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SELECTIVE PRIMARY HEALTH CARE: AN INTERIM STRATEGY FOR DISEASE CONTROL IN DEVELOPING COUNTRIES*

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Abstract—Priorities among the infectious diseases affecting the three billion people in the less developed world have been based on prevalence, morbidity, mortality and feasibility of control. With these priorities in mind a program of selective primary health care is compared with other approaches and suggested as the most cost-effective form of medical intervention in the least developed countries. A flexible program delivered by either fixed or mobile units might include measles and diptheria-pertussis-tetanus vaccination, treatment for febrile malaria and oral rehydration for diarrhea in children, and tetanus toxoid and encouragement of breast feeding in mothers. Other interventions might be added on the basis of regional needs and new developments. For major diseases for which control measures are inadequate, research is an inexpensive approach on the basis of cost per infected person per year.

INTRODUCTION

The 3 billion people of the less developed world suffer from a plethora of infectious diseases. Because these infections tend to flourish at the poverty level, they are an important indicator of a vast state of collective ill health. The concomitant disability has an adverse effect on agricultural and industrial development, and the infant and child mortality inhibits attempts to control population growth.

What can we do to help alleviate a nearly unbroken cycle of exposure, disability and death? The best solution, of course, is total primary health care for every human being. In the words of the declaration made at the 1978 World Health Organization conference at Alma Ata, it encompasses

> the attainment by all peoples of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life. Primary health care is the key to attaining this target... [and] includes at least: education concerning prevailing health problems and the methods of preventing and controlling them; promotion of food supply and proper nutrition, an adequate supply of safe water and basic sanitation; maternal and child health care, including family planning; immunization against the major infectious diseases; prevention and control of locally endemic diseases; appropriate treatment of common diseases and injuries; and provision of essential drugs [81].

The goal set at Alma Ata is above reproach, yet its large and laudable scope makes it unattainable in terms of its prohibitive cost and the numbers of trained personnel required. Indeed, the World Bank estimated that the cost of furnishing minimal, *basic* (not *total*) health services by the year 2000 to all the poor in developing countries would range in the many billions (in 1975 prices). The Bank's president himself, Robert McNamara, offered this somber prognosis in the 1978 annual report:

> Even if the projected—and optimistic—growth rates in the developing world are achieved, some 600 million individuals at the end of the century will remain trapped in absolute poverty. Absolute poverty is a condition of life so characterized by malnutrition, illiteracy, disease, high infant mortality, and low life expectancy as to be beneath any reasonable definition of human decency [43].

How then, in an age of diminishing resources, can we best attempt to secure the health and well-being of those trapped at the bottom of the scale long before the year 2000 arrives? We believe that a *selective* attack on the most severe public health problems facing a locality should be considered in order for us to have the greatest chance to improve health and medical care in less developed countries. Throughout the discussion that follows, we have tried to show the rationale and need for instituting selective primary health care directed at preventing or treating those few diseases responsible for the greatest mortality in less developed areas and for which interventions of proven high efficacy exist.

THE NATURE OF COLLECTIVE ILL HEALTH

The state of collective ill health found in many of the less developed countries should not be approached as a single problem. Traditional indicators such as infant mortality or life expectancy are insufficient for grasping the issues involved. Ill health is a complex, many-faceted problem, an amalgam of many diseases with multiple causes. Indicators are actually distilled composites of hundreds of different health problems and disorders. Each has its own causes and is responsible for its own societal and scientific difficulties; each may have diverse points at which interventions could be considered.

The diseases endemic to the less-developed countries are protean in their etiologies, mechanisms of transmission, impact on humans, and susceptibility to attack. It is highly unlikely that any single mode of

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control would be suitable for all. Each disease must be considered individually, with its unique mix of epidemiological, ecological, and social factors.

Consider, for example, the variety of measures necessary to prevent or treat insect-borne, water-related, or aerosol-borne infections. All are major causes of disability and death in less developed areas and all can exist simultaneously in one area. Even for controlling the first group of infections alone (exemplified by malaria and onchocerciasis), the characteristics of each insect vector (e.g. mosquitoes and black flies) must be considered separately in instituting the most efficient and effective control campaign. The breeding, biting, flying, and resting patterns and susceptibility to insecticides varies appreciably among species and subspecies, greatly affecting the efficacy of specific control measures [34, 73, 86] add to these considerations the hygiene, sanitation and rehydration programs believed efficacious for such water-related diseases as cholera and the prolonged drug therapy and extensive case-finding necessary to treat such aerosol-borne diseases as tuberculosis, and the dilemma of supplying the resources required by even a basic health service becomes all too apparent.

ESTABLISHING PRIORITIES FOR HEALTH CARE

Faced with the variety of health problems facing mankind, not all ills can be attacked now. Regretably, the rhetorical goal pledged at the Alma Ata conference—a socially and economically productive life for all attained through comprehensive primary health care—may not come to pass in the near future. In many regions priorities for instituting control measures must be assigned. We must choose measures that use the limited human and financial resources available most effectively and efficiently.

