HEALTH IMPLICATIONS OF SOME MAJOR WATER DEVELOPMENT PROJECTS

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Summary

The health implications of water supply are great. People without safe water are vulnerable to water-borne diseases, and those with only a scarce supply of water have difficulty in maintaining a clean body and living environment. In the UK in the mid nineteenth century, it was demonstrated that the supply of clean water drastically reduced the incidence of cholera. Therefore, even in modern times, it is vital for water

utilities to ensure that their facilities can maintain an adequate supply of safe water. There have been many cases of major epidemics caused by supply of polluted water by large water utilities. It is not easy for a policy maker to determine which strategy should be adopted: to construct a large number of water supplies with “reasonably” safe water, or provide a limited number of facilities with perfectly safe water. It is not uncommon in developing countries for part of the public water supply to be by means of communal taps, in addition to house connections, even in large cities. The cost of water supplied through house connections to the users is markedly higher than with communal taps. It is obvious that people who can afford water from house taps can lead a healthier life than those who fetch water from communal taps some distance from their houses. Policy makers need to give careful consideration to the extent to which people should be supplied by house connections versus communal taps.

The water supply system in Phnom Penh in the early 1990s had severely deteriorated as a result of the decade-long conflict. To recover from the disastrous circumstances after the conflict, Japan started the "Phnom Penh Water Supply Project" in 1993 in order to improve the water supply system. The project aimed to fulfill the urgent needs of water and to improve the water quality to meet the minimum needs for Phnom Penh residents. The project was successfully implemented due to effective cooperation between donor countries and international institutions, and by coordination between assistances for infrastructures and that for human resource development, all of which were implemented through the master plan designed on the basis of the Japan’s development survey.

Japan’s industrial structure was drastically changed after World War II, and human excreta, which used to be a valuable resource, caused health problems as well as environmental pollution. High population growth in urban areas, combined with poor public services and infrastructure, caused seriously adverse public health conditions. In order to cope with the health problem, Japan developed the Johkasou system, which greatly contributed to minimizing waterborne infectious diseases.

1. Introduction

When a water supply project is planned, the status of public health in the project area is always reviewed. Where the supply of safe water is scarce or limited, the public health condition of such an area tends to be poor. People who live in such places, have to fetch water from a distant source, so they are unable to maintain a high standard of cleanliness for their bodies and households. Neither bath nor shower is available; food ingredients are not washed to remove parasite eggs from vegetables; newborns and infants are not cleaned each time they excrete; and so forth. In hospitals patients cannot be kept clean enough during their treatment and in the wards, due to the limited amount of water.

It is the norm for international lending agencies to review the status of public health and examine the expected benefits of a water supply project, for which they are intending to lend funds.

Although piped water supply was introduced late in the eighteenth century in the UK, surface water as well as groundwater was supplied without filtration. It took a long time for the sand filtration method, which was invented close to the turn of the eighteenth century, to be widely used. In the 1830s, for example, a water supply company was supplying water abstracted at a point in the Thames River, near where urban wastewater was discharged. The rate of outbreak cases of cholera, where the company was supplying water, was eight times higher there than other areas where cleaner water was supplied.

In a study conducted in 1849 it was revealed that (1) the cholera outbreak rate was 163 per 10 000 inhabitants for whom water taken from a downstream section of the Thames river; (2) it was 47 in people for whom water was abstracted some distance upstream of the above point; and (3) it was only eight when the water was taken from a point further upstream. In an 1842 report, Edwin Chadwick had presented the view that lack of clean water supply was a major obstacle for laborers to acquire cleanliness-minded habits. Low-income families did not even have piped water supply, only unsafe water obtained from wells which were easily contaminated with sewage.

2. Health implication of water supply programs in general

The absence of safe water supplies or their malfunction has significant implication to the health of inhabitants in not only rural but also large urban areas. Thus upgrading in public health can be expected as a result of the provision of or improvements in water supplies. The cryptosporidiosis outbreak in Milwaukee, Wis., USA, which was caused by a malfunctioning filtration plant, and which affected more than 400 000 people in 1993, is well-known.

