraging enough to merit attention. Those addressing the links between improvements in water supply and sanitation and nutritional status are summarized in Table 2.

The results of a baseline study by Anderson (1981) are mostly speculative. Carefully collected baseline nutritional indices revealed a predominance of stunting in rural Bolivian (Quechua) pre-school children. Stunting was more pronounced at higher than at lower altitudes. Wasting was more frequent at lower altitudes. Dietary analysis revealed lower caloric and protein content at higher altitudes; gastroenteritis was more frequent at lower elevations. All deficits were most pronounced in the second year of life.

Table 1
Studies or Reviews of Studies Concerning the
Effect of Diarrheal Morbidity on Nutritional Status

Year	Author(s)	Location of Study	No. Subjects	Source of Information	Independent Variable(s)	Nutritional Variable(s)	Observations
1961	McGregor,I.A. et al	Gambia	195 Cohort	Brit.Med.J. 12/23: 1661-1666	Season Infections Food availability Preventive and curative care	Height Weight	Coincidence of growth faltering, infection and mortality in rainy season associated with increased maternal agricultural activity
1968	Guzman,M. et al	Guatemala	816 Cohort	Arch.Env.Hlth 17:107-118	Feeding Env.improvements Preventive and curative care	Height Weight Skinfold Bone development Head circ.	Feeding village children showed slightly better growth than children of villages with env. improvements, but still far below standards
1972	Mata,L.L. et al	Guatemala	45 Cohort	Am.J.Clin.Nut. 25:1267-1275	Infection with enteric viruses	Weight Height Head and thoracic circumference	Nutritional deficits from viral infection in first 3 months persist to 12 months. Growth deceleration associated with: - diarrhea - bronchopneumonia - pertusis Recuperation slow
1975	Martorell,R. et al	Guatemala	716 Cohort	Am.J.Dis.Child 129:1296-1301	Morbidity: - diarrhea - fever - respiratory illness Diet Age Sex	Growth in height and weight	Negative correlation with diarrhea only No significant interactions

Year	Author(s)	Location of Study	No. Subjects	Source of Information	Independent Variable(s)	Nutritional Variable(s)	Observations
1976	McGregor,I.	Gambia	258 Cohort	Oikos 27:180-192	Season Timing of birth Food availability Malaria Gastroenteritis	Weight Height Wt/Ht. Hemoglobin	Variation with season, infection rates and weaning Varies with season
1977	Rowland,M. et al	Gambia	?	Brit.J.Nutr. 37:441-450	Gastroenteritis Malaria Season	Height/age Weight/age	Significant relationship to gastroenteritis; for malaria to weight only.
1977	Cole,T.J. Parkin,J.M.	Gambia and Uganda	197	Trans.Roy.Soc. Top.med.Hyg. 71(3):196-198	Infectious morbidity - Gastroenteritis - Malaria - Measles - Helminths - URI - Lower RI	Weight	Growth significantly related to gastroenteritis ($p < 0.001$) and to malaria ($p < 0.01$) Effect of gastroenteritis: that of malaria = 13.1
1978	Taylor,C.E. et al Kielmann,A. et al	India "	2900 Cohort "	Ind.J.Med.Res. 68 (Suppl.) 1-20 Am.J.Clin.Nut 31:2040-2052	Sex Caste Nutrition care Preventive care Parity of mother No. of male children	Height Weight	Nutrition care, nutrition and medical care combined, caste and sex equally influenced anthropometric variables. Up to 50% remained below 70% of Harvard standards.

Year	Author(s)	Location of Study	No. Subjects	Source of Information	Independent Variable(s)	Nutritional Variable(s)	Observations
1979	Rowland,M.	Gambia Uganda	152	Unpublished paper	Diet Gastro-enteritis	WH/Age	Comparison of Ugandan and Gambian children: Ugandan growth > Gambian unrelated to diet, related to gastroenteritis.

Table 2

Studies of the Relationship of Improved Water Supply and/or Sanitation to Nutritional Status

Year	Author(s)	Location of Study	No.Subjects	Independent Variable(s)	Nutritional Variable(s)	Observations
1978	Tomkins,A.M. et al	Nigeria	183	Water supply - Protected copious - Unprotected scanty food hygiene	Height Weight Midarm circumference	Wt/Age and Wt/Ht. Greater in villages with copious protected water p<0.01
1981	Anderson,N.A.	Bolivia	221	Infection Potable water systems Breast feeding and weaning practices Diet Altitude	Weight Height 24 hr dietary history	Baseline data only - stunting - majority with adequate weight for height - majority with >1 SD. weight/age Diets 68% caloric defi cient; 30% protein defi-cient; 18% current diarrhea rate; 35% past diarrhea rate (38% in those < 3 yrs. 47% < 2yrs) girls > boys Diets were more deficient at high altitudes; diarrhea more prevalent at lower.
1981	Henry, F.	St. Lucia	75 Cohort	Water supply Latrines at different levels Controls for literacy house construction cooking facilities garbage disposal infant food preparation	Height Weight	Height and weight increments improved in areas with household taps and latrines

What possible role does improved water supply and sanitation have in improving the nutrition status of these infants? One would assume that water supply and sanitation improvements influence to a far greater extent the wasting found predominantly at lower altitudes than the stunting more prevalent at higher altitudes. Although diarrheal disease contributes mainly to wasting through caloric deprivation, one cannot ignore possible influences of diarrhea on chronic malnutrition through morphologic and physiologic changes in intestinal mucosa and resulting malabsorption. Thus improvements in water supply and sanitation practices might be expected to influence nutritional status at all altitudes although to a greater extent at lower altitudes where diarrhea and wasting are more prevalent. The role of genetic predisposition to short stature at higher elevations may be important, although as Anderson points out Quechua children in Peru have achieved a median height of 25% of standards when subjected to supplementary feeding.

