Potable Water and Village Health: Is Primary Prevention Affordable?

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ECONOMICALLY DEVELOPED NATIONS, by a fortuitous sequence of events, allocated substantial sums to water supply, excreta disposal, and general sanitary measures long before planned efforts were made to establish a rational network of personal health care services. Consequently, primary prevention led the way in the control of enteric diseases, largely because there were no satisfactory alternative strategies.

With the dramatic increase in chemotherapeutic, antibiotic, and other effective palliative treatments that may be delivered by auxiliary health workers to large rural populations in newly developing nations, one observes a reversal of the strategy pursued by economically developed countries in the attack on basic health problems. Fundamental environmental improvements, such as a potable water supply, are secondary in emphasis and in resource allocation. Is this logical?

To examine this issue, we selected the rural area of Fars Province, Iran, where an ambitious village health worker (VHW) project is underway (*1*). The area is convenient for observation by staff of a nearby university medical center. The environmental and socioeconomic circumstances are typical of many rural areas worldwide.

Fars Province has a rural population of 1,003,000, which is distributed among 3,708 villages. Approximately 50 percent of this population lives in villages having 500 or more residents. The economy is based on agriculture—wheat, sugar beet, and citrus fruits—and on sheep raising. The annual per capita income, including the market value of food produced and consumed, is approximately $250. The villages are customarily divided into compounds, each surrounded by a wall constructed of mud. Each compound houses from 2 to 12 residents. Sheep, and occasionally donkeys, are frequently housed in the compound. Animal fecal material is everywhere.

Gastroenteritis, accompanied by diarrhea, is one of the principal causes of disease and mortality among children. These conditions account for 25 percent of the visits to rural outpatient clinics and a significant proportion of hospital admissions among children (*2*). Additionally, the relationship of gastroenteritis to malnutrition and to death from respiratory disease among children has been reported (*3,4*).

Water contaminated with fecal material is a principal means for the transmission of organisms causing gastroenteritis. Consequently, the primary preventive measure for controlling the disease is to free the water supply from fecal contamination and to encourage the use of this supply as the sole source of water for drinking and for preparing food.

To ascertain the extent of available potable water for the primary prevention of gastroenteritis, a sample of villages in Fars Province was surveyed. The survey covered the type and location of water sources, the biological quality of the water, and how the size of the village and the presence of an auxiliary health worker affects these characteristics. The survey findings provide a basis for examination of the practicality of primary prevention as a principal means of controlling gastroenteritis.

Survey Design

Before this study, no assessment of the biological quality of drinking water had been made for Fars Province. The extent of the variability in drinking water quality among villages was unknown. Estimates were sought for the number of villages served by VHWs (40) and for villages not served by VHWs. Since the available sources for conducting the survey were limited, samples of 25 villages with VHWs and 25 without VHWs were selected. The 25 villages without VHWs were selected by geographic random sampling. Sequential sampling of additional villages was planned if the initial sample findings indicated a need for more precise estimates.

The standard total coliform count for the water

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Table 1. Bacteriological quality of water, by type of water supply in 50 villages, Fars Province, Iran, 1977

Source and distribution of water supply	Total coliform count (number per 100 ml)				
	< 10	10–99	100–999	1,000 or more	Total
Well with pipe	0	0	5	7	12
Well, no pipe	0	0	1	24	25
Total wells	0	0	6	31	37
Spring with pipe	1	0	2	0	3
Spring with canal	0	0	0	10	10
Total springs	1	0	0	10	13
Total villages	1	0	8	41	50

supply of each village was determined by use of the membrane coli-count sampler. The validity of this procedure has been thoroughly demonstrated (*5*). The criterion for an acceptable water supply was a coliform count of less than 100 per 100 milliliters. Under the test conditions, this standard was met if each of the 2 aliquots examined for each village was free of colonies or if 1 aliquot was free of colonies and the second had a count not exceeding 1 colony per milliliter. This criterion was liberal. A more rigid requirement would be one that is consistent with the usual standard for potable water—a most probable number of less than 3 colonies per 100 ml.

Water supplies were collected, in sterilized bottles, from the main drinking water collection sites of the individual villages. These samples were packed in ice and delivered to the laboratory within 4 hours. For each sample, water was introduced into the holding chamber of two membrane samplers and treated according to the manufacturers' specifications for total coliform count.

Results

The biological quality of water, according to source of supply, for the 50 villages is shown in table 1. Only one village, with a spring as the source, had potable water for drinking and preparing food. Wells without pipe distribution were all grossly contaminated; all wells with pipe distribution were also contaminated, but to a lesser degree. All springs with canal distribution (generally open canals) were grossly contaminated. Springs with pipe distribution, although contaminated, appeared to provide the best water quality.

The relationship of type of water supply to size of village is shown in table 2. The use of piping to assist in distribution is consistently related to size of population, ranging from 0 percent (0 of 15) for villages of less than 500 to 88 percent (7 of 8) for villages with populations of 2,000 and over.

Concerning the possible impact of the village health worker on the quality of the water supply, the communities served by VHWs were subjected to almost the same risk of contaminated water as communities with-

Table 2. Distribution of villages by population and by type of water supply in 50 villages, Fars Province, Iran, 1977

Source and distribution of water supply	Village population				
	< 500	500–999	1,000–1,999	2,000 and over	Total
Well with pipe	0	3	2	7	12
Well, no pipe	9	13	2	1	25
Total wells	9	16	4	8	37
Spring with pipe	0	3	0	0	3
Spring with canal	6	4	0	0	10
Total springs	6	7	0	0	10
Total villages	15	23	4	8	50

out VHWs, since 98 percent of the villages did not have a potable water supply, as the following table shows.

Coliform count (*number per 100 ml*)	*VHWs*	*No VHWs*
10	1	0
10–99	0	0
100–999	5	3
1,000 or more	19	22
Total	25	25

The VHW-served communities had a significantly higher proportion of pipe-distributed water supplies (10 of 18) than villages without these workers (2 of 19); the distribution of types of water supply was as follows:

Types of water supply	*VHWs*	*No VHWs*	*Total*
Well:			
Piped	10	2	12
Not piped	8	17	25
Total	18	19	37
Spring:			
Piped	3	0	3
Canal	4	6	10
Total	7	6	13
All villages	25	25	50

This difference in proportion was statistically significant. However, the inference that the VHW was responsible for the introduction of the piped distribution was not supported by historical evidence. In each of the villages served by VHWs, the piped distribution existed before the arrival of the VHW or was established through initiative independent of the VHW. In part, this initiative was related to village size. The higher proportion of piped distributions in villages served by VHWs was due to the number of residents. As the following table shows, 6 villages in the VHW sample had 2,000 or more residents in contrast to 2 villages in the non-VHW sample.

Village population	*Village health workers*		
	Yes	*No*	*Total*
< 500	7	8	15
500–999	10	13	23
1,000–1,999	2	2	4
2,000 and over	6	2	8
Total	25	25	50

Discussion

The almost universal contamination of the drinking water available to rural residents of Fars Province indicates a nearly total failure to provide effective primary prevention against gastroenteritis transmitted by water. The authorities in health, national development, and agriculture are aware of the elements necessary for a potable water supply. However, a firm conviction or a policy commitment to the priority of establishing a hygienic base for the promotion of rural health is lacking. As a result, there is no plan for financing and maintaining the necessary system, nor is there a realistic assignment of responsibility to a defined sector of the government for the attainment of this objective.

It is possible that primary prevention, as exemplified by potable water, may be an economically unobtainable objective for developing countries; therefore, secondary efforts, early detection, and remediable intervention may be cost effective. Obviously, disease treatment cannot be equated with disease prevention in terms of benefit to the individual. It is relevant, however, to examine the cost of providing a potable water supply to rural communities in Fars Province—for example, a village of 1,000 residents. The physical elements of a satisfactory system with current cost expressed in U.S. dollars are:

Construction of a well, including adequate cover and encasement (average depth, 15 meters)	$ 1,500
Purchase and installation of a water pump	2,500
Purchase and installation of a tank (reservoir, daily delivered volume, 100,000 liters)	20,000
Distribution to each household (pipe)	11,000
Total	$35,000
Per capita cost	$ 35
Per household cost (average household size = 6.5)	$ 227

The total cost of financing acceptable primary prevention against gastroenteritis is $35 per person and $7 per capita per year, if conservatively amortized over a 7-year period. An annual interest rate of 10 percent on the unpaid balance is used for amortization. The operating cost, including manual chlorination, would be approximately $1 per capita per year. Thus, the capital and operating cost of a potable water supply would be $8 per capita per year, or about 3 percent of the per capita income of the rural family. However, when related to the national per capita income of approximately $2,000, the annual cost of $8 is less than 0.5 percent. When one considers the offsetting benefits of reduced national expenditures for drugs for diarrheal disease, less expenditure of effort by nationally trained and paid auxiliary health workers in the treatment of diarrheal diseases, and fewer pediatric beds for severe diarrheal cases, the investment in potable water can be regarded as a savings rather than an additional cost, whether the cost is levied against the individual or considered as a national obligation.

Since both the nation and the individual have a critical interest in the benefit cost characteristics of a potable water supply, the concept of sharing costs is highly practical and commonly acceptable. The allocation of cost between the national level and the community can be a ratio of 90–10, 75–25, or 50–50, depending on the local economic resources.

The model described for a village of 1,000 would be applicable to villages with populations ranging from 300 to 5,000, with adjustments in scale but with no significant difference in basic elements nor in cost per capita. It should be noted that if the elements of a potable water supply exist—the well, the tank, and the motor—the total cost cited may be more than necessary to obtain a satisfactory water supply.

The provision of a potable water supply for villages of fewer than 300 residents requires careful planning to assure cost feasibility of the general dimensions cited for larger villages. The major elements would include a protected source, a spring, or a well; a pump sufficient to move water at a volume of 25 gallons per capita per day to an appropriate reservoir; a reservoir constructed from locally available materials and by local workers; manual chlorination; and two centrally located distribution points from the reservoir. In the small villages, each household would have the option of extending the distribution system to its compound at its own expense.

The commitment to proceed with the goal of a potable water supply as the essential base for controlling gastroenteritis in rural populations and allocating national funds for this purpose raises the question of which agency or agencies should be responsible for the task and what would be the role of the rural primary health care system in this effort. Fars Province has three sources that could initiate attainment of a potable water supply—the village people, the Ministry of Agriculture-Rural Cooperative Agency, and the Ministry of Health and Social Welfare. Although the villagers should be encouraged to take the initiative, they cannot alone provide the necessary technology, nor can they alone obtain the economy of the large-scale purchase or the standardization of design. The choice of the Ministry of Agriculture or the Ministry of Health as the lead organization generally should rest on the following criteria: (*a*) availability of technical expertise in water supply; (*b*) recent successful administrative relations with rural communities, including logistical capacity in the purchase and delivery of equipment and supplies, and (*c*) ability to enter into cooperative financial relationships with rural communities in joint financing of capital inmprovement projects.

What should be the role of the primary health care worker or team? If the village health worker is trained to perform clinical duties (personal care), he or she inevitably is preoccupied with this function, particularly if it includes responsibilities in midwifery and family planning. This worker cannot be all things to all people. Thus, the concept that the village health worker can be a vigorous expert and leader in environmental hygiene as well as a competent personal care attendant is not realistic.

A sanitarian, closely associated with the authority responsible for establishing potable water supplies and accountable to the health authority, must be included in the rural health team. The pursuit of primary prevention in rural areas through environmental control requires comprehension of technology and attention to detail and logistics. Thus, such responsibility should be assigned to a division within the Provincial health department. The division should have a supervisory unit and a field service consisting of sanitarians (12 grades of general education and 1 year of special training) assigned in a ratio of 1 worker per 10,000 population. The village health worker, based on our observations, should be encouraged to notify sanitarians of any breakdown in water sanitation or in other aspects of environmental hygiene.

Comment

The question, "Is primary prevention affordable?" as it relates to potable water is relevant and requires critical consideration in developing countries. In the area studied, potable water can be established and maintained by an investment of 0.5 percent of the national per capita income or by an investment of 3 percent of the annual income of the rural population to be served. When these costs are balanced against the gains of lower expenditures for drugs, less health worker time, and fewer pediatric beds for diarrheal patients, these modest figures are exaggerated statements of the net costs of potable water.

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