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**CELEBRATING 25 YEARS OF ORT**

**COMPLEMENTARY STRATEGIES FOR DECREASING  
DIARRHEA MORBIDITY AND MORTALITY:**

**WATER AND SANITATION**

INTERNATIONAL REFERENCE CENTRE  
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## COMPLEMENTARY STRATEGIES FOR DECREASING DIARRHEA MORBIDITY AND MORTALITY: WATER AND SANITATION

Are water and sanitation a complement to Oral Rehydration Therapy (ORT) or is ORT a complement to Water and Sanitation? We know that ORT is very effective against dehydration and loss of electrolytes from acute watery diarrhea. ORT, however, does not stop the diarrhea or prevent other episodes from occurring. In effect ORT treats acute diarrhoeal disease and prevents death. If we examine the progression of events from health to exposure to disease to death (figure 1), we see that sanitation and water, along with proper hygiene, can not only prevent death, but they can also prevent exposure and disease. As such, these improvements treat health. They not only stop acute watery diarrhea, but they also stop invasive and persistent diarrhea.

Improved sanitation, water and hygiene decrease exposure to pathogens. Most people live at high levels of exposure to enteric pathogens (figure 2). At these high levels, the incidence of diarrhea, both mild and severe cases, is high. Mortality is also high. Improvements in sanitation, water and hygiene can decrease exposure to pathogens, such that the number of cases of disease and death can be reduced. This reduction is achieved by reducing the number of episodes that occur as well as reducing the severity of episodes when they do occur.

Improvements in water, sanitation and hygiene do not necessarily reduce exposure to pathogens to the same extent. Their relative impact against diarrhea morbidity is shown in figure 3. In figure 3 four types of interventions are shown: water quality, water quantity, improved hygiene and improved sanitation. Although these four interventions reduce exposure to pathogens, they do not necessarily reduce exposure by the same mechanism. For instance, sanitation prevents pathogens from gaining access to the environment. Improved quality drinking water reduces pathogens consumed via drinking and perhaps cooking. Better hygiene keeps an environment clean (e.g., hands, food, counters and floors). Thus, these interventions should also be considered complementary to each other.

Evidence from many studies over a period of many years, as shown in figure 3, indicates that the largest reductions in diarrhea can be achieved by improvements in sanitation. The next largest reduction can be achieved by better hygiene, which represents to a large extent better hand washing practices, then more water, and last improvements in the quality of drinking water. Improvements in sanitation and hygiene reduce diarrhea by 33-36%, which achieve the World Summit for Children Goals of reducing diarrheal morbidity by 25%. Not shown in figure 3 is the effect of water and sanitation on total and diarrheal mortality. Evidence indicates that mortality is reduced by 60% and diarrheal mortality by 65%. These reductions are larger than the Summit Goals, which were set at 50%. Because mortality is reduced more than morbidity, this suggests that sanitation, water and hygiene reduce incidence and severity of diarrhea.

A great deal of attention has been focused on access to safe water, usually defined as potable water, sometimes on the premises, but often off the premises. If safe water is so important and central to international efforts, why have the results been so much less than anticipated? First, many pathogens are not waterborne. In figure 4, it can be seen that many outbreaks of pathogens commonly found in children, the lower half of figure 4, are largely the result of non-waterborne transmission. Recent evidence, from 1960-1992, suggests that for every outbreak of cholera that is waterborne, two outbreaks are not waterborne. The data shown in figure 4 likely over-estimate the proportion of waterborne to all outbreaks. First, other sources (e.g., food) of the outbreak may not have been examined. Second, during outbreaks it is also not known if the pathogen in the water caused the outbreak, or if the contaminated

water was the result of an outbreak. Many pathogens known to cause diarrhea, but not shown in figure 4, are not considered to be waterborne pathogens. These factors suggest that the proportion of waterborne outbreaks to all outbreaks is much less than generally assumed.

Water and sanitation efforts have been seen as cost-ineffective, either because of high costs or low effects, relative to other interventions against diarrhea or mortality. This can be explained, in part, by looking at levels of coverage, which are shown in figure 5. Improvements in water supplies, largely improvements in potable water, have kept pace with increases in population since 1980. Improved sanitation, although servicing more people today than in 1980, will actually service a smaller proportion of the world's population by the year 2000 if current rates of coverage continue. Thus, small benefits to diarrhea are being achieved by increasing coverage of potable water, but the gains are probably offset by the relative diminishing coverage of improved sanitation. Better efforts can be made to target certain population groups with certain services to achieve maximum health benefits.

Other reasons for the apparent cost-ineffectiveness of improvements in sanitation and water include: 1) inappropriate type of service being installed, 2) inability to know what level of coverage is necessary, 3) failure to target certain services to population needs and characteristics, and 4) negligence in factoring in all benefits of water and sanitation, not just those due to diarrhea. These are discussed in the next several figures.

The specific effects of water and sanitation have been examined recently for 4857 urban children, 3-36 months of age in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda). The data used for this analysis were collected as part of the USAID funded Demographic and Health Surveys (DHS). The effects from the different levels of service, for both water and sanitation, are shown in figure 6. Compared to no improved service, the largest reductions in diarrhea can be achieved by improvements in sanitation. The average reduction in diarrhea from these data was 25%. Additional benefits can be achieved as people switch from pit latrines to flush toilets, but pit latrines provide a substantial benefit. Community, or public water supplies, provide no benefit in terms of reductions in diarrhea. The benefits are marginal when water is made available on or in the premises. These effects controlled for factors (e.g., socioeconomic status, maternal education, child age and sex as well as other factors) commonly known to affect childhood diarrhea rates.

The effects of reduced diarrhea by bringing water closer to people's home is shown in figure 7. Diarrhea appears to be reduced substantially when water is brought closer to the home. A continual benefit occurs the closer the water is brought to the home. Although in urban areas, few people would have to go far to attain water, these people should benefit when water is brought closer to them.

