GASTROINTESTINAL DISEASES

XIV Meeting of the
PAHO Directing Council

TECHNICAL DISCUSSIONS
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PAHO Directing Council

Washington, D. C., September 1963

control of
GASTROINTESTINAL DISEASES

Ideas for the Formulation of a Plan for the Control of Gastrointestinal Diseases, including environmental sanitation measures, epidemiology, health education, and early diagnosis and treatment

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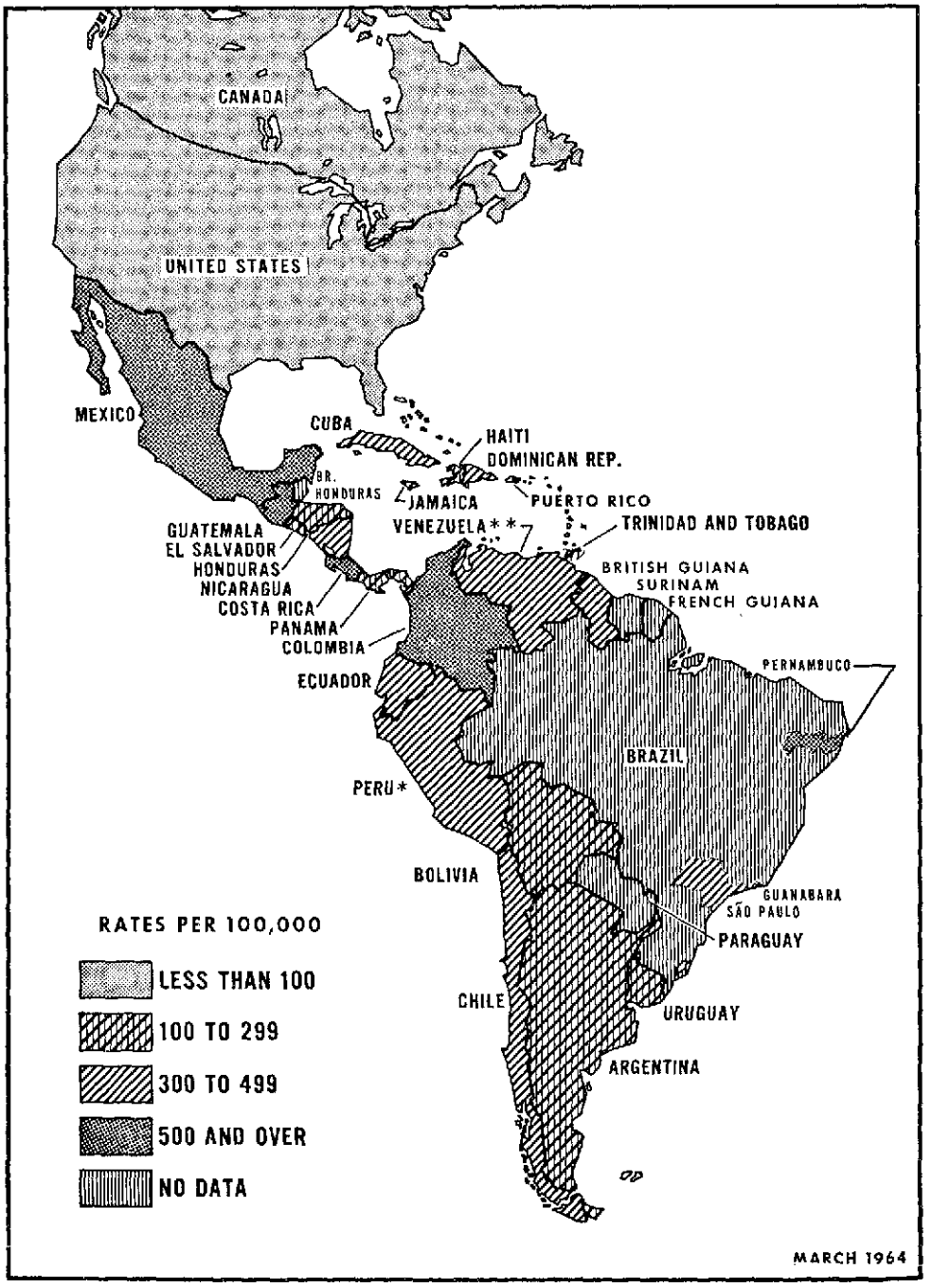
Deaths due to gastritis and enteritis [543-571-572] per 100,000 population, in children under five years of age in Latin America in recent years.



*Area with medical certification

**Estimated rate.

Source: Official data from countries, mostly for 1961 or 1962.

*REPORT OF THE TECHNICAL DISCUSSIONS**

The Technical Discussions at the XIV Meeting of the Directing Council of the Pan American Health Organization (Washington, D. C.) were held on 19 September 1963 and dealt with the theme: "Ideas for the Formulation of a Plan for the Control of Gastrointestinal Diseases, including environmental sanitation measures, epidemiology, health education, and early diagnosis and treatment." Dr. James Watt (United States of America) acted as Moderator, Dr. Francisco Castillo Rey (Venezuela) as Rapporteur, and Dr. Alfred Yankauer (Pan American Sanitary Bureau) as Technical Secretary.

The theme was first presented by the principal authors of the three working documents: Dr. John E. Gordon presented the paper on an epidemiological basis for the control of diarrheal disease; Eng. Nicolás Nyerges V. presented the paper on environmental sanitation measures; and Dr. Nelson K. Ordway, the one on diarrheal disease and the health care services in Latin America.[1]

After the authors had summarized the contents of the working documents, four other expert members of the panel commented on the presentations and on the central theme: Dr. Melvin H. Goodwin, of the Communicable Disease Center, U. S. Public Health Service (epidemiological aspects); Eng. Donald J. Schliessmann, also of the Communicable Disease Center (sanitation aspects); Dr. Albert V. Hardy, of the State Board of Health, Jacksonville, Florida (patient care aspects); and Dr. Viola Mae Young, of the National Institutes of Health (etiologic aspects).

The Moderator, in summarizing the principal points made by the previous speakers, pointed out that the nature of the concern about diarrheal disease is in itself an index of development. Cholera, for example, is no longer a concern to Latin America, though very much the focus of discussion in some other regions of the world. On the other hand, the spread of *Salmonella* through prepackaged foods, a major concern to highly industrialized areas, has less relationship to the present problems in Latin America.

The meeting was then opened to comments and questions from the floor. A vigorous discussion followed, with full and active participation by both delegates and panel members.

The comments from the floor included a description of a simplified practical method of operating a bacteriological laboratory and of the results obtained.

There was very general agreement with the ideas and proposals made in the working documents, with the minor exceptions noted below. The significance of active community participation in, and understanding of, the control measures undertaken in any of the several fields ran as a key issue throughout the discussions. Health education and community development were understood to be linked to the provision of facilities and services and to be absolutely essential. The use of auxiliary

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* The Report of the Rapporteur of the Technical Discussions was submitted to the Directing Council at the twelfth plenary session, 24 September 1963.

[1] In this publication the working documents of the Technical Discussions are presented as six separate papers.

and even lay personnel is of demonstrated value in implementing many control measures, but to be effective, must be linked with a continuing system of professional direction and supervision. With these important points in mind, as applicable to virtually all areas, the discussions can best be summarized by grouping them under the three main aspects of the theme identified earlier.

1. *Epidemiological Factors and their Implications for Control Programs*

The diarrheal diseases are best thought of as a group of diseases to which diverse etiological agents contribute, as is the case with the "common colds."

It was pointed out that, in areas of high endemicity, neither the finding of a known pathogen in the stools nor a rise in its serologic titer in a patient with disease is necessarily proof of etiology. The role of many possible pathogens, especially viral agents, is still quite unclear and the symbiotic pathogenic effect of viral-bacterial interaction is unexplored. A balance between organisms, environment, and host must exist and, in order to understand the disease picture, it may be as important or more important to understand the host and his environment as it is to understand the organisms.

It was emphasized repeatedly in the discussions that the epidemiological characteristics of diarrheal diseases as a group can be clearly described, that an epidemiological entity can be defined, and that control measures can be designed accordingly. These characteristics differ from place to place, being dependent upon host factors (such as age and nutrition), levels of living, sanitation and medical care, and patterns of behavior. Understanding these conditioning factors as they operate in a community (and, therefore, the epidemiological basis for control measures) calls for epidemiological field work at the local level, rather than sophisticated laboratory studies. On this basis an epidemiological approach to controlling the problems can be developed for different areas and communities, especially the type of approach that will involve the communities in helping and educating themselves.

Thus, for example, the epidemiological characteristics of diarrheal disease as it occurs in the Guatemalan highlands indicates that the clinical index case in a family, as well as high attack and mortality rates, focus on the infant and young child; that contact spread predominates; that epidemics occur over prolonged periods of time, at intervals suggesting the significance of a new crop of susceptibles (as with measles epidemics); and that the many relationships with nutrition also highlight the importance of host factors in conditioning the behavior of the disease. These relationships with feeding patterns and nutritional status are sharp enough to characterize an epidemiological entity, "weanling diarrhea," which was recognized as an important entity in many other areas of Latin America. Relationships to environmental sanitation are also evident in Guatemala, though less outstanding because effective sanitation measures had not been undertaken in the area studied. Thus, there is need for a continuing epidemiological intelligence system whereby all types of diarrhea are reported and not merely those caused by specific organisms. At the crudest level, this might consist of the reporting and analysis of deaths from diarrheal disease, which in itself can identify early the village epidemic waves.

Control measures must include attention to child care, nutrition, and illness care, as well as sanitation of the environment. Furthermore, the data indicate that none of these measures will be effective unless a type of health education that will motivate people to change practices and utilize medical services promptly is carried out concurrently.

2. *Environmental Sanitation Measures and their Implications for Control Programs*

It was agreed that the effectiveness of sanitation programs in reducing diarrheal disease morbidity was a proven fact, as was the primary importance in sanitation programs of providing an adequate supply of potable water delivered in accessible form. Excreta and waste disposal follows second in order of priorities. Other programs such as fly and insect control and housing and food sanitation depend upon and derive from the existence and effectiveness of these first two control measures, although there may be some geographic areas where these latter programs require special attention. The major focus of discussion, therefore, was upon these first two priorities.

It was agreed that water supplies adequate to cover per-capita needs for personal and domestic hygienic practices, as well as drinking and cooking, were essential. Water quality is important as it relates to potability and bacteriology. Financing problems, especially those posed by rural areas, make it essential to provide for costs recoverable from the community to be served. This, in turn, requires an approach that will involve the community from the very onset of the program, a factor most important to program planning and one that can enhance community education, which must always accompany water programs.

The problem of what constitutes "accessible water" was discussed at length. There is no doubt that a system of water piped into every home in a community is the most desirable system and the sanitation measure most effective in reducing morbidity from diarrheal disease. Furthermore, it provides the basis for more effective excreta disposal and housing improvement. Under certain circumstances it may be essential to the recovery of capital by providing a personal benefit that motivates repayment.

The major problem in the implementation of such a concept is the increase in cost that it entails, and this is an especially prominent feature of village water system development programs. A number of participants emphasized the positive value of accessible public taps and public bathing, laundry, and even excreta disposal facilities in the experience of their own countries, and pointed out that these had been developed with full and enthusiastic community support and participation. Furthermore, such systems are not inconsistent with the later provision of home outlets if the planning and construction are tailored accordingly. In view of the financial difficulties encountered, they considered this measure to be an effective and practical intermediate step.

It was clear from the discussion that differences in the definition of what constitutes "accessible water" stem from different experiences with different types of communities and community responses, and that each country will have to adapt its own program for the provision of water to its own conditions, needs, and resources. The existence of varying points of view highlights the need for research and the importance of a sound epidemiological and social basis for program planning and execution, with the word epidemiology defined in the broadest sense so as to include the study of community and host behavior. Both health education and related community organization measures and the nature of the water supply system to be developed (activities inseparably linked) can then be designed accordingly.

The problems of excreta and waste disposal hinge upon the choice and use of techniques and methods that effectively remove fecal matter from the human environment. The problem is sometimes complicated by industrial wastes, which destroy national resources and/or provide insect breeding grounds. The disposal of excreta, water-borne wastes, and sewage

effluents exists as a major public health problem in all parts of the Hemisphere, although it is manifested in different ways. Ideal solutions to all these problems are known, but the necessity of large-scale capital financing interferes with their achievement. Thus, domiciliary flush toilets are the ideal means of human fecal disposal and obviously depend upon water piped into each home. Yet, even where such conditions prevail, differences of opinion were expressed concerning the practicability (not the inherent desirability) of applying the ideal. The sewage disposal problems encountered and the high additional costs were cited as difficulties.

It was agreed that latrines which effectively remove feces from the human environment have an important place in excreta disposal programs. However, the key point is *effective* removal, since it has been shown that latrines may actually increase the hazard of environmental contamination when they are poorly planned, constructed, and maintained. This again highlights the importance of preparatory and coincident community education and participation in the program.

It was agreed that latrines have a clear place in programs for isolated homes that have no access to a community water supply. It was further agreed that provision of community water supplies should be coupled with an excreta disposal program in communities where such installations do not exist or are imperfect. The differences of opinion concerning the place of latrine construction in communities where water outlets in homes exist or are planned, like the differences of opinion expressed in the case of domiciliary outlets themselves, reflect differences in experience, population groups, and resources and re-emphasize the need for research and for an epidemiological and social basis for program planning and execution.

3. *The Relationship of Health Care Services to Control Programs*

It was agreed that in view of the relatively long-range effects of efforts to improve the sanitation, nutrition, and level of living of the population, the undeniable effectiveness of medical care measures in preventing deaths from diarrheal disease was of the utmost and immediate importance to program development and planning.

The major factor leading to death from diarrheal disease is dehydration, and simple inexpensive measures for its prevention, when applied early, have been found to reduce the incidence of dehydration and the mortality rate from diarrhea quite significantly. Education of the community, and the utilization of sweetened water mixed with small amounts of electrolytes and administered according to precise instructions, are the specific measures available. Examples were described of several successful programs of this kind, in which electrolytes provided in simple packaged form or in tablets were widely distributed. These measures need far more widespread acceptance, for they can serve as the focus of action at all levels of a health care service, and even as the focus of a direct approach to a community that has no health care services available.

More serious cases, when they occur, will need institutional care, but here also methods of treatment exist which, if applied, will save many more lives. Attention to the quality of care and to the pediatric training and supervision of medical and paramedical personnel become important. The dexterity required to carry out intravenous therapy (prescribed by trained physicians after diagnosis) can easily be acquired by auxiliary personnel. Emergency coverage and careful, continued patient-care supervision by the same physician also become important, but in spite of the difficulties these pose, much can be done to improve the existing situation without increasing costs.

This focus on patient care inevitably directs attention to the victim of diarrheal disease: the infant and preschool child. The importance of host factors in diarrheal disease, demonstrated epidemiologically, must be translated into patient care. This means that repair of nutritional deficits must follow, in therapy, repair of water and electrolyte deficits. The latter is a far longer process and requires a coordinated, preferably an integrated, structure of health care services. Realistic education becomes of vital importance, as does the desirability of applying preventive advice concerning infant feeding. The primary role of rehydration in immediate treatment was recognized by all the participants.

A suggestion that foodstuffs might be fortified by antibiotics was viewed by the group with caution, if not alarm, because of the inherently dangerous effects of altering host-organism ecology.

The role of antibiotics and sulfonamides in treatment received considerable attention. There appeared to be consensus that the utility of sulfonamides is doubtful. Some participants and panelists felt that antibiotics served no useful purpose. Other opinions were expressed to the effect that antibiotics were of use in special cases, particularly of the fulminating variety where etiology and drug sensitivity could be established. There was consensus that the importance of antibiotics has been overemphasized and that they are costly. Decisions again must be made on the basis of knowledge of local conditions and resources. However, the value of specific drug therapy in amebic dysentery, which in some areas contributes importantly to diarrheal disease in young children, was recognized.

SUMMARY

1. Measures of proven effectiveness exist that can reduce morbidity and mortality from diarrheal diseases, particularly as they affect young children. These measures are not as widely applied as they might be.

2. Simple field epidemiological methods of study can help give direction and emphasis to the control measures applied.

3. In the application of control measures there is need to collect systematically information that will clarify the precise effect of the specific measures applied, so that future program planning and execution can be undertaken in the most economical and effective manner possible.

4. The central theme in planning and executing control efforts should be the principle that people can do for themselves if they only know what to do, and if what to do is made possible.

ACUTE DIARRHEAL DISEASE IN LESS DEVELOPED COUNTRIES

*I. AN EPIDEMIOLOGICAL BASIS FOR CONTROL**

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Apart from its contributions to research, epidemiology has a major practical use as an instrument for action in the control of community disease. To this end, pieces of knowledge from clinic, laboratory, and field are fitted together to give a pattern of disease behavior within populations. A considered program for control then evolves through the identifying of various features in a complex of causality that is multifactorial, with variables individually related to an agent of the disease, to the human host, and to the environment that encompasses both. A recent analysis of chickenpox (1) illustrates the procedure. Epidemiology so employed serves as the diagnostic discipline of public health (2), through operational as contrasted to investigative activities (3).

The present purpose is to consider the diarrheas and the dysenteries of man, especially those of infants and young children, from this viewpoint. Our intent is to assemble recorded knowledge, to make free use of the opinions and interpretations of many colleagues, and to supplement these findings where appropriate with personal observations that have extended from the Arctic (4) to the tropics (5), over a period of many years (6). Research interests will be touched upon only to indicate those gaps in knowledge relating directly to control. In simple terms, the aim is to state what to do now with the information at hand: to examine the behavior of diarrheal disease in nature and the application of that knowledge to prevention and control in human populations.

The attempt to control the acute diarrheal diseases involves more than a restriction of the morbidity and mortality they cause. The attendant disability has important economic consequences. In less developed countries, where diarrheal disease is highly

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This article will also be published in English in the *Bulletin* of the World Health Organization.

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prevalent, a recognized synergism with nutrition seriously affects general health (7). The resultant deterioration in nutritional status, frequently to the level of malnutrition, is reflected in impaired resistance to other infections and the precipitation of specific nutritional disorders, notably kwashiorkor. A community program for the control of diarrheal disease is thus tied intimately to general health activities, and the relative emphasis it receives is of necessity a function of the broader effort. It is more than an action of itself, whether at the national, provincial, or local level. As with most public health activities, any program for control starts with the clinical aspects of the disease.

ACUTE DIARRHEAL DISEASE: A CLINICAL SYNDROME

Whether prevailing with high or low frequency, the endemic diarrheas everywhere are mainly of acute evolution. Chronic diarrheal disease is minimal; in less developed regions it is an inconsequential part of the whole and not included in this discussion. Like most acute infections, diarrheal disease follows a biological gradient from clinically undetectable unapparent infection to severe manifestations with an appreciable fatality. By arbitrary definition, it is possible to make crude clinical separation into mild, moderate, and severe forms of the disease.

Acute diarrheal disease includes a proportion of specific enteric infections, such as shigellosis, salmonellosis, and diseases caused by enteropathogenic colon bacilli, but it consists mainly of undifferentiated disease with no demonstrable specific infectious agent. The significant feature is that a similar clinical form occurs with all endemic diarrheas, whether of demonstrated specific etiology or otherwise. There is no characteristic clinical pattern, as with measles among the acute exanthemata, to distinguish one etiological entity from another, nor the total of cases attributable to a specific pathogen from those without a known infectious agent.

It is true that in Guatemala severe cases are more likely to be related to *Shigella* than to any other infectious agent and that cases with a demonstrated agent include more than a proportionate share of severe infections. However, a severe case has nothing to mark it as shigellosis, other than the greater probability of isolating an organism; and the majority of severe cases are of indeterminate microbial origin.

Epidemics in a general population are usually superimposed on an endemic base. Consequently, various pathogens are isolated in the course of an outbreak. In our experience no epidemics have been encountered without the predominance of some particular infectious agent among those isolated, although never to the extent of accounting for a majority of the cases. Furthermore, from a practical standpoint, diarrheal disease in epidemic form in less developed countries has not, in our experience, been distinguishable clinically from endemic cases.

This is not to discount recognition by Hardy (8) and most others who have worked in the two situations, that the diarrheas in preindustrial countries with poor environmental sanitation and prevailing malnutrition differ importantly in clinical form and in severity from those of more favored areas. The infectious agents broadly encountered are much the same, suggesting that clinical variations relate mainly to host resistance and the size of the infecting dose (9).

Among malnourished children, the disease is not usually an isolated episode of acute evolution. Systemic manifestations are often less pronounced than in the well-nourished child, but the attack tends to persist. Instead of the prompt recovery characteristic of children in better nutritional state, a low-grade indisposition often follows, sometimes for as long as three months,

with irregular loose stools, a progressively depleted nutrition, and occasional recurrent acute episodes. Two or three such events during a year are frequent in young children, and some have as many as eight or ten. Dehydration and electrolyte imbalance are frequent and difficult to correct. Because of this, the usually deficient diet is further restricted, which contributes to maintaining the situation. A bloody or mucopurulent exudate in stools is commoner than in the mild undifferentiated diarrheas of developed areas.

Clinically considered, acute diarrheal disease is a syndrome, occurring universally and in different degrees of severity, with essential differences characterizing special areas and different environmental conditions. In any single situation, clinical entities cannot be distinguished, although etiologically distinct diseases exist. This circumstance is neither unique among infectious diseases nor does it necessarily limit specific action. In acute sore throat or typhoid fever, for example, laboratory examinations compensate for the limitations of clinical appraisal. But, as will become evident, this is not true for acute diarrheal disease.

SPECIFIC ETIOLOGY OF ACUTE DIARRHEAL DISEASE

The designation of a disease as a clinical syndrome in no way precludes the existence of exactly determined disease entities within the group. Aseptic meningitis is an illustration of a typical clinical reaction induced by many different infectious agents, one of which is demonstrable in most instances.

On the other hand, the common cold, which also is a clinical syndrome or collection of diseases, includes several recognizable specific infectious disease entities. For example, those due to the syncytial viruses, para-influenzal viruses, rhinoviruses and reoviruses, and a number of others, are each irregularly represented in the total number of common colds at a particular time or place. However, the syndrome includes a much greater aggregate of cases, with good reason judged infectious and communicable, and yet with no demonstrable infectious agent. A considerable number are suggestively noninfectious, or at least scarcely communicable, notably those of allergic origin.

Acute diarrheal disease at a particular time and place is similar to the common cold in that it is a clinical syndrome of characteristic behavior, including a minority of known disease entities, a predominating bulk of undifferentiated, presumably infectious, processes, and an indefinite number of noninfectious processes. The proportions are by no means fixed; the pattern is dynamic, frequently changing, and with no characteristic distribution of its elements either locally or generally.

The recognized specific infectious diseases —shigellosis, salmonellosis, *Escherichia coli* diarrhea, and amebiasis—ordinarily constitute a minor part of the whole. In preindustrial regions with a high endemicity of diarrhea, the three bacterial agents with their multiple serotypes are often demonstrated in less than 20 per cent of cases. The usual figure is slightly higher; a proportion of 40 per cent is occasionally met; and to find 60 per cent of diarrheas associated with any one of the specific bacterial pathogens is exceptional.

Observations over a period of 17 months among children under five years of age in a Guatemalan Indian village showed that one or another of the pathogens was present in 24 per cent of 578 cases of diarrhea (Table 1). A specimen of feces, usually obtained by rectal swab, was cultured on three different media. Subsequently, 115 cases were subjected to intensive examination, by methods beyond any practical field application. Both rectal swabs and stools were used. If necessary, five serial specimens were examined before recognizing a negative result, and duplicate augmented

TABLE 1—*Bacterial Pathogens Present in 578 Cases of Acute Diarrheal Disease in a Rural Guatemalan Village, February 1961 to June 1962.*

Bacterium	Acute diarrheal disease	
	No. of cases	% of all cases
Shigella dysenteriae 1	10	1.7
Sh. dysenteriae 2	4	0.7
Sh. flexneri 1	2	0.3
Sh. flexneri 2	23	3.8
Sh. flexneri 3	32	5.5
Sh. flexneri 6	36	6.2
Sh. boydi	5	0.9
Sh. sonnei	9	1.6
Salmonella	1	0.2
Escherichia coli	17	2.9
None	439	76.0

lines of culture media were employed. The result was the isolation of a bacterial pathogen in 35.6 per cent of cases, the gain being mainly in numbers of *Salmonella* and *Esch. coli*, the less frequent members of the group. The demonstration of *Shigella* was not significantly increased.