To do the greatest good, health services should be directed toward controlling those diseases producing the largest amount of death and disability, and care should be made accessible to the greatest numbers. For this, health care planning is needed. The first step in planning is to estimate the causes of illness in the population, the amount of death and disability each produces, and the feasibility of various control measures. After weighing these factors, some attempts can be made to rank diseases deserving the most attention in a particular locality. Next, various means of dealing with the infections of greatest concern can be considered. The major possibilities for intervention are:

- Total primary health care
- Basic primary health care
- Multiple disease control through horizontal programs
- Vertical programs of selective primary health care
- Research into those diseases for which control is impossible or too costly at present.

We will now discuss in detail two essential steps in health planning for the developing world: targeting of diseases and evaluation of medical interventions.

TARGETING DISEASES FOR CONTROL

In selecting the health problems that should receive the highest priority for prevention and treatment, the following factors should be assessed for each disease:

- Prevalence
- Morbidity, or severity of disability
- Risk of mortality
- Feasibility of control (including relative efficacy and cost of intervention).

It cannot be overemphasized that the greatest immediate efforts in health care in less developed areas should be aimed at preventing and managing those few diseases that cause the greatest mortality and morbidity and for which there are medical interventions of relatively high efficacy. As a demonstration of a typical approach to selective health care we might arrive at the following table incorporating the four factors listed above.

Table 1 represents the beginnings of a cost-effectiveness analysis of typical illnesses—one viral infection, one protozoan infection, and one helminth infection—that all may be endemic in a less developed nation or area. All may present threats to public health, but it may not be possible to control all three infections simultaneously on a large scale. The importance of taking into account feasibility and cost of control as well as mortality and prevalence is made clear in Table 1. The newly discovered Lassa fever carries a 30–66% mortality in the few limited outbreaks seen in Nigeria, Liberia and Sierra Leone. Those who survive recover fully after an illness of 7–21 days. Its high fatality rate would seem to give it high priority for a major health program. However, its mode of transmission is not known, and its treatment is difficult: injections of plasma from recovered patients are required. Because no attempts have been made to develop a vaccine, Lassa fever is impossible to control at present [19]. Therefore, concentration on preventing Lassa fever would not do the greatest good for the greatest population. Ascariasis or roundworm is the most prevalent infection of man, infecting one billion people throughout the world [57, 82]. Its human burden is enormous and no one can deny the importance of alleviating it. Yet, fortunately, disability is minor and death from ascariasis is infrequent [34, 73]. Treatment requires periodic chemotherapy administered indefinitely [5, 34, 73]. Control may ultimately require massive, long-term improvements in sanitary and agricultural practices in order to reduce the inevitability of continuous reinfection. The difficulty of eliminating exposure to the round worm as well as the low intensity of the infection would lead us to rank ascariasis as deserving less attention than its ubiquity would seem to require.

Malaria has a far smaller mortality rate than Lassa fever in terms of virulence, and a lower prevalence than ascariasis. Yet its mode of transmission is well known and it produces much recurring illness and death—about 1 million children in Africa alone die from malaria [84]. It is endemic to Africa, Central and South America, and the Caribbean, the Indian subcontinent and Eastern Asia, and travelers frequently carry it elsewhere. What also distinguishes

Table 1. Evaluation of infections for priorities in disease control

Infection	Prevalence	Mortality	Morbidity	Feasibility of control
Lassa fever	Unknown; thought to be low	High (30–66%)	Moderate (Bedridden 7–21 days)	Extremely poor at present
Ascariasis	Extremely high; thought to affect 1 billion people	Extremely low (approximately 0.001%)	Low (minor disability and often asymptomatic)	Fair (long-term to indefinite drug treatment required)
Malaria	High; more than 300 million infected annually	Low (approximately 0.1%)	High (severe, many complications, often recurrent)	Good (chemoprophylaxis available; regular spraying programs for vectors practical)

Table 2. Priorities for disease control in the developing world based on prevalence, mortality, morbidity* and feasibility of control†

Infection	Reasons for assignment to this category
I. *High*	High prevalence, high mortality, high morbidity, effective control
Diarrheal diseases	
Measles	
Malaria	
Whooping cough	
Schistosomiasis	
Neonatal tetanus	
II. *Medium*	
Respiratory infections	High prevalence, high mortality, no effective control
Poliomyelitis	High prevalence, low mortality, effective control
Tuberculosis	High prevalence, high mortality, control difficult
Onchocerciasis	High morbidity, medium prevalence, low mortality, control difficult
Meningitis	Medium prevalence, high mortality, control difficult
Typhoid	Medium prevalence, high mortality, control difficult
Hookworm	High prevalence, low mortality, control difficult
Malnutrition	High prevalence, high morbidity, control complex
III. *Low*	
South American trypanosomiasis (Chagas disease)	Control difficult
African trypanosomiasis	Low prevalence, control difficult
Leprosy	Control difficult
Ascariasis	Low mortality, low morbidity, control difficult
Diphtheria	Low mortality, low morbidity
Amebiasis	Control difficult
Leishmaniasis	Control difficult
Giardiasis	Control difficult
Filariasis	Control difficult
Dengue	Control difficult

* For the estimates for prevalence, mortality, and morbidity upon which these rankings are based, see Appendix A, a table of major infections endemic to Africa, Asia, and Latin America.