The studies of Henry (1981) and Tomkins et al (1978) are more striking. In both there were decidedly significant differences in weight-for-age and weight-for-height of children benefiting from sanitary improvements. The Henry study is particularly noteworthy because of its longitudinal design. Water supply (household taps) was the critical variable. Although having a latrine as well did not produce a better result in anthropometric findings, results for prevalence of diarrhea and intestinal helminths were significantly better. Interpretation of the study is hampered by the small sample size. Growth in children initially retarded also tended to catch up after the third year of life. One wonders how many in the goup with early retarded growth survived until the third year.

Tomkins and colleagues (1978) compared children in villages having "scanty unprotected" with those having "copious protected" water supplies. One wonders if the beneficial effect they noted on weight increments was due to the protected quality of the water or to its copiousness. It is noteworthy that both copious and scanty water supplies were from open wells. The former, however, had parapets and drainage aprons and even greater flows and greater accessibility than the more traditional wells. The greater quantities of available water, with implications for personal and food hygiene, offer a more plausible explanation for the results.

This limited search has not produced a single study demonstrating a clear pathway from improved water supply through savings in maternal time and energy or increased food production to improved nutritional status of children. Studies of the consequences of mothers' agricultural activities are however instructive. Thompson and Rahman (1967) and McGregor et al (1961) some time ago described the results for children unfortunate enough to arrive at weaning at the beginning of the growing season in the Gambia. If their mothers' rice fields are at some distance from the village, there is a tendency to abrupt weaning and to leaving the child with a younger sibling or an elderly person in the family. These children have a demonstrated higher infection rate, a greater degree of weight faltering, and a higher mortality than those who pass through the growing season at the breast.

Vis et al (1981) have shown a similar pattern for women in northeast Zaire. Those with the greatest distances to fields had not only children with the highest infection rates, earlier weight faltering and higher mortality, but

themselves had the least weight gain in pregnancy, the smallest newborns, and the smallest volumes of breast milk. Other variables of importance were season, parity, and maternal infections.

By extrapolation these same consequences for the nutritional status of infants and children could result from long distances to water coinciding with critial times in the cycle of pregnancy, lactation, and child growth and development. It has been reported (Isely, 1981) that in hilly terrain a woman may consume 27% of her daily energy in carrying water. In the lactating woman such an expenditure would leave a very small caloric reserve.

5. CONCLUSION AND RECOMMENDATIONS

Evidence has been reviewed for the relationship of improved water supply and sanitation to nutritional status in young children. A two step hypothetical model of causation has been examined. Each step, as well as the overall equation, has been weighed in the light of available evidence in field studies. There seems to be sufficient evidence to support each linkage to a variable extent. The water supply/sanitation/diarrheal morbidity linkage has moderate support. That between diarrheal morbidity and nutritional status is strongly supported, whereas the overall relationship between water supply/ sanitation and nutritional status remains tentative, but promising. The consequences of this analysis for evaluation, research, and policy need to be carefully examined.

5.1 Evaluation of Water Supply and Sanitation Programs

The question before evaluators is whether to recommend nutritional status as an evaluation indicator now, or to await further research. At least two important research studies at Teknaf, Bangladesh (Rahaman, 1981) and at Jhansi, India (Srivastava, 1981) are in progress. In both, anthropometry is a major dependent variable in what amounts to a four cell research design where villages receive varying combinations of water supply, sanitation, and health education.

Several water supply and sanitation projects or components of other projects in primary health care or rural development that have been underway for one or more years, are considering the use of anthropometry as an evaluation indicator. Should this step be recommended?

The relative ease of taking measurements, their reliability in the hands of minimally trained personnel, their relatively low cost and the evidence supporting the relationship, especially the studies of Henry and Tomkins, all combine to support the recommendation that anthropometry be used in this way. As a consequence of such reasoning, projects in the Philippines, Togo, Somalia, and Lesotho are planning such a move. The cumulative results of these evaluations may be as useful as the results of the most perfectly designed research.

5.2 Research

Research is needed to clarify the role of increased quantity versus improved quality of water with respect to nutritional status. If increased quantity is the key factor, then how does it operate? There is evidence for example, that contaminated foods, particularly weaning foods, may be the principle mechanism for transmitting diarrhea and dysentery (Rowland and McCollum, 1977; Capparelli and Mata, 1975; Smith, 1980). How does an increased quantity of household water help to arrest this transmission? What is the role of excreta disposal?

The influences of such immutable factors as caste, altitude, and season need further exploration as to their relative importance in determining the end result of improved growth of children.

Also the role of oral rehydration and the effects of early feeding of children with diarrhea in mitigating nutritional ill effects needs to be clarified.

Lastly, the question of how the multiple ways in which maternal savings in time and energy brought about by shortening distances and lessening other difficulties in obtaining water can contribute to better child nutrition should be investigated. The speculated extrapolations from agriculture need to be verified.

5.3 Policy

Should water supply and sanitation improvements be viewed as part of a national nutrition policy? Chen (1981) would respond affirmatively. He views water primarily as a nutrient and improvements in water supply accessibility, reliability and quantity as having consequences primarily in the improved growth of children.

Whether one agrees or not, the value of associating water supply and sanitation and nutritional programs in the field seems obvious. Given that the role of diarrhea is at least equal to that of food availability among the determinants of nutritional status, effective means of diarrheal disease prevention need to be considered.

Policy and program changes should probably await the results of current research and evaluation efforts, however, in order to gather adequate support. The evidence in favor of such moves is growing but is not yet optimal.

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