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 diphtheria-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. (N Engl J Med 301:967-974, 1979)

T HE three 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 important indicators 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 in a control population demonstrates the extent of the problem. What can be done to help alleviate a nearly unbroken cycle of exposure, disability and death? The best solution, of course, is comprehensive primary health care, defined at the World Health Organization conference held at Alma Ata in 1978 as

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 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.1

The goal set at Alma Ata is above reproach, yet its very scope makes it unattainable because of the cost and numbers of trained personnel required. Indeed, the World Bank has estimated that it would cost billions of dollars to provide minimal, basic (not comprehensive) health services by the year 2000 to all the poor in developing countries. The bank's president, Robert McNamara, offered this somber prognosis in his annual report in 1978:

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.1

How then, in an age of diminishing resources, can the health and well-being of those "trapped at the bottom of the scale" be improved before the year 2000? A valid approach to this overwhelming problem can be based on the realization that the state of collective ill health in many of the less developed countries is not a single problem. Traditional indicators, such as infant mortality or life expectancy, do not permit a grasp of the issues involved, since they are actually composites of many different health problems and disorders. Each of the many diseases endemic to the less developed countries (Table 1) has its own unique cause and its own complex societal and scientific facets; there may be several points in the process for which interventions could be considered.4,5

Thus, a rationally conceived, best-data-based, selective attack on the most severe public-health problems facing a region might maximize improvement of health and medical care in less developed countries. In the discussion that follows, we try to show the rationale and need for instituting selective primary health care directed at preventing or treating the few diseases that are responsible for the greatest mortality and morbidity in less developed areas and for which interventions of proved efficacy exist.

Establishing Priorities for Health Care

Faced with the vast number of health problems of mankind, one immediately becomes aware that all of them cannot be attacked simultaneously. In many regions priorities for instituting control measures must be assigned, and measures that use the limited human and financial resources available most effectively and efficiently must be chosen. Health planning for the developing world thus requires two essential steps: selection of diseases for control and evaluation of different levels of medical intervention from the most comprehensive to the most selective.
Selecting Diseases for Control

In selecting the health problems that should receive the highest priorities for prevention and treatment, four factors should be assessed for each disease: prevalence, morbidity, mortality and feasibility of control (including efficacy and cost).

Table 2 incorporates these factors into an analysis of three representative illnesses of the less developed world. The newly discovered Lassa fever was associated with a 30 to 66 percent mortality rate in the few limited outbreaks recorded in Nigeria, Liberia and Sierra Leone. Those who survived recovered fully after an illness lasting seven to 21 days. Although this fatality rate seems to suggest giving Lassa fever high priority in a major health program, the prevalence of overt disease appears to be low. Furthermore, the only treatment available is injections of serum from patients who have recovered. Since its mode of transmission is unknown and there is no vaccine, Lassa fever is impossible to control at present. Therefore, concentration on preventing Lassa fever would be neither efficient nor efficacious.

Ascaris, the giant intestinal roundworm, causes the most prevalent infection of man, with one billion cases throughout the world. Yet disability appears to be minor and death relatively rare. Treatment, however, requires periodic chemotherapy for an indefinite period. Control may ultimately require massive, long-term improvements in sanitary and agricultural practices to reduce reinfection. In view of the difficulty of eliminating exposure to the roundworm and the low morbidity associated with the infection, ascariasis deserves less attention than its ubiquity seems to suggest.

Malaria is associated with a far smaller mortality rate than that of Lassa fever and a far lower prevalence than that of ascariasis. Yet its mode of transmission is well known, and it produces much recurring illness and death; about one million children in Africa alone die annually from malaria.

What also distinguishes malaria from Lassa fever and ascariasis is that it can be controlled through regular mosquito-spraying programs or chemoprophylaxis.

Of these three infections, then, malaria would be assigned the highest priority for prevention in the most effective approach to reducing morbidity and mortality.

