AN EVALUATION OF THE RELATIVE IMPORTANCE OF TECHNICAL AND NON-TECHNICAL FACTORS WHICH AFFECT WATER AND SANITATION PROJECTS IN DEVELOPING COUNTRIES

by

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Lastly, for their confidence.
DEDICATION

This work has been dedicated to
the memory of
a man, whose ideas and hopes for the future have
haunted me throughout this research.

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INTRODUCTION

According to the World Health Organization, 80 percent of human diseases are water related (Brisco, 1978). An effective approach toward controlling these diseases has been elusive. At one point, improvements in water supply alone were assumed sufficient. For example, a historical review performed by the World Bank studying the relationship between water supply and health concluded that improvements in water supply alone could drastically reduce the incidence of most water-related diseases (McJunkin, 1982). A more detailed analysis was completed by Bradley of several specific water-related diseases as presented in Table 1 (Feachem, 1978). The Table lists the predicted reductions in disease incidence when protected water sources are utilized. In the hope of controlling water borne-diseases, the United Nations General Assembly declared the 1980's to be the International Water and Sanitation Decade. The goal of the Water Decade was to provide safe and potable water for all the world's population and adequate waste disposal for approximately half of the globe's inhabitants by 1990 (UNESCO, 1977).

When health impact studies of improved water and sanitation were conducted, rather interesting and often counter-intuitive results become apparent. Generally, very few of the studies demonstrated that improvements in water and sanitation necessarily led to the expected reductions in
<table>
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<tr>
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<th>Percent Reduction</th>
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<td>90</td>
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<td>40</td>
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<td>Scabies</td>
<td>80</td>
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<td>Schistosomiasis</td>
<td>60</td>
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<tr>
<td>Skin Sepsis and Ulcers</td>
<td>50</td>
</tr>
<tr>
<td>Some Enterovirus</td>
<td>10</td>
</tr>
<tr>
<td>Thypoid</td>
<td>80</td>
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<tr>
<td>Tinea</td>
<td>50</td>
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<tr>
<td>Trachoma</td>
<td>60</td>
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<td>40</td>
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<tr>
<td>Yaws</td>
<td>70</td>
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<td>Yellow Fever</td>
<td>10</td>
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[From Bradley, 1978]
disease. For example, the incidence in Guatemala of diarrheal disorders prior to improvements in water supply was 39.7 per population of 1000. Three years after improvements were completed the incidence rate was 39.5 per population of 1000 per year. Other minor changes in morbidity are noted in Table 2. This Guatemalan study found that very minor health improvements are associated with improvements in water supply alone (Shiffman, 1978).

The incidence of diarrheal diseases for a rural community in Zambia was 338 per population of 1000 per year before piped water was introduced and was 212 per population of 1000 two years after improvements (McJunkin, 1982). Even though this reduction in disease incidence is large, the rate of 212 per 1000 is still alarming. Similarly, a Lesotho study of clinic and hospital records from villages with and without improvements in water supply found no difference in diarrheal incidence (Feacham, 1978).

In Bangladesh, the incidence of diarrhoeal diseases for consumers of unprotected water sources was 3.2 per population of 1000 per year, while users of protected water sources had a rate of 5 per population of 1000 per year. Approximately 14 percent of well users had positive cholera stool samples, contrasted with 8.4 percent for non-well users. The Bangladesh study is remarkable because it illustrates an increase
Table 2. Selective Annual Morbidity Rates
For Guanagazapa, Guatemala

<table>
<thead>
<tr>
<th>Diagnostic Categories</th>
<th>Incidence per 1000 Population</th>
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<tbody>
<tr>
<td></td>
<td>1973</td>
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<tr>
<td>Total Morbidity</td>
<td>123.0</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>39.7</td>
</tr>
<tr>
<td>Respiratory Diseases</td>
<td>53.7</td>
</tr>
<tr>
<td>Skin Infections</td>
<td>12.5</td>
</tr>
<tr>
<td>Conjunctivitis and Otitis</td>
<td>3.5</td>
</tr>
</tbody>
</table>

[From Shiffman, 1978]
in disease incidence with improvements in water supply rather than the expected decrease noted in Table 1 (Levine, 1976).

The literature contains many similar examples of poor or no return on investments made in water and sanitation (McJunkin, 1982; White, 1972). Several explanations have been proposed to explain the difference between expected and observed health effects, including poor statistical technique (Blum and Feachem, 1983; Kamwata 1978; McJunkin, 1987; Arlosoroff, 1988), inadequate government infrastructure (Warner, 1980), inappropriate designs (Arboleda-Valencia, 1986), lack of support for operation and maintenance activities (Kawata 1978), deficient community involvement (Feachem, 1978; IRC, 1986), and limited health education.

This study will take the perspective that community health is the result of a variety of technical and non-technical factors. Therefore, comprehensive programing is more likely to have a positive impact on community health than more specialized activities.

This research is intended to generate an appreciation of the success and failures of different approaches to the problems associated with community health. Field studies from different countries will be considered throughout this study, with special emphasis placed on the health impacts of technical and non-technical activities. Ultimately, this investigation should yield insight into how investments
directed at rural health can lead to improvements.

To accomplish these general goals the following specific objectives were undertaken:

1) Define technical and non-technical factors which impact the effectiveness of community health activities.

2) Study the significance of each factor and assess benefits and limitations associated with each, including an investigation of how the factors relate to each other.

3) Evaluate the effectiveness of different disease control strategies for specific diseases, isolating the effects of technical and non-technical activities. This evaluation should yield recommendations concerning the necessary mix of technical and non-technical services required for the control of specific diseases.

4) Develop general strategy for the interdisciplinary control of multiple diseases.

By satisfying these objectives, it is hoped that a useful perspective as well as an administrative tool can be developed to utilize more effectively a country's resources.
and yield health effects similar to Bradley’s estimates. In this way it is envisioned that this study may contribute to the global efforts to improve health in developing countries.
TECHNICAL FACTORS AFFECTING COMMUNITY HEALTH

INTRODUCTION

Technical factors which affect community health programs are exemplified by the activities of engineers involved in water and sanitation construction programs and doctors involved in medical programs. Often, technical factors require advanced training and extensive material support. This chapter will evaluate the activities of these agencies with the hope of providing a better understanding of their limitations and how they interact to solve problems concerning community health.

ENGINEERING

Reliance on Technical Solutions

In general, engineering agencies seem to rely on technical solutions to resolve community health problems (Isely, 1988). Such an orientation is often fitting for urban water systems, but not for rural programs. This technical approach has been noted and criticized by researchers, primarily because it often yields inappropriate solutions to problems faced by rural communities (Isely, 1988; McJunkin, 1987; Donaldson, 1987).

To attain a better appreciation of engineering activities in developing countries, it may be useful to
consider the observed preference for the development of technically sophisticated urban systems over simpler rural projects. In a study of Latin America and the Caribbean areas, the preference for urban activities over rural projects was apparent. The study noted that although 86 percent of urban populations had received drinking water by 1985, only 45 percent of the people in rural areas had an adequate supply. Sanitation facilities were available to 60 percent of urban dwellers and only 15 percent of the rural inhabitants (Arlosoroff, 1988). These figures reflect the predilection to develop urban systems over rural ones.

For many reasons urban systems are less costly to construct (on a per capita basis) and can often utilize more expensive and complicated technology. To comprehend the impact economics plays in determining the level of technology to be employed, it is useful to consider the potential costs and implications of different service levels. The service level is the type and quality of service to be provided to the consumer. Examples of service levels include protected springs and wells to chlorinated communal water taps, and household connections from large gravity-fed or pumped systems. With regard to public health, service levels essentially relate to risk, with higher service levels being associated with less risk to the user than lower service levels. Because developed areas are able to maintain more
elaborate water treatment systems, reduction in risk is accomplished by improving water quality - that is, by providing water which contains the least amount of harmful contaminants.

In developing countries, reduction in risk is related not only to water quality but also to other factors such as water quantity, degree of utilization of facilities, community behavior, and effective waste management. For example, many hygiene and gastrointestinal diseases are associated with the availability of water (Raman, 1978). If water is available in small quantities or must be carried over long distances, personal hygiene deteriorates, leading to increases in certain skin, eye and diarrheal diseases (Sommer, 1972; Jelliffe, 1972). Water quality concerns are often correlated with the type of service being provided. The possibility of contamination of water drawn from a public stand pipe and transported and stored in a potentially contaminated vessel is greater than water drawn directly from a household tap (Feachem, 1978; Saunders, 1976). Household taps are a higher service level and are associated with a greater reduction in risk than are public stand pipes.

The service level provided is determined by many factors, with economics being one of the most significant. Data suggests that the per capita construction costs for a given water treatment facility declines as the population
density increases (Rosenhall, 1978; Arboleda-Valencia 1986; Saunders, 1976). In a specific analysis of per capita costs, variations in population were considered along with different service levels and treatment practices. Results of this study are noted in Table 3 (Saunders, 1976). This analysis indicates that for a system designed to utilize public stand pipes, the cost per capita for filtering and chlorinating water for a population of 10,000 is less than the cost per capita of chlorinating a surface water source for a population of 1000. It is obvious that, as the population density increases, per capita costs decrease. This savings often allows the provision of higher service levels or utilization of more advanced treatment technologies, implying that urban systems can utilize sophisticated technical solutions.

Difficulties occur when urban technology is transferred to rural settings. In such cases, rural communities can neither afford nor support the more complex solutions. Many examples of the application of inappropriate technologies exist. As an illustration, in Kenya, tertiary wastewater treatment plants were built in rural locations. Before the project's construction phase reached mid-point, the first plants were being retired due to operation and maintenance problems. By the expected project completion date, none of the plants were operating (McJunkin, 1987).
<table>
<thead>
<tr>
<th>Village Population</th>
<th>Service Level</th>
<th>Water Source</th>
<th>Typical Costs Cost per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>PH</td>
<td>Well</td>
<td>10</td>
</tr>
<tr>
<td>1000</td>
<td>PH, HC</td>
<td>Well</td>
<td>20</td>
</tr>
<tr>
<td>1000</td>
<td>PH</td>
<td>Surface Water</td>
<td>9</td>
</tr>
<tr>
<td>1000</td>
<td>PH, HC</td>
<td>Surface Water</td>
<td>19</td>
</tr>
<tr>
<td>1000</td>
<td>PH</td>
<td>Surface Water</td>
<td>16</td>
</tr>
<tr>
<td>1000</td>
<td>PH, HC</td>
<td>Surface Water</td>
<td>34</td>
</tr>
<tr>
<td>10000</td>
<td>PH</td>
<td>Surface Water</td>
<td>8</td>
</tr>
<tr>
<td>10000</td>
<td>PH, HC</td>
<td>Surface Water</td>
<td>13</td>
</tr>
</tbody>
</table>

PH = Public Hydrant (1 per population of 100), HC = House Connection
All costs are in 1973 U.S. Dollars
[From Saunders/Warford, 1976]
Another more subtle example of the utilization of inappropriate technology was the product of a Water Department / United Nations High Commission for Refugees (UNHCR) planning session in Malawi. The primary goal of the meeting was to standardize shallow well construction techniques. At the end of the planning session, it was recommended that all future wells should be built using reinforced concrete. Technically, the proposal was properly designed, but the implications of imposing this standard were considerable. Because reinforced concrete was an unfamiliar technology, the role communities could play in construction would be greatly reduced. The traditional method utilized locally produced bricks and employed the skills of local brick layers. Due to the fact that rural communities have little available cash, their contributions toward a water or sanitation project are usually restricted to the provision of local material and labor. The proposal to protect wells by using reinforced concrete would put a greater burden on centralized government to provide trained technicians and purchase and transport necessary supplies. This would increase the cost and in turn reduce the total number of wells constructed.

These examples illustrate the fact that rural communities have unique needs which make the planning of water and sanitation projects a challenging activity. Difficulties concerning logistics and economies of scale compound one
another, making per capita costs higher. Logistical problems often relate to the inaccessibility of many rural sites: supplies must be transported over long distances; local skilled technicians are usually not available; and housing and transportation must be provided for the technicians. Furthermore, economies of scale diminish as population density decreases. As an example, where pipelines are constructed in communities with low population densities, the number of people served per kilometer of pipeline is obviously lower for rural than urban areas.

