THE IMPACT OF INADEQUATE SANITARY CONDITIONS ON HEALTH IN DEVELOPING COUNTRIES

Sharon R. A. Huttly[1]

The recognition of a link between poor sanitary conditions and cholera infection formed the basis of John Snow's pioneering epidemiological work about 150 years ago. Since then, considerable improvements in access to sufficient clean water and hygienic excreta-disposal facilities in the industrialized countries have drastically reduced the incidence of water- and excreta-related diseases. In the developing world, however, these diseases account for a large proportion of morbidity and mortality, especially among young children, and this is largely attributed to the lack of basic sanitary facilities. In the face of this, the International Drinking Water Supply and Sanitation Decade (1981-1990) was launched amid high hopes of providing global coverage of services.[b] Concerted efforts were undertaken by governments and aid agencies and a variety of schemes were pursued. Review of progress throughout the Decade showed that the original coverage targets would not be realized and that large numbers of people would remain without adequate sanitary facilities by 1990.[c] Aside from advances in technically-related matters, the Decade has brought about an improved understanding of the relationship between poor sanitary conditions and health. This article reviews current knowledge of the major water- and sanitation-related diseases and the potential impact of improved sanitary facilities on health.

Water-supply and sanitation facilities

Coverage

Fig. 1 shows the proportion of developing-country populations with access to adequate water-supply and sanitation facilities according to WHO regions and urban/rural areas as of 1985. Further details are available elsewhere.[d] Most striking are the differences in coverage between urban and rural areas, in each region. In addition, sanitation has received less attention than water supply, especially in rural areas. The proportion of countries reporting that more than half of their population were without access to safe, adequate water supplies was 38% and without adequate sanitation was 46% (compared to 45% and 47%, respectively, in 1980). The global coverage targets for 1990 are 87% and 61% in urban and rural areas respectively for water coverage, with corresponding figures of 78% and 31% for sanitation. It should be noted that these are coverage figures only and do not necessarily reflect the proper functioning or utilization rates of the facilities.

Relationship with poor health

The mechanisms by which water- and excreta-related diseases are transmitted must be understood in order to evaluate the effect of poor sanitary conditions on health and the likely impact of improved facilities. A framework first proposed by Bradley in 1968 *(1)* and modified by Feachem in 1975 *(2)* provided an important advance in this respect. Water-related diseases were categorized as:

(a) faecal-oral (water-borne or water-washed), for example diarrhoeal diseases, infectious hepatitis;
(b) water-washed only, for example scabies, conjunctivitis;
(c) water-based, for example dracunculiasis (guinea-worm disease), trachoma;
(d) water-related insect-vector transmitted, for example malaria, onchocerciasis.

Poor excreta-disposal facilities and hygienic practices are mostly associated with those diseases in categories *(a)* and *(b)*.

Attention has been primarily focused on those diseases transmitted through the faecal-oral route, since they are the most widespread and constitute a large proportion of the morbidity/mortality burden of the population, especially among young children. The faecal-oral route is not confined to one type, however. Transmission through contaminated water, food, hands and eating utensils or via the ground is possible. Hence improvements in water quality and quantity, in excreta-disposal facilities and in hygienic practices, are all important for the interruption of pathogenic transmission.

Potential for health impact

The Decade has brought about a much greater understanding of the mechanisms and magnitude of the impact of water-supply and sanitation interventions on health. Disappointing and conflicting results from a number of health-impact evaluations had led many to believe that the often huge investments necessary were not cost-effective. Thus, especially where resources were limited, water supply and sanitation were assigned a relatively low priority by aid agencies and governments alike. However, many researchers have argued that apart from the basic right of people to a clean and adequate water supply and good sanitation, the health impact of these facilities is complex and therefore not easily seen or understood, but can be substantial nevertheless.

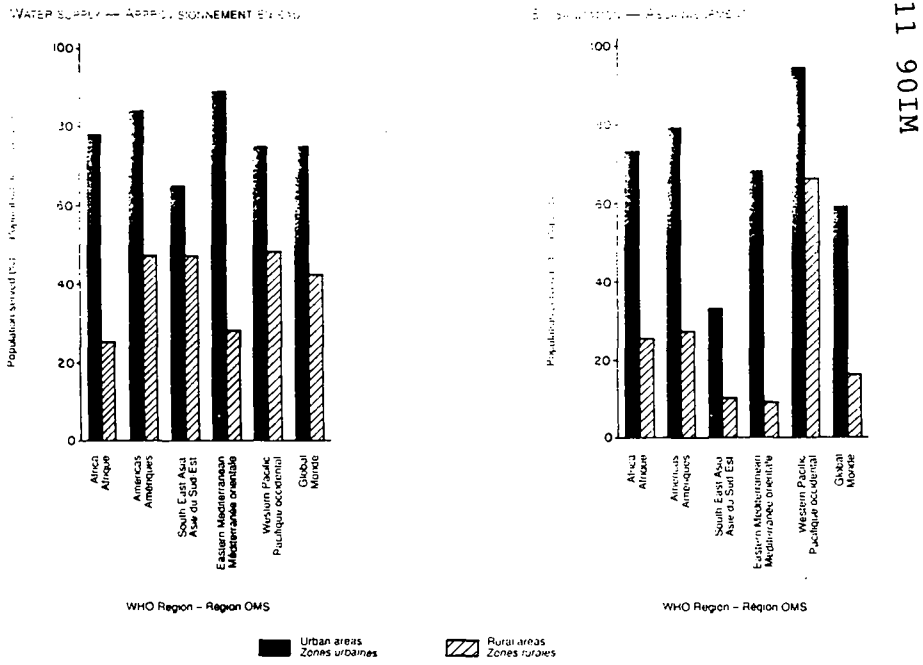
[1] Research Fellow, Maternal and Child Epidemiology Unit, London School of Hygiene and Tropical Medicine, London, United Kingdom

[a] United Nations. *Report of the United Nations water conference, Mar del Plata, March 14-25*. New York, 1977. (Document E/CONF 70/29).

[b] World Health Organization. *Review of progress of the International Drinking Water Supply and Sanitation Decade, 1981-1990: eight years of implementation*. Report by the Director-General. (Document EB83/3, 1988).

[c] World Health Organization. *The International Drinking Water Supply and Sanitation Decade: review of mid-decade progress (as at December 1985)*. (Document CWS/87.5, 1987).

WATER SUPPLY AND SANITATION COVERAGE BY WHO REGION, 1985
COUVERTURE DES SERVICES D'APPROVISIONNEMENT EN EAU ET D'ASSAINISSEMENT PAR REGION OMS, 1985



Firstly, health-impact evaluations of water-supply and sanitation projects are themselves complex to conduct. Although much progress has been made in this area, many studies suffered from methodological flaws which rendered their results difficult to interpret *(3)*. Secondly, extensive reviews *(4, 5)* have concluded several important facts:

- The level of intervention, the functioning and the utilization of services all influence the impact on health.
- Improvements in water quantity and excreta disposal appear more effective than those in water quality alone. It is often the case, however, that several sanitary improvements are implemented together in an integrated programme. Thus, assessing the relative health impacts of individual components is rendered more difficult.
- An integrated approach is often desirable whereby attention is paid to upgrading water-supply and sanitation facilities alongside appropriate education to maximize the use of facilities and improve hygienic practices.
- Most attention has focused on supply rather than demand for services and more anthropological inputs are necessary for understanding non-technical problems, especially in the area of hygienic practices.
- The presence of certain risk factors (for example, low socioeconomic status), and the level of pathogen exposure, also influence health impact.
- Improvements in water-supply and sanitation facilities may be a necessary but not a sufficient condition for improving health *(6)*. That is, aside from any direct impact or not, provision of these facilities may greatly enhance the impact of other interventions on health.

Estimation of the public health impact of adequate sanitary conditions is thus confounded by the above facts. It cannot be assumed, for example, that in populations served by improved facilities, water- and excreta-related diseases will be greatly reduced. A multifactorial approach is needed to bring about the desired benefits.

Water- and excreta-related diseases

As mentioned above, there is a wide range of water- and excreta-related diseases. A review of all these diseases, and the impact of improved sanitary facilities on them, is not feasible here. Instead, those which constitute the major health burden and/or are often the focus of health-impact assessments of water and sanitation interventions are reviewed.

[illegible] as transmitted in diarrhoeal diseases, schistosomiasis, hookworm infections and dracunculiasis (guinea worm disease). Nutritional status is also considered.

Diarrhoeal diseases

Diarrhoeal diseases are common throughout the developing world and are a leading cause of morbidity and mortality in young children. Older children and adults are also affected although the consequences are usually less severe.

Children. Snyder & Merson *(7)* estimated from longitudinal community-based studies that the median incidence rate of diarrhoea in children under 5 was 2.2 episodes per child per year, being higher (3.0) if only studies with frequent surveillance were considered. The annual number of diarrhoea-associated deaths in 1980 was estimated as 4.6 million (13.6 per 1 000 population under 5). Morbidity rates were generally higher in older infants (6-11 months) and children 12-23 months, while mortality peaked in children under 2. Similar trends have been observed in many other epidemiological studies.

More recently, incidence estimates based on 7 350 cross-sectional surveys in 70 countries have yielded a global median incidence rate of 3.4 episodes per child per year.[a] Diarrhoea was estimated to account for 35.8% of all deaths in the under-5s in the period 1981-1986. Based on these and demographic data for 1989,[b] young children in developing countries (excluding China) experience an estimated 1 500 million episodes of diarrhoea per year and 4 million diarrhoea-associated deaths (12.0 per 1 000 population under 5) *(Table 1)*. The morbidity/mortality burden is high in all regions although there is considerable variation. As children in Africa generally suffering the most, it should be noted, however, that there is also substantial variation within regions.

Adults. Community-based data on adult diarrhoeal morbidity are scarce but estimates suggest that incidence rates are 3-5 times lower than those found in children 6-11 months *(8)*. Diarrhoea may also be associated with a sizeable proportion of adult deaths but there are few available data. Three studies from sub-Saharan Africa reported diarrhoea to be associated with 4-21% of adult deaths *(8)*. In women of reproductive age in rural Bangladesh, 10.1% of deaths were due to diarrhoea *(9)*.

Impact of water-supply and sanitation improvements. Most studies have reported the impact on young children (under 5) and so the following discussion is restricted to this age group. In their review of data from 67 studies in 28 countries, Esrey et al. *(4)* found that improved water supplies and sanitation facilities demonstrated a median reduction of 22% in diarrhoeal morbidity rates of children under 5. If only the studies of better quality were considered, the median reduction was 27%. Impact was found to vary according to a number of factors, as noted above.

Data from several more recent studies, in various geographical settings and involving different levels of intervention, have also produced quite varied results. In rural areas of Nigeria and Bangladesh, longitudinal evaluation studies were conducted of integrated water, sanitation and hygiene education programmes *(10, 11)*. In Nigeria, an impact of the project on diarrhoea morbidity was found only in limited subgroups of the population. In Bangladesh, however, diarrhoeal morbidity rates in under-5s, similar prior to the intervention project, became 25% lower in the intervention area than in the control area. Several results are now available from the "new breed" of health-impact evaluation studies, adopting a health-facility-based case-control design. In Malawi and the Philippines, children from families using good-quality water supplies and sanitation [illegible] 25% less diarrhoea *(12)*. The evaluation of a rural sanitation programme in Lesotho, which included a hygiene-education component, showed that in households with a latrine children suffered 24% less episodes of diarrhoea *(13)*. In Sri Lanka, water quality was believed to play an important role in the association found between improved water supplies and diarrhoea *(15)*. Compared to children from families using unprotected supplies, those from families using handpumps or protected traditional wells experienced 6% and 35% fewer episodes of diarrhoea respectively.

In their review *(4)*, Esrey et al. showed a median reduction of 21% in mortality due to all causes associated with sanitary improvements (30% in the better-quality studies). Only two studies (in urban areas) reported on diarrhoea-associated mortality, both showing a positive impact with a reduction of about 40%. More recently, data from rural Bangladesh, adjusted for confounding variables, showed post-neonatal mortality rates to be 68% lower among families with a latrine *(16)*. In an urban area of southern Brazil, the availability of piped water was an important factor—diarrhoea mortality, after controlling for confounding variables, was 79% lower among those children from households with in-house supplies compared to those of households with no easy access to piped water *(17)*.

The infectious dose (ID) of a diarrhoea-causing pathogen (the number of ingested organisms required to cause diarrhoea) varies according to the particular pathogen and various host factors. Esrey et al. *(4)* suggested that water and sanitation improvements would be more likely to have an impact on diarrhoeas caused by high-ID pathogens (for example, cholera) than on those caused by low-ID pathogens (for example, *Entamoeba histolytica*, rotavirus). Their review of etiology-specific impact studies supported this hypothesis, with reductions of over 40% of median and high ID pathogenic diarrhoeas and 0-2% of protozoal diarrhoeas.

As noted previously, there are several routes for the faecal-oral transmission of diarrhoea-causing pathogens. Thus the mechanisms whereby the provision of improved water-supply and sanitation facilities reduce this transmission are recognized as complex and their measurement has not proved easy. For example, while high levels of faecal contamination in food and water are generally assumed to be associated with diarrhoeal diseases, a direct relationship has rarely been quantified *(18, 19)*—perhaps largely because of the difficulties inherent in doing so. Most evidence is indirect, based on observations of diarrhoea and water-pollution seasonality or on peak diarrhoea rates coinciding with the introduction of (contaminated) supplementary foods. Several studies have reported high levels of food and water contamination in the domestic environment *(18, 20-22)*. Even where clean water is supplied, high degrees of contamination occur between the source and use in the home *(14, 23-25)*. This may partly account for the growing evidence that improvements in water quantity or excreta disposal are of greater importance than water quality in the reduction of diarrhoeal diseases *(5, 26)*. Studies of food-handling practices have reported contamination of hands and utensils, as well as of raw foods, as contributing to food contamination.[g] Food preparation and storage [illegible] Uncercooked or [illegible] allow the survival and [illegible] pathogens, as does storage at ambient temperatures. However, little is known about the link between food-hygiene practices and either food contamination with enteric pathogens or the risk of diarrhoea. This uncertainty about the role of food as a diarrhoea-transmission vehicle is acknowledged by Esrey & Feachem[g] who estimated that it may contribute to 15-75% of all diarrhoea episodes.

The above findings also indicate a role for basic [illegible] hygiene education. The introduction of improved water supplies and, in some cases, access to greater quantities of water and suitable faecal disposal facilities, provides an ideal situation for integrated hygiene education programmes and this has been strongly promoted. This broadens the necessary range of skills required in implementing sanitary interventions to include those of anthropologists and communications personnel.

Although evidence is scarce on the effectiveness of hygiene-education programmes, reductions in diarrhoea incidence rates of 14-48% have been reported in a review of three studies *(27)*. In addition, an educational intervention in urban Bangladesh was based on three hygienic practices which had been recorded as associated with high rates of diarrhoea. During the six months following the intervention, diarrhoea incidence rates were 26% lower in the intervention than in the control communities *(28)*. An integrated water, sanitation and hygiene intervention programme in rural Bangladesh examined diarrhoea incidence in relation to household hygienic practices *(29)*. In both the intervention and control areas, diarrhoea incidence rates were inversely related to the number of improved hygienic practices (related to water-source use, disposal of faeces and maternal handwashing) that were reported by the household.

Intestinal helminth infections

Intestinal helminth infections constitute some of the most common in human beings throughout the world, the most prevalent being the soil-transmitted nematode infections. Inadequate sanitation facilities and poor hygienic practices provide for easy transmission via the faecal-oral route. Despite their high prevalence, these infections are generally accorded relatively low priority in health-care planning. Improvements in water-supply and sanitation facilities and appropriate health education, alongside chemotherapeutic treatment, seem to offer the best hopes for control.

The most widespread soil-transmitted nematodes are *Ascaris lumbricoides*, hookworms and *Trichuris trichiura*. The global number of people afflicted with these three infections has been estimated as 1 000 million, 900 million and 500 million respectively *(30)*. Data from a number of geographical areas, however, have shown that infection with *T. trichiura* occurs as frequently as that of *A. lumbricoides (31)*. Simultaneous infection is known to occur often. The number of worms per person (intensity of infection), however, is not uniform, with most people harbouring a few worms and a small number suffering a heavy burden. It is the latter group who are most susceptible to complications, such as intestinal obstruction. Other consequences include poor nutritional status, anaemia and, in the case of *T. trichiura*, bloody and sometimes persistent diarrhoea *(32)*.

[a] World Health Organization. *Seventh programme report, 1988-1989.* Programme for Control of Diarrhoeal Diseases. (Document WHO/CDD/90.34).

[b] World Health Organization. *Global estimates for health situation assessment and projections, 1990.* (Document WHO/HST/90.2).

[g] Esrey, S. A. & Feachem, R. G. *Interventions for the control of diarrhoeal diseases among young children: promotion of food hygiene.* (Document WHO/CDD/89.30).

TABLE 1. ESTIMATES OF DIARRHOEAL MORBIDITY AND MORTALITY AMONG CHILDREN <5, BY WHO REGION (EXCLUDING CHINA), 1989

TABLEAU 1. ESTIMATION DE LA MORBIDITÉ ET DE LA MORTALITÉ DUES AUX MALADIES DIARRHÉIQUES CHEZ LES ENFANTS DE <5 ANS, PAR RÉGION OMS (NON COMPRIS LA CHINE), 1989

	Africa Afrique	Americas Amériques	South-East Asia Asie du Sud-Est	Eastern Mediterranean Méditerranée orientale	Western Pacific Pacifique occidental[a]	Global Monde
Number of countries — Nombre de pays	43	32	11	23	14	123
Number of children <5 (millions) — Nombre d'enfants <5 ans (millions)	87.3	55.0	167.0	64.5	22.8	396.6
Number of episodes of diarrhoea per child per year — Nombre annuel d'épisodes de diarrhée par enfant	4.4	4.6	2.9	3.0	2.5	3.4
Total number of diarrhoea episodes (millions) — Nombre total d'episodes de diarrhée (millions)	383.7	252.6	476.1	193.9	57.3	1 362.6
Percentage deaths associated with diarrhoea[b] — Pourcentage de déces liés a la diarrhée[b]	37.7	35.2	28.3	39.1	29.0	35.8
Number of diarrhoea deaths (thousands) — Nombre de déces dus à la diarrhee (milliers)	1 498	339	1 630	916	129	4 827
Diarrhoea death rate per 1 000 — Taux de mortalité due a la diarrhée (pour 1 000)	17.4	6.0	9.5	14.0	5.5	12.0
Case fatality rate per 100 episodes — Taux de létalité (pour 100 episodes)	0.39	0.12	0.35	0.52	0.23	0.36

[a] Excluding China — La Chine non comprise.

[b] Source: World Health Organization. *Sixth programme report, 1986-1987.* Programme for Control of Diarrhoeal Diseases. (Document WHO/CDD/88.28) (anglais seulement).

Although case-fatality rates are low the sheer magnitude of the prevalence rates and worldwide distribution have led to estimates of *A. lumbricoides* contributing to 150 000 deaths per year *(33)*.

Actual prevalence and intensity rates of these nematode infections differ widely both between and within countries, partly depending on environmental and socioeconomic conditions. Epidemiological studies from many different geographical areas, however, have shown common trends *(34)*. Prevalence or infection rises rapidly in the first years of life, and then levels out in adulthood. Intensity, on the other hand, tends to peak in school-age children for *A. lumbricoides* and *T. trichiura* and in adults for hookworm infections.

Impact of water-supply and sanitation improvements. Despite the acknowledged role of poor sanitary conditions in the transmission of these nematode infections, the impact of improved water-supply and sanitation interventions on them has not been well studied. Data from Saint Lucia showed that prevalences of infections with *A. lumbricoides* and *T. trichiura* in young children were significantly lower in areas with improved sanitary conditions *(35)*, as was reinfection (6 months after chemotherapy) with *A. lumbricoides (36)*. Crowding and type of excreta-disposal facility were the only significant predictors of reinfection found in a multivariate analysis. A study of *A. lumbricoides* and *T. trichiura*, conducted in two urbans slums in Bangladesh, showed lower rates of prevalence, intensity and reinfection (9 months after chemotherapy) among young children in the area with improved sanitation (F. J. Henry et al., submitted for publication). In a rural area of the United Republic of Tanzania, however, a latrine campaign plus treatment against hookworm only resulted in a decrease in the intensity of hookworm infections for up to 6 months after the interventions *(37)*. While in Mozambique, an evaluation of a programme for improved pit-latrine construction showed no association between the type of latrine used and Ascaris infection or presence of Ascaris eggs in the soil *(38)*. The authors concluded, however, that behavioural factors were largely responsible for the apparent lack of impact of the latrines.

Dracunculiasis

Dracunculiasis (guinea-worm disease) has been identified as the only major water-related infection which can be eradicated through water-supply improvements alone. As such, its elimination by 1990 was adopted as a subgoal of the International Drinking Water Supply and Sanitation Decade. Although this target will not be achieved, great progress has been made in this direction and the goal is still seen as attainable, probably within the next decade.

Dracunculiasis is a painful, debilitating disease which confers no immunity and therefore frequently recurs each year through the continued use of infected water supplies. It is endemic in 19 African countries, India, Pakistan, Saudi Arabia and Yemen *(39)*, occurs mostly in remote rural areas and is greatly underreported. It has been estimated that approximately 10 million people are infected each year *(39)*, but accurate data are limited. Recently, however, the Decade has focused attention on the disease in endemic areas and many affected countries have undertaken eradication campaigns and greater surveillance.

Details of the parasite's life cycle and epidemiology of the disease are given elsewhere *(39)*. Adult female worms, ingested through contaminated water, emerge through painful blisters on the victim's skin about 12 months after infection. Although not in itself a fatal disease, complications such as tetanus resulting from secondary infection of the blisters are not uncommon. However, its social and economic consequences are most striking. Incidence rates vary widely in different areas, with some villages reporting up to 70% of their population affected in a year. Cases are most common among the economically active, however, and are usually seasonal, often occurring at critical times in the agricultural calendar. School absenteeism rates have also been noted as markedly higher during "the guinea-worm season". In a prospective study conducted in south-eastern Nigeria, the mean duration of symptoms was 12.7 weeks *(40)*. Severe disability (unable to leave the household compound) was found in 58% of episodes, these severe symptoms lasting 2-12 weeks. While few studies have sufficient data to quantify the economic impact of this disease, losses would appear to be substantial. Rao *(41)* estimated that in India, among the economically active, about 70 days of wages are lost for each episode. Possible indirect impacts on nutritional status have also been suggested.

Impact of water-supply improvements. Rapid declines in the incidence of guinea worm have been noted in countries where eradication campaigns (usually involving some form of water-supply improvement) have been undertaken *(42, 43)*. An evaluation study conducted in mid-western Nigeria showed that within three years of the implementation of handpumps, village point-prevalence rates of dracunculiasis could fall from over 50% to 0% or near 0% *(44)*. Prevalence rates in the control villages remained virtually unchanged. Moreover, the greatest impact was seen in villages with well-sited and correctly functioning boreholes. Socioeconomic benefits, including increased agricultural production, were also perceived by the villagers. In the evaluation of a similar programme in south-eastern Nigeria, the exclusive use of borehole water was inversely related, and the prevalence of dracunculiasis positively related, to the household borehole distance *(10)*. The problem of people consuming contaminated water away from the home, for example while farming, has been noted in these and other studies. This emphasizes the importance of a health-education component.

Nutritional status

Malnutrition is widely prevalent in the developing world due to various interrelated factors such as morbidity, diet, environmental conditions and socioeconomic levels *(45)*. In addition it is a common cause or associated cause of child death. Improvements in water-supply and sanitation facilities may have an impact on nutritional status not only via the well-documented malnutrition/morbidity relationship, but also through more time available for child care *(24, 46, 47)* and greater agricultural production *(44)*. Indeed, Esrey & Habicht[*] have suggested that anthropometric indicators are as sensitive as diarrhoea, indicators to sanitary improvements and can be measured more precisely.