For improved sanitation, at least in urban areas, 100% coverage may not be necessary to achieve maximum improvements in health (figure 8), as indicated by reductions in the proportion of stunted children, 3-36 months of age. An analysis of DHS data from Guatemala showed that 75% sanitation coverage of communities was sufficient to achieve maximum health impacts even if individual families did not have improved sanitation. When coverage of the community was at least 75%, it did not matter whether the family had an individual improved sanitation system or not. The rates of stunting were similar. Below 75% coverage, the rates of stunting were higher than when the coverage was at least 75%, regardless of whether or not improved sanitation was available. When community coverage was low, less than 75%, it was important to have access to improved sanitation, to reduce stunting in children. Stunting is a consequence of frequent diarrhea and stunting contributes to more severe diarrhea than when a child is not stunted.

Targetting can also occur to maximize health benefits. Data from Malaysia were used to examine the joint contribution of improved sanitation and water to literacy levels of mothers. The effects on infant mortality from these joint improvements are shown in figure 9. First, it can be seen that the effect of sanitation was much larger than the effect for water, regardless of whether or not mothers were literate. For example, the difference in infant mortality from improved sanitation was about 7 times larger than for water, when mothers were illiterate and twice as large when mothers were literate. For improved water, the effects of reducing infant mortality were larger when mothers were literate than when mothers were illiterate.

It does not necessarily follow that improvements in sanitation or water will achieve average effects. As shown for the case in Malaysia, the magnitude of the effects are highly dependent on certain conditions and characteristics of the population. In the case for Malaysia improved sanitation substituted for illiteracy among mothers. Conversely, improved water complemented literate mothers. Few insights have been gained during the previous 15 years on how improved sanitation, water and hygiene complement or compensate for certain prevailing conditions in communities. More needs to be learned.

Sanitation and water are more than interventions for the reduction of diarrheal morbidity and mortality. They are the cornerstone to achieve the World Summit Goals for Children (figure 10). Sanitation, hygiene and water can influence nutrition and health in ways other than a reduction in diarrhea. These interventions also protect females and provide assistance in promoting education.

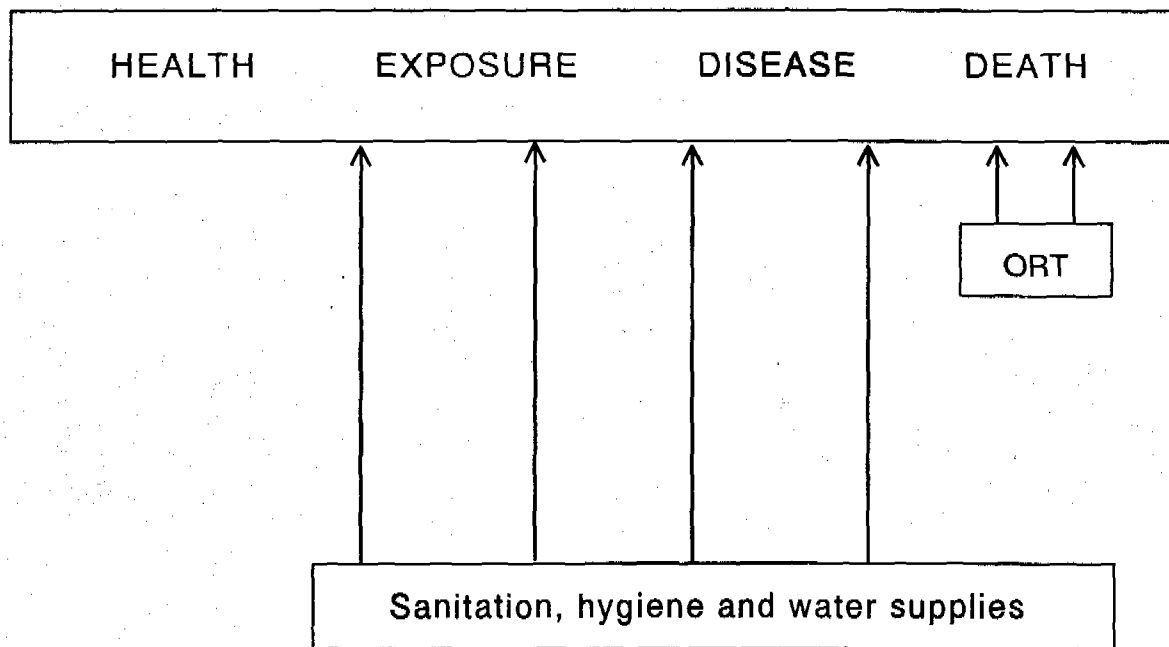
Other demonstrated health impacts include a reduction in other diseases (figure 11). Guinea worm can be eradicated with improvements in drinking water supplies, but ascariasis, schistosomiasis, and trachoma can be significantly reduced also by the provision of improved sanitation, hygiene and water. For those conditions where data were available, it is clear that the severity of these diseases was reduced more than was the incidence or prevalence.

Child nutritional status can also be reduced by the provision of improved sanitation (figure 12). Again, the examination of the DHS data from eight countries showed that among urban children, stunting can be significantly reduced. In the absence of improved water and sanitation, nearly 40% of young children were severely and moderately stunted. Severe and moderate stunting may be reduced by 39% when improved sanitation is made available. This approaches the Summit goal of a reduction by half in childhood malnutrition. The reduction in stunting by the provision of household water was 5%. It has also been reported that when water is brought closer to people's homes or more water is made available, mothers spend more time in food related activities - production, preparation and feeding.