By means of the process outlined above for Lassa fever, ascariasis and malaria, the major infections endemic to the developing world (Table 1) were evaluated and assigned high (I), medium (II) or low (III) priorities. Within categories exact rank is not of major importance, and rank may change or items may be added or deleted, depending on the geographic area under consideration. For instance, schistosomiasis, to which a high priority was assigned, does not occur in many areas of the developing world. Our re-

Table 1. Prevalence, Mortality and Morbidity of the Major Infectious Diseases of Africa, Asia and Latin America, 1977-1978.*

<table>
<thead>
<tr>
<th>Infection</th>
<th>Infections (Thousands/Yr)</th>
<th>Deaths (Thousands/Yr)</th>
<th>Diarrheas (Thousands of Cases/Yr)</th>
<th>Average No. of Days of Life Lost (Per Case)</th>
<th>Relative Personal Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>5-50,000,000</td>
<td>5-10,000</td>
<td>3-5,000,000</td>
<td>3-5</td>
<td>2</td>
</tr>
<tr>
<td>Respiratory infections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td>800,000</td>
<td>120</td>
<td>150,000</td>
<td>3-5</td>
<td>2</td>
</tr>
<tr>
<td>Measles</td>
<td>85,000</td>
<td>9000</td>
<td>80,000</td>
<td>10-14</td>
<td>2</td>
</tr>
<tr>
<td>Measles</td>
<td>200,000</td>
<td>500-1000</td>
<td>20,000</td>
<td>600-1000</td>
<td>3</td>
</tr>
<tr>
<td>Whooping cough</td>
<td>70,000</td>
<td>250-450</td>
<td>20,000</td>
<td>21-28</td>
<td>2</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>1,000,000</td>
<td>600</td>
<td>700-900</td>
<td>400-600</td>
<td>3</td>
</tr>
<tr>
<td>Neonatal tetanus</td>
<td>120-180</td>
<td>100-150</td>
<td>120-180</td>
<td>7-10</td>
<td>1</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>40,000</td>
<td>50-60</td>
<td>700-900</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Hookworm</td>
<td>7-900,000</td>
<td>50-60</td>
<td>1500</td>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>South American trypanosomiasis</td>
<td>12,000</td>
<td>60</td>
<td>1200</td>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td></td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin disease</td>
<td>30,000</td>
<td>-50</td>
<td>200-500</td>
<td>3000</td>
<td>1</td>
</tr>
<tr>
<td>River blindness</td>
<td></td>
<td>150</td>
<td>150</td>
<td>7-10</td>
<td>1</td>
</tr>
<tr>
<td>Meningitis</td>
<td>400,000</td>
<td>30</td>
<td>1500</td>
<td>7-10</td>
<td>1</td>
</tr>
<tr>
<td>Ascariasis</td>
<td>800,000-1,000,000</td>
<td>20</td>
<td>1000</td>
<td>7-10</td>
<td>1</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>80,000</td>
<td>10-20</td>
<td>2000</td>
<td>3000</td>
<td>1</td>
</tr>
<tr>
<td>Typhoid</td>
<td>1000</td>
<td>25</td>
<td>500</td>
<td>16-28</td>
<td>2</td>
</tr>
<tr>
<td>Leshmaniasis</td>
<td>12,000</td>
<td>5</td>
<td>12,000</td>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>1000</td>
<td>10</td>
<td>150</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Leprosy</td>
<td>500,000</td>
<td>Very low</td>
<td>12,000</td>
<td>1000-3000</td>
<td>1</td>
</tr>
<tr>
<td>Trachiasis</td>
<td>500,000</td>
<td>Low</td>
<td>100</td>
<td>7-10</td>
<td>1</td>
</tr>
<tr>
<td>Filariasis</td>
<td>150,000</td>
<td>Low</td>
<td>2-300</td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>Giardiasis</td>
<td>200,000</td>
<td>Very low</td>
<td>500</td>
<td>5-7</td>
<td>1</td>
</tr>
<tr>
<td>Dengue</td>
<td>3-4000</td>
<td>0.1</td>
<td>1-2000</td>
<td>5-7</td>
<td>1</td>
</tr>
</tbody>
</table>

*Based on estimates from the World Health Organization and on a Special Programme for Research and Training in Tropical Diseases, confirmed or modified by reports from published epidemiologic studies performed in well defined populations (see references). Figures do not always match those officially reported, because of "no reports" gained in the disease progress.

1.1 denotes bedridden; 2.1 able to function on own to some extent; 3.1 ambulatory; 4 minor.