Isolation of a pathogen from the stools of a patient does not, of course, establish an etiological relationship, and the diarrhea in a bacterial carrier may not be caused by the pathogen present. Furthermore, in no less than 12 per cent of the cases of diarrhea in the Guatemalan experience, where a recognized pathogen was demonstrated, two or more bacterial pathogens were present concurrently, it being an open question which, if either, was the responsible agent. Enteroviruses were frequently associated with bacterial agents; and, indeed, more often than not a pathogenic bacterium, when present, was accompanied by a protozoan or other intestinal parasite. High or low incidence of diarrhea was not a determining factor in the frequency of mixed infections.

In addition to this varying proportion of commonly recognized intestinal pathogens, the intestinal flora of man, in health as well as in acute diarrheal disease, contains a major fraction of commensal organisms, normal inhabitants of the intestinal tract, without accepted pathogenicity, most of them being coliform organisms. Between these extremes is a group of infectious agents of indeterminate and irregular pathogenic power, poorly evaluated as to numbers and of diverse kinds. They include certain serologically distinct *Esch. coli*, other bacilli, enteroviruses in profusion, coagulase-positive staphylococci, occasional fungi, and ubiquitous protozoa and helminths. As a group, they are of low-grade pathogenicity, with evidence to suggest that if they attain pathogenic activity it is mainly because of favorable factors in the host or environment. Conceivably this includes impaired host resistance (10), specific and nonspecific. Unpublished pathological observations by G. Dammin and D. S. Feldman (11) at the Institute of Nutrition of Central America and Panama (INCAP) suggest a mechanism analogous to that in cholera, an overgrowth that produces huge numbers at all levels of the intestinal tract, with a dietary or nutritional factor presumptively important as a predisposing influence (12).

Remote infections of other systems, principally of the respiratory tract and its appendages, potentially have the capacity to light up intestinal disorders. Measles has a prominent place among such parenteral infectious diseases (13). Experimental infection of volunteers with rhinovirus, a respiratory pathogen, has led to acute diarrhea (14).

Foods have the capacity to induce acute diarrhea by other means than infection. A number of the nutrient deficiencies have this capacity: pellagra, beriberi, and especially kwashiorkor. Some foods induce diarrhea because of their roughage content and a few are poisonous, for example, some varieties of mushrooms and fish.

Toxins formed in foods by the growth of staphylococci and other bacteria are a

frequent source of epidemic diarrhea and, to an ill-defined degree, of endemic disease. The diarrheas induced by emotional stress are others of noninfectious origin.

The impossibility of identifying, among the acute diarrheal diseases, clinical entities sufficiently distinct to permit an individualized program for control has been noted. Acute diarrheal disease can be delineated satisfactorily, but its elements, which other evidence shows to exist, cannot. The solution is to interpret the group as a clinical syndrome, acute undifferentiated diarrheal disease.

The summary of etiological agents just given likewise discounts the possibility that modern laboratory procedures are able to compensate for clinical deficiencies, as they can with some other infectious processes. Although research has been largely microbiological, an impressive effort has succeeded in distinguishing as disease entities only a relatively small number of the acute diarrheas of the world and, still more important, those identified lack other than microbiological characteristics separating them from the bulk of undifferentiated diarrheal disease. To center control activities on specific entities is to ignore the main problem. The possibility remains that the group has enough common epidemiological characteristics by which to establish principles for general control, and that recognizable epidemiological patterns exist within the complex, of sufficient importance and magnitude to warrant individualized measures in their limitation.

ACUTE DIARRHEAL DISEASE AS AN EPIDEMIOLOGICAL ENTITY

The occurrence of acute diarrheal disease in all populations of the world suggests innate host characteristics, physiological and biological, conducive to the disease and common to all mankind. Because of this universality, it is to be expected also that fundamental features in human behavior, with the exception of the artificial variations introduced by time and place, in cultural practices, and in the social environment of communities all have a bearing on the propagation and presence of the condition.

Such individual diseases as may be separated within the complex of acute diarrheal disorders show no differences from one another or in relation to the whole so far as potential effect on a general population is concerned. All produce epidemics. In endemic form they are, in varying degrees, a feature of populations everywhere; and under favorable circumstances of external environment and nutrition they prevail at hyperendemic levels in many parts of the world.

Not all acute diarrheal diseases are of infectious origin, but most of them are. Despite definite and diverse infectious agents, the main source of infection is man. A few types of disease are of animal origin, notably salmonellosis as in Costa Rica (15), but this disease also comes mainly from infected persons. In all recognized specific diarrheal disease, carriers have a significant place together with cases in the community reservoir of infection. In Guatemalan villages, carrier rates in the general population of children under five years of age without diarrhea were 7.8 per cent for *Shigella*, 0.1 per cent for *Salmonella*, and 4.2 per cent for enteropathogenic *Esch. coli* (Table 2). Epidemiological evidence points to a similar situation for diarrheas of indeterminate infectious etiology. The immediate source of infection, feces, is common to all infectious diarrheas, whatever the method of transfer.

All these diarrheas, whether etiologically distinct or undifferentiated forms of enteritis, have common modes of transmission. Only food poisoning is spread individually. Noteworthy differences occur, however, in the patterns of distribution. Endemic and sporadic diarrheal disease is transferred predominantly by direct contact, hand-to-

TABLE 2—*Carriers of Enteric Bacterial Pathogens, without Children Diarrhea, by Age, in Three Guatemalan Highland Villages, 1959–1962.*

Age (years)	No. of children	*Shigella*		*Salmonella*		*Escherichia coli*		Total	
		No. of carriers	%	No. of carriers	%	No. of carriers	%	No. of carriers	%
Under 1.....	647	10	1.5	1	0.2	31	4.8	42	6.5
1.....	690	61	8.8	0	—	38	5.5	96	13.9
2.....	678	71	10.5	1	0.1	25	3.7	93	13.7
3.....	676	69	10.2	0	—	24	3.6	90	13.3
4.....	459	35	7.6	2	0.4	14	3.0	47	10.2
Total.....	3,150	246	7.8	4	0.1	132	4.2	368	11.7

mouth infection. Indirect contact through objects freshly contaminated with feces has minor significance. Fingers other than those involved in direct contact spread infection by contaminating food and sometimes water stored in the household. Flies play a variable part, far less important than that of contact dissemination.

The classical concept of epidemic diarrheal disease is of disease originating from a common source (water, milk, or solid foods), with the outbreak rising and falling abruptly (4,5,16). By contrast, most of the epidemics personally observed in rural areas of less developed regions have been spread by contact. Characteristically they were of slow evolution. They failed to reach the high peak of common-source outbreaks and usually followed a protracted course, occasionally as long as three years.

The incubation period is among the more regular epidemiological characteristics. In epidemics of *Salmonella* infections it may be an interval as short as 12 hours, but sporadic cases usually become clinically evident two or three days after exposure; this is true also for the undifferentiated group and for the remaining specifically identified infections. In shigellosis, for example, the usual incubation period is less than four days.

The duration of communicability in acute diarrheal disease is not well known. Most of the evidence relates to shigellosis, where infectiousness is essentially for the duration of symptoms and briefly thereafter. Chronic convalescent carriers are stated to be few and the carrier state is said to end usually within days or weeks. However, existing observations relate mainly to adults and to patients in good nutritional state. The longer clinical course among malnourished children and the tendency of the disease to relapse suggest that communicability may be appreciably longer under such conditions, a possibility supported by the high carrier rates in many communities—of the order of 8 per cent. The subject needs investigation. Limited studies suggest that carrier rates for *Esch. coli* may be greater than indicated by the infrequent cases. *Salmonella* carriers in acute diarrheal disease have had minor attention because, again, cases are few. Serial studies of families, as in the INCAP observations, should provide information on the communicability of the undifferentiated diarrheas.

The known facts about resistance and susceptibility to acute diarrheal disease are also few. In less developed regions, relatively few cases occur during the first six months of life. During the second six months, few persons escape. Thereafter, incidence decreases with age, so that attack rates in late childhood are much lower and the incidence in the adult population is still less.

Repeated attacks in the course of the first and second years are the rule in develop-

ing countries. Almost every child can be certain of a bout of diarrhea during each of the first three years of life, and this frequency of attack may extend through the fifth year. In the Guatemalan experience, more than one attack occurred in about half of the children during the second year, and in one child out of three in each of the preschool years. It is evident that one attack gives no general immunity, and yet it is equally certain that resistance increases with age; older children and adults have far less diarrhea. The suggestion is of a pattern of resistance comparable to that in influenza, where a matrix of resistance is filled in with age, the elements being to some degree specific and enduring, and the final pattern being effective because it accounts for most of the prevailing agents. A particular pattern holds for a particular place. Transfer to another area and the resultant contact with a new set of infectious agents brings a fresh need to accommodate, as is evidenced by the well-known "traveller's diarrhea."

The results of long-term prospective field studies in Guatemala, to be presented in another paper,[1] illustrate the epidemiological characteristics of acute diarrheal disease in a representative developing area of Latin America where malnutrition prevails at a high level.

[1] See p. 14.

CONCLUSIONS

Acute diarrheal disease is a clinical syndrome, a collection of diseases, for the most part of infectious origin, some of specific etiology and some not. Most of them are undifferentiated, either clinically or microbiologically.

In less developed areas, signs and symptoms have an individuality sufficient to distinguish the disease from that occurring in economically and technically advanced areas. This characteristic does not extend in a particular region to differentiation of one disease of the syndrome from another. Attempted microbiological distinction leaves the bulk of cases unexplained, despite qualitatively similar findings in both circumstances.

The reactions of populations to the complex of acute diarrheal disease usually have common characteristics, which correspond to accepted ecological principle and which permit recognition of the disease syndrome as an epidemiological entity. Measures for practical prevention and control based on epidemiological behavior are desirable and feasible.

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ACUTE DIARRHEAL DISEASE IN LESS DEVELOPED COUNTRIES

*II. PATTERNS OF EPIDEMIOLOGICAL BEHAVIOR IN RURAL GUATEMALAN VILLAGES**

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The epidemiology of acute diarrheal disease in all forms, now to be presented, is based on a series of field observations of rural populations in the Guatemalan highlands during the past seven years. The ordinary data were collected by resident, non-medical health workers who visited all homes of the study area twice monthly under direction of a physician. Special circumstances were investigated by medical and laboratory staff based at the Institute of Nutrition of Central America and Panama (INCAP), Guatemala. Information on case incidence was possible only through field investigation, because cases were not reported. The same was true for reliable facts about deaths. As in many other pre-industrial areas, deaths are incompletely reported to official health agencies, and causes of death poorly specified, since most notifications were by non-medical persons (1,2). Because of the altitude, the climate in the highlands is temperate. The general area is representative of a less developed region of Latin America.

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INCIDENCE OF ACUTE DIARRHEAL DISEASE

The outstanding feature of attack rates in these village communities, as presented in Table 1, was the extent to which the disease predominated in children aged from 6 months through 2 years. This was the period of weaning (3). Acute diarrheal disease was comparatively infrequent dur-

ing the first 6 months, when infants were almost wholly breast-fed. After weaning was completed, usually in the third year, incidence declined sharply, so that attack rates at age 6, the year of entering school, averaged only 21.2 per 100 children per year. Schoolchildren of 7 to 14 years had only a fraction of the rates of early childhood, while for adolescents and adults past 15 years, incidence was essentially half that of schoolchildren. This progressive decline with age is well authenticated for many less developed areas of the world. What is not so well recognized is the concentration of cases during the period of weaning. This failure occurs because of the common statistical practice of considering all cases of the first year as a unit, and then grouping together results of the second to fifth years. The dangers of the weaning period, and especially the second year of life, are thus obscured.

TABLE 1—*Acute Diarrheal Disease Attack Rates per 100 Persons per Year, by Age, in Four Guatemalan Villages, 1956–1959.*

Age-group	No. of persons	Cases of diarrhea	Attack rate (cases/year/100)
0–5 months	92	43	46.7
6–11 months	79	87	110.7
1 year	135	162	120.0
2 years	122	129	105.7
3 years	119	66	55.4
4–6 years	406	86	21.2
7–14 years	839	69	8.2
15+ years	2,390	109	4.6
All ages	4,182	751	18.0

DEATH RATES FROM ACUTE DIARRHEAL DISEASE

Mortality rates from acute diarrheal disease followed the same trend as case incidence. In three other villages for which information was available over a 10-year period, death rates were greatest in the second year of life (Table 2). Indeed, they were more than twice those of the first year and were maintained at a high level during the third. Thereafter a sharp drop occurred to a level of 9.63 deaths per 1,000 population during the fifth year. For schoolchildren and adults, the rates were a fraction of those during the earlier years of life.

The significance of deaths from acute diarrheal disease with regard to the general health of these communities is further demonstrated by the proportion of deaths from this cause to deaths from all causes. In Guatemala, diarrheal disorders are the first cause of death, and the mortality from this cause is exceeded in no other Latin American country. For general village populations, the present studies showed 27 per cent of deaths as due to diarrheal disease.

The variations in this relationship with age were great. In infancy, despite a high attack rate, fatalities from acute diarrheal disease accounted for only 14 per cent of deaths, less than the average for the general population, 27 per cent. For the critical period from 1 to 4 years of age, the proportion was 46 per cent, and in two of the years, the third and the fifth, it was more than 50 per cent. This distinction between absolute and relative death rates is especially meaningful. Although age-specific death rates for diarrheal diseases in the preschool period were greatest in the second year of life and decreased progressively in subsequent years, the ratio of diarrheal deaths to all deaths remained constant or even increased. Schoolchildren between 5 and 14 years warrant special attention. The age-specific death rates were much lower than those of younger children and yet the proportion of diarrheal deaths to all deaths was exactly the same, 41 per cent, as in the second year, when age-specific rates for diarrhea were at a maximum.

The true significance of the situation is often difficult to appreciate by means of abstract figures, presented as rates for particular diseases or age groups. The

importance of these acute infections of the intestinal tract in countries like Guatemala is perhaps better appreciated by comparing frequencies of death from this cause with those prevailing in more favored societies (Table 2). For infants under one year, the death rate in this experience was 25 times that for infants in the USA. For the preschool group it was 519 times greater; and for the general population, the rate in Guatemala was 115 times greater.

To stress further the magnitude of this health problem in Guatemala and comparable countries in terms of death and disability is unnecessary. The death rates for diarrheal disease are impressive enough in themselves. In addition, diarrheal disease has an indirect effect on the mortality of children after the neonatal period by contributing to deaths from kwashiorkor (4) and such infectious diseases as measles (5).

The concentration of acute diarrheal disease in the early preschool years is evident, and should be the guide in developing an effective program for control. To this end, other characteristics of the impact on general populations are now examined.

INDEX CASE IN ACUTE DIARRHEAL DISEASE

Understanding of the manner in which an infectious disease progresses through a community is the first step in formulating a program for control. The usual sequence of events in family outbreaks of the common communicable diseases of childhood is an initial illness contracted by a schoolchild, or less commonly by an adult, and then the appearance of secondary cases, many among preschool children and fewer among older members of the family, according to immunity state. Acute diarrheal disease in the villages showed a striking departure from this behavior.

The usual index or primary case was not in an older child or adult. In 71 per cent of 390 family outbreaks during 12 months, the disease first appeared in a preschool child, in the group 0-5 years (6). Schoolchildren introduced the disease into the family somewhat less frequently than did adults, but the differences were negligible, 12 per cent for schoolchildren and 17 per cent for adults. These frequencies bore no proportional relationship to the numbers of persons of a particular age within a family. Although adults and schoolchildren together

TABLE 2—*Deaths from Acute Diarrheal Disease per 1,000 Population per Year, by Age, in Three Guatemalan Villages,[a] 1950–1959.*

Age (years)	Deaths from acute diarrheal disease	Diarrheal deaths per 1,000 population per year	Diarrheal deaths as % of all deaths	Ratio of diarrheal death rates, Guatemalan villages to USA, 1960
Under 1	87	16.98	14	25
1	123	35.63	41	—
2	102	27.97	53	—
3	44	12.17	43	—
4	34	9.63	55	—
1–4	303	21.27	46	519
5–14	70	2.55	41	—
15+	117	1.95	16	—
All ages	577	5.42	27	115

[a] Cumulative population, 106,456.

made up 80 per cent of households, they provided the index case in only 29 per cent of family outbreaks.

No less than a third of the total index cases were in infants less than one year old. More than half were children in the first three years of life. Because of the system of expanded families, where several closely related family units were represented within one household, there were few with only preschool children. Family outbreaks of diarrheal disease occurred in 22 of 27 such families, and a preschool child constituted the index case in 19 of them. Diarrhea appeared 12 times in the 28 families having only adult members.

In only 5 of 390 family outbreaks did the disease appear in more than one member of a family within a period of 24 hours. These multiple index cases are characteristic of epidemics with a common source, such as water or milk. Their scant frequency in this experience is consistent with contact spread as the major means of transmission.

There are several possible explanations of this pattern of events. The reservoir may be a healthy adult or an older child acting as a carrier, himself immune through previous attack. A host factor, such as poor nutritional state, may permit the appearance of clinical disease from an infectious agent not ordinarily pathogenic. First experience with an agent of low pathogenicity, favored by deficient environmental sanitation, is another possibility. The facts to provide an explanation are not available; a continued and detailed study of family outbreaks experienced by children from birth to school age is a promising approach.

SECONDARY ATTACK RATES

Secondary cases are those occurring in susceptible members of a family within an accepted incubation period following a primary or index case. Secondary attack rates for acute diarrheal disease are necessarily computed from total family members, excluding the index case, because susceptibles cannot be identified by existing methods. The incubation period was taken as 1-7 days. On this basis, the over-all secondary attack rate for 390 family outbreaks was only 1.4 per cent. The low rate suggests either that most family members were immune or that the agent was weakly communicable. A more informative datum is provided by children of preschool age, who may be judged as more regularly susceptible. The secondary attack rate for that age group was 4.1 per cent. Similar age-specific secondary attack rates were 1.3 per cent for schoolchildren and 0.3 per cent for adults of 15 years or older. Of 450 cases in families, 86.7 per cent were primary cases, only 7.5 per cent were secondary infections, and 5.8 per cent were tertiary or subsequent cases. A case was recognized as a new or primary case when the interval between cases was more than seven days.

The spread of clinical disease within the family was no greater when a preschool child constituted the index case than when an older person introduced the disease. When the primary case was in a child under 6 years the secondary attack rate was 1.2 per cent; the rates when the index case was in a schoolchild and an adult were 1.6 and 1.8 per cent, respectively.

There is a suggestion that most older family members were immune to the prevailing agents of diarrheal disease. At any rate, in these communities diarrheal disease did not ordinarily spread within families to adults, regardless of the age of the index case. The spread of infection, as contrasted to the spread of clinical disease, and the resulting inapparent attack and developing carrier state, are as yet undetermined, though important to an improved understanding of the origin of family outbreaks.

These observations departed so much from anticipated results that the study was repeated over a period of 17 months in another community, where attention was

primarily directed to diarrheal disease in children under 5 years of age. Among 504 invaded families a preschool child was found to constitute the first or primary family case in 94.5 per cent of instances, a figure evidently influenced by the bias incident to the selection of families, but in accord with the preceding series. The concentration of index cases was again high among children in the first three years of life; no multiple index case was noted; and the secondary attack rate was 8.4 per cent, again predominantly involving preschool children.

ENDEMICITY AND EPIDEMICITY

Interest in the manner of spread naturally extends from the family unit to the community. Acute diarrheal disease in Guatemala is commonly described as endemic or hyperendemic. Actually, it is neither. Nor is it, as are other communicable diseases of this general class, a fluctuating endemic process, continuously present with occasional and irregularly interspersed epidemics.

Deaths from acute diarrheal diseases were examined over a 10-year period for some 20 village communities, the data being obtained directly from local village registers in consultation with the official recording the information. Analysis showed a succession of epidemics of fairly regular periodicity, usually three outbreaks every 10 years, each of relatively long duration, with the increased death rate lasting a year or more, and frequently two or three years. In none of the epidemics examined, even those essentially within a single year, did the outbreak develop sharply, last a month or so, and end almost as abruptly as it began, as do common-source outbreaks related to water or other vehicles. Rather, the epidemics evolved slowly, and continued active through many consecutive months. The experience of four villages, including both small and larger communities, is illustrated in Figure 1. The broad behavior is better characterized as fluctuating epidemicity than as fluctuating endemicity (6).

The broad behavior of acute diarrheal disease was comparable to that of measles, which in the same region has a similar but not necessarily coincident periodicity, about three outbreaks in 10 years. The periodicity of measles is usually attributed to accumulation of a new crop of susceptibles by birth. The predominance of toddlers in the second and third year of life is common to epidemics of both diseases.

MODES OF TRANSMISSION

A principal aim of the INCAP studies on acute diarrheal disease has been to improve the definition of causality, and for this reason modes of transmission have had a prominent place in these studies.

An additional reason was the direct relation of transmission data to practical control measures. For present purposes, a summary of family and community observations must suffice.

Numerous epidemiological facts point to direct contact as the chief method of spread. The general course and behavior of the observed epidemics is best explained by contact dissemination. The extreme prevalence of index cases among young children suggests infection from within the family rather than from outside sources. Carriers of known pathogens are at a high level of frequency and are numerous among older children and adults. The paucity of multiple index cases in family outbreaks is strong evidence against a common-source origin. Perhaps most important of all, the hygienic habits of children as well as adults in a family are compatible with spread among infants by direct contact, a spread favored by the limited amounts of water normally available for personal cleanliness.

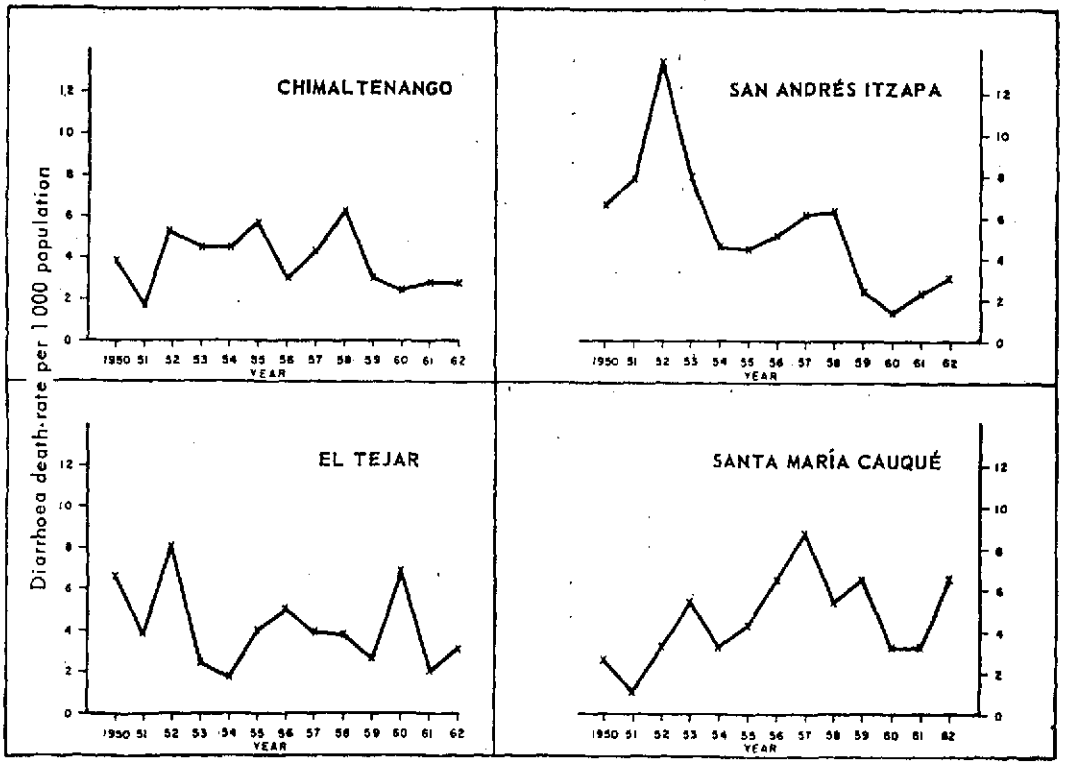
Common-source epidemics apparently do not contribute materially to the bulk of acute diarrheal disease in these communities. Milk as a vehicle is largely eliminated

because little is available, and when it is, the source is usually the family cow. Common eating establishments scarcely exist in the villages, and such food-borne infection as occurs is therefore restricted in large part to the family group. Water is the environmental factor to be seriously considered. Common water sources are usual in the villages and are known to be frequently contaminated. The age of attack was observed to be heavily weighted within the first three years of life and not broadly distributed, as is characteristic of water-borne infection. The heavy water drinkers of the population are not children of this age, but rather the working adults, among whom cases were few. Epidemics as observed were not of the common-source type. In one village, Santa María Cauqué (Figure 1), with a water supply that was originally proved to be contaminated, the forceful and successful effort made in 1960-1961 to provide a safer supply did not prevent the development of the 1962 epidemic, caused mainly by the Shiga type of dysentery bacillus.