Recently, the energy expenditure of women, by monitoring heart rates, in rural communities in Western Guatemala has been measured. The preliminary results are shown in figure 13. Several observations can be made from these data, observations which suggest that women benefit from improved water supplies. First, these women, who average 44 kg in body weight, expend an enormous amount of energy to get through their days. Second, a large difference in energy expended occurred between those with improved water on the premises and those without improved water supplies. The difference was nearly 1,000 kcal, equivalent to a one-third reduction in energy expended. A third observation was the proportion of energy expended in activities that required much exertion. Without water women expended nearly 2,000 kcal in strenuous activity; this is near the total amount of energy expended by the group of women with improved water. These savings may translate into higher birth weights of offspring and more energy for women to carry out other important tasks.

In summary, improved sanitation, hygiene and water reduce diarrheal morbidity and mortality. The effects of sanitation and hygiene are larger in this respect than for water. Sanitation, hygiene and water can be converted to other benefits in society, such as a reduction in the energy expended by women during the course of a day and saving in time that can be put to improving the health and well-being of all family members. In this respect, improved water is more important than improved sanitation. If the sum of the benefits from improved water, hygiene and sanitation were factored correctly in cost-utility calculations, more attention would be given to these interventions. These interventions would be seen as the cornerstone of development, and ORT would complement them, rather than water and sanitation complementing ORT.

**Figure 1: Effectiveness of Water and Sanitation Interventions  
From Progression of Events From Health to Death**



Esrey, ORT, 1994

Figure 2: Dose-response relationship for young children under various levels of exposure to an array of enteric pathogens

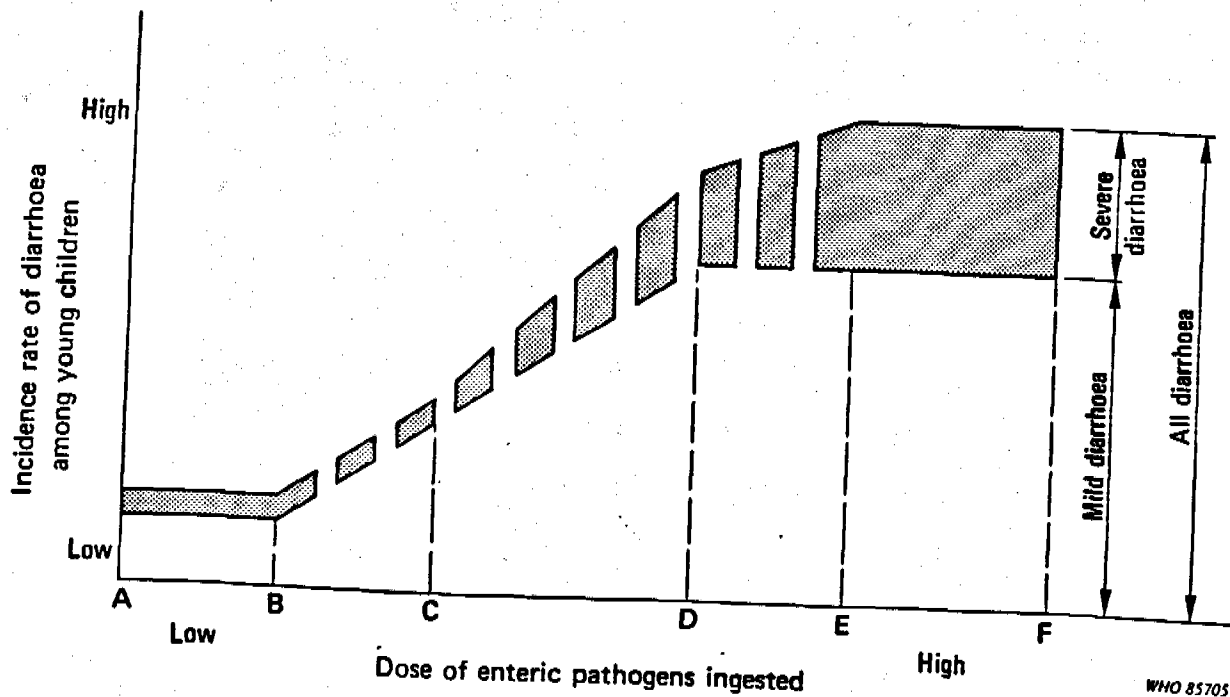
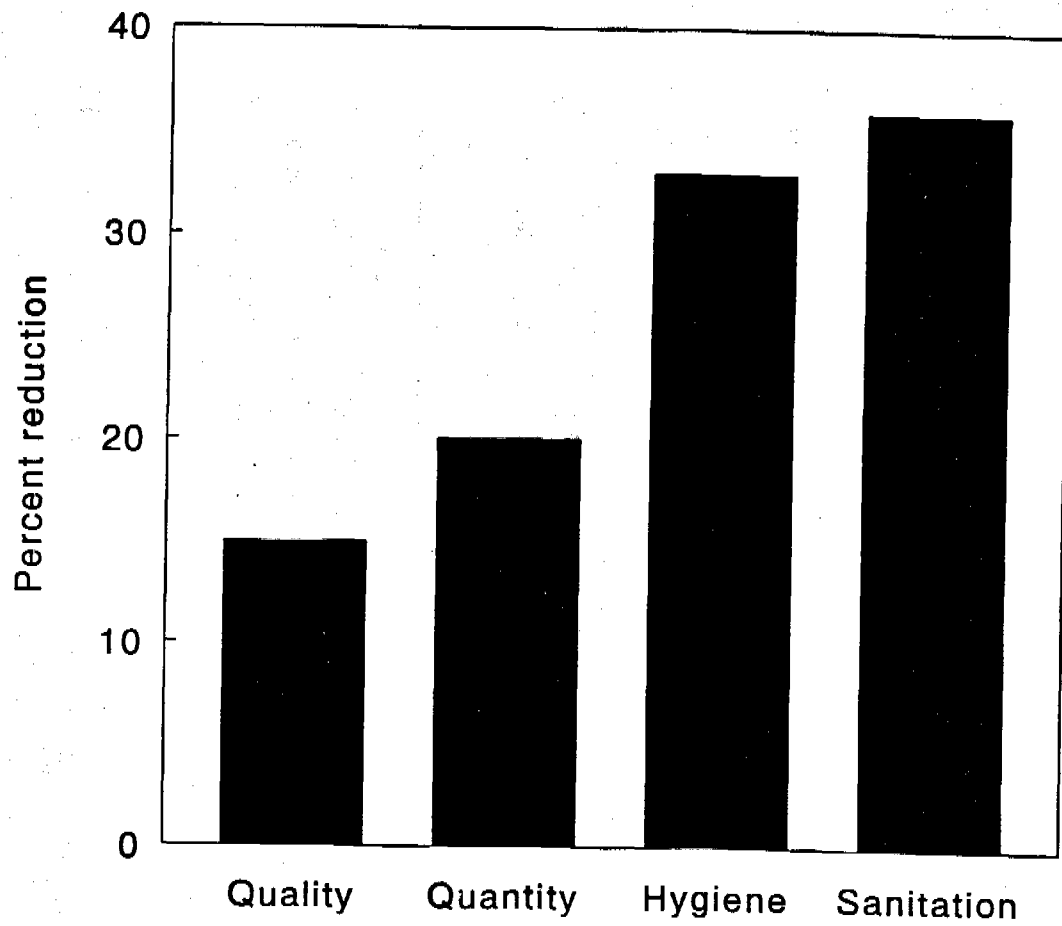