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A medium or low priority was assigned if control measures were inadequate. For example, there is no acceptable therapy for chronic Chagas' disease. Only toxic drugs and procedures of unknown efficacy, such as nodulectomy, are available for treatment of onchocerciasis. Leprosy and tuberculosis require years of drug therapy and even longer follow-up.

Table 3. Priorities for Disease Control in the Developing World, Based on Prevalence, Mortality, Morbidity and Feasibility of Control.

<table>
<thead>
<tr>
<th>Priority Group</th>
<th>Reasons for Assignment to This Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>I High</td>
<td>High prevalence, high mortality or high morbidity, effective control</td>
</tr>
<tr>
<td>Diarrheal diseases</td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td></td>
</tr>
<tr>
<td>Malaria</td>
<td></td>
</tr>
<tr>
<td>Whooping cough</td>
<td></td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td></td>
</tr>
<tr>
<td>Neonatal tetanus</td>
<td></td>
</tr>
<tr>
<td>II Medium</td>
<td>High prevalence, high mortality, no effective control</td>
</tr>
<tr>
<td>Respiratory infections</td>
<td></td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>High prevalence, low mortality, effective control</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>High prevalence, high mortality, control difficult</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>Medium prevalence, high morbidity, low mortality, control difficult</td>
</tr>
<tr>
<td>Meningitis</td>
<td>Medium prevalence, high mortality, control difficult</td>
</tr>
<tr>
<td>Typhoid</td>
<td>Medium prevalence, high morbidity, control difficult</td>
</tr>
<tr>
<td>Hookworm</td>
<td>High prevalence, low mortality, control difficult</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>High prevalence, high morbidity, control complex</td>
</tr>
<tr>
<td>III Low</td>
<td>Control difficult</td>
</tr>
<tr>
<td>South American trypanosomiasis (Chagas' disease)</td>
<td>Control difficult</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Leprosy</td>
<td>Low prevalence, control difficult</td>
</tr>
<tr>
<td>Ascariasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>Low mortality, low morbidity, control difficult</td>
</tr>
<tr>
<td>Amoebiasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Giardiasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Filariasis</td>
<td>Control difficult</td>
</tr>
<tr>
<td>Dengue</td>
<td>Control difficult</td>
</tr>
</tbody>
</table>
periods to ensure cure.\textsuperscript{4,21,23} Instead of attempting immediate, large-scale treatment programs for these infections, the most efficient approach may be to invest in research and development of less costly and more efficacious means of prevention and therapy. To reiterate, the most important factor in establishing priorities for endemic infections, even when evaluating diseases with high case rates, is a knowledge of which diseases contribute most to the burden of illness in an area and which are reasonably controllable.

**Evaluating and Selecting Medical Interventions**

Once diseases are selected 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 are considered below are comprehensive primary health care (which includes general development as well as all systems of disease control), basic primary health care, multiple disease-control measures (e.g., insecticides, water supplies), selective primary health care, and research. Below is a discussion of each approach, with emphasis on the relative cost involved in undertaking and maintaining these programs and on the benefits that have accrued.

This section of our analysis relies on 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 a population of about 500,000 (100,000 are five years old or less). For reference purposes, the average figures for Sub-Saharan Africa will be used: the birth rate is 46 per thousand total population, the crude death rate 19 per thousand total population, and the infant mortality rate 147 per thousand live births.\textsuperscript{24,25}

**Comprehensive versus Basic Primary Health Care**

Comprehensive primary health care for everyone is the best available means of conquering global disease, the humane and noble goal declared at Alma Ata. As defined by the World Health Organization, this system encompasses development of all segments of the economy, ready and universal access to curative care, prevention of endemic disease, proper sanitation and safe water supplies, immunization, nutrition, health education, maternal and child care and family planning. Since resources available for health programs are usually limited, the provision of comprehensive primary health care to everyone in the near future remains unlikely.

Basic primary health-care systems are far more circumscribed in their goals, which are to provide health workers and establish clinics for treating all illnesses within a population. Nevertheless, this approach is far from inexpensive. The World Bank has estimated that the cost of furnishing basic health services to all the poor in developing countries by the year 2000 will be $5.4 to $9.3 billion (in 1975 prices).\textsuperscript{14} This investment, which includes only initial capital investment and training costs, would provide one community health worker or auxiliary nurse-midwife for every 1500 to 2000 people and one health facility for every 8000 to 12,000 people or every 10 km\textsuperscript{2}, whichever is greater. In the model area in Africa, the World Bank estimated that supplying the minimum care offered by building one health post with one 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 figure must be added the recurrent costs of salaries, drugs, supplies and maintenance. Other costs not included are for training facilities, continuing education, expansion of referral services and development of communication, transportation and administrative networks to supply and manage the health facilities. Furthermore, the effectiveness of this model program for averting deaths or applying such preventive measures as education in sanitation and nutrition has not been clearly established.