In general, the impact on health resulting from a given water supply improvement should probably be estimated individually for each project, taking into consideration the health, geographic, climatic, economic, and cultural mix of the project population at that time. In a study in Venezuela, Wagner and Wannoni estimated the rate of reduction in disease, as a result of water supply schemes, at 75%—a figure which they considered conservative. Pyatt and Rogers, in a study of water supply systems in Puerto Rico, assumed that 60% of the recorded typhoid, diarrhea, and dysentery cases reflected actual water-related diseases. If an environment were found which approximated the one investigated by J. Watt *et al*, and if sanitary improvements were introduced which eliminated *Shigella*—a major cause of diarrhea—then an estimate of a two-thirds reduction in diarrheal disease might be justified.

Some attention should also be given to the “mix” program of physical facilities, water use and health education, system maintenance training, and so on, which go into a given investment amount. For example, it is possible that a water supply project in an area may realize health improvement benefits faster or greater than in another area, while using the same amount of financial resources. This difference might be brought about by changing the proportions of the investment such that a larger portion would be spent on water use and health education for the local population and a smaller portion on physical facilities.

White, Bradley and White have provided perhaps the most extensive set of estimates of the proportions of different diseases in rural areas of East Africa, which may be prevented by the introduction of improved water supplies. Overall they estimated that approximately 52% of water-related disease could be avoided if excellent water supplies were available. Table 1 shows a detailed breakdown of their estimates of expected rates of reduction.

Disease	**Reduction**
Typhoid	80
Paratyphoid and other Salmonella diseases	40
Bacillary dysentery	50
Amebiasis	50
Dysentery, unspecified	50
Louseborne typhus	40
Urinary schistosomiasis	80
Intestinal schistosomiasis	40
Schistosomiasis, unspecified	60
Ascariasis	40
Louseborne relapsing fever	100
Leptospirosis	80
Yaws	70
Trachoma	60
Trypanosomiasis (*T. gambiense*)	80
Trypanosomiasis, unspecified	10
Scabies	80
Inflammatory eye diseases	70
Otitis externa	40
Denatal caries	10
Gastroenteritis (age four weeks to two years)	50
Gastroenteritis (over two years)	50
Skin and subcutaneous infections	50
Chronic skin (leg) ulcer	50
Diarrhea of the newborn	50
Tinea	50

Source: Saunders, Robert J. and Warford, Jeremy J., *Village Water Supply*, The Johns Hopkins University Press (1976)

Table 1. Reduction in disease with safe water supply

3. Several aspects for health implication

3.1. Cost of water supply improvement and health

The magnitude and the course of investments for the improvement of water supplies will surely influence the performance of the project. While some countries, such as Trinidad and Tobago, opted to construct a water supply system with water treatment facilities, including sand filters, there are other countries such as Myanmar, which supply surface water, admittedly normally not infected by pathogens, with no treatment facilities. In the latter case, more people can benefit from the water supply, even though it is not always safe, than where water supplies are constructed together with treatment facilities. Of course, the cost of each project must be higher with water treatment facilities than without. In the former case, the health of benefiting residents will be drastically improved from the beginning although it takes time for the government of such a country to cover all its land with water supply due to limited financial resources. Even in the latter case, the government would have a plan to upgrade their water supply systems with water treatment plants in the near or distant future. In this case, the total benefits of water supply, with not only quantity but also quality, will be realized slowly.

Figure 1 illustrates two of the possible relationships between health levels (those which can be influenced directly or indirectly by water supply) and the cost of a water supply project. Here, health is measured by a hypothetical index from zero, representing the level of health prior to water supply improvements, to 100, the level of health where there are no diseases related to the water supply. Curve *A* represents a hypothetical case in which health begins to improve rapidly after an initial relatively small, low-cost improvement in the local water supply system, such as protecting an existing supply, digging a series of wells and installing hand pumps, or extending water service into homes. Curve *B* represents a case where a much greater initial investment is required before the significant improvement in health.