† For the estimates of relative efficacy and cost of disease control upon which these rankings are based, see Appendix B, a compilation of the results of health intervention studies.

malaria from Lassa fever and ascariasis is that it frequently can be effectively and relatively inexpensively controlled through regular mosquito spraying programs or chemoprophylaxis [34, 84]. Of these three infections, then, assigning malaria the highest priority for concentrated prevention and control would be the most effective way to reduce overall morbidity and mortality.

Using the process outlined above for Lassa fever, ascariasis and malaria, we evaluated the major infections* endemic to the developing world and assigned high (I), medium (II), or low (III) priorities. Within categories exact rank is not of major significance and it may change depending on the geographic area under consideration. Furthermore, even the priorities themselves may have to be modified depending on the climate and flora and fauna of a particular area. For instance, schistosomiasis, to which we assigned a high priority, is restricted in distribution, and the infection may not be a significant health problem in all areas of the world. Our results and rationale for the proposed hierarchy are listed as Table 2.

Group I represents the infections causing the great-

* We chose to look at infections because they are the greatest causes of illness in less developed areas and are more amenable to prevention or treatment than most noncommunicable diseases.

est amount of most easily preventable illness and death: diarrheal diseases, malaria, measles, whooping cough, schistosomiasis, and neonatal tetanus. With the exception of schistosomiasis, all the infections receiving highest priority for health care planning affect young children more than adults [3, 18, 55, 59, 89]. Together with respiratory infections and malnutrition, they account for most of the morbidity and mortality among infants and young children [9, 18, 89]. This age group (0–5 years) experiences a death rate many times greater than that experienced by their counterparts in Western countries. Their deaths contribute 40–60% of all mortality in most less developed countries [17, 58, 70, 89]. If infant and child deaths from these infections are reduced, then a large decline in overall death rate will result. Such a situation would be an optimal outcome of a selective disease control program.

Groups II and III encompass health problems of lesser importance or less amenable to containment. Again, feasibility of control in light of limited resources is an influential factor in the analysis. Respiratory infections, a major cause of disability and death, are not listed in Group I because of difficulties in their prevention and management. A wide variety of viruses and bacteria, each producing a relatively small proportion of the cases, are associated with respiratory tract infections, and no specific etiologic agent has been found in a significant proportion of patients [9, 67]. Just as in the West, pneumonia is frequently the cause of the terminal episode in elderly patients weakened by cancer or cardiovascular disease, so lower respiratory tract infections severely affect children in developing countries already afflicted with chronic malnutrition and parasitic infections [9]. Preventive and treatment measures are few, costly, and questionably effective. Pneumococcal and influenza vaccines will prevent only a small percentage of cases, and influenza immunization must be given almost yearly because the virus changes antigenically. Penicillin injections given to all children in the Narangwal project in India with clinical signs of pneumonia decreased the mortality rate by 50% [69], but this method must be evaluated more extensively before it is introduced on a large scale or considered as a significant improvement in thwarting respiratory disease.

We assigned a disease a medium or low priority if we found a lack of inexpensive control measures for it. For example, there is no therapy for chronic Chagas disease [34, 73]. Only toxic drugs and procedures of unknown efficacy, such as nodulectomy, are available for treatment fo onchocerciasis [34, 73]. Leprosy and tuberculosis require years of drug therapy and even longer follow up periods to ensure cure [27, 34, 83]. Rather than attempting immediate large-scale treatment programs for these infections, the most efficient use of resources may be investments made in research and development of less costly and more efficacious means of prevention and therapy (see the Research section below). To reiterate, the most important concept to keep in mind in establishing priorities for endemic infections, even when evaluating diseases with high case rates, *is the clear perception of those diseases that contribute most to the burden of illness in an area and which are readily controllable.*

EVALUATING AND SELECTING MEDICAL INTERVENTIONS

Once it has been decided which diseases are to be targeted for prevention and treatment, the next step is to devise intervention programs of reasonable cost and practicability. The interventions relevant to the world's developing areas that we chose to examine are total primary health care, basic primary health care, horizontal multiple disease control, categorical disease control, and research. What follows is a discussion of each approach, with emphasis on the relative cost involved in undertaking and maintaining these programs and the benefits that have accrued.

This section of our analysis relies upon reported results from individual studies conducted in various parts of the world. In addition, we have examined estimates of cost and effectiveness in terms of expected deaths averted by each intervention for a model area in Africa. The model area is an agricultural rural portion of sub-Saharan tropical Africa with about 500,000 people (100,000 are aged 5 years or less). For reference purposes, the average figures for sub-Saharan Africa will be used: the birth rate is 46 per 1000 total population, the crude death rate is 19 per 1000 total population, and the infant mortality rate is 147 per 1000 live births [36, 71].