These observations are not intended to imply that water, food, and milk have no part in the genesis of diarrheal disease in these village communities. What does appear certain is that the consistently high rates cannot be attributed to appreciable epidemics of common-source origin.

The role of flies in the mechanical transmission of acute diarrheal disease under the conditions pertaining in the usual Guatemalan village is as yet ill-defined. Transmission by flies appears to be of

FIGURE 1—*Deaths from Acute Diarrheal Disease per 1,000 Population per Year, Compiled from Local Registers of Four Guatemalan Communities, 1950–1962. (Populations, census of 1950: Chimaltenango, 14,838; San Andrés Itzapa, 5,277; El Tejar, 1,923; Santa María Cauqué, 923.)*



secondary importance, ranking below that by contact and by vehicles such as food, water, and milk. The seasonal peak of the disease occurs in May and June (Table 3), before flies are prevalent. Flies appear in late June and attain their greatest numbers in September, a time when the monthly incidence of diarrhea is declining.

All modes of transmission are related to the care and efficiency exercised in the disposal of human feces. Many features of environmental hygiene and sanitation influence the frequency of acute diarrheal disease, among them the disposal of wastes other than feces, the storage and preparation of food, the standards of housing, and the control of rodents, as well as the state of the water supply and the presence of flies, already mentioned. Feces disposal is singled out for consideration because, in the final analysis, it is the basic factor.

Attack rates from acute diarrheal disease in village families with privies were compared with those in families lacking such facilities. This was not an experiment of introducing privies and seeing what happened. A health department program for the construction of outdoor toilets had been instituted in these villages several years previously, and privies were no innovation. The results (Table 4) show that for children under one year of age the presence of a privy in the household compound was associated with numerically more diarrheas than in households without this facility, although the difference was not statistically significant. Children 1 to 5 years old had more diarrhea when they lived in a home without a privy, but only at a 5 per cent level of significance. When children in the second year of life were not included, there was no significant difference. The data thus give no indication that privies as used in the villages had any influence on the diarrheas of children in the first two years of life, the important part of the

TABLE 3—*New Cases of Diarrhea by Month in Three Guatemalan Highland Villages, Santa María Cauqué, Santa Catarina Barahona, and Santa Cruz Balanyá, as Determined by Home Visits, May 1959 to April 1963.*

Month	Cases of acute diarrheal disease	Annual total (%)
January	256	7.0
February	342	9.4
March	349	9.5
April	264	7.2
May	408	11.2
June	329	9.0
July	304	8.3
August	357	9.8
September	309	8.5
October	256	7.0
November	301	8.2
December	180	4.9
Total	3,655	100.0

TABLE 4—*Annual Acute Diarrheal Disease Case Rates per 100 Persons at Risk, by Age, in Households with and without Privies, in Four Villages of Rural Guatemala, 1956–1959*[a]

Age (years)	With privies			Without privies		
	Persons at risk	No. of cases	Rate per 100 persons per year[b]	Persons at risk	No. of cases	Rate per 100 persons per year[b]
Under 1	136	123	80.7	35	21	52.8
1–5	524	365	60.3	122	107	80.3
6–14	795	81	8.3	180	24	11.7
15+	2,109	113	4.6	410	35	7.3
Total	3,564	682	16.8	747	187	22.4

[a] Bruch *et al.*, 1963.
[b] Reported rates based on a pool of information obtained in four villages, two of them under observation for 12 months and two for 16 months. The rates given were calculated with proper adjustment for the difference in time of observation.

problem. For adults and for the population as a whole, privies were of benefit.

Food has been considered briefly as a means of infection in common-source epidemics of acute diarrheal disease, and as such judged unimportant in the village populations. Food and food practices have great significance, however, in spreading the prevailing diarrheal disease, especially among infants and young children; they act also through an inadequate nutrition, which favors clinical disease after infection.

NUTRITIONAL STATE AND DIARRHEAL DISEASE

Perhaps no clinical impression is more firmly fixed among physicians working in preindustrial populations than the belief that acute diarrheal disease is more frequent and more serious among the malnourished than in persons of normal nutritional state. Few quantitative data have been advanced in support of this hypothesis and, when given, they are expressed in terms of mortality rather than incidence (7,8). Using a standard classification based on weight for age (9), the frequency of acute diarrheal disease in children was determined on the basis of three degrees of malnutrition; where weight deficiency was more than 10 per cent and less than 25 per cent by the accepted standard; where the deficiency was between 25 and 40 per cent; and where it exceeded 40 per cent.

By the standards used, most of the children in the group suffered from an appreciable degree of malnutrition. This is in accord with other extensive investigations (10) of nutrional state in this area, which demonstrated that infants do well nutritionally during the first six months of life, in general conforming to the standard of weight for age. Thereafter, and especially during the weaning period, they depart broadly and consistently from the accepted scale. Table 5 shows that diarrheal disease occurred with greater frequency in the malnourished than in the normal, and that attack rates increased progressively the greater the degree of malnutrition.

TABLE 5—*Acute Diarrheal Disease Attack Rates per 100 Persons per Year, by Age and by Degree of Malnutrition, in Santa María Cauqué, Guatemala, February 1961 to June 1962.*

Age (years)	No. of persons	Cases of diarrhea	Attack rate (cases/year/100)
Normal Nutrition			
Under 1	22	27	86.6
1	1	5	—
2	0	0	—
3	1	2	—
4	1	1	—
Ages 1–4	25	35	98.8
1st Degree Malnutrition			
Under 1	16	55	242.6
1	14	40	201.7
2	20	29	102.4
3	12	31	182.3
4	12	17	100.0
Ages 1–4	74	172	164.1
2nd Degree Malnutrition			
Under 1	2	31	—
1	20	93	328.2
2	16	57	251.5
3	16	56	247.0
4	17	17	70.6
Ages 1–4	71	254	252.5
3rd Degree Malnutrition			
Under 1	1	1	—
1	3	20	—
2	3	11	—
3	2	3	—
4	0	0	—
Ages 1–4	9	35	274.5

The related question of greater severity of disease among the malnourished is considered in Table 6. If blood and mucus

TABLE 6—*Cases of Severe Diarrheal Disease by Degree of Malnutrition, in Children under Five Years of Age, Santa Maria Cauqué, Guatemala, February 1961 to June 1962.*

Malnutrition	Cases of acute diarrheal disease	Severe cases	
		No.	%
None	35	8	22.9
1st degree	172	65	37.8
2nd degree	254	74	29.1
3rd degree	35	14	40.0
Malnutrition all degrees	461	153	33.2

were absent from stools, diarrheas were designated as mild or moderate according to whether the duration was less or more than four days. Patients with either of these signs were classed as having a severe attack, irrespective of its duration. A difference was established between the frequency of severe diarrhea in malnourished children and that in normal children. The difference increased regularly with advancing age, nutritional deficiency presumably being longer continued. The small numbers of persons in the normal group and a heavy loading with infants in the first year of life precludes statistical significance. Severe diarrhea was numerically less frequent in persons with moderate nutritional deterioration than in the mildly malnourished. The moderately malnourished, as would be expected, were of an older average age than those mildly affected.

WEANLING DIARRHEA

Most Guatemalan highland children are breast-fed from birth, as were 98.7 per cent of 301 infants in this experience. The weaning process usually begins at about 6 months of age, with the addition of foods other than breast milk, and ends about the close of the second year, the mode being 25.5 months. For some children, the weaning process was continued past the 36th month (see Table 8). The main stresses incident to weaning are of two kinds: initial experience with contaminated food after safe breast milk, and the substitution of poorer and often insufficient food.

Infants and young children fed wholly on breast milk had relatively low attack rates for acute diarrheal disease (Table 7). This includes children continuing to be wholly breast-fed at an older age, with due allowance for the small numbers and for the probability, despite statements to the contrary, that they received some other foods. The tidbits so commonly offered from the family table escape memory or are considered inconsequential because of the irregularity with which they are given and the small amounts. The frequency with which supplementary feeding was

TABLE 7—*Cases of Acute Diarrheal Disease among Wholly Breast-fed Children, by Quarter Years, in Three Guatemalan Highland Villages, 1959–1962.*

Age (months)	All children breast-fed	Breast milk only		Cases of acute diarrheal disease among children breast-fed only	Incidence (cases per 100 wholly breast-fed children per year)
		No.	%		
0–2	294	284	96.6	51	71.8
3–5	290	239	82.4	100	167.4
6–8	288	95	33.0	45	189.5
9–11	280	13	4.6	7	215.4
12–14	261	3	1.1	3	400.0
15–17	221	0			
Total		634		206	130.0

formally instituted at about the sixth month is indicated by the decided decline during the 6-9-month period, in the numbers stated to be wholly breast-fed. No child was wholly breast-fed past the 14th month.

Initiation of the weaning process, the addition of other foods besides breast milk, was associated with a greatly increased frequency of diarrheal disease, whether weaning began at an early age or relatively late. Table 8 shows that in general the disease rates more than doubled. Few children in this experience received milk as a supplementary food. Other liquids in the form of gruels or semisolid pastes were common, but various solid foods were the main addition and were given almost without exception.

The highest rates for acute diarrheal disease prevailed during the time when weaning was being completed, namely, when breast-feeding had ended and the child was transferred to a completely independent diet. The rates shown in Table 9 are measurably greater than those for corresponding ages when weaning was in process and the child was still partially breast-fed. The three-month period immediately following the completion of weaning was also associated with high rates, numerically less than during the more stressful weaning period, but still statistically the same.

These results on the relation of breast-feeding and the weaning process to the incidence of acute diarrheal disease agree with those of a similar comprehensive field study in the rural Punjab area of India (3), although attack rates were regularly greater in Guatemala, and death rates less. The difference is partly due to varying technical methods in computing the rates. In India, frequency of attack was expressed as a three-month prevalence, based on whether or not diarrheal disease occurred during the period as determined by monthly home visits. In Guatemala, the rates express the incidence, i.e., the actual numbers of cases

TABLE 8—*Cases of Acute Diarrheal Disease and Incidence per 100 Children per Year, among Breast-fed Children in course of Weaning, in Three Guatemalan Highland Villages, 1959–1962.*

Age (months)	All children breast-fed	Breast milk supplemented with other foods		
		No. of children	Cases of acute diarrheal disease	Incidence (cases/year/100)
0–2	294	9	1	44.4
3–5	290	48	17	141.7
6–8	288	190	103	216.8
9–11	280	264	187	283.3
12–14	261	254	178	280.3
15–17	221	220	164	298.2
18–20	169	168	124	295.2
21–23	124	123	79	256.9
24–26	72	72	36	200.0
27–29	44	44	31	281.8
30–32	23	23	15	260.9
33–35	9	9	10	444.4
36–38	5	5	3	240.0
39–41	2	2	0	0.0
42–44	0	—	—	—
Total....	2,082	1,431	948	265.0

obtained by twice-monthly visits. All death rates were greater in the Indian area than in Guatemala: those for all deaths, for infant mortality, and for neonatal deaths. However, in both areas, the proportion of deaths from acute diarrheal disease to total deaths was essentially the same, indeed somewhat greater in Guatemala during the second and third years of life. Weaning was completed earlier in India than in Guatemala, the mode being 19.5 months in India and 25.5 months in Guatemala.

The increased opportunity for infection and the deteriorating nutritional state that accompany the change in diet at weaning are both important determinants of weanling diarrhea, and they act synergistically.

SUMMARY AND CONCLUSIONS

A four-year study of acute diarrheal disease in rural Guatemala, with home

TABLE 9—*Cases of Acute Diarrheal Disease and Annual Incidence per 100 Originally Breast-fed Children, at Age Weaned from Breast, and during the Subsequent Quarter Year, in Three Guatemalan Highland Villages, 1959–1962.*

Age (months)	All children breast-fed	Weaned from breast in period shown in 1st column			Weaned in preceding 3 months		
		No.	Cases of acute diarrheal disease	Incidence (cases/year/100)	No.	Cases of acute diarrheal disease	Incidence (cases/year/100)
0–2	294		0				
3–5	290		0				
6–8	288		0				
9–11	280	1	1	400.0			
12–14	261	3	4	533.3	1	1	400.0
15–17	221	8	5	250.0	2	4	800.0
18–20	169	13	14	430.8	4	1	100.0
21–23	124	20	13	260.0	13	11	338.5
24–26	72	24	19	316.7	15	6	160.0
27–29	44	18	7	155.6	20	16	320.0
30–32	23	13	6	184.6	16	7	175.0
33–35	9	6	6	400.0	12	5	166.7
36–38	5	2	1	200.0	6	0	0.0
39–41	2	2	1	200.0	2	0	0.0
42–44	0	2	—	0.0	2	0	0.0
45–47	—	—	—	—	2	0	0.0
Total.....	.....	112	77	275.0	95	51	214.5

visits twice monthly to all the families in three villages, demonstrated that the greatest frequency of the disease, as in most of the less developed countries, was among infants and younger preschool children. Deaths from diarrheal disease at these ages were so numerous, in contrast to the few among adolescents and adults, that the disease was the first cause of death for the population as a whole. Most preschool children over the age of 6 months had some measurable degree of malnutrition. The greater the malnutrition, the greater was the number of cases of acute diarrheal disease. The severity of the disease followed the same progression.

The incidence of diarrheal disease was greatest when children were being weaned and immediately thereafter. This paralleled an observed departure from the normal growth curve. It also occurred at a time of initial serious exposure to environmental risks and increased exposure to other than family contacts. Primary cases in 390 family outbreaks were predominantly in infants and younger preschool children. Secondary attack rates were minimal, mainly involving other children of the same general age. The mode of transmission was chiefly by direct contact. Community diarrheal disease was characterized by epidemics at relatively short intervals, about three in a decade, of slow evolution and prolonged duration.

The characteristics of the disease, as evidenced by infants and toddlers, are sufficiently individual to justify the recognition of weanling diarrhea as an epidemiological entity. Measures for control rely on improving maternal and child health practices, with strong emphasis on nutrition, on health education of the public, and on medical care of patients. Environmental measures were found less effective for this

age group, although they are considered a critical necessity in long-term community control. Weanling diarrhea in less developed countries is so important a part of the general problem of acute diarrheal disease that it requires specific attention and the application of the indicated individual measures for its control.

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ACUTE DIARRHEAL DISEASE IN LESS DEVELOPED COUNTRIES

*III. METHODS FOR PREVENTION AND CONTROL**

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A common error among those who undertake the control of a community disease in areas without well-organized health services is to attempt to use procedures that have proved successful only under much better conditions. Similarly, a highly developed health agency in a better favored region sometimes lets misplaced scientific enthusiasm interfere with the main objective, by incorporating in a general program measures that in reality are experimental.

The management of a disease on a community basis in no way differs in principle from the procedure in clinical medicine. The obligation is first to examine the patient, next to effect a diagnosis, and then to prescribe. A community program for the control of acute diarrheal disease, or of any morbid process, requires an initial reconnaissance by direct field survey (1), an assessment of facilities and budget, and an estimate of the available personnel, professional and auxiliary. The designing of a program is based on what is practical and possible rather than what is ideal, with added provision for the subsequent evaluation of the results attained. The recommendations that now follow are directed primarily to the three-quarters of the world where acute diarrheal disease prevails at high levels of incidence and where existing facilities are limited.

METHODS OF CONTROL

Control resolves into two approaches: one, to limit the number of cases and, consequently, of deaths, by preventive measures; the other, to attack mortality directly through medical care. It is well to appreciate that no disease has ever been controlled by treating all patients, no matter how effective the available measures. Also, prevention has yet to attain the true eradication of diseases, although a few have been eliminated in some areas for appreciable periods.

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The question of priority as between prevention and medical care should not intrude. A sound program includes both, and for acute diarrheal disease the practical goal is clearly adequate control, not eradication.

Control activities may be divided also into those for which society takes responsibility through its official health agencies, and the measures that of necessity the individual must undertake himself. There is a common tendency to think of control solely in terms of transmission of the infectious agent, without attention to the role of host factors in the process of pathogenesis. An infectious agent may spread widely in a community without producing appreciable levels of manifest disease. A distinction is necessary between simple transmission and the effective transmission that results in disease. Host qualities have much to do with the latter, and act as surely in interrupting transmission as does the carrying capacity of water for the agent.

From a practical standpoint, the control of acute diarrheal disease in less developed countries depends on the successful management of the severe diarrheas, those that kill (2) and those that aggravate other common disease processes (3), or sometimes precipitate them, as in kwashiorkor (4). Evidence already introduced (Gordon *et al.*)[4] shows that, in the countries most concerned, diarrhea predominates in the first year of life and during the remainder of the preschool period, being more prevalent in the second than the fifth year. These considerations suggest priorities based on age. In control measures for young children, the emphasis is on educational and other measures for promoting maternal and child health, on the medical care of patients, and on nutrition, while for the general population it is on environmental sanitation.

The available methods of control of acute diarrheal disease fall within three general categories: the provision of medical care to persons clinically ill, the sanitation of the external environment, and the promotion of personal hygiene. These variables are interrelated, not independent. Both engineers (Nyerges)[5] and physicians (Ordway & Yankauer)[6] recognize the frequent failure of environmental sanitation when it is not accompanied by education of the public as to the proper use and care of the facilities. In addition to its main purpose of reducing the number of deaths, the treatment of patients also reduces community dosage of infection by decreasing the number of existing foci and shortening the period of communicability, a recognized epidemiological principle (8). All three aspects of treatment are relevant to any program for control.

The question of priorities, which so commonly plagues administrators, would thus seem to resolve into estimating the relative values of the several methods within a category, and then judging, according to the local epidemiological situation, the emphasis to be given to each category, all being concerned in some degree (Gordon, Béhar, & Scrimshaw).[7] The decision will also be based on whether the primary target is the severe diarrheas prevailing in the early years of life or all diarrheal disease in the general population, and whether the aim is short-term effect or long-term alleviation. Whatever the broad content of the program, prompt and reliable information on the occurrence of new cases is the first essential.

Reporting of Acute Diarrheal Disease

The aim, fostered by many good health departments, of requiring reports of individual cases of acute diarrheal disease by etiological agent has the common result of discouraging notification. Even under optimal conditions, as in the military services, this system has not proved work-

[4] See article on p. 14.

[5] See article on p. 36.

[6] See article on p. 51.

[7] See article on p. 6.

able (10). A better idea of the prevailing situation is usually gained from reports of undifferentiated diarrheal disease, but in order for this to be informative a change is necessary in the standard list of causes of death and disease (WHO, 11), so that the several conditions to be regarded as acute diarrheal disease are grouped together, either under diseases of the gastrointestinal tract or under the acute infections. The former is preferable because, as has been shown (2), not all diarrheal disease is of infectious origin.

The reporting of individual cases in communities without local health services, or with the limited facilities of so many technically underdeveloped countries, is likely to prove little more than a gesture. A better method is the reporting of epidemics instead of cases, by the procedure outlined in *Control of Communicable Diseases in Man*, of the American Public Health Association (8). Without some organized responsibility for health, the reporting of epidemics is just as unpractical as the notification of individual cases. It can be based on a judgment derived from deaths rather than from cases. Most countries have registrars of births and deaths, even in the smaller communities. On the basis of accumulated experience of sufficient years, a certain number of deaths from acute diarrheal disease occurring within a specified time can be regarded as constituting an epidemic in that particular area. Such a circumstance can be reported to higher jurisdiction by the most uninformed official, or, indeed, may be derived by the receiving authority from an intelligent review of the reports of deaths, provided that the base-line data are at hand.

Preventive Measures

We depart from tradition in placing the health education of the public first among preventive measures, for two reasons. One is that many of the important preventive measures relate directly to personal hygiene and personal health practices, and are applicable only by individual initiative, a fact well recognized in the Mexican program for the control of diarrheal disease in rural populations (12). The second reason is that control measures originating as a community effort and instituted through official agencies frequently fail in their potential usefulness because individuals lack the knowledge of their proper use or remain unconvinced of their value. It should be clear, however, that the health education of the public consists in far more than propaganda. It involves instruction and training in the use of preventive and curative measures, and presupposes their provision.

This opinion, that health education is of primary importance, traces back to an axiom originating with Haven Emerson, who said that "the first thing to do in public health is to persuade people to get out of their own dirt." The implication is clear, that the initiative is with the individual himself, that his incentive is from imparted knowledge and acceptance of the worth of the idea, and that provision of sanitary facilities is the means to an end and not the basic consideration. Health education finds a place in all the measures now to be listed, from prevention to control of epidemics, and is not to be excluded from the high level of international protective measures.

The high incidence and high mortality rate of acute diarrheal disease in the first years of life and its association with the weaning process (2) make maternal and child health practices a main feature of control programs, especially of those with limited means and objectives. Spread by contact predominates, and thus is clearly related to hygienic practices by the mother and other people who tend the child. Breast-feeding is fortunately almost universal in most of the less developed countries. However, cultural changes in many areas lead to the early substitution of artificial

feeding, with disastrous results if personal hygiene and sanitary practices are not able to keep pace. Breast-feeding through at least 12 months is desirable, although, without supplementary food, it is not to be relied upon to provide adequate nutrition beyond six months. Cleanliness in the preparation of food supplements has more than usual importance in this first contact of the infant with enteric pathogens, solid foods in some circumstances being more significant a source of infection than supplementary milk (2). There are areas where the milk is always boiled but the water with which it is diluted is not.

The traditional acceptance of environmental sanitation as a fundamental feature in the long-term control of acute diarrheal disease in total populations is wholly justified, even without its additional value in the control of hookworm disease, typhoid fever, and other intestinal infections. Its short-term effect on the weanling diarrhea of infants and young children is not so well established. Furthermore, the value of improved sanitary facilities has often been debased by the lack of coordination with health education.

Water-borne epidemics, so prominent a feature in metropolitan communities, are of less consequence in the diarrheal disease of well-studied rural populations of developing countries. Furthermore, the common tendency is to emphasize the purity of water and to neglect its quantity and ready availability. Simple boiling compensates for many deficiencies in quality. Personal hygiene has been stressed in this discussion as prominent among control measures because the main mode of transmission is by contact. Cleanliness requires adequate amounts of water, and when water has to be carried in small earthen jars on the head for several kilometers, the quantity available is necessarily small.

The disposal of human feces is of critical concern, yet the construction of privies too often results in an edifice instead of an institution, a monument to Hygeia but not something that the people understand, use, and appreciate. Field studies showed that privies had a minimal effect in restricting the frequency of diarrhea among infants and young children, the part of the population on which the disease exerted its major effect (13).

