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A Comparative Review of the Economic Impact of Selected Infectious Diseases in Africa

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A Comparative Review of the Economic Impact of Selected Infectious Diseases in Africa

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EXECUTIVE SUMMARY

GENERAL

This report reviews the methodology for measuring the burden of illness from a disease and translating that burden into an economic impact. The economic consequences of disease are described in terms of the direct costs for treatment and the indirect costs of productivity lost due to morbidity and mortality according to the theory of human capital. Public good benefits, such as the effects of new lands liberated from disease or psychological benefits of reduced prevalence of illness, while important, are typically not included because they are difficult to measure. Standard measurements of productivity are based on the formal labor market. However, methodology for expanding the framework for measuring production to include total household dynamics is under development.

Alternatives to the human capital theory approach to valuation are based on consumer demand. In one method, people are asked what they would be willing to pay for health improvement; in another method, financial allocations are analyzed to determine what people have in fact paid for health improvement. These approaches have not been applied in developing countries. Some problems with these alternatives are the wide variation in values and the philosophical objection to encourage decisions regarding health care based on one's ability to pay.

Debates about value judgments are inherent in the process of placing an economic value on the effects of disease. Whatever methodology is used, there is a need for a balance among three generations: the young who will provide future production; the working age who provide support for themselves, for the development of the future generation, and for the older dependents; and finally the non-working older generation. Economic principles can elucidate the problems, but economic principles alone cannot resolve the issues.

DISEASES

Malaria, HIV/AIDS, onchocerciasis and dracunculiasis (guinea worm disease) are selected because of their programmatic importance to USAID's Africa Bureau. Schistosomiasis is included for methodological reasons because studies on schistosomiasis were among the first to systematically examine the effect of disease on productivity. For each of these five diseases, a number of sentinel studies are selected to represent the state-of-the-art in the evaluation of economic impact. It should be clear that not all important health problems in Africa are addressed. Notably absent are tuberculosis and injuries, which are coming to be recognized as major health problems of adult populations in developing countries.

Malaria is a major economic burden in African populations; indirect costs contribute substantially to this burden. Four studies place a monetary value on a case of malaria; the monetary value ranges from $5.96 in Solenzo District, Burkina Faso to $12.80 in Mayo-Kebbi District, Chad. One study leaves the indirect cost of malaria in terms of a non-monetary value, healthy days of life lost; that study found that malaria accounted for 10.2% of healthy days of life lost in Ghana (corresponding to 32,567 healthy days lost to malaria per 1000 people per year). However, a study looking directly at the effects of malaria on agricultural production found no significant effect.

The impact of HIV/AIDS on African economies is staggering. The direct lifetime cost of caring for a person with AIDS ranges from $104 to $1,585; the ratio of the direct cost to per capita GDP ranges from 1.2 to 3.3. The indirect cost of the loss of productive lives is even greater; the ratio of the indirect cost to per capita GDP ranges from 10.5 to 21.3. Macroeconomic effects are likely

to be seen in the inability to replace skilled and educated workers and on key exports such as agriculture.

The savannah strain of onchocerciasis has been a major burden in West Africa. In Burkina Faso alone, over the period from 1975 to 1982, the interruption of transmission by the Onchocerciasis Control Programme prevented 2,701 cases of blindness and 23,409 person-years of disability caused by blindness. Premature mortality associated with the disease, although not directly caused by the disease, was also substantially reduced (OCP added 37,364 person-years lived). However, a study of the forest strain of onchocerciasis in Liberia found no short-term effect of ivermectin treatment on non-blinding sequelae of infection.

Dracunculiasis generates a significant economic burden in rural areas where it is endemic. As many as 18% of infected people may be so disabled that they cannot leave their family compound. A successful eradication program in a village in Nigeria demonstrated that the disease was preventing economic growth -- trading opportunities, new construction, new school, and increased school enrollment.

Schistosomiasis in a workforce generates not only direct costs for treatment, but also indirect costs that may be as much as 10% of production, except for a few patients with severe clinical symptoms. However, productivity losses may be underestimated from a public health standpoint because studies of workers on plantations necessarily exclude those unable to work at all.

COMPARABILITY PROBLEMS

It is difficult to compare the economic impact of disease from different studies when they use different levels of analysis, e.g., macro or household. For diseases of programmatic importance, great priority should be attached to providing data for the same level across diseases. The most important gap at the present time is the lack of HIV/AIDS data at the household level. Studies of the impact of AIDS on villages and businesses are also needed.

Problems of comparability arise from using different types of sources, e.g., household surveys or company records. Even studies using the same type of source may be difficult to compare because of technical differences. For example, household surveys in different studies may have totally different sampling schemes or questionnaires.

The fact that different studies include different specific benefits also makes comparisons difficult, but sometimes these differences are inherent in the diseases under study. Among adults, for example, malaria, dracunculiasis and schistosomiasis are mainly problems of morbidity, while HIV/AIDS and onchocerciasis generate considerable morbidity and mortality.

The goal of finding a common scale on which to measure economic impact is elusive. The value of even a tangible product, like sugar cane or rubber, depends on market forces inside and outside the country. The estimation of productivity is more complex when there is no tangible product in the marketplace.

HEALTHY LIFE YEARS LOST

The usage of healthy life years lost (or healthy days of life lost) to compare diseases in the Ghana Health Assessment Project represents one workable compromise for estimating economic impact. The data requirements for using healthy life years are: (1) annual incidence; (2) case-fatality rate; (3) average ages at onset and death from disease and the expectations of life at these ages; and (4) the extent and duration of disability caused by the disease and a case-disability rate analogous to a case-fatality rate.

DISCOUNTED PRODUCTIVE YEARS OF LIFE LOST

Healthy life years lost are becoming widely used to measure impact, but not without some modification. In general, the number of healthy life years depends on age. Accordingly, if not weighted, children have larger expected life years. Productivity weights are assigned so that adults are weighted more than children. Time preference for a healthy day of life today over a healthy day of life in the future is also incorporated with a discount rate typically between 3% and 10% per annum. The result is called discounted productive years (days) of life lost.

As stated earlier, there is a need for a balance among different generations: the young who will produce in the future; the working-age adults who are currently producing; and the non-working adults who produced in the past. From this perspective, productivity weighting schemes are designed to provide a social adjustment for the inter-intra-generational implication of the concept of healthy life years. Indeed, there is no optimal resolution of such issues.

The weighting schemes can have a dramatic effect. For example, if the disease burdens caused by sexually transmitted diseases in African cities are ranked together with the diseases reported in the Ghana Health Assessment Project, the results depend on the weighting scheme. Using discounted healthy life days lost per capita, measles ranks first and HIV/AIDS ranks second; using discounted productive healthy life days lost per capita, HIV/AIDS ranks first and measles ranks second (because the productivity weights make the effect on adults relatively more important).

However, although estimation of discounted productive years of life lost is a useful method of comparing the burden of diseases, it does not directly attach a monetary value to disease burden. In order to obtain a monetary measure of lost productivity, a common practice is to multiply discounted productive years of life lost by an estimate of average annual income. Unfortunately, the result is a very crude measure of productivity that is difficult to defend. Household level analyses which incorporate roles and activities such as market production, home production and social roles would contribute to the understanding of how households cope with disability of its members; such analyses would have support from an expanded framework for measuring production that is the subject of active research.

COST-BENEFIT AND COST-EFFECTIVENESS

Policy makers and health planners need to know more than the economic impact of disease. An analysis of economic impact is designed to identify priorities among health problems only as a first step toward obtaining resources for a more refined analysis of resource allocation for specific interventions and subsequent program evaluation. The essence of the problem is that economic impact studies provide a total, or average per capita, cost of disease, while intervention decisions are made at the margin, i.e., the effect of additional resources on reducing the burden of disease.

Cost-benefit analysis asks if a particular intervention is worth doing. The analysis requires that a monetary value be placed on both the resource costs and the output consequences of the program. Cost-benefit analysis is analogous to economic impact studies that place a monetary value on health outcomes.

Cost-effectiveness analysis asks what intervention will achieve the desired health objective at the lowest cost. Cost-effectiveness analysis is analogous to economic impact studies with non-monetary valuation, such as healthy life years lost. Cost-effectiveness is a necessary step in developing a cost-benefit analysis. However, it can only be used as a project evaluative tool when the outcome(s) is standardized.

Cost-effectiveness for health programs in developing countries is frequently measured in terms of dollar cost per discounted healthy life year gained. In developed countries, the analogous measure

is cost per quality-adjusted life year gained.

CONCLUDING REMARKS

While estimates of the economic impact of disease can be quite useful, they can also present an incomplete picture if the dynamics of disease are ignored. Other things being equal, a disease whose incidence is increasing should be a greater priority than a disease whose incidence is stable or decreasing. For example, malaria and AIDS in Africa deserve a high priority not only because of their estimated burdens but also because of their rising incidences.

The dynamics of disease may also interact directly with the dynamics of development. Throughout this report, the goal of disease control has been to remove impediments to economic growth, and yet, the development process itself can generate adverse health consequences. If adverse changes can be anticipated, then proper planning may prevent harmful side-effects of development projects. It is obviously preferable to prevent the occurrence of a disease than to have to assess the burden of a disease after it has become widespread.

Finally, many value the improvement of health not only as a means to economic development, but also as a goal of economic development. In establishing priorities for disease control, it would be wise to bear in mind the larger context of issues in economic development.

RECOMMENDATIONS

METHODOLOGIES

- Discounted productive years of life lost should be used in studies of the impact of disease and cost-effectiveness of interventions because it incorporates effects of morbidity and mortality in one measure. However, applications of this measure must make explicit the assumptions regarding health, productivity weights and time preference (in that a healthy day of life in the present is more valuable than one in the future).

- Productivity weights, at best, provide the basis for estimating cost and benefit at the household level. They do not provide a basis for examining the dynamics within the household, e.g., how a healthy/unhealthy member affects the health status of other members of the household or the community. Household level analyses which incorporate roles and activities such as market production, home production and social roles would contribute to the understanding of how households cope with disability of its members. This information, although costly and prone to measurement error, is acutely needed for HIV/AIDS.

DATA REQUIREMENTS

- Future research should emphasize the development of standard data sources and units of measure for comparing the economic impact of disease and the economic benefits of disease control programs. This may include the establishment of new data collection systems. Such systems should be sensitive to the life cycle nature of the "discounted productive years of life lost" methodology, i.e., indicate the importance of the inter-generational flow of resources to health promotion.

INTRODUCTION

Health policy debates are increasingly appealing to economists for justification of support of disease control programs in the developing world (e.g., Jamison and Mosley, 1991). An important component of such debates is an estimate of the burden of illness generated by a disease. The removal of that burden represents the potential benefit to be gained by eliminating that disease. The purpose of this report is to review the methodology for measuring the burden of illness and translating the burden into an economic impact. The emphasis throughout will be on malaria, HIV/AIDS, onchocerciasis and dracunculiasis because these diseases are of programmatic importance to USAID's Africa Bureau. Studies of schistosomiasis are also presented because they are some of the earliest attempts to demonstrate the effects of disease on productivity.

The scope of this report is necessarily limited because the links between economics and disease control are varied and complex. An analysis of economic impact is designed to identify priorities among health problems only as a first step toward obtaining resources for a more refined analysis of resource allocation for specific interventions and subsequent program evaluation (Prost and Jancloes, 1992); these later stages in the process of health policy development are properly studies in themselves. Not all important health problems in Africa are addressed. Notably absent are tuberculosis and injuries, which are coming to be recognized as major health problems of adult populations in developing countries (Bloom and Murray, 1992; Smith and Barss, 1991).

The economic consequences of disease will be described in terms of the cost of medical treatment, including hospitalization and drugs, and the cost of morbidity and mortality due to the illness. These two components of cost will be termed direct costs and indirect costs, respectively, following widely used conventions (e.g., Over and Kutzin, 1990); however, it should be noted that this terminology is not universally accepted. Before the specific details of these costs are given, a conceptual framework for assignment of these costs is presented.

The direct cost of a disease includes the cost of hospitalization and drugs and any other costs connected with the treatment program. An essential principle of economics is that cost means opportunity cost which is "the benefit foregone in the best alternative use of resources" (Mooney and Creese, 1992). Unfortunately, nominal costs do not always reflect opportunity costs. Such market distortions, which are not uncommon in the health care sector, complicate the assignment of costs. Another important principle is that the costs should include all costs incurred by the public sector and the private sector. However, these costs should not include payments of health benefits or pensions because they are considered to be transfer payments from the working population to others.

The indirect cost of the morbidity and mortality experienced due to disease is the loss of productivity, according to the human capital approach. This approach assumes that the objective of improving health is to increase individuals' output, so that productivity is the basis for assigning monetary values to good health. Productivity losses caused by a disease include time away from work due to morbidity, loss in productivity at work due to morbidity and loss of a lifetime of productivity due to premature mortality. Unfortunately, this method does not explicitly recognize problems of inter-generational equity; no value is given to the young, who will provide future production, or to the non-working older generation, who have produced in the past.

In order to implement the human capital approach, the simplest way to measure the productive value of an individual is as gross labor costs of employment or even just the earnings. These measures are related directly to the macroeconomic variable called gross national product. However, this method of assigning productive value is flawed. No weight is attached to productive individuals who are employed outside the formal labor market (e.g., housewives). Since males on average earn more than females, the health of female workers would be automatically valued less than the health of male workers. Also, control of a disease that disproportionately affects lower-income people would be given lower priority than control of a disease affecting upper-income people (assuming equal numbers infected). Income or gross labor costs do not capture the total value of an employee's output.

A broader theoretical framework has been proposed for examining the economic consequences of tropical diseases in the context of total household dynamics (Popkin, 1982). Market production, household production, and social interactions may be affected by disease, and the model assumes that there is interchangeability between these dimensions. Popkin suggests this framework is more appropriate for assessing the economic impact of disease based on the following observations:

(1) Changes in health status may not affect market production because an individual may alter home production and leisure to compensate for health changes.

(2) An individual's health status change may not affect market production because of *intrahousehold* substitutions.

(3) Seasonality of market and home production activities may mediate the effects of changes in health status.

(4) Certain household outputs are not readily measured, but are important indicators of quality of home production, such as child development, learning, and leisure activities.

(5) Social activities, for example participation in mother's clubs, irrigation associations, and churches may have important long-run economic effects.

(6) Interactions between household and community-level social structures should be considered, for example: caste and social restrictions, class relationships, political structures, and labor markets which affect the access of individual households to the means of production and jobs at certain wage levels.

This broader theoretical framework is gaining acceptance among researchers and policy makers who want to better understand and manage health and development. It is clearly recognized that the examination of adult ill-health in the developing world involves more than reduced productivity of the ill adult and the medical cost of treatment. If the ill person dies, not only is his or her productive output lost completely, but the health of the surviving household members may suffer. Less obvious but also significant are the coping processes of the ill adult,

family, friends, employer and co-workers that attempt to reduce the effect of illness (Over et. al., 1992).

A totally different approach to valuing health is based on people's own willingness to pay for reductions in the risk of death, injury or illness. People's own perceptions of needs may differ considerably from an epidemiologist's assessment of priorities (Prost and Jancloes, 1992, p. 6). This issue is particularly critical in discussing specific health interventions because public support is necessary for sustainability of programs in the long run (Dunlop, 1984, p. 1036). In the implementation of this method, potential victims are asked what they are willing to pay for reducing their probability of illness, disability, or death by a specific amount (e.g. risk of death from 3/10,000 to 2/10,000). It should be noted that values obtained with this method are usually much larger than those based on the human capital approach (Mooney and Creese, 1992, p.27). Serious problems with this approach are the wide range of values derived for health programs and the prospect that this method would encourage decisions regarding health care based on one's ability to pay.

Another approach based on implied values is similar to the willingness-to-pay method, but assumes that the value to individuals of improved health is a function of what is actually paid for a specific outcome. Sources of data include judicial awards to compensate for loss of life and financial allocations by popularly elected officials to reduce risks of death (Dunlop, 1984, p. 1036). For example, "...if a decision is made, at the margin, to spend 1 million dollars to save a life, then by implication the value of that life must be at least 1 million dollars otherwise the investment would not be made" (Mooney and Creese, 1992, p. 28). Although this method sounds easy to apply, preliminary experience shows that it generates a wide range of values. As with willingness-to-pay, it could be either an advantage or a disadvantage that the values reflect those of the existing social structure-- an advantage if one accepts the structure and a disadvantage if one perceives the structure to be full of inequities.

An important category of benefit not usually included in empirical studies of disease control is the public good which affects the entire population. This category is especially appropriate when a disease is eradicated (Dunlop, 1984, p. 1032). New lands may be open to migration and settlement. Those never infected with the disease may still benefit psychologically from knowing a risk has been eliminated. However, it is difficult to generalize about these benefits in a simple way because special features of the population, the land and the eradicated disease are critically important. For example, land freed of onchocerciasis in West Africa is not "free," but rather is subject to traditional patterns of ownership.

Debates about value judgments are inherent in the process of placing an economic value on the effects of disease. Whatever methodology is used, there is a need for a balance among three generations: the young who will provide future production; the working age who provide support for themselves, for the development of the future generation, and for the older dependents; and finally the non-working older generation. Economic principles can elucidate the problems, but economic principles alone cannot resolve the issues.

METHODOLOGY

This review of the economic impact of infectious diseases includes the following diseases selected because of their programmatic importance to USAID's Africa Bureau: malaria,

HIV/AIDS, onchocerciasis and dracunculiasis (guinea worm disease). Studies of the economic impact of schistosomiasis are also included for methodological reasons since these were, historically, some of the earliest attempts to demonstrate the effects of disease on productivity. For each disease, certain papers were selected as sentinel studies to represent the state-of-the-art in impact evaluation and the references for these studies may be found in Table 1.

This review of selected infectious diseases follows the same format as the evaluation of parasitic disease control programs by Dunlop (1984). Dunlop structured his discussion around the following processes: conceptualization and specification of benefits expected from a specific control measure; empirical measurement of the benefits identified; and finally, valuation of these benefits. However, this review differs from Dunlop's review in its concern for the economic impact of disease rather than the evaluation of a specific control strategy. Consequently, the benefits in this review correspond to the burden of illness that would be alleviated if the disease were eliminated from the study population. Thus, the potential benefits of disease elimination are classified into direct costs and indirect costs of disease. The direct costs represent the potential reductions in costs of treatment and the indirect costs represent the potential gains in productive output as defined in the introduction.

In the next section, the analysis of the sentinel studies for each disease is structured around three kinds of tables. The first table defines the benefits identified by the authors of each study in terms of the components of direct costs or indirect costs or both. The second table lists the sources of data used in constructing measures of the benefits identified in the first table. The third table shows how values were assigned to the benefits defined for each study. The discussion for each disease concludes with an overall synthesis of the major findings.

A section discussing what comparisons can be made across diseases follows the section in which each disease is treated separately. The comparative review summarizes the methodological details according to the level of analysis (national, firm, community or household), the benefits included (components of direct costs and indirect costs), and the types of data sources. As a shorthand, studies are referred to by the numbers assigned in Table 1. The Ghana Health Assessment Project (Nimo et al., 1981) is singled out as a case study in comparing the impacts of different diseases. The project's use of healthy life years lost as a measure of comparative impact has often been a starting point for analyses by others, although this methodology has also been the subject of controversy. The comparative review section explains the issues surrounding the use of healthy life years lost as a measure of impact and concludes with a discussion relating the analysis of economic impact to cost-benefit and cost-effectiveness studies.

ECONOMIC IMPACT OF SELECTED DISEASES

Malaria

The six studies of the economic impact of malaria listed in Table 1 are reviewed -- the first four studies were recently prepared by USAID's Vector Biology and Control Project (VBC) in an effort to provide a comprehensive analysis of the economic impact of malaria in Africa based on available information. The other two studies represent important methodologies for estimates of the impact of malaria in Africa on productivity. The four VBC studies of malaria identify both reduced treatment costs and gains in productivity as potential benefits of malaria control, while the other two address only the gains in productivity.

TABLE 1: SOURCES OF SENTINEL STUDIES

MALARIA

1 Rwanda (Ettling and Shepard, 1991)
2 Burkina Faso
Solenzo District (Sauerborn et al., 1991)
3 Chad
Mayo-Kebbi District (Shepard et al., 1991)
4 Congo
Brazzaville (capital city) (Shepard et al., 1991)
5 Ghana (Ghana Health Assessment Team; Nimo et al. 1981)
6 Cameroons
Mayo Danai (Audibert, 1986)

HIV/AIDS

1 Zaire and Tanzania (Over et al., 1988; Over and Kutzin, 1990)
2 "Typical African Country" (Way and Over, 1992)
3 "Central African Country" (Scitovsky and Over, 1988)
4 Malawi (Forsythe, 1992: Draft Report)
5 Kenya (Oot et al., 1992: Draft Report)

ONCHOCERCIASIS

1 Upper Volta (Burkina Faso) Onchocerciasis Control Programme
(Prost and Prescott, 1984)
2 Upper Volta (Burkina Faso) (Evans and Murray, 1987)
3 Liberia (Clark, 1990) Liberian Agricultural Company

DRACUNCULIASIS

1 Nigeria (Huttly, Blum et al. 1990) and (Smith et al., 1989)
5 villages: Amata, Amena, Amenu, Amankanu, Umumgbala
Imo State (Imo State Drinking Water Supply/Sanitation Project)
2 Nigeria (Watts, Brieger, and Yacoob 1989)
Idere Town, Oyo State; Asa and Moro, Kwara State
3 Nigeria (Brieger and Guyer, 1990)
Idere Town, Oyo State
4 Nigeria (Edungbola and Watts, 1990)
Igbon Village, Oyo State
5 Ghana (Belcher et al, 1975) Danfa Project

SCHISTOSOMIASIS

1 Sudan (Collins, Brotherhood, et al., 1976)
Guneid Township
2 Tanzania (Foster, 1967)
Arusha Chini Estate, Tanganyika Planting Company
3 Tanzania (Fenwick, 1972)
Arusha Chini Estate, Tanganyika Planting Company
4 Tanzania (Fenwick and Figenschou, 1972)
Arusha Chini Estate, Tanganyika Planting Company
5 World (Wright, 1972)
Endemic Areas
6 Brazil (Barbosa and Pereira Da Costa, 1981)
Tiuma and Catende estates, State of Pernambuco

Table 2 provides the benefits included in these six studies in greater detail. In the VBC studies, reductions in treatment costs encompass cost of hospitalization, outpatient treatment at a health facility, and the cost of supplies and courses of drugs. Potential gains in productivity are measured in all the VBC studies as savings in adult productivity due to: reduced adult morbidity, reduced child morbidity, and premature deaths averted. The fifth study, the Ghana Health Assessment Project, examines productivity in terms of the additional days of healthy life that would result from reduced morbidity and mortality. The sixth study focuses directly on agricultural output of rice-growers in the Cameroons (Audibert, 1986). Neither the fifth nor the sixth study develops monetary measures for the effect of malaria on productivity.

Benefits to be gained through malaria control are measured based on numerous sources of data described in Table 3. In fact, the four VBC studies were designed to make use of a variety of sources. Direct cost estimates are based on Ministry of Health information for Rwanda, health services budgets and a district survey for Burkina Faso, a district survey for Chad, and a study of patterns in sub-Saharan Africa for Brazzaville, Congo. Estimates of malaria morbidity and mortality are based mainly on national records for the first, third and fifth studies (Rwanda, Chad and Ghana) and on surveys for the second, fourth and sixth studies (Burkina Faso, Congo and Cameroons). Estimates of productivity are constructed from data on average incomes (Rwanda and Congo), from national data on agricultural output (Burkina Faso) and from a special survey on the monetary value for time (Chad). An estimate of healthy life years lost for Ghana is derived from population census data, life tables and age-specific death rates, cause of death on death certificates, inpatient and outpatient statistics and special surveys. Agricultural output in the Cameroons is determined from household survey information and data from the company managing the agricultural production.

The method of benefit valuation is summarized for each malaria study in Table 4. The direct treatment costs per case of malaria are determined in a similar manner for the four VBC reports--national level records of health care services use supplemented by surveys to determine household expenditures on drugs, service fees and travel. For the same four reports, the indirect costs per case of malaria are based on an estimate of daily productive output per adult. The daily productive output is based for Rwanda on average rural wages, for Burkina Faso on the marginal product of labor relating the market value of agricultural output to the amount of person-time needed to produce it, for Chad on the value of time and production found in a survey, and for the Congo on the average value of time for all adults in Brazzaville derived from special studies. The daily output is multiplied by estimated annual losses of adult time which are assumed to be the entire duration of adult (age 15 and over) illness and one-third of the duration of child (younger than age 15) illness. Future earnings losses due to child mortality are based on projections of life beyond the age of 15 years; the daily adult output is applied to the adult life projected subject to a discount rate. Similarly, a discounted productive life expectancy may be obtained to account for adult mortality from malaria. However, these studies show no losses due to adult mortality from malaria except in Rwanda where over half of the malaria deaths occurred in adults. Direct costs and indirect costs per case of malaria are transformed into costs per capita using the 1989 national population in Rwanda, the 1985 Solenzo District population in Burkina Faso, the 1987 Mayo-Kebbi District population in Chad and the 1984 Brazzaville population in the Congo. In contrast to the VBC studies, the Ghana study leaves results in terms of time lost and avoids assigning monetary values to rural production because of the theoretical difficulties in doing so. In Ghana, the results for each disease are expressed in terms of healthy days of life lost per 1000 people and the corresponding percentage of healthy days of life lost. The study

TABLE 2: BENEFITS INCLUDED IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Benefits Included In Analysis
MALARIA				
1	Ettling & Shepard	1991	Rwanda	Reduced hospitalization costs Reduced costs of treatment and supplies, courses of drugs Adult productivity saved from reducing adult morbidity Savings in adult productivity by reducing child morbidity Lifetime earnings saved from averting premature mortality Reduced costs of care at health facilities
2	Sauerborn et al.	1991	Burkina Faso	Reduced costs of care at health facilities Reduced expense to families of travel, drugs, supplies Adult productivity saved from reducing adult morbidity Savings in adult productivity by reducing child morbidity Lifetime earnings saved from averting premature mortality
3	Shepard et al.	1991	Chad	Reduced hospitalization costs Reduced costs of treatment and supplies, courses of drugs Adult productivity saved from reducing adult morbidity (100% lost per day of adult illness) Savings in adult productivity by reducing child morbidity (30% per day lost due to child illness) Lifetime earnings saved from averting premature mortality
4	Shepard et al.	1991	Congo	Reduced hospitalization costs Reduced costs of treatment and supplies, courses of drugs Adult productivity saved from reducing adult morbidity (100% lost per day of adult illness) Savings in adult productivity by reducing child morbidity (30% per day lost due to child illness) Lifetime earnings saved from averting premature mortality
5	Nimo et al.	1981	Ghana	Healthy days of life saved through treatment of disease Healthy days of life saved by prevention of premature death
6	Audibert	1986	Cameroons	Increased agricultural output with control of debilitating disease

TABLE 3: DATA SOURCES IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Measurement of Benefits in Analysis: Data Sources
MALARIA				
1	Ettling & Shepard	1991	Rwanda	Ministry of Health records of direct costs of treatment both within and outside facilities Malaria Case reporting system, by type of health facility National data on rural wages
2	Sauerborn et al.	1991	Burkina Faso	Representative Household Survey (1985) of health service utilization, expenditures, and agricultural production Budgets for health services Household survey data on malaria cases and deaths Malaria seasonality from national death reporting system Burkina Ministry of Agriculture data used to estimate annual output of agricultural products
3	Shepard et al.	1991	Chad	Number of malaria cases from national medical reporting system (fever corresponds to clinical diagnosis of malaria) Adjustment of malaria cases for seasonality and age based on distribution documented for Burkina Faso Case fataiity rates based on Gambian rates Survey data provide expenditures on treatment of malaria, and value of time and productivity.
4	Shepard et al.	1991	Congo	Population and average income derived from published data Malaria epidemiological data based on special studies Costs of treatment estimated based on a sub-Saharan African pattern of health expenditures (Vogel, 1988)
5	Nimo et al.	1981	Ghana	Population census, age-specific death rates and life tables Cause of death as recorded on death certificates Inpatient and outpatient statistics Special surveys
6	Audibert	1986	Cameroons	Cameroons Survey of 150 households, 4 rounds of survey; epidemiological information, health status and work status Data on agricultural production from company

TABLE 4: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
MALARIA				
1	Ettling & Shepard	1991	Rwanda	**Direct Costs** Institutional costs from average cost per case per day Household costs from drug purchase and traditional methods **Indirect Costs** Adult productivity per day from average rural wages Duration of adult illness and one-third duration of child illness (adult as caretaker) Productive adult life lost from child and adult mortality Per capita for national population Total economic cost per case $11.82 ($2.58 direct) Total economic cost per capita $2.88 ($0.63 direct)
2	Sauerborn	1991	Burkina Faso	**Direct Costs** Institutional costs from average cost of health care visit Household costs from drugs, service fees and travel **Indirect Costs** Adult productivity per day from marginal product of labor based on seasonal value of agricultural output Duration of adult illness and one-third duration of child illness (adult as caretaker) Productive adult life lost from child mortality Per capita for Solenzo District (rural) Total economic cost per case $5.96 ($1.35 direct) Total economic cost per capita $1.15 ($0.26 direct)
3	Shepard et al.	1991	Chad	**Direct Costs** Institutional costs from average cost in health facility Household costs from average treatment cost at home **Indirect Costs** Adult productivity per day from time and production survey Duration of adult illness and one-third duration of child illness (adult as caretaker) Productive adult life lost from child mortality Per capita for Mayo-Kebbi District (rural) Total economic cost per case $1[illegible].80 ($0.20 direct) Total economic cost per capita $0.60 ($0.01 direct)

TABLE 4: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
MALARIA				
4	Shepard et al.	1991	Congo	**Direct Costs** Institutional costs from average cost in health facility Household costs from average treatment cost at home **Indirect Costs** Adult productivity per day from reported average value of time Duration of adult illness and one-third duration of child illness (adult as caretaker) Productive adult life lost from child mortality Per capita for Brazzaville (urban) Total economic cost per case $8.77 ($3.20 direct) Total economic cost per capita $0.74 ($0.27 direct)
5	Nimo et al.	1981	Ghana	**Indirect Costs** Healthy days of life lost to illness, disability, and premature death Malaria accounts for 10.2% of healthy days of life lost 32,567 healthy days lost to malaria per 1000 people per year
6	Audibert	1986	Cameroons	**Indirect Costs** Association of agricultural output of all family members with malaria (look for negative) No effect of malaria found

from the Cameroons measures the relationship between rice paddy output and disease status.

The major findings from these studies are that malaria is a major economic burden in African populations and that the indirect costs of malaria contribute substantially to this burden. In the study by the Ghana Health Assessment Project, malaria accounted for 10.2% of healthy days of life lost, the largest percentage for any single disease; this value corresponded to 32,567 healthy days lost to malaria per 1000 people per year. In translating the impact of disease into a monetary measure of 1987 U.S. dollars, the four VBC studies find a total economic cost per case of malaria ranging from $5.96 in Solenzo District, Burkina Faso to $12.80 in Mayo-Kebbi District, Chad; the percentage of total cost due to indirect cost varies from a low of 64% in Brazzaville, Congo to a high of 98% in Mayo-Kebbi District, Chad.

However, these quantitative estimates of disease burden depend on many assumptions subject to criticism. One of the most troubling areas is the monetary valuation of adult time. Estimates of average monetary value of adult time for an entire sector of the population ignore the workings of labor markets and household production. The study in Burkina Faso (Sauerborn et al, 1991) goes furthest in incorporating these details by estimating a marginal product of labor adjusted seasonally for different activities such as brewing millet beer and growing cotton. Seasonality is also critical in understanding why there was no effect of malaria on rice-growing in the Cameroons; the study, which was designed to examine the effect of chronic diseases like schistosomiasis, measured disease status during the dry season for logistical reasons and missed episodes of malaria during the wet transmission season.

A more subtle problem of interpretation arises from implicit weights used in the aggregation of effects of disease on children and adults. The Ghana Health Assessment Project's measure of healthy life years lost puts great weight on life-threatening childhood diseases because a child has many more years left to live than an adult. It should not be surprising then that the diseases accounting for the greatest number of days of healthy life lost in the Ghana study are malaria, measles, childhood pneumonia, sickle cell disease and severe malnutrition. In the VBC studies, figures for total cost mask real differences in patterns. For example, the relatively high indirect cost of malaria in Mayo-Kebbi, Chad is due to high levels of child mortality while malaria mortality among adults makes a significant contribution to total cost in Rwanda.

HIV/AIDS

The five studies of HIV/AIDS listed in Table 1 are reviewed -- the first is an analysis of Tanzania and Zaire appearing in two papers, the second and third are analyses of theoretical constructs "Typical African Country" and "Central African Country", and the fourth and fifth are draft reports on Malawi and Kenya prepared by USAID's AIDSTECH project. Four of these studies examine both treatment costs and productivity effects of the disease, while the study of the "Central African country" reviews only the economic impact of treatment cost.

Table 5 provides the benefits included in these five studies in more detail. Reduced treatment cost of HIV/AIDS in health facilities is identified as a benefit in each of the five reports. The analysis of Tanzania and Zaire also notes the need for more in-depth studies to assess the cost of "crowding out" of other patients at health facilities due to the burden of HIV infection. Direct costs in the theoretical construct in the second study include, in principle, total household costs such as funeral expenses, but, as yet, there are no data from household surveys on which to base such estimates.

Table 5 also characterizes potential gains in productivity in a variety of ways. The first

study recognizes as benefits discounted healthy years of life saved, productivity-weighted discounted healthy years of life saved, and discounted lifetime earnings saved per case of HIV/AIDS prevented. The second study examines the increased growth of gross domestic product (GDP) in the absence of AIDS. The fourth and fifth studies look at productive years of life saved and discounted lifetime earnings saved per case of HIV/AIDS prevented. These last two studies also note the impact that HIV infection may have in specific employment sectors, in both the modern and informal small farming (ISF) sectors.

Measurement of benefits in the studies of HIV/AIDS relies on sources of data described in Table 6. Estimates of the direct cost of AIDS focus on health care facilities. The study of Tanzania and Zaire uses data from health care facilities which treat AIDS patients to estimate the cost of treatment, including resources provided by the patient's family, the government and charitable organizations. High and low estimates of the cost of care are presented to account for the tremendous variation in health care options available. The low estimate assumes the patient is restricted to the relatively low cost of urban or rural "health zone" system, while the high estimate assumes the patient has access to private health care. The theoretical construct "Typical African Country" in the second study bases direct cost on figures from the first study relative to gross domestic product (GDP). The theoretical construct "Central African Country" in the third study also bases direct cost on figures from the first study. The report on Malawi bases its estimate of direct cost of care on a review of inpatient treatment costs for 28 AIDS patients. The review was conducted in 1989 at two central and two district level Malawian hospitals. The report on Kenya bases its estimate of direct cost of care on a survey of average daily costs at government, mission and private hospitals in Kenya. The average length of hospital stay for AIDS patients was determined by consensus of a meeting of a group of health care providers.

Table 6 also describes the data sources used in determining the indirect costs of AIDS in all studies except the third which only dealt with direct costs. A life table in the absence of AIDS is used in the first, fourth and fifth studies in order to calculate the number of years of life lost due to AIDS. The same three studies also use national data on average annual income in order to transform years of life lost into the potential earnings lost because of deaths due to AIDS. In addition, the fourth and fifth studies from AIDSTECH examine employment figures by economic sector in order to report on the impact on specific sectors. In quite a different approach, the second study constructs production functions based on a 25-year history of macroeconomic variables from 35 African countries. The production functions are used to determine the effect of AIDS on the gross domestic product through its effects on the factors of production.

The method of assigning economic value to direct costs by these studies is summarized in Table 7. The analysis of Tanzania and Zaire includes financial costs of all resources used in the course of treatment and assumes that every symptomatic HIV infected person will seek care in a health facility. High and low estimates of this direct cost are presented for each country in 1985 U.S. dollars. The theoretical construct in the second study assigns direct cost in three levels relative to assumed per capita GDP of $305 in 1990. The low estimate equal to per capita GDP corresponds to predominantly rural uneducated households, the middle estimate equal to double per capita GDP corresponds to households with primary education and the high estimate of quadruple per capita GDP corresponds to urban households with secondary education. The theoretical construct in the third study bases its estimate on the figures from the first study, but allows for no variation within country. In Malawi, average lifetime costs per treated case are estimated under the assumption that each patient will experience one year of illness before death.

TABLE 5: BENEFITS INCLUDED IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Benefits Included in Analysis
HIV/AIDS				
1	Over et al.	1988	Zaire Tanzania	Reduced costs of care at health facilities Discounted healthy years of life saved per case of HIV/AIDS prevented
	Over & Kutzin	1990		Productivity weighted discounted healthy years oflife saved per case of HIV/AIDS prevented Discounted lifetime earnings saved per case of HIV/AIDS prevented
2	Way & Over	1992	"Typical African Country"	Reduced costs of care at health facilities Reduced costs for households (incl. funeral expense) Increased growth of gross domestic product (GDP)
3	Scitovsky & Over	1988	"Central African Country"	Reduced costs of care at health facilities
4	Forsythe	1992	Malawi	Reduced costs of care at health facilities Productive years of life saved per case of HIV/AIDS prevented Diminished losses to specific employment sectors, both "modern" and ISF (informal small farming) Discounted lifetime earnings saved per case of HIV/AIDS prevented
5	Oot et al.	1992	Kenya	Reduced costs of care at health facilities Productive years of life saved per case of HIV/AIDS prevented Diminished losses to specific employment sectors, both "modern" and ISF (informal small farming) Discounted lifetime earnings saved per case of HIV/AIDS prevented

TABLE 6: DATA SOURCES IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Measurement of Benefits in Analysis: Data Sources
HIV/AIDS				
1	Over et al.	1988	Tanzania Zaire	Records of the direct cost of treatment of AIDS in health facility (resources from family, government, charity)
	Over & Kutzin	1990		High and low estimates of direct cost within country Life table in absence of AIDS National data on average income
2	Way & Over	1992	"Typical African Country"	Theoretical construct of direct cost based on figures from study 1 relative to per capita GDP Macroeconomic data from 35 African countries 1960-1985 Urban (industrial) and rural (agricultural) production
3	Scitovsky & Over	1988	"Central African Country"	Theoretical construct of direct cost based on figures from study 1
4	Forsythe	1992	Malawi	Direct inpatient treatment costs for AIDS was estimated from review of 28 medical records of AIDS cases conducted at two central and two district level hospitals Life table in absence of AIDS National data on employment by economic sector National data on average income
5	Oot et al.	1992	Kenya	Average daily costs of hospitalization from 3 government, 4 mission and 1 private hospital Average length of stay in hospital for AIDS patient from meeting with group of health care providers Life table in absence of AIDS National data on employment by economic sector National data on average income

TABLE 7: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
HIV/AIDS				
1	Over et al.	1988	Tanzania	**Direct Costs** Financial costs of all resources used in the course of
	Over & Kutzin	1990	Zaire	treatment, whether financed by the patient's family, the government or charitable organizations Assumes that every symptomatic HIV infected person will seek at least some treatment at a modern health facility Tanzania per case: Low $104; High $631 Zaire per case: Low $132; High $1,585 **Indirect Costs** Healthy years of life saved per case prevented with 5% discount rate (8.8 years) Weight healthy years of life lost by age-specific productivity: 0-5(0);5-15(.20);15-50(1);50-65(.85);65+(.25) with 5% discount rate (6.2 years) Discounted (5%) lifetime earnings lost from average income Tanzania per case: Low $2,425; High $5,093 Zaire per case: Low $890; High $2,669 [1985 U.S. dollars]
2	Way & Over	1992	"Typical African Country"	**Direct Costs** Theoretical construct: cost relative to per capita GDP ($305 in 1990) Low: Per Capita GDP (rural uneducated) Middle: 2 x Per Capita GDP (primary education) High: 4 x Per Capita GDP (urban secondary education) **Indirect Costs** Reduced growth of gross domestic product 1990-2015 AIDS effect on labor force from epidemic model Labor force effect on production from economic model
3	Scitovsky & Over	1988	"Central African Country"	**Direct Costs** Theoretical construct: $100 [1986 U.S. dollars]

TABLE 7: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
HIV/AIDS				
4	Forsythe	1992	Malawi	**Direct Costs** Lifetime costs of AIDS treatment per case treated Assuming 1 year of illness before death (K515 or $132) **Indirect Costs** Productive years of life saved per case at 0% discount Productivity weights by age from employment surveys (18.7 years) Discounted (5%) lifetime earnings lost from average income (K10,500 or $2,692) Economic sectors at risk HIV Prevalence by occupation; Highly skilled labor [3.9 Kwachas to U.S. dollar]
5	Oot et al	1992	Kenya	**Direct Costs** Lifetime costs per case treated from average daily cost (453 shillings) and average length of stay (60 days) (27,200 shillings or $886) **Indirect Costs** Productive years of life saved per case at 0% discount Productivity weights by age from employment surveys (26 years) Discounted (5%) lifetime earnings lost from average income (194,700 shillings or $6,342) Economic sectors at risk HIV prevalence by occupation; Highly skilled labor [30.7 shillings to U.S. dollar]

In Kenya, average lifetime costs per treated case are estimated from the product of average daily cost of hospitalization (453 shillings) and average length of stay (60 days).

Table 7 also summarizes the valuation of indirect costs saved per case of HIV/AIDS prevented. The first, fourth and fifth studies make projections of years of life that would be experienced in the absence of AIDS. The first study then uses a 5% discount rate to arrive at an average savings of 8.8 years of life. The first study also calculates a productivity-weighted result of 6.2 years using age-specific productivity weights relative to productivity of 1 for a healthy adult aged 15 to 50: weight 0 for ages 0 to 5; weight .20 for ages 5 to 15; weight .85 for ages 50 to 65; and weight .25 for ages over 65. Finally, national data on average incomes for three different socio-economic groups are used to provide a range of monetary values for productive healthy life years saved per case prevented. The low and high monetary values of productive healthy life years are $2,425 and $5,093 for Tanzania and $890 and $2,669 for Zaire. In contrast, the AIDSTECH studies (fourth and fifth) report undiscounted productive years of life saved per case of HIV/AIDS prevented. Employment surveys are the basis for weighting productivity by age, i.e., employed means productive. For Malawi, a productive lifetime is estimated to be 25.3 years in the absence of AIDS, and the average productive life lost per case of HIV/AIDS is 18.7 years. For Kenya, a productive lifetime is estimated to be 36 years in the absence of AIDS, and the average productive life lost per case of HIV/AIDS is 26 years. The conversion of productive life lost into income lost is based on average incomes in specific economic sectors, the urban/rural distribution of employment in these sectors, and the urban/rural AIDS differential. The average discounted lifetime income lost is K10,500 for Malawi ($2,692) and 194,700 shillings for Kenya ($6,342). The AIDSTECH studies also indicate which sectors may be at especially high risk based both on HIV seroprevalence studies in occupational groups and occupations with highly skilled labor. Finally, the second study utilizes a production function relating industrial and agricultural output to the labor force and other factors based on macroeconomic data from 35 African countries. In the model, the direct cost of AIDS is drawn from consumption (smaller effect) or from investment/savings (larger effect). The indirect cost of AIDS is the resulting shortfall in the growth of gross domestic product (GDP) because the effect of AIDS on the labor force is translated into an effect on domestic production.

The major finding from these studies is that the impact of AIDS on African economies is staggering. The lifetime cost of caring for a person with AIDS ranges (in 1985 U.S. dollars) from $104, the low end of the range in Tanzania, to $1,585, the high end of the range in Zaire. The ratio of lifetime direct costs to per capita GDP ranges from 1.2 in Malawi to 3.3 in Tanzania. However, even these large direct costs are dwarfed by the indirect costs of the loss of productive lives. The ratio of indirect cost to per capita GDP ranges from 10.5 (in Zaire) to 21.3 (in Kenya). Macroeconomic effects are likely to be seen in the inability to replace skilled and educated workers and on key exports such as agriculture. Kenya may face a particular problem in mining. AIDS could generate a cumulative deficit from 1990 to 2015 on the order of one and one-half years of gross domestic product in African countries; the indirect effects of lost productivity are about 15 times the direct costs.

Although the impact of AIDS by any measure will be enormous, the estimates of direct and indirect costs are subject to criticism. It would be more informative and less confusing to explicitly construct a range of costs reflecting enormous variation within country instead of creating a mythical "average" cost. The estimates of direct cost could be improved with more

systematic surveys of health care facilities and households. The lack of information on how households are coping with the AIDS epidemic is especially critical; this glaring hole is currently being filled in part by a World Bank household survey in Tanzania. The estimates of indirect cost again raise the difficulty of assigning monetary values to adult time. Although average incomes for a sector of the population can provide a very, very rough sense of the magnitude of the impact, estimates based upon an understanding of the labor market are needed. The model of "Typical African Country" in the second study is moving in this direction. The model explicitly allows for the effect of AIDS on the labor force in an epidemiological/demographic component and the effect of labor force on gross domestic product in a macroeconomic component. The AIDSTECH reports also include a rough, empirical analysis of the impact on the labor force of different economic sectors, such as finance/insurance/real estate.

Onchocerciasis

The three studies of onchocerciasis listed in Table 1 are reviewed. The first two studies are associated with the Onchocerciasis Control Programme (OCP) in West Africa; the analysis is restricted to Burkina Faso (previously Upper Volta). The two OCP studies weigh the cost of OCP's vector, i.e., blackfly, control activities against the benefit of eliminating the indirect cost of onchocerciasis. Since an analysis of the intervention is beyond the scope of this review, only the indirect cost is considered here. The third study is associated with a pilot program of community-based distribution of the drug ivermectin in the rubber plantation of the Liberian Agricultural Company (LAC) in Liberia. The third study includes both direct costs and indirect costs.

The benefits of onchocerciasis control identified by these studies are shown in more detail in Table 8. Distinct epidemiological patterns of the savannah strain of onchocerciasis in the OCP area and the forest strain of onchocerciasis in Liberia influence the examination of benefits. The savannah strain causes a great deal of blindness while the forest strain causes very little blindness. The two OCP evaluations measure a reduced number of cases of blindness and healthy

TABLE 8: BENEFITS INCLUDED IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Benefits Included in Analysis
ONCHOCERCIASIS				
1	Prost & Prescott	1984	Upper Volta (Burkina Faso)	Cases of blindness prevented Healthy years of life saved by preventing blindness Healthy years of life saved by averting premature mortality
2	Evans & Murray	1987	Upper Volta (Burkina Faso)	Cases of blindness prevented Healthy years of life saved by preventing blindness Healthy years of life saved by averting premature mortality
3	Clark	1990	Liberia	Reduced health care utilization by LAC plantation workers Improved productivity of LAC plantation workers

years of life saved (weighted in four different ways) by prevention of blindness and premature death. The study of plantation workers in Liberia examines direct cost in terms of health care utilization and indirect cost in terms of productivity.

Sources of data employed in the two OCP studies are shown in Table 9. Both studies of OCP use data collected by OCP's Epidemiological Evaluation Unit (EPI) to look at changes in the incidence of blindness. The first study of OCP uses tax records to determine the prevalence and duration of blindness and mortality from blindness in the intervention area in the early years of OCP (before OCP reduced the incidence of blindness); blind individuals are exempt from paying taxes, so individuals are motivated to record cases of blindness. In contrast, the second study of OCP uses EPI survey records to cross-check (and critique) methodology for estimating the number of blind individuals and the duration of blindness from tax records. The first study estimates the population at risk for blindness based on the 1975 population census and assumes the population at risk grows at the same rate as the national population; the second study adjusts the 1975 population census for under-enumeration, and assumes the population at risk for blindness does not grow.

The third study employs several types of company records in order to explore the relationship between worker productivity and non-blinding sequelae of onchocerciasis infection (see Table 9). A 1987 census enumerated the workers of the LAC plantation. The plantation hospital provided information on health care utilization by the workers. The estate offices of the plantation provided records of total number of days worked, total number of days of sick leave, and total number of days of unexplained worker absenteeism. Payroll records were reviewed to determine the monthly amount of bonus pay for each rubber tapper. Infected workers were identified through mean microfilarial density (MMFD) measures calculated from skin snips.

The method of benefit valuation for the two studies of OCP is summarized in Table 10. The OCP studies look at cases of blindness prevented, healthy years of life saved (undiscounted and discounted) and productive years of life saved (undiscounted and discounted). Neither study includes the potential benefits of avoiding infection without ocular involvement or with partial visual impairments. The two OCP studies use the same conceptual framework but use different assumptions and estimates throughout. Concerning the issue of weighing disability versus death, the first study assumes that one year of disability (blindness) is equivalent to premature death and may even be worse than premature death from society's point of view since the blind person will require assistance from other productive individuals. On the other hand, the second study proposes that blind persons may still be productive and assigns to a year of blindness a value of 50% a year of healthy life. The first study assumes that defining the working ages to be 15 to 60 years is acceptable, while the second study proposes that defining the working ages to be 15 to 49 years is more appropriate, based on direct studies of employment histories of workers in Burkina Faso (Upper Volta). Other important differences are a longer duration of blindness per case and a smaller population at risk in the second study as compared to the first study.

The third study approaches valuation of benefits quite differently because it attempts to measure the short term economic effect of ivermectin treatment (see Table 10). Several statistical tests are performed. Direct costs of health care utilization are measured before and after the distribution of ivermectin in order to detect a decrease in use. Indirect costs of lost productivity are measured before and after the distribution of ivermectin in order to detect increases in days worked, increases in bonus pay, decreases in days of sick leave and decreases in days of sick

TABLE 9: DATA SOURCES IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Measurement of Benefits in Analysis: Data Sources
ONCHOCERCIASIS				
1	Prost & Prescott	1984	Upper Volta (Burkina Faso)	Fiscal tax records are used to determine the prevalence and duration of blindness and the mortality from blindness. (Blind individuals are exempt from paying taxes) OCP epidemiological followup on incidence of blindness 1975 population census is used to estimate the population at risk for blindness Growth rate of population in Upper Volta
2	Evans & Murray	1987	Upper Volta (Burkina Faso)	Fiscal tax records are used to determine the prevalence of blindness. (Blind individuals are exempt from paying taxes) OCP Epidemiological Evaluation Unit (EPI) Survey records for prevalence and duration of blindness and the mortality of blind and sighted people 1975 population census, adjusted for under-enumeration, is used to estimate the population at risk for blindness
3	Clark	1990	Liberia	1987 plantation census provided demographic data on each subject Health care utilization data was collected from the plantation hospital records Estate offices records provided total number of days worked, total number of days of sick leave, and total number of days of absenteeism Payroll records provided data on the monthly amount of bonus pay earned (based on pounds of rubber collected in excess of the quota) Data on mean microfilarial density (MMFD) calculated from skin snips

TABLE 10: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
ONCHOCERCIASIS				
1	Prost & Prescott	1984	Upper Volta (Burkina Faso)	**Indirect Costs** Cases of blindness prevented Compare blindness incidence pre-control in OCP area Healthy years of life saved Years of disability due to blindness [9 years (hyperendemic); 7 years (mesoendemic)] Diminished life expectancy [14 years (hyperendemic); 13 years (mesoendemic)] At-risk population [500,000 (hyperendemic); 500,000 (mesoendemic)] One year of blindness equivalent to premature death Productive years of life saved Ages 15 to 60 years are "productive" Discounted healthy years of life saved by OCP 10% discount rate Discounted productive years of life saved by OCP 10% discount rate

TABLE 10: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
2	Evans & Murray	1987	Upper Volta (Burkina Faso)	**Indirect Costs** Cases of blindness prevented Compare blindness incidence pre-control in OCP area Healthy years of life saved Years of disability due to blindness [16 years (all areas)] Diminished life expectancy [12.7 years (hyperendemic); 9 years (mesoendemic)] At-risk population [317,000 (hyperendemic); 185,000 (mesoendemic)] One year of blindness equivalent to 50% of healthy year Productive years of life saved Ages 15 to 49 years are "productive" Discounted healthy years of life saved by OCP Range of 3%-15% as discount rate Discounted productive years of life saved by OCP Range of 3%-15% as discount rate
3	Clark	1990	Liberia	**Direct Costs** Health care utilization (look for decrease) Comparison before and after treatment **Indirect Costs** Days worked and adjusted bonus pay Comparison before and after treatment (look for increase) Association with microfilarial load (look for negative) Days of sick leave and absenteeism Comparison before and after treatment (look for decrease) Association with microfilarial load (look for positive) No significant effects of disease were found.

leave and decreases in days of absenteeism. Associations with the measures of productivity and microfilarial load are also examined. The hypotheses are that days worked and bonus pay should be negatively associated with load and that days of sick leave and absenteeism should be positively associated with load.

The major finding from OCP is that the savannah form of onchocerciasis is a major burden in West Africa. In Burkina Faso alone, over the period from 1975 to 1982, interruption of transmission by OCP prevented 2,701 cases of blindness and 23,409 person-years of disability caused by blindness. Premature mortality associated with the disease, although not caused directly by the disease, was also substantially reduced (the control program added 37,364 person-years). There is also consensus that OCP is an efficient use of resources. However, the two evaluations of OCP disagree on almost every methodological issue and on the resulting measures of cost-effectiveness. The first OCP study concludes that the cost per year of healthy life added, the cost per year of productive life added, the cost per discounted year of healthy life added and the cost per discounted year of productive life added have values $20, $20, $150 and $150, respectively. The corresponding values for the second OCP study are $273, $705, $2119 and $4852. This situation points out that there may be multiple criteria for judging cost-effectiveness. (A general discussion of cost-effectiveness follows later in this report.) The work by Clark (1990) found no significant effects on productivity of decreases in the non-blinding ocular, systemic, and dermal sequelae of onchocerciasis infection. This result is not entirely surprising since the forest strain of onchocerciasis in the LAC plantation causes milder disease than the savannah strain of onchocerciasis.

Dracunculiasis (guinea worm disease)

The five studies of dracunculiasis listed in Table 1 are reviewed. The first four studies are scattered across the three Nigerian states of Imo, Oyo and Kwara; the last study examines the Danfa Project area which is north of Accra, Ghana. The second and third studies briefly discuss the cost of a program to interrupt transmission and the fourth study describes a strategy which has been successful in eliminating dracunculiasis in a village. However, since an analysis of intervention strategies is beyond the scope of this review, the emphasis here will be on the indirect cost of disease.

All of the studies include reduction in disability as a benefit (see Table 11). The first study considers all household members, the second study deals with mothers with young children, and the third, fourth and fifth studies focus on males as heads of household or full-time farmers. The second study looks at the benefit of increased time women have for performing self care, child care and domestic duties as well as generating income; gain in income is expressed in terms of earnings saved per episode of disability prevented. The third, fourth and fifth studies include increased agricultural production as a benefit. The third study expresses increased production in terms of earnings saved per episode of disability prevented and per year for the village as a whole. The fourth study extends the discussion of community benefits to include increased economic growth and expansion of physical facilities in a village.

Sources of data for each of these five studies are summarized in Table 12. All but the second study, which is just a pilot study, build on baseline household surveys. The second study is also distinctive because of its exclusive focus on mothers with young children. The first study

TABLE 11: BENEFITS INCLUDED IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Benefits Included in Analysis
DRACUNCULIASIS				
1	Huttly et al.	1990	Nigeria	Reduction in disability of household members
	Smith et al.	1989		
2	Watts et al.	1989	Nigeria	Reduction in disability of mothers Increased time for self care, child care, domestic duties and income generation Earnings saved per episode of disability prevented
3	Brieger & Guyer	1990	Nigeria	Reduction in disability of full-time farmers Increased agricultural production Earnings saved per episode of disability prevented Earnings saved per year in village
4	Edungbola & Watts	1990	Nigeria	Reduction in disability of household heads Increased agricultural production Increased economic growth of village Expansion of physical facilities of village
5	Belcher et al.	1975	Ghana	Reduction in disability of household heads Increased agricultural production

TABLE 12: DATA SOURCES IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Measurement of Benefits in Analysis: Data Sources
DRACUNCULIASIS				
1	Huttly et al.	1990	Nigeria	Cross-sectional surveys of health status, conducted biannually 1983-1986 in five farming villages Longitudinal survey of 195 households selected for diarrhea study includes numeric scores (1-5) of dracunculiasis disability for all members of household
	Smith et al.	1989		
2	Watts et al.	1989	Nigeria	Qualitative survey of 42 households selected for women with active lesions of dracunculiasis and children less than 2 years old; direct observations and in-depth interviews elicit the impact of disability from dracunculiasis
3	Brieger & Guyer	1990	Nigeria	Total population survey in 1981 of health status, socioeconomic information, and agricultural production Case study methodology applied to 20 affected farmers; qualitative interviews conducted in June 1988 identify time and duration of illness, crops usually planted and crops that could not be planted because of dracunculiasis
4	Edungbola & Watts	1990	Nigeria	Prevalence survey of dracunculiasis in village in 1978-1979 provided baseline measures before elimination of dracunculiasis in 1982 Prevalence survey in March 1986; 5-yr retrospective with qualitative information about changes in village Direct observation and participatory action in village
5	Belcher et al.	1975	Ghana	Eight villages identified for study during epidemic in 1973 Household surveys were conducted in study areas to identify previous illness and traditional treatments In-depth interviews conducted in 20 households in which male head had been incapacitated by dracunculiasis during the year; information about disability, type of agricultural activities missed due to disability, and whether alternative labor sources had been used

TABLE 13: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
DRACUNCULIASIS				
1	Huttly et al.	1990	Nigeria	**Indirect Costs** Duration of symptoms per episode (67 episodes for 59 cases) [mean 12.7 weeks; range 3-29 weeks]
	Smith et al.	1989		Distribution of scores assigned to severity of illness per two-week observation period; scores of 1,2,3 or 4 are assigned to no, mild, moderate and severe disability, respectively; a score of 5 is reserved for confinement to bed. 18% of two-week observation periods score 4 or 5]
2	Watts et al.	1989	Nigeria	**Indirect Costs** Degree of incapacity for 42 women; [Bedridden(16); Hobble short distances(12); Bad Limp(9); Walk(5)] Domestic roles around house continue (cooking and cleaning) but tasks away from home are not possible (water & firewood fetching, collecting vegetables, marketing) for majority of women (30 of 42) Self-care was the most likely to be neglected, e.g.bathing and laundry required water, eating was difficult because of illness (nausea) Child care was given priority although most (34 of 42) needed help carrying child, and child health status was affected (missed immunizations, diarrhea bouts and guinea worm seen in children of afflicted mothers) Economic activities ceased for most ill women (37 of 42); Income losses 12 women in Idere, Oyo State estimated average loss of 293 naira ($75) during current illness episode (average per capita income for region is 500 naira) [U.S. dollar conversions as reported in article]

TABLE 13: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study	Year	Country	Valuation of Benefits in Analysis
DRACUNCULIASIS			
5 Belcher et al.	1975	Ghana	**Indirect Costs** Loss of work by 112 adults [43 untreated adults: average 5.3 weeks of disability] [69 treated adults: average 2.4 weeks of disability] Reduction in agricultural production Of 20 affected men interviewed, 2 had access to assistance from relatives; none received help from neighbors; 2 had initial cash to pay partially for day laborer

TABLE 13: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Valuation of Benefits in Analysis
DRACUNCULIASIS				
3	Brieger & Guyer	1990	Nigeria	**Indirect Costs** Duration of disability for 20 male farmers [mean 3.9 months; range 1-7 months] Type of disability for 20 male farmers [Difficulty walking(1);Walk with stick(2);Bedridden(17)] Acres not planted were converted into potential yield; this estimate was assigned the current market value of the crop Impact of days lost on each staple crop 26.5 heaps yam total for 8 growers (2,650 naira) 90 bags cassava total for 4 planters (9,000 naira) 17 bags melon total for 3 farmers (2,040 naira) 64.5 bags maize total for 10 farmers (12,900 naira) Market value of losses Losses for 20 farmers 26,590 naira;1329.50 naira avg loss Estimate 270 infected full-time farmers in village Total annual loss (270 x 1329.50) 358,965 naira ($90,000) (average per capita income for region is 500 naira) [U.S. dollar conversions as reported in article]
4	Edungbola & Watts	1990	Nigeria	**Indirect Costs** Loss of work by household heads Loss of cash crops by women; with control program, contaminated water sources converted to irrigation supply] Reduced economic growth of village; with control program, other villages no longer shunned area, therefore merged several periodic markets, improving trade opportunities; also, improved children's school attendance (enrollment grew from 101 to 332); retention of teachers in the community (residing in village), which improves motivation for community projects Lack of physical facilities; growth with control program included a community secondary school, church, market, town hall and businesses (poultry farm and maize project)

employs a numeric scale of functional disability from dracunculiasis as part of a longitudinal study with visits of the same households every two weeks. The other four studies have a qualitative data collection component to gather information about disability and its effects on time use by household members -- in-depth interviews in the second, third and fifth studies, and direct observation and participatory action to record changes from 1978 to 1986 in the fourth study.

The potential benefits of reducing disability are valued based on the information available about the indirect costs in each study. The specific effects of dracunculiasis will be discussed for each of these papers individually since the findings are so diverse (see Table 13).

The first study reports on the duration of episodes and the severity of illness for each two-week observation period. Disability is scored 1, 2, 3 or 4 according to whether disability is not present, mild, moderate or severe, respectively; a score of 5 is assigned to the bedridden. Out of all two-week observation periods of infected people, 18% score 4 or 5.

The second study summarizes the degree of incapacity of 42 women and describes which tasks they must neglect during a bout of guinea worm infection. The domestic tasks of cooking and cleaning may continue but tasks away from home are not possible for many women; therefore fetching water, collecting firewood and gathering vegetables must be done by someone else. Self-care is often neglected--water is needed for bathing, and eating may be foregone because of nausea or because of the necessity of moving away from the house for defecation. Child care is given high priority by the infected women but nonetheless child health status often suffers during the time the mother is incapacitated. Twelve of the infected women reported an average loss of income of about 293 naira ($75) during the current illness episode.

The third study summarizes duration and type of disability for 20 male farmers. The study also evaluates potential gains in agricultural productivity for the four staple crops -- maize, cassava, yam and melon. Acres not planted are converted into potential crop yields and the market value of the staple crops lost is calculated. The 20 farmers experienced a total loss of 26,590 naira or an average of 1329.50 naira per farmer. When multiplied by an estimate of that total number of infected farmers in the village (270), the annual community loss is estimated to be worth 358,965 naira or close to $90,000.

The fourth study demonstrates the indirect cost of dracunculiasis by examining changes in the community that followed eradication of dracunculiasis. Heads of household were better able to work. The physical facilities expanded to include a community secondary school, church, market, town hall and several businesses. School attendance grew threefold; teachers remained in the village after the control program, thereby boosting community participation in self-help projects. Since the surrounding villages no longer shunned the area, trade opportunities improved significantly. The contaminated water sources provided irrigation for cash crops therefore increasing the yield and income from cash crops.

The fifth study looks at time lost from work because of dracunculiasis. The average is 5.3 weeks of complete disablement in untreated patients, while the average for treated patients (given antibiotics and instructions for cleaning/soaking/dressing wounds) is 2.4 weeks. Of 20 farmers interviewed, none received help from neighbors. Of the same 20 men, only two received help from relatives and only two were able to hire day laborers (but not enough to complete tasks).

The major finding from these studies is that dracunculiasis generates a significant economic burden in rural areas where it is endemic. As many as 18% of infected people may be so disabled that they cannot leave their family compound and they are sometimes confined to bed;

symptoms may last for weeks. This high degree of disablement affects communities in many ways. Two Nigerian studies report per capita losses of income per episode at 293 naira for 12 women and 1,329 naira for 20 male full-time farmers in Idere, Oyo State. These figures are 59% and 266% of the annual per capita income of the region, 500 naira. The disease also affects productive activities that do not generate income. Women lose the ability to take care of their children, their home and themselves. Infected children often cannot go to school.

The effects of the disease can be seen dramatically at the community level by observing changes in Igbon, Oyo State, Nigeria following a successful eradication program. Trading opportunities improved because surrounding villages no longer avoided the area. A local secondary school was built, school attendance increased threefold, and teachers remained in the community. Other new construction included a church, a market, a town hall, a poultry farm and a maize project.

Provision of a clean, protected supply of water can eliminate dracunculiasis. Rough estimates indicate that control is highly cost-effective. The study of women in Idere (second study, compares an average loss of 293 naira ($75) per episode with a cost of $14 per capita to provide handpumps, hand-dug wells and water catchment jars. The study of men in Idere (third study) compares an estimated annual community loss of 358,965 naira ($90,000) with the cost of providing 67 cement ring wells ($20,100) and 2,000 nylon water filters ($6,000). Clearly, dracunculiasis control should be a high priority in communities where it is endemic.

Schistosomiasis

The six studies of schistosomiasis listed in Table 1 are reviewed. Five of the six studies reviewed were conducted on sugar cane plantations -- one in Sudan, three on the same plantation in Tanzania, and one in Brazil. Benefits of a control program for schistosomiasis are therefore described from the perspective of the plantation, not the national ministry of health or a community. The third study also describes the cost of a schistosomiasis control program based on snail control and chemotherapy; however, an analysis of intervention strategies is beyond the scope of this review. The remaining study (listed fifth) is a worldwide calculation of the potential gains in productivity with control of schistosomiasis. Studies outside of Africa are considered for methodological reasons; the schistosomiasis literature is some of the earliest work to systematically examine the effect of disease on productivity.

The benefits for each study are shown in Table 14. All six studies evaluate the differences in productivity between infected and uninfected workers and look for increased productivity for uninfected workers. The fifth study employs the gross national product (GNP) as an aggregate measure of productivity. The sixth study extrapolates from losses on a sugar estate to losses for the entire state of Pernambuco, Brazil. Only two of the six studies (the second and third studies located on a plantation in Tanzania) include reduced treatment costs (drugs and hospitalization) of infected workers as a benefit of control; the third study also includes goodwill resulting from protection of wives and children.

Sources of data for the first study (in Sudan) are summarized in Table 15. The first study relies entirely on the research team to collect physiological and clinical data on 194 cane cutters and productivity data on 129 cane cutters. Productivity is measured as weight of cane cut per unit time and the period of observation is two days.

TABLE 14: BENEFITS INCLUDED IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Benefits Included in Analysis
SCHISTOSOMIASIS				
1	Collins et al.	1976	Sudan	Increased worker productivity
2	Foster	1967	Tanzania	Reduced hospitalization costs for plantation Reduced costs of drug treatment and supplies Increased worker productivity with S. mansoni control program
3	Fenwick	1972	Tanzania	Reduced hospitalization costs for plantation Reduced costs of drug treatment and supplies Increased worker productivity with S. mansoni control program "Goodwill" resulting from protecting wives and children
4	Fenwick & Figenschou	1972	Tanzania	Increased worker productivity with S. mansoni control program
5	Wright	1972	World	Increase in GNP of world regions
6	Barbosa & Pereira Da Costa	1981	Brazil	Increased worker productivity with S. mansoni control program Increased productivity for plantation Increased productivity for Pernambuco state

TABLE 15: DATA SOURCES IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study		Year	Country	Measurement of Benefits in Analysis: Data Sources
SCHISTOSOMIASIS				
1	Collins et al.	1976	Sudan	Physiological tests of aerobic capacity of 194 cane cutters conducted in laboratory setting Data on infection from counts of S. mansoni eggs in stools Clinical examinations for hepatosplenomegaly Field productivity of 129 cane cutters in weight of cane cut per unit time
2	Foster	1967	Tanzania	Data on infection from counts of S. mansoni eggs in stools for 200 men (some cane cutters, some irrigators) Health care utilization data from estate dispensary (July 1962-Jan 1963) and hospital (August 1962-Jan 1963) Company records for work attendance for cane cutters and irrigators (July 1962-Dec 1962) Company records for field productivity of cane cutters in weight of cane cut (July 1962-May 1963)
3	Fenwick	1972	Tanzania	Hospital records of schistosomiasis treatment before control [relies on study 2] Company records of bonus payments for infected and uninfected cane cutters [relies on study 4]
4	Fenwick & Figenschou	1972	Tanzania	Assessment of bonus earnings of cane cutters from estate records, 1968-1969 Classification of infection status and exclusions based on estate hospital records (stool samples, treatment history)
5	Wright	1972	World	Prevalence rates from NAS survey of tropical health (based on WHO data) and some annual public health reports from countries Per capita GNP estimates by country from World Bank
6	Barbosa & Pereira Da Costa	1981	Brazil	Data on infection from counts of eggs in stools Physical examinations used to identify clinical status Estate records of Tiuma from harvests 1966-1967 and 1967-1968 used retrospectively to assess productivity of cane cutters as total earnings Estate records of Catende from harvest 1977-1978 used prospectively to assess productivity of cane cutters as total earnings Agricultural records of Pernambuco state

Sources of data for the three studies of Arusha Chini estate in Tanzania (second, third and fourth studies) are also in Table 15. The second study relies on the research team to screen workers for infection. Estate records provide data on health care utilization and work attendance for cane cutters and irrigators. Estate records provide data on field productivity for cane cutters only. Productivity is measured in weight of cane cut and bonus payments over the period from July 1962 to May 1963. The third study depends on the other two for data -- the second study provides hospitalization records of schistosomiasis treatment before a control program was established in 1968 and the fourth study provides an estimate of the effect of infection on productivity during the control program. The fourth study uses estate records to determine bonus earnings of cane cutters over a two-year period 1968-1969; infection status and exclusions are based on estate hospital records showing results of examinations of stool samples and history of treatment for schistosomiasis.

The fifth study is quite different (see Table 15). It relies on a National Academy of Sciences (NAS) survey of tropical health based in part on WHO data; some annual public health reports from countries are also used. Productivity data at the national level are in the form of estimates of per capita gross national product (GNP) published by the World Bank.

The sixth study (in the state of Pernambuco, Brazil) is similar to the African studies on sugar cane estates (see Table 15). Data on infection and clinical status derive from a survey completed in 1966 for the retrospective study on Tiuma Sugar Estate and from examinations performed by the research team in 1977 for the prospective study on Catende Sugar Estate. Estate records on earnings are used to assess productivity of cane cutters. The retrospective study on Tiuma Sugar Estate looks at harvests from 1966-1967 and 1967-1968; the prospective study on Catende Sugar Estate looks at the harvest of 1977-1978.

The methods of valuation of direct costs of schistosomiasis are summarized in Table 16. Only the second and third studies handle direct costs. The second study includes the annual cost of additional dispensary attendance by infected irrigators, additional days spent in the hospital by infected cane cutters and irrigators (not including admissions for schistosomiasis) and schistosomiasis treatments on Arusha Chini estate in Tanzania. The cost for the dispensary attendances, hospital days and schistomiasis treatments include salary for days lost from work. From a public health perspective, the cost of days lost from work would be included under indirect costs, but, from the perspective of a plantation owner, salary for days lost represents a direct outlay of cash. One final modification is to adjust for double-counting costs by subtracting from the cost of schistosomiasis treatments an estimate of treatments for schistosomiasis administered to workers admitted to hospital for other reasons. The third study considers only the cost of schistosomiasis treatment -- medicine, hospital days and days lost from work. However, since the third study was conducted during a control program started in 1968, it estimates what the costs of schistosomiasis would have been in the absence of a control program. Basing the number of treatments required upon the second study, which had been conducted on the same plantation in 1962 and 1963, the third study assumes 1,350 treatments a year and calculates the treatment costs over 1968-1970, of which one-third constitutes an annual cost.

The methods of valuing the benefit of reducing the indirect costs of productivity lost by infected workers are also summarized in Table 16. The first and second studies, which were

TABLE 16: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

Disease/Study	Year	Country	Valuation of Benefits in Analysis
SCHISTOSOMIASIS			
1 Collins et al.	1976	Sudan	**Indirect Costs** Weight of cane cut per unit time Positive correlation with maximum aerobic capacity Infected workers more productive because of experience Conclusion that disease does not affect productivity
2 Foster	1967	Tanzania	**Direct Costs** Outpatient attendances Lower for infected cane cutters; higher for infected irrigators Financial cost Additional 819 attendances annually for irrigators; annual cost 2,457 shillings (medicine) and 2,706 shillings (salary for days lost); total 5,163 shillings annually Proportion admitted to hospital (exclude schisto treatments) No difference between infected and uninfected cane cutters; higher proportion for infected irrigators Hospital days (exclude schistosomiasis admissions) More hospital days for infected workers Financial cost Additional 1,677 hospital days per year; annual cost 18,447 shillings (including salary) Schistosomiasis treatment 1,350 treatments annually; annual cost 100,980 shillings incl. days lost from work); adjusted annual cost 73,715 shillings if excluding overlap with schistosomiasis treatments in hospital for those admitted for other causes **Indirect Costs** Proportion of work shifts lost without discernible cause (absenteeism) Higher proportion lost for infected workers Financial cost (includes irrigators only) Annual cost for 400 irrigators equiv. to 9 men at 2,400 shillings per year; total annual cost 21,600 shillings Mean output (quantity of cane cut) per work shift No difference between infected and uninfected cane cutters Total annual direct and indirect cost: 118,925 shillings (5,946 pounds sterling or $11,357 U.S.) [1 pound sterling is $1.91 U.S. dollars]

TABLE 16: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

	Disease/Study	Year	Country	Valuation of Benefits in Analysis
3	Fenwick	1972	Tanzania	**Direct Costs** Cost of 1,350 schistosomiasis treatments annually -- medicine, hospital days and lost days of work (lost days of work used for treatment): $11,958 **Indirect Costs** 1,700 workers with infection rate of 85% (1,445 infected) Assume uninfected workers 5% more productive than infected workers, so 1,376 uninfected workers do work of 1,445 infected workers; save 69 workers at $420 per year Annual cost of lost productivity: $28,980 No economic value assigned to goodwill generated Total direct and indirect costs per year: $40,938
4	Fenwick & Figenschou	1972	Tanzania	**Indirect Costs** Bonus earnings for cane cutters Infected men earned 11% less than uninfected men Treated men earned 7% less than uninfected men Quantity of cane cut Infected men produced 3% less than uninfected (estimate based on data during exceptional rainfall); infected men would probably produce 5% less than uninfected men under better conditions
5	Wright	1972	World	**Indirect Costs** Number disabled by schistosomiasis (totally; partially) Africa (1,735,983; 16,327,200); Mauritius (1,400; 20,304); SW Asia (43,622; 639,406); SE Asia (749,930; 6,261,350); Americas (119,325; 1,534,545) Assume totally disabled contribute nothing to GNP Assume partially disabled have 10% reduction in production Estimated annual losses Africa $445,866,945; Mauritius $755,480; SW Asia $16,527,275; SE Asia $118,143,755; Americas $60,496,755 Total: $641,790,130

TABLE 16: VALUATION OF BENEFIT IN STUDIES OF ECONOMIC IMPACT OF DISEASES

	Disease/Study	Year	Country	Valuation of Benefits in Analysis
6	Barbosa & Pereira Da Costa	1981	Brazil	**Indirect Costs** Earnings during harvest Less earnings for severely infected (hepatosplenic form); no difference between uninfected and lightly infected (intestinal form) -- based on retrospective study Less earnings for severely infected (hepatosplenic form) compared with lightly infected (intestinal form) [35.1% less] -- based on prospective study Reduced production for Catende sugar estate 57 hepatosplenic workers (4% of workforce) lose 6,077 60-kg sugar sacks (0.93% of 634,068 total in 1978); Loss of $135,030.95 in 1978 ($22.22 per sugar sack) Reduced production in Pernambuco state, Brazil Assume 2% of workforce is hepatosplenic so that they generate losses of 0.465%; Loss of 101,842 sugar sacks in 1978 from total 21,901,563; Loss of $2,263,000 in 1978 ($22.22 per sugar sack)

conducted on plantations in Sudan and Tanzania, respectively, look for reductions in the quantity of cane cut per work shift by infected men as compared with uninfected men. Neither of these studies finds such an effect. In fact, ironically, infected cane cutters often appear to be more productive than uninfected cane cutters because they are more experienced. The studies in Tanzania and Brazil take a broader view of worker productivity by considering a period of observation of several months; under these conditions, productivity incorporates the effect of schistosomiasis on absenteeism as well as any effects on efficiency while on the job. On Arusha Chini estate in Tanzania, the second study finds the cost of absenteeism for infected irrigators (an increase in wages for 9 additional workers out of 400 workers or 2.25%) and the fourth study estimates a 5% reduction in quantity of cane cut by infected cane cutters; the third study uses the 5% estimate from the fourth study and converts that to a monetary value based on wages. The sixth study examines earnings during harvest by uninfected and infected workers. The important difference turns out not to be between uninfected and infected but between those with milder infection (intestinal form) and those with more severe infection (hepatosplenic form). Hepatosplenic workers earn 35.1% less than infected workers without hepatosplenomegaly. At the level of the Catende sugar estate, a workforce with 4% hepatosplenic workers translates into losses of 0.93% of sugar production.

The fifth and sixth studies extend valuation of indirect costs beyond the sugar cane plantations to regions (see Table 16). The fifth study uses estimates of the number of infected people in many countries, broken down into those who are totally disabled and those who are partially disabled. Under the assumption that complete disablement means no productivity and partial disablement means 90% productivity, productivity lost per year is assigned to infected people from published gross national product (GNP) per capita. The sixth study is much narrower in scope. It generalizes the results from Catende sugar estate to Pernambuco state. The key assumption is that 2% of the workforce is hepatosplenic workers, which is half the 4% found on Catende sugar estate, so that losses from the total are cut in half to 0.456%. From the total annual production in the state and the selling price of 60-kg sugar sacks, losses are expressed in number of sugar sacks and U.S. dollars.

The major finding from these studies is that schistosomiasis in a workforce generates not only direct costs for treatment, but also indirect costs that may be as much as 10% of production except for a few patients with severe clinical symptoms. Productivity losses per worker range from over 2% for infected irrigators (second study) to 3%-5% for infected cane cutters (fourth study) to 35% for infected hepatosplenic cane cutters, i.e., those with clinical signs of hepatosplenomegaly (sixth study). These productivity losses may be underestimated from a public health standpoint because studies of workers on plantations necessarily exclude those unable to work at all. A global review assumes a productivity loss of 10% for infected people with moderate symptoms and a loss of 100% for infected people with severe symptoms.

However, even small percentage losses can generate huge costs when aggregated over a region. For example, a 2% prevalence of hepatosplenic workers (individual losses of 35%) on sugar estates generates aggregate production losses of around only 0.5%; this percentage loss for the state of Pernambuco, Brazil translates into over 100,000 sugar sacks and close to $2,300,000 in 1978 U.S. dollars.

The combination of direct costs and indirect costs of schistosomiasis may be great enough on individual plantations to justify the expense of a control program. A study of Arusha Chini

estate in 1970 (third study) estimates that maintenance of a program of snail control, screening of new employees and treatment of imported cases would cost $9,546, but would generate $7,448 in treatment savings and $15,960 in productivity savings every year.

The methodological lesson from these studies is that the direct effects of treatment are easier to measure than the indirect effects of lost productivity. The effects of disease on the productivity of those who are healthy enough to be in the workforce are likely to be less than 5% or 10%. Nevertheless, the aggregate effects of annual productivity losses may be in the millions of dollars for a state or hundreds of millions of dollars for a region. The estimated burden would be even greater if it included the effect of schistosomiasis on productive activities outside formal labor markets.

COMPARATIVE IMPACT

This section discusses what comparisons of economic impact can be made across diseases. The findings are based on a critical review of the sentinel studies of malaria, HIV/AIDS, onchocerciasis, dracunculiasis and schistosomiasis presented in Table 1. This review will first describe how the diversity of the effects of diseases and methodological approaches makes comparisons difficult. The Ghana Health Assessment Project is then explored as a model for comparing diseases in terms of healthy years of life lost. Since an estimate of economic impact is intended to be the first step in a process of designing and evaluating cost-effective strategies in public health, the discussion will be set in the context of the relationship between economic impact and studies of cost-benefit and cost-effectiveness.

Lack of comparability across studies

The methodological details of the sentinel studies are summarized in the following three tables: Table 17 on level of analysis, e.g., macro or household; Table 18 on the benefits included; and Table 19 on sources of data. In each table, studies are identified by the numbers assigned to them in Table 1. For example, the number 6 in the malaria columns refers to the study by Audibert in the Cameroons.

The level of analysis ranges from a highly aggregated macro (national or global) perspective to an examination of the individual in a household (see Table 17). The studies of some diseases encompass a range of approaches. For malaria, there are two studies at the macro level, three studies at the sub-national (district or urban area) level and three studies at the household level. For onchocerciasis, there are two studies at the macro level (Burkina Faso's part of the Onchocerciasis Program Control area) and one study at the plantation and community level. For schistosomiasis, there are four studies exclusively at the plantation level, one study exclusively at a macro level (country and global) and one study that extrapolates from the plantation level to the sub-national (in that case, state) level.

However, it is also evident that research on a specific disease may be concentrated on particular levels of analysis. All of the studies on dracunculiasis look at the effects of disability

TABLE 17: LEVEL OF ANALYSIS

LEVEL OF ANALYSIS	MALARIA	HIV/AIDS	ONCHOCERCIASIS	DRACUNCULIASIS	SCHISTOSOMIASIS
Macro Level	1 5	1 2 3 4 5	1 2		5
Subnational Level	2 3 4	4 5			6
Firm Level: Plantations			3		1 2 3 4 6
Community or Village Level			3	1 2 3 4 5	
Household Level	2 3 6			1 2 3 4 5	

on individuals, households and communities while all of the studies on HIV/AIDS pull together data for a country as a whole. The two examples of subnational level for HIV/AIDS (fourth and fifth studies) refer to economic sectors of the country rather than geographic subdivisions.

It is not possible to make direct comparisons between analyses at different levels. For diseases of programmatic importance, great priority should be attached to providing data for the same level across diseases. The most important gap indicated in Table 17 is the lack of HIV/AIDS studies at the household level. Table 17 demonstrates a clear need for household level information on both the direct costs of AIDS such as drugs to treat opportunistic infections and the indirect costs of the time required of family members to care for both the patient and the patient's children. In fact, preliminary versions of Table 17 have already motivated the Africa Bureau to contribute resources to a household survey of the impact of HIV/AIDS currently being conducted in Tanzania by the World Bank. Studies of the impact of AIDS on villages and businesses are also needed.

The benefits included in the analyses are summarized in Table 18. As previously discussed, benefits are grouped into gains in productive output and reduced treatment costs. Increased productivity is derived from reductions in adult and child morbidity and mortality. The patterns of morbidity and mortality vary greatly. Malaria typically causes adult morbidity and child morbidity and mortality. HIV/AIDS causes morbidity and mortality among adults (the effects on children were not examined in these studies). The effect of the savannah strain of onchocerciasis on adult morbidity and mortality is analyzed while the concern about the forest strain of onchocerciasis (third study) is adult morbidity. The studies of dracunculiasis and schistosomiasis examine problems of adult morbidity rather than adult mortality. Although it is conventional in studies of productivity to ignore children, a study of dracunculiasis in Nigeria (fourth study) did note improved school attendance when dracunculiasis was eradicated from a village. In the first four malaria studies, child morbidity is assumed to affect productivity by

TABLE 18: BENEFITS INCLUDED IN ANALYSIS

BENEFITS INCLUDED	MALARIA	HIV/AIDS	ONCHOCERCIASIS	DRACUNCULIASIS	SCHISTOSOMIASIS
GAINS IN PRODUCTIVE OUTPUT					
Increased productivity (less adult morbidity)	1 2 3 4 5 6	1 2 4 5	1 2 3	1 2 3 4 5	1 2 3 4 5 6
Increased productivity (less child morbidity)	1 2 3 4			4	
Increased productivity (less adult mortality)	1	1 2 4 5	1 2		
Increased productivity (less child mortality)	1 2 3 4 5				
REDUCED TREATMENT COSTS					
reduced cost of supplies and drugs	1 2 3 4		3		2 3
reduced costs at health facilities	1 2 3 4	1 2 3 4 5	3		2 3

requiring an adult to care for the child, rather than by impeding the child's activities. The variety of effects of diseases makes it difficult to achieve consensus on meaningful indicators for making comparisons. Reduced treatment cost, the other major category of benefit, is less problematic. Most of the cost information is from national or regional records of health facilities, but surveys may gather information on household expenditures for supplies and drugs. Public good benefits, such as the effects of new lands liberated from disease or psychological benefits of reduced prevalence of illness, while important, are typically not included because they are difficult to measure.

Data sources for the various studies included in this review are diverse (see Table 19). Some types of data are utilized exclusively for a single disease. For example, studies of dracunculiasis rely on in-depth interviews and studies of onchocerciasis rely on tax records. Unfortunately, interest in collecting useful data for a particular disease from all available sources tends to work against establishment of standardized sources to aid in comparisons across diseases.

Even studies using the same type of source maybe difficult to compare because of technical differences. For example, the mere fact that company records are used for malaria in the Cameroons, onchocerchiasis in Liberia and schistosomiasis in Tanzania and Brazil does not guarantee comparability. All of these enterprises developed record-keeping systems independently to satisfy their own needs.

The goal of finding a common scale on which to measure economic impact is elusive. The value of even a tangible product, like sugar cane or rubber, depends on market forces inside and outside the country. The estimation of productivity is more complex when there is no tangible

TABLE 19: DATA SOURCES

DATA SOURCES	MALARIA	HIV/AIDS	ONCHOCERCIASIS	DRACUNCULIASIS	SCHISTOSOMIASIS
Case-reporting	1 3			5	5
Household/community survey	1 2 3 6		1 2	1 2 3 4 5	
Inpatient and outpatient statistics	1 2 4 5	1 2 3 4 5	3	5	2 3 5
Tax records			1 2		
Population census	4 5		1 2 3		6
Vital statistics	1 2 5	1 2 4 5			
In-depth interviews				2 3 5	
Direct observation				4	1
Macroeconomic variables	1 2 3 4	1 2 3 4 5			5
Agricultural statistics	2	2			6
Company records	6		3		2 3 4 6

product in the marketplace. (The second schistosomiasis study measured field productivity of sugar cane cutters, but not irrigators for this reason.) As noted in the introduction on human capital theory, wages are often used to measure productivity, but such an approach ignores valuable activities not rewarded by the formal labor market. Many would also argue that productivity should not be the sole criterion for ranking diseases, although it is an important one.

The Ghana Health Assessment Project: A case study

The usage of healthy life years lost (or healthy days of life lost) to compare diseases in the Ghana Health Assessment Project (GHAP) represents one workable compromise for estimating economic impact. GHAP has already been introduced as the fifth malaria study; here, it will be described in more detail from a methodological point of view. The data requirements for GHAP include: (1) annual incidence of the disease; (2) case-fatality rate of the disease; (3) average ages at onset and death from the disease and the expectations of life at these ages; and (4) the extent and duration of disability caused by the disease and a case-disability rate analogous to a case-fatality rate. In this study, healthy days of life lost are the sum of days lost to disability and days lost to premature death. Table 20 indicates the ranking for the diseases included in this review, based on the Ghana Health Assessment Project -- in rank order, malaria, schistosomiasis, onchocerciasis and guinea worm. This type of ranking of diseases and health problems has been very useful in planning. The Ghanaian government has used these findings in restructuring the nation's health system based on a primary health care strategy (Nimo et al, 1981).

GHAP's approach has been adopted by others, but not without some modification. In GHAP, no productivity weighting of specific ages was applied so that diseases that kill children rank more highly than diseases that kill adults. Productivity weights assign the greatest value to so-called working ages, often taken to be an interval such as 15 to 59 years. Another problem in GHAP is that a day of health today is not given more value than a day of health ten or twenty years from now. The standard procedure for incorporating time preference is to discount values in the future at a rate typically between 3% and 10% per annum. Assignment of productivity weights and discount rates to healthy days of life lost yields discounted productive healthy days of life lost.

As stated in the introduction, there is a need for a balance among different generations: the young who will provide future production; the working age who provide support for themselves, for the development of the future generation, and for the older dependents; and finally the non-working older generation. From this perspective, productivity weighting schemes are designed to provide a social adjustment for the inter-intra-generational implications of the concept of healthy life years. Indeed, there is no optimal resolution of such issues.

Other studies have used such modifications to healthy days of life lost. Over and Piot (1992) rank the disease burden caused by sexually transmitted diseases in African cities together with the diseases reported in the Ghana Health Assessment Project. Using discounted healthy life days lost per capita, measles ranks first and HIV/AIDS ranks second; using discounted productive healthy life days lost per capita, HIV/AIDS ranks first and measles ranks second (because the productivity weights make the effect on adults relatively more important). In the

TABLE 20

Healthy Life Lost as a Result of Vector and Soil Transmitted Diseases in Ghana

	Days of life lost (per 1000 persons per year)	Lower and Upper limits	
Malaria	32,567	27,000	41,000
Schistosomiasis	4,368	750	12,500
Onchocerciasis	1,926	1,540	3,100
Guinea worm	108	45	180

From:
Morrow, R.H. 1984. The application of a quantitative approach to the assessment of the relative importance of vector and soil transmitted diseases in Ghana. Soc. Sci. Med. 19:1039-1049.

first HIV/AIDS study in this review, Over and colleagues estimate the discounted healthy years of life saved per case of HIV/AIDS prevented with productivity weights (6.2 years) and without productivity weights (8.8 years). The two studies of the Onchocerciasis Control Programme in this review also use discounted productive healthy years of life saved. The two onchocerciasis reports are instructive in showing disagreements about the components of the calculation.

However, although estimation of discounted productive life years lost is a useful method of

comparing the burden of diseases, it does not directly attach a monetary value to disease burden. In order to obtain a monetary measure of lost productivity, a common practice is to multiply discounted productive life years lost by an estimate of average annual income. Unfortunately, the result is a very crude measure of productivity that is difficult to defend. Household level analyses which incorporate roles and activities such as market production, home production and social roles would contribute to the understanding of how households cope with disability of its members; such analyses would have support from an expanded framework for measuring production that is the subject of active research.

Cost-benefit and cost-effectiveness

Policy makers and health planners need to know more than the economic impact of disease. An analysis of economic impact is designed to identify priorities among health problems only as a first step toward obtaining resources for a more refined analysis of resource allocation for specific interventions and subsequent program evaluation. The essence of the problem is that economic impact studies provide a total, or average per capita, cost of disease, while intervention decisions are made at the margin, i.e., the effect of additional resources on reducing the burden of disease. Unless the intervention is an eradication program, the reduction in burden of disease is less than the total impact of disease.

There are essentially two types of decisions to be made for health interventions. The first type of question concerns allocative efficiency: Is a particular procedure worth doing? Cost-benefit analysis may be used to address this question; this analysis requires that a monetary value be placed on both the resource costs and the output consequences of the program in order to arrive at a decision. Cost-benefit analysis is useful for comparing development strategies across sectors, for example, investment in the health sector or the agriculture sector. Because a monetary value must be placed on health outcomes, cost-benefit analysis is analogous to economic impact studies with monetary valuation and faces the same difficulties discussed throughout this chapter. The second type of question concerns operational efficiency: Of the various interventions for a disease or health problem, which will have the most impact at the lowest cost? Cost-effectiveness analysis may be used to compare the ability of various interventions to achieve a specified health objective. Cost-effectiveness analysis is analogous to economic impact studies with non-monetary valuation, such as healthy life years lost.

Cost-effectiveness analysis is more widely used than cost-benefit analysis because of the difficulty in assigning monetary value to health outcomes. Barlow and Grobar (1986) identify four measures of cost-effectiveness: number of persons protected; reduction in the number of cases of a specific disease ("case-years prevented"); number of deaths averted ("lives saved"); and increase in the number of healthy years of life. All of these measures lie within the health sector, but only the last measure provides a broad conceptualization for analyzing alternative health programs with very different kinds of outcomes. "For these situations decision-makers must choose between non-comparable outcomes (e.g. disability of workers in comparison with deaths of children), or utilize a more comprehensive measure of effectiveness, such as healthy days of life lost, which incorporates both morbidity and mortality, to make alternative outcomes more closely comparable (Morrow et al., 1992, p.5)".

Cost-effectiveness for health programs in developing countries is frequently measured in

terms of dollar cost per discounted healthy life year gained (Jamison and Mosley, 1991). In developed countries, the analogous measure is cost per quality-adjusted life year (QALYs) gained (Mooney and Creese, 1992). Of course, as with economic impact itself, the selection of discount rates and productivity weights involves value judgments and usually proves to be a source of debate.

CONCLUDING REMARKS

This report has reviewed current practice in estimating the economic impact of disease. While such estimates can be quite useful, they can also be misleading if the dynamics of disease are ignored. Other things being equal, a disease whose incidence is increasing should be a greater priority than a disease whose incidence is stable or decreasing. For example, malaria and AIDS in Africa deserve a high priority not only because of their estimated burdens but also because of their rising incidences (Brinkmann and Brinkmann, 1991; Chin, 1991).

The dynamics of disease may also interact directly with the dynamics of development. Throughout this report, the goal of disease control has been to remove impediments to economic growth, and yet, the development process itself can generate adverse health consequences. Jamison and Mosley (1991) present recent evidence for health problems related to rapid urbanization and industrialization in developing countries, although the idea that development may have unintended or unexpected consequences is certainly not new. One classic example is the role that water projects in Africa have played in increasing the prevalence of disease (see Table 21).

If adverse changes can be anticipated, then proper planning may prevent harmful side-effects of development projects. An example of a water project which successfully achieved its development goals without increasing the levels of disease is the Tennessee Valley Authority Waterway in the southern United States. The TVA was a development agency organized in 1933 which had several objectives: (1) development of a navigable waterway; (2) reservoir storage and flood control; (3) power generation; (4) reforestation; and (5) agricultural development. Malaria control was incorporated into the design of the waterway from the outset utilizing environmental measures that reduced the opportunity for mosquito breeding (Aron and Silverman, 1992). It is obviously preferable to prevent the occurrence of a disease than to have to assess the burden of a disease after it has become widespread. To achieve this aim, Hughes and Hunter (1970) stress the necessity of coordinating development activities within a comprehensive ecological framework.

Finally, many value the improvement of health not only as a means to economic development, but also as a goal of economic development. In establishing priorities for disease control, it would be wise to bear in mind the larger context of issues in economic development.

TABLE 21

Water Development Projects Which Have Resulted in Increased Prevalence in Parasitic Infection in Africa

Country	Project/Site	Year	Disease	Change in Prevalence
EGYPT	Low Dam at Aswan	1930's	Schistosomiasis	Data from 4 areas. Prevalence 2-11% in 1934; increased to 44-75% in 1937.
	High Dam at Aswan	1942	Malaria	Epidemic in 1942-43 resulted in 130,000 deaths due to invasion of Anopheles gambiae from Sudan.
GHANA	Lake Volta Akosombo Dam	1950's	Schistosomiasis	Low prevalences reported for children (5-10%) in decade before lake reached its maximum level; 90% and above in lakeside communities after 1968 (150,000 population living along lakeshore)
KENYA	Nyanza Province		Malaria	Mosquito surveys indicate 4-fold increase in house-entry rates in irrigated areas, but no public health assessment was made.
MALI	Cercle de Bandiagara	1977	Schistosomiasis	Survey in 1976 and 1977 showed an increase in prevalence from 79.4 to 93.4% in the same population. S. mansoni transmission demonstrated for the first time in 1977 survey.
SUDAN	Gezira	1950	Schistosomiasis	Prevalence of S. haematobium was less than 1% in 1924-44 but in 1952 it had risen to 21% adults, and 45% in children; S. mansoni prevalence was 5% in 1947, 8.8% in 1952, and 86.0% in 1973.

From: Hunter, J.M. et al. 1982. Man-made lakes and man-made diseases: Towards a policy resolution. Soc. Sci. Med. 16:1127-1145

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APPENDIX

ANNOTATED BIBLIOGRAPHY FOR ECONOMIC IMPACT

The annotated bibliography contains six sections: malaria; HIV/AIDS; onchocerciasis; dracunculiasis (guinea worm); schistosomiasis; and economic development and methodology. Each section, numbered separately, contains a list of references with abstracts. A few references appear in more than one section. Readers may also be interested in a 1992 USAID document Annotated Bibliography: Cost of AIDS Treatment, which has been prepared by Andy Thompson of AIDSTECH/Family Health International.

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MALARIA

1. ***AAAS. 1991. Malaria and Development in Africa: A Cross-Sectoral Approach. American Association for the Advancement of Science, Washington, DC.***

This report provides recommendations for the prevention and control of malaria in sub-Saharan Africa. These recommendations should assist the setting of policies and of priorities for investments in malaria control in the region by the U.S. Agency for International Development (AID) and other international development agencies, as well as ministries and scientific institutions in Africa, and others concerned with African development. The recommendations of the report are as follows: *(1)* broaden the attack on malaria by strengthening cross-sectoral cooperation for malaria control; *(2)* utilize a cross-sectoral approach and resources to combat malaria associated with development efforts; *(3)* strengthen local capacity, including developing cross-sectoral approaches; *(4)* utilize a community-based approach in order to sustain malaria control; *(5)* raise global awareness of the magnitude of the malaria problem in sub-Saharan Africa; and *(6)* encourage innovative approaches to malaria prevention and control. The results of this study offer promise for a social, behavioral, and environmental approach to malaria control.

2. ***Audibert, M. 1986. Agricultural non-wage production and health status: A case study in a tropical environment. J. Dev. Ec. 24:275-291.***

This study attempts to assess the effect of health status on the productivity of agricultural, non-wage workers. The author suggests that studies of productivity of self-employed peasants are important for two reasons: *(1)* increases in agricultural production in developing countries will rely on the output of small peasants for some time to come; and *(2)* study of the relationship between health status and labor productivity could be biased if based only on the experience of wage-earners. The situation examined is rice-growing introduced into Mayo Danai, Northern Cameroons with a hydro-agricultural plant funded by the World Bank. Data are collected from surveys of rice-growers and from records of the public company responsible for managing the project. The formulation of the model of analysis considers interrelations between determinants of the level of rice production and specific conditions of measurement of the variables. The output of each rice-grower depends on the level of technology (determined by the public company responsible for management) and on these inputs: cultivated surface, fertility of cultivated soil, amount of labor devoted to rice-growing and the quality of labor. The differences between the rainy season and the dry season are also important in determining output. Only a single production function is estimated, but possible competition with production of millet is investigated. Findings of this study include: *(1)* rice output increases at the same rate as the cultivated surface and the fertility of the soil when all other factors are controlled for; *(2)* rice output is negatively related to the duration of transplanting (the shorter duration of transplanting insures that all plants are at about the same level of maturity which is very important during the irrigation of paddy); *(3)* progressive training (experience) in rice-growing is significantly related to level of output; and *(4)* the marginal effect of parasitic endemic disease is not negligible--a 10% increase in the prevalence of schistosomiasis (S. haematobium) results in a 4.9% decrease in output. However, neither prevalence of malaria (P. falciparum) nor millet production is significantly related to rice production.

3. ***Bradley, D.J. 1991. Morbidity and mortality at Pare-Taveta, Kenya and Tanzania, 1954-66: The effects of a period of malaria control. In: Disease and Mortality in Sub-Saharan Africa, edited by Feachem, R.G. and D.T. Jamison. World Bank, Oxford University Press, New York, pp. 248-263.***

This is a reanalysis of a longitudinal study of health in an African community living on the border of Tanzania and Kenya. The usefulness of re-examining this study lies in the fact that data are available to measure not only the effects of introduction of a major malaria intervention, but also the effects of withdrawing the intervention. Therefore, these data provide outstanding causal information concerning the effects of disease control programs. Initially there were two goals of the Pare-Taveta project: *(1)* assess the public health importance of malaria in relation to other endemic diseases in a specific community, and *(2)* determine if malaria transmission could be stopped by sprayings with residual insecticides. The most important information from Pare-Taveta may be the effects observed on child mortality--statistically significant falls in the crude death rate and the infant mortality rate as well as increases in the crude birth rate were recorded for the years 1955-1959. The improvements in child mortality (ages 1 to 4 years) were reversed when the control program was removed and transmission resumed, although effects on mortality at other ages (even infant mortality) showed no such reversion to previous levels. The effects of malaria on morbidity were measured through various indicators of health status. The only positive changes in health status with antimalarial activities were increases in hemoglobin levels (relieving the anemia due to malaria) and establishment of normal levels of serum proteins, such as albumin and gamma globulin. All other measures of health status, including anthropomorphic data and the presence of helminth infections, showed no difference between protected and malarious populations. Surprisingly, malaria control reduced neither attendance at outpatient hospital departments nor the proportion of cases ascribed to malaria. However, data from sisal plantation dispensaries showed a decline in the proportion of visits due to "malaria" (from 16.2% to 4.0%), while annual attendance for any cause actually rose during the same time period (from 6.9 to 8.4 visits per person per year).

4. ***Brinkmann, U. and A. Brinkmann. 1991. Malaria and health in Africa: The present situation and epidemiological trends. Trop. Med. Parasitol. 42:s204-s213.***

This article draws attention to the fact that WHO does not provide data on malaria in Africa due to the "insufficiency and irregularity of reporting," and that estimates of the total number of cases and the number of deaths range from 35 million to 189 million per year. An intensive literature search of epidemiological studies of malaria produced information on the current situation and epidemiological trends in Africa. About 60% of the population of sub-Saharan Africa lives in the humid tropics, which constitute areas of stable malaria transmission; individuals acquire protective immunity by the age of five. Seasonal transmission occurs only during the wet season in the savanna and sahel regions of sub-Saharan Africa, which contain about 30% of the population; individuals acquire immunity at a later age (10 years) and may lose the immunity during the dry season. The rest of the population of sub-Saharan Africa (10%) lives in areas of high altitude or urban areas, both of which have unstable malaria transmission and are subject to epidemics. Malaria is responsible for about 40% of fever cases, mortality is about 5 per 1000 per year, and case fatality ranges from 2% to 24%. Admissions for malaria account from 20% to 50% of all admissions, although only 8% to 25% of persons with malaria visit health services. Self-treatment is more common in urban areas (more than 60%), but an increasing number use some form of self-protection in rural areas (2% to 25%). Chloroquine resistance has reached a prevalence of about 30% at the RII Level in most countries. For four countries, Togo, Rwanda, Burkina Faso and Zambia, data are available on the number of malaria

cases per 1000 inhabitants per year over several years. The growth rates of annual incidence are 7.3% for Zambia, 10.4% for Togo and 21.0% for Rwanda. The data for Burkina Faso show a downward trend of -14.7% from 1973 to 1981; since 1981, malaria incidence has been increasing at 11.0% per year. Hospital data from Zambia indicate that mortality is increasing at a rate of 5.2% per year in children and at a rate of 9.7% per year in adults. The increases in the number and severity of cases in Africa are due to many factors. Resistance to antimalarial drugs is increasing so that self-treatment may be insufficient. As populations move, individuals are placed in transmission zones where they have no immunity to the local strains of parasites. The use of insecticides in agriculture has created resistant vectors (anopheline mosquitoes) and has eliminated competitors and predators of vectors. All of these factors are linked to development.

5. ***Ettling, M.B. and D.S. Shepard. 1991. Economic cost of malaria in Rwanda. Trop. Med. Parasitol. 42:s214-s218.***

A conceptual framework for estimating the economic costs of malaria is described in the Shepard et al (1991) paper in this supplement of Tropical Medicine and Parasitology. Using this conceptual framework, the direct and indirect costs of malaria in Rwanda are analyzed from three perspectives: the national economy of Rwanda (expressed as GDP); the Ministry of Health (MOH), which is responsible for providing health services to the population; and the individual household, which expends time and income due to illness of its members.

The incidence of malaria in Rwanda has risen eightfold since 1979; in 1989, one in every five Rwandese had a malaria attack that was severe enough to warrant attendance at a health facility. The primary health care system is extensive and well-utilized by the people; however, there is often a shortage of antimalarial drugs at rural government health facilities. In 1986, chloroquine was absent from the shelves 20% of the time; as chloroquine resistance becomes more important, shortages of other antimalarials, which are much more expensive, exacerbate the problem of treatment. Direct costs of malaria are estimated for both public and private institutions: $4,000,000 for all facilities, and $2,000,000 for public facilities (representing 19% of the MOH budget). Based on information from the MOH, 85% of malaria cases seek treatment in health facilities, 10% purchase drugs from pharmacies or other market vendors and about 5% use traditional treatments. The direct costs of malaria incurred by households include: *(1)* costs for treatments outside the health facilities; *(2)* out-of-pocket expenses incurred even when cases are treated inside a health facility (these expenses may represent expenditure of from 4 to 37 days of individual cash income); and *(3)* drug costs for patients treated within health facilities. The combined direct costs of malaria in Rwanda for 1989 is estimated at $4,438,361. The average direct cost per case is $2.58; the average per capita cost is $0.63.

Indirect costs are based on the value of adult (age 15 or older) time of $1.01 per day (corresponding to an average yearly adult product of $369). The cost of premature death from malaria was estimated through a discounted productive life expectancy (DPLE) in which productivity counts from age 15 onwards and the discount rate is 5%. The DPLE, calculated for five age groups on the basis of malaria mortality data, is multiplied by the average yearly adult product. The cost of premature death in 1989 was $11,800,668. Illness time also contributes to the indirect costs of malaria. Adult productive time is lost due to malaria in various ways: adult hospitalized days; attendance of hospitalized child; days of work lost at home (estimated to be three days per adult case); and home care of an ill child (estimated to be one adult day of productivity per child case). The indirect cost of illness time in 1989 was $4,080,480. The total indirect cost of malaria in 1989 was estimated at $15,900,000. The average indirect cost of malaria per case was $9.24; the average indirect cost per capita was $2.25. The total economic cost per case was $11.82; the total economic cost per capita was $2.88.

The number of malaria cases and deaths is expected to increase annually by 21.1%; costs of

drugs and supplies are assumed to quadruple due to chloroquine resistance and currency devaluation. The costs of malaria are expected to increase while the MOH budget is shrinking due to economic crises. By 1995, malaria is projected to cost 2.4% of the Rwandan GDP, exacerbating an already serious impact.

6. ***Hammer, J.S. 1991. Economics and Malaria: Disease Impact and Policy Rationale. (UnPub)***

The author reviews how the burdens of pain, suffering, and death caused by malaria are translated into financial terms. This review includes a discussion of Shepard et al's 1990 report from the Vector Biology and Control Project on the economic impact of malaria in Africa. The author points out that current calculations of the burden of disease are severe underestimates of the true costs because proper measurement of these costs requires a concerted research effort. Disease control can be justified for the following economic reasons related to the failure of markets: *(1)* most control activities are public goods; *(2)* consumers often lack information about the value of prevention and available care; and *(3)* poverty alleviation schemes are needed to correct inequities in outcomes. Cost-effectiveness is not relevant for summary judgments over whole diseases or types of policies; rather, cost-effectiveness is relevant to the evaluation of specific projects when you know specifically what resources you are putting in and what results you can guess will come out.

7. ***Hunter, J.M., L. Rey and D. Scott. 1982. Man-made lakes and man-made diseases: Towards a policy resolution. Soc. Sci. Med. 16:1127-1145.***

The risk of spread of parasitic infections associated with the development of water resources has been stressed many times. The conditions most frequently listed as being apt to spread in tropical zones are schistosomiasis, malaria, bacterial and helminthic intestinal infections and arbovirus infections. The pressure of population increase in the developing world demands an expansion of agricultural production that is achieved through intensification of water impoundment and irrigation. The typical sectoral dichotomy in which a department of agriculture creates a disease outbreak through its development activity, leaving its counterpart department of public health to cope on a curative basis, is strongly deplored. Disease prevention measures should be integrated with development projects from the beginning; infrastructural investment and operational costs for health maintenance should be incorporated into the total cost-benefit analysis. A communications network is proposed to create an international register of water development projects.

8. ***Lennox, R.W. 1991. Malaria in Africa: The need for economic analysis. Trop. Med. Parasitol. 42:s198.***

This article is an introduction to the Tropical Medicine and Parasitology supplement that addresses the economic costs of malaria in Africa. The author points out that, even in the times when researchers and policy-makers believed in global eradication of malaria, Africa south of the Sahara was not part of the plan due to lack of infrastructure. Currently, shrinking development budgets from donor agencies as well as problems such as mosquito vector resistance to insecticides, parasite resistance to chloroquine, and changing population dynamics continue to discourage more decisive action. This supplement addresses the losses due to malaria in purely economic terms, considering malaria as an impediment to development. The costs include premature death, transportation to seek care, lost time from work, and fees paid for remedies of dubious value. However, the impact is difficult to measure in the context of labor shortages, seasonal outbreaks and the responsibilities of extended families. The articles in this supplement

reflect an effort to estimate these costs by applying a variety of economic models to existing data. Future work will address macroeconomic issues and the information gained will be used to choose between various development alternatives. It is suggested that this approach will take "... malaria out of an entirely humanitarian context and includ[e] it in the larger framework of strategic planning for healthier economies."

9. ***Mills, A.J. 1987. Economic Study of Malaria in Nepal: The Cost-Effectiveness of Malaria Control Strategies. Evaluation and Planning Centre for Health Care, London School of Hygiene and Tropical Medicine. (UnPub)***

This report presents the results of a cost and cost-effectiveness analysis of malaria control in Nepal, paying particular attention to the costs of spraying and case detection and treatment, and to the relative cost of unintegrated and integrated patterns of organization. An analysis of the 1984 recurrent expenditures of districts of the National Malaria Eradication Organization (NMEO) found that per capita costs varied widely over the country. Per capita costs of case detection and treatment in the NMEO districts were two to three times those in integrated districts. However, because relatively fewer slides were taken and cases detected in integrated districts, their costs per slide and per case tended to be quite close to those of NMEO districts. A variety of cost-effectiveness ratios are calculated. Present government control costs are not fully compensated for by savings in estimated government treatment costs that would be incurred in the absence of control. If savings in estimated private treatment costs are added to government treatment costs, net savings result at a level of cases between the low and the high estimates. Inclusion of lost work days has a dramatic effect, resulting in large net savings. The cost-effectiveness ratios are particularly sensitive to assumptions on the case fatality rate, age of death and value of lost lifetime earnings due to death from malaria. Firm conclusions on the relative advantages of integrated and unintegrated forms of organization were not possible in the absence of better evidence on their relative effectiveness in controlling malaria. However, it appeared that integrated districts were cheaper at low levels of malaria (because the unintegrated districts have high fixed costs where staff time in integrated districts is diverted to malaria when necessary), but that their costs rapidly approached those of the NMEO as cases rose.

10. ***Najera, J., B. Liese and J. Hammer. Malaria. 1992. In: Health Sector Priorities Review, edited by Jamison, D.T. and W.H. Mosley. World Bank, Oxford University Press, New York. (In Prep)***

This paper is part of a review of health sector priorities recently undertaken by the World Bank. The focus of the paper is on the public health significance of malaria and on the cost and effectiveness of currently available technologies for malaria prevention and control. The most critical activities that could accelerate the progress in malaria control are: *(1)* reassessment of programs in countries of Asia, the Americas and North Africa; and *(2)* extension of coverage of population by the health care system in countries of Africa south of the Sahara. Top priorities are the development of human resources to staff control programs and the development of new antimalarial drugs and potential vaccines.

11. ***Nimo, K.P., V. Agadzi, R. Asante, R. Biritwum, C. Jones, R.J. Morrow jr., A. Neill, K. Nelson, J. Owusu, K. Saakwa-Mante, P.G. Smith and F. Wurapa. 1981. A quantitative method of assessing the health impact of different diseases in less developed countries. Int. J. Epi. 10:73-80.***

The impact of disease in a community is measured by the number of healthy days of life lost through illness, disability, and death. This measure requires estimates of the following for

each disease: incidence rate; case fatality rate; average age at onset and death and expectations of life at these ages; and extent and duration of illness and disability. Multiple sources of data are used in the analysis: census data, cause of death as recorded on death certificates, inpatient and outpatient statistics, and special surveys. The above measures were estimated for about 50 causes of death deemed important in Ghana by the Ghana Health Assessment Project team. The diseases and health problems were then ranked in importance based on the healthy days of life lost. Malaria accounted for 10.2% of healthy days of life lost, the largest percentage for any single disease. Although the ranking is useful information, decisions regarding priorities should favor programs which most reduce the burden of illness, disability, and death for a given unit of cost. A program may simultaneously reduce the effects of more than one disease, and a particular disease may be affected by more than one program. This point is illustrated by a comparison of two programs to treat measles--vaccinations and outpatient care for patients with measles. Sixteen times as many days of healthy life are saved by the immunization program.

12. ***Oaks, S.C., V.S. Mitchell, G.W. Pearson and C.C.J. Carpenter, eds. 1991. Malaria: Obstacles and Opportunities. Institute of Medicine, National Academy Press, Washington, DC.***

Against the backdrop of a worsening worldwide malaria situation, the Institute of Medicine was asked to convene a multidisciplinary committee to assess the current status of malaria research and control and to make recommendations to the U.S. government on promising and feasible strategies to address the problem. During the 18-month study, the committee reviewed the state of the science in the major areas of malariology, identified gaps in knowledge within each of the major disciplines, and developed recommendations for future action in malaria research and control. A major finding of the committee is the need to increase donor and public awareness of the growing risk presented by the resurgence of malaria. Overall, funding levels are not adequate to meet the problem. The committee believes that funding in the past focused too sharply on specific technologies and particular control strategies. Future support must be more balanced. The issue for prioritization is not whether to select specific technologies or control strategies, but to raise the priority for solving the problem of malaria. This report highlights those areas which the committee believes deserve the highest priority for research or which should be considered when U.S. support is provided to malaria control programs.

13. ***Sauerborn, R., D.S. Shepard, M.B. Ettling, U. Brinkmann, A. Nougtara and H.J. Diesfeld. 1991. Estimating the direct and indirect economic costs of malaria in a rural district of Burkina Faso. Trop. Med. Parasitol. 42:s219-s223.***

This paper builds on a conceptual framework for estimating the economic costs of malaria as described in the Shepard et al (1991) paper in this supplement of Tropical Medicine and Parasitology. This paper emphasizes the importance of seasonality of epidemiology and of seasonal variation in productivity in estimating the economic costs of malaria. Information necessary for these estimates is not generally available from health information systems, national or project budgets; as a result,the cost analysis based only on these sources will underestimate household out-of-pocket costs and loss of household production. This study combines a household survey with other economic data to generate more reasonable estimates of costs of disease in Burkina Faso --direct costs of treatment and indirect costs of lost productivity. The majority of malaria episodes (80%) in Burkina Faso are treated at home or by a traditional healer. The majority of patient expenditure for professional care is made up of drug costs and transportation costs -- which would not be included in service reports. Aggregate economic data also fail to capture the seasonal variation in the opportunity cost of time lost to disease. A survey of 626 households in Solenzo District, Burkina Faso was conducted in 1985 in order to obtain a true

estimation of the burden of malaria on families in terms of direct costs and indirect costs. Other data sources are also utilized in this study: *(1)* national death reporting system to determine the seasonal pattern of malaria; *(2)* market prices to value farm production (cotton, millet and sorghum) and non-farm production (millet beer and straw mats); *(3)* Ministry of Agriculture data to estimate annual output of agricultural products; and (4) budget data to estimate costs of health services used. The economic cost per case averaged $5.96, of which $1.35 was direct costs. The economic cost per capita was $1.15, of which $0.26 was direct costs.

This study suggests three policies that will reduce [illegible] rall burden of malaria. First, prevention of childhood deaths from malaria would [illegible] impact on indirect costs of disease. Difficulties in preventing childhood [illegible] arise from the fact that most episodes of malaria occur in the rainy season when access to health services is more problematic and adult time required to obtain health care for children is more costly. Second, shortening the duration of disease through administration of immediate and effective treatment would reduce costs. Home-based treatment protocols designed for mothers or caretakers would improve the rate of treatment. Third, policy should aim for a major reduction in the cost of drugs, since many patients purchase drugs in private pharmacies. This could be accomplished through a revolving drug fund at the community level.

14. ***Shepard, D.S., U. Brinkmann, M.B. Ettling and R. Sauerborn. 1990. Economic Impact of Malaria in Africa, Vector Biology and Control Project. (UnPub)***

This report is a fuller discussion of the economic impact of malaria in Africa that appears in Shepard et al (1991) in the supplement of Tropical Medicine and Parasitology. First, it documents that malaria consistently ranks highest as a cause of illness. For example, it cites the finding from the Ghana Health Assessment Project team's analysis of 1975 data that malaria caused the largest loss of potential days of life *[see Nimo et al, 1991]*. Second, it documents that the number of cases and deaths from malaria has been increasing during the past decade *[see also Brinkmann and Brinkmann, 1991]*.

This study focuses primarily on two categories of economic impact: *(1)* direct costs, which are costs of treatment and control; and *(2)* indirect costs, which are the value of lost income due to morbidity and premature mortality. A final category of impact would be intangible effects, representing the discomfort of being ill or of knowing that a loved one is ill, but this category has not been included due to lack of data. Since there are no data available to assess the economic impact of malaria in Africa as a whole, four national or sub-national case studies are presented: Rwanda; Burkina Faso (Solenzo District); Chad (Mayo-Kebbi District); Congo (Brazzaville). Costs are represented in terms of cost per case, cost per capita and percent of per capita gross domestic product. For sub-Saharan Africa overall, the current (1990) cost of malaria averages 0.6 percent of GDP and is projected to double to 1.1 percent by 1995. By comparison, the entire budget for the Ministry of Health of Rwanda was only 0.9 percent of GDP in 1988. Thus, the total direct and indirect costs for this one disease outstrip the public resources available for all diseases. Effective malaria control measures would have a substantial payoff. Studies of economic costs of illness would allow donor and host country officials to demonstrate the value of selected control strategies through cost-benefit analyses. For example, a program to provide insecticide-impregnated bednets to children might have a per capita annual cost of $0.62, but could reap economic benefits of $1.08 per capita per year. For an average area in sub-Saharan Africa, an expenditure of up to $0.20 per capita is economically justified if it achieves only a 10% reduction in the cost of malaria. A complete understanding of the mechanism and the magnitude of malaria's economic impact will require further research.

15. *Shepard, D.S., M.B. Ettling, U. Brinkmann and R. Sauerborn. 1991. The economic cost of malaria in Africa. Trop. Med. Parasitol. 42:s199-s203.*

The economic impact of malaria can be grouped into three broad categories: direct costs, indirect costs, and intangible effects on health. Direct costs are defined as direct drains on individual, household, and government resources brought about by expenditure on the treatment and prevention of malaria. Indirect costs include losses to individual, household, and national productivity due to malaria. Malaria's intangible economic impact on health is experienced as lower quality of life.

The study adapts a framework for assessing the economic costs of illness to the limited data available on malaria. The limited model includes the direct costs and indirect costs of illness. Direct costs of illness are the costs of treatment and control activities and indirect costs are the value of time lost to morbidity and premature mortality. Direct costs were estimated by applying the average estimated health systems costs per case to the number of cases. Indirect costs were assessed by multiplying adult output per day times the estimated productive time lost through both adult and childhood cases. Four case studies (Rwanda, Solenzo medical district of Burkina Faso, Mayo-Kebbi district of Chad and Brazzaville, Congo) were chosen to illustrate the diversity in kinds of data which can be used (aggregate national health statistics versus household surveys) and in locations (urban versus rural). Estimates for all sub-Saharan Africa were derived from the averages of these sites. In 1987, a case of malaria cost $9.84 (in 1987 U.S. dollars) -- $1.83 in direct costs and $8.01 in indirect costs. The cost is equivalent to 3.3% of the average value of goods and services produced per capita per year in Africa. By 1995, the average cost of a malaria case is projected to rise to $16.40 (still in 1987 U.S. dollars) due to increasing case severity and chloroquine resistance. At the same time, per capita output is predicted to decline, so the burden will rise to 5.8% of per capita annual output. For Africa as a whole, the annual economic burden of malaria was $0.8 billion as of 1987 and will rise to $1.7 billion in 1995; it represented a 0.6% share of GDP previously and will represent a 1.0% share for 1995.

HIV/AIDS

1. *Anderson, R.M. 1991. AIDS and its demographic impact. In: Disease and Mortality in Sub-Saharan Africa, edited by Feachem, R.G. and D.T. Jamison. World Bank, Oxford University Press, New York, pp. 214-220.*

This chapter reviews some preliminary results of attempts to model the demographic impact of AIDS. Mathematical models use demographic data, epidemiological data on transmission of HIV-1, and data on the key epidemiological parameters of the disease. The key epidemiological parameters include: percentage of persons infected who develop AIDS; incubation period for those infected; likelihood for vertical transmission in utero, during childbirth and during breastfeeding; effect of other genital infection in promoting transmission; degree to which infectiousness changes throughout the incubation period; and the rate of change in sexual partners and the types of sexual behavior occurring in specific communities. Analyses of these simple models reveal three important predictions: *(1)* AIDS is predicted to be able to reverse the sign of population growth rates; *(2)* the time scale of this reversal is predicted to be long, on the order of many decades; and *(3)* whether or not AIDS will decrease or increase dependency ratios depends critically on the values of the major demographic and epidemiological parameters prevailing in a community. The author states the need for more precise models, and the potential for more accurate data from longitudinal studies.

2. ***Becker, C.M. 1990. The demo-economic impact of the AIDS pandemic in sub-Saharan Africa. World Development 18:1599-1619.***

This paper examines available data on the incidence and spread of HIV/AIDS in Africa. Assessments of the impact of the spread of AIDS on African population growth and economic performance are then offered. The discussion of the cost of AIDS is based largely on Over et al's (1988) analysis of Tanzania and Zaire. Long-run economic considerations of savings and investment receive particular attention. Rural development is emphasized in part because HIV is less prevalent in rural areas. *[However, rural areas might feel the brunt of the AIDS epidemic by 2015 (Way and Stanecki, 1991).]* Eventual control of the disease requires increased condom use and reduced numbers of sexual partners.

3. ***Caraël, M. and P. Piot. 1989. HIV infection in developing countries. J. Biosoc. Sci. S10:s35-s50.***

This report describes the epidemiology of AIDS in Africa and the Caribbean as of 1989. Studies of risk factors in heterosexual transmission, blood transfusions, injections and scarifications as well as perinatal transmission are reviewed. The sociological background for heterosexual behavior in Central Africa and East Africa is characterized as traditionally strict in limiting female pre-marital and extra-marital sexual intercourse. Urbanization and the availability of prostitutes are considered important in loosening restraints on sexual intercourse. However, variability in behavioral patterns is acknowledged.

4. ***Center for International Research. 1991. Recent HIV Seroprevalence Levels by Country: February, 1991, U.S. Bureau of the Census, Washington, DC.***

This report presents data from HIV seroprevalence studies compiled by the Center for International Research of the U.S. Bureau of the Census. Several criteria are used to minimize, but not eliminate, biases in seroprevalence estimates: *(1)* larger samples are generally favored over smaller samples; *(2)* more recent estimates are selected over older estimates; and *(3)* better-documented data are selected over poorly-documented data. High-risk groups sampled include prostitutes and STD clinic patients. Low-risk groups include pregnant women and blood donors. Four maps show HIV seroprevalence for both risk groups in urban areas and both HIV types (HIV-1 and HIV-2); shading on the map is at the country level although the prevalence estimates are not based on a national sample. The prevalence studies on which the maps are based are listed.

5. ***Chin, J. 1991. The epidemiology and projected mortality of AIDS. In: Disease and Mortality in Sub-Saharan Africa, edited by Feachem, R.G. and D.T. Jamison. World Bank, Oxford University Press, New York, pp. 203-213.***

This report reviews the current HIV/AIDS epidemic in Africa and provides short-range projections (5 to 10 years) of its potential impact on mortality rates and demographic patterns in sub-Saharan Africa. At the end of the 1980s, the HIV/AIDS epidemic in Africa was most severe in central and eastern Africa but was also extending to adjacent countries of southern Africa and into West Africa. Projections of the demographic impact are based on a Global Programme for AIDS (GPA) model that utilizes HIV serological survey data and observed annual progression rates from HIV infection to the development of AIDS. By 1992, the cumulative total will be about 1.5 million AIDS cases and deaths. During the early to mid-1990s, most countries in sub-Saharan Africa can expect large increases in mortality for children under 5 years of age and

adults between the ages of 20 and 49. In the 1990s, the impact of AIDS in the countries of Central Africa will be largely in the cities and national population growth rates of 3% or 4% will be reduced by 1% or less.

6. ***De Bruyn, M. 1992. Women and AIDS in developing countries. Soc. Sci. Med. 34:249-262.***

A review of the recent literature reveals that the impact of HIV/AIDS is particularly great on women in developing countries for four reasons. *(1)* Women are either blamed or not recognized as potential patients. *(2)* Various factors place women at increased risk of exposure to HIV infection. *(3)* The psychological and social burdens are greater for women than for men. *(4)* Women's social position makes it difficult for them to undertake prevention measures. Policy-making should involve women through organizations like the Society for Women and AIDS in Africa. The approach should be multisectoral, involving health, education, justice and elected bodies.

7. ***Forsythe, S. 1992. The Economic Impact of HIV and AIDS in Malawi, AIDSTECH/Family Health International. (UnPub)***

This report is an assessment of the potential economic impact of AIDS prepared in February of 1992 for USAID/Malawi. This report analyzes both the direct costs of care at health facilities and the indirect costs of lost productivity. Specific sectors of the economy are also considered. In 1992, the national HIV prevalence rate is expected to rise to between 11.0% and 12.6%. The economic impact of AIDS will be observed in increasing health care costs and overcrowding at hospitals. The lifetime costs of treatment per case are estimated to be K515 (or $132 where K3.9 = $1). The human capital approach is used to obtain estimates of the value of lives that are lost to AIDS. An estimated 18.7 years of productive life are lost per case. Using estimates of average income and a 5% discount rate to weight the future, the monetary value of the life lost is K10,500 (or $2,692 where K3.9 = $1). Analysis of economic sectors utilized HIV seroprevalence data by district from a 1989 blood donor survey. The highest HIV prevalence is likely to occur within the modern sector industries of finance/insurance/real estate and transport/communications. The country is facing the risk of losing educated workers, the risk of lost exports and the risk from unmet seasonal demands for labor. Over the long run, AIDS is likely to most impact Malawi's agricultural sector, which comprises an overwhelming proportion of exports, and is likely to have the most difficulty in coping with AIDS due to seasonal demands for labor.

8. ***Goodgame, R.W. 1990. AIDS in Uganda--Clinical and social features. N. Engl. J. Med. 323:383-389.***

The report highlights some distinctive features of the Ugandan AIDS epidemic. *(1)* "Risk groups" are largely irrelevant. *(2)* Tuberculosis is ubiquitous. *(3)* Opportunistic infections indicate environmental exposure. *(4)* HIV testing is largely unnecessary. *(5)* The standard of care is undefined. *(6)* Counseling is controversial.

9. ***Kiereini, E.M. 1990. AIDS impact on women and children in Africa. Int. Nurs. Rev. 37:373-376.***

This article is the transcript of a speech presented at the 6th International Conference on AIDS in 1990. The impact of AIDS on women in Africa is described in vignettes. Women must carry the burden of caring for ill family members. Women who are infected carry a stigma.

Greater priority should be given to research on women and children with AIDS.

10. ***Ntonzi, J.P.M. and M. Lubega. 1990. Patterns of sexual behavior and the spread of AIDS in Uganda. Paper prepared for IUSSP Seminar on Anthropological Studies of Sexual Behavior Relevant to HIV Transmission. (UnPub)***

Patterns of sexual behavior in Uganda are divided into premarital sexual behavior, extramarital sexual activities and marital sexual patterns. The behavioral patterns for the major ethnic groups are markedly heterogeneous. Factors related to the spread of HIV/AIDS include polygamy, urban residence, urban to rural visits and major truck transport routes. Condoms have not been accepted by Ugandans.

11. ***Oot, D., K. Colson, B. Obonyo, S. Forsythe, D. Sokal, L. Lux and A. Johnston. 1992. Economic Impact of HIV/AIDS in Kenya: A Preliminary Assessment. AIDSTECH/Family Health International (UnPub)***

This report was prepared for USAID/Kenya in April of 1992. It analyzes the economic impact of AIDS in Kenya in terms of the direct cost of hospital treatment for AIDS, the economic costs of lives lost to AIDS, and the impact on particular sectors of the economy. The prevalence of HIV among the adult population is projected to reach 8% to 16% by 1995. The lifetime costs per case treated is estimated to be 27,200 shillings (or $886 where 30.7 shillings = $1). An estimated 26 years of productive life are lost per case. The monetary value of productive life lost per case is estimated with a 5% discount rate to be 194,700 shillings (or $6,342 where 30.7 shillings = $1). The impact on specific economic sectors is analyzed. Prevalence is likely to be high in mining and transportation/communications because of the location of the businesses. Community/social/personal services, finance/insurance/real estate, and electricity/water are likely to have difficulty in coping with AIDS due to the high skill level of their workforce and the resulting difficulty in replacing workers lost to AIDS. The seasonal demands for labor in modern sector agriculture and small farming are likely to create demand pressures for employment which cannot be met. The potential loss of export earnings in modern sector agriculture and mining is likely to seriously impact Kenya's trade balance.

12. ***Over, M. and M. Ainsworth. 1989. The economic impact of fatal adult illness from AIDS and other causes in sub-Saharan Africa: A research proposal. (UnPub)***

This is a 1989 research proposal at the World Bank to investigate two questions. *(1)* What are the economic costs and impacts of AIDS illness and death among adults on households and communities? *(2)* How can the government target patient and/or survivor assistance programs in order to maximize the benefit to survivors for a given government budget? The survey is currently underway in Tanzania.

13. ***Over, M., S. Bertozzi and J. Chin. 1989. Guidelines for rapid estimation of the direct and indirect costs of HIV infection in a developing country. Health Policy 11:169-186.***

The direct cost of an illness is defined as the cost of treatment, which is determined by the supply and demand for health care services in the health care market. The indirect cost of an illness is defined as the value of the time lost to the ill person or decedent's family or employer due to illness or death. The value of the time lost is calculated based on the supply and demand of the labor market. The purpose of calculating cost estimates of HIV infection for a developing country is twofold: *(1)* to inform policymakers in allocation of resources to efforts to prevent the

spread of the epidemic and *(2)* to plan programs to assist the infected person and his or her family in coping with the burdens of the disease and death. The estimation method should demonstrate the benefit to society of preventing a case of infection with HIV. The methodology for calculating the estimates is influenced by time constraints and the presence (or absence) of systems of data collection from patient records. The methodology for estimating the total cost of one case of infection with HIV is described in detail in the article--the following is a brief summary. Direct cost of an AIDS case is estimated by the sum, across all opportunistic illnesses, of the average cost per AIDS case for each illness. These costs must then be converted to the present value of the cost of a case of HIV infection. In order to arrive at the indirect costs, an estimate of the value of the time lost to morbidity and mortality, one must apply four different weights to the lost years of life. These include: weights discounting future life-years; weights that attach different value to adult vs. dependent years of life; different weights from one individual to another, based on the human capital approach or the willingness-to-pay approach; and weights based on morbidity, either through the healthy-life-year (productivity approach) or the quality-adjusted-life-year (subjective value of health). Finally, the total cost is obtained by the sum of the direct and indirect costs.

14. ***Over, M., S. Bertozzi, J. Chin, B. N'Galy and K. Nyamuryekung'e. 1988. The direct and indirect cost of HIV infection in developing countries: The cases of Zaire and Tanzania. In: <u>The Global Impact of AIDS</u>, Alan R.Liss, New York. pp. 123-135.***

The goals of this paper are the following: *(1)* describe an approach of estimating the direct costs (cost of treatment) and the indirect cost (value of healthy years of life lost) of HIV infection in a developing country; and *(2)* present these estimates for each infected person. Direct costs of a case of HIV infection vary considerably, even within the same country, because of the range of clinical symptoms present, socioeconomic characteristics of the patient, and the medical or institutional characteristics of the health care options available to the patient. It is preferable to present a range of cost estimates to represent the various situations. The estimates make the important assumption that each symptomatic infected adult will seek at least some treatment from modern sector facilities. Estimates of direct cost per case in Tanzania and Zaire are compared to estimates of direct cost in the U.S., England, and a Caribbean nation; the comparison reveals a correspondence between direct cost of care and GNP per capita, similar to the relationship of overall national health care spending and GNP per capita. Although the cost of treatment for a case of symptomatic HIV infection seems large relative to per capita health care spending, it should be compared to per patient expenditure for other serious diseases of adults in the same country. Comparisons such as this are important to the process of establishing treatment protocols; benefits to society of the higher spending should be carefully assessed. Indirect cost is computed in several steps. First, estimates of future healthy years of life lost are discounted at an annual rate of 5%. The discounted healthy life years lost by an HIV-infected person (8.8 years) rank fifth, after several childhood diseases including sickle-cell (17.0 years) and neonatal tetanus (15.3 years). Second, total future years of healthy life lost are disaggregated by age groups which differ in assigned productivity weights; prevention of a case of HIV infection is estimated to save 6.6 productivity-weighted discounted healthy life years. Third, a monetary value is attached to each productive healthy life year saved. There are two competing approaches to placing a monetary value on healthy life years -- willingness-to-pay and human capital theory. The willingness-to-pay approach is not utilized because of the lack of data to consider "psychic value that society attaches to saving a life." The human capital approach considers the economic returns to society for a year of the infected person's labor, measured imperfectly as annual income. This study produced three estimates of the dollar value of discounted future years of healthy life lost based on average wage estimates for three socioeconomic groups of the population: rural residents, urban residents with primary education, and urban residents with secondary education or more. The total economic cost

of an individual case of HIV infection is obtained by combining the direct and indirect cost. Indirect costs dominate the direct costs; this would be expected for other important diseases as well, although the relevant data are not available. A hypothetical situation is described in which the information provided by this analysis (the dollar value of a case of HIV infection prevented) would aid in decision-making regarding resource allocation across sectors.

15. ***Over, M. and J. Kutzin. 1990. The direct and indirect costs of HIV infection: Two African case studies. Postgraduate Doctor Middle East 13:632-638.***

WHO estimates that about 4 million people in Africa are currently (i.e., in 1988) infected with HIV, and are likely to develop AIDS. The "costs" of the disease are defined as social and economic consequences which accrue due to illness and death of infected persons. These costs are estimated for each case of HIV infection, not of AIDS alone. The estimates demonstrate the benefit to society of each case of HIV infection prevented; such estimates are most useful in decisions regarding the allocation of resources to prevention. The total cost of a case of HIV infection includes both direct and indirect costs. Direct cost is the economic cost or the value of the resources used for treating the disease; in principle, the opportunity costs of denying access to health resources to patients with other (often curable) diseases should be added in. Indirect cost is the value of the time lost to the sick person and family or employer due to illness or death. The indirect cost is measured as the number of productivity-weighted discounted years of healthy life lost multiplied by the average income per year of the infected person. An important finding in the estimation of the cost of HIV infection in Tanzania and Zaire is the wide variation in cost for an individual case within the same country. The variation is due to several factors, including the symptoms present, the patient's socioeconomic status, and the medical and institutional characteristics of the available health care system. Because there is such great variation in treatment cost and greater expenditure per case does not improve the probability of survival, it is feasible to reduce medical expenditure per case. Policies should address the more urgent needs of families and employers who suffer the impact of the indirect costs of each case of infection with HIV.

16. ***Over, M. and P. Piot. 1992. HIV infection and sexually transmitted diseases. In: Health Sector Priorities Review, edited by Jamison, D.T. and W.H. Mosley. World Bank, Oxford University Press, New York. (In Prep)***

The objective of this report is to examine the case for assigning a high priority to the prevention (primary and secondary) of the spread of sexually transmitted diseases (STDs) including HIV/AIDS. Methodology for estimating the static burden of STDs is based on the approach of the Ghana Health Assessment Project, which calculated healthy life years lost for 50 disease categories. Methodology for estimating the dynamic burden of an STD epidemic is based on work by Bongaarts, by Anderson, May and McLean and by the U.S. Department of State's Interagency Working Group. An exploration of the role of a core high-risk group responsible for maintaining transmission builds on the work of Hethcote and Yorke on gonorrhea.

17. ***Piot, P. and M. Caraël, M. 1988. Epidemiological and sociological aspects of HIV infection in developing countries. Br. Med. Bull. 44:68-88.***

This paper is a review of the HIV/AIDS epidemic in Africa and the Caribbean as of 1988. *[It covers much the same ground as Caraël and Piot (1989).]*

18. ***Sanders, D. and A. Sambo. 1991. AIDS in Africa: The implications of economic recession and structural adjustment. Health Policy 6:157-165.***

The focus of this paper is on those socio-economic factors predisposing to the spread of HIV infection as well as on the aggravation of these factors by economic recession and structural adjustment programs (SAPs). The colonization of Africa brought about large scale economically motivated migration of people from rural to urban areas. The current economic crisis and SAPs introduced by many African governments have aggravated both urban drift, mainly as a result of increasing landlessness, and urban poverty as a result of contraction of cash incomes and inflation. Accompanying declines in formal sector employment in most of Africa have led to increased dependence on informal income, which for women, has often meant resorting to prostitution.

19. ***Scitovsky, A. and M. Over. 1988. AIDS: Costs of care in the developed and the developing world. AIDS 2:s71-s81.***

This paper defines three epidemiological patterns of AIDS according to the WHO/Global Programme on AIDS (WHO/GPA). In pattern I countries, most transmission and most cases occur among homosexuals and intravenous drug users. Pattern II countries are characterized by heterosexual transmission. Pattern III countries have only recently (as of 1988) had cases of AIDS, which are introduced through contaminated blood and blood products. The pattern of the epidemic in specific countries can significantly influence estimates of the cost of the disease.

In presenting a methodology for estimating the cost of care, seven important distinctions are discussed. *(1)* Positive versus normative estimates distinguish between "actual care" and "best practice care". As medical technology changes, normative cost will evolve first followed by changes in the positive cost. *(2)* Prospective studies follow people from time of diagnosis until death in contrast to retrospective studies which depend on patient records and the ability of the patient and family members to recall health expenditures. Prospective studies generate better quality data but they are difficult and costly to perform. *(3)* Random samples, which are constructed from a list of all persons with AIDS, are superior to convenience samples, which rely on ease of access to patients in particular facilities. In developing countries especially, cost estimates based on convenience samples can be very distorted because they only reflect the costs of care for a minority who have access to such care. However, random sampling is often difficult to conduct in a study of HIV/AIDS. *(4)* The term "cost" is used in practice to mean either the actual economic cost of producing a medical service or, in countries with a predominantly fee-for-service health care system, the charge (or price) for a specific medical service. In developing countries, databases of either costs or charges usually do not exist. In these situations, a researcher must develop basic cost data on the health system itself before estimating the specific cost of AIDS treatment. *(5)* In comparing the costs of treating an AIDS case across countries, one may convert costs based on either purchasing power parities or official exchange rates. In developing countries, only exchange rates are available for use in estimation. *(6)* There are three ways of summarizing costs. Lifetime costs are costs of all medical services used by a patient from diagnosis with AIDS until death. Cost per patient alive at any time during a given year, however, is the most frequently estimated type. Costs per person-year are recommended for better comparisons of data across different studies. *(7)* Incidence-based estimates use the lifetime costs of all persons diagnosed in a particular year. Prevalence-based estimates total medical care costs incurred in a given year by all persons with the disease. Incidence-based estimates and prevalence-based estimates of costs of disease are both useful to planners.

The costs of treating AIDS cases in the developing world (excluding Brazil) are small relative to the costs in developed countries because of lack of access to modern health care facilities (tertiary care) and the lower cost of the time of the health care personnel. Treatment costs are in

rough association with per capita gross national product (GNP). Studies from developing countries are generally based on small convenience samples or apply imperfectly known average hospital and outpatient costs to estimated utilization patterns which have been constructed based on expert opinion. For example, a value of $100 in lifetime costs is assigned to a theoretical Central African Country. Initial studies have focused only on AIDS, but should be expanded to include all HIV-infected people.

20. ***Stanley, E.A., S.T. Seitz, P.D. Johnson, P.O. Way and T.F. Curry. 1991. The IWG model for the heterosexual spread of HIV and the demographic impact of the AIDS epidemic. Paper prepared for the UN/WHO Workshop on Modelling the Demographic Impact of the AIDS Epidemic in Pattern II Countries--Progress to Date and Policies for the Future. (UnPub)***

The IWG model for the spread of HIV/AIDS, developed for Pattern II countries, has been used for technical research, policy analysis, and decision-making. This model evaluates the spread of HIV by various routes: heterosexual sex (including both long-term [married] and short-term [casual] partners); blood transfusions; and perinatal transmission. The IWG model addresses demographic and epidemiological questions regarding the spread of HIV/AIDS. Demographic issues include: the age pattern of infection; the effects of the epidemic on the age structure of the population; effects on infant and child mortality; and the overall impact on population growth rates. The important epidemiological questions are: relative importance of the various infection routes; mechanisms of spread between age groups; the role of very high risk takers in the spread of the epidemic; rural to urban spread of the disease; effects of other STDs; and the impact of various interventions on the epidemic. A comparison of the effectiveness of several interventions, such as promoting condom use, a national blood screening program, and treating other STDs, is very useful in policy decisions. The IWG model has as its baseline a demographic model, with both rural and urban components. Two major types of population divisions, status groups and status group characteristics, are then added to the model. Finally, processes important in the spread of HIV/AIDS are included in the model. This paper contains the equations used to model infection rates in Appendix I. Appendix II documents analysis of sensitivity of the model to input data. The total population was most sensitive to the initial female population; the infected population, however, was more sensitive to the infectivity of men and to the infectivity of women. This analysis demonstrates that interventions which result in only a slight decrease in transmission probabilities may have a major impact on the spread of the AIDS epidemic.

21. ***Stoto, M.A. 1991. Models of the demographic impact of AIDS in Africa, Institute of Medicine. (UnPub)***

This paper describes the currently available models of the HIV/AIDS epidemic and summarizes what these models say about the potential future of the demographic impact of AIDS in Africa. This analysis is based, in large part, on a recent United Nations/World Health Organization publication The AIDS Epidemic and its Demographic Consequences (United Nations, 1991). The possible demographic impacts predicted by these models vary from minor to substantial. The modeling efforts have concentrated on gross demographic variables; little is known about the potential impact of the epidemic on family structure.

22. ***Torrey, B.B. and P.O. Way. 1990. Seroprevalence of HIV in Africa: Winter, 1990. U.S. Bureau of the Census, Washington, DC.***

This report presents data from HIV seroprevalence studies compiled as of May 1990 by the Center for International Research of the Bureau of the Census. *[The same database is used*

in the report on HIV seroprevalence levels in February of 1991.] High-risk groups sampled include prostitutes and STD clinic patients. Low-risk groups include pregnant women and blood donors. Maps and charts are used to illustrate seroprevalence in both risk groups and for both types of HIV infection (HIV-1 and HIV-2).

23. ***Way, P.O. and M. Over. 1992. The projected economic impact of an African AIDS epidemic. Paper prepared for Annual Meeting of the Population Association of America, April 28-May 2, 1992, in Denver, Colorado. (UnPub)***

The demographic impact of the AIDS epidemic in Africa is calculated using the U.S. Dept. of State's Interagency Working Group (IWG) model on a hypothetical "typical African country." The demographic results are fed into a macroeconomic model relating factors of production to urban (industrial) and rural (agricultural) output; thus, the impact of AIDS can be expressed in terms of its effect on gross domestic product (GDP). The production functions have been estimated for sub-Saharan Africa based on the analysis of 35 African countries for which data were available from the 1960-1985 period. The majority of the impact of AIDS occurs from the indirect effects of lost productivity due to premature deaths. The total economic impact over the period 1990-2015 was about 15 times greater than the estimated direct cost.

24. ***Way, P.O. and K. Stanecki. 1991. How bad will it be?: Modelling the AIDS epidemic in Eastern Africa. Paper prepared for the Annual Meeting of the American Association for the Advancement of Science. Washington, DC, February 14-19, 1991. (UnPub)***

This paper employs the U.S. Department of State's Interagency Working Group (IWG) model of the AIDS epidemic in sub-Saharan Africa. The IWG AIDS model of the spread of HIV in Pattern II countries is applied to a "hypothetical country" in sub-Saharan Africa, with a projection time of 25 years (1990-2015). Since the population of this hypothetical country is taken as one percent of the sub-Saharan population, the rates reported in this paper represent both the country and the region; the reported numbers multiplied by 100 would represent the region. The results of this analysis regarding both the demographic and epidemiological impact of the epidemic are briefly summarized.

The demographic findings reflect the increased seroprevalence in both the urban and rural areas, although the urban areas generally are more heavily affected. The population growth rate declines over the 25 year period from 2.8% to 2.2% if the AIDS epidemic is removed; in the presence of the AIDS epidemic, the decline is more marked, reaching a low of 1.8% in the year 2015. The number of deaths expected in the year 2015 may increase by as much as 1/3, with a concentration of deaths in the urban areas. A significant loss of life expectancy is predicted for the urban areas; in the year 2015, the loss in life expectancy due to the AIDS epidemic may be as great as 19 years. Increases in infant (22%) and child (47%) mortality rates are expected for the urban areas, while increases at the national level may reach up to 8% and 16% respectively. The predicted age patterns of mortality indicate that the very young and the middle adult years will be most affected by the epidemic. Without the AIDS epidemic, about 12% of the population would be expected to die between ages 15 and 45 years; in the presence of the AIDS epidemic, it is expected that over 54% of those attaining age 15 will not live to age 45.

The epidemiological results of this analysis project the number infected, the number of new infections, and the number of AIDS cases. Over the projection period, the number infected increases by a factor of 12--from 59,000 persons (5.9 million regional) in 1990 to about 700,000 (70 million regional) by 2015. Of the initial infected population, about two thirds are in the urban areas, but, by the end of the projection time, the numbers are more evenly divided between urban and rural areas. The number of new infections is a measure of the growth of the epidemic and is

an indicator of effectiveness (or ineffectiveness) of preventive measures. The number of new infections is expected to level off in the urban areas during the course of this projection, while increasing rapidly in the rural areas. The number of new AIDS cases and the number currently with AIDS are the best measures to use in estimating the impact of the epidemic on the health system. The model estimates about 7,000 (700,000 regional) AIDS cases in the initial population, increasing to over 120,000 (12 million regional) by the year 2015. Given the short life expectancy following the development of AIDS, the relationship between new AIDS cases and the current population with AIDS is quite direct. The population with AIDS tends to be about twice the number of new infections. Since the epidemic is growing more rapidly in rural areas, more new AIDS cases are projected in rural areas than in urban areas in the year 2015. This report also includes a cost-effectiveness analysis of four possible interventions: promotion of condom use, an STD control program, an information/education/communication program (IEC) to reduce the incidence of casual sex, and a 100% blood screening program.

25. ***Way, P.O. and K. Stanecki. 1991. The demographic impact of an AIDS epidemic on an African country: Application of the IWG-AIDS model. (UnPub)***

This paper reviews the findings of a previous modelling exercise (Way and Stanecki, 1991) which employs the U.S. Department of State's Interagency Working Group (IWG) model of the AIDS epidemic in sub-Saharan Africa. The IWG model allows the user to specify demographic information, sexual behavior, current infection levels and the time frame of the projection. The model estimates demographic consequences and epidemiological effects, thus allowing the prediction of the impact of various interventions on the epidemic, such as use of condoms or implementing a national blood screening program. Results of the modelling exercise are expressed for the period 1990 to 2015. *(1)* There is evidence of a growing epidemic in Africa, with seven-fold increases in the number of cases over the 25-year projection period. *(2)* The effect on population size and growth rates is moderate. Population growth rates are reduced by the AIDS epidemic (by as much as 50 million for sub-Saharan Africa), but they still remain strongly positive. *(3)* Mortality measures are greatly affected; the crude death rate (CDR) may increase in a hypothetical African country (a theoretical composite) by as much as 50%. Age patterns of mortality are strongly affected--excess urban mortality due to AIDS is six to seven times the normal levels for those in their 30's and 40's. Excess AIDS mortality reduces urban life expectancy by 19 years in the year 2015. *(4)* Recent improvements in infant and child mortality are reversed by the AIDS epidemic. Urban levels of infant mortality increase by more than 20% (nationally 8%); urban mortality under age 5 increases nearly 50% relative to the non-AIDS scenario (nationally 16%). *(5)* An extended incubation period (on the order of 10 years) means that much of the impact of increased morbidity and mortality lies beyond the period of most rapid increase in seroprevalence. *(6)* Behavior change and STD treatment are the key factors in reducing the epidemic; national blood screening programs show little effect on the epidemic. The authors suggest that the policy implications of these findings indicate a need for behavior changes. Population growth will continue to be a problem, and family planning programs are necessary to improve the health and welfare of mothers and children. Levels of young adult and infant and child mortality in urban areas are increasing at an alarming rate, and health programs currently in place are not meeting the needs generated by the epidemic. Life expectancy in many cities in Eastern Africa has declined to levels reminiscent of the 1950s and 1960s.

ONCHOCERCIASIS

1. *Clark, J.P. 1990. Economic Impact of Chemotherapy of Onchocerciasis on Productivity of West African Rubber Tree Tappers. Dissertation, Johns Hopkins School of Hygiene and Public Health. (UnPub)*

The purpose of the study was to investigate the effect of ivermectin distribution on labor productivity at a rubber plantation in Liberia, West Africa (Liberian Agricultural Company). The LAC rubber plantation is in a zone with the forest strain of onchocerciasis which does not cause severe blinding as does the savannah strain of onchocerciasis in the OCP area. The study looked for reduced health care utilization and improved productivity following community-based distribution of ivermectin. The data included use of health services, days worked, adjusted bonus pay, days of sick leave, days of absenteeism and microfilarial load (a measure of the level of infection). No effect of the ivermectin distribution on labor productivity was observed.

2. *Evans, T.G. and C.J.L. Murray. 1987. A critical re-examination of the economics of blindness prevention under the Onchocerciasis Control Program. Soc. Sci. Med. 25:241-249.*

This article is a response to the evaluation by Prost and Prescott (1984) of the OCP in Upper Volta (Burkina Faso). The authors identify two series of problems with the previous study: *(1)* technical difficulties associated with data quality and assumptions made in that analysis, and *(2)* the use of the same measure of cost-effectiveness for health programs with different purposes--measles control is largely a humanitarian program while onchocerciasis is constructed as an economic concern. In both studies, the outcome is measured in terms of healthy years of life saved. For Prost and Prescott, the years of disability due to blindness are 9 years in hyperendemic areas and 7 years in mesoendemic areas; in this study, it is 16 years in all areas. For Prost and Prescott, life expectancy is diminished by 14 years in hyperendemic areas and 13 years in mesoendemic areas; in this study, the corresponding figures are 12.7 years in hyperendemic areas and 9 years in mesoendemic areas. For Prost and Prescott, the size of the population at risk for blindness is 500,000 in hyperendemic areas and 500,000 in mesoendemic areas; in this study, the size is 317,000 in hyperendemic areas and 185,000 in mesoendemic areas. Prost and Prescott assume that a year of blindness does not contribute to the total of healthy life years, i.e., a year of blindness is treated like a year lost due to mortality; in this study, a year of blindness is assumed to be 50% of a healthy year of life. For Prost and Prescott, ages 15 to 60 years are considered productive; in this study, ages 15 to 49 are productive. For Prost and Prescott, the estimated cost per year of productive life added is $20 and the estimated cost per year of discounted productive life added is $150; in this study, the estimated cost per year of productive life added is $705 and the estimated cost per year of discounted productive life added is $4,852. In addition to these technical differences, the authors question the appropriateness of comparing two health programs with such vastly different outcomes as measles control versus onchocerciasis control.

3. *OCP. 1985. Ten Years of Onchocerciasis Control in West Africa: Review of the Work of the Onchocerciasis Control Programme in the Volta River Basin area from 1974 to 1984, World Health Organization, Geneva.*

This report examines the Onchocerciasis Control Programme in West Africa after 10 years in operation. The report describes the biology of the disease, the parasite and the vector and

reviews the strategy and operations of the control project. Some studies of the effect of the OCP on socioeconomic and health development are reviewed. OCP's vector (blackfly) control has been successful in interrupting transmission, but a major operational problem has been the re-entry of vectors into the control area and the development of vector resistance to larvicides. The central planning problem for the future is the maintenance of control activities after OCP. *[Subsequent to this report, the drug ivermectin has been proven effective against the microfilaria of onchocerciasis. Planning must consider the proper roles of vector control and ivermectin distribution.]*

4. ***Prescott, N., A. Prost and R. Le Berre. 1984. The economics of blindness prevention in Upper Volta under the Onchocerciasis Control Program. Soc. Sci. Med. 19:1051-1055.***

This paper examines the cost-effectiveness of the Onchocerciasis Control Programme (OCP) in Upper Volta (Burkina Faso). It differs from previous economic analyses of onchocerciasis control in three important respects. *(1)* It uses empirical data as the basis of an estimate of the epidemiological effectiveness of the intervention. *(2)* It focuses on the prevention of permanent disability and premature death due to onchocercal blindness as the major health improvement attributable to OCP. *(3)* It emphasizes cost-effectiveness rather than cost-benefit analysis. *[This report presents the same results as Prost and Prescott (1984).]*

5. ***Prost, A. and N. Prescott. 1984. Cost-effectiveness of blindness prevention by the Onchocerciasis Control Programme in Upper Volta. Bull. WHO 62:795-802.***

This report presents a cost-effectiveness analysis of the Onchocerciasis Control Programme (OCP) in Upper Volta (Burkina Faso). The analysis considers the number of healthy years of life added by the prevention of permanent disability and premature death attributable to onchocercal blindness. The quantitative results are $20 per productive year of healthy life and $150 per discounted productive year of healthy life. Using this calculation, onchocerciasis control is more cost-effective than measles control which costs $17 per productive year of healthy life and costs $221 per discounted productive year of healthy life. *[See Evans and Murray (1987) for critique of these estimates.]*

6. ***Warren, K., D. Bundy, R. Anderson, A.R. Davis, D.A. Henderson, D.T. Jamison, N. Prescott and A. Senft. 1992. Helminth infections. In: Health Sector Priorities Review, edited by Jamison, D.T. and W.H. Mosley. World Bank, Oxford University Press, New York.(In Prep)***

This chapter reviews the public health significance and approaches to control for helminthic infections. Special attention is paid to chemoprophylaxis as a primary strategy. Important drugs are the benzimidazoles, praziquantel and ivermectin. Programs need to consider distribution of two or three anthelminthic agents.

DRACUNCULIASIS (GUINEA WORM)

1. ***Belcher, D.W., F.K. Wurapa, W.B. Ward and I.M. Lourie. 1975. Guinea worm in southern Ghana: Its epidemiology and impact on agricultural productivity. Am. J. Trop. Med. Hyg. 24:243-249.***

This study was conducted in a 200-square mile area as a part of the Danfa Comprehensive Rural Health and Family Planning Project. A total of eight villages in this area with high attack

rates of guinea worm disease in 1973 were identified for intensive study. In six villages, one third of all adults were interviewed regarding traditional treatments, beliefs, and attitudes about the disease. The 1973 project census had a question about guinea worm disease in the previous 12 months. A drug trial was conducted and chemical treatment of water sources was administered to kill the cyclops, the intermediate host. The incidence of guinea worm infection was related to the type of water source and a seasonal pattern was identified. In-depth interviews were conducted in 20 households in which the male head had been incapacitated by guinea worm disease during the year.

2. ***Brieger, W.R. and J. Guyer. 1990. Farmers' loss due to guinea worm disease: A pilot study. J. Trop. Med. Hyg. 93:106-111.***

Previous efforts to demonstrate loss of productivity among farmers due to disability from guinea worm disease have neglected to associate the patterns of farming and the timing of agricultural activities to disability. Twenty in-depth interviews were conducted which indicated that the losses to full-time farmers were related to the time of year people were affected by guinea worm. Information was collected in the interviews regarding time and duration of illness, the crops usually planted and the crops that the farmers could not plant due to guinea worm disease. Acres not planted were converted to their potential yield and then multiplied by the current market value of the specific crop. This was the means of determining economic loss to farmers. Twenty farmers were selected as case studies because they had suffered from guinea worm between October 1987 and May 1988. The average duration of disability from guinea worm was 1 to 7 months, with an average of 3.9 months. Most farmers (17 out of 20) were bedridden for a period of time. Losses were experienced in all crops due to inability to plant. Only 4 farmers reported no losses. When crops are considered individually, the seasonality of infection becomes important in determining if the farmer experiences losses in a particular crop.

This study gives reason to suspect "days lost" surveys. The timing of illness may not coincide with planting of a particular crop and duration of illness may be short enough to allow for compensation for the days lost. It is important also to recognize that peasant farmers usually plant multiple crops and therefore one episode of guinea worm will not result in a total loss for the year. Some crops, such as cassava, can be harvested all year long and provide an insurance policy against disasters. Surveys should account for seasonal patterns of planting as well as variability in the onset and duration of illness episodes. It is necessary to inquire about each crop planted to calculate losses. The cost of an intervention program using 2,000 nylon water filters and 67 cement ring wells was estimated to be $26,100 for Idere town. This cost amounts to 29% of the value of farm losses estimated for Idere during the 1987-88 season.

3. ***Edungbola, L.D. and S.J. Watts. 1990. The elimination of dracunculiasis in Igbon, Oyo State, Nigeria: The success of self-help activities. J. Trop. Med. Hyg. 93:1-6.***

This study is the result of self-help efforts by a village community in collaboration with health researchers to eliminate guinea worm disease. Indigenes who have left their village to work in the cities often return to their home villages and assist in community self-help projects -- usually the construction of schools, churches and mosques. The well construction that provided safe drinking water and eliminated guinea worm in Igbon village in Oyo State Nigeria is the first reported example of these efforts directed toward disease control.

The village of Igbon had a point prevalence rate of 59% at the height of disease transmission and the villagers associated guinea worm with several community problems: three classes of the primary school had been combined into one class due to illness; the teachers lived in another village with piped water; although Igbon was located along a main road (Ilorin to

Ibadan road) there was no market in the village; and outsiders avoided the village because of the disease. Community discussions resulted in agreement on the priority of strategies for guinea worm control. Protection of existing water sources was essential and the community appointed watchers who were stationed at the ponds to prevent people from wading into the water and to assist those with guinea worm in drawing water. Concrete platforms were constructed and a plastic bowl was provided to draw water. Drug treatment and educational programs were requested by villagers and a single treatment of the contaminated ponds was applied, which would interrrupt the disease transmission cycle for 3-4 weeks. Permanently protected water sources were needed and villagers planned to dig wells to serve various quarters of the village. Money contributions by each villager were used to hire laborers to dig the wells; later, some individuals dug private wells but they let neighbors use the safe water. By the second year of the work, no villager was without access to the permanently protected water.

Interviews with household heads 5 years later indicated that all residents recognized benefits of eliminating guinea worm disease, specifically in their improved ability to work and the physical expansion of the village. Physical changes in the village following guinea worm control included building a secondary school, a church, a market, a town hall and businesses such as a poultry farm and a maize project. Formerly contaminated water was used to irrigate cash crops, increasing women's income. A new periodic market was established and the area was no longer shunned. Primary school enrollment tripled and the teachers established residence in the community. Students came to Igbon as boarders to attend secondary school. The presence of teachers in communities has been shown to boost community involvement in education and other projects.

4. ***Huttly, S.R.A., D. Blum, B.R. Kirkwood, R.N. Emeh, N. Okeke, M. Ajala, G.S. Smith, D.C. Carson, O. Dosunmu-Ogunbi and R.G. Feachem. 1990. The Imo State (Nigeria) drinking water supply and sanitation project II. Impact on dracunculiasis, diarrhoea, and nutritional status. Trans. R. Soc. Trop. Med. Hyg. 84:316-321.***

Morbidity due to dracunculiasis (guinea worm disease), diarrhoea in persons of all ages and nutritional status of young children were used as health impact indicators in the evaluation of the Imo State Drinking Water Supply and Sanitation Project in southeastern Nigeria. Five farming villages in the most northeastern part of Imo State were studied. Between March 1984 and October 1984, three intervention villages were supplied with boreholes. Questions on the prevalence of dracunculiasis and diarrhoea were included in twice-yearly water, sanitation and hygiene surveys conducted over the period February 1983 to May 1986. About 935 wife/child household units in the intervention area and 470 in the control area were interviewed. In addition, a detailed study of dracunculiasis disability was conducted in a sample of household units included in the longitudinal diarrhoea morbidity survey between February 1984 and May 1986. *[see Smith et al (1989) for the disability study]*. The study area was found to have a low level of endemicity of dracunculiasis. While no impact could be demonstrated on overall period or point prevalence rates in the cross-sectional surveys, a prospective longitudinal survey showed a significant reduction in the percentage of two-week periods positive for dracunculiasis in areas served by the project, while the areas without intervention showed no such change. In the cross-sectional surveys, it was found that, in the project villages, those persons drinking only borehole water had significantly lower period prevalence rates one year later. Moreover, those living further from the nearest borehole had higher rates of dracunculiasis. A greater association with water availability than water quality was suggested for rates of diarrhoea in young children.

5. ***Smith, G.S., D. Blum, S.R.A. Huttly, N. Okeke, B.R. Kirkwood and R.G. Feachem 1989. Disability from dracunculiasis: Effect on mobility. Ann. trop. Med. Parasit. 83:151-158.***

This report is based on data collected in a longitudinal survey of households conducted over two years as part of the Drinking Water Supply and Sanitation Project in Imo State, Nigeria *[see Huttly et al, 1990]*. A sample of 100 households in year 1 and 195 households in year 2 was visited every two weeks. One goal of this study was to document prospectively the duration and extent of disability from dracunculiasis. At each visit, mothers were asked if anyone in the household had dracunculiasis, and cases that had been identified in the previous visits were located and observed for physical and functional disability. A 5-point scale was used to score disability with 0 being no dracunculiasis and 5 being confined to bed. Most (59 of 67) cases had complete information on the duration of disability; only 8 were excluded due to incomplete data. Since many people had repeated infections, either in both of the study years or in the same season, there were more episodes than cases (67 episodes for 59 cases). Of the 67 episodes, 40% occurred in persons 15-49 years of age, 40% in children 5-14 years of age and 20% in the remaining age groups. The mean duration of symptoms was 12.7 weeks with a range of 3-29 weeks. Although 27% of the observation periods resulted in no disability (score 1), 18% were severe enough to prevent a person from leaving his or her house. Of 67 episodes, 58% resulted in severe disability with a mean duration of 4.2 weeks; among these, the mean duration was higher for persons over age 50 (8.0 weeks) than for those under age 50 (3.8 weeks). Disability was most severe in the fifth two-week period of illness with a mean disability score of 2.9. Two periods of peak disease occurrence were identified, and these corresponded to the dry season in each of the study years. The dry season is also a period of high agricultural activity when the staple crops, yam and rice, are harvested and gardens are prepared for the next planting season.

6. ***Watts, S.J. 1987. Population mobility and disease transmission: The example of guinea worm. Soc. Sci. Med. 25:1073-1081.***

Guinea worm is a parasitic disease affecting 5-15 million people every year in areas of Africa, India and Pakistan which do not have protected, year-round drinking water supplies. Guinea worm can only be transmitted to others at unprotected drinking water sites which contain suitable species of cyclops, the intermediate host. A typology of population mobility which distinguishes between rural and urban sectors, and between circulation and uni-directional permanent migration is used. Most population movements involving transmission of guinea worm occur within the rural sector. Control strategies should focus on periodic market centers which may be sources of infection within the rural areas or have a water supply that is susceptible to contamination. A knowledge of population mobility can provide information on target groups for control and health education strategies.

7. ***Watts, S.J., W.R. Brieger and M. Yacoob. 1989. Guinea worm: An in-depth study of what happens to mothers, families, and communities. Soc. Sci. Med. 29:1043-1049.***

This paper reports on the impact of maternal morbidity due to guinea worm on the care and health of children under 24 months old, and the ways in which the mothers and their families cope with the often extended periods of disability. Of 42 mothers with guinea worm in two hyperendemic areas of Oyo and Kwara States in Nigeria, 28 were either bedridden or only able to hobble short distances with the help of a stick; the average period of incapacity was almost 9 weeks. Of the 4 maternal roles identified (child care, self care, domestic tasks, income generation), the women gave priority to child care; 34 of the 42 mothers needed help in child care. Coping networks operated principally within the extended family, but also included women from other

households and other communities. The earnings losses for sick women can be understood in terms of loss of current income, income spent on treatment of the illness and cooked food and loss of capital needed for economic recovery. Twelve women in Idere were able to estimate an average loss of income of 293 naira ($75) during their current illness episode; yet handpumps, hand-dug wells and catchment jars cost as little as $14 per capita.

SCHISTOSOMIASIS

1. ***Audibert, M. 1986. Agricultural non-wage production and health status: A case study in a tropical environment. J. Dev. Ec. 24:275-291.***

This study attempts to assess the effect of health status on the productivity of agricultural, non-wage workers. The author suggests that studies of productivity of self-employed peasants are important for two reasons: *(1)* increases in agricultural production in developing countries will rely on the output of small peasants for some time to come; and *(2)* study of the relationship between health status and labor productivity could be biased if based only on the experience of wage-earners. The situation examined is rice-growing introduced into Mayo Danai, Northern Cameroons with a hydro-agricultural plant funded by the World Bank. Data are collected from surveys of rice-growers and from records of the public company responsible for managing the project. The formulation of the model of analysis considers interrelations between determinants of the level of rice production and specific conditions of measurement of the variables. The output of each rice-grower depends on the level of technology (determined by the public company responsible for management) and on these inputs: cultivated surface, fertility of cultivated soil, amount of labor devoted to rice-growing and the quality of labor. The differences between the rainy season and the dry season are also important in determining output. Only a single production function is estimated, but possible competition with production of millet is investigated. Findings of this study include: *(1)* rice output increases at the same rate as the cultivated surface and the fertility of the soil when all other factors are controlled for; *(2)* rice output is negatively related to the duration of transplanting (the shorter duration of transplanting insures that all plants are at about the same level of maturity which is very important during the irrigation of paddy); *(3)* progressive training (experience) in rice-growing is significantly related to level of output; and *(4)* the marginal effect of parasitic endemic disease is not negligible--a 10% increase in the prevalence of schistosomiasis (S. haematobium) results in a 4.9% decrease in output. However, neither prevalence of malaria (P. falciparum) nor millet production is significantly related to rice production.

2. ***Barbosa, F.S. and D.P. Pereira da Costa. 1981. Incapacitating effects of Schistosomiasis mansoni on the productivity of sugar-cane cutters in northeastern Brazil. Am. J. Epi. 114:102-111.***

Studies were carried out on two sugar estates in the humid coastal forest region of northeastern Brazil, a highly endemic area of Schistosoma mansoni. A retrospective study was conducted using the estate records of Tiuma from harvests 1966-1967 and 1967-1968. A prospective study was conducted on Catende sugar estate for the harvest of 1977-1978. The results obtained in the retrospective study were not conclusive, but clear-cut results emerged from the prospective study. On Catende sugar estate, the severe hepatosplenic clinical form of schistosomiasis is seen in 4% of field workers. A group of hepatosplenic workers was compared with a group of men with the (milder) intestinal form of the disease. Reduction of productivity

among the hepatosplenic workers compared to the other group was 35.1%. The loss to the Catende sugar estate from reduced productivity caused by S. mansoni was calculated as 0.93% of the harvest of 1978, approximately $135,000. When this figure was extrapolated to the State of Pernambuco, the losses totaled almost $2,300,000.

3. ***Collins, K.J., R.J. Brotherhood, C.T.M. Davies, C. Doré, A.J. Hackett, F.J. Imms, J. Musgrove, J.S. Weiner, M.A. Amin, M. El Karim, H.M. Ismail, A.H.S. