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1611 N. Kent Street, Room 1002
Arlington, Virginia 22209 USA

Telephone: (703) 243-8200
Telex No. WUI 64552
Cable Address WASHAID

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

WATER SUPPLY AND SANITATION IN THE HEALTH SECTOR IN THE ASIA REGION: INFORMATION NEEDS AND PROGRAM PRIORITIES

WASH TECHNICAL REPORT NO. 36

FEBRUARY 1986

Prepared for
the Near East and Asia Bureau,
U.S. Agency for International Development
WASH Activity No. 141

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John Briscoe, Ph.D.

February 1986

Water and Sanitation for Health Project
Contract No. 5942-C-00-4085-00, Project No. 936-5942
is sponsored by the Office of Health, Bureau for Science and Technology
U.S. Agency for International Development
Washington, DC 20523

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EXECUTIVE SUMMARY

This is an issues paper, the objective of which is to identify and discuss concepts which are central in defining the appropriate role for water supply and sanitation services within the context of the health sector. The core of the paper is the development of a framework for identifying the portions of the overall costs of water supply and sanitation services that are (i) serving nonhealth needs which are recognized by the consumers (and are correctly borne by the consumers themselves), and (ii) serving unrecognized and often external health needs (and are correctly supported from public funds). The framework is used to assess two major issues; namely, what are the information needs if rational policies are to be devised, and what appear to be the conditions under which investment of health-sector resources in water supply and sanitation projects may be appropriate. The conclusions are summarized below.

Information Needed

Better information is needed on:

- Methods for determining rapidly, and at modest cost, the effect on health of different levels of water supply and sanitation service in specific settings
- Improved information on the recurrent costs of water supply and sanitation systems
- Methods for determining the willingness to pay for different levels of water supply and sanitation service in specific settings
- Methods for translating willingness to pay into actual contributions toward the cost of the service.

Program Generalizations

Through application of the framework, some general conclusions emerge which are of immediate relevance in defining the role of water and sanitation projects in the health sector in the Asia Region.

Urban Water Supply

Costs

The per capita capital costs of water supply systems increase sharply as the level of service is increased. Much better information is needed on recurrent costs. Applied investigations of engineering and management techniques for reducing the costs of water supply systems are also needed.

Willingness to pay

In many cities the poor, who use far less water and use water of much poorer quality than the rich, pay more per month for this water than do the rich. Willingness to pay for basic services is high, even among the poor. Willingness to pay for high-level services (multiple taps in the house) is high among the middle and upper classes. Little reliable information on demand

is available, but it is likely, once a basic level of service is obtained, that the price elasticity of demand for the urban poor is relatively high.

Health impact

The evidence of the relationship of level of service to health impact is mixed. Site-specific information is needed.

Overall role

Because consumers are usually willing to pay the full costs of service, the corresponding health impact can be provided at no financial cost to the health sector. For health and equity reasons, high priority should be given to improving the service provided to poor urban dwellers who are not served by the public systems. Documentation of the institutional, economic, and engineering features of nonpiped distribution systems is needed so that constraints to improvement in the quality of service and reduction in the cost of water can be identified. Of high priority, too, is the identification of means for reducing the high levels of unaccounted-for water.

Urban Sanitation and Sewerage

Costs

Costs increase sharply as the level of service increases. Information on recurrent costs is inadequate.

Willingness to pay

Information is poor. It appears, however, that willingness to pay for basic services in urban areas is substantial, even for low-income groups.

Health impact

Information on the effect of level of service on health is inconsistent, and site-specific data are needed. It appears, however, that the major health impact is gained when basic sanitation facilities are used and that the marginal impact of higher levels of service is small.

Overall role

Because even low-income urban dwellers are probably willing to pay for some of the costs of basic sanitation services, and since the health impact of introducing such services is substantial, investments in basic sanitation for urban dwellers are probably cost-effective health investments. Support is needed for the development of institutions for periodically removing and disposing of sludge from on-site sanitation facilities in urban areas. There appears to be little justification in expending public resources on higher levels of sanitation. Where sophisticated sanitation services are provided, consumers should be made to bear the (high) full costs of the services.

Rural Water Supply

Costs

Because water supply systems are characterized by large economies of scale, and because rural systems are small and the population densities low, the per capita costs of rural systems are often higher than the per capita costs of urban systems that provide comparable levels of service. Applied investigations are needed to identify least-cost solutions in a variety of rural settings and to identify design procedures which can reduce the cost of these supplies.

Willingness to pay

Progress in rural water supplies depends critically on incorporating the concept of willingness to pay into the design and operation of such systems. Little information is available, however, on willingness to pay for water in rural areas. It is likely that willingness to pay is higher than has previously been assumed, especially among middle- and higher-income groups, and where the service provided represents a marked improvement (in terms of convenience, reliability, and perceived quality) over the existing service. In arid areas, an "improved service" could be simply a more convenient and reliable supply; in wet areas, an "improved service" would often imply piping of water to the yard or house. Systematic investigations of willingness to pay for water in rural areas should be given high priority.

Health impact

As with urban water supplies, the effect of different levels of service on health is largely a matter of conjecture. Site-specific studies are needed.

Overall role

Where willingness to pay is high (that is, where income is relatively high, the opportunity cost of women's time is relatively high, and the level of service represents a marked improvement over the existing service), rural water supplies often represent cost-effective health interventions.

Rural Sanitation

Costs

The costs of rural sanitation facilities are typically substantially lower than the costs of similar services in urban areas.

Willingness to pay

Information on willingness to pay for rural sanitation facilities is virtually nonexistent. It appears that willingness to pay may be heavily dependent on culture and level of development. In many instances (for example, Bangladesh), except for the wealthiest villagers, willingness to pay is low, and often, even if the services are provided free of charge, the facilities will not be used. In other countries (for example, Thailand), willingness to pay may be substantially higher. Empirical data are needed.

Health impact

In general, the health impact of using basic rather than no sanitation facilities is probably lower in rural than in urban areas. As in urban areas, additional health impact from the use of higher levels of service is unlikely.

Overall role

Where willingness to pay is high, rural programs for the provision of basic services will often be cost-effective investments of health-sector resources. Where willingness to pay is low, these programs become less cost-effective, particularly because adequate maintenance of the facilities is unlikely. The provision of higher levels of service is unlikely to be a cost-effective intervention in either urban or rural areas and, therefore, such programs should not be subsidized from public funds.

Chapter 1

BACKGROUND

In 1978 at Alma Ata, the governments of the world made a commitment to reaching the goal of "Health for All by the Year 2000" by implementing a comprehensive set of Primary Health Care programs. In a related development in 1980 in New York, the decade of the 1980s was declared the "United Nations' International Drinking Water Supply and Sanitation Decade," and ambitious targets were set for providing adequate water supply and sanitation facilities for all by the year 1990.

Implicit in the resolutions of Alma Ata and New York were two assumptions. First, it was assumed that improvements in water supply and sanitation conditions were an indispensable element in an overall strategy of health improvement. And, second, it was assumed that, primarily through large increases in development assistance, increased resources would become available to the health sector in general and to the water and sanitation sector in particular.

When governments and international agencies came to draw up specific plans for implementation of these resolutions, however, a series of problems arose. It was immediately apparent that there were serious resource availability problems arising both from the political commitment of developing country governments to maintaining expensive, subsidized services for the middle class in urban areas, and from domestic and external sources. In view of these resource limitations, it was apparent that neither could all components of Primary Health Care be implemented simultaneously nor could adequate water supply and sanitation facilities be constructed in all urban and rural areas. In other words, it was obvious that difficult resource allocation decisions would have to be made. And, finally, it was evident that the closely related issue of financing of services was a key to developing sustainable health and water supply and sanitation programs.

These concerns are fundamental to the development of USAID policies in general and policies in the Asia Region in particular. At the Asia Bureau Health, Population, and Nutrition Conference in 1982, it was concluded that AID resources available through the health account should be used primarily to support health interventions which were deemed cost-effective in terms of reducing young child mortality. General AID health-sector policy dictates that water supply and sanitation facilities should be part of PHC programs "only when financial resources and support systems are available (USAID, 1982);" the Asia Bureau tentatively concluded that such conditions may exist only in the better-off countries of the Region, such as Thailand and the Philippines (Asia Bureau, 1983).

Not entirely satisfied that this analysis captures the complexity of water supply and sanitation issues within the context of the health sector in the Region, the Asia Bureau (now part of the Asia and Near East Bureau) commissioned this "issues paper" to assist Bureau and Mission staff in identifying the appropriate role of water supply and sanitation activities in view of limited development assistance funds for health.

It should be reiterated that this is an issues paper, not a policy paper. The purpose is to develop a framework which helps identify the salient underlying issues in water and sanitation programs as part of the health sector, to sum up what is known and unknown at present about each of these issues, and to suggest what might be worth trying to find out through future studies.

Chapter 2

CONCEPTUAL FRAMEWORK

The objective of USAID activities in the health sector is to assist countries to develop sustainable programs for reducing severe morbidity and mortality, especially among young children. AID is able to influence the attainment of this objective in two ways: particular health-sector programs can be funded by USAID and recipient government policy in the health and related sectors can be influenced. The objective of this analysis is to suggest under what conditions water supply and sanitation programs might be included in the AID health-sector portfolio and which recipient country policies in the water supply and sanitation sector might be the object of a "policy dialogue" between USAID and the recipient country.

As a first step in clarifying the principal concepts necessary for a description of the problem, it proves useful to focus attention on two related policy decisions, namely how to allocate health-sector resources among various health-related activities (include water supply and sanitation services) and how to finance such activities.

In applying the general principles of public finance (Musgrave, 1959) to the specific problem of the role of water supply and sanitation programs in the health sector, two principles are of fundamental importance. These are:

- Resource allocation: Additional resources should be allocated to any given activity as long as the extra net benefit to society exceeds the benefit foregone from the best alternative use of the same resources.

- Financing: Under certain conditions user charges, based on long-run marginal cost, promote economic efficiency.

Benefit-cost analysis has traditionally been advanced as a useful tool for guiding policy choices on these issues. Computing all of the dollar benefits of water supply and sanitation projects, however, is virtually impossible because of the multiple impacts of such projects, the difficulty in accurately predicting the results of these many impacts, and the arbitrariness of the procedures for reducing the multiple impacts to a common denominator. In practice, therefore, it is necessary to allow the users themselves to (implicitly) transform the vector of perceived outputs into a dollar value and to use the resulting "willingness to pay" for the service as a partial guide to resource allocation. Although exclusive reliance on this criterion is inappropriate primarily because individual consumers do not perceive all impacts accurately and because they take no account of "external" benefits, recognition of the concept of consumers' willingness to pay is "absolutely essential to achieving noticeable improvement in water supply and sanitation in rural areas" (Saunders and Warford, 1976). Because 80 percent of the $10 billion invested in water supply and sanitation facilities annually in the developing countries comes from the developing countries themselves (UNDP, 1984), the extent to which the costs of water supplies can be recovered from both urban and rural beneficiaries will be the primary determinant of the pace at which coverage can be increased (Shipman, 1984).

The implications of the general principles of public finance for both the health and the water supply and sanitation sectors have been carefully enunciated, particularly by the World Bank. Much of the analysis in this paper hinges on a clear understanding of the conditions under which a substantial public role (including subsidies) is or is not appropriate. Accordingly, drawing heavily on the work of de Ferranti (1983), this paper outlines the factors which need to be taken into account in determining the correct role of the public sector, and the closely related issues of the roles of subsidies and user charges, in different health-related activities.

2.1 Appropriate Roles for the Public and Private Sectors

Arguments in Favor of a Public Role

It is often argued that market mechanisms are inherently incapable of ensuring the socially optimal allocation of resources available to the health sector because:

- For certain categories of service (such as immunizations), the benefits of participation are not limited to those who participate (that is, externalities are often large).
- Difficulties in evaluating and perceiving the effects of health-related services mean that consumers of health services often cannot make rational, well-informed choices.
- The possibilities for competition among suppliers of certain types of services (such as urban water supplies) are limited.
- Certain groups (including the poor, women, and children) are often inadequately represented in the decision-making process.

Arguments Against a Strong Public Role

It is also often argued that, for at least certain health-related activities, market mechanisms are preferable to mechanisms which rely on a strong public role because:

- The alleged market failures outlined above apply only to certain health-related services, not to all.
- Goods and services are produced more efficiently by the private sector.
- Private markets may be more effective in mobilizing resources for health-related activities than mechanisms which rely chiefly on tax revenue.

The Appropriate Roles of the Public and Private Sectors in Different Health-related Activities

Still following de Ferranti's analysis closely, in the following table health-related activities are separated into three main groups, depending on the appropriate role of the public sector:

Table 1
Public- and Private-Sector Roles in Health Programs

Group	Examples of Activities	Characteristics	Implied Major Role for:	Appropriate Overall Role: Public Sector	Private Sector
A	Spraying against malarial mosquitos	Large externalities	Public sector	MAJOR	MINOR
		Uninformed consumers	Public sector		
		Often public goods	Public sector		
		Resource mobilization unlikely through user charges	Public sector		
B	Preventive maternal and child health services	Social benefits often exceed private benefits	Public sector	SOME	SOME
		Consumers' information imperfect	Public sector		
	Rural water supplies	Disadvantaged groups needs might not be met	Public sector		
	Basic excreta disposal services	Resource efficiency might be improved through competition	Private sector		
C	Curative medical services	Externalities small	Private sector	MINOR	MAJOR
		Consumers well informed	Private sector		
	Urban water supply	Production sometimes a natural monopoly	Public sector		
	Sophisticated excreta disposal services	Potential for resource mobilization high	Private sector		

2.2 Appropriate Roles for User Charges and Subsidies

Water supply and sanitation services can be financed either through user charges or through subsidies from public funds. The arguments which determine the balance between subsidies and user charges are closely related to the foregoing arguments which determine the balance between public- and private-sector roles, but supplemented by additional points from pricing theory (de Ferranti, 1983). Accordingly, the activities in Group A (such as spraying of malarial mosquitos) are those for which subsidies from public funds are appropriate and user charges inappropriate, the activities in Group B (such as rural water supplies and basic sanitation services) are those for which a mixture of public subsidies and user charges are appropriate, while those in Group C (such as urban water supplies and higher levels of sanitation service) are those for which substantial cost recovery through user charges is desirable.

2.3 A Simple Resource Allocation Approach

A fundamental difficulty in comparing investments in, for example, water supply facilities with investments in a tetanus vaccination program is that water supply facilities have multiple impacts (economic, social, and health), while a vaccination program directly affects only health outcomes. If such programs are compared by comparing total costs with health impacts, by, for instance, comparing the "cost per infant death averted" (Walsh and Warren, 1979), then it is not surprising that the programs which have a unique impact appear superior to those which have multiple impacts (Briscoe, 1984a).

One approach to resolving this incomparability problem is to attempt to partition out the costs of the water supply program, and then to use that part of the total cost which is assigned to the health impacts as the numerator in the cost-effectiveness calculations. In general, this problem of joint cost allocation is a difficult one; in the particular case of water supply and sanitation programs, with a reasonable set of assumptions such partitioning can be done, thus making comparisons of water supply and sanitation projects with other health projects possible.

First, regarding water use practices, a detailed assessment of water use practices in Bangladesh (Briscoe, et al., 1981) has shown that the choice of sources of water for domestic purposes is affected primarily by distance to the source and the social consequences of use of a particular source. In this setting, perceived water quality, which did not correspond to bacteriological quality, affected only the choice of a source of drinking water. A similar situation has been shown to pertain in rural Africa (White, et al., 1972) and in Latin America, where it has been concluded that "the reduced incidence of disease ... and the avoidance of death ... apparently would not be reflected in the willingness to pay since in both cases these are fortuitous events on the future horizon and therefore difficult to perceive as directly useful to the consumers" (Inter-American Development Bank, 1985). Similarly, it has been shown in many settings that the reasons for using latrines in rural areas are primarily those of privacy, convenience, and status, with perceived health benefits seldom being of importance, even after intensive health education efforts (Dutt, 1972; Krishna, 1968; Kochar, 1976; Laver, 1985). It may therefore be assumed that:

- Amenity benefits (including time savings in the case of water supply and privacy, convenience, and status in the case of excreta disposal) are perceived accurately.

- Health benefits do not affect household decisions, both because these benefits are not perceived by the household and because the benefits are partially external to the household (that is, they accrue to others who may not use the service).

- The value placed on the vector of perceived benefits can be measured by willingness to pay.

Where it is possible to estimate the costs of the willingness to pay for and the health impact of different levels of water supply and sanitation service, Table 2 below can be constructed:

Table 2

Assessing the Cost per Unit of the Health Impact of Water Supply and Sanitation Investments

Service Level (I)	Cost (Capital + O&M)	Willingness to Pay	Cost to Government	Health Impact	Marginal Impact ---------- Marginal Cost
1(High)	C_1	W_1	$G_1=C_1-W_1$	I_1	$(I_1-I_2)/(G_1-G_2)$
2(Intermediate)	C_2	W_2	$G_2=C_2-W_2$	I_2	$(I_2-I_3)/(G_2-G_3)$
3(Low)	C_3	W_3	$G_3=C_3-W_3$	I_3	$(I_3-I_4)/G_3$
4(No Improvement)	0	0	0	I_4	--

Table 2 indicates that where consumers are willing to bear a substantial portion of the costs of services, only a small part of the total cost becomes attributable to health, and the activity becomes relatively more cost-effective than would otherwise be the case. While the same logic applies to other health projects, in most situations consumers are only willing to pay for curative services (which have a limited impact on health). Thus, while full costs can be recovered from the consumers of urban water supplies, only about 15 percent of the costs of publicly provided health services in developing countries have typically been recovered through user charges (de Ferranti, 1983).

From Table 2 it is apparent that, in determining the appropriate level of service in a particular community, there are two different "solutions." First, there is the "market solution": without any public intervention, the level of

service provided will be that for which the population is willing to pay (that is, the highest level of service for which $W_R \geq C_R$). This "solution" may be level 4, that is, no improvement, in many cases. Second, there is the "socially optimal" solution: if the marginal impact/marginal cost ratio for any level of service (say level "n") is higher than the marginal impact/marginal cost ratio for all alternative programs in the health sector, then G_R units of public resources should be invested (along with W_R units of private resources) to ensure that the socially optimal level of service ("n") is provided.

The remainder of this paper will:

- Assess the implications of the approach for the overall policy issues of resource mobilization, resource allocation, and financing.

- Assess the implications of the model for specific policy issues which have been identified as key by USAID (such as the correct roles for the public and private sectors, the development of strong institutions, support for existing local organizations, and mechanisms for addressing recurrent costs).

- Summarize the state of existing knowledge of each of the information needs of the model and suggest priorities in strengthening this information base.

- Draw some tentative conclusions on the implications of the model for the role of water and sanitation programs in the overall health sector strategy in the Asia Region.

Chapter 3

INFORMATION NEEDS

In attempting to use the approach to investigate the appropriate role for water supply and sanitation activities in the USAID health sector portfolio in the Asia Region, the following specific questions need to be answered:

Question 1: What resources are available for allocation to water supply, sanitation, and other health-related activities?

Question 2: What are the costs of different levels of water supply and sanitation service?

Question 3: How can these costs be reduced?

Question 4: What is the willingness to pay for different levels of service in different natural and economic settings?

Question 5: What financing mechanisms can be used to recover the costs of water supply and sanitation services?

Question 6: How can institutions, particularly existing local organizations, in the water supply and sanitation sector be strengthened?

Question 7: What is the health impact of different levels of water supply and sanitation service and hygiene education programs in different settings?

Question 1: What resources are available for allocation to water supply, sanitation, and other health-related activities?

To governments of developing countries, the most important constraint in improving the level of water supply and sanitation (and other basic health services) is often perceived to be the paucity of public resources available for construction and maintenance of facilities. In specifying the level of resource availability, however, it is generally assumed that the "available resources" are those which are available after allocations have been made to "existing commitments." What are these "existing commitments?"

It is generally assumed that subsidies in this sector are justified in order to maintain basic services to those who cannot afford to pay the full cost of such services. In fact, in many developing country settings subsidies are used to underwrite the costs of the high levels of water supply and sanitation services which are enjoyed by the politically important middle- and upper-class urban consumers. The urban poor, however, often pay the full costs for their services, or pay high unit costs because the formal services do not reach them. To quote just two of many such examples, in Lima, Peru, residents of poor areas which are not reached by the piped water supply system pay more than 20 times more than the middle class for a cubic meter of water (Adrianza and Graham, 1974), and in Surabaya, Indonesia, the rate for the unserved poor

is between 20 and 60 times the rate for those served by the piped water system (Suleiman, 1977).

Reflecting back on the early discussion of activities for which subsidies are or are not justified (summarized in Table 1), it is striking that large portions of the water, sanitation, and health budgets in developing countries are spent on precisely those activities (namely, urban water supply, waterborne sewerage, and curative medical services) for which the justification for public subsidies are the weakest. Exacerbating this inappropriate resource allocation procedure is the fact that most of these subsidies do not go to poor people but to the upper and middle classes. For the health budget, the situation is similar, with the majority of resources spent for curative services for the middle and upper classes in urban areas.

The upshot is that, when the size of the "pie" which is to be divided among competing water supply, sanitation, and health programs is being determined, consideration should not be limited to newly available resources, but the resources which have historically been allocated to particular programs (usually high-level urban services for the middle and upper classes), too, should be included (see Mosley, 1983, and Goldman, 1984).

A useful exercise for USAID in the Asia Region, then, would be to document, for each of the countries in the Region, the existing allocations of public and private resources to health and water supply and sanitation activities, to identify the income groups who benefit from the expenditures of public resources, and to discuss the findings with the governments of the countries.

Question 2: What are the costs of different levels of water supply and sanitation services?

Table 2 contains the information needed to make decisions on whether public resources should be allocated to water supply and sanitation activities. Under any particular setting, it is necessary to know the costs of different levels of water supply and sanitation service (the focus of attention in this section), the willingness of different groups in the population to pay for such services, and the health impact of different levels of service (the focus of attention in subsequent sections).

(a) Capital Costs

Substantial information on the capital costs of water supply and sanitation facilities are available. The World Bank (Burki, et al., 1977) has estimated "typical" per capita capital costs as indicated in Table 3.

In any particular setting, however, the actual capital costs might be quite different from these "typical" costs. In some settings (particularly arid areas), the costs of water supplies might be much higher; in others (such as in Bangladesh, where the groundwater table is high, where a low-cost drilling method has been perfected, and where handpumps are locally manufactured), the per capita costs are much lower. As indicated in Table 4, costs also increase sharply as the level of service is increased.

Table 3

Typical Capital Costs (in 1976 $s) of Water and Sanitation Projects

	Urban	Rural
Water supply through public standposts	$30	$25
Basic excreta disposal facilities	$20	$ 5

Table 4

Total Investment Costs (in 1983 $) Per Capita of a Rural Water Supply
(Source: World Bank Data in Chandler, 1984)

Level of Service	Cost
House connections	$150
Standpipes	40
Handpumps	25

(b) Recurrent Costs

Because the focus of development agencies has largely been on the construction of new facilities, relatively good information is available on the capital costs of water and sanitation facilities. Typically, however, recurrent costs have been considered to be the responsibility of the recipient government or institution and have been of little more than passing interest in the project preparation procedure. As in many other development sectors, "the sheer absence of data on the recurrent expenditure implications of projects...is extraordinary" (Heller, 1979). In the absence of such data, "rules of thumb" based on little (if any) empirical data are used to "estimate" the recurrent costs of projects. (A common rule, which, for lack of better information is still used by certain major development agencies, assumes annual operation and maintenance costs of water projects to be 3 percent of the total capital cost of a project).

This neglect of recurrent cost issues in the water and sanitation sector (as in other sectors) has had serious consequences. For many developing country governments, it is easier to mobilize capital through grants or loans from

donors than it is to generate the internal revenues needed for operating and maintaining facilities. The result is usually heavy overcapitalization, with the choice often being to build a new facility rather than to repair an existing malfunctioning facility. This "recurrent cost problem" has now been widely recognized by development agencies. The World Bank considers the problem to be so serious that it has been suggested (Baldwin, 1983), that, in choosing technologies, the standard procedure of discounting future (recurrent) costs should be abandoned and that a dollar incurred in operations and maintenance in the future be considered equal to a dollar spent on construction at the beginning of a project.

The recurrent cost problem has been identified as a critical development problem by USAID. It is now AID policy that "all Project Papers should analyze the recurrent cost implications of the project" (USAID, 1982c). The difficulty with implementing this policy, however, is that virtually no empirical data are available on the actual recurrent costs of water supply and sanitation services in developing countries. Accordingly, a high priority item in the water supply and sanitation sector is the collection and analysis of information on the recurrent costs of water supply and sanitation services and of the effect of design, institutional, and economic factors on these costs.

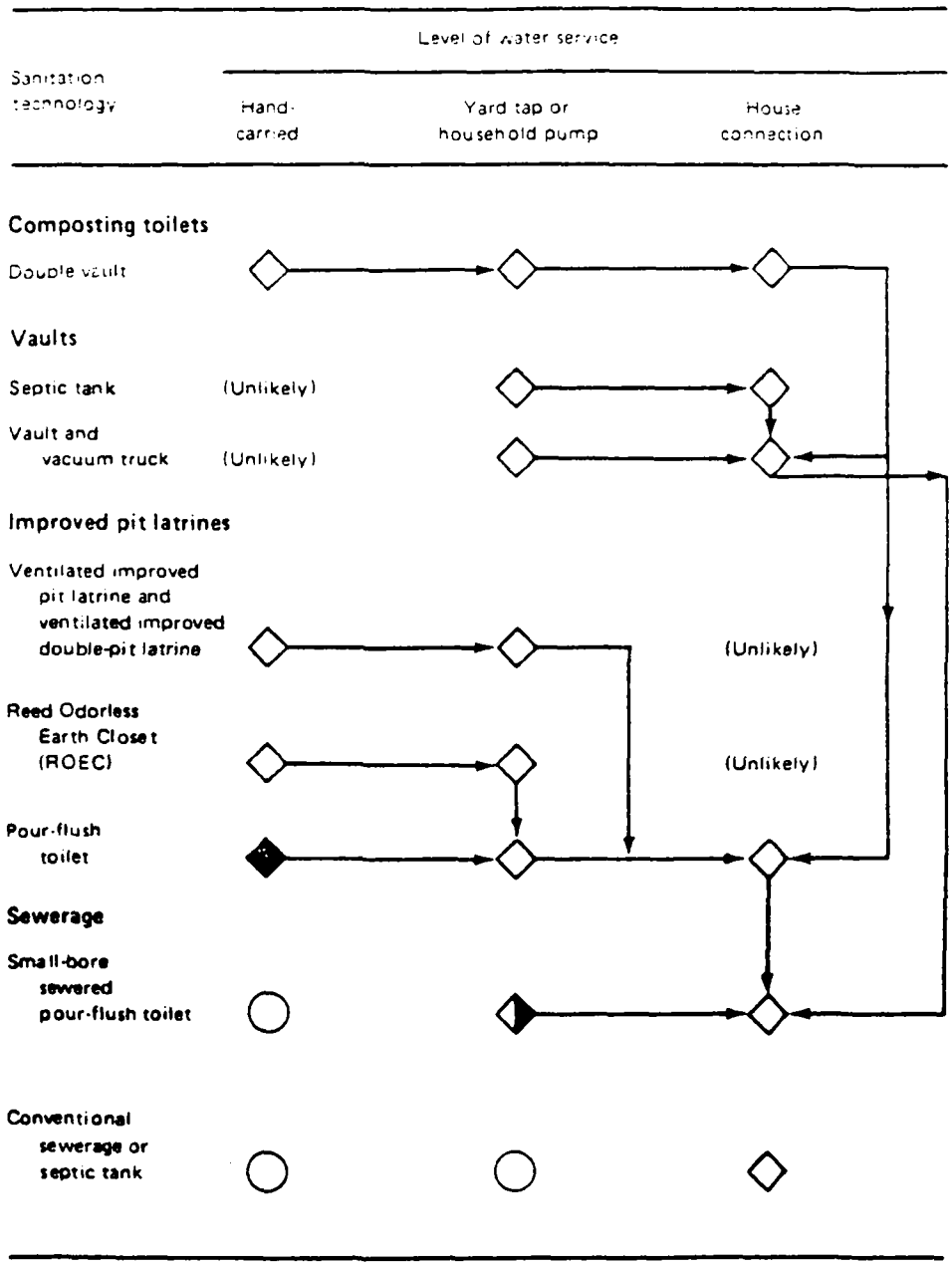
Question 3: How can these costs be reduced?

Water supply and sanitation facilities are expensive to construct and to maintain. If the populations served are to be increased, and if facilities are to be maintained through user charges, then it is essential that the capital and recurrent costs of these systems be reduced.

(a) Sewerage and Sanitation

Under the leadership of the World Bank, substantial advances have been made in the last decade in developing low-cost sanitation technologies which are appropriate for both urban and rural areas. As shown on Table 5, the average annual investment and recurrent costs per household for the low-cost systems (notably pour-flush latrines and ventilated improved pit latrines) are an order of magnitude less than similar costs for septic tank or sewerage systems (Kalbermatten et al., 1980).

For areas in which the low-cost services are acceptable, the high-priority technical problems are now the development of technologies for desludging on-site latrines in urban areas and the further reduction of the unit cost of the latrines. In many intermediate-income urban areas, however, households can afford a higher level of service without yet being able to afford full waterborne sewerage. A key element of the World Bank approach is that of "upgrading" (see Figure 1) from one service level to a higher level, as the availability of water increases and as willingness to pay increases. For the medium-cost technologies (such as low-volume flush systems) substantial applied research on the latrines, the sewers and the disposal systems is still required.



◇ , Technically feasible; ◆ , feasible if sufficient pour-flush water will be hand carried;
○ , Technically infeasible; ◑ , feasible if total wastewater flow exceeds 50 liters per capita daily.

Figure 1

Potential Sanitation Upgrading Sequences
(after Kalbermatten et al., 1980)

Table 5

Average Annual Investment and Recurrent Cost per Household for Sanitation Technologies
(after Kalbermatten et al., 1980)

System	Mean Total Annual Cost per Household (1978 $)
Low-cost	
Pour-flush toilets	20
Ventilated improved pit latrines	30
Low-cost septic tank	50
Medium-cost	
Aquaprivy	170
Japanese vacuum-truck cartage	190
High-cost	
Septic tank	370
Sewerage	400

(b) Water Supply

In water supply systems, as in sanitation systems, costs vary sharply with the level of service. Typically (as shown in Table 4), the investment required to pipe water into multiple taps in a household is substantially greater than that required to provide water through a communal standpipe or handpump.

Water distribution systems, which often comprise a major portion of the overall costs of a water supply system, are usually designed according to standards used in developed countries. In many circumstances, this practice is inappropriate and leads to inefficient (that is, more costly) designs. To cite but two of many examples:

- Because real interest rates are much higher in developing than developed countries, less excess capacity should be built into developing country than developed country systems.
- By reducing peak load factors and providing for in-house storage, the costs of distribution systems may be reduced.

In each case, what is needed is a sustained theoretical and empirical investigation of the methods for reducing system costs. In many cases, good ideas will not work out the first time they are tried. Rather, it will be necessary (as with the current work being done by USAID and others on reducing peak load factors in systems in the Philippines and Indonesia), to carefully monitor initial experiments and to make a series of modifications until an acceptable operational procedure is developed.

A particularly grave problem facing most authorities responsible for water supply in most developing countries is that of unaccounted-for water. In any particular system, there is an optimal level of leakage, at which the marginal cost of detecting and repairing leaks is equal to the marginal cost of the water which is lost through these leaks. In the United States, water supply utilities typically operate with approximately 12 percent of water not accounted for and with virtually all of this due to leakage in the system (Blum, 1977). In developing countries, it is common to find utilities operating with between 60 percent and 70 percent of water not accounted for (Bachman and Hammerer, 1984). Much of this unaccounted-for water may not be lost through leakage but may be used by consumers who are not billed for the water. While this proportion of the water should not be considered as "lost" (because it is still being used for socially productive purposes), it is evident, first, that the levels of leakage in most systems are much greater than the optimal levels, and, second, that the high levels of unaccounted-for water undermine the financial viability of the utility, thereby making it impossible to raise sufficient operating revenues let alone raise the resources necessary for expansion of services. The World Bank and other development agencies, recognizing the importance of this problem, have started to make reductions in unaccounted-for water a condition for loans in this sector.