Due to these additional expenses, rural programs cannot afford sophisticated technical solutions. Yet the propensity to address rural problems solely with technical solutions restricts the consideration of other options which may provide cost-effective solutions. The United Nations Development Program (UNDP) and the World Bank have done extensive research on available options, yielding many publications on low-cost water and sanitation alternatives (World Bank/UNDP TAG series). Such an approach usually requires minimal technical and material support, frequently reducing logistic problems and the need for specially trained technicians. By using locally available technologies and materials, rural water and sanitation programs can be as cost effective as urban programs. Such approaches often rely heavily on non-technical factors such as community interac-
tion and participation. Because engineering agencies have a preference for technical activities, it is not surprising that such agencies are often criticized for ineffectively supporting these non-technical endeavors (Isely, 1985; Churchill, 1987; Warner, 1987).

Cooperation with Other Technical Agencies

Another observation concerning development strategies adopted by engineering agencies is that they are primarily concerned with construction and maintenance of water and sanitation projects, with other health-related activities largely neglected. Originally, the Water Decade spurred interest in the problems associated with water supply and sanitation. The Water Decade was initially conceived at the United Nations Mar del Plata Water Conference in 1977 (McJunkin, 1982). The Mar del Plata resolution seemed to be primarily concerned with how technical solutions should be applied to provide potable water and effective sanitation facilities. This orientation is still prevalent and manifests itself in many ways. For example, in a recent article published in the American Water Works Journal, a list of individuals who should be consulted when implementing a water program was developed (Eaton, 1985). These individuals
included:

a) financiers,
   b) policy makers,
   c) design engineers,
   d) contractors,
   c) operation and maintenance personnel, and
d) consumers.

The list does not involve a representative from a health care agency, suggesting that the provision of water and sanitation does not concern health.

A more comprehensive approach toward community health issues is noted in the 1978 Alma Ata Declaration. Central to this declaration is the use of primary health care (PHC) programs. PHC differs from traditional western health care in that it focuses on preventive practices rather than curative medicine. One of several components of PHC is the provision of an adequate supply of safe drinking water and proper sanitation. The Alma Ata Declaration is different from the Mar del Plata resolution in that it regards water supply and sanitation as one element of health care. Considering the Alma Ata orientation, it is obvious that medical and engineering institutions have a shared goal of improving community health (Freij, 1978). Because water and sanitation programs are often criticized because of the inability of such programs to positively impact health,
engineering agencies should work in conjunction with medical agencies to enhance project benefits. Benefits of cooperation between medical and engineering agencies were noted in the refugee-impacted areas of Malawi. The Ministry of Health and the Ministry of Works both had ground water protection programs. Initially, the efforts of both ministries were poorly coordinated and they independently sited wells in the same communities. This redundancy meant that the service being provided was not uniformly distributed over the region. Some communities had an abundance of protected water points while others had none. Construction crews often were confused over which well sites were associated with the different ministries. Later, a non-governmental organization supported better cooperation between these two ministries such that water department personnel provided equipment and technical expertise to Ministry of Health field workers. The Ministry of Health personnel, known as Health Surveillance Assistants (HSA), each had ten target villages for which they were responsible. The HSA claimed residence in one of the target villages and traveled to the others by bicycle several times a month to provide different public health services such as immunization, nutrition clinics, health education and water and sanitation activities. This combination of the strong grassroots linkage of the HSA with the technical skills and equipment of the Water Department's UNHCR ground
water program led to the construction of 42 wells by community volunteers during a 5 week period.

Another reason why engineering agencies should coordinate their activities with medical agencies concerns the use of medical field statistics. Epidemiological data generated from field health officers can provide useful information on disease incidence and outbreaks. This information can help engineers prioritize their work such that resources can be focused in regions with the greatest need. An example of how disease surveillance information can be utilized to aide engineering practices occurred in Swaziland. Disease incidence information was available, though not fully utilized, for monitoring the spread of cholera. Accurate diagnosis of stool samples in rural settings is often not possible, but clinics did keep records of general disease categories. When these data are analyzed by age, a useful relationship becomes evident. Diarrheal diseases primarily impact infant morbidity and mortality while cholera impacts all age groups, such that an increase in the number of severe cases of diarrhea in older age groups implies the possibility of a cholera episode (Conalley, 1983). Because time is an important factor in controlling cholera, a disease which spreads rapidly, such information can be used by engineers to quickly assess suspected areas and mobilize equipment and personnel if needed. In the Swaziland, due to
lack of cooperation between engineering agencies and the Ministry of Health this approach could not be utilized.

A similar early warning program is being introduced in Thailand to monitor malaria. Incidence data were analyzed on a monthly basis for a period of 8 years to determine endemic malaria incidence for the northern regions of the country. Sector chiefs are responsible for comparing monthly observed means with expected means in their area. When the difference in the two exceeds two standard deviations, Zone and Regional Malaria Offices are notified and the outbreak is investigated. Even though the program is fairly new, retrospective analysis of data has shown that this approach is an effective warning system for impending epidemics (Cullen, 1984). As mentioned earlier, such information is important for engineers in directing their resources to the areas of greatest need.

Disease monitoring also proved a useful tool in siting wells for the UNHCR groundwater program in Malawi. In November 1988, an influx of refugees impacted several communities. Kaliozi was one of the communities most affected, with an increase in population from 165 to 3,800. Disease surveys of Kaliozi revealed a significant increase in diarrheal-related deaths, culminating with the death of the community leader. Further field studies highlighted the fact that almost all of the drinking water was obtained from
surface water sources located down gradient from the settlement. This information was made available to the district engineer of the ground water program, who immediately sited two wells near the community and provided supplies for the construction of communal pit latrines. Simultaneously, Ministry of Health personnel mobilized a community health education program encouraging inhabitants to use protected water sources located in adjacent communities; otherwise, they were to boil or chlorinate all drinking water. Because the Ministry of Health and the Ministry of Works shared their resources and were able to quickly respond to the situation, diarrheal-related deaths in Kaliozi were reduced to zero within 3 weeks (O'Donouhue, 1989).

These examples of cholera data in Swaziland, the malaria early warning system in Thailand, and Malawi's UNHCR groundwater program demonstrate that field medical data is essential in assigning resources in the areas where they are most needed. Better cooperation between engineering and medical agencies not only assist the engineer in prioritizing work but in certain instances may also enhance operation and maintenance activities. Such an effect was noted in the rural wells program in Togo. Originally, it was decided that, for every village which was to receive a well, a health committee was to be organized and trained to look after the well and pump and to promote hygiene and health in the village. Even
though cooperation between the technical well drilling
brigade and the teams responsible for supporting the health
committees was lacking, maintenance activities for com-
munities included in this integrated program exceeded those
activities associated with communities who were not included.
As these results were realized, the two ministries recognized
the benefit of cooperation and began to coordinate other
activities such as site selection, timing of well drilling
and the provision of spare parts (Warner, 1987).

In addition to under-utilizing medical resources,
engineering agencies appear to have a tendency to under value
non-technical factors such as education and community
participation (Werner, 1980; Warner, 1987). Generally there
appears to be a perception that the function of a community
is merely to provide a source of labor for construction and
to support operation and maintenance activities. This
limited view of community involvement underestimates the
complexity of community problems and the usefulness of the
community to assist in the resolution of these problems. In
a rural sanitation project noted in a World Bank study, 2000
pit latrines were installed in rural villages at no expense
to the communities. Two years after completing the project,
the staff returned to the site to find that most of the
latrines were being used as storage closets (Churchill,
1987). This example suggests that technical factors alone
are not sufficient to ensure proper usage. Health education and community participation could have enhanced proper utilization of these facilities.

MEDICAL AGENCIES

Preference for Curative Technical Solutions

As with engineering agencies, medical agencies also exhibit a distinct preference for technical solutions, specifically curative over preventive practices. This is most noticeable in the orientation to build and support large hospitals rather than smaller rural health clinics (Chen, 1978; Isley, 1985). For example in Kenya, the Kenyatta National Hospital consumes 25 percent of the national health budget. A study of child mortality rates noted that, for the community surrounding the Kenyatta hospital, mortality rates were 35 percent higher than the national average (Mosley, 1983). It would be expected that mortality rates for the hospital's service area should decrease in proportion to the investment which was being made. In Ghana during the past 20 years, the number of doctors, hospital beds and real per capita expenditure on health has increased three fold. Despite these investments, health indicators have not changed. Infant mortality still averaged 130 per 1000 live births, with a life expectancy at birth of less than 50 years. Such health statistics as these suggest that, despite
increased investment in curative activities, community health is still poor (Ghana Health Assessment Project Team, 1981).

In a United Nations study, a multiple regression analysis of a variety of health and social factors was performed on infant mortality in 41 countries. The analysis indicated a strong association between infant mortality, literacy rates, and per capita income. It did not find any significant correlation between infant mortality and person per doctor ratios or person per hospital bed ratios (Mosley; 1983). All of these examples suggest that the present curative approach toward community health is not necessarily the solution to rural health problems.

**Cooperation with Other Technical Agencies**

As with engineering agencies, medical agencies appear to resist cooperation with other technical groups (Isely, 1988). This appears counter-productive. If improvements in water and sanitation can lead to reductions in disease, a reduction in the workload of clinics and hospitals is likely.

Some of the most obvious effects with regard to cooperation concerns the lack of effective program support. For example, Burkino Faso's water program was divided into a water supply component and a health component. The technical water supply component was responsible for well drilling, pump installation, masonry work, and maintenance of facilit-
ies. The health component was responsible for sanitation, health education and community mobilization. Due to lack of cooperation, each component operated independently, with the technical water component proceeding on schedule while the health component lagged behind. The gap between the health component and the engineering component created many problems concerning the coordination of inter-related activities, such as site selection and community participation, including labor and financial contributions (Isely, 1985).

Another example of the difficulties associated with inter-departmental cooperation can be found in Swaziland. The Ministry of Health utilized a PHC infrastructure which trained government employees and community volunteers who worked out of local rural clinics. Many of the health workers found themselves involved in small water and sanitation projects, usually protecting springs and encouraging construction of pit latrines. Despite excellent support and training in sanitation, field workers often lacked the technical skills needed to properly cap springs. Moreover, there was noticeable resistance toward cooperating with Rural Water, the para-governmental agency coordinating the Water Decade effort in Swaziland. Even though these two agencies did have nominal linkages at a fairly high administrative level, little interaction occurred at the community level. Cooperation could have helped both agencies. The Ministry of
Health could have utilized Rural Water’s technical experts to upgrade health worker’s training and provide equipment and support for the construction of small scale water systems. Rural Water could have utilized the most obvious effects with regard to cooperation concerns the lack of effective program support. For example, Burkino Faso’s water program was divided into a water supply component and a health component. The technical water supply component was responsible for well drilling, pump installation, masonry work, and maintenance of facilities. The health component was responsible for sanitation, health education and community mobilization. Due to lack of cooperation, each component operated independently, with the technical water component proceeding on schedule while the health component lagged behind. The gap between the health component and the engineering component created many problems concerning the coordination of inter-related activities, such as site selection and community participation, including labor and financial contributions (Isely, 1985).

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Another example highlighting the importance of inter-agency cooperation occurred in the refugee impacted communities of Dedza and Lilongwe districts in Malawi. In 1989, over 125,000 refugees were scattered over 300 villages in Dedza district. Public health services for this district included construction of shallow wells and boreholes; pump maintenance; water testing; construction of pit latrines for individual homes and ventilated improved pit latrines at food distribution centers; chlorination of water sources; im-
munization of children under age five for measles; BCG and DPT; construction of nutritional rehabilitation centers; nutrition classes; high protein food supplements for malnourished children; antenatal clinics; health education; drug distribution for minor ailments; disease and sanitation surveillance and a variety of clinical activities. All of these activities were directed at the village level and relied heavily on community participation. This approach was sustained by continual training and supervision of field staff and village health committees.

In contrast, the Lilongwe district, even though it was affected less by refugees, having approximately 27,000 refugees scattered over 245 villages, offered less services than the program in Dedza district. Public health services in Lilongwe were limited to the construction of shallow wells and boreholes, chlorination of water sources, construction of pit latrines, and distribution of oral rehydration therapy (ORT) packets. Furthermore, the quality of the services being rendered was often deficient. For example, of the 27,000 refugees registered, the HSAs provided these few services to only 3,000 to 6,000 refugees.

One explanation for the difference between the two districts concerns the cooperation and coordination of related activities. The Dedza activities were coordinated primarily at bi-weekly meetings. These meetings often included UNHCR
representatives, district health officers, water and sanitation engineers, hospital administrators, public health nurses, health educators, and field supervisors. Because of the diversity of resources and perspectives represented at these meetings, strategies were developed which included many technical and non-technical factors. In comparison, strategy meetings for Lilongwe were held every two months and included members of the government's central hospital (primarily staff from the hospital's accounting office), junior district health officers, field supervisors, public health nurses, and sanitarians. Because meetings were infrequent and not all available resources were represented, it was difficult to instill a sense of cooperation. These two contrasting cases again illustrate the importance of administrative cooperation.

The Sante Rurale (SANRU) Project in Zaire is yet another example of how the integration of engineering activities into medical activities can enhance PHC. Originally the program design contained provisions for the development of water and sanitation projects in addition to medical activities. This program utilized nurses and community health workers from mission hospitals, health centers and dispensaries who were inexperienced in the technical aspects of water and sanitation. During the early years of the program, emphasis was on health-based components, and little was done with regard to
Later, the Rural Hydraulics Division of the Ministry of Rural Development was enlisted to provide a training program for health workers on spring capping techniques. This initial cooperation lead to Rural Hydraulics involvement in subsequent field activities. Within two years, roughly 25 percent of SANRU’s project activities concerned some aspect of water supply and sanitation (Warner, 1987). This effective association between SANRU and the Rural Hydraulics Division led to better support of field health officers and rendered services to rural communities which otherwise may not have been provided.

**SUMMARY**

It is interesting that engineering and medical institutions have similar infrastructural limitations. For both, there is a distinct preference for technical solutions to problems. This preference was highlighted for engineering activities in a study of Latin American projects and for medical programs by studies from Kenya, Ghana, and an United Nations regional study. This inclination toward technical solutions limits an agency's ability to generate solutions appropriate for problems in rural area. Furthermore, the lack of cooperation between technical agencies restricts an agency's capacity to produce comprehensive solutions to
problems. Cooperation can enhance both engineering and medical programs. Examples of how engineering programs could be improved were noted in Swaziland, Thailand, and Malawi for disease monitoring activities and for operation and maintenance activities in Togo. Medical programs can also be enhanced by better cooperation as seen in Malawi's UNHCR program and Zaire's SANRU program.
NON-TECHNICAL FACTORS AFFECTING COMMUNITY HEALTH

INTRODUCTION

Simply providing technical solutions to the problems concerning water and sanitation has not necessarily produced significant improvements in community health. It was previously thought that such diseases as typhoid fever and cholera could be completely controlled by improvements in water quality and waste disposal (Isley, 1981), but studies have shown that this is not necessarily true (Levine, 1976). This chapter will investigate the role of non-technical factors in the provision of health-related services. This section will specifically consider the effects education and community participation have on programs.

EDUCATION

Benefits

The effects of education on improvements in health behavior have been positively correlated in several studies. One of the more notable achievements in Kenya was the progressive reduction in infant mortality between 1962 and 1983, as shown in Table 4. A multiple regression analysis of these and other data found that 86 percent of the decline in infant mortality between 1962 and 1979 can be attributed to
Table 4. Kenyan Infant Mortality Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Mortality per 1000 Live Births</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>174</td>
</tr>
<tr>
<td>1969</td>
<td>157</td>
</tr>
<tr>
<td>1979</td>
<td>125</td>
</tr>
<tr>
<td>1983</td>
<td>90</td>
</tr>
</tbody>
</table>

[From Mosley, 1983]
education. A closer examination reveals that child mortality is specifically sensitive to the mother's educational level, as indicated in Table 5. This clearly demonstrates that higher levels of education are associated with greater reductions in child mortality (Mosley, 1983).

Another example of the role education plays in community health concerns a study from Bangladesh where it was found that high family income was associated with better nutrition only in families with literate mothers. Nutritional standards of high income families with illiterate mothers were not significantly different from the nutrition levels of low income families (Mosley, 1983). Again it is noted that higher educational levels are positively correlated with improved health.

Educational approaches require a special effort. Just as an engineer must design a system for specific situations, educational programs must fit a cultural context. There are many informative examples of how cultural values can be integrated into educational programs to create changes in community behavior. A particularly useful approach is the use of religion as a vehicle for behavioral changes.

In Moslem countries, health behavior modification is especially difficult because Islamic culture generally resists change. This is reflected in the Egyptian adage that "he who leaves his past gets lost." There is a similar
Table 5. Child Mortality in Kenya For Different Maternal Education

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Number of Children Dying By Age 2 per Population of 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Education</td>
<td>163</td>
</tr>
<tr>
<td>1-7 Years of Education</td>
<td>104</td>
</tr>
<tr>
<td>More than 8 Years of Education</td>
<td>61</td>
</tr>
</tbody>
</table>

[From Mosley, 1983]
saying in Algeria, "The future is robbed of it's menace if reduced to the past" (Yacoob, 1985). In such circumstances, development objectives meet less resistance if they can be reduced to Islamic principles. The effectiveness of this approach was noticed in a family planning program in Senegal which gained acceptance by using maxims from the Koran to explain the positive relationship between child spacing and maternal mortality (Yacoob, 1985).

Another example of this approach is from northern Sudan where the Ministry of Health utilized religious aphorisms in conjunction with a series of pictures of different behavioral practices. The series started with sayings from the Koran asking all believers to cleanse their bodies before prayer. The command was interpreted to affect a variety of health behaviors including: burning wastes outside villages, general village clean up, elimination of stagnant water with earth to control mosquito breeding, placing cisterns out of the reach of goats, cleaning cisterns, and use of clean containers to fill cisterns. There was also a series on schistosomiasis which showed pictures of a young boy urinating and another defecating into a river, followed by a view of a woman downstream washing clothes.

The success of this program has been attributed to two key factors. First, the restriction was imposed that only one specific behavioral modification should be targeted at a
time, simplifying the message delivered. Second, messages based on values which the community could appreciate were used. These two attributes led to greater community acceptance, enhancing participation. The above examples demonstrate that appropriate educational methods improved community health behavior by reinforcing proper health practices with accepted cultural values.

Limitations

Education programs are not to be considered a panacea, for they are fraught with difficulties. Because behavior must be changed in fundamental ways, education programs often take years to realize benefits. The highly successful Guinea worm control program in Togo took five years to develop (Foly, 1987). Likewise, Malawi’s successful Health Education and Sanitation Program (HESP) took 10 years to mature and is still being modified (Liebler, 1986).

Shorter programs seem to produce uncertain effects. A one year health education program did change behavior in a Central American project. Such behavioral changes included increased frequency of hand washing, removal of human and animal waste from the home environment, protection of stored water, cleanliness of the household yard, installation of latrines, and exclusion of domestic animals from the kitchen and dining areas. General bathing did not increase in
frequency, nor were clean cloths worn more often. Most importantly, there was no impact on infant mortality even though extensive stool studies did suggest an improvement in intestinal efficiency (Shiffman, 1978). Such a change in intestinal efficiency suggest a reduction in infestation of parasites.

COMMUNITY PARTICIPATION

Benefits

To further maximize benefits attributed to improved water supply and sanitation, it may be necessary to generate a "felt need"—that is, a value or need which is appreciated by the community (Foly, 1987; Caudil, 1988). An effective way of generating a felt need is by merging education and community participation. This approach is different from more formal educational techniques in that the emphasis is on clearly presenting material and attempting to get the community involved in the process of appreciating problems and developing solutions.

An example of the importance of generating a felt need concerns the Tanzanian Department of Health's revitalization of a mobile clinic. The program was having difficulty recruiting community health workers and was only able to attain a 10 percent participation level in its immunization program. Both of these facts indicated a lack of community
interest. The program was significantly modified to support a participatory model of primary health care. This approach utilized community demonstrations which presented problems to the community and evoked responses to potential methods of dealing with relevant health issues. This method generated a felt need for the services being offered, and with significantly greater participation in the immunization program, the project's inability to recruit health workers was also no longer a problem (Caudill, 1988).

A common infrastructure used to promote participatory programs is the community health committee. Through these groups, interaction between community members and technical agencies can be supported. An informative example of the use of community committees occurred in northern Transval, South Africa, where community health committees were employed in a campaign to eradicate trachoma. Curative measures such as tetracycline therapy and surgery affect temporary relief from the cycle of reinfection but have little or no impact on behavioral patterns; hence they do not affect the spread of the disease. In the Transval program, community health care workers, referred to as care groups, were recruited from within the community and were provided with training in diagnosis and treatment of trachoma, with special emphasis on promoting behavioral changes.

In several communities, local chiefs resisted the care
groups, which restricted the availability of this service. Furthermore, households initially considered the visits of the care group intrusive due to the belief that only relatives may give advice on family matters. Care groups resolved this difficulty by defining themselves as educators, which was more socially acceptable. In addition, the care groups further adapted to social situations by developing an entertaining format using songs and dances for their health messages. This approach enhanced their acceptability because their presentations were enjoyed by community members. The songs and dances specifically promoted the use of individual face cloths, personal cleanliness, and fly control by digging pit latrines and refuse pits. The effects of these efforts are exhibited in Figures 1, 2, and 3. These figures show that communities with care groups participated more in the suggested activities than communities without care groups. This program led to a reduction in the incidence of trachoma, most noticeably for the pre-school age group as demonstrated in Table 6.

Unexpected benefits came in the middle of the study when a cholera epidemic arose in the region. The care groups redefined their mission to reflect the changing needs of their constituents by promoting chlorination of drinking water and the use of oral rehydration therapy (ORT). This
Before Care Group

After Care Group

Figure 1. Influence of Care Group Activity: Construction of Refuse Pits. [From Sutter, 1983]
Figure 2. Influence of Care Group Activity: Construction of Pit Latrines. [From Sutter, 1983]
Figure 3. Influence of Care Group Activity: Use of Individual Face Cloths. [From Sutter, 1983]
### Table 6. Influence of Care Group Activity on Prevalence of Intense Upper Tarsal Disease Analyzed by Age

<table>
<thead>
<tr>
<th>Community</th>
<th>Year</th>
<th>Percent Diagnosis With Disease Age 0-6 Years</th>
<th>All Ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nkuzana</td>
<td>1976</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Mahatlane</td>
<td>1978</td>
<td>49</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>1982</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Njakanjaka</td>
<td>1976</td>
<td>46</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>1979</td>
<td>44</td>
<td>33</td>
</tr>
</tbody>
</table>

[From Sutter, 1983]
reorientation indicates the potential responsiveness of community groups to address a variety of issues of importance. Even after the cholera outbreak, the care groups became means for providing other pertinent technical information on related issues of nutrition and home improvements (Sutter, 1983).

There are other examples of significant benefits associated with participatory projects. A study demonstrating how participatory water projects can enhance medical programs is noted in a Water and Sanitation for Health (WASH) examination of water projects in Indonesia and Togo. The projects were grouped as follows: villages with participatory water supply projects, villages with non-participatory water supply projects and control villages with no water supply.

In Togo, the participatory water project being considered was attempting to provide water to a rural population of 120,000 people in the Savannah and Plateau regions. In addition to the construction of wells, the program supported a complimentary "socio-health" component which relied heavily on the participation of village committees. By mid-project, 80 percent of the wells were completed, and 350 village committees had been organized and their officers trained. Of these communities, 80 percent had set up funds to maintain their pumps. The non-participatory water project utilized external teams drilling tubewells and installing pumps.
Community-participation was not considered in the later program.

In Indonesia, the participatory water supply project was a joint USAID/CARE effort which stressed "community involvement and participation" throughout the whole project. Local Indonesian field workers were employed to support the activities of community organizations and the educational objectives of the project (Thompson, 1982). The non-participatory water supply project utilized a sanitarian based at a community health center. In this program a community participation approach was not relied upon. Control villages were once again communities whichors in the success of a water and sanitation program. Occasionally, engineers must work with cultural attitudes and ideas which are not readily changed by educational approaches. Such community beliefs can be addressed through appropriate program and facility design. Failure to consider community beliefs can have major adverse effects on a project. For example, in Swaziland, a distribution system was laid out in such a way that two chiefdoms could be served by the same source. Due to a dispute between the two chiefs, the inhabitants of the second chiefdom believed that, because the reservoir for the system was within the first chiefdom, the system could easily be poisoned and refused to use the system.

Because of a lack of interaction between the communities
and the agency responsible for building rural water systems, the political/cultural context was not considered in the system design. Earlier recognition of this problem would probably have led to modifications in the distribution system or the development of separate sources. This would have required an exchange of information between the community and the responsible agency at an early stage of program development. Such an example suggests the importance of community participation in generating appropriate design.

Another illustration is from Papua New Guinea, where a community refused to draw water from a pipe that was buried near a women's menstrual hut (Abcede, 1987). A better understanding of community values would have led to a layout of the distribution system which would have been more acceptable. In another community in Papua New Guinea, people were so frightened by the high water pressure that they were inhibited from using piped water (Abcede, 1987). Better use of break pressure tanks and pressure reducing valves in the design would have enhanced community acceptance.

A rewill be discussed in the next chapter, community utilization of constructed facilities and changes in health behavior can be critical factors in the success of a water and sanitation program. Occasionally, engineers must work with cultural attitudes and ideas which are not readily changed by educational approaches. Such community beliefs
can be addressed through appropriate program and facility design. Failure to consider community beliefs can have major adverse effects on a project. For example, in Swaziland, a distribution system was laid out in such a way that two chiefdoms could be served by the same source. Due to a dispute between the two chiefs, the inhabitants of the second chiefdom believed that, because the reservoir for the system was within the first chiefdom, the system could easily be poisoned and refused to use the system.

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were so frightened by the high water pressure that they were inhibited from using piped water (Abcede, 1987). Better use of break pressure tanks and pressure reducing valves in the design would have enhanced community acceptance.

A reason given for the under-utilization of protected water sources in Matlab, Bangladesh is the belief that giving children cold water would cause them to get sick and lose their voices. It was thought that well water should not be used by children because it is usually cooler than surface water (Brisco, 1978). Fortunately, this belief did not significantly impact actual behavior as noted in household studies of children’s drinking water practices (Brisco, 1984). Still, engineers could have utilized simple solar designs (i.e., attaching lengths of small diameter black hose to the pump spout) resolving the issue by raising the water temperature. Also, a participatory or educational approach could have been used to debunk this belief and reinforce more scientific reasons for preferring tubewells. Once again, interaction between the community and the system designers is necessary.

Because of the restricted interaction between the drilling brigade and the communities in a well program in Togo, wells were sited in inappropriate locations. Some were drilled far from town, minimizing utilization. One was even placed in a sacred graveyard (Warner, 1987). Better coor-
dination with the community during the siting process would have improved utilization of the wells.

In almost all of these cases, if the engineer had known in advance of local attitudes concerning drinking water, the system could have been designed to take such values into account. It is nearly impossible to predict what the issues are from one chiefdom or village to the next. Full recognition of water use patterns can only be done by promoting community interaction through participation at the earliest stages of program development.

Much of the funding for the Water Decade was arranged so that national and donor agencies provided capital costs while communities took responsibility for operation and maintenance expenses (Bradley, 1977; Donaldson, 1988). For those cases where it is expected that the community will be primarily responsible for continual maintenance of the system, participatory approaches are useful in that they naturally promote community ownership and make transferring of maintenance responsibility possible. A study of water supply improvements of 43 Mexican projects without community participation and 94 with participation found that 51 percent of the systems without participation were functioning at the time of the survey while projects with community participation had 71 percent of its water systems functioning (Churchill, 1987). Community members, especially women's groups,
often play a role in site maintenance. In Botswana, wells are surrounded by a thorn fence to keep animals away. These fences are regularly maintained by community members. In Zimbabwe, women's groups are responsible for keeping water points, and washing and bathing facilities clean. Zambian women's groups are involved in the upkeep of drainage for public taps. In Malawi, women have been encouraged to use pipeline routes as paths and to report leakages to the village caretaker (Churchill, 1987).

Because operation and maintenance activities rely on the community's future resources, the community therefore has a legitimate stake in deciding how those resources should be used. This suggests that a community's aspirations and future must be included in the project design (Donaldson, 1987). To attain the type of information needed to anticipate future operation and maintenance concerns, communities should be involved in all stages of the project, again especially the earliest planning stages.

The assessment of community needs and aspirations, along with discussions with users of the cost and benefits of different types of water supply and sanitation projects, is among the most neglected aspects of water and sanitation activities. This neglect features prominently in reasons often given for the failure of projects. It is therefore important that engineers explain what can be expected in
terms of water quality, quantity, reliability, government contributions and benefits (Feachem, 1978; Churchill, 1987; IRC, 1986). This obligates engineers to fully utilize their communication skills such that technical alternatives are presented clearly and simply (Warner, 1987). Furthermore, responsible agencies must be willing to negotiate the final design with the community. Often such interactions are considered to be nuisances while they should be considered necessary if community support is required to realize desired health benefits and if the community is going to be held responsible for the sustainability of the system (Feachem, 1978).

An example of how community responsibility can be incorporated into the community decision-making processes occurred in Guatemala. Here rural communities using gravity feed systems had the opportunity to determine what service level would be provided. The choices offered each community included public taps, group connections and private connections. In Burkino Faso, a well program also provided communities with the choice between a protected open well with low maintenance cost and considerable community responsibility to prevent contamination or a hand pump with higher community costs and less immediate community responsibility (IRC, 1986). As expected, such approaches seem to produce a greater sense of community involvement and responsibility,
which leads to the long term sustainability of water and sanitation projects.

Limitations

Intrinsic to the use of community groups is the assumption that local communities exist in some autonomous and democratic form in rural areas and can be readily mobilized to manage their own collective welfare in an egalitarian fashion. Generally this is not the case in traditional societies; powerful elites often play a dominant role in many communities (Mosley, 1983). The problems associated with local leaders can be a significant limitation to community participation. To avoid this pitfall, utilization of the existing community infrastructure may be necessary. Such infrastructure includes community leaders, village elders, traditional figures or religious and political leaders. An illustration of how important these infrastructures can be is found in Egypt where traditional midwives handle 80 percent of all births. Earlier, the role of traditional midwives as health care providers was recognized by the government such that they received a certain amount of training and were licensed. Later this recognition was withdrawn, which meant there was no means to improve their practice. The effects of ignoring this existing infrastructure have included an increase in the incidence of neonatal tetanus (Mosley, 1983).
There are many PHC successes associated with the use of local infrastructures, most notably in Nigeria, Kenya, Indonesia and Malawi (Mosley, 1983; Lungu, 1988). But failures have occurred as well. In Indonesia, local leaders were so counter-productive that health workers were frustrated in their efforts such that only 6 percent of all health workers could be classified as dedicated (Mosley, 1983).

SUMMARY

In this section such non-technical factors as education and participation have been considered. Examples of programs which contain these components have been reviewed, highlighting both the strengths and limitations of each factor.

From studies mentioned above it is apparent that education has been positively associated with community health, especially in Kenya and Bangladesh. Examples from Senegal and Sudan have shown that appropriate educational techniques are effective in addressing health concerns even for communities resistant to change. Programs which contain community participation components also seem to be fairly effective in improving community health, especially those which utilize local community health committees as noted in Togo, South Africa, Tanzania and Cameroon.

In conclusion, despite the limitations of educational and participatory approaches, it appears evident that these
non-technical factors can have a significant role in attaining community health goals, improving system design or enhancing operation and maintenance activities.
CASE STUDIES OF DISEASE CONTROL METHODS

INTRODUCTION

Reviewing case studies can be a constructive technique to assess the effectiveness of different disease control methods. Diseases can be organized in a variety of ways (Feachem, 1978; Kalbermatten, 1983), but not all methods of organization are necessarily meaningful or useful. In this research, special consideration will be given to the technical and non-technical components of disease control. By highlighting these specific factors, it is hoped that the significance of each factor will be more apparent. This method should provide valuable insight for program development by recommending specific technical and non-technical programs to be implemented for effective disease control.

Three sources of information will be reviewed: (1) the available literature; (2) interviews with experts from the Pan-American Health Organization, the World Bank, Water and Sanitation for Health (WASH), United Nations High Commission for Refugees (UNHCR) and the United States Agency for International Development (USAID); and (3) the author's own field experience in rural water supply and sanitation in Swaziland and Malawi.

Six diseases have been selected for study. They include schistosomiasis, malaria, shigellosis, trachoma, cholera, and
Guinea worm. Different control methods for each disease will be evaluated separately. The analysis will consist of four components:

1) General significance of the specific disease being studied.
2) Pathology of the specific disease, with special emphasis placed on transmission routes.
3) Investigation of different control methods to interrupt the disease cycle.
4) Recommendations of the most effective or best combination of specific services needed to control the disease of interest.

Much has been written concerning the difficulties associated with doing health impact studies in developing countries (Feachem, 1986; Blum, 1985. In many cases, funds may not be available for expensive field studies. Those studies which are funded often are poorly designed or use inappropriate statistical methods (Blum, 1983). For these reasons there is great inconsistency in the quality and quantity of information available. In this research, different case studies are reviewed. For some diseases there may be an abundance of good information available, such as in the cholera studies of Matlab, Bangladesh, while other diseases have few detailed field studies. This lack of
information does affect the proposed technical/non-technical evaluation. As more information becomes available, recommendations derived from this method becomes more credible. In this study, results from actual field activities will be considered such that strengths and weakness of different control programs can be considered in a practical fashion. This technical/non-technical evaluation should yield realistic recommendations which enhance the effectiveness of disease control efforts.

SCHISTOSOMIASIS

General Significance

Schistosomiasis is a fairly common debilitating disease, being prevalent in 74 countries where it affects over 200 million people (Sherif, 1984). Recently, there has been an increased awareness of the consequences of water development schemes such as dams and large scale irrigation farming projects have on ecosystems. Disruption of existing ecosystems may produce favorable conditions for host and vector species of parasitic and infectious diseases. This relationship has been especially well documented for schistosomiasis (Mott, 1984). For example, before the Akosombo Dam was built, 5-10 percent of Ghanaian children had schistosomiasis. By 1969, a year after Lake Volta reached its maximum level, up to 90 percent of the children aged 10-14 living around the
lake were infected (Gibson, 1983). Yet it may not always be a sound policy to automatically cease water development due to increases in health risk. In the case of the Aswan high dam, efforts required to control schistosomiasis should be balanced with the benefits associated with improved agriculture. Prior to the dam, ordinary irrigation allowed Egypt only 1 crop per year. After the dam was completed, perennial irrigation was possible, providing for 2 or 3 crops per year (Mobarak, 1982). Such improvements in agriculture generally lead to better nutrition, which in turn improves health conditions.

Pathology

The causative agent for schistosomiasis is the trematode Schistoma, a blood fluke. There are three different pathogenic strains of schistosoma prevalent in different areas of the world, effecting different organs within the human body and producing different symptoms. Schistosoma mansoni is prevalent in Africa, the Middle East and South America. S. japonicum, appears throughout much of the Orient. Both of these strains produce intestinal symptoms. S. Haematobium occurs in Africa, the Middle East and India, causing urinary disorders.

The life cycle for a schistosome is complicated. An infected individual excretes schistosome eggs which hatch in
water, releasing free swimming miracidia which penetrate a specific fresh water snail, Biomphalaria glabrata. While in the host snail, the miracidia migrate to the snail liver and develop into a cyst form. After about 6 weeks the cysts are released back into the water, hatching free swimming cercariae which are able to penetrate human skin. Once inside a human host, these blood flukes move through the veins to the lungs, then through arteries to the liver where the trematode becomes sexually mature. The schistosome finally migrates to the bladder if it is S. Haematobium or the walls of the intestines if it is S. Japonica or S. Mansoni. Here the schistosomes mate and deposit their eggs in the lumina of the respective organ. The eggs are excreted into water, repeating the cycle.

This disease is usually not fatal even though chronic infestation has been associated with liver involvement, trauma of the intestinal walls and urinary malfunctions. The population at risk is infected while young and remains infected throughout life (Ongom, 1972).

Childhood symptoms, under the age of five years, include abdominal pain, blood in faeces or urine, and fever. For ages older than five years, the only apparent symptom is faecal or urinary blood loss and some lethargy (Ongom, 1972).
Control Methods

In comparing different strategies for schistosomiasis control which are being used in different countries, similar programs become apparent. In Egypt, there are eight different regions where schistosomiasis is endemic. The national strategy is modified to be appropriate for each region, but generally it promotes area-wide mollusciding followed by chemotherapy in three phases:

A. Active intervention, where maximum use of both molluscicides and chemotherapy are utilized.

B. Consolidation, where mollusciding is reduced while drug therapy is continued.

C. Maintenance, with continued epidemiological surveys and minimal mollusciding.

This program was effective especially in Egypt's Fayoum Governate where prevalence was 46 percent in 1982 and today is less than 7 percent. This reduction was primarily due to the use of the molluscide Niclosamide. An effectiveness study found that Niclosamide can be carried as a lethal dose down canals for distances up to 110 km from the point of application (Jordon, 1977).

Northeastern states in Brazil have a slightly different program in that they promote chemotherapy, mollusciding, health education and improvements in sanitation. This integrated strategy has worked well. During the pilot
studies, prevalence of schistosomiasis was reduced to below 4 percent. Presently, the program is being expanded throughout other endemic regions (Liese, 1986).

In 1976, the Philippine government initiated a "Do no harm" policy for all irrigation projects. To check the spread of schistosomiasis, the policy fostered the use of environmental control methods, improvements in water supply and sanitation, health education and chemotherapy. From 1978 to 1982, the prevalence of schistosomiasis was reduced from 24 to 17 percent. In 1982, the Ministry of Health decentralized the program and integrated it into on-going primary health care activities. The transition period was difficult, but notable program improvements were detected, especially on the island of Leyte where four times as many examinations and treatments were carried out. By 1985 prevalence on Leyte dropped to 9 percent.

Sudan's Blue Nile Health Program began in 1979 for the control of malaria, schistosomiasis and diarrheal diseases. Control of schistosomiasis included mass chemotherapy, health education, molluscidying and improvements in water supply and village sanitation. At the village level, local health committees supplemented field staff activities, filling a role which proved invaluable in motivating community participation and cooperation, especially with regard to health education, water supply and sanitation activities. Com-
pliance in the program was almost 100 percent and disease prevalence was reduced from 40 percent to 13 percent in the 18 villages monitored.

From the above case studies it seems apparent that control of this disease is usually accomplished by either one or all of the following methods:

A. Chemotherapy
B. Molluscides
C. Improvements in water and sanitation
D. Health education

These methods were compared in the control of schistosoma mansoni in three isolated valleys on St. Lucia, West Indies (Jordon, 1977).

With regard to the improvement of water supplies, water collection activities were monitored at 15 sites to assess behavioral changes. In addition, faucets were installed in each home, showers and laundry units were built, and three small swimming pools were constructed. Once the water system was completed, collecting and carrying water from the river virtually ceased. Cloths washing at the observed sites was reduced by 60 percent, bathing was reduced by 30 percent, while swimming showed no change. This was followed by a health education program and further construction of laundry and shower facilities near popular laundry points. Thereafter, all observed contact with surface water was reduced by
90 percent. In a similar government project where in-home faucets were substituted with community standpipes, no reduction in transmission was noted.

The snail control part of the project used a 25 percent emulsifiable concentration of a molluscide, Bayluscide. Snails were periodically collected and sentinel snails were exposed to natural waters and examined for cysts. Figure 4 shows the reduction of snail infected areas resulting from the use of Bayluscide (Jordon, 1977).

With regard to chemotherapy, disease modeling simulations suggest that, for drug therapy to be effective, a large portion of the infected population must be treated over a short period of time (Liese, 1986). One of the drug options presently available is Metrifonate which is cheap but effective only for S. haematobium, and requires 3 consecutive treatments. Oxamniquine is effective against all strains of schistosomiasis requiring only a single dose, but it is fairly expensive (1986 US $2.00/ per dose). Praziquantel is the most favored single dose drug, effective for all forms of schistosomiasis as well as many other helminths. Again, the cost is fairly expensive ($4.00 per treatment) (Liese, 1986). For the comparison study on St. Lucia, Hycanthone, which is similar to Oxamniquine, was used at a dose of 2.5 mg/kg body weight. Later about 1/6 of the studied population were found to be positive 2 years after receiving the initial dose and
Figure 4. Location of Biomphalaria Glabrata-Infested Areas Before and After 4 Years of Mollusciciding. [From Jordon, 1977]
were given a booster dose of Oxamniquine.

Table 7 shows the results of the comparison giving the percent reduction in disease incidence and the cost per person. The above results demonstrate that chemotherapy is the most cost-effective option for controlling schistosomiasis, with snail control being a distant second. Improvements in water supply associated with health education costs the most and at the same time provides the least protection.

This comparison of control methods must be considered very carefully because investments in water supply and education have benefits in areas other than the targeted disease such as reduction in infant mortality, reduction in time and efforts spent fetching water and improved personal hygiene, as well as possible agricultural benefits. In contrast, snail control and chemotherapy effect only the targeted disease and have few secondary benefits and only provide temporary protection.

Recommendations

In light of the effectiveness of drugs and molluscides, technical solutions appear to have greater impact on the control of schistosomiasis than non-technical aspects such as health education or attempts to reduce exposure through community behavior modification. Still, non-technical factors do play a role in promoting participation in chemo
Table 7. A Comparison of Schistosomiasis Control Methods on St. Lucia

<table>
<thead>
<tr>
<th>Control Method</th>
<th>Initial Incidence (Percent)</th>
<th>Final Incidence (Percent)</th>
<th>Cost per Person (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvements to Water and Sanitation</td>
<td>22.7</td>
<td>11.3</td>
<td>4.00</td>
</tr>
<tr>
<td>Snail Control</td>
<td>22.0</td>
<td>9.8</td>
<td>3.70</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>18.8</td>
<td>4.0</td>
<td>1.10</td>
</tr>
</tbody>
</table>

[From Jordon, 1977]
therapy programs at the village level.

MALARIA

General Significance

A World Health Organization study estimated that malaria kills one million people each year (Gardiner, 1984). Despite this large number of deaths, there has been a noticeable improvement in the past three decades; 18 percent of the world's population now resides in areas where malaria has been eliminated (WHO, 86) by drainage of marsh lands; stocking mosquito breeding waters with fish which consume mosquito larvae; and chemical controls including chemotherapy, larvacide and insecticides. These actions have decreased the incidence of clinical cases from 300 million to 100 million per year and reduced the number of countries endemic with malaria from 87 to 50 (WHO, 1986; McJunkin, 1982). These figures indicate remarkable improvements. But there is reason to believe that this trend may have come to an end, for most of the easy victories may have already been won. Drainage of land is only possible under certain hydrologic circumstances and tends to affect only certain species of mosquitos. Several of the insecticides and larvacides, such as DDT, are restricted due to bioaccumulation in mammals while both mosquitos and parasites are quickly becoming resistant to chemical controls (WHO, 1986).
Pathology

Malaria is an illness caused by any of four different strains of the parasite plasmodia. The life cycle of plasmodia consists of two cycles: a sexual cycle which occurs within the insect host and an asexual cycle which occurs within the human or animal host. (Bennenson, 1985)

In the sexual cycle immature male and female cells called gametocytes are ingested by the female anopheles mosquito during a blood meal from an infected vertebrate animal. Once the cells become sexually mature they fuse and imbed themselves into the walls of the mosquito's stomach. In the tissue of the stomach, cysts form within which the parasites multiply and are released into the body cavity of the anopheles mosquito. At this stage the parasites develop into sporozoites and migrate to the insect's salivary gland. During the next blood meal, the sporozoites are injected along with anticoagulants into a warm blooded host. While sporozoites are introduced into the new host, the mosquito is ingesting free floating gametocyte and infected red blood cells, completing the sexual cycle.

The asexual cycle starts with the inoculation of a sporozoite into a mammalian host. The sporozoites migrate to the liver where they asexually replicate producing gametocytes. Some of these cells are released into the bloodstream as immature cells which are ingested by the mosquito
during subsequent blood meals. Other gametocytes invade red blood cells where they replicate, burst out of the erythrocytes, and invade more red blood cells. It is in this cycle that most of the clinical symptoms are observed. These symptoms include chills, sweating, headaches, shock, renal failure, acute encephalitis and coma. Case fatality rates among untreated children and non-immune adults can exceed 10 percent (Bennenson, 1985).

Control Methods

As noted earlier, present control options are now more limited than in the past. Still, promising research is being done in the development of malaria vaccines. Because of the dual cycle involved in the transmission of the plasmodia parasite, three vaccines are required. With experimentation progressing, the availability of such vaccines seems eminent. The actual importance of vaccines in controlling this disease may be limited by cost as well as the relatively short immunization period. Earlier field studies of sporozoite antigen vaccines provided protection for periods up to five months (WHO, 1986; WHO, 1984). Still, it may prove to be one of the most effective ways of controlling seasonal malaria.

Other chemical options concern the development and use of new insecticides. After repeated treatment in Kenya's Kisumu region with fenitrothion during a four year study
period, the daily parasitological inoculation rate was reduced from .00958 infective bites per individual before treatment to .00037 after treatment, a decrease of 96 percent. In two years, general mortality decreased from 23.9 to 13.5 deaths per 1000 population, and infant mortality decreased from 157 to 93 per 1000 live births (Fontaine, 1976; Payne, 1976). Similar results using other insecticides were noted in Sri Lanka, Guyana, Mauritius and Venezuela (Mosley, 1983). These studies suggest that for areas hyperendemic with falciparum malaria, use of insecticides may be an effective way of controlling malaria.

It appears that technical factors such as the use of insecticides for the control of malaria may be more important than non-technical factors in that they may be applied involuntarily to a population while reducing infant mortality by 50 percent (Kouznetsov, 1977). Non-technical factors, such as education, do play a role in situations where malarial control is linked to drug therapy or programs which encourage the elimination of breeding sites. As with Schistosomiasis, non-technical factors often influence the degree of community participation in prophylaxis programs.

This observation is confirmed by a study in southern Ghana which was designed to assess the effects urbanization has had on the prevalence of malaria while specifically examining popular malarial control methods which are to be used.
The study noted a low parasitic rate for an urban district of 1.5 percent positive with low titers of malaria antibodies compared to a rural rate of 23 percent and fairly high titers of malaria antibodies suggesting a significantly greater degree of endemicity for the rural community. The researchers found that the different prevalence rates between the two communities reflected differences in education and affluence. Specifically, in the urban community there was more widespread knowledge about health and disease and greater access to health care facilities.

These factors come together by effecting specific community behavior as noted in Table 8. This study suggests that widespread use of antimalarial drugs has had a significant effect on the prevalence of malaria, particularly the use of chloroquine to treat sporadic febrile episodes and as a regular prophylaxis (Gardiner, 1984). Caution should be applied in supporting such chemotherapy, since as the use of these drugs becomes widespread, the potential for the plasmodia to become resistant to the drug increases. Figure 5. shows the global extent of chloroquine resistant malaria (CDC, 1988).

**Recommendations**

Despite the limitations associated with the use of chemical prophylaxis, in many cases it may be the best option
Figure 5. Distribution of Chloroquine-resistant Plasmodium Falciparum, 1988. [From CDC, 1988]
Table 8. Episodes of Febrile Illness and Antimalarial Practices
Among Residents of Urban and Rural Locations

<table>
<thead>
<tr>
<th>Anti-malaria Practice</th>
<th>Urban (Percent)</th>
<th>Rural (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drugs Taken to Treat Febrile Illness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroquine</td>
<td>64</td>
<td>97</td>
</tr>
<tr>
<td>Other Anti-malarial</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Analgesics/Antipyretics</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Herbal Drugs</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Anti-malarial Drugs Used for Prophylaxis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>63</td>
<td>97</td>
</tr>
<tr>
<td>Type of Prophylactic Drug</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroquine</td>
<td>91</td>
<td>100</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Frequency of Use of Prophylaxis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>77</td>
<td>100</td>
</tr>
<tr>
<td>Irregular</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Use of Anti-mosquito Coils in Bed Room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>Occasionally</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Often</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Daily</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>Use of Anti-mosquito Bed nets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td>91</td>
<td>100</td>
</tr>
</tbody>
</table>

[From Gardiner, 1984]
available for the control of malaria. The Ghana study supports this observation. Other technical solutions, especially with regard to chemical control methods such as the use of insecticides, also appear to be effective in reducing the incidence of malaria as noted in the Kenyan study. Non-technical factors, as noted earlier, do appear to play a role in strategies which emphasize the use of chemotherapy. Such approaches which rely on community awareness developed through educational approaches generate a community wide felt need which enhances participation in control programs.

TRACHOMA

General Significance

In the last century trachoma was a major blinding disease in Europe and North America. Presently it is prevalent throughout the developing world in all climatological regions. It is especially a concern in regions which are relatively dry and dusty. Also it seems to have the greatest impact in low income population clusters which have poor hygiene and overcrowded living conditions (Bennenson, 1985).

Pathology

Trachoma is an eye infection caused by the bacteria
Chlamydia trachomatis. It is characterized by abrupt inflammation of the inner surface of the eyelids followed by vascular invasion of the cornea. If left untreated it can persist for a couple of years. Longer durations are possible if frequent reinfection occurs. Trachoma is unlike conjunctivitis which is a self limiting viral infection, lasting only a few weeks. In more advanced stages of trachoma, there is gross deformity of eyelids and progressive visual disability leading to blindness. Secondary bacterial infections also compound this illness.

Transmission occurs through contact with ocular and nasal discharges. Flies also contribute to the spread of this disease but are not considered the primary transmission route (Bennenson, 1985).

Control Methods

The link between trachoma and water pertains to the availability of water for hygiene purposes. In the Ryuku Islands, trachoma was six times more prevalent (24.3 percent), in a city which had only public stand pipes compared to another city which had house connections where the percent infected was only 4.1 (McJunkin, 1982).

In Mexico, a study was performed on 1097 subjects in two communities where trachoma was prevalent. The most important parameter associated with the occurrence of inflammatory
trachoma in children was the frequency of face washing. Children who washed their faces 7 or more times per week had significantly less trachoma than those who washed less frequently (significance less than 0.001). It is interesting that this effect was independent of age, use of clean water and soap. Children who were infrequent face washers and who used clothes to dry their faces or clean their noses were at greater risk.

With regard to technical issues, water quality was not correlated with either the occurrence of trachoma or the frequency of face washing. Furthermore, in Tanzania it has been noted that up to fifty children can wash their faces with one pint of water (Taylor, 1985). These two observations suggest that technical issues such as water quality and quantity may be less important in controlling trachoma than hygiene practices. Non-technical methods of control seem to be extremely important in checking the spread of trachoma. In fact, face washing is one of the few hygiene practices amenable to change and for which expensive intervention is not required (Taylor, 1985).

**Recommendations**

It appears reasonable to assume that where control methods rely on changes in personal hygiene behavior, non-technical factors, such as health education, will be con-
siderably more significant than the technical factors in reducing prevalence of the diseases. This was noted for the control of Shigellosis and also appears true for trachoma as well.

SHIGELLOSIS

General Significance

Shigellosis can be found in both tropical and temperate climates. This ailment is considered a dangerous disease for several reasons. It has a fairly high mortality rate (5-20 percent) even for hospitalized cases, with most of the deaths associated with children under ten years. Furthermore, several strains of shigellosis are becoming increasingly resistant to multiple antibiotics (Kahn, 1982). This resistance to chemotherapy is of special concern for Shigellosis dysenteria, the most virulent of the Shigellosis strains.

Pathology

Shigellosis is an acute bacterial disorder of both intestines. The causative agent consists of four species of Shigellosis: S. dysenteriae, S. Flexneri, S. Boydii, and S. Sonnei. The symptoms for this illness include diarrhea, fever, vomiting and cramps. The only significant reservoir
for the disease is man, with the most apparent method of transmission being the fecal-oral route. This disease requires the ingestion of very few organisms (i.e., 10-100). Due to the specificity of the host and the transmission route, water, milk, and fly-borne outbreaks are generally related to poor sanitation (Bennenson, 1989).

**Disease Control**

It has been noted in the literature that shigella-caused diarrheas decreased 5 percent with outside house connections but fell 50 percent when sanitation and washing facilities were available within the home (Walsh, 1979). Later studies considered simple methods of intervention such as the use of soap and water. A study in Bangladesh of patients who were confirmed shigellosis cases were matched according to age, sex, social and economic factors. The case group was provided with soap, water and instructions on the importance of hand washing. Table 9 shows the percent of each group with secondary infections, asymptomatic and symptomatic after 10 days. As the data suggest, hand washing had a positive effect in interrupting shigellosis. Comparison of cases which were provided with only potable water and no soap and cases which were provided with just soap and no potable water has shown that the use of soap was a more important factor than water quality. These results are illustrated in
Table 9. Effect Hand Washing has on Secondary Infection of Shigellosis in Bangladesh

<table>
<thead>
<tr>
<th>Carrier State</th>
<th>Percent of Secondary Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>10.1</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>2.2</td>
</tr>
</tbody>
</table>

[From Khan, 1982]
Figure 6. The reduction of shigellosis was less pronounced for Shigella dysentery. This difference on 1097 subjects in two communities where trachoma was prevalent (Sutter, 1983). The most important parameter associated with the occurrence of inflammatory trachoma in children was the frequency of face washing. Children who washed their faces 7 or more times per week had significantly less trachoma than those who washed less frequently (significance less than 0.001). It is interesting that this effect was independent of age, use of clean water and soap. Children who were infrequent face washers and who used clothes to dry their faces or clean their noses were at greater risk.

With regard to technical issues, water quality was not correlated with either the occurrence of trachoma or the frequency of face washing. Furthermore, in Tanzania it has been noted that up to fifty children can wash their faces with one pint of water (Taylor, 1985). These two observations suggest that technical issues such as water quality and quantity may be less important in controlling trachoma than hygiene practices. Non-technical methods of control seem to be extremely important in checking the spread of trachoma. In fact, face washing is one of the few hygiene practices amenable to change and for which expensive intervention is not required (Taylor, 1985).
Figure 6. Secondary Infections of Shigella Species: in Groups Who Used Only Soap or Water. [From Khan, 1982]
Recommendations

It appears reasonable to assume that where control methods rely on changes in personal hygiene behavior, non-technical factors, such as health education, will be considerably more significant than the technical factors in reducing prevalence of the diseases. This was noted for the control of Shigellosis and also appears true for trachoma as well.

CHOLERA

General Significance

Cholera is one of the most dramatic water-borne diseases, primarily due to its sudden appearance when not endemic and its high mortality rate, exceeding 50 percent, if not treated (Bennenson, 1985). For infants, death can occur within 24 hours due to dehydration and circulatory collapse associated with vomiting and diarrhea (Rosenberg, 1977).

Pathology

The causative agent for cholera is the Vibrio bacteria cholera. Specifically cholera can be caused by either classical or El Tor biotypes and Inaba and Ogawa serotypes. Often both are present, but generally during a cholera episode only one strain is dominant. Transmission occurs via the consumption of food or water contaminated by V. cholera
One of the most thoroughly investigated cholera control programs concerns the effects water and sanitation improvements have had in the Matlab, Bangladesh. In this area, diarrhea accounts for about 30 percent of the mortality (Brisco, 1978). An epidemiological study of the cause of death among children under five years of age is shown in Table 10 (Chen, 1980).

These results came from 228 villages containing a 1974 population of 263,000. It is interesting to note that, while children below the age of 5 constituted 16 percent of the population, this same group accounted for 53 percent of all deaths. For this region, the average life expectancy at birth is 50 years. If the child survived to the age of 2, life expectancy increased to 57, and at age five it is 63. Another way of considering these data is that 28 percent of all live births would not survive to their fifth birthday (Chen, 1983). This suggests that infant death is an important health concern in this region, with diarrheal disease being a leading cause of death. It is believed that cholera and other diarrheal diseases are transmitted primarily by contaminated drinking water, which should make it relatively easy to control.

Surprisingly, field studies of the health effects associated with improved water and sanitation produced
Table 10. Cause of Death For Matlab, Bangladesh

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Infant (0-1 year)</th>
<th>Child (1-4 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhoea</td>
<td>19.6</td>
<td>15.1</td>
</tr>
<tr>
<td>Watery</td>
<td>16.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Dysentery</td>
<td>2.8</td>
<td>7.6</td>
</tr>
<tr>
<td>Tetanus</td>
<td>37.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Measles</td>
<td>3.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Fever</td>
<td>7.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Respiratory</td>
<td>10.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Drowning</td>
<td>0.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Skin</td>
<td>1.9</td>
<td>0.04</td>
</tr>
<tr>
<td>Other</td>
<td>62.2</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>142.6</strong></td>
<td><strong>34.3</strong></td>
</tr>
</tbody>
</table>

Rates adjusted per population of 1000
[From Chen, 1980]
counter-intuitive results (Sommer, 1972). Construction of protected wells, referred to as tubewells, did not protect against cholera and non-cholera diarrheas (Levine, 1976). In fact, tubewell users had as much or more illness than non-tubewell users. Details are given in Table 11 (Brisco, 1978). The p-values, in this study suggest that tubewell users had marginally greater risk for cholera and non-cholera diarrheas than non-tubewell users.

Further examination of tubewells produced several important observations. Tubewell water was not considered attractive for a variety of reasons. Tubewells were generally less accessible than surface water sources, they required an effort to pump, and in several cases the yield was inadequate for the population being served (Brisco, 1978; Kawata, 1978). Aesthetic concerns also inhibited use. Immediately after pumping, the water appeared clear but later turned turbid and formed a brown scum which precipitated. There were noted complaints that it caused discoloration of food and clothing and tasted of iron. Considering these facts, it is not surprising to find that only 20 percent of the studied families in the Matlab area used tubewells for drinking water (Black, 1982). Another extremely important observation that may explain the unexpected increase in cholera concerns the frequency of mechanical breakdown. Breakdowns occurred annually 2 to 3 times per well, with an
<table>
<thead>
<tr>
<th>Diarrheal Disease</th>
<th>Incidence Rate (per Population of 1000)</th>
<th>Rate Ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholera Cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubewell Users</td>
<td>14.2</td>
<td>1.7</td>
<td>0.08</td>
</tr>
<tr>
<td>Non-tube Well User</td>
<td>8.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-cholera Cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubewell Users</td>
<td>7.5</td>
<td>2.3</td>
<td>0.07</td>
</tr>
<tr>
<td>Non-tube Well User</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[From Levine, 1976]
average of a 3 week interruption of service for each event (Brisco, 1978). During these down periods, tubewell users had to collect drinking water from sources even more contaminated than those of the non-tubewell users. (Kawata, 1978). The resulting increased exposure may account for some of noted increase in the incidence of cholera.

Additional studies observed that households had multiple sources of water such as tubewells, canals, rivers and tanks. One of the most popular sources of drinking water is tanks, which are rectangular ponds resulting from the removal of earth to build mounds on which houses were built. Tanks are filled by monsoon rains and retain water all year round (Huges, 1982). The utilization of these multiple sources are illustrated in Figure 7.

Further investigations concerning the actual use of different water sources noted that 75 percent of all families had access to tanks, with 50 percent of these people claiming them as sources for drinking water. Tanks were considered so popular that 95 percent of all tubewell users claimed them as their primary source of drinking water (Khan, 1981).

A risk assessment of the relationship of different water sources and cholera demonstrated that risk was high if surface water was used for any purpose. Variation in risk associated with different surface water was related to two factors: the potential of contamination and the potential for
Figure 7. Water Usage of Tubewell Users and Non-users. (From Brisco, 1978)
dilution.

Because tanks are shared by a small number of families they are correlated with a relatively lower risk than more accessible waters. Furthermore, because it was not considered acceptable to wash cloths in tanks which serve as sources of drinking water, custom provided some reduction in risk to 7.8 percent. In contrast, rivers with heavy boat traffic and open latrines had a high rate of infection of 10.4 percent. Canals, which were similar to rivers but with significantly less potential for dilution, were correlated with the highest rates for surface waters, i.e. 13 percent.

Additional microbiological studies of sources revealed that in neighborhoods with cholera infections, 44 percent of surface water sources were positive for V. cholera whereas only 2 percent of surface waters were positive in the control neighborhoods. When cases and controls were reviewed for cholera contamination, individuals who drank from culture-positive sources were just as likely to be infected as those who drank from culture-negative sources but used culture-positive sources for other purposes, such as bathing, washing or cleaning of food (Hughes, 1982). This suggests that alternative routes of transmission were available.

In assessing these studies, it may be useful to consider the relationship of exposure to disease. An interesting way of considering of this association is noted
in Esrey's graph of the dose of a hypothetical enteric pathogen versus the incidence of diarrhoea. The dose-/response curve shown in Figure 8 not only demonstrates an increase in incidence as exposure is increased, but it also makes a distinction between severe cases and mild cases, with severe cases being associated with higher exposures. As exposure is reduced from point F to D, only severe cases are reduced. Only after exposure is reduced to point C will a reduction in mild diarrhoea cases be noted (Esrey, 1983; Brisco, 1986).

Esrey's view of dose/response is interesting although it is questionable that only severe cases occur beyond a specific point of exposure. Considering the variability of human immunogenic responses, especially in populations where nutritional factors and multiple diseases are prevalent, such interesting in that it suggests the existence of a threshold of investment below which little or no health effect will be observed (Shuval, 1981). This threshold becomes greater as the pathogen of interest increases in virulence and as multiple routes of transmission become available.

Vibrio cholera is approximately log-linear with regard to dose/response, that is cholera can be induced by relatively small doses of pathogenic organisms. This implies that exposure to the causative agent must be significantly reduced along all transmission routes, whether it be related directly
Figure 8. Dose-response Relationship for a Community Under Varying Exposure of Enteric Pathogens. (From Esrey, 1983)
to drinking water, or indirectly to more general human exposure to water (ie. bathing, river crossing, fishing) or non-water related exposure (food, fomites, vectors).

With regard to the Matlab studies, multiple transmission routes are possible, making control of cholera a complicated act. In fact, an earlier hypothesis suggested that, because there was no reduction in disease incidence despite improvements in drinking water, the source of infection must be non-water related (Feachem, 1978).

Later microbiological studies performed by Spira, demonstrated that V. cholera could be isolated in 7.8 percent of drinking water samples and 12.9 percent of cooking water samples. The organisms could only be isolated in 0.13 percent of food samples, 0.3 percent of hand rinses and 0.0 percent of utilities and food preparation boards. Spira's Matlab study (1980) suggests that water is still the most significant source of contamination.

A study of bathing and washing practices in Matlab noted that small amounts of water is repeatedly taken into the mouth and the nose, and rinsed. This procedure is accompanied by vigorous hawking and spitting (Brisko, 1978). Ingested water by means of such behaviors are believed to provide a potential route for cholera transmission.
Control Methods

In consideration of all of the studies noted above it seems clear that health effects associated with improvements in water supply and sanitation were confounded by traditional patterns of water use, especially with regard to bathing practices, as well as the use of multiple sources, including the use of canals and rivers which are associated with higher risks (Levine, 1976). From these studies it becomes obvious that, to realize the expected health benefits of any technical solution, it is important to understand all significant routes of transmission as well as verify that the facilities are being fully and singularly utilized.

The fault in the technical solutions lay not with technology itself as much as it concerns the social and cultural context which the tubewells were applied. A better understanding of traditional patterns of water use could have enhanced the expected effects of the technical improvements by including a health education program in the water and sanitation technical package. These observation were confirmed in other studies of the Matlab region. Diarrhoea rates were studied for other factors with protection correlated to education and wealth. On closer examination, protection appeared to be related specifically to such non-technical issues as personal hygiene, nutritional status and degree of overcrowding (Brisco, 1978).
These results are not limited to Bangladesh. A World Bank study states that there appears to be a tenuous link between improvements in health and investments in water supply and sanitation services. These services are necessary but not sufficient to improve mortality and morbidity figures. Other factors such as literacy, level of female education and income are correlated to a greater degree to improvements in health than are improvements in water and sanitation services (Churchill, 1987).

Recommendations

These studies of cholera in Matlab imply that, for a reduction in the prevalence of cholera, a program needs to consider both technical and non-technical factors equally. The technical aspects of the project include the provision for an adequate supply of potable and aesthetically satisfying water, as well as the use of proper sanitary facilities. Important non-technical aspects of the project highlight the need for changes in water-use behavior such that exposure to the pathogen is reduced. These changes in community behavior often require a carefully developed health education program.

GUINEA WORM

General Significance

Guinea worm, also known as Dracontiasis, is a debilitat-
ing skin disease caused by the infectious agent Dracunculus medinensis, a nematode. Guinea Worm is prevalent in many countries in South America, Asia, Africa, the Middle East and the West Indies, with it being more prevalent in regions with dry climates (Bennenson, 1985). This disease is only fatal when a fairly large number of worms inhabit the host or when bacterial infection of the ulcer occurs. At present there is no known cure, and drugs are ineffective in controlling this disease. Generally this illness is not found in breastfed infants below the age of eighteen months.

**Pathology**

In southern Ghana, Guinea worm occurred exclusively in villages dependant upon pond water during the dry season. Infected individuals often have a skin ulcers containing a female worm which may be up to one meter in length. When the carrier wades into a body of water the blister burst and larvae are released which in turn infect the cyclops, a small crustacea. The cycle is completed when the cyclops are ingested by humans. The larvae leave the cyclops while in the human stomach or duodenum and are absorbed into the viscera. After developing into adult worms the male and females nematode mate and the female then migrates to the subcutaneous tissue, usually in the legs. Twelve months after consuming cyclops contaminated water, humans develop
skin ulcers containing the female worm. When larvae produced by this worm burst out of the ulcer and into available surface water the cycle continues (Bennenson, 1985).

Symptoms of the disease include burning and itching of the skin around the lesion, fever, nausea, vomiting and diarrhea. The number of cases have a seasonal peak coinciding with climatic and agricultural activities. The largest number of cases occur near the end of the dry season just prior to the start of heavy rains. During this period cyclops reach their highest population density, while at the same time there is an increase in human activities which require heavy physical exertion, such as clearing fields and planting crops, which increase the consumption of water from infected ponds. Because farmers are working in distant fields, periods between meals are lengthened which may reduce stomach acid production, diminishing a physiological barrier against the Guinea worm larvae (Belcher, 1974).

Control Methods

Any provision of potable water which eliminates human contact with surface water can completely eliminate Guinea worm in a given community. A World Neighbor project in Togo concerned a small rural community where 20 percent of the population was infected with Guinea worm. The common belief was that Guinea worm was caused by witchcraft. Slowly over a
period of 5 years, community members became aware of the water-related nature of the disease through an interactive community education approach. This approach was utilized by a local health committee made up of interested community members and supported by a local hospital and a donor agency. Once the role of water in transmitting Guinea worm was understood by members of the community at large, the necessity to improve water sources became a need felt community wide. This approach allowed the community to participate in problem identification, discuss options, and initiate and fund a solution to the problem (ie, the construction and maintenance of 10 wells), as well as providing for project evaluation.

Table 12 demonstrates that the financial investment for the whole project was very small and shared by the donor group and the community. Most importantly, this approach lead to nearly an 100 percent reduction in the incidence of Guinea worm, as shown in Table 13. This participatory method also led to some unexpected secondary effects. Community members began using the same approach to address other community health problems such as ORT and nutrition (Foly, 1987).

Recommendations

The results from this Togo study imply that non-techni
<table>
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<th>Fiscal Year</th>
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[From Foly, 1987]
<table>
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<th>Year</th>
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(From Foly, 1987)
cal factors such as health education did have an effect in controlling Guinea worm. But when health education was combined with technical factors such as the drilling of wells, the disease was almost completely eliminated. It appears that for the complete control of Guinea worm, non-technical activities such as health education and community participation require complimentary technical activities such as the provision of piped water.

SUMMARY

In this chapter different disease control strategies were reviewed for different diseases. Considering the recommendations of all of these studies, disease control strategies appear to fall into three logical categories with regard to technical and non-technical factors. For some diseases, technical factors are the primary and most cost-effective components of disease control, especially where effective chemicals or drugs are available. This would include diseases such as schistosomiasis and malaria. With other diseases, non-technical factors may be the primary components of disease control, especially for diseases where improved personal hygiene is an important control method. This would include diseases such as trachoma and shigellosis. Lastly, for the control of diseases such as cholera and guinea worm a combination of non-technical and technical
factors appears to be equally important.

Such conclusions are useful in generating appropriate strategies for disease control. By careful review of available field studies, the most important factor or combination of factors for the control of a specific disease can be determined. Once this has been done, a proper mix of technical and non-technical services can be offered. In the next chapter, an approach will be developed based on this evaluation of disease control methods to recommend comprehensive strategies for the interagency control of multiple diseases.
A PROPOSED APPROACH FOR THE INTERAGENCY CONTROL OF MULTIPLE DISEASE

INTRODUCTION

It has been shown that both technical and non-technical factors play a significant role in the control of communicable disease. As noted earlier, the development of comprehensive programs which include both of these factors is often impeded by a lack of cooperation and coordination. This chapter will propose an approach to program development that will support comprehensive planning by providing a logical structure designed to integrate interagency efforts to control regionally prevalent diseases.

PROPOSED APPROACH

The phases of the proposed approach are detailed below and graphically illustrated in Figure 9.

Determination of Participating Agencies

For this approach to be effective, appropriate representation of certain agencies is required. The exact makeup of the core planning group should be selected and empowered by the regional political authority, such as a district commission or provincial governor. The core planning group should include personnel from the Ministry of Health, agencies
Determination of Participating Agencies

Assessment of Prevalent Diseases

Analysis of Transmission Processes for Individual Disease

Evaluation of Effective Control Methods

Technical Engineering Medical

Non-technical Education Participation

Optimal Mix of Services

Compilation of Services

Development of a Comprehensive Strategy

Evaluation of Strategy
  Changes in Socio/Economics
  Changes in Technology
  Changes in Vector Resistance
  Changes in Disease Patterns
  Changes in Agency Mix

Figure 9. Flow Chart of the Proposed Approach
responsible for water and sanitation programs, educational organizations, and community support agencies. These representatives provide the diversity of perspectives necessary to generate a realistic and comprehensive strategy. Care should be taken to limit membership of the core planning group so that the group is not ineffective due to its unwieldy size, but as more is known about the diseases to be controlled, inputs from other agencies may also be required. Supplemental agencies may include agricultural ministries, housing commissions, forestry departments, road contractors, non-governmental organizations, private volunteer organizations and other specialty groups. In some cases, even political groups will have to be integrated into the planning process. For example, in Malawi, the Malawian Congress Party (MCP), the singular political organization in the country, supports and controls many community activities and must be included in planning processes if the project is to be politically viable.

Assessment of Prevalent Diseases

By reviewing clinical records of a region, a list of prevalent diseases and the seasons when they are prevalent can be generated. In general, the collection and analysis of this data is the responsibility of the Ministry of Health. These disease listings should be compiled for specific
regions. Even small countries may have very different regions with different priority diseases. In Swaziland, a country with less than 6,000 square miles, there are three distinct environmental regions, with different prevalent diseases associated with each region. For example, in the low-veld region, where the climate is semi-arid and surface water moves relatively slowly, schistosomiasis and malaria are the dominant communicable diseases. In the high-veld, where it is wetter and cooler, diarrhoeal and upper respiratory ailments are more prevalent. The orientation of disease control strategies for the two different regions are necessarily going to be different due to this difference in prevalent diseases.

Setting a criteria for prioritizing diseases is beyond the scope of this research, but such a system of disease ranking has been proposed by Walsh and Warner (1979). To conserve limited resources, Walsh and Warner proposed selective primary health care. In this proposal the diseases were prioritized by four factors; prevalence, morbidity, mortality and feasibility of control (including efficacy and cost). This controversial ranking system has been criticized by many, for such an approach encourages a narrowing of the scope of PHC activities. Such recommendations run counter to the holistic approach intrinsic in most PHC programs (Berman, 1982; Brisco, 1984). The criticism of Walsh and Warner's
proposal suggests that prioritizing of diseases should be the responsibility of the Ministry of Health for each country or region. This allows for the inclusion of a region's unique disease and/or logistic needs as well as permitting tailoring of the program such that a balance can be attained between program resources and the proposed orientation of health care propagated by the government.

**Analysis of Transmission Processes of Individual Diseases**

The next phase of the proposed approach parallels the study of disease control methods highlighted earlier. Each disease is considered separately. Such an analysis should be performed by a panel with representatives from medical, public health and community support agencies. Special emphasis should be placed on the study of transmission routes including studies of how social behavior aids transmission. As noted earlier in the case studies of Matlab, Bangladesh, social behavior studies were critical in understanding the dynamics of cholera transmission and how those dynamics interfered with proposed control programs. Additional information concerning seasonality, geographical and environmental requirements are also necessary in discerning how specific disease spread. The ultimate goal of this phase of the proposed approach is to understand fully the transmission mechanism of the disease such that the importance of dif-
different control methods can be appreciated.

**Evaluation of Control Methods**

The intent of the analysis of individual disease should be to provide necessary information to evaluate control methods. In evaluating different control programs, the effects of technical factors such as engineering and medical activities as well as non-technical activities including education and participation should be isolated and considered separately to assess the significance of each factor. This evaluation should be performed by a committee of experts from all participating agencies: medical, public health, sanitation, water, health education and community organizations. This assessment is dependent upon program evaluations from available literature, expert opinions, and field studies. Lastly, the recommended options should be listed in priority of expected effectiveness.

**Establish Optimal Mix of Services**

From the evaluation of control methods, the optimal mix of technical and non-technical services for a specific disease control program can be recommended. As noted earlier, this mix can be completely technical, completely non-technical or a combination. This appraisal of services must consider constraints of limited resources, availability
of trained personnel or problems of logistics unique to the region for which the planning is being done. At the completion of this phase, recommendations are generated of the specific services to be provided.

The process of analyzing individual diseases and evaluating control methods should be repeated for each of the diseases on the priority disease list. The recommendations for the appropriate mix of technical and non-technical services will be compiled in the following phase.

Compilation and Comparison of Services

This phase of the proposed approach concerns the compilation and comparison of services for all diseases to be controlled. By merging these individual disease control recommendations, it is possible to see where programs overlap and consolidate redundant programs to allow for combined and conditional services. Redundancy, as noted in earlier examples of Malawi's Ministry of Health and Ministry of Works ground water programs, would be detected and avoided during this phase of the proposed approach.

Combined services are activities which are sufficiently similar that they can be merged and instituted simultaneously. Several examples can be identified in the development of health and hygiene educational programs. For example, a region which lists diseases such as trachoma and shigellosis
may want to develop a program which emphasizes hand and face washing. Combining services are also useful for vector control programs which rely on the spraying of pesticides. The creation of a complete list of vectors to be controlled makes selection of appropriate pesticides easier and facilitates scheduling of pesticide applications.

Conditional services are those services which are initiated only after other activities have been completed. An example of this occurred in the refugee camps in Malawi's Mangochi district. Inhabitants of Kalanji and Chumbagame camps were complaining of infestations of bed bugs and insisted on the initiation of a spraying program. At the same time, the sanitation engineer was attempting to improve pit latrine coverage. Infestation of bed bugs, even though it is more an inconvenience than a public health threat, generated a greater community-wide felt need than poor pit latrine coverage. This situation lead to the establishment of a contingent service. Only those homes with pit latrines were sprayed for bed bugs. Subsequent spraying was contingent upon proper upkeep of pit latrines. This encouraged homeowners to participate in the pit latrine program and reduced infestation of several insect vectors.

A comprehensive strategy can only be generated after all of the services are compiled, redundant services are consolidated, all combined services have been grouped and
conditional services are associated.

Development of a Comprehensive Strategy

This stage of the proposed approach uses the compilation of control programs to generate a comprehensive strategy. During this phase, administrative agencies define their specific responsibilities. Such an activity includes personnel and resource evaluations and requires the development of a schedule of activities. At this stage of the proposed approach, coordination can be encouraged between organizations. If a sanitation program requires community participation, for example, it must coordinate its activities with a health education agency whose responsibility lies in educating the community as to the importance of an improved sanitation system. This must be done prior to any construction to generate community support. As noted in the Guinea worm example from Togo, an educated community participates and supports technical solutions effectively. The cornerstone for development of a realistic and comprehensive disease control strategy is the interagency coordination of responsibilities and activities. The importance of this phase of the proposed approach can not be underestimated.

Evaluation of Comprehensive Strategy

Comprehensive health care programs are not static
activities. Because of the dynamic nature of health care planning, frequent reevaluation is required, specifically to redress changes in labor, economics, technologies, vector resistance and disease patterns. Furthermore, as more information becomes available on the effectiveness of the enacted control activities, program modifications may be required.

Changes in social and economic conditions can necessitate changes in disease control strategies. For example, due to fighting in northern Mozambique, transportation of goods and services to Malawi required use of expensive and dangerous overland routes. This led to sporadic shortages of a variety of items. Cement, pipes, pipe fittings, pumps and medical supplies were available intermittently and only in limited quantities. In developing a vector control program, it was difficult to rely on the supply of any particular pesticide, for stocks were regularly depleted and new shipments were received on an erratic basis. Such changes in available resources require regular re-evaluation of disease control strategies, and, in some situations, the comprehensive strategy will have to be reconsidered. If agencies are not able to complete their duties, program adjustments must be made to compensate for such deficiencies.

Technology is also constantly changing. New vaccines are being developed to control the spread of many com-
municable diseases. Pit latrine designs are continually being modified. Pumps are being developed with better maintenance records. Higher pressure plastic pipe is now being manufactured at lower cost. The list of improvements in technology is lengthy. Such changes often necessitate reevaluation of control strategies. Technologies which formally were not cost effective or previously did not exist may later be viable. If the evaluation determines that there have been significant changes in technology, the process will have to be repeated starting from phase 4, the evaluation of effective control methods. This reevaluation of control methods will allow for careful comparison of all available technical options, new and old.

Another consideration concerns the development of immunity of parasites and vectors to pesticides and chemotherapy. These changes in immunity require modification of control strategies. If the evaluation found that the present strategy is ineffective due to vector resistance to treatment, the process will also have to be reinitiated at phase 4 so that the effectiveness of the other options can be reconsidered.

Often changes in human activities, especially the construction of large water resource projects and changes in agricultural practices affect human health and alter disease patterns. As noted in the discussion of schistosomiasis,
several regions of Africa and Asia which previously had no incidence of schistosomiasis are now endemic. Such changes in disease patterns require appropriate programing changes. These program changes can be initiated by repeating the procedure at phase 2, the assessment of prevalent diseases.

Lastly, as information concerning the effects of the imposed disease strategy materialize, modifications in the control strategy will be required. Such activities can be performed easily due to the broad composition of the planning group and frequent meetings. Such reevaluation should be a continuous process. Programs being implemented by engineering and educational agencies to control certain diseases can be regularly evaluated by using medical field personnel to assess changes in disease patterns. If the infrastructure is well supported, such data can be collected and analyzed on a monthly basis.

As mentioned above, the evaluation may recommend the involvement of other agencies. This expansion would reinitiate the proposed process from the first phase, determination of participating agencies. Regional authorities would be consulted and, if appropriate, representation by other organizations could be added. Even though the assessment of revalent diseases and the analysis of transmission processes may not have changed, evaluation of control methods, the mix of services and the compilation and comparison of services
would have to be restudied.

SUMMARY

The phase "comprehensive programming" often brings to mind large expenditures in unwieldy programs (McJunkin, 1987). It is envisioned that the approach being proposed in this chapter will avoid this pitfall. The approach outlines a logical procedure to develop a strategy to control multiple diseases with interdisciplinary resources. These logical steps require the following phases:

1. Determination of participating agencies
2. Assessment of prevalent diseases
3. Analysis of transmission processes for individual diseases
4. Evaluation of effective control methods
5. Establish Optimal mix of services
6. Compilation and comparison of services
7. Development of a comprehensive strategy
8. Evaluation of strategy

Use of the proposed approach should lead to the development of well integrated programs. The integration of programs should reduce duplication of effort and enhance complementary activities. Ultimately, such an approach should produce more
effective disease control programs yielding improvements in community health.
SUMMARY AND CONCLUSIONS

Studies have shown that improvements in water and sanitation in developing countries often do not achieve expected health benefits. These studies demonstrate that investments do not necessarily lead to improvements in health. Interest in this discrepancy between expected and actual benefits prompted this research.

How technical and non-technical factors impact the effectiveness of community health activities was investigated in detail in this research. For technical agencies, such as those dealing with engineering and medical activities, it was shown that there is a preference for resolving community health issues with technical solutions. For engineering agencies, this approach includes a preference for projects which sometimes rely on inappropriate technologies. Similarly, medical agencies seemed to allocate substantial resources to curative activities rather than less sophisticated but more comprehensive preventive health care programs. This reliance on technical solutions restricts an agency's ability to consider all possible activities which affect community health. For health benefits to be realized, comprehensive solutions are required.

A major obstacle to comprehensive problem solving concerns the lack of coordination between agencies. It was
noted that technical agencies often refrain from cooperating even though such efforts can enhance both medical and engineering activities. Engineering programs could be improved by utilizing disease monitoring activities to assess the needs of rural communities. It was also demonstrated that operation and maintenance activities can be improved through better coordination with field medical staff who are directly involved in community activities. Likewise, medical programs can be enhanced via cooperation with engineering agencies by being associated with a popular service, the provision of water. Furthermore, public health programs, such as protection of water sources, drainage activities, and proper construction of pit latrines, water testing and chlorination can be strengthened by utilizing an engineering agency's technical resources.

The role of non-technical factors such as education and community participation have been positively associated with improvements in community health. Even though educational programs often take several years before changes in community behavior become apparent, examples demonstrated that education, specifically culturally appropriate educational techniques, can be effective in addressing health concerns. This seems to be possible even for communities resistant to change.

The role community participation plays in community
health was also studied as a non-technical factor. Programs which merged health education with community participation to generate a community wide felt need appeared to be effective in improving community health. The more productive programs seem to integrate local community health committees and or local infrastructure into the decision making process. Not only were the primary goals of improving community health achieved in several of the examples, but some substantial secondary benefits were also documented. These secondary benefits included improving engineering design, enhancing operation and maintenance activities, and inducing support for such medical programs as immunization campaigns.

From these studies it appears evident that non-technical factors play a significant role in improving community health. In fact, it should be viewed as a significant mistake to develop a program without fully considering the importance of the associated non-technical activities.

Despite the significant benefits associated with cooperation, the findings of this study suggest that coordination is often lacking, with agencies acting independently. This approach appears to be less effective in dealing with community health problems than the more integrated programs studied.

This research further investigated the relationship of technical and non-technical factors by studying disease
control methods of several specific diseases. By careful review of available field studies, the relevant importance of different activities became apparent. In this section of the research, the most important activity or combination of activities for control was determined for six different diseases. This review suggested that disease control strategies fall into three logical categories. For some diseases, technical factors are the primary components of disease control, especially where effective chemical or drug methods of control are available. With regard to certain other diseases, non-technical factors are the primary components of disease control, especially for diseases where improved personal hygiene is an important control activity. Lastly, for the control of other diseases, both non-technical factors and technical factors are equally important and necessary.

This study led to the development of a general planning approach for generating a comprehensive strategy for the interdisciplinary control of multiple diseases. This proposed approach relies upon the following phases:

1. Determination of participating agencies
2. Assessment of prevalent diseases
3. Analysis of transmission processes for individual diseases
4. Evaluation of effective control methods
5. Determination of optimal mix of services
6. Compilation and comparison of services
7. Development of a comprehensive strategy
8. Evaluation of the strategy

It is expected that the proposed approach will assist the development of programs which better integrate technical and non-technical activities. It is also believed that this proposal will reduce the duplication of activities of different agencies and allow for coordination of complimentary activities. Such coordination should lead to better utilization of limited resources and more effective control of diseases. In this way it is hoped that this research can contribute to the global efforts to improve health in developing countries.
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AN EVALUATION OF THE RELATIVE IMPORTANCE OF TECHNICAL AND NON-TECHNICAL FACTORS WHICH AFFECT WATER AND SANITATION PROJECTS IN DEVELOPING COUNTRIES

by

Richard Billings

Committee Chairman: J. Sherrard

Civil Engineering

(ABSTRACT)

Technical factors, such as engineering and medical approaches, and non-technical factors, such as education and community participation, were evaluated with regard to how they affect water and sanitation programs. Benefits and limitations of each factor were assessed to determine which limitations significantly impact the effectiveness of programs. With this appreciation of technical and non-technical factors, case studies of control methods of different diseases were evaluated. This led to recommendations of appropriate mixes of technical and non-technical services for disease control. This evaluation was utilized to develop a planning approach to effectively integrate interagency efforts for the control of multiple diseases.