The pilot projects for providing basic health-care services that have been evaluated vary in their effectiveness in improving the general level of health care. For example, an outside evaluation of primary health service in Ghana revealed that a third to half 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; only one fifth of the children under the age of five years had 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.\textsuperscript{27,28}

The cost and effectiveness of several experimental programs providing primary health care in localized areas have been compared in Imesi, Nigeria\textsuperscript{29,30}; Etimesgut, Turkey\textsuperscript{31}; Narangwal, India\textsuperscript{32}; Jamkhed, India\textsuperscript{33}; Guatemalan villages\textsuperscript{34}; Hanover, Jamaica\textsuperscript{35}; and Kavar, Iran.\textsuperscript{14} The estimated cost per capita varied widely among the programs, particularly because they were initiated at different times over the past 15 to 20 years and furnished different services to their communities. In general, however, the cost per capita ranged between 1 and 2 per cent of the national per capita income of the particular country. The cost for infant deaths averted were difficult to compare because of the paucity of control groups and inconsistency of the population groups monitored. Figures ranged from $144 to $20,000, with a median of $700. The only precise calculations for the costs per infant death averted ($144) or child death averted ($988 per one to three-year-old child) were for a medical-care and nutrition-supplementation project in Narangwal, India.\textsuperscript{31} The estimates were much higher for deaths averted by nutrition supplements.

Under some circumstances, programs of basic primary health care have been successful, but the cost
and the degree of improvement in community health have varied markedly enough that refinements in the approach are still needed.

**Multiple Disease-Control Measures**

These interventions, which include vector control, water and sanitation programs and nutrition supplementation, are more specific and easily managed than primary health-care programs, and they control many similarly transmitted diseases simultaneously. They can decrease mortality and morbidity and have served as interim strategies for health care in less developed countries.

**Vector Control**

Vector control is directed at managing the insects and mollusks that carry human disease. This approach has the advantage of being comparatively inexpensive, but it must be continued indefinitely and may be ephemeral since the vectors tend to become resistant. The examples below reveal some of the complexities of maintaining vector control.

The control of malaria transmission through insecticides has been highly effective. In the tropical regions and savannas of Africa, twice-yearly spraying has decreased the crude death rate by approximately 40 per cent and infant mortality by 50 per cent.\(^{1,2}\) The World Health Organization has estimated that the average cost for house-to-house spraying with chlorophenoxythion (DDT) is $2 per capita annually.\(^{3}\) Therefore, the cost per adult and infant death averted is $250, and the cost per infant death averted is $600. Unfortunately, eradication of malaria with insecticides is becoming more difficult to accomplish. Because mosquitoes can be expected to become resistant to DDT within a few years, other, much more expensive pesticides must be substituted; the use of propoxur or fenethylation will raise the cost of the chemicals five to 10 times.\(^{4}\) Furthermore, there is no way of knowing how long these insecticides will remain toxic to the mosquitoes. Among the mosquitoes in which widespread resistance to insecticides has developed are *Culex pipiens fatigans*, the major vector of urban filariasis, and *Aedes aegypti*, the vector of yellow fever and dengue.\(^{5}\)

Two other vector-control programs illustrate the prolonged maintenance required by this type of health intervention. Onchocerciasis, a potentially blinding helminth infection affecting 30 million people in Africa, is being managed in the Volta River Basin through a 20-year larvicide operation to control the blackfly vector. The program is estimated to cost $18 per capita for the entire 20-year period or $0.90 per capita per year.\(^{6}\) Disability will be prevented, and economic activity in 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 the snail-transmitted helminth infection schistosomiasis through molluscsides. An annual cost per capita of about $3.70 and good results have been reported: the prevalence of the infection has decreased from 45 to 35 per cent in adults and from 21 to 4 per cent in children. 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 amount of disease in an area, but the financial investment involved is enormous. The success of such projects also depends on rigorous maintenance and alteration of engrained cultural habits.

With the installation of community water supplies and sanitation in developing areas, deaths from typhoid can be expected to decrease 60 to 80 per cent,\(^{7}\) deaths from cholera 0 to 70 per cent,\(^{8,9}\) from other diarrheas 0 to 5 per cent,\(^{10}\) from ascariasis and other intestinal helminths 0 to 50 per cent,\(^{11,12}\) and from schistosomiasis 50 per cent,\(^{13,14}\) (after 15 to 20 years). The World Bank has estimated that the cost of providing community water supplies and sanitation to all those in need by the year 2000 will be $135 to $260 billion.\(^{15,16}\) Construction of a rural community standpipe costs $20 to $26 per capita, and rural sanitation costs $4 to $5 per capita. In urban areas the costs are $31 and $23, respectively. In our model area of Sub-Saharan Africa the initial investment would be $12 to $15 million. If amortization and annual maintenance costs are only 10 per cent of this sum, the annual cost per deaths averted will be $2400 to $2900, and the cost per infant and child deaths averted will be $3600 to $4300.

What must be realized is that the above sums are largely for public standpipes, which are not highly effective in reducing morbidity and mortality from water-related diseases. It is well documented that connections inside the house are necessary to encourage the hygienic use of water.\(^{17}\) For example, shigella-caused diarrheas decreased 5 per cent with outside house connections but fell 50 per cent when sanitation and washing facilities were available within the home.\(^{18}\)

All these estimates depend on exclusive use of protected sanitation and water supplies, without continuing use of environmental sources. In Bangladesh, for example, there was no reduction in cholera in areas supplied with tube wells, primarily because of the use of contaminated surface water as well as the protected water supply.\(^{19}\) In St. Lucia, contact with surface water could not be discouraged until household water supplies and then swimming pools and laundry units were installed, and an intensive health-education campaign was instituted.\(^{20}\) In other words, changing peoples' habits in excretion and water usage takes more than introducing an adequate, dependable and convenient new source. Realistically speaking, a
pervasive and effective health-education campaign is required.

Nutrition Supplementation

Nutrition programs have been advocated as among the most efficient means of decreasing morbidity and mortality in children, but supplementation alone has had no notable effect. Malnutrition is an underlying or associated factor in many deaths from infections in children; in a group of Latin American children, it was associated in 50 per cent of the cases. Poor nutrition may also increase susceptibility to disease or predispose an infected child to more severe illness. Conversely, infection may be a prominent cause of poor nutrition since less food is ingested and absorbed by a sick child. Therefore, if infections could be controlled it is probable that the nutritional status of children would improve greatly. There have been some situations, however, in which malnutrition has been reported to protect against certain infections, e.g., the Sahel famine was thought to suppress malaria, and iron deficiency was reported to protect against bacterial infections.

In view of these findings, it is not surprising that few nutrition-supplementation programs alone have effected a major decrease in the death rate. The Narangwal Project is one of these few, but even in that program the cost per death averted in infants was $213. In children one to three years old the cost was $3000 —1.5 to three times higher than the cost of medical care alone.

Selective Primary Health Care

The selective approach to controlling endemic disease in the developing countries is potentially the most cost-effective type of medical intervention. On the basis of high morbidity and mortality and of feasibility of control, a circumscribed number of cases are selected for prevention in a clearly defined population. Since few programs based on this selective model of prevention and treatment have been attempted, the following approach is proposed. The principal recipients of care would be children up to three years old and women in the childbearing years. The care provided would be measles and diphtheria-pertussis-tetanus (DPT) vaccination for children over six months old, tetanus toxoid to all women of childbearing age, encouragement of long-term breast feeding, provision of chloroquine for episodes of fever in children under three years old in areas where malaria is prevalent and, finally, oral rehydration packets and instruction.

If even 50 per cent of the children and their mothers and 50 per cent of the pregnant women in a community were contacted, deaths from measles would be expected to decrease at least 50 per cent, deaths from whooping cough 30 per cent, from neonatal tetanus 45 per cent, from diarrhea 25 to 30 per cent and from malaria 25 per cent. Oral rehydration has been used successfully in hospitals in outbreak patient clinics and recently in the home to treat diarrheas of numerous causes.

These services could be provided by fixed units or by mobile teams visiting once every four to six months in areas where resources were more limited. Mobile units have been successfully used in immunization programs for smallpox and measles, in treatment services directed against African trypanosomiasis and meningitis and in provision of child care in rural areas.

The cost of fixed units would be similar to that of basic primary health care, although efficiency should be much greater. Cost estimates for a mobile health unit used in the model area in Africa for malaria control and water and sanitation programs were based on an 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 306-km trip that reached 753 patients; the estimated cost per infant and child death averted was $200 to $250. Medications accounted for 30 to 50 per cent of this cost, but this figure could be decreased with contributions of drugs from abroad or their manufacture within the country.

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

Research

For a number of prevalent infections, treatment or preventive measures are expensive, difficult to administer, toxic or ineffective. These infections, which include Chagas' disease, African trypanosomiasis, leprosy and tuberculosis, may better be dealt with through an investment in research. In terms of the potential benefits, the cost of research is low. Indeed, the total amount now being spent on research in all tropical diseases is approximately $60 million, exceedingly small in relation to the number of people infected. As Table 4 shows, expenditures 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.

The estimated cost for the research and development leading to the pneumococcal vaccine licensed in the United States in 1978 was $3 to $4 million (Austrian R: personal communication). Death and disability in developing countries would be reduced by heat-stable vaccines for measles, malaria, leprosy and rotavirus and Escherichia coli-induced diarrheas.
adult population of the area covered by the service. As
the table suggests, selective primary health care may
be a cost-effective interim intervention for many less
developed areas.

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and filariasis and by depot drugs for malaria and
intestinal helminths.

Conclusions
Until comprehensive primary health care can be
made available to all, services aimed at the few most
important diseases (selective primary health care)
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 the foregoing calculations, we
based our analysis of cost effectiveness on 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 avail-
able data makes it impossible to measure distinct
and undeniable secondary benefits. For example, water
supplies close by would save time for the women who
carry water, and increased amounts could irrigate a
home garden.

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

Table 4. Research Funding for Major Diseases of the

<table>
<thead>
<tr>
<th>Disease</th>
<th>Amount of Funding ($)</th>
<th>Cost/Equivalent Prevention ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>15,000,000</td>
<td>0.62</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>3,000,000</td>
<td>0.94</td>
</tr>
<tr>
<td>Filariasis</td>
<td>2,000,000</td>
<td>0.01</td>
</tr>
<tr>
<td>Trachoma</td>
<td>2,000,000</td>
<td>0.08</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>1,200,000</td>
<td>0.10</td>
</tr>
<tr>
<td>Leprosy</td>
<td>2,000,000</td>
<td>0.16</td>
</tr>
</tbody>
</table>

by improved chemotherapy for leprosy, tuberculosis,
American and African trypanosomiasis, onchocercia-
sis, filariasis and by depot drugs for malaria and
intestinal helminths.

Table 5. Estimated Annual Costs of Different Systems of
Health Intervention.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Per Capita Cost ($)</th>
<th>Cost Per Death Averted ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic primary health care</td>
<td>0.40-7.50</td>
<td>144-20,000 (I)</td>
</tr>
<tr>
<td>Malaria control</td>
<td>2.00</td>
<td>300 (I)</td>
</tr>
<tr>
<td>Schistosomiasis control</td>
<td>2.00</td>
<td>600 (I)</td>
</tr>
<tr>
<td>Filariasis control</td>
<td>0.90</td>
<td>Few infant &amp; child deaths</td>
</tr>
<tr>
<td>Leishmaniasis control</td>
<td>3.70</td>
<td>Few infant &amp; child deaths</td>
</tr>
<tr>
<td>Community water supplies &amp; sanitation</td>
<td>30-54</td>
<td>3000-4000 (LC)</td>
</tr>
<tr>
<td>Integrated nutrition</td>
<td>1.75</td>
<td>213 (I)</td>
</tr>
<tr>
<td>Financial nutrition</td>
<td>2.00</td>
<td>3000 (I)</td>
</tr>
<tr>
<td>Effective primary health care</td>
<td>0.25</td>
<td>200-250 (LC)</td>
</tr>
</tbody>
</table>

Delivered by village health workers.
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