Total vs basic primary health care

Total primary health care for everyone is the ideal solution to conquering disease, the humane and noble goal declared at Alma Ata. As defined by WHO, total primary health care encompasses development of all segments of the economy, ready and universal access to comprehensive curative care, prevention of endemic disease, proper sanitation and safe water supplies, immunization, nutrition promotion, health education, maternal and child care, and family planning. Since it must be acknowledged that resources available for health programs are usually limited, the provision of total primary health care to everyone in the near future remains unlikely.

Basic primary health care is more limited than total primary health care but is quite a comprehensive and expensive intervention nonetheless. The goal of this service is to provide health workers and establish clinics for treating all illnesses within a population.

The World Bank has estimated the cost of furnishing basic health services to all the poor in developing countries by the year 2000 as $5.4–9.3 billion (in 1975 prices) [10]. This investment would provide one community health worker or auxiliary nurse midwife for every 1500–2000 people plus one health facility for every 8000 to 12,000 people, or every ten kilometres, whichever is greater. This estimate includes only initial capital investment and training costs. It does not cover salaries for the health workers, the restocking of supplies, maintenance, continuing education, and expansion of referral services. In addition, little is known about the effectiveness of the health workers in this system and particularly how much opportunity they will have to apply such preventive measures as education in sanitation and nutrition. In the model African area, the World Bank estimated that supplying the minimum care offered by building one health post with 1 vehicle per 10,000 people and training 125

auxiliary nurse midwives and 250 community health workers would cost $2,500,000 or $5 per capita. To this must be added the recurrent costs of drugs and supplies, maintenance, and salaries for those health workers. Other costs not included are expansion of referral services, attrition among staff, continuing education, lack of qualified personnel, training facilities, and expansion of communication, transport, and administrative networks to supply and maintain contact with the health facilities. (If the estimates were to cover services needed to attain total rather than basic primary health care, the costs of water supplies and sanitation, vector control, nutrition supplements, and local and national economic development would also have to be added.) We do not know how effective this model program of providing basic health services would be in averting deaths.

The pilot projects for providing basic health care systems that have been evaluated vary in their effectiveness in improving the general level of health care. For example, an outside evaluation of a primary health service in Ghana observed that one third to one half of the population of the districts lived outside the effective reach of health units providing primary care. Only about one fifth of the births were supervised by trained midwives, one fifth of the children under age 5 had ever been seen in a child health clinic, and two thirds of the population lacked environmental sanitation services. Furthermore, the services were often of poor quality, notably in the crucial area of child care [41, 91].

The cost and effectiveness of a few other programs providing primary health care in localized areas are compared in Table 3. The estimated cost per capita varies widely among programs, particularly because they were initiated at different times over the last 15–20 years and furnished different services to the communities involved. In general, the cost per capita ranged between 1 and 2% of the national per capita income of the particular country. The figures in Table 3 for deaths averted are difficult to compare because frequently control groups were not established and the population groups monitored were not consistent across studies. The only investigators to make precise calculations for the costs per infant and/or infant and child death averted were the ones at a medical care and nutrition supplementation project in Narangwal, India [69]. Their estimates were: $144 per infant death averted and $988 per each 1–3 year old child whose death was averted by medical care. The estimates were much higher for deaths averted by nutrition supplements. Comparing and evaluating the costs for averting deaths of infants and children with the other programs listed in Table 3 is even more difficult because the provisions of each are different and frequently control areas were not incorporated into the projects.

In summary, under some circumstances, programs of basic primary health care have been successful, but the cost as well as the degree of improvements in community health have varied markedly enough that refinements in the approach still need to be made.

The following interventions that would decrease mortality and serve as interim strategies for health care in less developed countries are examples of less inclusive approaches than total or basic primary health care.

Horizontal multiple disease control

Vector control. Vector control entails programs directed at managing insect, mollusc, and other carriers of human disease. Vector control has the advantage of being comparatively inexpensive, yet even when the measure is successful it can not always be counted on as a permanent prophylaxis, because the vector tends to develop a resistance to it. The examples below briefly set forth some of the complexities of maintaining vector control.

The control of malaria transmission through spraying has been highly effective. Indeed, house-to-house spraying is one of the most successful preventive programs for mosquito control today. WHO studies estimate an average cost for house-to-house spraying with DDT at $2 per capita annually [84]. In tropical and savanna Africa, twice-yearly spraying has decreased the crude death rate by approximately 40% and infant mortality by 50% [25, 40, 56]. Therefore, the cost per averted adult and infant death equals $250 and the cost per averted infant death equals $600. Because infants and children have a much higher death rate from malaria than adults, the cost of infant and child deaths averted would fall between these two estimates. Unfortunately, eradication of malaria through applications of insecticides is becoming more difficult to accomplish. Malaria control requires continued spraying with DDT at least twice yearly. *Anopheles gambiae*, the major African malaria vector, has developed resistance to DDT in many areas. Because the mosquito can be expected to develop resistance within a few years after a spraying program has been initiated another pesticide must be substituted. Others are available but they are more expensive. DDT takes about one-third of the total budget of the malaria spraying program—replacing it with another insecticide such as propoxur or fenetrithion will raise the cost of the chemicals 5–10 times, vastly increasing the total cost of the spraying program [84]. Furthermore, there is no way to tell how long they will remain toxic to the mosquito. Other genera of mosquitoes have also developed widespread resistance to insecticides. *Culex pipiens fatigans*, the major vector of urban filariasis, is universally resistant to DDT-type compounds insecticides and its resistance to other chemicals is increasing. Resistance of the dengue vector *Aedes aegypti* to DDT-type compounds is common in Southeast Asia and tropical America [86].

Two other vector control programs illustrate the perpetual maintenance required by this type of health intervention. Onchocerciasis, a helminth infection that affects 30 million people in Africa, is being managed in the Volta River Basin through a 20-year larvicide operation to control the *Simulium* vector. The program is estimated to cost $18 per capita for the entire 20-year period or $0.90 per capita per year [10]. It will only have a minimal effect on mortality because the infection causes relatively few deaths. However, morbidity is high—the infection can cause severe skin disease and blindness, and it has supposedly caused depopulation of a fertile river valley. Disability will be prevented and economic activity in

Table 3. Results of selected village health worker projects*

Location	Dates	Approximate size of treatment population (all ages)	Reported results		Annual per capita cost§	Estimated cost per infant and/or child death averted
			Infant mortality†	Child mortality‡		
Imesi, Nigeria [15]	c. 1960	6000	Control: 91 Treatment population: 57	Control pop.: 51 Treatment pop.: 18	$2.00	$230 (I, C)
JEtimesgut, Turkey [21, 22]	1965–present	55,000	Treatment population, 1967–1973: 142–93 Turkey, general pop.: 1967–73: 153–110	Treatment pop. 1967–77: 59–37	6.50–7.50	19,000–21,000 (I)
Narangwal, India [69]	1968–1973	2500	Control pop.: 130 Nutrition care pop.: 97 Medical care pop.: 70 Nitrition plus medical care treatment: 81	Control pop.: 19 Nutrition care pop.: 11 Medical care pop.: 11 Nutrition plus medical care treatment: 13	1.50–2.00	144–234 (I) 1000–4000 (C)
Jamkhed, India [6, 32]	1971–present	40,000	Treatment pop., 1971: 97 Treatment pop., 1976: 39 Control pop., 1976: 90	Not evaluated	1.25–1.50	725–850 (I)
Guatemalan [79] villages	1972–1977	3000	Treatment pop., 1969–1970/2: 139–55 Guatemala, general pop., 1969–1970: 89–85	Treatment pop., 1969–1970/2: 28–6 Guatemala, general pop., 1969–1970: 26–22	4.00–4.50	350–400 (I, C) 600–700 (I)
Hanover, Jamaica [1, 2]	1973–present	65,000	Treatment pop., 1973–1976: 47–11 Jamaica, general pop., 1973–1976: 26–23	Treatment pop., Before 1972–1974: 13–15 After 1973–1975: 5–6	0.40 (C)	470 (I, C)
Kavar, Iran [17]	1973–present	8200	Control pop.: 128 Treatment pop. 64	Not evaluated	3.75–4.00	1200 (I)

* Modified from Gwatkin *et al.* [32].

† Deaths: 0–12 months per 1000 live births.

‡ Deaths: 12–60 months per 1000 popu.ation aged 12–60 months except for Narangwal, where deaths were reported at 12 36 months; Hanover, where deaths were reported at 1–48 months; and Etimesgut, where deaths were reported at 0–60 months per 1000 population in that age group.

§ Recurring plus capital costs. The cost figures for the Elderslie pilot project upon which the Hanover costs are calculated are currently being revised. A significantly higher estimate is likely.

‖ I = infant, C = child.

the area may increase if the program is successful, but continuous, indefinite applications of insecticide will be necessary.

Since 1965, St Lucia has had a program to control helminth-caused schistosomiasis through molluscicides. The annual cost per capita runs about $3.70 and significant results have been reported: the prevalence of the infection in adults (persons over age 14) has decreased from 45 to 35‰ and in children under age 10 it has dropped from 21 to 4% [35]. Despite these heartening figures, eradication of the vector cannot be considered on the horizon. Schistosomiasis is a long-term, chronic infection, and the death rate will not begin to decline until many years after continuous mollusk control.

Water and sanitation programs. Proper sanitation and clean water make a substantial difference in the disease of an area but the financial investment involved is enormous. The success of such projects also depends upon inducing the population to change long-engrained cultural habits, an endeavor whose outcome can never be predicted.

With the installation of community water supplies and sanitation in developing areas, deaths from typhoid can be expected to decrease 60–80% from cholera by 0–70% [8, 7, 42, 68, 78, 90] from other diarrheas by 0–5% [20, 42, 65] from ascariasis and other intestinal helminths by 0–50% [5, 11, 37, 64] and from schistosomiasis by 50% [35, 37] (after about 15–20 years). The World Bank estimates the cost of providing access to community water supply and sanitation to all those in need by the year 2000 as $135–260 billlion. That is, constructing a rural community standpipe costs $20–26 per capita and rural sanitation costs $4–5 per capita. In urban areas the per capita cost rises to $31 for a standpipe and $23 for sanitation. In the model area of sub-Saharan Africa we have been discussing the initial investment would be $12–15 million. If amortization and annual maintenance cost is only 10% of this sum, the annual cost per deaths averted would be $2400–2900. The cost of each infant and child death averted would be $3600–4300.

What must be realized is that the sums just cited are the figures for providing public standpipes for the great majority, which is not going to be highly effective in reducing morbidity and mortality from water-related diseases. It is well documented that connections inside the house are what encourage the hygienic use of water—even a water supply a few steps outside the house will not be as heavily patronized by the populace [74]. For example, one study found that shigella-caused diarrheas decreased 5% with outside house connections but fell 50% when sanitation and washing facilities were available within the home [64]. More infant and childhood deaths would probably be averted if household water and sanitation were supplied.

All these estimates depend on the sole use of the protected sanitation and water supplies rather than on the continuing use of environmental sources. In Bangladesh, for example, there was no reduction in cholera in areas supplied with tube wells, primarily because the populace used contaminated surface water as well as the protected water supply [68]. In St. Lucia, contact with surface water could not be discouraged until household water and sanitation plus swimming pools and laundry units were installed and an intensive health education campaign was instituted [35]. In other words, changing people's habits in excretion and water usage takes more than just introducing an adequate dependable and convenient new source. Realistically speaking, a health education and hygiene campaign [31, 78] as pervasive and effective as the soft drink and cigarette advertisements seen throughout the world is required.

Nutrition supplementation. Nutrition programs have been advocated as one of the most efficient means of decreasing morbidity and mortality in children, but supplementation alone has not been shown to reduce the infant and child rate significantly. Malnutrition is an underlying or an associated cause of many deaths from all infections in children. In one investigation of deaths of Latin American children, it was an associated cause in 50% of the cases [60]. There is a definite interaction between infection and malnutrition—less food is ingested and absorbed by a sick child, thus worsening the malnutrition. In turn, malnutrition probably increases the susceptibility to disease, or predisposes a child to more severe illness should he become infected [47, 49]. In some areas of the world infection seems to be the most prominent cause of poor nutrition [48, 63]. Therefore, we suspect that if infections could be controlled the nutritional status of children should improve greatly. In some cases malnutrition may actually protect against certain infections, for instaance the Sahel famine and malaria, and iron deficiency and bacterial infections [51–53, 66].

In the face of these findings, it is not surprising that few nutrition supplementation programs alone have affected a significant decrease in the death rate. The Narangwal project is one of these few, but even here, the cost per death averted in infants was $213. In children aged 1–3 years the cost was $3000, 1½–3 times higher than the cost with medical care alone [69].

Categorical disease control

The categorical approach to controlling endemic disease in the developing countries is the most selective type of medical intervention. Based on the factors of high morbidity and mortality, and sure feasibility of control, a few diseases are targeted for prevention in a clearly defined population. Given the limitations of funding and manpower, we believe that categorical or selective primary health care is the least wasteful and most promising intervention in many parts of the world.

No programs based on the categorical model of prevention and treatment of a group of specifically selected diseases in a defined population have been attempted. Therefore we propose an approach we believe will result in a significant decline in the death rate in any appropriate area in which it is tried. The treatment population would be children aged 0–3 years, and women in the childbearing years. The care provided would be:

- Measles and DPT vaccination for children over 6 months
- Tetanus toxoid to pregnant women
- Encouragement of long-term breast feeding

Table 4. Research funding for endemic infections, 1978

Infection	Funding for research	Cost per infected person/year ($)
Malaria	15,000,000	0.02
Schistosomiasis	7,000,000	0.04
Filariasis	2,000,000	0.01
Trypanosomiasis	5,000,000	0.38
Leishmaniasis	1,200,000	0.10
Leprosy	2,000,000	0.16

- Chloroquine for children under 3 years in malarious areas to ingest during febrile episodes
- Oral rehydration packets and instruction

(Oral rehydraation has been used successfully in hospitals [12, 54], outpatient clinics [44] and recently in the home [38] in treating diarrheas of multiple etiologies.) If even 50% of children and their mothers and 50% of pregnant women in a community are contacted, deaths would be expected to decrease at least 50% from measles [13, 26] 30% from whooping cough [45] 45% from neonatal tetanus [39], 25–30% from diarrhea [38, 44] and 25% from malaria.

These services could be provided by fixed or mobile units visiting once every 4–6 months. In areas where resources are too limited to provide fixed health units, a mobile unit could be the most efficient system. Mobile units have been successfully used in immunization programs for small pox and measles [23, 24], treatment services directed against such diseases as African trypanosomiasis and meningitis [29] and provision of child care in rural areas [28, 72, 76].

The cost estimates for a mobile health unit in the model area in Africa that was used in malaria control and water and sanitation programs are based on the extensive study of the Botswana health services by Gish and Walker. They estimated $1.26 as the cost-per-patient contact in 1974. On a sample 490-mile trip that reached 753 patients, transport cost $0.52 mile or $254.78, equipment cost $11.04, drugs cost $430.42, salaries came to $255.02, for a total of $951.26 [28].

Using this cost-per-patient contact, the cost per infant and child death averted would be $200–250. Medications account for 30–50% of this cost, but this could be decreased with contributions of drugs from abroad or their manufacture within the country.

One advantage of the mobile unit is its extreme flexibility. The care can be modified at any time according to the patterns of mortality, morbidity, and disability in the area served. Chemotherapy for intestinal helminths, treatment of schistosomiasis, and supplementation with new vaccines or treatments as they become available are all examples of selective primary health care that could be added or subtracted to this core of basic preventive care. It is important, however, that the service concentrate on a minimum number of severe problems that affect large numbers of people and for which there are forms of intervention of established efficacy that can be provided at low cost.

Research

For a number of prevalent infections, treatment or preventive measures are expensive, difficult, toxic or inefficacious. These infections, which include Chagas disease. African trypanosomiasis, leprosy, and tuberculosis, might better be dealt with through an investment in research. In terms of the benefits that accrue, the cost of research is small. Indeed, the total amount now being spent on research in all tropical diseases is approximately $60 million, quite small in relation to the number of people infected. As Table 4 shows, expenditures made for research on some of the major diseases in the developing world have by far the lowest per capita cost of all medical interventions discussed [85].

The estimated cost for research and successful development of the pneumococcal vaccine recently licensed in the United States in 1978 was $3–4 million (Robert Austrian, personal communication) and the development costs are at least 75% of this cost. The cost of developing a rota virus vaccine developed over 5 years would probably be $10–12 million and may prevent up to 60% of clinical cases of diarrhea in small children. Research developments that would reduce death and disability in developing countries would be: heat-stable vaccines for measles, malaria, rota virus and *E. coli* diarrheas, and leprosy; improvements in chemotherapy for leprosy, tuberculosis, American and African trypanosomiasis, onchocerciasis, and filariasis; and depot chemotherapy for intestinal helminths.

CONCLUSIONS

Until comprehensive primary health care can be made available to all, services targeted to the few most important diseases may be the most effective means of improving the health of the greatest number of people. The crucial point is how to measure the effectiveness of medical interventions. In all of the foregoing calculations, we based our analysis of cost-effectiveness on the indicator of changes in mortality or deaths averted. We did not measure the illness and disability that would be prevented. No other benefits for which intervention may have been responsible were measured because they are much more difficult to quantify. The inadequacy of available data make it impossible to measure distinct and undeniable secondary benefits. For example, mosquito control for malaria may decrease filariasis or leishmaniasis transmission. Nutrition supplements, even if not given to the young child, may be distributed to the whole family and thereby increase the well-being of them all. Water supplies close by might release time for the women from water carrying; that time can be devoted to other projects, or an increased water supply can irrigate a home garden.

Table 5. Estimated annual costs of health intervention

Intervention	Per capita cost, $	Cost per infant and/or child death averted, $*
Basic primary health care†		
Range	0.40–7.50	144–20,000 (I)
Median	2.00	700
Mosquito control for malaria	2.00	600 (I)
Onchocerciasis control program	0.90	Few infant and child deaths
Mollusc control for schistosomiasis	3.70	Few infant and child deaths
Community water supplies and sanitation	30–54	3600–4300 (I, C)
Narangwal nutrition supplementation	1.75	213 (I) 3000 (C)
Selective primary health care‡	0.25	200–250 (I, C)

* I = infant, C = child.
† Delivered by village health workers.
‡ In this case, delivered by mobile units.

Accordingly, Table 5 summarizes the estimated costs per capita and per death averted for the various health interventions considered. The per capita costs are calculated in terms of the entire infant, child, and adult population of the area covered by the service. As the table shows, selective primary health care may be a cost-effective interim intervention for many less developed areas.