Impact of water-supply and sanitation improvements. Of the six studies reviewed by Esrey et al. *(4)* which investigated the impact of improved sanitary facilities on nutritional status, all showed a positive association (although not always significant). More recently, a water and sanitation intervention in south-eastern Nigeria reported a significant impact in acute but not chronic malnutrition in young children *(10)*. The evaluation of a latrine programme in Lesotho showed that children from households with a latrine had better height-for-age (D. L. Daniels et al., submitted for publication). In Bangladesh, where nutritional status is particularly poor, no such impact by improved water and sanitation facilities was detected despite a significant reduction in diarrhoeal diseases *(48)*. A hygiene-education intervention in urban Bangladesh, aimed at sanitary behaviours such as excreta disposal, similarly showed an impact on diarrhoea but not on nutritional status *(49)*. Other studies have shown associations between water- and sanitation-related factors and nutritional status *(47, 50-52)* but this was not the case in Sri Lanka *(53)*. It appears likely that the potential impact of improved sanitary conditions on nutritional status depends on many other factors, as is the case for diarrhoeal diseases.

Conclusions

The magnitude of the health problems associated with poor sanitary conditions is evident from the above. It is also clear, however, that simply providing a clean, adequate water supply and good sanitation facilities does not automatically result in any significant improvement in health. There are many factors to consider, both in programme design and implementation, and in health-impact evaluation.

One such issue in assessing health impact is the multifactorial nature of most of the major health indicators considered. Indeed, in the case of diarrhoeal diseases it has been suggested that improvements in water supply and sanitation facilities would realize relatively little health benefit in either low or high socioeconomic populations, an appreciable impact only being seen in middle-level communities *(55)*. [illegible] *(54)*. [illegible] *(56)*. [illegible] *(57)*. It has pointed out several flaws in the analytic methods used to assign the impact to water-supply and sanitation improvements. These flaws include misleading cost-effectiveness analyses that fail to take account of the multiple health benefits, direct or indirect, of sanitary improvements. Also, it was concluded that long-term effects on child survival are probably substantial, in addition to the more immediate impacts on morbidity. Thus while it is clear that there are many factors to consider, a major role for improving water supplies and sanitation facilities in development activities seems justified *(6, 57)*.

As the International Drinking Water Supply and Sanitation Decade draws to a close, continued efforts are necessary to reach the many people who still lack coverage by adequate sanitary facilities. The insights gained in recent years into the relationship between sanitary conditions and health are invaluable for future programmes which should capitalize on these experiences. Improvements ranging from more technological aspects (for example, the development of low-cost facilities, appropriate siting of improved water supplies) to more behaviour-related factors (for example, improving the disposal of faeces of young children, who rarely use latrines) can all help combat the appalling morbidity and mortality burden suffered in the developing world.

Acknowledgements

Dr F. J. Henry's contributions to earlier drafts of this article are gratefully acknowledged.

SUMMARY

One of the achievements of the International Drinking Water Supply and Sanitation Decade (1981-1990) is a better understanding of the relationship between poor sanitary conditions and health. This article reviews current knowledge of the major water- and excreta-related diseases and the potential impact of improved sanitary facilities on health.

Four health indicators are considered—diarrhoeal diseases, soil-transmitted nematode infections, dracunculiasis (guinea-worm disease) and nutritional status. These constitute some of the major health problems in the developing world. Although there are large variations in morbidity and mortality rates both between and within geographical areas, some global estimates are presented. Children under 5 experience an average of 3.4 episodes of diarrhoea per year and a diarrhoeal mortality rate estimated at 12 per 1 000, leading to 4 million diarrhoea-associated deaths per year. Diarrhoea may also be associated with a sizeable proportion of adult deaths. Approximately 1 000 million people are believed to be infected with *Ascaris lumbricoides*, 900 million with hookworms and 500 million with *Trichuris trichiura*. Dracunculiasis, primarily occurring in remote rural areas, is known to be greatly underreported, but estimates suggest that 10 million people are infected each year. Malnutrition is widely prevalent and a common cause or associated cause of child death.

The complex issues involved in measuring the health impact of improved sanitary facilities and the mechanisms by which these impacts may occur are discussed. These complexities, plus the differences in sanitary improvements and environmental set-

[*] Esrey, S. A. & Habicht, J. P. *Nutritional anthropometric indicators for evaluating water and sanitation projects.* Paper presented at the International workshop on measuring the health impact of water and sanitation programmes, Cox's Bazaar, Bangladesh, 21-25 November 1983.

things, and the diverse nature of the health indicators considered, all contribute substantial variations in the health impact observed. There is good evidence, however, that sanitary improvements have multiple health benefits, direct and indirect, both in the short and the long term.

The insights gained during recent years into the relationship between poor sanitary conditions and health are invaluable for improving water supply and sanitation programmes. During this time, many recommendations have been made; these include emphasis on technological issues and, increasingly, on behaviour-related factors. An integrated approach has been advocated, involving hardware implementation alongside appropriate education in order to maximize facility usage and hygienic practices and to bring about the desired health benefits.

RÉSUMÉ

Insuffisances de l'assainissement et santé dans les pays en développement

Parmi les succes de la Décennie internationale de l'eau potable et de l'assainissement (1981-1990) figure une meilleure compréhension des relations entre de mauvaises conditions d'hygiène et la santé. Cet article contient un bilan des connaissances actuelles sur les principales maladies liées à l'eau et aux excreta et sur l'impact que pourrait avoir sur la situation sanitaire l'amélioration des services d'assainissement.

Quatre indicateurs sanitaires sont pris en considération: les maladies diarrhéiques, les infestations par les nématodes, la dracunculose (ou maladie due au ver de Guinée) et l'état nutritionnel. Ils représentent certains des principaux problèmes de santé dans le monde en développement. Malgré d'importantes variations des taux de morbidité et de mortalité entre régions géographiques et à l'intérieur de mêmes régions, quelques estimations mondiales sont présentées. Les enfants de moins de 5 ans présentent en moyenne 3,4 épisodes de diarrhée par an et un taux de mortalité par diarrhée estimé à 12 pour 1 000, ce qui correspond à 4 millions de décès liés à la diarrhée par an. La diarrhée peut également être associée à une proportion non négligeable de décès d'adultes. On estime à environ 1 000 millions le nombre des personnes infestées par *Ascaris lumbricoides*, 900 millions par les ankylostomes et 500 millions par *Trichuris trichiura*. Les cas notifiés de dracunculose, qui sévit surtout dans les zones rurales isolées, sont, on le sait, très inférieurs au nombre réel des cas mais, d'après les estimations, 10 millions de personnes seraient infectées chaque année. La malnutrition est très répandue et une cause courante ou associée de mortalité infanto-juvénile.

Les problèmes complexes posés par la mesure de l'impact sur la santé de l'amélioration des services d'assainissement et les mécanismes ainsi mis en œuvre sont passés en revue. Ces complexités, ajoutées aux différences dans les améliorations apportées aux services d'assainissement et les contextes environnementaux ainsi qu'à la diversité des indicateurs sanitaires pris en considération, font que les impacts observés varient sensiblement. Cela étant, il est amplement prouvé que l'amélioration des conditions d'hygiène est à maints égards favorable pour la santé, directement et indirectement, à court et à long terme.

Les études faites ces dernières années sur les relations entre une mauvaise hygiène et la santé ont donné des résultats précieux pour l'amélioration des programmes d'approvisionnement en eau et d'assainissement. Parallèlement, de nombreuses recommandations ont été formulées. Elles privilégient entre autres les aspects technologiques et, de plus en plus, les facteurs liés au comportement. On a préconisé une approche intégrée associant des réalisations concrètes et des activités éducatives appropriées pour optimaliser l'utilisation des installations et les pratiques d'hygiène et obtenir ainsi les résultats attendus sur le plan sanitaire.

REFERENCES — RÉFÉRENCES

1. BRADLEY, D. J. & EMURWON, P. Predicting the epidemiological effect of changing water sources. *East African medical journal*, **45**: 284-291 (1968).
2. FEACHEM, R. G. Water supplies for low-income communities in developing countries. *Journal of the Environmental Engineering Division, Proceedings of the American Society of Civil Engineers*, **101** (EE5): 687-702 (1975).
3. BLUM, D. & FEACHEM, R. G. Measuring the impact of water-supply and sanitation investments on diarrhoeal diseases: problems of methodology. *International journal of epidemiology*, **12** (3): 357-365 (1983).
4. ESREY, S. A. ET AL. Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta-disposal facilities. *Bulletin of the World Health Organization*, **63** (4): 757-772 (1985).

   ESREY, S. A. ET AL. La lutte contre les maladies diarrhéiques du jeune enfant: interventions visant à améliorer l'approvisionnement en eau et l'élimination des excreta [résumé]. *Bulletin de l'Organisation mondiale de la Santé*, **63** (4): 769 (1985).
5. ESREY, S. A. & HABICHT, J.-P. Epidemiologic evidence for health benefits from improved water and sanitation in developing countries. *Epidemiologic reviews*, **3**: 117-128 (1986).
6. BRISCOE, J. A role for water supply and sanitation in the child survival revolution. *Bulletin of the Pan American Health Organization*, **21** (2): 93-105 (1987).
7. SNYDER, J. D. & MERSON, M. H. The magnitude of the global problem of acute diarrhoeal disease: a review of active surveillance data. *Bulletin of the World Health Organization*, **60** (4): 605-613 (1982).

   SNYDER, J. D. & MERSON, M. H. Ampleur du problème des diarrhées aiguës: analyse des données de surveillance active [résumé]. *Bulletin de l'Organisation mondiale de la Santé*, **60** (4): 612 (1982).
8. KIRKWOOD, B. R. Diarrhoea. In: Feachem, R. G. & Jamieson, D. T. (eds), *Disease and mortality in sub-Saharan Africa*. New York, Oxford University Press, 1990.
9. FAUVEAU, V. ET AL. Epidemiology and cause of deaths among women in rural Bangladesh. *International journal of epidemiology*, **18** (1): 139-145 (1989).
10. HUTTLY, S. R. A. ET AL. The Imo State (Nigeria) Drinking Water Supply and Sanitation Project —2. Impact on dracunculiasis, diarrhoea and nutritional status. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **84**: 316-321 (1990).
11. AZIZ, K. M. A. ET AL. Reduction in diarrhoeal diseases in children in rural Bangladesh by environmental and behavioural modifications. *Transactions of the Royal Society of Tropical Medicine and Hygiene: in press* (1990).
12. YOUNG, B. & BRISCOE, J. A case-control study of the effect of environmental sanitation on diarrhoea morbidity in Malawi. *Journal of epidemiology and community health*, **42** (1): 83-88 (1988).
13. BALTAZAR, J. ET AL. Can the case-control method be used to assess the impact of water supply and sanitation on diarrhoea? A study in the Philippines. *Bulletin of the World Health Organization*, **66** (5): 627-635 (1988).