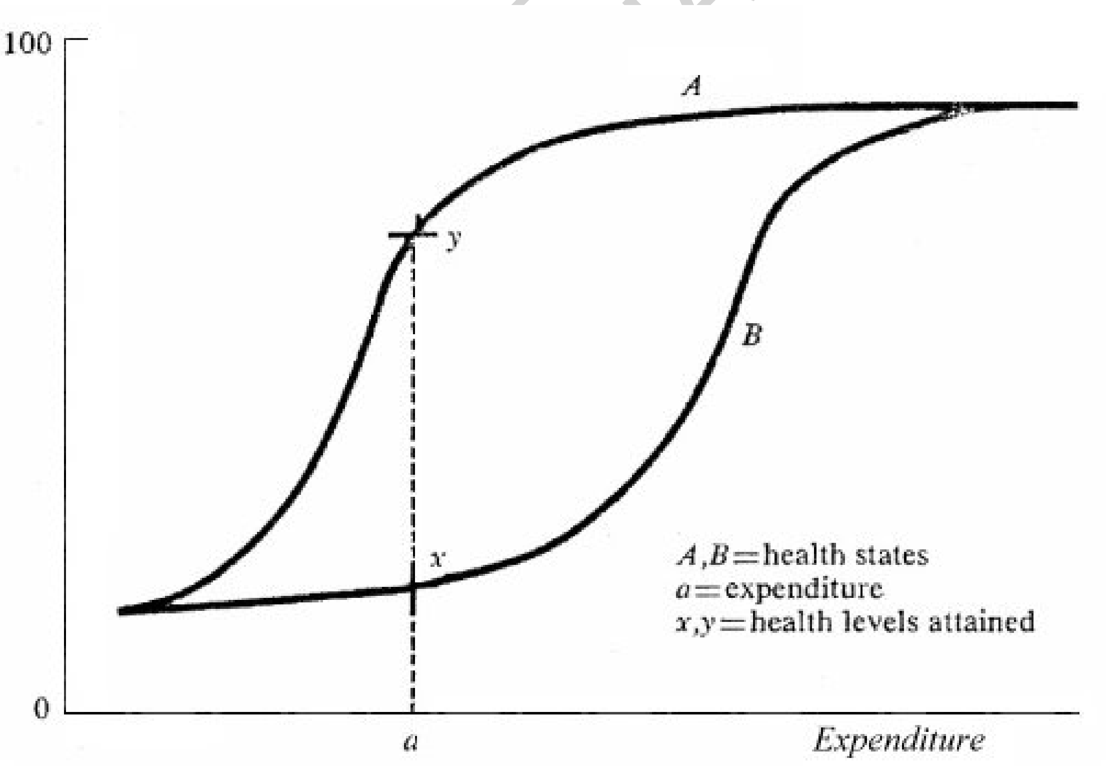

Figure 1. Hypothetical relations between health and cost of water supply.

3.2. Water quality

It is always desirable to design a water supply aiming at a quality of water that is perfectly safe, i.e. pathogen free. In fact, such an objective is not achieved, or not designed as a result of trade-off between the quality of service and the cost. It is debatable whether lower standards of water quality, in order to achieve cost savings, are desirable. It is certainly true that a water supply which sometimes distributes highly contaminated water would not be acceptable. It may be difficult, however, to justify significant expenditure to eliminate marginal taste, color, or odor problems unless these problems make the water absolutely unacceptable to the consuming population.

Clearly, so-called "reasonably safe" water is better than no water, and the money spent on supplying absolutely safe, tasteless, colorless, and odorless water might be better used by supplying more people with only reasonably safe water. But the choice depends upon one's definition of the term "reasonably safe." It may be a problem, of course, to lower the World Health Organization water quality guidelines in defining what is reasonably safe water. In practice, many countries have either lowered or simply not been able to implement the water quality guidelines suggested by WHO.