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APPENDIX A

Persons with infections, with disease, and dying of the major infectious diseases in Africa, Asia and Latin America, 1977–1978*

Infection	Infections (1000s per year)	Deaths (1000s per year)	Disease (in 1000s of cases per year)	Average No. days of life lost (per case)	Relative personal disability†
Diarheas	3–5,000,000	5–10,000	3–5,000,000	3–5	2
Respiratory infections		4–5000		5–7	2 3
Malaria	800,000	1200	150,000	3–5	2
Measles	85,000	900	80,000	10–14	2
Schistosomiasis	200,000	500–1000	20,000	600–1000	3–4
Whooping cough	70,000	250–450	20,000	21–28	2
Tuberculosis	1,000,000	400	7000	200–400	3
Neonatal tetanus	120–180	100–150	120–180	7–10	1
Diphtheria	40,000	50–60	700–900	7–10	3
Hookworm	7–900,000	50–60	1500	100	4
South American trypanosomiasis	12,000	60	1200	600	2
Onchocerciasis—	30,000				
skin disease		Low	2–5000	3000	3
river blindness		20–50	200–500	3000	1–2
Meningitis	150	30	150	7–10	1
Amebiasis	400,000	30	1500	7–10	3
Ascariasis	800,000–1,000,000	20	1000	7–10	3
Poliomyelitis	80,000	10–20	2000	3000+	2
Typhoid	1000	25	500	14–28	2
Leishmaniasis	12,000	5	12,000	100–200	3
African trypanosomiasis	1000	5	10	150	1
Leprosy		Very low	12,000	500–3000	2–3
Trichuriasis	500,000	Low	100	7–10	3
Filariasis	250,000	Low	2–3000	1000	3
Giardiasis	200,000	Very low	500	5–7	3
Dengue	3–4000	0.1	1–2000	5–7	2
Malnutrition	5–800,000	2000			

* Based on estimates from the World Health Organization and its Special Programme for Research and Training in Tropical Diseases, confirmed or modified by extrapolations from published epidemiological studies performed in well-defined populations (see bibliography that follows). Figures do not always match those officially reported, because under-reporting is great.

† 1 = Bedridden, 2 = able to function on own to some extent, 3 = ambulatory, 4 = minor.

APPENDIX B
Efficacy of Control measures for specific infections

Cause	Preventive measures	Efficacy, cacy, %‡	Cost†	Curative measures	Efficacy, cacy, %	Cost‡
Diarrheas						
Undifferentiated	Household water and sanitation	0–50	1	Early oral rehydration	50–95	3–4
	Breast-feeding (<age 3 months)	60	0			
Cholera	Water and sanitation	0–70	1	Early oral rehydration	50–95	
	Vaccine	0–40	4	Antibiotics and hydration	95	3
Shigella	Sanitation	0–50	2			
	Water supply	0–50	2	Antibiotics	95	3
	Household water and sanitation	60–90	1			
Respiratory infections	(Specific vaccines)	?		Early treatment with penicillin	45	3
Malaria	Mosquito control	30–100	3	Chemotherapy	90	3
	Chemoprophylaxis	0–80	4			
Measles	Vaccine	90	3–4			
Schistosomiasis	Mass chemotherapy	75	3	Chemotherapy	60–90	3
	Water and sanitation	40–60	1			
	Mollusk control	80	2			
Whooping cough	Vaccine	80	3	Antibiotics	50–75	3
Tuberculosis	Vaccine	0–80	4	Chemotherapy	95	2
	Active case finding	30–50	1	6–24 months		
Neonatal tetanus	Vaccine	95	4	Chemotherapy and supportive care	25	1
Diphtheria	Vaccine	90	3	Antitoxin plus antibiotics	95	2
Hookworm	Water and sanitation	50–60	1	Chemotherapy	95	3
American trypanosomiasis	Improved housing	90	1	Chemotherapy	poor	2
	Reduvid control	90	2			

Onchocerciasis	Simulium control	90	4	Chemotherapy	poor	3
	Chemotherapy	Poor	3			
	Nodulectomy	Poor	2			
Meningitis	Vaccine	95	3	Antibiotics	80	2
	Chemoprophylaxis	70	3			
Amebiasis	Water and sanitation	0–85	1	Chemotherapy	90	2
Ascariasis	Water and sanitation	50–80	1	Chemotherapy	90	3
	Chemotherapy	60	3			
Poliomyelitis	Vaccine	80–90	3			
Typhoid	Vaccine	0–80	3	Antibiotics	95	3
	Water and sanitation	60–80	1			
Leishmaniasis	Animal and sandfly control	50–90	2	Chemotherapy	80	1
African trypanosomiasis	Tsetse fly control	80	3	Chemotherapy	90	2
	Chemoprophylaxis	80	3			
Leprosy	Vaccine	0–50	4	Chemotherapy	95	1
	Active case finding	50	1	1.5–10 years		
	Chemoprophylaxis	50	1			
Trichuriasis	Water and sanitation	50	1	Chemotherapy	70–80	2
Filariasis	Chemotherapy	50–90	2	Chemotherapy	70	2
	Mosquito control	60–95	2			
Giardiasis	Water and sanitation	0–50	1	Chemotherapy	90	2
Dengue	Mosquito control	0–90	3			
Malnutrition	Nutrition education and supplements	0–50	3			

* Based on findings of various reports.

† Cost (includes delivery system): 1 = $30 per capita served, 2 = $3–$30 per capita served, 3 = $1.50–3 per capita served, 4 = <$1.50 per capita served.

‡ Note: the efficacy of a particular treatment or control measure can vary remarkably among studies, usually depending on patient or community acceptance.