    BALTAZAR, J. ET AL. La méthode cas-témoins peut-elle être utilisée pour évaluer l'impact de l'approvisionnement en eau et des conditions d'hygiène sur la diarrhée? Exemple d'application aux Philippines [résumé]. *Bulletin de l'Organisation mondiale de la Santé*, **66** (5): 635 (1988).
14. DANIELS, D. L. ET AL. A case-control study of the impact on diarrhoea morbidity of improved sanitation in Lesotho. *Bulletin of the World Health Organization*, **68** (4): 455-463 (1990).

    DANIELS, D. L. ET AL. Effets de l'amélioration de l'assainissement sur la morbidité liée à la diarrhée au Lesotho: études cas-témoins [resumé]. *Bulletin de l'Organisation mondiale de la Santé*, **68** (4): 463 (1990).
15. MERTENS, T. E. ET AL. Childhood diarrhoea in Sri Lanka: a case-control study of the impact of improved water sources. *Tropical medicine and parasitology*, **41**: 98-104 (1990).
16. RAHMAN, M. ET AL. Impact of environmental sanitation and crowding on infant mortality in rural Bangladesh. *Lancet*, **ii**: 28-31 (1985).
17. VICTORA, C. G. ET AL. Water supply, sanitation and housing in relation to the risk of infant mortality from diarrhoea. *International journal of epidemiology*, **17** (3): 651-654 (1988).
18. [illegible] contamination of weaning foods and enteropathogenic *Es[illegible]* [illegible] in rural Bangladesh. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **76**: 259-264 (1982).
19. HENRY, F. J. ET AL. Environmental sanitation, food and water contamination and diarrhoea in rural Bangladesh. *Epidemiology and infection*, **104** (1): [illegible] (1990).
20. [illegible] Presence and ecology of infantile diarrhoea and major routes of transmission in Huascar, Peru. *American journal of epidemiology*, **129** (4): 785-799 (1989).
21. ROWLAND, M. G. M. ET AL. Bacterial contamination in traditional Gambian weaning foods. *Lancet*, **i**: 136-138 (1978).
22. HENRY, F. J. ET AL. Bacterial contamination of weaning foods and drinking water in rural Bangladesh. *Epidemiology and infection*, **104** (2): 253-259 (1990).
23. BLUM, D. ET AL. The Imo State (Nigeria) Drinking Water Supply and Sanitation Project. —1. Description of the project, evaluation methods and impact of intervening variables. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **84**: 309-315 (1990).
24. FEACHEM, R. G. ET AL. Pollution, hygiene and health. In: *Water, health and development—An interdisciplinary evaluation*. London, Tri-Med Books Ltd., 1978. (pp. 112-138).
25. HENRY, F. J. & RAHIM, Z. Transmission of diarrhoea in two crowded areas with different sanitary facilities in Dhaka, Bangladesh. *Journal of tropical medicine and hygiene*, **93** (2): 121-126 (1990).
26. CAIRNCROSS, S. The benefits of water supply. In: Pickford, J. (ed.), *Developing world water II*. London, Grosvenor Press, 1987. (pp. 30-34).
27. FEACHEM, R. G. Interventions for the control of diarrhoeal diseases among young children: promotion of personal and domestic hygiene. *Bulletin of the World Health Organization*, **62** (3): 467-476 (1984).

    FEACHEM, R. G. Lutte contre les maladies diarrhéiques chez les jeunes enfants: promotion de l'hygiène personnelle et domestique [résumé]. *Bulletin de l'Organisation mondiale de la Santé*, **62** (3): 475 (1984).
28. STANTON, B. F. & CLEMENS, J. D. An educational intervention for altering water-sanitation behaviors to reduce childhood diarrhoea in urban Bangladesh — II. A randomized trial to assess the impact of the intervention on hygienic behaviors and rates of diarrhoea. *American journal of epidemiology*, **125** (2): 292-301 (1987).
29. ALAM, N. ET AL. Mothers' personal and domestic hygiene and diarrhoea incidence in young children in rural Bangladesh. *International journal of epidemiology*, **18** (1): 242-247 (1989).
30. WHO Expert Committee. Public health significance of intestinal parasitic infections. *Bulletin of the World Health Organization*, **65** (5): 575-588 (1987).

    COMITE OMS D'EXPERTS. Importance des parasitoses intestinales en santé publique. *Bulletin de l'Organisation mondiale de la Santé*, **66** (1): 23-34 (1988).
31. BUNDY, D. P. Epidemiological aspects of Trichuris and trichuriasis in Caribbean communities.