As is experienced in such countries as Indonesia and Thailand, the taste of drinking water sometimes matters to consumers more than safety does. In a groundwater supply project in an urban area in Indonesia, the people served by the project did not use the piped water for drinking; instead, they preferred to use water obtained from a nearby polluted stream since the piped water had high hardness and iron, and bad taste. In some parts of rural Thailand, residents like to drink rainwater stored in large pots, often inhabited by mosquito larvae, around the house, even though piped water became available.

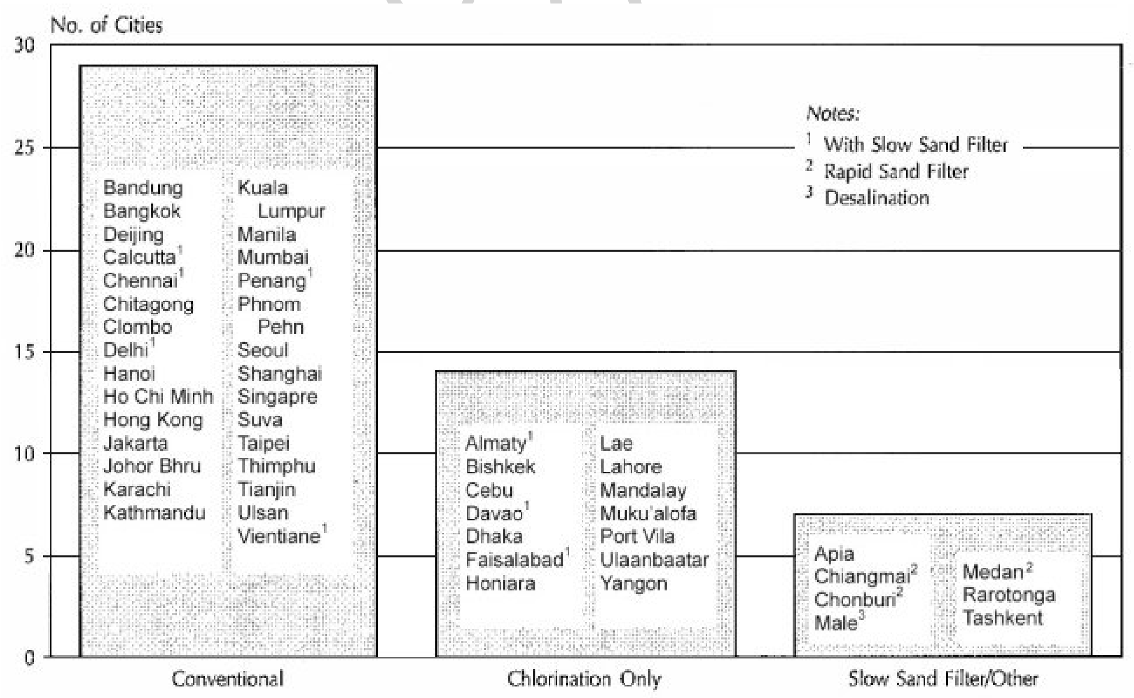

Figure 2. Main water treatment processes in Asian cities

The quality of water supply has no universal solution. In general, groundwater is considered safer than surface water, at least at the source. The best means of handling the problem is probably to approach it afresh for each project, keeping in mind the dual goals of providing so-called reasonably safe water and keeping project costs as low as possible.

Aiming to supply safe water, water supply systems should be designed to be equipped with some water treatment facilities. The level of treatment; however, widely varies from country to country, or from installation to installation. Figure 2 classifies cities by the level of water treatment employed in rather large-scale water utilities in Asia.

3.3. Quantity of water

The quantity of water which individuals consume has been found to be associated with the incidence and prevalence of several diseases common to rural and small urban areas in developing countries. Worldwide, there are great variations in the amount of water consumed as shown by the WHO survey data in Table 2. Urban and rural standpost consumers always consume less than those who have house connections. Rural dwellers, of course, do not have a significant number of water-consuming appliances, and also do not have flush toilets. The major factors influencing their water consumption are: (a) the distance from an individual's dwelling to the water tap, (b) the degree of regularity and reliability of running water, (c) the flow rate or ease of collecting water the tap, and of course (d) the charge (if any) for a bucket of water.

	Urban				**Rural**	
	House connections		**Public standposts**			
	Minimum	***Maximum***	***Minimum***	***Maximum***	***Minimum***	***Maximum***
Africa	65	290	20	45	15	35
Latin America	160	380	25	50	70	190
Eastern Mediterranean	95	245	30	60	40	85
Algeria, Morocco, Turkey	65	210	25	40	20	65
South Asia	75	165	25	50	30	70
Western Pacific	85	365	30	95	30	95
Average	90	280	25	55	35	90

Note: Average daily consumption rounded to nearest 5 liters.

Source: Saunders, Robert J. and Warford, Jeremy J., *Village Water Supply*, The Johns Hopkins University Press (1976).

Table 2. Daily water consumption from community supplies

The relative convenience (or proximity) of a water tap positively influences the health of water users because they tend to consume more water if the tap is near, and because not much water will be stored in containers, where it is prone to contamination. One study in St. Lucia found significant differences in the schistosomiasis infection rates between a group of villages served with individual house taps, public laundry and shower facilities, and public wading pools, and another group of villages served only with widely dispersed public standposts.

In the case of large cities, overall per-capita consumption varies from a meager 16 to 340 liters per day, according to a survey conducted by the Asian Development Bank. Figure 3 shows per-capita consumption in medium-sized cities in Asia.

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Biographical Sketches

Katsuyoshi Tomono is Senior Engineering Adviser of the Environmental Planning Institute, Tokyo Engineering Consultants, Co., Ltd., where he has worked since 1999. He graduated from Hokkaido University and received the degree of Bachelor of Engineering in Sanitary Engineering in 1961. After graduation, he worked for Nihon Suido Consultants, Co., Ltd. from 1961 to 1980. He served as Manager of Design Division with responsibilities for planning, design and construction supervision of water supply and sewer system projects in Japan and abroad, and studies on water treatment engineering and economic evaluation of projects. He then spent seven years as Project Engineer at the Infrastructure Department, Asian Development Bank, until 1987. He was responsible for appraisal and evaluation of bank-financed loan projects in the water supply, sewerage and sanitation sectors. From 1987 to 1999, he worked for the Japan Water Works Association as Senior Researcher for several fields, including development studies on advanced water treatment, high-pressure water service, risk management, etc.
He has authored or co-authored many research articles for the Japan Water Works Association and American Water Works Association, over more than 20 years. The subjects of his study include the art of water treatment in Japan, the costs and benefits of risk management in water supply, the economies of scale in water supply, etc.

Yasumoto Magara is Professor of Engineering at Hokkaido University, where he has been on faculty since 1997. He was admitted to Hokkaido University in 1960 and received the degree of Bachelor of Engineering in Sanitary Engineering in 1964 and Master of Engineering in 1966. After working for the same university for four years, he moved to the National Institute of Public Health in 1970. He served as the Director of the Institute since 1984 for Department of Sanitary Engineering, then Department of Water Supply Engineering. Meanwhile, he obtained a Ph.D. in Engineering from Hokkaido University in 1979 and was conferred an Honorary Doctoral Degree in Engineering from Chiangmai University in 1994. Since 1964, his research subjects have been in environmental engineering and have included advanced water purification for drinking water, control of hazardous chemicals in drinking water, planning and treatment of domestic waste including human excreta, management of ambient water quality, and mechanisms of biological wastewater treatment system performance. He has also been a member of governmental deliberation councils of several ministries and agencies including Ministry of Health and Welfare, Ministry of Education, Environmental Agency, and National Land Agency. He meanwhile performs international activities with JICA (Japan International Cooperation Agency) and World Health Organization. As for academic fields, he plays a pivotal role in many associations and societies, and has been Chairman of the Japan Society on Water Environment.
Professor Magara has written and edited books on analysis and assessment of drinking water. He has been the author or co-author of more than 100 research articles.