Disposal of wastes other than feces is principally useful for limiting fly breeding, although in many localities more specific measures of fly control are required. As a community remedies its deficiencies in the amounts of available water, it also automatically increases its problem of waste disposal, as the amount of waste comes to exceed the capacity of the simple facilities that previously sufficed.

Improved housing can be expected to decrease the incidence of acute diarrheal disease. Dirt floors and creeping children are a bad combination.

Food and nutrition will inevitably attain greater prominence among control measures as the significance of weanling diarrhea is more fully appreciated. The greater incidence and severity of acute diarrheal disease among malnourished children than among well-nourished infants and toddlers (Gordon, Guzman *et al.*)[8] requires greater attention to an adequate diet.

The addition to the infant diet of foods other than breast milk also increases the likelihood of infection. Supplementary feeding during the weaning stage must cease to be the haphazard process so common in underprivileged populations, and must become an orderly regimen brought about by health education and by the guidance of workers in maternal and child health. The critical period is when breast-feeding ends and the child transfers to a general diet. In most of the less developed regions, the nutritional state has already deteriorated materially by this time, as indicated by the deviation from a normal growth curve,

[8] See article on page 14.

and deterioration accelerates with weaning. The increased risk of diarrheal disease continues in the months that follow, and is still a factor in the later preschool years.

Preventive methods specifically relating to food and nutrition are directed toward both mother and child. Mothers benefit from instruction in how to prepare properly the foods that supplement breast-feeding and to constitute the diet after weaning. They need to know how to protect food from flies, rodents, and other sources of contamination, and to store and preserve food. In many cultures, food prejudices and superstitions are such that certain foods are wrongly considered dangerous, and their prohibition leads to nutritional difficulties.

In other circumstances, food itself is considered the cause of the acute diarrhea (and may well be so, indirectly, if it contains an infectious agent). As a result, mothers withhold all food from the sick child for long periods. The effect is extreme malnutrition, with the infectious process aggravated even to the point of death. At an early age children must have training in food habits, from hand washing before eating to such elementary matters as not eating food dropped on the floor. Adults, too, must be taught the hazards of contaminating food with dirty hands.

Although the procedure lacks controlled field or clinical trial, the addition of antibiotics to foods given to infants has recently been advanced as a prophylactic measure (14,15), and the suggestion has aroused interest. The assumption is that massive contamination and bacterial overgrowth with normally non-pathogenic or mildly pathogenic organisms in foods given to infants are major factors in acute diarrheal disease. Presumably, prevention could be brought about by the addition of antibiotics to feeding formulas. However, weanling diarrhea is common even where formula feedings are not supplied. Also, epidemiological evidence incriminates solid foods as of greater importance in less developed countries, and treatment of these foods would be difficult, if not impossible, supplied as they are mainly from the regular family menu. In theory, at least, the use of antibiotics in this way could encourage the development of resistant strains among infectious agents, promote secondary enteritis, limit the development of specific immunity, and lessen attention to simple food hygiene. Furthermore, the dominant mode of spread by direct contact would remain unaffected. On the existing evidence, the addition of antibiotics to food is not a method to be considered in any administrative program for control.

Care of the Patient, Contacts, and the Immediate Environment

A fundamental principle in the control of acute diarrheal disease in less developed countries is that the community rather than the individual patient or the family group is the point of attack. The period of communicability of the sick individual is short, other sources of infection are multiple, and the familial secondary attack rate is low (13).

Under conditions of village life, isolation and quarantine are impossible. Even the elementary prohibition of food handling is difficult, although happily of less consequence than in metropolitan areas (13). No method of specific immunization of contacts is known, and attempts to institute chemoprophylaxis, while occasionally reported favorably in shigellosis, have not proved worth while when tested under controlled conditions (8). However, a procedure useful in numerous other diseases where specific preventive measures are lacking is the close observation of contacts and the prompt institution of full therapy at the first evidence of illness. Concurrent or terminal disinfection, other than ordinary cleaning, has limited value, again because there are so many other sources of infection.

This does not discount the value of sanitary disposal of feces.

The part of a control program relating to the patient consists essentially in the clinical management of the acute illness, with the major objective of reducing the number of deaths. Modern methods of management, especially rehydration, are notably efficient, although less so in the diarrheas of malnourished children, who respond more slowly than normal patients.

Those who recommend procedures for clinical management in less developed countries often fail to recognize that the bulk of patients with diarrheal disease do not have access to hospital facilities, organized clinics, or the medical care to be expected in metropolitan centers. In the world as a whole, the areas with high rates for diarrheal disease, India (85 per cent) and Guatemala (70 per cent), are rural rather than urban. In many places, medical care is provided mainly by the folk practitioner, the local untrained midwife, or the village wiseman. A conviction arising from experience in many such areas is of the need to develop and test a simple program of management applicable to the particular local conditions, one which can be used in the absence of a physician and disseminated by health education given to the mothers of young children.

Most deaths from acute diarrheal disease are the result of dehydration. Rehydration is the basis of all good treatment, and therefore of any plan of home management. The first step is to ensure that the mothers of young children understand the dangers arising from dehydration, and know how to recognize it, how to prevent it, and how to correct it at least in its early stages.

In the event of acute diarrhea, feeding should be discontinued, though for no more than 6-12 hours. Fluids are given in small amounts (5-15 ml) by mouth: boiled water with sugar, small amounts of salt, and the locally available fruit juices. The process should be repeated frequently day and night, until the child is able to take larger amounts and food tolerance returns. Within the next 12 hours, diluted boiled milk should be given, and its concentration progressively increased during the succeeding 48-72 hours, until whole milk is used. Concurrently, cereals, vegetables, fruits, and meats are offered in increasing amounts, until by the third day the child is receiving an adequate diet for age, in accordance with the local availability of food and the food habits of the population. This regimen should be followed even in the continued presence of loose stools. The severity of the diarrheal process and its complications are frequently due to an over-restricted diet, and children sometimes die from starvation rather from the diarrhea itself. The modern drugs so readily available today, even in isolated villages, are to be avoided, since they are usually of questionable value and are often harmful.

A survey of the customary practices of the area in caring for children with diarrheas is well worth including in field investigations of the disease. In rural Guatemala, purgatives and, still worse, strong vermifuges are frequently administered in the mistaken belief that the ascarids so frequently expelled by children in early diarrhea are the real cause of the disease. These practices, along with severe dietary restriction and failure to recognize dehydration, are the main reasons for the high mortality from diarrheal disease.

Epidemic Measures

The usual epidemic of acute diarrheal disease in less developed countries is not the overwhelming outbreak of common-source origin so common in towns or cities, involving hundreds and sometimes even thousands of persons.

The commoner epidemic is of a kind that occurs regularly in thousands of small communities the world over, most of them rural and in less developed areas. Normally

they remain unrecognized, even locally, until they reach their height, for they are of slow evolution and long duration, since the usual mode of transmission is by direct personal contact. The epidemic is generally allowed to run its natural course, for the tendency in the villages is to view such events as an unavoidable part of life.

A simple reporting system applicable to places where these epidemics are most frequent has already been described. To attempt the investigation and control of all outbreaks is wholly impracticable. Such an effort would overwhelm the resources of most health departments in the regions affected. A more practical plan is to designate one physician in the central health agency to carry out continuous investigations of some of the outbreaks, enough to give an understanding of the representative geographic distribution and clinical severity of the disease.

The immediate gain in limiting the general incidence and decreasing the costs in death and disability would be inconsequential; the problem is too great in the areas most affected. The main objective is educational, to engender among village residents an appreciation of the problem, to show that control is feasible and therapeutic measures possible, and thereby to encourage preventive action against the otherwise certain outbreaks of the future. The direct gain is a better understanding of the size and nature of the problem regionally, a more accurate assessment of deaths than that derived from the usual vital statistics, and an appraisal of the practicability of control within locally available resources.

The main reliance in the study of epidemics is on field methods of an operational epidemiology (1). Laboratory aid sufficient to demonstrate a dominant infectious agent and the probable proportion of communicable cases is profitable, but not essential to the stated objectives. What should be recognized is that much of the necessary information for control can be obtained in the absence of facilities more directly related to research. The questions to be answered are: Who gets the disease? Who dies? What are the modes of transmission and the periodicity of epidemics? What are the principles to apply in preventing epidemic recurrence?

International Measures

The World Health Organization supports an international *Salmonella* center in Copenhagen, Denmark. National centers exist in many parts of the world. Several serve also for *Shigella*. They are concerned primarily with microbiological research, and function as reference laboratories for the identification and classification of strains received from the field. Epidemiologically, they provide information on the geographic distribution of serotypes.

Infectious agents in acute diarrheal disease are of many kinds; in addition to the microbiological factors, other factors have great importance in causality, and all are continuously changing. Increasing recognition of this dynamic behavior requires that these centers for the study of intestinal infections should expand their sphere of activities. Microbiological research should include studies on enteropathogenic *Esch. coli* as well as *Salmonella* and *Shigella*, and, if possible, on enteroviruses and intestinal parasites. Furthermore, the existing centers are promising nuclei around which to create epidemiological centers for acute diarrheal disease, still concerned with microbiological problems, but with their activities expanded to include field investigation and participation in studies of the kind described below.

RESEARCH

This discussion has raised a number of questions whose answers are pertinent to more efficient control. There are many others. The history of preventive medicine

shows progress to depend on the progressive acquisition of new facts. Research is therefore an integral part of comprehensive control programs at the national or provincial level.

In recent years, investigation of the acute diarrheal diseases has been mainly in laboratory and clinic. This is admirable. It has been productive, and its contributions to more effective control are material and far-reaching. Research has followed this trend because, in the advanced countries where scientific investigation is most active, this is the kind of study best suited to the existing conditions. Acute diarrheal disease in such areas is neither highly prevalent nor clinically severe.

The more immediate need of regions with much diarrhea is for ordinary facts about the natural history of the disease under local conditions. This information is obtainable by means of field epidemiology (1). Field research is important because it bears directly on the practical problems of control, and is within the capacity of official and other agencies in less developed countries. It is not intended as a substitute for the carefully ordered investigations of laboratory and clinic. The ideal effort combines all three types of research, and is in accord with the earlier recommendation of greater responsibilities for the present *Salmonella* and *Shigella* centers. Useful field studies would include the following:

Repeated Periodic Field Surveys

Sampling surveys of multiple localities, done once, within a few days, have a useful purpose in defining the general nature of the problem in previously unexplored regions. They soon exhaust their local potentialities and most of the gain, so far as principle is concerned, is already in hand. In general, the single, short-term survey has been overdone. A more valuable procedure is to conduct a series of repeated surveys at prescribed intervals in a few selected representative rural and urban areas, in order to determine how much diarrheal disease exists, what is the dominant mode of transmission, and to what extent nutritional state and maternal and child health practices influence frequency of attack. The dynamic movement of the disease and the need to measure the effect of control measures make repeated studies desirable, perhaps twice yearly over several years, in order to account for seasonal differences. Such investigations are logically an obligation of national health departments. They function well under provincial auspices or established urban health agencies.

Complicated laboratory facilities are unnecessary. There need be none, or simply enough to determine the proportion of specific infectious diarrheas. The objective is to define the size and seriousness of the problem and to determine the requirements for projected control programs. Investigations of this kind could well be fostered by the proposed national and international diarrheal disease centers, with professional consultation and planning, and, if need be, with additions to local resources.

Intensive Family Studies

A promising approach to causality is the concentrated, continuous, prospective epidemiological case study of a small series of family outbreaks, from the index case to the last carrier. A case, in the epidemiological sense, has three elements: the patient, his close contacts, and the immediate environment. Such studies combine to advantage field and laboratory procedures. They are profitable as wholly ecological investigations, and thus disprove the frequent statement: "We can't do anything because we haven't anything to do it with." The fundamental requirements are a clear brain and a little sweat.

Long-Term Prospective Studies of a Fixed Population

This paper has described the results of three comprehensive incidence investigations over a period of several years: one in India, one in the Artic, and one in Guatemala. From a world standpoint, comparable investigations in less developed areas of Africa and South America and in Asia would be useful. The Cleveland investigations by Dingle *et al.* (16) and those by Hardy & Watt (17) and by Goodwin *et al.* (18) in rural areas of the USA revealed new facts suggesting the value of similar observations in representative rural and urban areas of Europe.

Study of Selected Epidemics

Outbreaks of infectious disease have traditionally been a favored subject for research. While the primary objective of epidemic study is control, a policy of intensive investigation of occasional episodes in areas of high incidence can provide better knowledge of the modes of transmission and the patterns of causality and thus lead to improved control. Again, field methods alone can contribute important information even when microbiological studies are impracticable.

SUMMARY AND CONCLUSIONS

The present-day approach to the control of acute diarrheal disease has given too much emphasis to the obligations and duties of public health agencies, and little recognition to the fact that control depends to a great extent on individuals. The stress has been too much on what society should do for the individual and too little on what the individual must, of necessity, do for himself, as good epidemiological evidence shows.

This is not to disparage the constructive measures embodied in building privies, improving water supplies, providing laboratory facilities, and pasteurizing milk. What is implied is that correction of faulty practices of personal hygiene, understanding of dietary practices and requirements, better command of maternal and child health procedure, and elimination of cultural prejudices have special significance in restricting diarrheal disease in its most prevalent and most severe form: the weanling diarrhea of infants and small children.

The two objectives of public and personal effort are not in conflict, nor are they separate and independent. The argument is for equal attention to people and to things, to babies as well as to water. Both endeavors are within the range of recognized public health activities, since the improvement of personal hygiene by health education is definitely a function of health agencies. The two interests complement each other. The provision of physical facilities without the sympathy and understanding of the people who are to use them has repeatedly proved ineffective. The cultivation of a hygienic way of living creates demand for the physical facilities with which to achieve it.

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PLAN FOR THE CONTROL OF GASTROINTESTINAL DISEASES

ENVIRONMENTAL SANITATION, EPIDEMIOLOGY, HEALTH EDUCATION, AND EARLY DIAGNOSIS AND TREATMENT

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I. RELATIVE IMPORTANCE OF ENVIRONMENTAL SANITATION IN THE CONTROL OF DIARRHEAL DISEASES

The statistical data gathered in past decades clearly indicate that no health measure undertaken in a single field, without the support of secondary health measures, has to date been able to eradicate enteric infections or to reduce them to low levels of endemicity. It is also evident that the relative importance that is given to certain measures that have proven to be effective in preventive medicine, curative medicine, and environmental sanitation will determine the effectiveness of the control campaign in each case. Therefore, a brief comment on the relative value of activities in the three fields is in order.

From the practical viewpoint, the really effective and economical, as well as the simplest, measures available to preventive medicine are mass vaccination of susceptible populations and the use of certain preventive drugs. Significant results have been obtained in this way, and this approach is the main hope of public health workers in future attacks on disease. As to diarrheal disease, the hope of attaining rapid success has to date eluded the scientists.

Other measures available in this field cannot be considered independently from other factors and influences that are outside the scope of preventive medicine, since they normally require a series of propitious conditions to achieve optimum results. One of the most important of the conditions seems to be facilities for personal hygiene in the home, a condition attainable through environmental sanitation.

The importance of curative medicine in the reduction of mortality rates is indisputable. But this is a matter for another paper; the only obvious fact that needs to be underlined here is that the techniques used in curative medicine do not affect the morbidity picture and do not wholly solve the mortality problem.

By the process of simple elimination, therefore, one arrives at the conclusion that in countries or regions where environmental sanitation is poor, the emphasis in plans to control enteric infections should be placed on specific environmental sanitation measures.

The truth of this conclusion is well known, since for more than 20 years diarrheal diseases have been associated with poor environmental conditions. All the statistical data point in that direction, and outstanding

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improvement has come about only in countries where the environment has become comparatively sanitary.

II. RELATIVE IMPORTANCE OF ENVIRONMENTAL SANITATION MEASURES

Water Supply

Convincing data are available to prove that the mere change of this environmental factor can bring about a significant reduction in the prevalence of *Shigella*, the agent responsible for a high percentage of the cases. Therefore, this paper reaffirms the thesis held by most public health workers that the sanitation measure of highest priority for the control of diarrheal diseases is safe water supply. Since the water programs have to be conducted under certain specific conditions, special attention will be given to a detailed discussion of these.

Excreta and Sewage Disposal

Although the mechanism of transmission of these diseases has not yet been established in full detail, excreta undoubtedly represent a link in the chain of transmission. Proper disposal of excreta, with or without running water, appears to be an important means of interrupting that chain. For this reason, and because of the role this measure plays in the control of other diseases as well, most public health workers give high priority to the sanitary disposal of excreta. Later in this paper the details of this aspect of diarrheal disease control will be discussed.

Control of Flies and Other Insects

The campaign against flies and other insects is undoubtedly important, for when the vectors are eliminated one of the possible mechanisms of transmission is interrupted. Its relative importance becomes apparent when favorable results in the water supply program begin to appear, and transmission by vectors moves to first place.

Unfortunately, science to date has not been able to develop an insecticide capable of exterminating the vector population. The present campaign, therefore, is being conducted on two fronts: directly, through insecticides to reduce the vector population during peak periods; and indirectly, by attacking the breeding places through garbage collection and measures for community and household cleanliness. Sanitary disposal of excreta and sewage to a certain extent exerts indirect influence on the control of transmission by vectors.

Housing Sanitation

No one can deny the importance of sanitary housing; healthful conditions in the home are not only valuable in themselves, but also conducive to social and economic development. The role of such sanitation in diarrheal disease control is evident in the degree to which these diseases decrease with the improvement of personal hygiene and cleanliness in the home. However, one cannot conceive of a healthful and clean home environment without sufficient water available. It is possible to keep temporarily acceptable conditions in even the most humble home, if it has certain essential facilities for personal and domestic hygiene, the first among which is water. Therefore, housing sanitation programs of large scope cannot prosper without prior or simultaneous programs of water supply. On the other hand, water supply programs can be carried out by themselves since they bring immediate benefits, either directly or by opening the road to other sanitation programs.

Food Control

The importance of food control on the national scale is especially evident in countries where the food industry is highly developed. Since this is not the case in most

Latin American countries, attention should be directed mainly toward improving the techniques of home preparation and suitable use of foods, especially food intended for children under 4 years of age. Aside from the fact that this is basically a matter of health education, it requires certain minimum hygienic facilities, chiefly the availability of water. Thus we arrive once more at the conclusion that, in terms of relative importance, water supply comes first.

III. IMPORTANT ASPECTS OF THE WATER SUPPLY PROGRAM

The available statistical data and experience point to the fact that the quality of water, in contrast to the quantity supplied, has no great influence on the prevalence of the disease, provided the water meets certain minimum conditions of potability. Experience seems to indicate that significant results can be obtained in controlling the disease if a sufficient amount of running water can be provided in the home. Water supply through public outlets will not produce the desired results, and the attitude of planners who consider such systems acceptable should be rejected if favorable results are to be achieved.

Quality of Water Furnished

The relatively lesser importance of the quality of the water furnished is an advantage to water supply programs from both the financial and the technical points of view, for it obviates the need for costly treatment in all cases where it is not required by the social and economic conditions of the beneficiaries. This is the case especially in rural areas where socioeconomic evolution is in its initial phase and where water supply is therefore chiefly a health measure.

Although the fact is obvious, it is worth underlining that in speaking of sacrificing quality in favor of quantity, what is meant is the physical and chemical quality of the water, not its bacteriological quality. Nevertheless, strict bacteriological control poses no unsurmountable problem in programs with limited funds, since from the bacteriological viewpoint potability can readily be achieved in most cases through proper selection of sources and through chlorination.

Quantity of Water Furnished

When reference is made to quantity, the term is relative and the amount of water will vary according to the social and economic status of the beneficiaries. From the viewpoint of diarrheal disease control, sufficient quantity is the amount necessary for drinking, cooking, personal hygiene, and cleanliness in the home.

In the case of urban water supplies which furnish from 175 to 200 liters or more per person each day, the problem is automatically solved. The problem yet to be solved is that of certain rural water mains designed to distribute water through public outlets on the basis of a per-capita consumption of 50 to 70 liters per day or less.

Annex I of this paper[1] shows some interesting aspects of the relationship between distribution system costs and per-capita provision in 247 different systems of the rural water supply program conducted by the Ministry of Health and Social Welfare of Venezuela.

The conclusion is reached that a minimum per-capita supply of 100 to 135 liters per day can be achieved without major financial sacrifice, and that optimum rural water provision is from 150 to 200 liters per capita daily. The use of certain arithmetical calculations in making cost estimates is suggested as a means of reducing costs. It is pointed out that systems designed to provide only 50 to 70 liters per capita will not fully meet the needs in the control of diarrheal diseases. Moreover, their usefulness in other areas will be only temporary, since subsequent

[1] See p. 43.

population growth will require the partial or total reconstruction of such systems.

Direct Water Supply

The statement that considerable variations in per-capita supply of water will result in only small variations in the total cost of a distribution system is a valid one, provided a complete pipeline network, which theoretically will permit making connections to all houses of the system, is taken as a standard.

However, the temptation to save costs in water supplies by reducing the amount of pipelines installed and supplying instead through a few public outlets is very strong. A water supply system built in this manner will have only a poor and temporary impact on the beneficiaries. The only visible improvement would lie in shortening the distance for carrying water to the house; but in all other respects the same, or almost the same, conditions would prevail as before the water main was introduced. The use of contaminated sources would possibly have been avoided, but this type of system will not prevent contamination while the water is being transported to the home and during home storage in primitive containers. Nor does such a system succeed in inducing people to use sufficient water for personal and domestic hygiene. In other words, the sanitation aspect of distribution systems based on public water outlets is very limited, and its usefulness in diarrheal disease control is statistically insignificant.

Apart from the health implications, the difference between the two distribution methods in the social and economic plane is obvious. It is not the primitive water main, but running water in the home that will really raise the standard of living, dignify the existence of man, and contribute to his well-being. Moreover, it is only when water inside the home becomes first a wish and then a necessity that the suitable financing of water supply services will become possible.

In addition to the difficulties in obtaining initial funds, one of the main reasons for the slow progress in some countries may be attributed to the failure to recognize the validity of the previous statement. The water supply system built for distribution through public outlets invariably is a non-recoverable investment, which will have to be made over again when the system has outlived its usefulness. Moreover, most such systems become a financial burden in operation and upkeep; since the service provided is of limited value, the revenue derived from water rates is negligible, or nil. On the other hand, water supply systems that provide good service are going concerns, and as such are able to finance their own operation and maintenance, recover part of the initial investment, or even be wholly self-financed, depending on the size and social and economic status of the group benefited.

It may therefore be said that primitive systems of water supply should be undertaken only as a temporary measure and for specific purposes, such as bringing together and stabilizing a dispersed population to prevent its migration to cities, or in cases where a direct service would be financially prohibitive because of the scattered and irregular location of the houses.

Annex II[2] contains an analysis of the implications of direct water supply and divides the problem into three parts: the expansion of a distribution network; the installation of house connections; and piping water from the sidewalk into the home. The greatest expenditure lies in expanding the distribution network beyond the original size meant for distribution through public outlets. The benefits to health and to the economy that direct service brings fully justify the additional expenditure.

The installation of house connections is a logical consequence of this approach, especially since the added investment is only 6 per cent of the total cost of the water supply

[2] See p. 47.

system. This figure can be further reduced by using economical materials and construction methods, depending on the local conditions and the experience available.

One of the most important aspects of the problem of the direct provision of water is the effort to make the beneficiaries undertake the work necessary to pipe water into the house.

The organization of a campaign for this purpose should receive maximum attention from the agencies responsible for water supply programs. The coordination of such campaigns with other similar ones such as housing improvement, community development, and so forth, could bring about the most favorable health, social, and economic results.

IV. DISPOSAL OF EXCRETA AND SEWAGE

There are several aspects to this problem. First, there is the population group that as yet has no direct water supply service, so that the sanitation activity indicated is the promotion of latrine construction. The second population group is the one that is provided with direct water service but has the problem of sewage disposal, either individually through septic tanks, sumps, irrigation fields, etc., or collectively through a sewerage system. Then there is the large number of sewerage networks that serve only a part of the population, and the problem in this case lies in promoting the largest possible number of house connections. And, finally, save for a few exceptions, the great majority of existing sewerage networks in Latin America dispose of their sewage without prior treatment. This practice is alarming as it will lead to the destruction of natural water resources within a few years.

Latrine Construction

It must be emphasized that latrine construction is only a temporary solution and one that is inacceptable, both technically and from the health viewpoint, wherever there is a direct water supply service. There is no denying its usefulness to a dispersed population, or in population groups that for the moment cannot benefit from a direct water supply, but efforts and investments in latrine campaigns should not be made at the expense of the water supply program.

In latrine construction the direct collaboration of the beneficiaries is essential, since it takes place on their property. Education and promotion are effective activities, coupled with giving technical advice and aiding in the acquisition of inexpensive building materials. A variation of this approach, used in some countries, consists in providing prefabricated pieces contributed by the agencies in charge of the program, the beneficiaries contributing their labor. The per-capita construction cost varies from $5 to $15 per latrine; the additional sum required for the campaign itself varies greatly.

Sewage Disposal

The possibility of disposing of sewage by individual methods such as septic tanks, sumps, irrigation fields, and so forth, is limited by the nature of the terrain, availability of space, and the number of persons served. This aspect should be borne in mind when planning on the national and the local scale, in both urban and rural areas, since the problem can be solved through partial or total financing by the beneficiaries themselves. Under favorable conditions, in such activities as housing development of the rural type, rural housing programs, housing improvement, community development, and so forth, significant results can be achieved through educational campaigns, together with technical advice, to promote the construction of individual disposal systems in selected areas, after a prior study of local conditions. Such a campaign could be conducted along the same lines as the latrine construction program.

The provision of a public sewerage service

in large cities seems to be a reasonable objective, provided a suitable water supply system is available and the urban development is more or less orderly, as is not the case in most Latin American cities. Nevertheless, there is usually a great demand for this service, as well as some capacity-to-pay on the part of future beneficiaries; also, the economic structure and potential of municipal governments will facilitate the obtaining of funds needed for a strong initial investment. The per-capita costs vary greatly, but are comparable to those of the water supply program—about $50 per capita.

The greatest problem lies in small cities or rural areas, where it will be necessary to conduct the water supply program first in order to convince the beneficiaries of the desirability and necessity of a sewerage service. Even so, great difficulties will be met in financing the sewerage program, because it is not a productive financial investment and total or partial recovery of the outlay is far more difficult, at least in the initial stages. It is nevertheless desirable to plan the sewerage program at the same time as the water supply program, and then to await the proper opportunity to introduce a partial sewerage construction program, to be conducted by stages as funds become available.

House Connections

The operation of sewerage networks at only partial capacity because not all the properties that could be served have been connected with them, is the least of the problems. An educational campaign, together with certain legal action in urban areas of sufficient economic capacity, can produce favorable results within a short time. In low-income areas, it would be advisable to draw up a financing plan that will permit interested parties to pay for the cost of connections by installments, with the property serving as guarantee.

Treatment of Sewage

The disposal of sewage, without prior treatment, in streams and water bodies is beginning to present a problem in most Latin American countries, as it is having an adverse effect on the natural water resources. The problem will undoubtedly increase with the expansion of sewerage services and will require proper attention.

Waste-water control is an activity to which a certain amount of effort and financial resources should be devoted. It might begin with a study and evaluation of the problem, taking into account future needs for disposal of domestic and industrial waste waters. On the basis of the results of this study, the necessary legislation should be enacted or existing legislation modified, with the understanding that the immediate financing of treatment plants will be within the reach only of cities or industries that have considerable financial potential.

V. EXECUTION OF PROGRAMS

The basic requirement for any successful program is planning, based upon an assessment of the situation in the country. The first step would be to organize and provide for the financing of a survey and exact evaluation of present problems and future trends, and immediately thereafter to draw up short-term and long-term plans. This initial phase may require considerable time, effort, and investment of funds, depending on the local conditions.

However, short-term planning for the purpose of starting the program immediately can be undertaken without an exact or thorough knowledge of the nation-wide situation. In fact, several countries have initiated programs to meet the most pressing and obvious needs, while simultaneously organizing evaluation studies and formulating long-term plans.

The methods for conducting control programs in general have been fully discussed

in other papers.[3] Nevertheless, some additional suggestions can be made with respect to the phase covering the study of localities and the preparation of projects.

The water supply and sewerage systems of large cities require individual appraisal in each instance, in both the preliminary studies and the design and preparation of project plans. Depending on the magnitude of the problem and the availability of trained technical personnel, it may be necessary to utilize the services of private sanitary engineering specialists, either regularly or as temporary consultants.

There should be a different approach to the rural area because of the large number of small localities to be served. In such cases it is advisable to set up "mass production methods"; this will make it possible to use personnel with limited experience and to reduce considerably the cost of drawing up plans, while still maintaining the high technical quality of the designs. All stages of the process can be standardized, from the presentation of the field report up to the preparation of models and typical design details. A classic example of such a method, using the "production line" type of organization, may be found in the Projects Section of the Rural Water Supply Program of the Venezuelan Ministry of Health and Social Welfare.

Another practical measure is the grouping of several localities into one central system with a common source and common water lines, at a considerable saving in per-capita costs. This has the added advantage of facilitating the supply of services to small localities or groups of houses that could not be served individually on an economical basis.

The construction phase should be organized according to local conditions in each country. Experience has shown that large-scale programs for urban areas operate better under autonomous agencies or semiofficial institutions that have their own specific statutes for the conduct of the program. Most countries have recognized the need for submitting large-scale building programs to bidding by private construction companies. In the case of rural water supplies, the great number of "small" problems and the difference in the approach make it advisable to establish separate programs, with due coordination and exchange of information with the large-scale programs. The advantages of private construction under the bidding system apply here as well, although for works of little importance it would be acceptable to use methods of direct administration and construction with local human resources and through community development activities. The latter method merits special attention, since it permits the direct contribution of the beneficiaries.

Although the program's direct and immediate results are determined by the efficiency of the construction work, there is another aspect of equal importance: the transformation of the sanitation activity into practical benefits will depend on the administration, operation, control, and maintenance of the services. The building of the works is not an end itself, but the means of achieving specific results, and only an adequate service can ensure these.

VI. FINANCING OF THE WATER SUPPLY PROGRAM

On numerous previous occasions, each time the subject of financing arose, emphasis has been placed on the fact that water supply should be regarded as a service enterprise in the truest sense of the word. On the one hand, suitable service must be provided in keeping with the needs of the beneficiaries, and on the other, the service must pay for itself according to the basic requirements of a sound business. So long as this basic principle is not accepted in Latin America, any discussion of financing problems will be

[3] See article on p. 26.

useless. Therefore, efforts must be directed, not toward changing present thinking by resorting to social, economic, and political arguments, but rather toward overcoming the difficulties that stand in the way of converting the water supply works into a true business enterprise. It may be said that, with the sources of capital now available, the main problem is no longer that of obtaining funds for financing, but rather the creation of conditions indispensable to the economic soundness of the investment, as a prerequisite for mobilizing such capital.

Once this principle has been accepted, favorable financing can be obtained in urban areas without great difficulty. In rural areas it will be necessary to change radically the present approach to the problem and to establish firmly the policy of direct service as essential to recovery of the investment. This implies revising the objectives and estimates set forth in the Charter of Punta del Este, and the recommendations made by the PAHO Advisory Committee on Environmental Sanitation, at its meeting in Washington, D. C., in November 1961.

The per-capita costs proposed in those recommendations no longer suffice on the basis of the new criterion; the figures of $7.50 to $15 per-capita should be doubled, to an average of from $15 to $30 for rural water supplies with direct service. Although these figures may seem high, such water supplies will make it possible to recover the investment partially or totally and will therefore greatly facilitate their financing. The advantages to public health and welfare have already been made clear.

Needless to say, programs of direct water supply to the home will not reach the entire population for the next 10 to 15 years. It should also be recognized that it will not be possible to conduct such programs economically in areas where the population is widely dispersed. Parallel programs must therefore be undertaken for certain specific purposes, and limited to those areas, because it will not always be possible to postpone the solution for so many years. For example, the Ministry of Health and Social Welfare of Venezuela is conducting a pilot program for dispersed localities of up to 500 inhabitants, where direct service would be financially prohibitive. In such cases there is prior acceptance of the fact that the investment is not recoverable and that the program's benefits will be limited. The main purpose of the health activity is to supply drinking water in such a way as to prevent the use of contaminated sources; it will, moreover, prevent migration to the cities, through the improvement of local living standards and as a result of the fact that a common water supply tends to hold a dispersed population together. The financing of such programs is done through a 50 per cent contribution of the total cost by the regional governments and by the beneficiaries, the latter mainly through labor, a 25 per cent contribution by the Ministry of Health and Social Welfare, and another 25 per cent by UNICEF, mainly in materials, the cost of which need not be repaid.

Annex III gives further details of the financing of the water supply program.

Annex I

RELATIONSHIP BETWEEN COST OF DISTRIBUTION SYSTEMS AND AMOUNT OF WATER SUPPLIED PER CAPITA

Table 1 shows the relative costs of pipes of different diameters and materials, compared with their transport capacity. While unit costs of materials and labor may vary greatly from country to country, this variation affects all items in the table and relative

TABLE 1—*Comparative Cost and Transport Capacity of Different Types of Pipelines.*

Diameter and material*	Relative capacity	Cost in US$			Relative cost (%)		
		Material**	Labor†	Total	Material	Labor	Total
2″ C.I. class 150	1.00	1.54	1.54	3.08	100	100	100
3″ C.I. class 150	2.93	2.31	1.76	4.07	150	114	132
4″ C.I. class 150	4.01	3.12	1.95	5.07	202.6	126.6	164.6
6″ C.I. class 150	17.52	4.46	2.58	7.04	289.5	167.5	228.6
8″ C.I. class 150	55.07	5.91	3.33	9.24	383.8	216.2	300
3″ A.C. class 150	3.92	1.40	1.67	3.07	90.9	108.4	99.6
4″ A.C. class 150	5.36	1.86	1.78	3.64	120.7	115.6	118.1
6″ A.C. class 150	23.38	3.17	2.29	5.46	205.8	148.7	177.2
8″ A.C. class 150	73.60	4.73	2.95	7.68	307.1	191.6	249.4
2″ G.S. class 150	1.00	1.58	1.48	3.06	102.6	96.1	99.9
3″ G.S. class 150	2.93	3.09	1.65	4.74	200.6	107.1	153.9
4″ G.S. class 150	4.01	4.35	1.87	6.22	282.5	121.4	201.9
6″ G.S. class 150	17.52	7.36	2.64	10.00	477.9	171.4	324.7
8″ G.S. class 150	55.07	9.84	2.97	12.81	639	192.9	415.9

* C.I. (cast iron); A.C. (asbestos cement); G.S. (galvanized steel).

** Cost of material was estimated on prices of imports from the USA on 1 January 1963, CIF, Puerto Cabello, Venezuela; imports from Europe, the Far East and Latin America are lower by up to 30% or more. Local variations in cost of materials and labor will have little effect on the relative costs of pipes of different sizes made from the same materials.

† Cost of labor was calculated on the average daily wage of $3.60 for unskilled and $7.90 for skilled labor, including social welfare deductions.

costs will remain more or less the same. The table shows that a comparatively small increase in the cost of the pipe will produce a substantial increase in transport capacity.

Table 2 summarizes the results of a study of 247 distribution systems serving 272,538 persons in localities of up to 5,700 inhabitants, divided into the following groups: 0-500; 501-1,000; 1,001-1,500; 1,501-2,000; and 2,001-5,700 inhabitants. The distribution systems were designed to supply water directly to all houses that could be connected to the network. These localities were included in the Rural Water Supply Program of the Ministry of Health and Social Welfare of Venezuela during the period 1 July 1959—31 December 1962, and most of the systems are either in full operation or in the construction stage.

Since ambitious standards of design and optimum building materials were used, the per-capita cost is higher than average for Latin America, but the main purpose is to show that in the small localities approximately 70 per cent of all pipes are 2″ to 3″ in diameter and these represent about 60 per cent of the cost of all pipes. The water provided per capita by these mains is 150-200 liters per day, an amount considered sufficient to take care of all the needs of inhabitants in rural areas.

Assuming that for reasons of economy a smaller pipe is used, it will reduce the per-capita amount of water to one third of the above amount, or 50-70 liters per day. A comparison of the relative cost and capacity of pipes in Table 1 with the relative cost of the distribution systems summarized in

Table 2 shows that the use of a smaller pipe theoretically reduces the cost by 24-26 per cent. In practice, however, this saving amounts to 20 per cent at the most, since the cost of pipes 2″ in diameter, the minimum size acceptable, is only 16-33 per cent of the total cost of the distribution system. Moreover, the reduced per-capita supply resulting from this saving will not suffice to meet all the needs of the beneficiaries. There-

TABLE 2—*Summary of Length of Pipelines in the Distribution System, by Diameter and by Size of Locality.*

	Inhabitants					
	0-500	501-1000	1001-1500	1501-2000	2001-5700	Total
Localities studied	91	69	32	19	36	247
Inhabitants	26,266	51,673	40,716	33,805	120,070	272,538
Average No. inhabitants per locality	209	749	1,272	1,799	3,335	1,103
Total cost all water systems						
Bolivars	9,462,804	11,084,020	9,523,500	7,286,593	20,387,745	57,744,662
Dollars	2,084,318	2,441,418	2,097,687	1,604,976	4,490,692	12,719,087
Average cost per system						
Bolivars	103,987	160,638	297,609	383,505	566,326	233,784
Dollars	22.9	35.4	65.5	84.5	124.7	51.5
Average per-capita cost						
Bolivars	360	215	234	216	170	212
Dollars	72	47	52	48	38	47
Total length of distribution pipelines, Km.	160.5	219.3	161.9	127.0	322.0	990.7
Length of 2″ pipes						
Km.	69.9	64.8	55.5	31.7	90.9	312.8
%	43.6	29.5	34.3	25.0	28.2	31.6
Length of 3″ pipes						
Km.	54.0	89.3	56.8	45.0	115.6	360.7
%	33.6	40.7	35.1	35.4	35.9	36.4
Length of 4″ pipes						
Km.	25.8	45.3	36.9	29.6	74.8	212.4
%	16.1	20.7	22.8	23.3	23.3	21.4
Length of 6″ pipes						
Km.	9.9	19.5	10.8	16.4	29.0	85.6
%	6.2	8.9	6.6	12.9	9.0	8.7
Length of pipes 8″ and over						
Km.	0.9	0.4	1.9	4.3	11.7	19.2
%	0.5	0.2	1.2	3.4	3.6	1.9
Relative cost of 2″ pipes, %	33.5	21.3	25.1	16.7	19.4	22.5
Relative cost of 3″ pipes, %	34.0	38.8	33.8	31.2	32.6	34.2
Relative cost of 4″ pipes, %	20.4	24.7	27.5	25.6	26.4	25.1
Relative cost of 6″ pipes, %	10.9	14.7	11.0	19.7	14.2	14.2
Relative cost of pipes 8″ and over, %	1.2	0.5	2.6	6.8	7.4	4.0
Relative cost of all pipes, %	100.0	100.0	100.0	100.0	100.0	100.0

fore, systems designed for such reduced supply will not fulfill their function in the control of diarrheal disease, and their usefulness in other areas will be only temporary, since population growth will eventually require their total or partial reconstruction.

Assuming that the original amount of water provided by the system is reduced to two-thirds, or 100-135 liters daily per capita, a saving of some 10 per cent is obtained. This amount of water may be considered sufficient under certain social and economic conditions, but the possibilities of a gradual expansion or improvement of the distribution service to subsequently reach the proportions of an urban water supply will be limited.

The other factor that influences the diameter of distribution pipes is variation in consumption, since the systems are designed to take care of maximum hourly demands. The supply systems discussed above were designed for an hourly consumption of 250-300 per cent of the average consumption, or the volume planned. By ignoring this feature, the pipe diameter could be reduced and cost reductions could be achieved similar to those previously described. Therefore, within certain limits, cost reductions can be made by this simple artifice in mathematical calculation, instead of by reducing the amount of water provided. The adverse effect of reducing the cost of design will show up only during the brief periods of maximum consumption, which will cause a reduction in residual pressures. In other words, the adverse effect will appear in certain less favorable points of the network during the few minutes of peak consumption, whereas reduction of the amount provided is a perpetual defect; it affects not only the functioning of the water system as a means of controlling diarrheal disease, but also the possibility of bettering and extending the service so as to make possible a gradual transition to the urban-type system.

Another factor affecting pipe diameter is the method used to estimate head loss. Planners tend to use simple, approximate estimates for rural systems, since the systems are also simple. In essence, this method consists in estimating the main lines, without regard to the favorable effects of secondary pipelines. Nevertheless, as stated, in small localities about 70 per cent of the pipes are 2 to 3″ in diameter; that is to say, the secondary pipelines are similar in diameter to those supposed to be main lines. Therefore, more precise calculations could, in some cases, result in savings comparable to those obtained through a reduction in the amount of water supplied.

Table 3 contains a summary of the relationship between the cost of the distribution system and the per-capita amount of water supplied. It is difficult to make generalizations as to this relationship in the case of the remaining components of the water supply system, such as the conduction line, pump station, and storage tanks, since it depends on many features in the design; but in principle it is possible to estimate an average variation similar to the one above.

TABLE 3—*Percentage Variation in the Cost of the Distribution Network, by Amount Supplied and by Designed Capacity.*

Amount per capita (lts/day)	Cost of design for maximum hourly consumption (% of average hourly supply)		
	165–200	200–250	250–300
150–200	90	96	100
100–135	81	86	90
50–70	72	77	80

The conclusion is that a minimum amount of 100 to 135 liters per capita per day can be provided in rural supply systems without great financial sacrifice, and a daily amount of 150-200 liters per capita can be achieved with an increase in cost that is slight when compared with the benefits resulting to every feature of the water supply system.

Annex II

RESULTS OF PROVIDING DIRECT WATER SUPPLY

There are several aspects to the problem of piping water direct into the home. The construction of works for bringing water from the source to the center of a locality will not concern us here, since these are a common component of any system. This study will be limited for the most part to systems and methods of distribution within the locality, specifically in rural areas, since the need for direct service into the home in urban areas is never questioned.

From the technical and the financial viewpoints, the most important aspect is the pipeline network, and reference will again be made to the distribution systems summarized in Table 2. The present cost of distribution pipelines in the 247 systems in question is about 35 per cent of the total cost of the complete water supply service. This figure includes the cost of house connections, which will be discussed further on. It is most difficult to estimate the probable cost of pipelines in cases where the systems were designed to supply water through public outlets. Depending on the number of branches or lines used to feed such strategically located public outlets, the cost of the supply system could probably be reduced to one half or one third of the present cost. A reduction of about 20 per cent could be achieved in the rest of the works as a result of the considerably reduced consumption. In this way, the total cost of the water supply system would be something like 50 to 60 per cent of the present cost. However, this apparently great saving would mean converting systems of this kind into nonrecoverable investments and permanent financial burdens. On the other hand, in their present form, these systems do cover the operating and maintenance costs and make possible the direct or indirect recovery of about 50 per cent of the original investment within the first 10 years of operation. In addition, they act as the backbone for other public health programs and, it is hoped, will effectively contribute toward the control of diarrheal disease and of waterborne diseases in general. For all of these reasons, it is believed that an increased investment is more than justified from every point of view.

The second aspect of the matter lies in the direct house connections from the distribution pipeline to the front of the house. Table 4 shows a study made of 187 water supply systems, which serve 228,448 inhabitants and were designed with a total capacity for 460,000 persons. These systems

TABLE 4—*Summary of Relative Cost of House Connections in 187 Localities with 228,448 Inhabitants.**

	Bolivars	Dollars	Average percentage
Total cost of projects	50,732,610	11,174,583	
Total cost of all house connections	2,894,002	637,445	
Average cost of connections by project	15,475	3,409	
Percentage cost of house connections in the total cost			6
Cost of materials (all projects)	24,205,187	5,331,538	
Percentage cost of connections in total cost of materials			12
Per-capita cost of house connections	13	2.86	

* The average of population served directly in each locality is 83%.

come under the same Rural Water Supply Program for localities of up to approximately 5,000 inhabitants, mentioned earlier. According to the policy of the Venezuelan Ministry of Health and Social Welfare, they were designed to pipe water direct into the home by means of house connections, insofar as possible. The population living on the fringe of the locality is supplied through a small number of public outlets.

As may be seen from Table 4, an average of 83 per cent of the total population benefited is served through house connections; these represent 6 per cent of the total cost of the water supply system. The percentage of the population with direct service is considered close to the maximum that can be handled economically, since the remaining beneficiaries live outside the center of the locality and are so dispersed that extension of direct service to them would result in injustifiable cost increases. However, as experience has shown, once the water supply service begins to operate efficiently it attracts dispersed population to the center of the locality or arouses the wish for water piped direct into the house, to such a degree that in some cases the beneficiaries paid the cost of building the pipelines leading to their homes, even though they were several hundred meters long.

Needless to say, once the idea of a complete system of direct water supply is accepted, the additional cost of house connections is more than justified, since it comes as the logical sequence to the guiding principle of the program.

These, then, are the two so-called "public" parts of a water supply system whereby the services are placed at the disposal of the beneficiaries in front of their homes. Bringing the water from there into the home is the third aspect of the problem. Remarks here will be limited to supplies for rural areas or for urban fringe areas with rural characteristics, since the customs and socioeconomic conditions of most urban populations will automatically promote the construction of the necessary waterworks by the interested parties. The cost of these installations in rural areas is estimated at 2 to 5 per cent of the total cost of the water supply system, depending on the distance of the house from the street, and on the number of taps—up to three or four—to be installed in the house.

Public cooperation can be enlisted at the outset of the water supply construction program only through the beneficiaries' direct collaboration. Public interest should be directed mainly toward promoting the desire to have water in the home. The cooperation given by beneficiaries will vary all the way from contributing unskilled labor to defraying the entire cost of the installations. This is one of the most important aspects of water piped direct into the home, for in the final analysis, the success of the program will depend on the people's response. In fact, this factor is of such great importance that it deserves a separate campaign, either under the water supply program or conducted at the same time, so as to create a favorable climate. A campaign of this kind could be included in community development movements, health education programs, establishment of water boards, public information, and so on. An interesting possibility would be to organize housing improvement campaigns in conjunction with campaigns for piping water direct into the home. This could be accomplished almost entirely through the efforts of the beneficiaries themselves, except for technical guidance and possible provision of low-cost materials. A true psychological impact could be made in this way—an impact that would mark the beginning of a rapid social and economic development in backward areas, with obvious beneficial results to public health.

Annex III

FINANCING OF WATER SUPPLY PROGRAMS

Part VI of this paper contains a definition of the basic requirements for plans to finance water supplies.

The per-capita cost, estimated at from $50 to $60, as an average, for urban water supplies in Latin America should be financed by the national, regional, or municipal government through either budget allocations or long-term loans. Under favorable circumstances the entire investment should be considered recoverable. The installation of house connections and private plumbing will require no special financing, since the former can be built together with the water supply system and the latter will be paid for directly by the beneficiaries.

In the case of rural water supplies, the financing plan will vary according to local conditions. The cost of the study, plans, and supervision is estimated at from 5 to 8 per cent of the total cost of the water supply system and should normally be contributed directly by the agency responsible for conducting the program.

Construction of the works, excluding house connections, represents from 86 to 89 per cent of the total cost. About one half of this is for material and equipment, which invariably should be financed by public funds, normally either national or state, or else through an international loan. The other half, that is, 43 to 45 per cent of the total cost, is for labor and local transportation, which can be contributed partly by the beneficiaries or financed by short-term loans from local enterprises, or through national or state budget allocations.

The installation of house connections, about 6 per cent of the total cost, can be financed locally through relatively short-term loans, with the municipal or state government contributing the initial cost and subsequently collecting from the users in easy monthly or quarterly installment payments, or during their periods of income (at harvest time, for example). The same applies to financing the installations needed to bring water from the sidewalk into the house.

The Rural Water Supply Program of the Venezuelan Ministry of Health and Social Welfare is one example of the possible systems of financing. A long-term loan, granted by the Inter-American Development Bank and backed by the Government of Venezuela, covered up to a maximum of 50 per cent of the cost of the works. This amount was mainly for the cost of pipelines, accessories, equipment, and transportation from the port to the building site.

The balance, which in practice should be approximately 55 per cent of the total cost of the works, was shared by the Ministry of Health and Social Welfare and the regional governments. The Ministry contributed the study, plans, and the supervision of construction, while labor is the responsibility of the regional governments, either through contracts with private building firms or through direct construction, in cooperation with the interested parties. Well drilling and the supply of pumps and storage tanks are items that may be contributed by both the Ministry and regional governments, depending on local conditions. The initial cost of house connections is similarly shared and may later be collected by either the regional governments or by the boards in charge of administering the water supply system.

The installation of plumbing inside the home has not yet been organized into formal campaigns, but the beneficiaries themselves have undertaken it with help from the regional governments in the form of materials.

Water rates are established beforehand, depending on the financial capacity of the beneficiaries, on the total cost of the water supply system, operating costs, and so forth. The theoretical recovery of the initial investment includes operating and maintenance costs and exceeds 50 per cent. In view of the fact that the administration of water supplies is the responsibility of the boards established and chosen for that purpose, the recovery of the invested funds is indirect, since the collection remains in the hands of those boards, which use the income they receive to operate, maintain, and expand the service, to establish reserve funds, etc.

Table 5 is a summary of the entire discussion of means for financing water supply systems.

TABLE 5—*Various Methods for Financing Water Supply Programs.*

Item	Costs		Method of financing*
	% of total	*per capita* (Dollars)	
Complete system of urban water supply	100	50–60.0	National, state, or municipal budget; bonds; long-term loans.
Plumbing in the home in urban areas	Varies		Direct by beneficiaries.
Study, plans, and supervision in rural areas	5–8	0.75–2.40	Budget of agency in charge of the program; occasionally some international agencies.
Provision of materials and equipment for rural water supplies	43–45	6.45–13.50	National or state budget; long-term loans; limited contribution of municipalities.
Provision of labor in rural areas	43–45	6.45–13.50	State budget; building enterprise (short-term); varied contributions from beneficiaries; limited contribution from national budget.
Installation of house connections in rural areas	6	0.90–2.40	National, state, and municipal budget, with charge to beneficiaries by installments of part or all the investment.
Plumbing in the home in rural areas	2–5 (in addition to total cost)	0.30–2.00	National, state, and municipal budget (cost of campaign and possibly materials); beneficiaries (labor as a minimum); non-profit organizations and campaigns.

* For sources of international capital see: documents relating to the Charter of Punta del Este; the Alliance for Progress; and the *Boletín de la Oficina Sanitaria Panamericana*, Vol. 48, No. 5, November 1959.

DIARRHEAL DISEASE AND THE HEALTH CARE SERVICES IN LATIN AMERICA

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"Diarrhea is conceived of as a disturbance of intestinal motility and absorption which, once and by whatever means initiated, may become self-perpetuating as a disease through the production of dehydration and profound cellular disturbances, which in turn favor the continuing passage of liquid stools."(1)

Mortality ascribed to diarrheal disease is the most striking pathological characteristic of the middle and southern sections of the Americas. The mortality is essentially limited to children under five years of age, who account for 90 per cent of such deaths in these sections of the Hemisphere. On the basis of available reports, it is estimated that diarrhea is recorded as the cause of death in almost one quarter of the million young children who die annually in countries of the Middle and South America. These diarrheal deaths exceed by ninety-eight per cent the number that could be expected if the diarrheal disease death rates of North America were to prevail throughout the Hemisphere.

The lethal episode in most of the million Latin American deaths under five years of age, however, often reflects a complex synergistic chain of pathological antecedents and coincident conditions which include nutritional deprivation and repeated bouts with infectious agents of disease. It is probable, therefore, that diarrhea contributes directly or indirectly to most of those deaths which occur after the immediate neonatal period.

The reduction of early childhood mortality will require efforts to improve the economy, the social structure, and the nutrition and sanitation of the population—a process that draws upon all the forces of positive cultural, educational, and social change. This is a gradual process that will take many years to complete. It seems clear, however, that organized health care services can greatly reduce mortality in a relatively short period of time, even in the absence of economic improvement and the provision of better living conditions and environmental sanitation. This paper will be limited to a description and analysis of such a role and to suggestions on specific ways in which these services can be strengthened as part of the planning process. A subsequent paper will deal in more detail with intravenous fluid therapy of serious diarrheal dehydration.[3]

At the XVI Pan American Sanitary Conference in 1962, Dr. John B. Grant defined health care as a comprehensive integrated "program of services which promote health, prevent disease, restore health, and alleviate disability . . . closely related to

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[3] See article on p. 65.

environmental health services on the one hand, and to social protection and educational services on the other." (3) This is the sense in which the term is used in this paper.

These observations and comments on the programs and practices of Latin American health care services are based upon visits to several Latin American countries by one or both of the authors. They are not intended to portray a comprehensive picture of the existing situation, but rather should be considered as a series of selected points chosen to represent successful experiences from which something can be learned or to raise questions which can lead to solutions through discussion or through applied trial.

The role of health care services in reducing the *incidence* of diarrheal disease in childhood is limited to measures to promote personal and household cleanliness, sanitary food handling, and improved nutrition. Shortages of personnel and supplies make it impossible, however, to reach a significant proportion of the Latin American population with a system of preventive personal child health supervision by professional personnel capable of achieving such difficult objectives within existing levels of living. Community-wide educational measures of this type are more appropriately considered as part of a program of environmental sanitation and nutrition.

On the other hand, health care services, when considered as a comprehensive whole, have unique and important contributions to make toward the reduction of preventable *deaths* from diarrheal disease. These contributions will be considered first in terms of the objectives of patient care, and second in terms of the organization of services to meet these objectives. The emphasis on patient care is of the utmost importance because it forms the basis of the priorities around which services must be organized to achieve maximal effect with minimal resources.

PATIENT CARE

Diarrheal disease in Latin America is an affliction of the very young. It appears as an important clinical problem in the newborn period and attains enormous proportions during the ensuing few months. The course of its incidence thereafter appears to vary with infant feeding practices related to the supplementation of or substitution for breast milk, with some countries showing a fall-off in morbidity as early as the sixth month of life and others as late as the third year. It is a major cause of illness throughout childhood and generally leads the list of ailments for which children come to hospitals and health centers.

The age-specific mortality rates for diarrhea are highest during the first year of life. The heavy concentration of deaths occurring during the first few months of life was pointed out some years ago by Verhoestraete and Puffer (4). It is illustrated by more recent data from two countries in the Americas (Tables 1 and 2). In Venezuela almost half the deaths in children under five years of age occur during the first six months of life, while in Colombia the proportion is almost one third. Differences between countries may be related to type and techniques of infant feeding.

Regardless of the cause of differences, the young infant is peculiarly susceptible to the metabolic disturbance of diarrheal dehydration; he cannot readily make his feelings and needs known; and he depends upon others to feed him. These factors pose special problems in treatment.

As has been pointed out earlier, diarrhea in young children is frequently associated with other infections and with protein-calorie malnutrition. In Latin America, as in all the developing areas of the world, strains of *Escherichia coli* have frequently become incriminated, especially in the production of nosocomial epidemics in young

TABLE 1—*Distribution of Deaths from Diarrhea in Children under Five Years of Age, by Age at Death—Colombia, 1960.**

Age	Number	Per cent in age group	Average per cent per month in age group
Under 28 days.	1,187	6.0	6.0
1–5 months...	4,932	24.8	5.0
6–11 months..	5,303	26.7	4.4
12–23 months..	4,840	24.3	2.0
24–59 months..	3,634	18.2	0.5
Total.....	19,896	100	

* Includes deaths from dysentery, gastroenteritis, and diarrhea of the newborn. Figures for diarrhea of the newborn taken from data of 1961.

TABLE 2—*Distribution of "Diagnosed Deaths" from Diarrhea* in Children under Five Years of Age, by Age at Death—Venezuela, 1961.*

Age	Number	Per cent in age group	Average per cent per month in age group
Under 28 days.	328	7.4	7.4
28 days—			
2 months....	385	15.5	7.7
3–5 months...	1,063	24.1	8.0
6–8 months...	802	18.2	6.1
9–11 months..	537	12.2	4.1
12–23 months..	669	15.2	1.3
24–35 months..	171	3.9	0.3
36–47 months..	99	2.2	0.2
48–59 months..	57	1.3	0.1
Total.....	4,111	100	

* Deaths certified by a physician as due to diarrhea (gastroenteritis and diarrhea of the newborn).

multiple pathology in a single child is the rule rather than the exception. While immediate attention to measures of rehydration or prevention of dehydration takes first priority, complete appraisal of the child and the treatment and follow-up of associated conditions are integral features of good medical practice.

Limitation of resources and personnel may make it impossible to render comprehensive care of this sort to every child presented to health care services for treatment of a diarrheal episode. More careful total appraisal and therapy appropriate to the diagnoses are, however, essential for seriously ill children and those who do not respond to treatment routines. Treatment and follow-up of severe nutritional disease are always indicated. These points are discussed again in a later section.

Parent understanding of the reasons for the treatment measures taken is another aim of good medical practice. Theoretically, such understanding could result in a reduction of future diarrheal disease in the child. Achievement of the educational aim is hampered by ignorance, illiteracy, and indigenous popular culture, as well as by shortages of personnel and resources. Here again, it may be necessary to select the type of case upon which to expend extra efforts. A recent study by Heredia Duarte *et al.* (5) suggests that the effect of educational efforts in reducing subsequent diarrhea may be more productive when directed toward the families of children with malnutrition complicated by diarrhea, than when directed toward the families of all children with diarrheal disease. The aims and values of educational efforts in Latin America need to be more precisely and realistically documented and measured, however, before one can do more than acknowledge them as elements of good pediatric practice.

Specific Etiology and Chemotherapy

Most cases of diarrhea are considered to originate as enteric infections, and in parts of the world where this malady is frequent and causes many deaths, a recognized causative agent can frequently be isolated. *Shigella* and *Salmonella* species have long been recognized as causative of diarrheal disease, and in the past decade enteropathogenic infants. *Esch. coli* may be recovered with

some frequency in endemic diarrhea as well, particularly in children under one year of age; their prevalence appears to be considerably greater in some areas than others.[4]

Of particular interest in Venezuela has been the recent immigration of very large numbers of country dwellers into city slum areas. This population move has been associated with a considerable upsurge in cases of diarrhea. *Shigella* has assumed renewed importance and, most interestingly, *Endamoeba histolytica* has been recovered with frequency from cases of diarrhea with bloody stools, even in children under two years of age (12,14).

The relative importance of viruses in endemic diarrhea is at the moment disputable. Whatever their role, no antiviral chemotherapy is available.

Clinically, there is little to distinguish among diarrheal infections due to viruses or bacteria. Perhaps 15 per cent of all cases of diarrheal disease are associated with the passage of bloody stools, though this percentage may rise to nearly 50 in *Shigella* infections (15).

The foregoing brief review of the infectious etiology of diarrheal disease is a necessary prelude to consideration of the use of sulfonamides and antibiotics in treatment. Up to this moment, only *Shigella* and enteropathogenic *Esch. coli* have been shown to be effectively eliminated from the body with chemotherapy. The use of appropriate antibiotics has been an important feature of the therapy of newborn infants with *Esch. coli* infections, but the same antibacterial effectiveness of a variety of drugs against *Shigella* has not been attended with comparable clinical improvement of the patient.

From a statistical standpoint it is known that the duration of diarrhea may be somewhat shortened if *Shigella* can be eliminated, but the majority of recent studies continue to show the ineffectiveness of antibiotics in altering the clinical picture of diarrheal disease (5,6,9,10). For example, in a double blind study in Caracas, of which a preliminary report has appeared (16), the effect of chloramphenicol was indistinguishable from that of a placebo.

It is reasonable to conclude that the identification of an infectious agent and the chemotherapy of a case of diarrheal disease are of limited usefulness, with the exception of infections due to enteropathogenic *Esch. coli* in *nursery* epidemics and to *Endamoeba histolytica*. Antibacterial agents are expensive as well as ineffective on the whole. Among the potentially harmful results of their use is the production of diarrhea or the possible invitation to enteric infection by resistant organisms such as *Staphylococcus aureus*. Mycotic infections and bone marrow depression have been reported.

The potential hazards associated with the routine use of chemotherapeutic agents very likely outweigh their possible benefits. Their widespread use is a heavy drain on limited budgets, especially when more important aspects of therapy are not adequately provided for.

Despite lack of documented effectiveness, antibacterial therapy enjoys widespread acceptance. The compulsion to prescribe drugs may be a reflection of both popular and professional tradition which views all non-surgical treatment as synonymous with materia medica.

Suppression of Diarrhea as a Sign

With the exception of withholding food, the short-term usefulness of which will be discussed under "Oral Fluid Therapy," measures designed to suppress the passage of loose stools are notably unsuccessful. Paregorics can be pushed to the point of depression of the central nervous system without affecting the frequency or character of the stools. Neither practical nor theoretical effectiveness has been demonstrated for proprietary preparations designed to:

[4] Current and recent references include reports from Mexico (6,7), Brazil (8,9,10,11), and Venezuela (12,13).

(1) absorb hypothetical toxins, (2) soothe the inflamed intestinal mucosa, (3) alter intestinal function by changing bacterial flora, or (4) disguise liquid stools by the hygroscopic action of inert solids. The crucial demonstration of reduced fecal loss of water and electrolytes has not been made with these preparations, nor has it been shown that they selectively remove only noxious substances from the gut.

Fluid Therapy

With the exception of certain rare complications, death from diarrhea is due to dehydration or its serious consequence, shock. Treatment of diarrheal disease thus resolves itself into averting or repairing dehydration through appropriate fluid therapy.

Prevention of Dehydration: Oral Fluid Therapy

It is uniformly accepted by pediatricians that severe dehydration due to diarrhea may be averted if oral administration of fluids is commenced early in the illness. The prevention of dehydration, as opposed to the prevention of diarrhea itself, is a basic feature in all programs for the control of diarrheal disease. The important features of this therapy are: (1) provision by mouth of liquids which, at least theoretically, approximate in content and volume the aggregate of those fluids lost *abnormally* in the diarrheal stools and *normally* via lungs, skin, and kidneys; and (2) suspension of all food intake for a brief period. Twelve hours of calorie starvation usually suffice and may be more than adequate. Rarely should 24 hours be exceeded. The child's usual food does not *cause* diarrhea, but it may briefly aggravate it. Prolonged restriction of food can only augment the frequently present malnutrition, without fundamentally improving the diarrheal process.

Vomiting associated with diarrheal disease is an infrequent problem in the course of the illness, but makes its appearance in most children as dehydration becomes more severe. Early oral fluid therapy thus averts not only dehydration but also the vomiting which makes oral administration of fluids difficult or impossible. Vomiting can frequently be controlled by the administration of teaspoonful amounts of fluids at intervals of five or more minutes.

Solutions for oral therapy in general use in Latin America vary in their composition from boiled water and sweetened tea, which have essentially no electrolyte content, through one-third to one-half isotonic solutions, to Ringer's solution, which is isotonic.[5] Examples of such solutions are listed in Table 3. Most are dispensed as solid concentrates to be dissolved in boiled water at home by the mother. In general, they have been accepted by infants and children with eagerness. When reluctance has been encountered in Mexico, the addition of cinnamon, *manzanilla*, or *yerba buena* to the solution has made it acceptable. The sucrose contained in certain of the solutions provides a useful source of calories during the period of suspension of other feeding, and also makes the electrolyte solution more palatable.

The various solutions described in Table 3 have been given to many patients with considerable success. Little is known, however, of their effect on the electrolyte economy of the body when treatment is not successful. As long as renal blood flow is adequate, the kidney is able to make extensive adjustments in the interest of homeostasis of body fluids.

The upper limits to the concentrations of sodium and total electrolytes in solutions for oral therapy, above which the ratio of electrolyte to water is too high, are not clearly defined, either on theoretical grounds or from experience in their use. The amount

[5] "Isotonicity" refers to the normal osmotic concentration of body fluids, approximately 300 mOsm/L.

TABLE 3—*Useful Electrolyte and Sugar Concentrates Available in Latin America.*

Type of product and availability	Composition	Directions for solution	Concentration when dissolved as directed		
			Na (mEq/L)	K (mEq/L)	Total electrolytes (mOsm/L)
Materials available in homes	Table salt, ½ teaspoonful. Cane sugar, up to 3 tablespoonfuls	Dissolve in 1 liter of water	40	0	80
Pill distributed by Ministry of Health and Social Welfare, Venezuela	Sodium chloride 1.5 gm Potassium chloride 0.5 gm	Dissolve 2 pills in 1 liter of water. Add 2 tablespoonfuls of *panela* or *raspadura de panelón*	52	13	130
Packet (*sobrecito*) distributed by Ministry of Health and Welfare, Mexico	Sodium chloride 3.0 gm Potassium chloride 1.0 gm Sucrose 46 gm	Dissolve contents of packet in 1 liter of water (4½ glasses)	52	13	130
Proprietary pill (Hydrax ®, Johnson and Johnson) available in Brazilian health centers and pharmacies	Sodium chloride .214 gm Potassium chloride .142 gm Sodium citrate .262 gm Excipient .63 gm	Dispensary use: Dissolve 1 pill in 150 ml of water or 5% glucose solution. Home use: dissolve 3 pills in 2 glassfuls of water	42	12	108
Original formula of Dept. of Pediatrics, Louisiana State University School of Medicine, described in *Boletín* of PASB, 1954	Sodium chloride 1.5 gm Potassium chloride 2.0 gm Sucrose 50 gm*	Dissolve in 1 liter of water	26	27	106

* A liquid concentrate is also described, prepared by dissolving salts in 15 ml of water, then adding 60 ml of syrup of raspberry in place of the sucrose (17).

of sodium in a popular United States concentrate, originally designed to provide 50 mEq/L of this ion, was reduced by half some years ago in the belief that occasional cases of hypernatremia encountered during its use were attributable to too high a sodium content. It is perhaps more likely that the hypernatremia in these cases expressed the biochemical lesion of prolonged, unremitting diarrhea with dehydration uncontrolled or uncontrollable by oral fluids. One awaits with interest the report of proposed Mexican observations of serum sodium in children referred for medical care after unsuccessful oral therapy with solutions prepared from *sobrecitos* (packets) and administered as recommended (18).

A word of caution is in order about the use of Ringer's or lactated Ringer's solutions, which are recommended in some parts of Latin America and are dispensed either as the solution itself or as powders in *papelillos* (envelopes), obtainable without prescription and designed for solution in a liter of water.

Ringer's solution contains 147 mEq/L of sodium and has an osmotic concentration of 309 mOsm/L. Lactated Ringer's solution contains 130 mEq/L of sodium and has an osmotic concentration of 272 mOsm/L. The potassium content of each solution is negligible at 4 mEq/L. Neither is suitable for the replacement of diarrhea losses, and their recommendation and use should be abandoned.

In prescribing a concentrate the doctor is of course aware that the mother may confuse *teaspoon* with *tablespoon* or may dissolve the product in an inadequate amount of water and thus provide a solution more concentrated than is intended. If, as is usually recommended, the solution is boiled after dissolving the salts, there may be still further concentration.

The effectiveness of programs to prevent diarrheal dehydration through early administration of fluids by mouth is probably considerable, but objective evaluation is difficult. An effective program depends upon the existence of a health organization which at the same time carries out other activities in sanitation, nutrition, medical care, and health education which might also affect diarrheal disease deaths. For this reason the Mexican experience, to be described later, is of particular interest.

Oral fluid therapy is recommended unequivocally as the regimen of choice in early mild cases of diarrhea. It is indeed practiced widely and promptly through all facets of the health service in some countries in the Hemisphere, notably Venezuela, but it is not relied upon everywhere to the extent that its promise dictates.

Fluid Therapy of Dehydration

Once dehydration has made its appearance, fluid therapy becomes more complex in that deficits must be repaired—quite a different problem from simply giving fluids and electrolytes to replace those being lost from the body by normal and abnormal routes.

The goals of rehydration are threefold and indissoluble: prevention or treatment of shock, restoration of effective renal function, and replenishment of deficient water and electrolytes. These are assured through restoration and maintenance of an adequate circulating blood volume.

Rehydration progresses in two phases: a rapid phase of repair of deficits of sodium chloride and water, and a more gradual phase of restoration of deficient potassium, adjustment of residual deficits and osmotic and acid-base disturbances, and return to normal alimentation. The requisite fluids for these two phases are different, as are their rates of administration.

Routes of administration of fluids are subcutaneous, oral, intragastric, and intravenous.

Subcutaneous fluids have been used successfully in South Africa, but with poor success in Poland (1). There is no knowledge of their routine use in Latin America in the treatment of dehydration. Considerable experience and facility have been acquired in the use of other, physiologically more desirable routes, described in the following paragraphs.

Fluids have been given *orally* to as many as half or even more of the children coming to rehydration centers. Success is usually assured if the child is not vomiting. Vomiting is frequently readily controlled through the administration of teaspoonful amounts of the hydrating solution at intervals of five or more minutes. For unrelenting vomiting, drugs have been used with success, including tranquilizing agents in small dosage.

Oral fluid therapy was successful in 90 per cent of 508 moderately and severely dehydrated young children treated by De la Torre and Larracilla Alegre (7). The success of this experience was attributed in large measure to careful home supervision and follow-up and constant avail-

ability of a physician for consultation. Hospital beds were saved, but there appears to have been no net saving in the time expenditure of medical and paramedical personnel. Intravenous therapy is probably more practical in cases of such severity

The administration of fluids by *gastroclysis* appears today to be enjoying less extensive use, owing in large part to the increasing skill of doctors and nurses in intravenous techniques. In two states in Venezuela, dehydrated children are being treated exclusively with gastroclysis, in order that comparison may be made with the intravenous therapy used elsewhere in that country. Although results are not yet available, a value judgment seems already to have been made, in that a particularly ill child, instead of being treated by gastroclysis in a rural hydration center, is likely to be referred to a hospital rehydration center for intravenous therapy (18).

Many persons, including some who frequently make use of this route of administration, have difficulty in achieving a steady rate of flow through the nasogastric tube, for the rate tends to change abruptly with change in position of the child. This difficulty is overcome in one of two ways, each of which is set up as a routine measure in certain centers: quieting of the child with a tranquilizing drug, or immobilization of the child with restraining sheets.

In cases of severe dehydration, *intravenous* therapy and hospital care are mandatory.

Treatment of Severe Dehydration in Hospitals

While mortality due to diarrhea is falling in many areas because of the prevention of severe dehydration through better nutrition, health education, and early recognition and fluid therapy of afflicted children, the mortality rate of dehydrated children admitted to hospitals and rehydration centers remains high. The details of intravenous therapy of diarrheal dehydration and the definition of the principles and techniques of successful therapy are dealt with more extensively elsewhere.[6] Here, brief consideration will be given to the thesis that not only the technical details of fluid therapy but also the quality of continuing personal responsibility for the care of patients may be reflected in mortality statistics.

The need for a close doctor-patient relationship is as integral a feature of good patient care during short periods of acute illness in the hospital or emergency treatment center as it is in the long-term health care and supervision of the child. At the moment, however, treatment of the acutely ill person in many hospitals and health centers is fragmented by the frequent passage of responsibility for patient care through a succession of physicians who serve for but a few hours each. In some hospitals no physician is in attendance during large segments of the day, particularly at night, when nursing coverage too may be scanty. Some existing residency programs make no provision for nighttime medical supervision except on an emergency basis, so that care for the critically ill patient again may pass through a succession of doctors who have no continuing awareness of the patient's changing needs. These shortcomings come sharply into focus in considering the care of dehydrated, undernourished children, half of whom at the present time die during their first day or two in the hospital.