Figure 3: Reduction in diarrhea incidence by type of intervention



Esrey, ORT, 1994

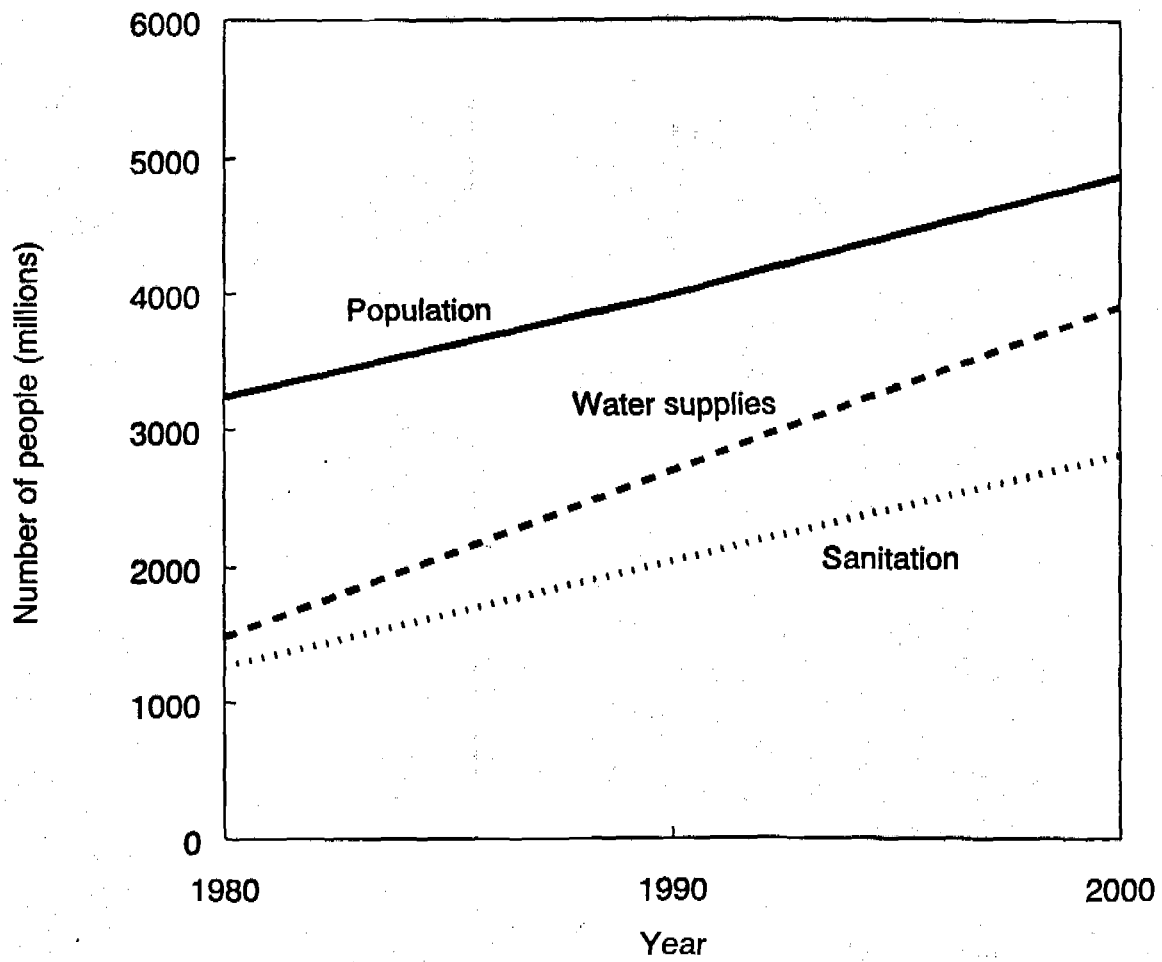


Figure 4: Mortality and tendencies for waterborne transmission across species

<u>Species</u>	<u>Percent mortality</u>	<u>Percent waterborne</u>
<i>V. cholerae</i> , classical biotype	15.7	83.3
<i>Shigella dysenteriae</i>	7.5	80.0
<i>Salmonella typhi</i>	5.8	74.0
<i>V. cholerae</i> , el tor biotype	1.4	50.0
<i>Shigella flexneri</i>	1.3	48.3
<i>Shigella sonnei</i>	0.7	27.8
Enterotoxigenic <i>E. coli</i>	<0.1	20.0
<i>Campylobacter jejuni</i>	<0.1	10.7
Non-typhoid salmonella	<0.1	1.6