For larger cities, the problems of reducing unaccounted-for water are complex and require long-term commitments for their solution. The experience of São Paulo in Brazil, which has reduced the level of unaccounted-for water by approximately 50 percent over a ten-year period (Yassuda et al., 1981), shows that with the necessary commitment, progress can be made. For the most part, however, it is necessary for such large systems to draw upon specialized technical assistance from consulting firms or other utilities with particular experience in this area. Given the relatively small role of USAID in large urban water supplies in the Asia Region, this is probably not an area to which USAID resources should be devoted.

Although little documentation is available for any but the large cities, it is virtually certain that the situation for medium and small urban and rural water supply systems is equally serious. As with the larger utilities, high proportions of unaccounted-for water mean high unit costs of water and little possibility for developing financially viable institutions. In these settings (in which USAID activities are more significant than in the large urban setting), virtually no assistance is available to managers for addressing the problem of unaccounted-for water. Because of the size and number of such systems, what is needed is a generic approach which indicates to a system manager what information needs to be collected and which, in view of that information and the general characteristics of the system, the most cost-effective measures for reducing unaccounted-for water might be. Development of such "guidelines" would be a contribution of major practical importance.

Question 4: What is the willingness to pay for different levels of service in different natural and economic settings?

Once the costs of different levels of services have been determined, the next piece of information required to assess the appropriate level of an activity (see Table 2) is the willingness of different groups in the population to pay

for the service. As discussed earlier, clarification of the role of water supply and sanitation services vis à vis other investments in the health sector, and progress in both the urban and rural water supply and sanitation sectors, depend critically on incorporating an understanding of the concept of willingness to pay into the planning and operation procedures.

(a) The Determinants of Willingness to Pay

(i) Water

A simple notion of the concept of willingness to pay has been used to indicate to development agencies the level of service which consumers might be willing to support. Most commonly it has been (and is) assumed that consumers will be willing to spend no more than 5 percent of total income on water supply and sanitation services (Saunders and Warford, 1976), thus setting a limit on the technologies which are considered to be "affordable" in any particular setting. As the importance of the concept of willingness to pay has become more widely appreciated, and as more data on actual behavior have been gathered, it has become evident that income is but one of several factors determining willingness to pay, and that a more sophisticated understanding of the concept is required.

As an example of the shortcomings of the notion that willingness to pay is dependent on only the income of families, consider the experience of a series of USAID rural water supply projects in Northeast Thailand (Dworkin and Pillsbury, 1980). In the first of these projects, handpumps were installed. After a few years, it was found that many families were not using the (free) supplies and that more than 50 percent of the handpumps were not working, in part because the population was unwilling to cover the costs of maintenance and operation. In a second project, piped water was distributed through public standposts. The fate of the project was little different, because the population again proved unwilling to pay for the costs of this service, but preferred to continue to use the traditional (often contaminated) surface water supplies. Finally, in a third project, USAID and the Government of Thailand decided to experiment with a higher (and more expensive) level of service. House connections were allowed, with connecting households required to pay the full costs of operation and maintenance of the systems. The fate of this project was quite different: although the rates were substantially higher than rates in Bangkok, a high proportion of the families were willing to, and did, make the necessary regular payments for the service. The project, unlike its two predecessors, was a success. The institutions necessary to run the projects developed, and, because the consumers were willing to pay for the recurrent costs of the projects, the institutions were financially viable.

Within the present context, the principal message of the Thailand project was the willingness to pay was not uniquely a function of the income of the population, but was also dependent on the perceived quality (including convenience, reliability and perceived -- but not bacteriological -- water quality) of the improved service relative to the traditional service.

It is thus evident that a more satisfactory specification of the willingness-to-pay function for a family would take account not only of the income of the family but also of the perceived quality of the improved service relative to the perceived quality of the existing service. Where, as in the case of the

handpumps and the standposts, the "new" service was, as in the case of the household connection project, perceived as being substantially superior to the existing service, then willingness to pay would be high. (A similar phenomenon exists for certain types of health care: contrary to what conventional price theory would predict, users in several countries prefer providers with higher fees over lower-cost alternatives, almost certainly because of the higher perceived quality of the more expensive services [de Ferranti, 1983]).

In other settings, of course, where the existing source is not (as in Northeast Thailand) a nearby surface source, but a distant and unreliable borehole (as in many arid areas), then a reliable handpump nearer to the home will certainly be considered to be a major improvement over the traditional source.

In a similar vein, there are other factors which might be expected to affect willingness to pay for a water supply. The opportunity cost of time of household members is evidently important (as indicated by the high use of water vendors by single people in urban areas), and thus the willingness to pay might be expected to vary according to family composition and the opportunity cost of women's time.

A simple specification of the willingness-to-pay function, then, might be that willingness to pay is a function of:

- Income
- Opportunity cost of time
- Convenience, reliability, and perceived quality of new service
- Convenience, reliability, and perceived quality of old service.

Table 6, which follows, is an attempt to indicate qualitatively the anticipated effect of some of these determinants on willingness to pay.

Table 6

Anticipated Willingness to Pay (as Proportion of Household Income) for Water Services in Different Social and Natural Settings

		Income Group	Urban		Rural	
			Wet	Arid	Wet	Arid
Level of Service	High	Rich	+++++	+++++	+++	+++++
		Poor	+++	++++	++	++++
	Medium	Rich	++++	+++++	++	++++
		Poor	+++	++++	+	+++
	Low	Rich	+++	++++	+	++++
		Poor	++	+++	0	+++

Note: "+++++" indicates very high; "+" indicates very low willingness to pay.

(ii) Sanitation

Just as people value different levels of water supply service differently under different social and natural conditions, so, too, are different levels of excreta disposal facilities valued differently in different settings. Like water supplies, excreta disposal facilities confer benefits other than health upon the user. Excreta disposal facilities are valued by users because of the privacy, convenience, and status which ownership and use of such facilities confer on the household.

As was done in the water supply case, we can assume that:

- The amenity benefits (mainly privacy, convenience, and status) are perceived accurately.
- Health benefits do not affect household decisions (because of lack of knowledge and externalities).
- The value placed on the perceived benefits can be measured by willingness to pay.

As in the case of water supply, then, it is possible to "partition" the costs of an excreta disposal program so that only a portion of the total costs (specifically that portion that the consumers are not willing to pay for) are assigned as "health-related costs."

In the case of excreta disposal, the specification of the willingness-to-pay function is similar to that specified for water supply. That is, willingness to pay is a function of:

- Income
- Cultural factors
- Convenience, privacy, and status of new service
- Convenience, privacy, and status of old service.

As before, it is possible (see Table 7) to speculate on the anticipated willingness to pay for different levels of excreta disposal facilities under different conditions.

(b) Determining Willingness to Pay in a Particular Setting

(i) Urban Areas

A large number of studies of the impact of price on demand for water have been carried out in developed countries, using data collected through billing systems (for example, Howe and Linaweaver, 1967). In general, these studies have shown that the demand for water is fairly inelastic regarding price (with a 10 percent increase in price typically accompanied by a 2 percent to 4 percent reduction in the quantity of water used in the long run).

Table 7

Anticipated Willingness to Pay (as Proportion of Household Income) for Sanitation Services in Different Social and Natural Settings

		Income Group	Urban	Rural
Level of Service	High	Rich	++++	+++
		Poor	+	+
	Medium	Rich	+++	++
		Poor	+	+
	Low	Rich	++	+
		Poor	+	0

Few adequate published studies are available of the effect of price on demand for water in developing countries. One good study (Katzman, 1977), done in Malaysia, estimated price elasticity by examining water use before and after a price increase was introduced. This method is likely to underestimate actual short-run price elasticity for two reasons. First, in developing countries demand is often suppressed because the delivery system cannot provide the quantities of water which people wish to use. Price increases often correspond to the commissioning of new works and thus often correspond to an improvement in the service and in increase in the quantity of water used. Under such circumstances, the apparent price elasticity would underestimate the actual price elasticity. Second, apparent price increases are often no more than adjustments for inflation and not actual price increases, again leading to underestimates of true price elasticity (Golladay and Katsu, 1981). These factors notwithstanding, the short-run price elasticity estimated in Malaysia was similar to the short-run price elasticities found in studies in the industrialized countries (Carver and Boland, 1980). Furthermore, as has been shown in the United States (Carver and Boland, 1980), the long-run price elasticity is substantially greater than the short-run elasticity.

In a cross-sectional study in Nairobi, Kenya, (Hubbell, 1977), the price elasticity of demand was found to be about -0.5, a value similar to that derived from a cross-sectional analysis of national-level data by Meroz (1968). These studies suggest that in the long run, water consumption in developing countries is moderately responsive to price.

In the United States, where demand for domestic water is considerably less price responsive, there is now some experience with managing demand for water by increasing prices. In Santa Fe, New Mexico, price increases alone have reduced per capita demand by more than 10 percent, while in Tucson, Arizona, price increases coupled with other conservation measures have reduced per

capita water demand by 25 percent (Zamore et al., 1981). Evidence exists that, even where short-run elasticities are relatively low, demand is substantially affected by price. In developing countries, the price elasticities will often be substantially higher than in industrialized countries, and the effect on demand of price increases correspondingly greater.

In the low-income urban areas of many developing countries, households of similar socioeconomic status pay different prices for the same type of water supply service. In Lima, Peru, for instance, many poor families are served by tanker trucks with the prices charged depending on the distance the truck has had to cover to transport the water. Under such conditions, it is possible to use cross-sectional data to estimate the demand for water and thus to determine the willingness to pay for water in low-income urban areas. Despite the advantages of such cross-sectional approaches, few published efforts of this type have been undertaken in developing countries (Golladay and Katsu, 1981).

A rich source of data on demand for water in urban areas of Central and Latin America has been developed at the Inter-American Development Bank (IDB). Since 1977, all urban water projects which have been prepared for IDB financing have had to include a cost-benefit analysis using the CIMOP (an acronym for Public Works Simulator) procedure developed by the IDB (Powers, 1978). As part of the preparation of each project, data on the price and quantity of water consumed prior to the project were collected from the project area, and data on the price and quantity of water to be consumed after the project were estimated from consumption patterns in similar areas which enjoy the improved service. Estimates of the price elasticity of demand for principal consumer classes were estimated in all cases. To date, these results remain relatively inaccessible in confidential project files. Because the countries served by the IDB include both very poor and quite advanced countries, because the IDB has put a great deal of careful effort into the theoretical and empirical issues related to estimating these demand curves, and because no comparable data base exists in any other part of the world, it would be of great value if the IDB were to pull together the results from these studies and make them available for a wider audience.

(ii) Rural Areas

In a World Bank book on rural water supplies, Saunders and Warford (1976) reviewed available studies on the willingness to pay for water in rural areas of developing countries. At the time (the mid-1970s), most of these surveys were deemed to be superficial or had attempted to have villagers answer a series of unrealistic hypothetical questions. In both cases, little about willingness to pay has been learned. Saunders and Warford have suggested that an appropriate procedure may be to "test the market" by gradually introducing new tariffs and then observing the response of the users to new prices, an approach which is usually virtually impossible because of political reasons.

Over the past decade, however, some progress has been made in this area. Most important has been the modification of the CIMOP method developed by the Inter-American Development Bank for use in rural areas. The procedure followed by the IDB in rural areas involves estimating the price (both monetary and time) paid for the quantities of water consumed prior to the installation of a yard tap, and the quantity which will be consumed at the price charged for the

new service (the latter usually being estimated from surveys in similar areas which already have an improved service). To date, approximately ten rural water supply projects in Latin America have been prepared using this method. As with the data on demand for water in urban areas, this represents a unique and rich data base on water demand in rural areas of a wide range of countries (ranging from Chile to Haiti). A document summarizing the data which have been developed in this effort and drawing conclusions to be used in other parts of the world would be invaluable.

In the Asia Region, no similarly rich or systematic data base exists. It can be argued, however, that there is some "revealed preference" type of information which has been collected, albeit not systematically, over decades of experience with rural water supply projects. Recalling that a good deal could be learned about willingness to pay for different levels of service in rural Thailand from the successful and unsuccessful AID projects, a useful first step might be to collect the information specified in Table 8 for a number of successful and unsuccessful rural water supply projects in countries in the Asia Region, and to use these data to qualitatively assess the effect of the income, opportunity cost of time, quality of prior service, and quality of new service on choice of water supply. Obviously such information would be most informative where it is national policy that beneficiaries pay for the services provided. Accordingly, it might be appropriate to start collecting information in those Asian countries -- of which there are several (Saunders and Warford, 1976) -- in which the beneficiaries are expected to pay part of the construction and all of the operation and maintenance costs.

Question 5: What financing mechanisms can be used to recover (at least partially) the costs of investments in water supply and sanitation facilities?

For the operation of a water supply or sanitation service, income and revenues (from a combination of public and private sources) must be generated to cover the costs of the service provided. As suggested earlier (Table 1), basic excreta disposal services and rural water services should be paid for through a combination of public subsidies and user charges, while urban water supplies can usually aim for full cost recovery from user charges.

(a) User Charges

For many reasons AID and many other development agencies are strongly supportive of a policy of charging users for water supply, sanitation, and other services. The arguments for user charges include the promotion of efficiency and cost recovery, the development of financially viable institutions, and the initiation of self-sustaining programs in which resources for expansion are generated internally.

Water rates are often set on the basis of considerations of historical prices and the average cost of supply. Many development agencies (and the World Bank in particular) have argued that this procedure is incorrect and that the basic objective of a tariff system should be to provide an effective mechanism through which consumers can indicate whether or not the value to them of incremental output exceeds its cost. As the cheapest water sources are the first to be tapped, the marginal cost price will normally be higher than the

Table 8

Information to be Collected from Successful and Unsuccessful Rural Water Supply Projects

Project Name	I			II		
Income Group	Poor	Middle	Rich	Poor	Middle	Rich
Community Characteristics						
Income						
Education						
Opportunity cost of time						
Cost						
Time						
Pre-Project Supply						
Level of service						
Reliability						
Perceived water quality						
Cost						
Time						
Post-Project Supply						
Level of service						
Reliability						
Perceived water quality						
Choices Made						
Old or new						
Quantity						

average cost, thereby implying that utilities should be able to generate resources which can be used for expansion of services.

While incorporation of the concepts of willingness to pay and marginal cost pricing are fundamental to progress in the water supply and sanitation sector in developing countries, strict enforcement of these criteria would effectively mean that large numbers of people would be denied even basic services. Accordingly, in practice, it is generally advisable to modify the marginal cost approach by using a tariff schedule which consists of two steps: a low, subsidized "lifeline" rate for basic services, and a charge equal to the long-run marginal cost for all additional consumption (Saunders, et al., 1977).

Despite the clarity of the theory of marginal cost pricing, substantial practical problems still remain. A major issue in instituting any quantity-based pricing system is that meters are required to measure the volumes used. Because water meters have been developed to function effectively under the high pressure and continuous supply conditions found in developed countries, meters often give spuriously high or low readings when installed under the conditions found in many developing countries. The need for the development of "appropriate technology" meters is great. Even where meters can function, designers have to consider whether the benefits derived from installing meters outweigh the substantial costs incurred in installing, maintaining, and reading the meters (Middleton et al., 1977). It is also generally believed to be possible to meter supplies only where house connections are installed. There are several examples where community supplies are successfully metered and user charges collected. For example, in Khartoum kiosk operators are billed for the water they use, and they in turn charge those who purchase water from them, and in the Philippines meters are installed at community standpipes with the community monitoring who uses water and levying a charge according to the volume used.

(b) Public Subsidies

The institution of sound financing practices, including marginal cost pricing, is fundamental to progress in the water supply and sanitation sector in developing countries. Nevertheless, as discussed with reference to Table 2, where the health benefits (which are generally nonperceived and external to the consumer) are substantial, public subsidies for water supply and sanitation services may be appropriate. These subsidies, which may take the form of grants or low-interest loans, should correctly vary depending on the willingness to pay for the services, and on the anticipated health impact. Thus, for instance, it is the policy of the Indonesian Government to make grant financing available for urban water supply projects which provide a minimum level of domestic water, to provide concessionary loans for higher levels of service and to force utilities to seek funds for further expansion from commercial sources or internally generated funds (Porter, 1983).

(c) The Appropriate Mix of Public and Private Financing

The appropriate mix of public and private financing, as is implicit in Table 2, will depend, first, on the difference between the cost of a service and the willingness to pay for the service (with larger subsidies being required when this difference is larger) and, second, on the likely marginal health impact.

In the urban water supply sector, as indicated in Table 6, willingness to pay for services is high for all income groups at all levels of service. Accordingly, it is generally possible (and desirable) that urban water supply services aim for full recovery of all costs and even generation of funds for subsequent expansions of service. Despite this, as shown in Table 9, in a substantial number of developing countries it is still not policy to recover full costs for urban water supplies.

Table 9

Cost-recovery Policies in the Water Sector of 124 Developing Countries (after Saunders and Warford, 1976)

	O&M + Capital	O&M + Partial	O&M Only	Partial O&M	No Payment
Urban	30%	24%	17%	26%	2%
Rural	6%	16%	20%	31%	28%

In the rural water supply sector, the situation is more complex. Where willingness to pay is high (for high-level services in wet areas and for any level of service in arid areas [see Table 6]), costs, too, are high. The combination of low per capita incomes and high per capita costs means that without some form of subsidy such services are seldom viable. Since the health benefits of improved rural water supply services are often substantial -- a recent WHO review (Esrey et al., 1985) suggests that, where quality and availability of water are improved, diarrheal disease morbidity is typically reduced by over 35 percent through such improvements -- public subsidies are often used to cover some of the costs of such supplies. Accordingly, as shown in Table 9, cost recovery through user charges is much less common in rural than urban areas, with public subsidies being correspondingly greater in rural areas.

For basic sanitation services, while costs are often not as high as those of water supplies, willingness to pay (see Table 7) is typically much lower, particularly in rural areas. Because the health benefits of basic sanitation services are probably higher in urban than in rural areas, and because willingness to pay is higher in urban areas, the proportion of population with basic sanitation services is correctly much higher (75 percent vs. 15 percent, Feachem, et al., 1983a) in urban than rural areas. Even in urban areas, however, it is generally necessary to provide subsidies from public sources for the provision of basic sanitation facilities.

Question 6: How can institutions, particularly existing local organizations, in the water supply and sanitation sector be strengthened?

In the water supply and sanitation sector (as in other sectors of development activity), probably the most important reason for the slowness of progress is

the inadequate development of local institutions to operate and maintain the services and to generate the revenues necessary for reinvestment. Accordingly, USAID has afforded high priority in its overall development strategy to institutional development in general (USAID, 1983) and to the development of local organizations in particular (USAID, 1984b).

In urban areas, there are generally two separate institutional problems which need to be addressed. First, and most obvious, there is the problem of development of the institution responsible for the operation and management of the piped water supply system. As indicated in Table 1, the arguments for a public role in urban water supplies is generally weak, with the most persuasive argument being the "natural monopoly" characteristic of such utilities. Because the monopoly issue can be addressed through the exercise of oversight responsibility by a public board, the model of a regulated, privately run water supply utility probably has considerable scope in many developing countries.

The second set of "institutions" in developing countries are far less identifiable and far less well understood. These "institutions" are the private vendors who distribute water to low-income urban dwellers who are not served by the piped water supply systems (Zaroff and Okun, 1984). As indicated earlier, the rates paid by the poor urban dwellers who are served by these informal systems are typically an order of magnitude higher than rates paid by those served by the formal system.

From one perspective, these vending systems appear to be simply an anachronism which will disappear when the efficient means of transporting water (by pipeline) replaces the inefficient means (transport by truck, by animals, and by humans) on which they depend. On the other hand, despite major efforts in urban water supply for many years, the numbers served by such systems are large, (typically accounting for 20 percent to 30 percent of total urban population) and are increasing.

Part of USAID's general development policy mandates that rather than creating new organizations, support should be directed to pre-existing local organizations, particularly in the service sectors. As indicated in the USAID policy document (USAID, 1984b), it should be general policy to strengthen existing organizations prior to considering the development of new ones because:

> "(a) Existing organizations persist because they often meet real needs and serve their clientele well, whereas new organizations may take years to become effective and gain local credibility.
> (b) Even where existing local organizations seem deficient to planners, it is unlikely that new organizations will escape whatever administrative, technical or political pathologies weaken the existing organizations."

Accordingly, as with other private enterprise development projects (USAID, 1982a), attention should be given to identifying and evaluating the constraints under which the organizations operate and to eliminating or to reducing these constraints. Given the almost total ignorance of how vending systems operate (Okun, 1982), the first step needs to be field research aimed at documenting the engineering, financial, economic, and social aspects of the operation of these institutions. Given the enormous financial drain placed on

poor families by the cost of water delivered through these systems (in Lima, Peru, for instance, for those served by vendors, payments account for as much as 25 percent of family income) and given the high priority accorded the urban poor in the Asia Bureau Health Population and Nutrition Strategy (Asia Bureau, 1984), such field research is of high priority.

In the urban sanitation sector, the situation is similar in some respects. In the Indian subcontinent, for instance, many poor urban dwellers rely on "scavengers" for the removal of night soil, yet little is known — with the exception of one excellent study in Karachi (Streefland, 1976) — of the operation of these informal institutions. As low-cost urban sanitation programs expand (as is occurring rapidly in the Asia Region), so too will the need for institutions which service these facilities expand. Given USAID's commitment to private-sector institutional development, and given the relatively poor performance of the main actors in this sector in terms of institutional development, this could be an opportunity for USAID to make a substantial contribution.

In rural areas, the institutional problems are even more difficult and even more poorly understood than in urban areas and will only be touched on in this presentation. As was implicit in the Thailand example described earlier in this paper, it may be that in many cases the problems most commonly identified (technology which is too complex, lack of spare parts, and motivated and trained manpower) are not primary problems but rather reflections of the fact that the service which has been provided is not valued by the population. Consequently, it may be that a major part of the solution to the problems of weak water supply institutions in rural areas is a more thorough assessment of recurrent costs and willingness to pay in the planning phase of rural water projects. In addition, although this occurs at a much lower level than in urban areas, there are rural vending systems in many parts of the developing world. Careful analysis of the operation of these systems might well provide useful insights both into the factors which affect willingness to pay for water and the possibilities for private-sector involvement in operating and maintaining rural water supply systems.

Question 7: What is the health impact of different levels of water supply and sanitation service in different settings?

The final requirement of Table 2 is information on the health impact of different levels of water supply and sanitation service under different social and natural conditions.

(a) Results of Evaluations of the Effect of Water Supply, Sanitation, and Hygiene Education Interventions on Health

At the start of the International Drinking Water Supply and Sanitation Decade, it was implicitly claimed that diseases in children in developing countries would be reduced by 80 percent if water supply and sanitation conditions improved. Probably because of the exaggerated nature of such claims, the pendulum has now swung to a point where it is often claimed that water supply and sanitation programs have little effect on health. In the original Selective Primary Health Care calculations, for instance, it was assumed that improved water supply and sanitation conditions would reduce diarrheal diseases by just 5 percent. A recent, authoritative WHO study (Esrey et al.,

1985) has shown that the water supply and sanitation programs typically have large impacts on diarrheal disease (Table 10) and even larger impacts on diarrheal mortality.

Table 10

Impact of Water Supply and Sanitation Interventions on Diarrheal Morbidity

Improvement in	Number of Studies	Median Percent Improvement
Water Quality	9	18%
Water Quantity	17	25%
Quality and Quantity	8	37%
Excreta Disposal	10	22%

As a result of this assessment, the WHO Diarrhoeal Disease Control Programme now recommends that water supply and sanitation programs be included in national diarrheal disease control programs (WHO, 1985).

If water supply and sanitation programs are to have an impact on health, it is necessary not only that such facilities be constructed, and that they function adequately, but also that these facilities are used appropriately. As it has become evident that serious problems are frequently encountered with the use of improved facilities, so more attention has been given to the hygiene education component of water supply and sanitation programs. In many cases, (Aziz et al., 1983) hygiene education programs have been shown to have little impact on actual hygiene practices. In three instances (summarized on Table 11), only one of which is in a community setting, the impact of intensive hygiene education interventions on the incidence of diarrhea has been measured.

In Table 11 it is evident that, where water supply conditions are such that adequate quantities of water can be obtained for personal hygiene purposes, and where personal hygiene practices can be improved through hygiene education programs, such interventions may have a substantial impact on diarrhea.

(b) Effect of Level of Service on Health

Despite the large number of studies of the impact of water supply and sanitation interventions which have been carried out, little of the available information is useful in estimating the likely health impact of different levels of water supply and sanitation services. This is so in part because most studies have concentrated on whether a particular program had an effect on health outcomes and have not addressed the more important policy question of the differential impact of different levels of services.

Table 11

Effect of Hygiene Education Programs on Diarrheal Disease
(after Feachem, 1984)

Country	Setting	Intervention	Outcome Measure	Result
Bangladesh	Households with index case of shigellosis	Soap and water and education vs. nothing	Secondary Shigella cases	Reduction of 84%
United States	Day care centers, children under 3	Handwashing of staff and education of children vs. nothing	Incidence of diarrhea over 10 months	Reduction of 48%
Guatemala	Lowland villages children under 6	Hygiene education vs. nothing	Incidence of diarrhea	Reduction of 14%

Regarding water supply, the pioneering work of David Bradley (White, Bradley and White, 1972) clarifies the mechanisms by which improved water supplies affect health. Specifically, as shown in Table 12, improvements in the quality of water affect the waterborne transmission of diseases, and waterborne improvements in the quantity of water used for hygienic purposes affect the water-washed transmission of diseases.

On a priori grounds, Bradley's system suggests that basic services (such as a community standpost) may be sufficient to reduce the transmission of waterborne diseases (providing the quality of water at the source is adequate and contamination does not occur in transportation and storage), but that reductions in water-washed diseases depend on attaining that level of service necessary to induce the use of increased quantities of water for personal hygiene. What of the empirical evidence?

Table 12

The Transmission of Water-related Infections
(after White, Bradley, and White, 1972)

Transmission Mechanism	Preventive Strategy
Waterborne	Improve quality of drinking water. Prevent casual use of other unimproved sources.
Water-washed	Increase water quantity used. Improve accessibility and reliability of domestic water supply. Improve hygiene.
Water-based	Decrease need for contact with infected water. Control snail populations. Reduce contamination of surface waters by excreta.
Water-related insect vector	Improve surface water management. Destroy breeding sites of insects. Decrease need to visit breeding sites. Use mosquito netting.

Shigellosis is the classic example of a disease which is primarily water-washed. In Table 13, the results of four Shigella studies carried out in different settings in the 1950s are summarized. From these data, it is impossible to assess the impact of the provision of the most basic level of service (because no data are available on families without an improved water supply), but it appears that there is (in the specific case of shigellosis) little benefit to having water delivered to the yard rather than off the premises, and that there is a substantial improvement when water is actually available inside the house. In Table 14, the results of a study of diarrheal incidence among children in India are reported. These data suggest, in contrast to the data presented in Table 13, that the major gain occurs when the quality of the outside water source is improved, and that little is gained by piping the water into the house.

Table 13

Shigellosis and Levels of Water Supply
(after McJunkin, 1983)

Sanitary Facilities for Each Dwelling	Kentucky 1954-56 %	Guatemala 1955-56 %	California 1952-53 %	Georgia 1949-53 %
1. Water Inside/Flush Toilet Inside	1.1%	-	1.6%	0.4%
2. Water Inside/Privy Outside	2.4	6.3%	3.0	2.2
3. Water Outside/Privy Outside	5.9	9.4	5.8	5.0
4. Water on Premises	5.8	-	-	4.1
5. Water off Premises	6.0	-	-	5.8

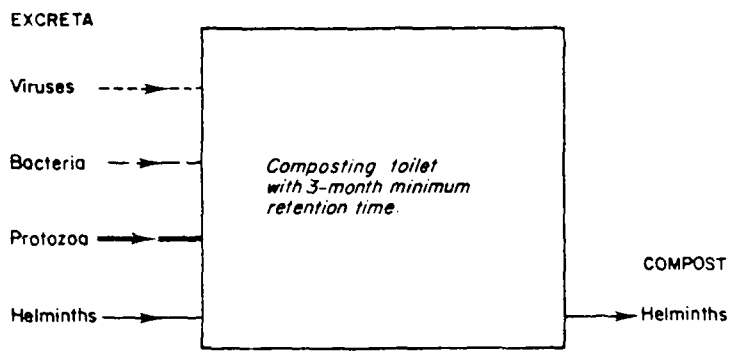
Table 14

Diarrhea and Levels of Water Supply in India
(after McJunkin, 1983)

Source	Diarrheal Incidence %	Reduction from Open Well %
Open Well	18.4%	-
Standpost	7.8	57.7%
House tap	6.2	66.3

The results of these studies on the impact of different levels of service on diarrheal disease are, then, contradictory. The first set of data suggests that a high level of service is necessary before transmission is interrupted, while the second suggests that only moderate improvements in service will suffice. While there are many possible explanations which could reconcile these findings (perhaps because the studies dealt with different outcomes, perhaps because of characteristics of the populations studied), the fact remains that existing empirical data give no basis for a universal conclusion of the impact of different levels of water supply service on health outcomes.

Regarding sanitation, as demonstrated in Figure 2, on a priori grounds there is little reason to believe that a well-maintained improved pit latrine or pour-flush latrine would have less impact on health than a much more expensive waterborne sewerage system. As was the case with water supply, however, few



Pathogen flow through a batch composting toilet (double-vault)

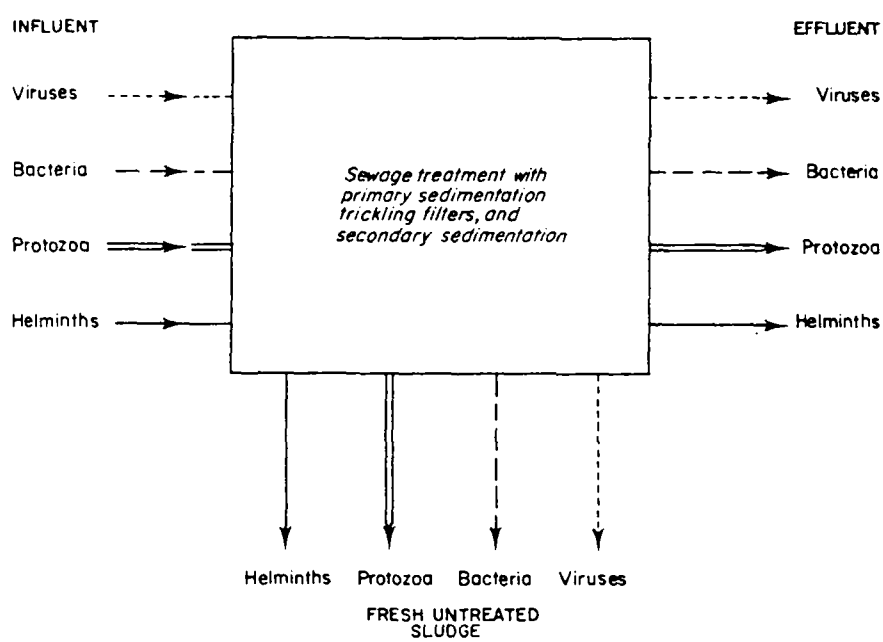


Figure 2

Pathogen Flow Through Low-cost and High-cost Sanitation Systems (after Feachem et al., 1983)

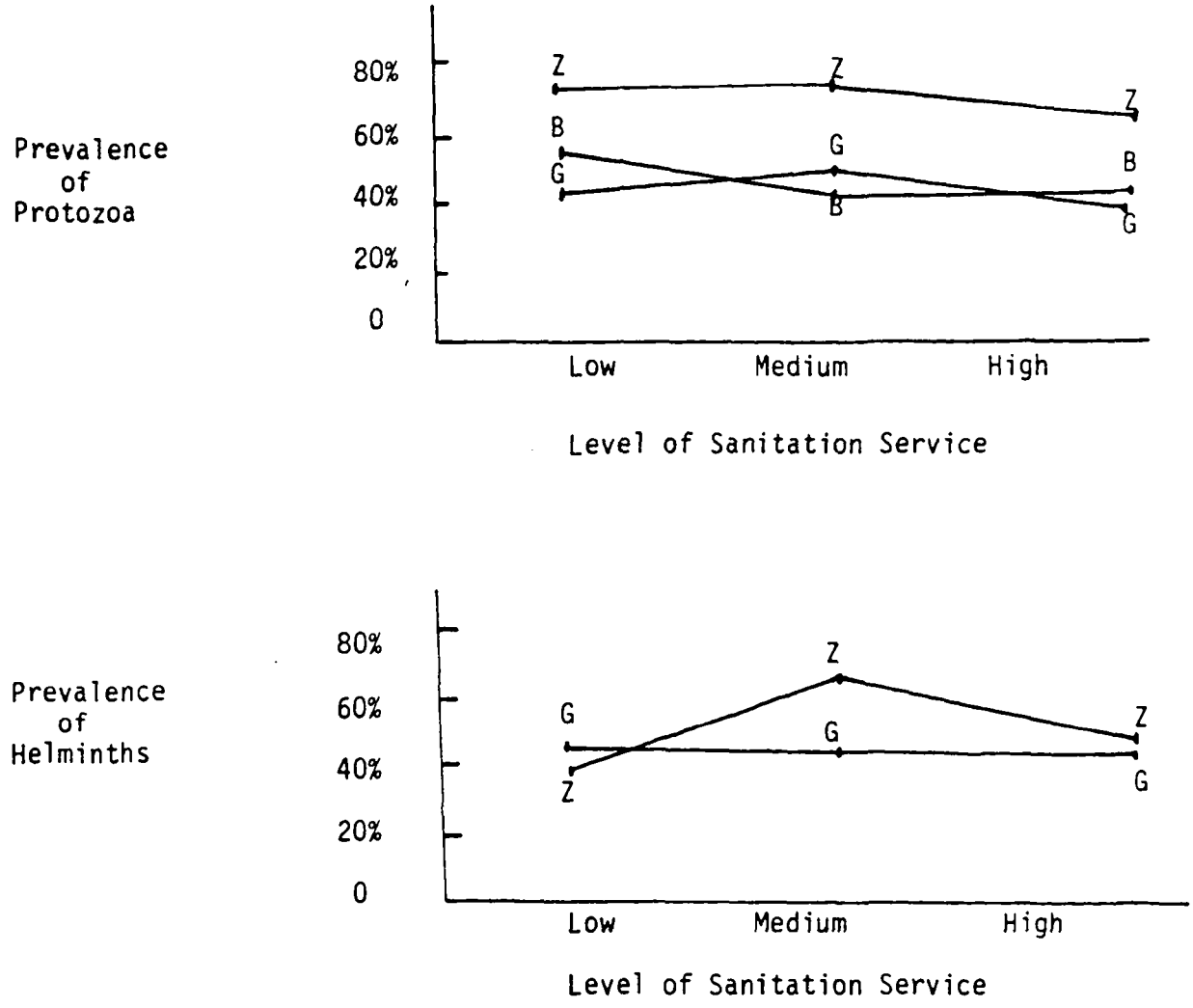
empirical data are available on the effect of different levels of sanitation service on health. From the Georgia and Kentucky data in Table 13, it would appear that there is little impact when a family changes from using no privy to using an outside privy (comparing lines 3 and 5) but a substantial improvement when an inside rather than an outside privy is used (comparing lines 1 and 2). In Figure 3, the results of a recent study on the effect of the level of sanitation service on intestinal parasitism in urban areas of Africa are presented. These results do not indicate whether families using any latrine have a lower incidence of parasitism than those who do not use such facilities, but do suggest that after a basic level of service is met there is little additional health benefit from the (very expensive) further improvements in service. As in the water case (and perhaps for similar reasons), these results are contradictory, with one set of data suggesting that a high level of service is necessary if health impact is to be substantial and one set of data suggesting that the marginal health benefits from increasing the level of service above a basic level are small.

(c) Improving Information on the Impact of Level of Service on Health

There are several reasons why the state of knowledge on the impact of different levels of water supply and sanitation services is so poor. First, it is extremely expensive (sometimes costing more than $1 million per study) and takes a long time (at least five years) to conduct such studies using the standard quasi-experimental design. Few of the published studies have had the necessary resources available. Second, even where the studies have had these resources available and have been well designed and executed, there are systemic problems with the methodology leading, in most cases, to meaningless results (Drake, et al., 1983). Most published studies of the impact of water supply and sanitation programs suffer from such serious methodological problems (Blum and Feachem, 1983) that little credence can be placed in the results. Indeed, the situation is so serious that an Expert Panel, convened by the World Bank in 1975, concluded that:

> "...because of the high cost, limited possibility of success and restricted application of results (of studies of the quantitative relationship between water supply and health)...the Bank should not undertake such studies [World Bank, 1976]."

Since 1975, however, there have been two major advances which suggest that it may now be possible to develop a more valid and yet rapid and inexpensive method for assessing the health impact of different levels of water and sanitation service. First, while in 1975 diarrhea was an "inscrutable syndrome" (because pathogens could be isolated in less than 20 percent of the cases), today, largely because of the identification of rotavirus, enterotoxigenic E. coli, and Campylobacter as major diarrhea pathogens, it is now possible to identify pathogens in approximately 40 percent of cases detected through field surveillance, and approximately 80 percent of cases which are serious enough to report to a clinic (Black, 1984). Second, over the last 15 years (primarily in connection with chronic diseases in developed countries) there has been rapid progress in understanding the problems of case-control studies and in the development of methods for improving the reliability of the method. It is now appreciated that the method offers substantial possibilities for the conduct of rapid, inexpensive yet valid



Legend: Countries are represented by the following symbols:

B - Botswana; G - Ghana; Z - Zambia

Figure 3

Intestinal Parasitism and the Level of Sanitation Service in Three African Cities (after Feachem et al., 1983b)

epidemiological studies of a variety of infectious disease problems (Smith et al., 1983).

Over the past two years, under the auspices of the WHO, the usefulness of the case-control method in evaluating the health impact of water supply and sanitation programs has been assessed (Briscoe, Feachem, and Rahaman, 1985). The method seems to hold promise for providing, at modest cost and in a short time, site-specific information on key policy questions (such as the impact of different levels of service on the incidence of severe diarrhea). If, after the initial field trials are completed, the method is deemed to provide valid results, then planners will have a tool which can be used to provide information on the health impact of different levels of service. Because it should take no more than six months to complete such studies, it should be possible to provide answers to specific policy-relevant questions during the early stages of the project preparation cycle.

(d) Interpreting the Results of Health Impact Evaluations

(i) Necessary but Insufficient Interventions

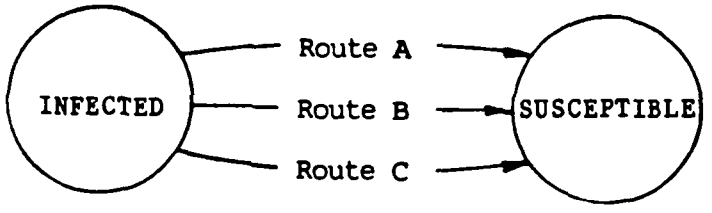
In the best of situations (one in which a sound evaluation of the health impact of different levels of water supply and sanitation facilities has been conducted), there still remain two related questions which need to be addressed before a conclusion on the overall health impact of a proposed project can be identified. First, it is necessary (as is done in this section) to consider the possibility that an improvement may be a necessary but insufficient condition for improving health and, second, it is necessary (as is done in the next section) to understand the relationship between the immediate effects (which are generally measured in impact evaluations) and the longer-term effects of the project.

For a water supply improvement to have an impact on a fecal-oral disease (such as a diarrheal disease) it is necessary, first, that the number of organisms ingested are reduced and, second, that this reduction translates into a reduction in disease. One can briefly repeat an argument produced in more detail elsewhere (Briscoe, 1984b) which shows that under conditions of poor overall sanitation, major reductions in exposure may translate into only small reductions in disease.

Consider the simple model shown in Figure 4, below, in which there are three parallel routes through which organisms can be transmitted from one person to another. For the most common type of dose-response relationship (log-linear), it can be shown (Table 15) that elimination of just one transmission route (including the major transmission route) has little impact on disease. Table 15 also shows that elimination of the major transmission route is nevertheless of great importance in reducing disease, because it is only when this prior, apparently ineffective intervention has been undertaken, that subsequent interventions (reducing transmission through the other routes) can be effective. In the simple example given, the elimination of Route A alone only reduces disease incidence by 26 percent. The importance of eliminating Route A, however, is not this direct effect, but rather the fact that it creates the conditions for subsequent interventions to be much more effective. In the example given, if Route B is eliminated prior to the elimination of the Route

A, there is little impact on disease whereas, if Route B is eliminated only after Route A is eliminated, this has a major impact on disease.

Simple as it is, this model captures some essential features of the real world in which water supply and sanitation interventions operate, and thus has important implications for assessing the impact of such interventions. In the many parts of the developing world, where there are several parallel routes for effectively transmitting fecal-oral pathogens, it is quite possible that an improvement in, say, water supply would have little direct impact on health and yet be an important health intervention. In other words, in these circumstances such improvements are a necessary but insufficient condition for reducing disease.



	Number of Organisms Transmitted Via the Route
Route A	70
Route B	28
Route C	2

Figure 4

Multiple Routes for the Transmission of Fecal-oral Pathogens

Table 15

Effect of Eliminating Different Routes on Disease Incidence

Exposure Group	Proportion of Original Number of Organisms Still Transmitted	Proportion of Original Number of Cases of Diseases Still Incurred
1. Routes A + B + C	100	100
2. Eliminate Route A only	30	74
3. Eliminate Route B without having eliminated Route A	72	93
4. Eliminate Route B after having eliminated Route A	2	15

As discussed in more detail elsewhere (Briscoe, 1984b), the little available empirical evidence (including that presented in Figure 1 of this report) suggests that this phenomenon is operative in the poorer parts of the developing world. Under such conditions, care needs to be exercised before deeming that a water supply or sanitation program was not justified as a health intervention because there was little direct impact on disease.

(ii) Relationship of Short- and Long-run Impacts

Child survival programs (including oral rehydration therapy, immunizations, and water supply and sanitation interventions) are usually evaluated by assessing the impact on morbidity or mortality due to a particular disease. In most such analyses, it is assumed that if disease A accounts for 30 percent of deaths and if the intervention reduces deaths due to disease A by 50 percent, then there will be an overall reduction in mortality of 15 percent. As illustrated in Figure 5, however, there are three distinct ways in which such specific changes may relate to overall changes in child mortality.

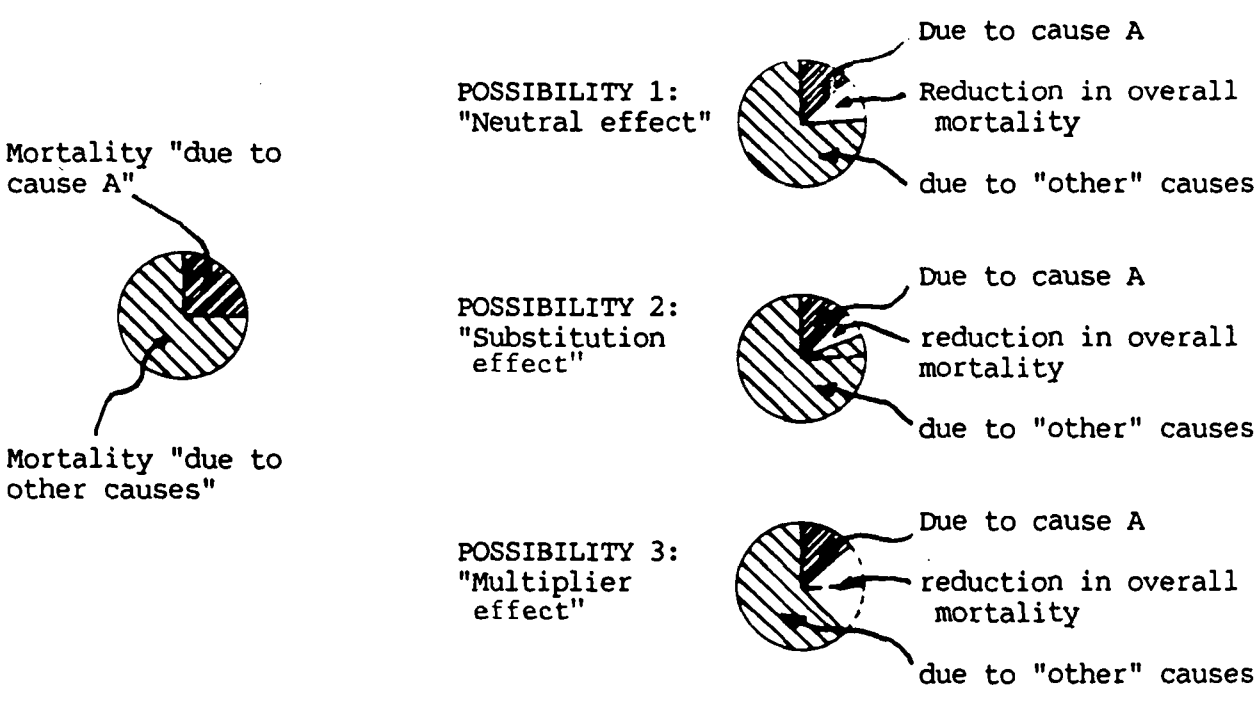


Figure 5

Possible Impacts of an Intervention on Mortality Due to Specific Disease and Overall Mortality

A key question in assessing the overall impact of a particular health intervention is whether this type of intervention is one for which the "neutral", "substitution", or "multiplier" effect is operative. Because so few studies testing these hypotheses have been carried out, and because the effect of specific interventions will certainly be different in different settings, any general conclusions must be regarded as extremely tentative. The few relevant studies which are available suggest that measles immunizations may save lives not only due to measles but also due to other causes (that is, the "multiplicative" effect is operative), while for oral rehydration therapy in Bangladesh, at least, children whose lives are "saved" may not return to normal mortality risks (that is, the "substitution" effect is operative) (Mosley, 1948). What might the effect for a water supply and sanitation intervention be?

Only one published study (on the causes of mortality declines in urban France in the nineteenth century (Preston and Van de Walle, 1978) is available which furnishes data adequate for testing this hypothesis. The authors of this study have attributed the different mortality patterns (shown schematically in Figure 6) in the three cities to the differences in the dates when water supply and wastewater disposal conditions were improved in each of the cities. From the detailed age- and cohort-specific mortality patterns, it can be deduced which of the three mortality patterns ("neutral," "substitution," or multiplier") is operative.

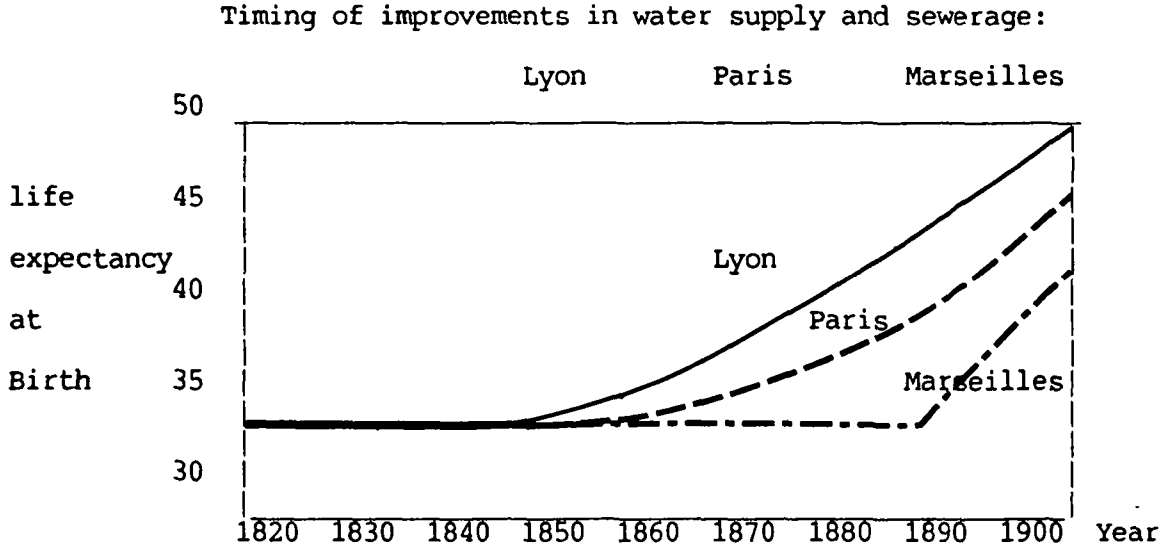


Figure 6

Mortality Declines in Urban France in the Nineteenth Century
(after Preston and Van de Walle (1976)

Table 16

Age- and Cohort-specific Death Rates under "Substitution," 'Neutral," and "Multiplier" Paradigms

Possibility 1: "Neutral" Effect

Age Years	Average $_nq_x$ in Interval 1816-45 (x10,000)	Ratio, Average $_nq_x$ in Period to that in 1816-1845				
		1816-1845	1846-1860	1861-1874	1875-1890	1891-1905
5-19	643	1.00	0.85	0.70	0.55	0.40
20-34	616	1.00	1.00	1.00	1.00	1.00
35-49	710	1.00	1.00	1.00	1.00	1.00
50-64	1344	1.00	1.00	1.00	1.00	1.00
65-79	3606	1.00	1.00	1.00	1.00	1.00

Possibility 2: "Substitution" Effect

Age Years	Average $_nq_x$ in Interval 1816-45 (x10,000)	Ratio, Average $_nq_x$ in Period to that in 1816-1845				
		1816-1845	1846-1860	1861-1874	1875-1890	1891-1905
5-19	643	1.00	0.90	0.80	0.70	0.60
20-34	616	1.00	1.00	1.00	1.00	1.00
35-49	710	1.00	1.00	1.00	1.00	1.00
50-64	1344	1.00	1.00	1.00	1.00	1.00
65-79	3606	1.00	1.00	1.00	1.00	1.00

Possibility 3: "Multiplier" Effect

Age Years	Average $_nq_x$ in Interval 1816-45 (x10,000)	Ratio, Average $_nq_x$ in Period to that in 1816-1845				
		1816-1845	1846-1860	1861-1874	1875-1890	1891-1905
5-19	643	1.00	0.85	0.70	0.55	0.40
20-34	616	1.00	1.00	0.85	0.70	0.55
35-49	710	1.00	1.00	1.00	0.85	0.70
50-64	1344	1.00	1.00	1.00	1.00	0.85
65-79	3606	1.00	1.00	1.00	1.00	1.00

In Table 16 above, the age- and cohort-specific death rates which might be expected under each of the three hypotheses are presented. In each case, it is assumed that the impact on the youngest age group increases over time. In Table 17, the actual age- and cohort-specific death rates for the city in which improvements first took place (Lyon) are presented.

Table 17

Actual Age- and Cohort-specific Death Rates in Lyon (1)

Age Years	Average $_nq_x$ in Interval 1816-45 (x10,000)	Ratio, Average $_nq_x$ in Period to that in 1816-1845				
		1816-1845	1846-1860	1861-1874	1875-1890	1891-1905
5-19	643	1.00	0.85	0.64	0.57	0.38
20-34	616	1.00	0.94	0.95	0.75	0.63
35-49	710	1.00	0.93	0.94	0.82	0.75
50-64	1344	1.00	1.04	1.02	0.90	0.90
65-79	3606	1.00	1.14	1.07	1.06	1.08

Comparing the diagonal structure evident in Table 17 with the structure of each of the versions of Table 16, it is evident that the pattern of mortality in Lyon conforms closely to the pattern which would be expected when the "multiplier" effect is operative.

Unfortunately, no other similarly rich data sets which could be analyzed in a similar way exist. Although, as with other interventions, the effect of water supply and sanitation interventions would be different in different settings, from the single adequate set of data it appears that water supply and sanitation interventions have a multiplier effect on mortality. The effect of this multiplier effect is illustrated in Table 18, in which the long-run effects of the actual environmental improvement (Type B) in Lyon is compared to the effects of a (hypothetical) intervention (Type A) which had the same impact on mortality in the youngest age group in the first period but for which there was no increase in impact over time and for which the mortality experience of the older age groups was unaffected.

As is evident from Table 18 (and a more detailed discussion elsewhere-Briscoe, 1985), by not considering whether the effect of a particular program is likely to have a "neutral," "substitution," or "multiplicative" effect, the effect of those programs which have a "multiplicative" effect (such as, tentatively, measles vaccination and water supply and sanitation programs) may be seriously underestimated and the effect of those programs which have a "substitution" effect (such as, tentatively, oral rehydration therapy programs) may be seriously overestimated.

Table 18

The Effect of Different Interventions on Short- and Long-term Mortality (after Briscoe, 1985)

	Intervention Type (%): None	Type A	Type B	Impact of B / Impact of A
Deaths Averted in Youngest Age Group:				
(i) In initial 15-year period	0	15.5	15.5	1.00
(ii) In fourth 15-year period	0	15.5	62.4	4.03
Life Expectancy of Cohort:				
(a) born in the first period following intervention:				
(i) Assuming that age-specific mortality rates have stabilized 15 years after the intervention	100.0	102.7	103.7	1.37
(ii) Using true mortality rates experienced by the cohort	100.0	102.7	105.4	2.00
(b) born in the last (4th) 15-year period, assuming that mortality rates have stabilized	100.0	102.7	118.7	6.93

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