In hospitals, the road to improved patient supervision lies chiefly in the extension and improvement of internship and residency training programs, conducted wherever possible under the supervision of a well-trained senior staff with full time responsibility for patient care and residency training.

These considerations also apply to rehydration centers operated only during day-time hours. The interruption of close

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[6] See article on p. 65.

medical supervision and the suspension of supervised fluid therapy of dehydrated children at the end of the day, making necessary their transfer home for further care while they are still critically ill, cannot help but result in fatalities that might have been prevented if a qualified attendant had been present. In view of the serious limitations on number of doctors and registered nurses, it may be necessary to develop auxiliary personnel specifically trained to staff such centers during nighttime hours.

THE ORGANIZATION OF SERVICES

The key to the success of health care programs in reducing the mortality from diarrheal disease in recent years has lain most importantly in measures to reduce dehydration from diarrhea through early case-finding and appropriate, early, oral fluid therapy. Backing this crucial phase of the program are the emergency hydration centers in hospital outpatient departments or health units. The degree of success of these units in carrying out more vigorous rehydration measures depends to a considerable extent on the referral of those patients in whom earlier simple attempts to prevent dehydration, while not successful, have nonetheless minimized fluid loss.

An indication of the way these features operate within an organized health program is given in the country examples which follow. These examples have been selected only because the authors are familiar with them and because they represent efforts deliberately planned at a national level and executed locally over large areas of the country. They in no way reflect upon many excellent programs of more limited local coverage or upon countries with whose efforts the authors are not familiar.

Venezuela

Venezuela offers an example of an integrated program at the national level, carried out by the Division of Maternal and Child Health of the Ministry of Health and Social Welfare. During the Division's 27 years of growth, health centers and rural medical centers have been established throughout the Republic. Since 1941 particular emphasis has been focused on diarrheal disease, and since the end of 1958 rehydration centers have been created in rapidly increasing numbers of health centers, as part of a national campaign against gastroenteritis. The plan for control of diarrhea is the same throughout the country. All physicians assigned to any unit of the health care services dealing with children attend refresher-orientation courses, which include practical experience in applying rehydration techniques. These techniques are published as written norms of service. The efforts of nurses and auxiliaries, supported by educational materials also furnished as part of the program, are aimed at early case-finding and early administration of an electrolyte solution prepared from pills which are distributed throughout the country.

In practice, children may be treated on an ambulatory basis or they may be detained at the center for intravenous therapy if the physician believes that home treatment may prove inadequate. Therapy in the center may last from a few hours to a few days if necessary. The health centers, which also give care to mothers and children and to ill persons of all ages, are open 24 hours a day for emergency care such as rehydration of a child with diarrhea. When an infant is detained at the center for intravenous fluid therapy, the mother stays with him, not only to act as attendant but to learn more about the prevention and management of diarrhea. The integrated unit provides a structure for continuity of care and follow-up of any associated nutritional disease.

In Caracas rehydration centers have been established, both in the central hospitals and in sectors of the city. The effectiveness of this program in reducing deaths due to diarrheal disease is shown in the

progressive fall in mortality rates since 1939 and the acceleration of the decline in more recent years as the specific attack against dehydration has intensified (Table 4). The fall in Caracas is all the more remarkable in view of the huge influx of country dwellers into congested slum areas and the change in diarrhea etiology, to which attention is called elsewhere in this report.

TABLE 4—*Gastroenteritis* Mortality Rates per 100,000 Population, in Venezuela and in Caracas, 1939–1962.*

Time period	Venezuela		Caracas	
	Rate	% decline in time period	Rate	% decline in time period
1939–1943 . .	296.1	—	195.2	—
1944–1948 . .	220.6	25.6	180.7	7.4
1949–1953 . .	165.0	25.2	99.8	44.8
1954–1958 . .	162.4	1.5	78.4	21.4
1959–1961 . .	108.6	33.1	44.1	43.7
(1962)**	75.2	30.7	34.3	22.2

* Excludes diarrhea of the newborn.
** Provisional figures.

The reduction in mortality from diarrhea in Venezuela has been accompanied by a remarkable reduction in case fatality in children admitted to rehydration centers. In 1959, with only 20 centers in operation, the case fatality was 7.3 per cent. In 1962, with 107 centers, it was 3.2 per cent. The reduction in case fatality is ascribed to the opportunity afforded for carrying out hydration measures on children before dehydration became severe. In the same three-year period, there are said to have been no appreciable changes in socioeconomic status, diarrhea morbidity, numbers of children reporting for treatment, or plan of hydration therapy (19).

Chile

Chile is an example of a country in which an organized national program to prevent diarrheal disease deaths has functioned within the structure of a comprehensive health care service. Of particular interest is the operation of services within the city and suburbs of Santiago. This zone is divided into five major areas, each covering 500,000 or more persons. Responsible for the health of children and central to each area is a children's hospital or children's division in a general hospital, staffed with personnel who supervise and deliver the health care in outlying *consultorios* (clinics). After regular hours, emergency medical care is available in a centrally located *posta* (post), from which major problems may be referred to the hospital if necessary. Although the organization of the Santiago area services varies somewhat, the staff organization in some areas is such that a health team headed by a physician is responsible for its own individual group of patients in the *consultorio* and its members can establish a close relationship with the patients they serve. Exchange of information between hospitals and *consultorios* is prompt, and physicians have opportunities to work also in the hospital. Follow-up of hospital discharge is carried out through the appropriate *consultorio*.

Possibly, the fall in over-all diarrheal mortality in Chile from 5,774 in 1955 to 4,661 in 1961 in children under five years of age, despite a rising population and a rising or stationary infant mortality rate during that period, reflects the effectiveness of this program. In the southern area of Santiago, the age-specific mortality due to diarrhea in children under two years of age fell from 1,010 per 100,000 in the summer of 1960 to 490 in the summer of 1963. The experience of the Arriarán Hospital provides other evidence of the effectiveness of the program in reducing death in diarrheal disease. In 1955, when 1,849 children with diarrheal dehydration had to be turned away from the hospital for lack of beds, an outpatient center was established. By 1960,

however, the population for which this hospital was chiefly responsible was supplying relatively few cases, and the decision was made to move the hydration center into a *consultorio* serving the suburban area from which most of the cases were coming. The cases of dehydration requiring treatment since then have been so relatively few that it has not been found desirable to operate the *consultorio* in this way, and the few cases needing hydration have been admitted to the hospital. It is the universal impression that diarrhea morbidity has changed but little during this time, while the reduction of severe illness and the fall in mortality have been striking (18).

Mexico

The Mexican campaign against the diarrheas is of special interest because it represents a direct approach to the community; it mobilizes the people themselves to help solve their own problems and combines educational and early treatment efforts. It is significant that the most successful efforts to date have been in areas without ready access to health care services.

The technique of organization is simple enough. After a prior consultation with the Coordinator of Medical Services, with local physicians and nurses, and with community leaders in the central village of each municipality that is to be organized, an open meeting is held with citizens of the community. The hazards of diarrheal disease are discussed and a plan for prevention of dehydration is presented, based on early recognition of diarrhea by the parents themselves and administration of a sugar-electrolyte mixture dispensed in a *sobrecito*.

Community members are designated as responsible for segments of the town or village population. After further indoctrination, these *jefes de manzana* (block leaders) carry on educational work in their sector on a family-to-family basis, focusing on the importance of prompt treatment, especially in young children. They themselves are the source of such treatment and distribute the *sobrecitos* when diarrheal disease occurs in a family, instructing the parents in their proper usage and following the case carefully to ensure that, if response is not satisfactory, distant medical assistance will be sought. Major efforts are timed to coincide with the peak of the diarrheal disease season, which is rather sharply limited to four or five months.

The cooperation of rural communities in this campaign has been impressive. Preliminary data (which need further refinement) suggest that, in contrast to other communities, a reduction of diarrheal disease deaths on the order of 50 per cent has occurred in those communities which have organized programs. There are indications that severe diarrheal dehydration is being reduced, although no effect on diarrhea morbidity has been observed.

Apart from the need for validating and expanding this approach to the problem, the Mexican experience raises a number of questions for further exploration and study. How important is the electrolyte-sugar "packet" itself (regardless of its contents) as a tangible force which impels the *jefe de manzana* to his educational zeal and motivates the mother to increase the fluid intake of her child? Can this approach to communities be carried out by less highly trained professionals with the same dedication and effect? How much of the success depends upon community forces and drives peculiar to the areas of Mexico in which the campaign has functioned? It would be a mistake to think that identical techniques can be applied successfully elsewhere. A receptive community, responsive to its leadership, approached through the right channels by dedicated professionals sensitive to the nuances of the group, must be important ingredients of success. These ingredients will differ from country to country and from community to community.

IMPLICATIONS FOR PLANNING

The Integration of Services

As the result of the categorical development of organized health care services in Latin America and the predominant role of the healing tradition in medicine, preventive and educational methods and services, particularly as they relate to mothers and children, have tended to be divorced from or viewed separately from treatment methods and services. Fragmentation of care between hospital and health center services may continue even when health centers deliver medical care.

While these conditions of parallelism, fragmentation, and separateness are in fact slowly disappearing, their elimination can be speeded. The reduction of diarrheal disease deaths requires that action of many types be planned at different operating levels. Education of the community must be accompanied by attention to the effectiveness and availability of treatment services, or its results will be nullified. The structure of health care services must provide for the continuing flow of information and patients to and from the central hospital and the health center, or peripheral source. Where integration is not possible, coordination of effort based upon mutual understanding and agreement can be achieved. The planning process can be used to develop health care services as a comprehensive whole.

The Quality of Services

There is need to plan programs which will establish and maintain the quality of professional services, with time and support devoted to the initial and continuing pediatric training of the personnel who will be dealing directly with diarrheal disease in children. Continuing technical supervision of both medical and nursing personnel, based on successful pediatric experience and providing for continuing consultation, is an additional means of maintaining quality. Medical centers in which well-trained pediatricians function exist in virtually all the countries of Latin America. The potential contributions of pediatrics to the national health care services are, however, not always fully utilized. This potential does not necessarily lie in the production of more pediatricians. It lies rather in the structuring of organized services in such a way as to permit pediatric influence to be more widely felt.

The need to provide for continuous individualized patient care and the importance of the personal relationship between the doctor-medical team and the patient and his family has been pointed out. It is recognized that shortages of professional personnel hinder the attainment of the ideal. Much can be done, however, to strengthen systems of hospital residencies. This is important not only to the training of physicians but also as an integral feature of patient care in hospitals. Where residency programs cannot be strengthened the special training and assignment of paramedical personnel to work under medical supervision can be considered. In urban health centers the assignment of a medical team to be responsible for health care of a group of families, rather than to see patients indiscriminately in clinics, can also be built into the planning.

Planning which takes account of the quality of the medical care delivered to children is not an end in itself. It is a means of reducing childhood mortality and therefore must be incorporated into public health programs.

The Selection of Priorities and the Relationships to Other Programs of Child Health Care

The investment of scarce resources to develop any one aspect of child health care must be weighed against their investment

in other aspects of such care, their investment in other health programs, and their investment in other sectors of national development. A program of health care which provides for the early and adequate treatment of diarrheal disease in young children can significantly reduce mortality in early childhood. It should, therefore, receive significant consideration in the planning process.

Such consideration should take into account the fact that the personnel in many Latin American child health care programs are deployed in routines of frequent clinic visits and home visiting for "health supervision," which could be reduced substantially so as to release personnel for the specific activities of parent education more immediately related to diarrheal disease and the malnutrition so frequently associated with it. One of the most important of these activities is follow-up and after-care, especially of the malnourished child. The successful treatment of diarrheal dehydration unaccompanied by educational efforts and follow-up of the underlying malnutrition may be but the prelude to recurrence and death.

Provision of convalescent resources for the severely malnourished child (who has been saved from death by dehydration) in the form of day-care centers and convalescent wards and institutions is an important, though generally neglected, aspect of both nutrition and diarrheal disease programs. Isolated instances of successfully operated facilities and coordinated services of this nature can be found in Latin America, but their potential for releasing the more expensive hospital beds for other uses and for reducing hospital readmission rates has not yet been tapped on a significant scale.

This approach to child health care services does not disregard preventive measures but attempts to underscore their particular applicability to those persons most vulnerable to risk during a period when they are likely to be most receptive to counsel.

In considering the most economical and efficient means of implementing these concepts, attention should also be given to the often excessive use of expensive drugs, the over-complicated nature of some hospital rehydration routines, and the successful use of nursing staff in intravenous therapy.

The Need for Studies

Throughout this paper, and in a subsequent article,[7] allusion has been made to a number of subjects which deserve careful study. These are not subjects of academic interest only. The studies needed are those which will simplify and perfect the techniques that can most efficiently be applied by the health care services to save more lives. They represent combinations of the epidemiological and clinical approaches to diarrheal disease in children.

In a number of centers in Latin America competent investigators are exploring some of these areas of study. However, a common satisfactory language to define such terms as shock, dehydration, and malnutrition is needed; hospital mortality rates are not being reported and analyzed comparably by times of death and age of patient. Other subjects for research such as the relationship between the rate of infusion of intravenous fluids and treatment results, and the effects of different oral electrolyte fluids, are not being investigated at all, even though current practices differ widely (2).

Thus there is need for a regional research planning conference which will define terms or suggest studies to arrive at satisfactory definitions. Such a conference could also spell out by common agreement the diarrheal disease study areas most significant to future health care service planning.

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[7] See p. 65.

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INTRAVENOUS FLUID THERAPY OF DIARRHEAL DEHYDRATION, WITH SPECIAL REFERENCE TO LATIN AMERICA

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INTRODUCTION

In a recent review of diarrheal disease in Latin America (1)[3] it was emphasized that deaths from that cause are heavily concentrated in the first two years of life and that they are due to dehydration or its serious consequence, shock. It was shown that significant reduction of mortality has been achieved by health care services through measures designed to prevent, recognize, and treat dehydration.

The present communication is limited to a consideration of the intravenous fluid therapy of diarrheal dehydration as carried out in hospitals and rehydration centers in Latin America. A separate and more extensive consideration of this complex subject is undertaken in the hope that renewed discussion may result in new emphasis on fluid administration, which may, in turn, lead to a lowered mortality of dehydrated children. At the moment most Latin American hospitals report mortality rates of well over 10 per cent, and one center records a mortality of more than 40 per cent. As in the previous communication, observations and comments are selective. They are intended to be thought-provoking and do not present a detailed picture of the existing situation.

In Latin America intravenous fluid therapy is widely practiced. It is carried out by a variety of routes, with rare resort to cut-down and even rarer use of bone marrow infusion for brief periods in emergencies. By and large, puncture of superficial veins is a skill developed to a high degree in medical centers among certain nurses and even auxiliaries—indeed more than among pediatricians. In certain parts of Brazil extensive use is made of subclavicular vein puncture as described by Aubaniac (2,3). This technique is carried out with ease by physicians with requisite skill, and complications such as hemothorax or pneumothorax are so rare as to be virtually inconsequential in trained hands. It is possible that the full extent of complications is not known, however, since autopsies are not usually carried out on children who die.

In order to provide a perspective for the ensuing discussion of the details of therapy, brief consideration will be given first to the pathogenesis of diarrheal dehydration, the physiology of recovery, and the historical background of fluid therapy.

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PATHOLOGICAL PHYSIOLOGY OF DIARRHEAL DEHYDRATION

As diarrheal dehydration progresses, successive biochemical abnormalities make their appearance. Diarrheal stools consist of ileal fluid which fails to be reabsorbed and is altered in its electrolyte structure as it passes more or less rapidly through the colon. Physiologically, and therefore therapeutically, important constituents of these stools are water, sodium, potassium, and chloride. The typical diarrheal stool is alkaline and hypotonic. The kidney attempts to conserve body water and maintain normal acid-base balance by excreting concentrated acid urine. Progressive depletion of body water leads, however, to reduced renal blood flow, renal function becomes impaired, and metabolic acidosis makes its appearance. The body responds to the hydrogen ion excess by reducing carbonic acid through increased alveolar ventilation. The kidney continues its attempt to maintain normal osmotic relationships, but eventually the need to conserve body water takes precedence and output of urine becomes negligible. Severe dehydration is consequently associated with elevated osmolarity of body fluids. The theoretical biochemical end-point of severe diarrheal disease is thus: (1) loss of body fluids (dehydration); (2) relative loss of water in excess of electrolytes (hyperosmolarity, hypernatremia); (3) reduced circulating blood volume (hypovolemia, anhydremia, hemoconcentration); (4) metabolic acidosis (lowered pH and bicarbonate); and (5) reduced blood carbonic acid (lowered blood P co_2).

The clinical features of dehydration are well known. Attempted respiratory compensation for the metabolic acidosis is recognized in hyperventilation. As dehydration proggresses the patient may become stuporous, comatose, and "toxic." Shock, with pallor, cyanosis, and weak, thready pulse, is a serious feature of severe dehydration and when fully developed may be irreversible.

The theoretical picture may be altered by sweating, vomiting, and therapy with water and electrolytes. Most cases do not progress to the point of severe hyperosmolarity. Absence of overbreathing in the child with severe dehydration due to diarrhea is an ominous sign since it bespeaks a breakdown in an important defense mechanism of the body and warns that vascular collapse or shock is present or impending.

The presence of severe malnutrition in children 1 to 4 years of age is associated with extracellular hypotonicity and expansion of the intracellular fluid phase (4,5). Dehydration due to diarrhea in these children is characteristically present with hypo-osmolarity.

NATURAL HISTORY OF THE BIOCHEMICAL RECOVERY FROM SEVERE DIARRHEAL DEHYDRATION

Recovery commences as soon as intravenous fluids are started and progresses in three successively longer stages, to each of which an arbitrary but distinct biochemical end-point may be recognized.

1. *Restoration of Adequate Circulatory and Renal Function*

This restoration is attested by the output of liberal amounts of dilute urine. Depending on the rate of administration of fluids, the duration of this stage is roughly from 6 to 24 hours. Diarrhea characteristically lessens or ceases in the first few hours. Body water expands rapidly and persistent extracellular overhydration can be demonstrated; this may be apparent clinically in edema of the eyelids. Good renal function is almost always present, as shown by high concentration of the first voided urine; diminished glomerular filtration persists but ordinarily poses no particular problem. Changes in serum osmolality are variable; usually a return toward normal takes place. A rise in blood pH to approximately 7.20 may be anticipated, though serum CO_2 may be

changed but little if compensatory hyperventilation becomes more effective.

2. *Restoration of Normal Acid-Base and Osmotic Relationships*

Depending on the magnitude of the original disturbances, this phase comes to an end 3 to 5 days after initiation of therapy for dehydration. Treatment during this and the subsequent phase includes administration of potassium to repair the cellular deficit. Blood pH becomes normal in 1 to 4 days, while serum CO_2 almost invariably lags behind by another 24 to 48 hours owing to enhanced reactivity of the respiratory center to P co_2, with consequent continued overventilation. Serum sodium returns promptly to normal in hyponatremia and in most cases of mild to modest hypernatremia, while several days may elapse in severe hypernatremia. Blood urea nitrogen falls to a starvation normal of 4 to 6 milligrams per 100 ml. Glomerular filtration recovers and rises to supranormal levels.

3. *Readjustments Associated with Cellular Repair*

These are characterized by a host of reparative processes lasting some weeks. The biochemical end-point is perhaps the attainment of a stable potassium balance. Only the first part of this stage has received fragmentary study. Sodium that entered cells during the dehydration process returns to the extracellular space. Overexpansion of the extracellular space, presumably a manifestation of cellular injury, is present for at least two weeks; during this period supranormal glomerular filtration continues. Replenishment of cellular potassium progresses at a rate of 1 to 2 mEq/kg/day. Serum chloride remains high, 108 to 112 mEq/L, for at least 10 days to two weeks—that is, as long as observations have been made. Organic anions are low during this phase, presumably because of their retention in cells as the potassium deficit is replenished. Temporary intolerance of cow's milk, a phenomenon of infrequent occurrence, appears to be due to temporary suppression of intestinal lactase activity.

HISTORICAL ASPECTS OF FLUID THERAPY FOR DIARRHEAL DEHYDRATION

In a current review of diarrheal disease, Oropeza and Sahagún Torres (6) describe four "stages" of medical thinking: the organicist stage (introduction of the diagnostic terms "gastroenteritis," "colitis," etc.); the nutritional stage (concern over quantitative and qualitative features of the diet); the microbiological stage (still dominating much of our thinking, as shown by the widespread and indiscriminate use of antibacterial drugs); and the biochemical stage. In each stage there is a great tendency to focus on one aspect of the total disorder rather than on the treatment of the afflicted child.

The "biochemical stage" may be said to have begun before 1920 at the Johns Hopkins Hospital, when it was discovered that diarrheal dehydration is associated with depression of blood bicarbonate, which could be brought back to normal through parenteral administration of sodium bicarbonate. The irrelevance of this observation to proper therapeutic management was well expressed by Powers (7): "You probably know what to do for acidosis, but do you know what to do for the babies? They used to live seven hours but they last only four now."

Approximately 20 years later concern over the low CO_2 still tended to dominate therapeutic considerations in diarrheal dehydration, as illustrated by a report of 51 per cent mortality in children who, thanks to therapy with sodium lactate, were "completely relieved of acidosis" before death (8).

In current practice alkali treatment of children believed to be "acidotic" is recommended in many, if not most, centers.

The large amounts of sodium used in the correction of low serum bicarbonate were

probably primarily responsible for the development of the syndrome described two decades ago as "post-acidotic hypocalcemia," a biochemical abnormality now thought rather to be a more or less constant concomitant of hypernatremia. While hypernatremia represents the theoretical endpoint of severe and usually prolonged dehydration, its appearance may be hastened and its extent aggravated by inappropriate therapy with excessive amounts of sodium. Hypernatremia indicates considerable suppression of renal function, which is in general perhaps better measured by the level of blood urea.[4]

The recognition of loss of body potassium has led to an important contribution to the therapy of dehydration in the last 20 years, for this ion can be provided once adequate urinary output has become re-established. There is a tendency in some clinics to confuse serum potassium with the total body potassium, most of which resides in the cells. Serum potassium levels, at best a crude reflection of total potassium, are not useful in therapeutic planning. It is enough to know that body potassium is depleted in diarrheal dehydration and should be restored as part of the therapeutic program.

In recent years the recognition of individual differences in osmolality in diarrheal dehydration has led to recommendations of a variety of therapeutic regimens whose practical superiority in the management of the particular osmotic disturbances for which they are designed has not been demonstrated, and which direct the therapist's attention from the dehydrated child, which he can see and evaluate, to interesting biochemical concomitants, which usually he cannot. As in the energetic therapy of acidosis, such regimens threaten to ignore the patient's basic problem, dehydration, through focusing on one isolated parameter. The treatment of acidosis with sodium bicarbonate or its equivalent is, of course, incompatible with the simultaneous treatment of hypernatremia by withholding sodium.

Current Mexican descriptions of renal tubular necrosis in a variety of conditions have led to the use of peritoneal dialysis in selected cases of infantile diarrhea (9). Up to this moment it has not been possible, early in the therapy of diarrheal dehydration, to distinguish between this serious anatomical complication and functional suppression of glomerular filtration; the latter responds rapidly to the rapid intravenous administration of fluids.

THEORY AND PRACTICE OF INTRAVENOUS FLUID THERAPY

There is virtually uniform agreement among therapists that the initial infusion of the dehydrated child should be rapid and that the fluids should contain potassium once adequate urinary output has been established. There are, however, various interpretations of "rapid." Nor is there agreement as to the appropriate composition and concentration of the initial hydrating fluid. Even the desirability of using different solutions for the repair and the maintenance phases of treatment is not uniformly accepted.

While all systems of fluid therapy are based on the replenishment of losses which are known for the *average* dehydrated patient, in the treatment of the *individual* patient it is important to define the termination of the initial phase of rapid repair, that of the replenishment of most of the sodium chloride and water deficit, in terms of his own requirements, which may of course be more or less than the assumed average. This approach implies: (1) consideration of the initial phase of repair as something quite separate from the subsequent period of maintenance therapy and gradual repair of the potassium deficit; and (2) the desirability of a readily recognizable physiological

[4] The rise in blood urea in dehydration also reflects the catabolism of amino acids emerging at an accelerated rate from tissue cells.

end-point by which to recognize the completion of the initial phase of rapid repair.

The first principle is not adequately satisfied by the majority of currently employed regimens, which lump together fluid needs for repair and subsequent maintenance into a single 24-hour package, arbitrarily defined as a total volume of fluid in the range of 130 to 200 ml per kilogram of body weight per day. While amounts of fluid up to 4 per cent of the body weight are occasionally recommended in the initial period, in general smaller amounts are given. The initial period of "rapid infusion" may actually last several hours. Its duration is likely to vary considerably according to the size of the child. In the regimens employed by many Latin American clinics the small child profits from the initial infusion more than the large child, since these regimens are most frequently expressed in terms of a certain number of drops per minute, regardless of the size of the child; the small child therefore receives more fluid per unit of body weight in the same unit of time.

The best index of completion of the early phase of rehydration—with the exception of the uncommon patient with renal tubular necrosis—is the passage of dilute urine. This implies not only the collection and measurement of all urine voided by the patient, but determination of its specific gravity or osmolality. In general, insufficient attention is paid to these simple and time-honored measures, because of inadequacy of nursing coverage, lack of familiarity with simple techniques of urine collection, and inability to determine specific gravity on small quantities of urine. Specific gravity is, however, easily measured on single drops of urine, using either a series of tubes of known specific gravity made up by combining non-volatile liquids heavier and lighter than water in proper proportions (10), or directly and simply with the more expensive refractometer. The demonstration of an initially high specific gravity with progressive fall as fluids are administered is, together with increasing urine volume, important evidence that renal failure is not present.[5]

In Latin America the choice of the initial infusion fluid is guided by the therapist's appraisal of the patient, usually in terms reflecting current assumptions as to differences in osmolarity of body fluids in dehydrated subjects. Dehydration in a well-nourished or but mildly undernourished child is characterized as "hypertonic," while that in an undernourished child is said to be "hypotonic." The implied relationship is, however, usually not borne out by laboratory observations (Table 1), which show that dehydration is usually "isotonic." Indeed, it is widely overlooked that the Mexican description of hypotonicity in malnutrition (4,5) did not apply to infants. The assumed osmotic disturbance, as well as the extent of "acidosis" (inferred from the degree of clinical illness and the extent of hyperventilation), lead to a choice of solutions ranging in electrolyte content from about 100 to even more than 300 milliosmoles per

TABLE 1—*Incidence of Types of Dehydration, According to Nutritional Status, in Children with Diarrhea at the University Hospital in Caracas, Venezuela* (11).

Type of dehydration*	All cases	Normal nutrition	Mal-nutrition
"Hypotonic"	17	9	8
"Isotonic"	101	65	36
"Hypertonic"	41	29	12
Total	159	103	56

* Isotonic: Serum Na 131–149 mEq/L.

[5] Specific gravity, as opposed to osmolality, may be misleading if glucose is present. In urine of usual composition, an osmolality of 300 mOsm/L corresponds to a specific gravity of approximately 1.010. A glucose solution of the same osmolality has a specific gravity of 1.029. It is therefore desirable, particularly if solutions containing 5 per cent glucose are used initially in rehydration, to be prepared to determine by simple means whether high urinary specific gravity can be accounted for by the presence of glucose.

liter, frequently including sodium lactate; in addition, 1/6 molar sodium lactate may be given. The solution characteristically contains glucose in 5 per cent concentration, and if initial infusion is in fact rapid it is likely that glucose will appear in the urine; a test for glucosuria is ordinarily not made.

In contrast to this doctrinal separation of cases for purposes of therapy, several investigators have reached the conclusion that the electrolyte composition of the initial hydrating fluid bears little relevance to therapeutic success, as long as it is hypotonic (12). Solutions with isotonic and nearly isotonic electrolyte concentrations are said to be less effective than hypotonic solutions in initial hydration. Among the adverse effects of the more concentrated solutions are cited the production of edema and sclerema—the latter perhaps an inevitable feature of recovery from severe dehydration in certain cases.

Except in the case of *documented* severe hyponatremia, there would appear to be little indication for administration of a solution more concentrated than 150 mOsm/L. Indeed, the effectiveness of even more dilute solutions appears to have been borne out in Venezuela, where, although solutions of sodium chloride in 0.45 per cent (154 mOsm/L) and 0.3 per cent (103 mOsm/L) concentrations are recommended for assumed "hypotonic" and "hypertonic" dehydration, respectively (11), in practice the more dilute solution has been successfully used in most parts of the country, to the virtual exclusion of the more concentrated solution.

The concentration of glucose in the initial infusion fluid need be no greater than that required to bring the total osmolar concentration to approximately 300 mOsm/L. Since this solution is designed to be infused rapidly, the lower the concentration of glucose, the less is the likelihood of glucosuria. A useful commercially available solution is 0.45 per cent sodium chloride in 2.5 per cent glucose, isotonic in its total osmolar concentration, one-half isotonic in its electrolyte content.

While a theoretical case can be made for the use of small amounts of alkaline solutions in the treatment of diarrheal acidosis, such therapy threatens to direct attention from the more urgent therapy of dehydration and, as employed in many clinics in the form of one-sixth molar sodium lactate, provides large quantities of sodium without adequate "free water." Further potential disadvantages of the administration of excessive amounts of sodium have been referred to earlier. Occasionally, alkali *replacement* of continuing stool losses is necessary in young infants. This is to be distinguished from *repair* of the acidosis, which can be carried out by the kidneys with solutions of sodium chloride, even when blood pH is 6.90 or lower, once satisfactory renal blood flow has been re-established. Recent experience at the Children's Hospital of Mexico is said to show that normalization of serum electrolytes occurs as rapidly with one-half isotonic solution of sodium chloride as with solutions of similar osmolarity containing some lactate or bicarbonate (12).

Once satisfactory output of urine is achieved, the rate of infusion is slowed and the infusion fluid should contain potassium and a higher concentration of glucose. A solution for maintenance and concomitant repair of the potassium deficit should have approximately equal amounts of sodium and potassium and be about one-third isotonic in electrolyte content, although solutions up to 150 mOsm/L are tolerated. The solution should contain glucose in 10 per cent concentration. Such a solution, infused in an infant at a rate of 100-120 ml/kg/day, provides approximately 3 mEq/kg each of sodium and potassium and half or more of the infant's caloric expenditure. A 10 per cent solution of glucose, rather than the 5 per cent solutions in general use, is of particular importance for the partial maintenance of nutrition in the undernourished children who are the typical victims of

diarrheal disease. The hypertonic solution is well tolerated by small veins.

The common practice of adding a potassium concentrate to a mixture of sodium chloride and glucose solutions has two disadvantages. Error is always possible in calculation of the added potassium, and its addition may bring the electrolyte concentration of the infusion solution to an undesirably high level.

In most situations two different solutions are thus advisable in the therapy of the dehydrated child: one for the initial rapid hydrating period, and the other for the following phase of maintenance and repair of the potassium deficit.

The more complex solutions of Talbot (Table 2) and Mönckeberg (13) have been suggested as single solutions useful both for initial rehydration and in the subsequent stage of maintenance and repair of the potassium deficit. While the high potassium content of Talbot's solution is theoretically undesirable in the early stages of rehydration, from an empirical standpoint this solution has been used with success. Mönckeberg's solution can be criticized in that it is quite concentrated, is alkaline, and contains relatively little potassium in relation to sodium.

TABLE 2—*Multi-Electrolyte Solutions for Maintenance and Concomitant Repair of Potassium Deficit.**

Solutions	Electrolytes per liter				
	Cations (mEq)		Anions (mEq)		Total
	Na	K	Cl	Lactate	(mOsm)
25-20 solution† (Modified Butler's)	25	20	22	23	95
26-27 solution (Ordway's)	26	27	53		106
40-35 solution§ (Talbot's)	40	35	40	20	143

* The solutions in Table 2 are commercially available. Unfortunately, these are prepared with 3.5 or 5 per cent, and not 10 per cent, glucose. The addition of 70 ml of 50 per cent glucose to the 550 ml of 5 per cent glucose in a "500 ml" flask of commercially prepared solution yields 620 ml of 10 per cent glucose. The 11 per cent reduction in electrolyte concentration brought about in this way is of no therapeutic moment.

† Contains also 3 mEq/L each of magnesium and phosphate.

§ Contains also 15 mEq/L of phosphate.

CAUSE OF DEATH IN HOSPITALIZED CHILDREN WITH DIARRHEAL DEHYDRATION

Reflection on the continued high mortality of children admitted to hospitals with diarrheal disease—for the most part, well over 10 per cent—gives rise to the hope that current methods of treatment might be so altered as to reduce the mortality figures significantly. It is not at the moment clear what most hospital deaths are due to, a frequent expedient being to ascribe deaths to the complex of infection, malnutrition, and dehydration. If these parameters could be separately identified through objective measurements, it would be possible to recognize more precisely the cause of death in children who die from diarrheal disease. Careful studies of severally ill children with diarrheal dehydration in a few selected centers could shed much light on this question. The discussion to follow focuses first on certain requisites preliminary to undertaking such studies, and then on two of the many important questions to which answers might be sought.

The *first requisite* is a common terminology for the three parameters cited.

1. Assessment of *infection* ordinarily presents no problem, but it requires careful appraisal of the child, a high quality of patient care and, in children who die, adequate post-mortem examination, as was pointed out in another communication (1).

2. Currently, *malnutrition* is assessed by expressing the admission weight of the child as a percentage deviation from the weight of an average normal, hydrated, well-

nourished child of the same age. The use of body weight for age comparisons was originally proposed by Gomez and his collaborators in Mexico (14). The criteria suggested by Gomez for subdividing malnutrition into first, second, and third degrees of severity according to percentage deviation from the norm are, however, not uniformly followed throughout Latin America.

While body weight is, to be sure, an objective measurement, the admission weight of a dehydrated child expresses his acute dehydration as well as his chronic malnutrition. The reference standard (average weight for age), on the other hand, implies average normal growth as well as average normal nutrition and thus ignores genetically determined growth factors and environmental influences. The single comparison expressed as a percentage deviation from the standard makes it impossible to separate these various influences and thus seriously limits the usefulness of this index when applied to the individual child.

For the purposes of the precise studies to test hypotheses such as those described later, it is suggested that crown-heel length and average weight for length be used as reference standards. The patient's crown-heel length, determined with simple, rigid equipment as the patient lies supine on a flat surface, might be expressed both in absolute units and as percentage deviation from average length for age. This would express maturity and genetic influences as well as chronic malnutrition. A more restricted index of malnutrition would next be obtained by comparing the patient's weight immediately before dehydration set in or after recovery from dehydration (see following paragraph) with average weight for length. In cases of kwashiorkor, patient weight in the absence of both edema and dehydration, while necessary, might not be possible to obtain.

3. Objective criteria for measurement of degree of *dehydration* are particularly urgently needed. All appraisals of the moment are based on clinical impression; none enjoy widespread acceptance or use.

The most accurate appraisal, and the one incidentally yielding the highest figure for percentage loss, is derived from the difference between weight on admission and that immediately before the onset of dehydration. In the child who has had health supervision, the pre-dehydration weight can be assessed accurately through extrapolation of the recorded previous weights on a growth chart, or better still, if the child recovers, through interpolation of a line joining past and future observations. The more expedient method would be to compare the weight on admission with that at an arbitrary later period. For the surviving child this might be at 5-7 days, when most children would have re-established a normal feeding pattern. For the child who dies, the subsequent weight would be at the time of death. Weight regained, as measured in this way, is considerably lower than that measured from the extrapolated or interpolated pre-dehydration weight but is probably comparable with the same type of measurement in other patients. In either method the weight loss should be expressed as a percentage of the pre-dehydration or recovery weight, not of the admission weight.

The *second requisite* is a common terminology for the reporting of hospital mortality. Currently, one-third to two-thirds of hospital deaths from diarrheal disease occur within the first 48 hours after admission. However, many hospitals exclude such deaths from their mortality figures, as being "non-institutional."

Few data are available to permit further breakdown of deaths in the initial 48 hours into the actual time of demise. In a recent report Meneghello *et al.* (15) exclude from their mortality figures all cases dying in the first three hours; of the 25 later deaths, 12 occurred before 24 hours. In the rehydration center at Maracay, Venezuela, in the month of June 1963, of 6 deaths occurring before

48 hours, four were within 24 hours (12). In Brazil, of 418 children admitted to the Salles Netto Rehydration Center in Rio de Janeiro during the six-month period January-June 1963, 60 per cent of whom were admitted for treatment of dehydration (the others for malnutrition or infection), there were 48 deaths occurring at the following intervals after admission: less than one hour, 3; 1-3 hours, 8; 3-6 hours, 11; 6-12 hours, 7; 12-24 hours, 7; 24-48 hours, 9; 2 days and over, 3 (12).

It is obvious that treatment regimens cannot be compared without including all deaths regardless of how soon after admission they occur, and that uniformity in the reporting of time intervals is to be desired. This is particularly important when so high a proportion of hospital deaths occur so soon after admission.

The desirability of arriving at such common definitions through the medium of research planning meetings has been suggested elsewhere (1).[6] After agreement on terminology, studies could be planned that might lead to a better understanding of the pathological physiology of diarrheal dehydration and to more effective hospital therapeutic regimens. In such studies the following two hypotheses could be tested, among others:

1. It is likely that the majority of malnourished children admitted to rehydration centers and hospitals for treatment of dehydration do not have severe dehydration per se, although they are without any question quite ill. The malnourished child soon shows poor skin turgor and other signs of dehydration, and these signs may persist for some time after clinical recovery is attested by the child's general behavior and the passage of satisfactory amounts of dilute urine. The well-nourished child, on the other hand, may have extensive dehydration without the usual clinical signs. Indeed, the comment is recurrently made in treatment centers that shock seems to be more frequent in well-nourished children. The well-nourished child, although he has a reserve of good health not available to the malnourished, has in relation to his body weight a more limited water reserve, since a large fraction of his weight is made up of fat.

The likelihood that most malnourished children treated for diarrhea do not have severe dehydration is inferred from a variety of observations, though from very limited published data: the prompt recovery from dehydration following infusion of relatively small amounts of fluids at relatively slow rates; the appearance within a few hours after admission of a satisfactory urine output of low specific gravity; values for blood pH above (usually well above) 7.10, indicating metabolic acidosis of no more than moderate severity, good respiratory compensation, or generally both; in occasional cases for which data are available, little or no weight gain following recovery from dehydration.

The deaths of many malnourished children appear likely, therefore, to be due to causes other than loss of water in stools or vomitus. The cause of death may be related to an accompanying infectious process or some metabolic abnormalities as yet not understood.

2. Some hospitalized children may indeed be dying of dehydration or the effects of dehydration; if so, the possibility of altered, perhaps more vigorous, early therapy suggests itself as a means of reducing early mortality.

Deaths from dehydration would be expected to occur in the first few hours after admission, the very period which, as noted above, is often excluded from reported hospital series. Indeed, Meneghello *et al.* (15) ascribe the deaths of 12 infants dying between 3 and 24 hours (see above) to dehydration and inadequate rehydration. The likelihood that deaths reported by others may also de due to dehydration or shock is

[6] See p. 51.

inferred on the basis of several considerations: many physicians working in rehydration centers note a concentration of deaths in the first 12 hours; deaths are more common in infants with "toxicosis"; infants who die in this early period ordinarily do not void.

The younger the infant, the more susceptible he may be to shock, and one reflects whether the uniformly high case-fatality among young infants may not be in part due to shock resulting from dehydration. The recent recognition in Mexico City of acute renal tubular necrosis, determined by kidney biopsy or at post-mortem in large numbers of infants with diarrheal dehydration, suggests that prolonged restriction of renal blood flow may have been operative (9). It is significant that most of the Mexican infants were under 4 months of age.

The treatment or prevention of shock is, in its simplest form, the rapid expansion and maintenance of adequate circulating blood volume. Disagreement over what exactly is meant by "rapid" has been noted. If, however, children indeed are dying of shock it would be worth while to know whether more rapid initial infusion than that currently practiced might reduce mortality. This observation would not be difficult to make on a controlled basis in many centers where large numbers of children are admitted for rehydration.

Maintenance of circulating blood volume implies not only continuing adequacy of fluid administration, but very likely in some cases administration of whole blood, plasma, or perhaps other colloids. Blood and plasma are infrequently used in the treatment of the dehydrated child in Latin America, although they are administered in some instances for anemia or hypoproteinemia. In general, when blood is used in the treatment of shock, it is administered several hours after admission of the patient and only when clinical signs of shock have become quite evident. It may be that by this time the shock is irreversible.

The importance of early administration of blood was first emphasized by Powers in 1926 (16), undoubtedly at a time when the understanding of fluid therapy was considerably less sophisticated than it is now:

> "After the administration of fluids, patients with intestinal intoxication often show astonishing improvement within a period of less than two hours. This improvement is often temporary and misleading. It seldom persists in severe cases, even when adequate fluid intake is maintained. It is for this reason that the administration of fluid should be reinforced by a blood transfusion in practically all cases, regardless of an apparent initial improvement . . .
>
> "It is impossible to state with exactness in just what manner transfusion helps these patients; both quantitative and qualitative changes in the blood are quickly brought about so that improvement in function of the circulatory renal and respiratory system—and thus of the cells throughout the organism—is made possible. . . Unmistakable indications for a transfusion may come too late for that treatment to be any longer effective. Having knowledge of these facts, therefore, we have felt that it is better to err in subjecting the patient to unnecessary transfusion rather than to withhold a treatment which subsequent development may show might have been a life-saving measure. We believe that our general good results in the treatment of this malady are due to the fact that we have found out that we cannot discriminate correctly, and foretell which patients are safe without transfusion."

For practical reasons, blood or plasma may not be available in many centers, or the requisite time for cross-matching may cause so much delay that the assumed benefit of early administration may be lost. For these reasons the use of other colloids such as dextran solution might well be explored on an experimental basis.

SUMMARY

1. The choice of a solution for intravenous rehydration is in many clinics based on clinical estimates of the patient's osmotic disturbance and the severity of acidosis. Even when biochemical measurements are possible, however—and these correlate

poorly with the clinical assumptions—the relevance of this knowledge to appropriate therapy is not known. Recommended solutions vary widely, from alkaline multi-electrolyte mixtures with a concentration of 300 mOsm/L ("isotonic") or even higher, to one-third or one-half isotonic solutions of sodium chloride. The simpler, less concentrated solutions are theoretically preferable in that they provide more "free water." They are being used with good results in both "hypertonic" and "hypotonic" dehydration by an increasing number of clinics.

2. Since most children with diarrhea are malnourished and many have associated infections, several factors may contribute to therapeutic success or failure. If the relative contribution of each of these factors could be more precisely defined, beneficial changes in therapeutic emphasis might ensue. First, however, objective, individualized estimates of dehydration and malnutrition are needed. Dehydration should be measured in terms of weight lost or regained rather than by clinical appraisal. The estimate of malnutrition should if possible be based on comparison of the patient's weight with his own potential, rather than with the average weight of a healthy child of the same age. Average weight for length, rather than weight for age, is suggested as a more appropriate reference standard.

3. The mortality of hospitalized children with diarrheal disease is high, usually well over 10 per cent. Inasmuch as a large, frequently the major, fraction of deaths occur in the first few hours or first two days following admission, accurate reporting of the time of death after initiation of therapy is desirable. This information is at the present time infrequently provided and, indeed, deaths in the first 48 hours are often systematically excluded from hospital statistics as "non-institutional."

4. Standards of reference, techniques of measurement, and conventions of relating observed to standard weight and of recording time of death should be agreed on by all workers and uniformly reported, in order that results of therapy in different clinics may have more nearly comparable bases of comparison.

5. Uniformity of observation and reporting could shed light on the following two hypotheses, among others: (a) dehydration is in general less severe in poorly nourished than in well nourished children; (b) most early deaths in diarrheal disease are due to dehydration or shock.

6. If dehydration and shock prove to be important factors in death occurring soon after admission, careful scrutiny of the first, rehydration phase of fluid therapy will be in order. At the moment, the emphasis in this phase of fluid therapy is largely qualitative. It is quite possible that attention to quantitative factors—i.e., speed of infusion and volume infused in the first few hours—may be more important. Whole blood, plasma, or other colloids should perhaps receive more extensive use in the prophylaxis and treatment of shock.

APPENDIX

A Plan of Intravenous Fluid Therapy for Diarrheal Dehydration

The following rehydration routine (17) is presented as a frame of reference for such terms as "rapid" and "hypotonic," as used in this communication. The regimen is *simple:* it uses one solution for *repair* without regard to osmotic or acid-base disturbance, and a second solution for *maintenance* following rehydration. It is *practical:* it relies on the volume and specific gravity of urine as the physiological determinant of adequacy both of repair and maintenance therapy. It differs from most regimens in current use in Latin America in the speed of repair therapy, the

calculation of flow rates for repair therapy in terms of body weight, the occasional early use of blood transfusion in selected cases, and the clear differentiation between the initial stage of repair and the subsequent period of maintenance. The severity of malnutrition in children in the southern part of the United States successfully treated by this regimen, has been on the average less than that encountered in many Latin American centers.

Convulsions have been infrequently encountered in severely dehydrated children in the first 12 to 24 hours of therapy. These have not been limited to markedly hypernatremic children and have not been controllable by the intravenous administration of calcium or hypertonic sodium chloride. It is believed that the convulsions represent the expression of central nervous injury, already present on admission as attested by elevation of cerebrospinal fluid protein, and becoming manifest during recovery of function brought about by the expansion of blood volume and body fluids. Whether less rapid administration of fluids and consequent prolongation of dehydration would avert the rare occurrence of convulsions is not known. The further course of these occasional children has been uneventful.

Of great practical use in the fluid therapy of small infants are commercially available infusion droppers that deliver 60 drops per milliliter. The number of drops per minute through such indicators is the same as the number of milliliters per hour.

I. *Rapid Repair*

1. Infuse, within 30 to 60 minutes, an amount of 0.45 per cent NaCl in 2.5 per cent glucose equal to 5 per cent of the body weight.

2. In certain young, small, severely dehydrated, critically ill infants transfuse, within the next 30 to 60 minutes, 20 ml/kg of whole blood.

   The decision to transfuse is based on clinical judgment at the time of admission. Once planned, transfusion is not withheld because of clinical improvement in the first minutes of therapy.

3. Following step 1 or 2, continue to infuse 0.45 per cent NaCl in 2.5 per cent glucose at a rate of 10 ml/kg/hr until patient voids more than once and urine milliosmolality is 300 or less. The desired concentration of the urine corresponds in general to a specific gravity of 1.010 or less. If the urine contains glucose, however, specific gravity remains high and adequacy of voiding must be inferred from its frequency.

II. *Maintenance and Gradual Repair of Potassium Deficit*

1. Infuse a maintenance solution (Table 2) containing 10 per cent glucose in a daily volume calculated as follows:

Age	Body Weight kg	Daily Fluid volume (ml/kg)
0-1 day		0*
2-3 days		60
4-5 days		80
6-7 days		100
One week and older	0-15	100-120
	15-25	80-100
	25-40	60-80
	40-60	40-60
Adult	Over 60	2500-3000 ml per person

2. Check output and concentration of urine no less frequently than every 4-6 hours. In patients 2 days of age and older, adjust the rate of infusion—and consequently the 24-hour volume—as necessary to assure frequent passage of urine with a specific gravity of 1.010 or less.

* 20-40 ml/kg of 5 or 10% glucose in water are permissible in the first two days of life.

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