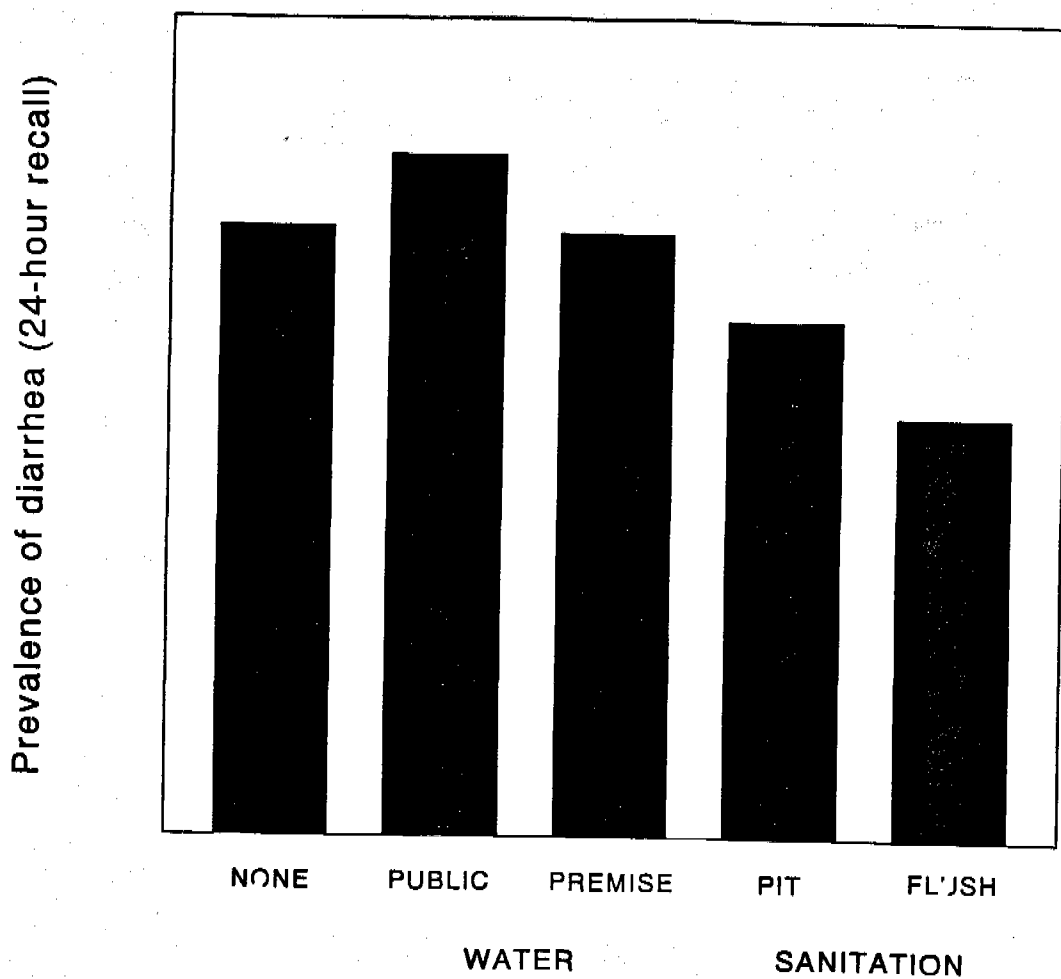
Source: Ewald, *Epi Infect*, 1991

Figure 5: Coverage of sanitation and water supplies by population from 1980 to 2000



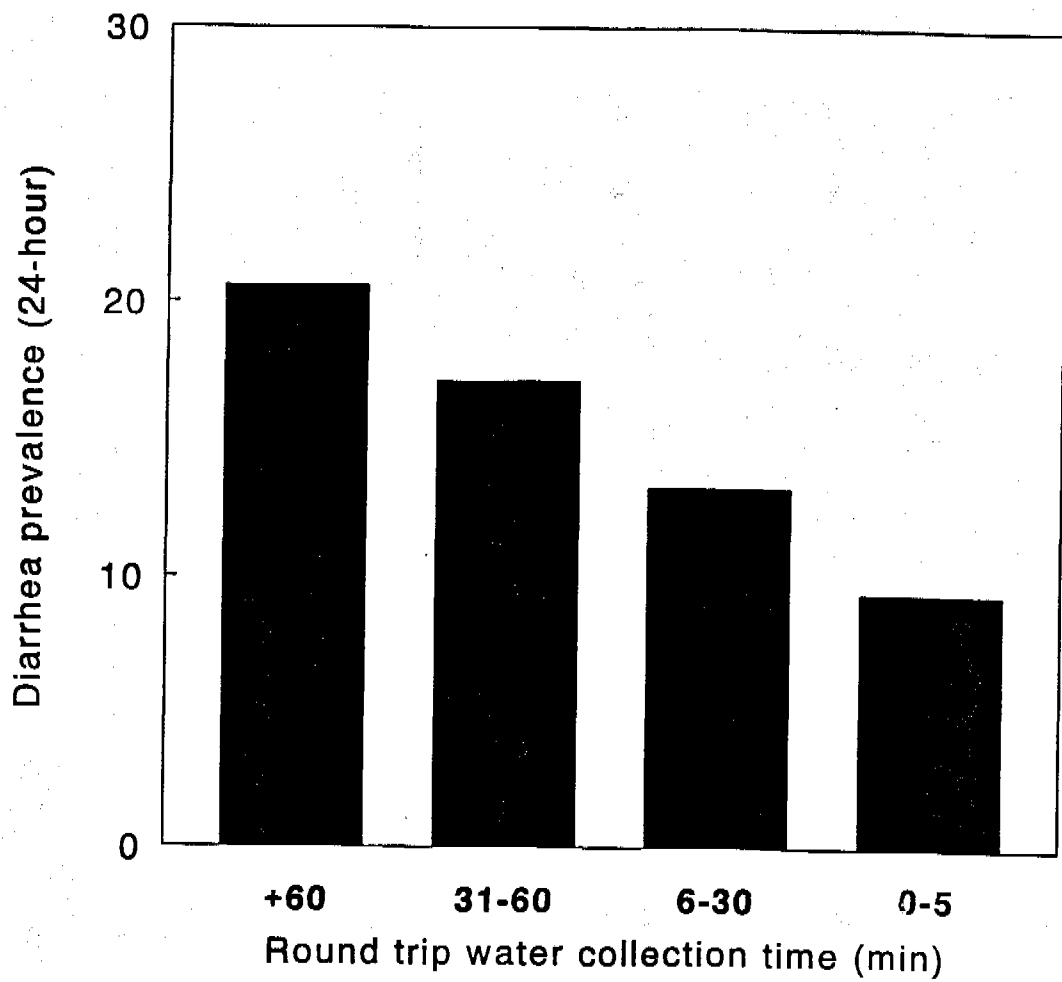
Source: WHO, 1993

**Figure 6: Diarrhea prevalence among 4857 urban children from 8 countries by water and sanitation system**



Esrey, CIDA, 1994

**Figure 7: Prevalence of diarrhea among 4758 rural children by round trip water collection time**



Esrey, CIDA, 1994

Figure 8: Probability of stunting among urban Guatemalan children by level of sanitation coverage - community and individual

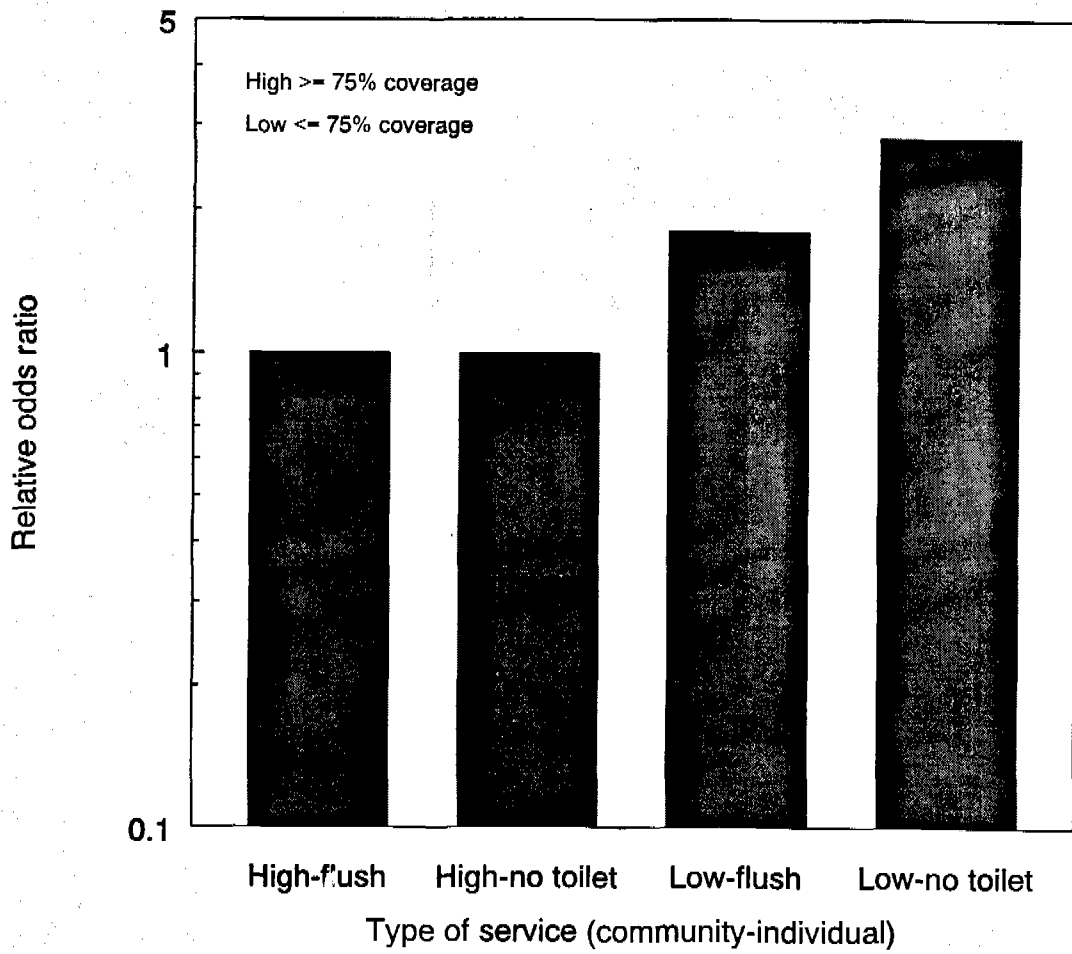
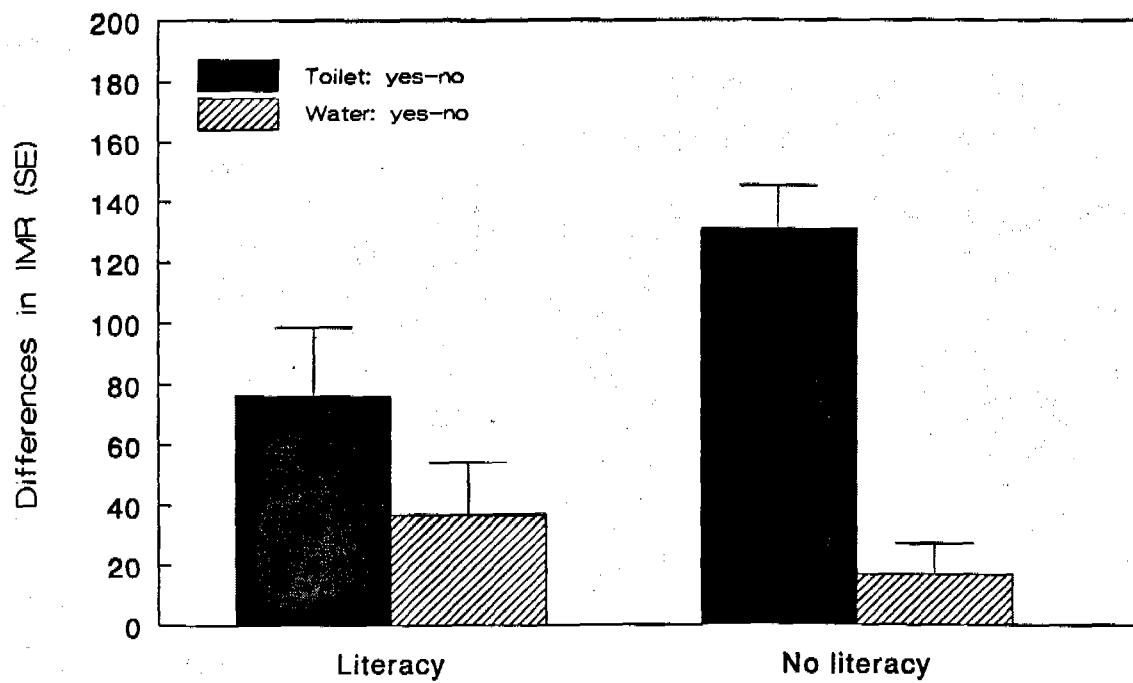
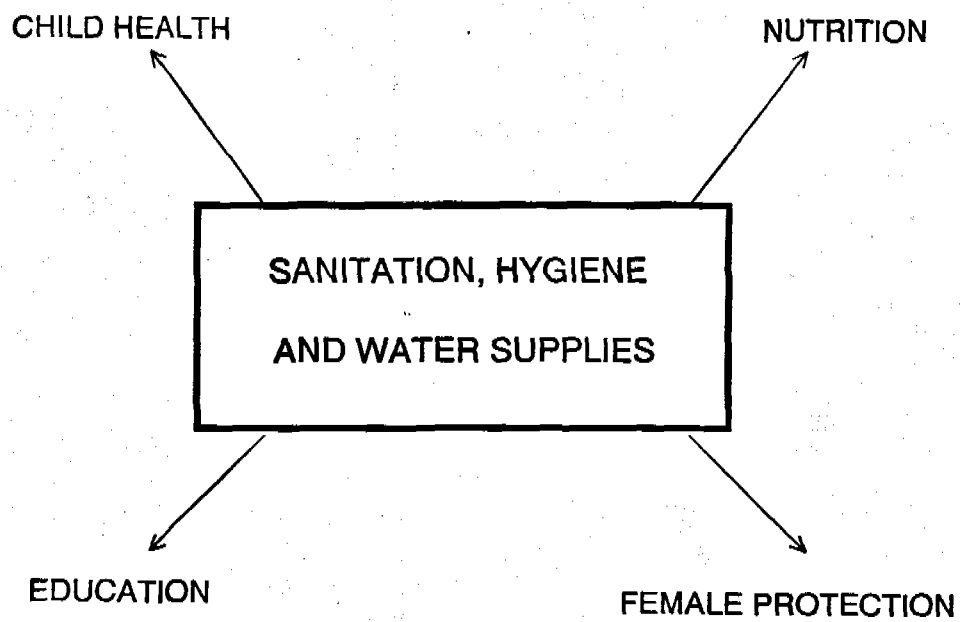


Figure 9: Adjusted effects of water and sanitation and maternal literacy among infants in Malaysia



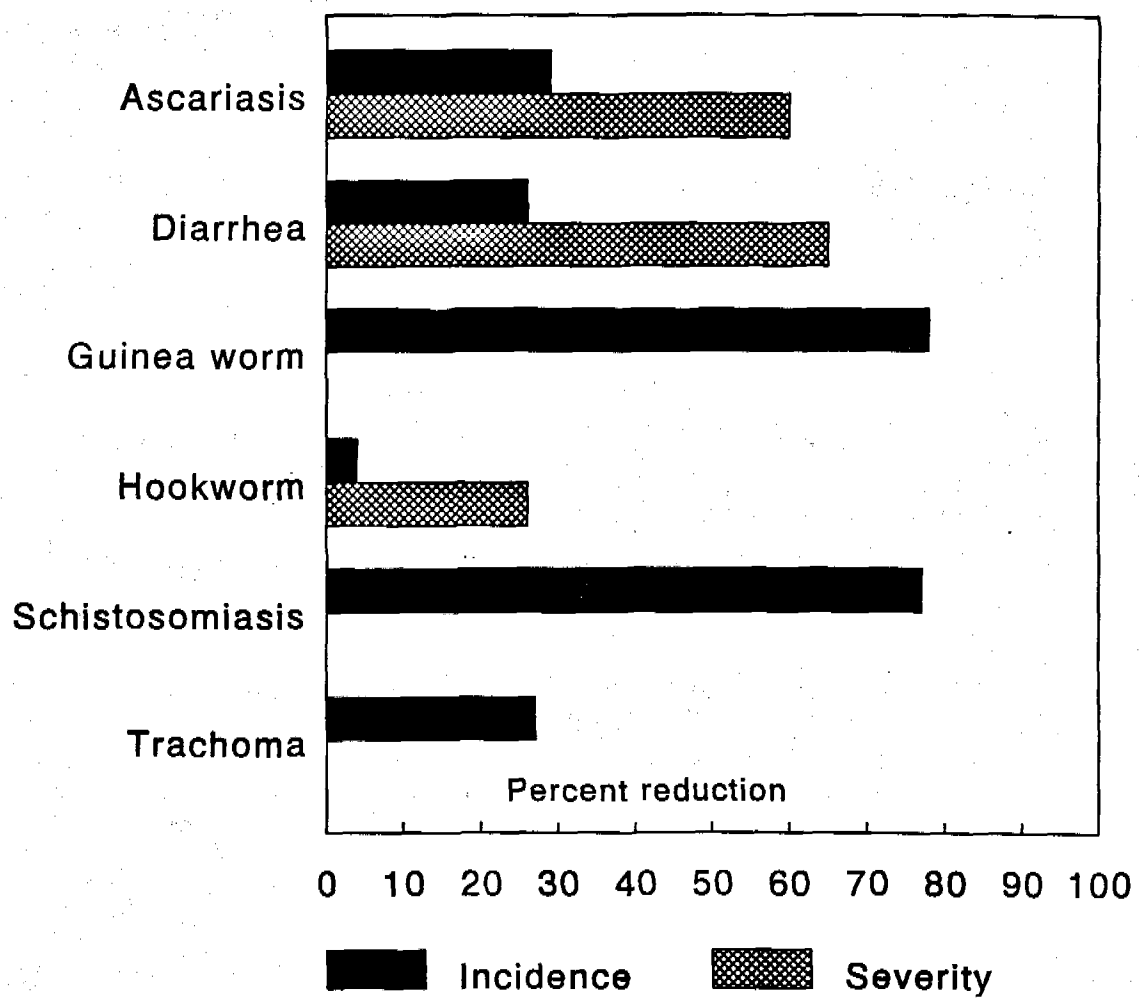
Esrey et al, AJE, 1988

Figure 10: Sanitation, hygiene and water: links to Summit Goals



Esrey, ORT, 1994

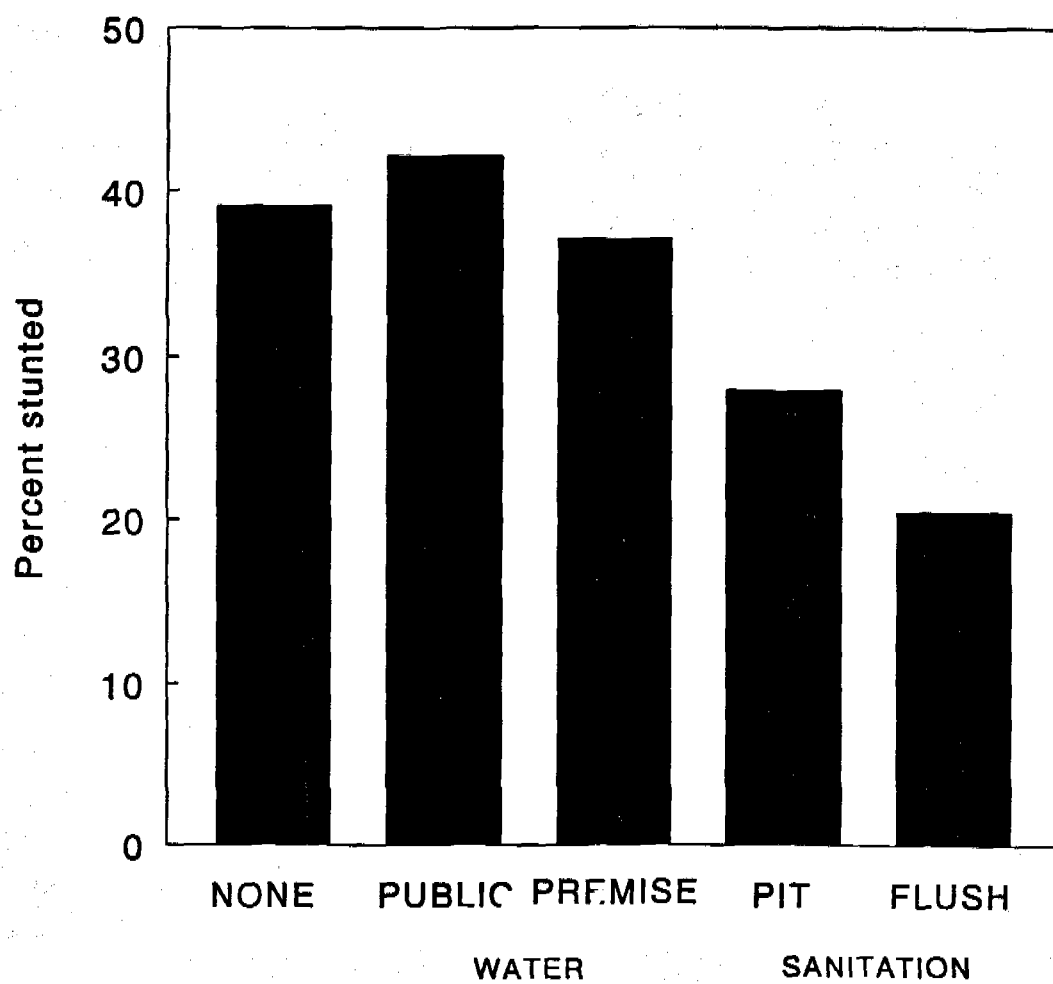
Figure 11: Selected health benefits from improved sanitation and water



Esrey, BULL WHO, 1991



**Figure 12: Percent stunted among 4857 urban children from 8 countries by water and sanitation system**



Esrey, CIDA, 1994

Figure 13: Energy expenditure among rural Guatemalan women by water supply type and adjusted for body weight

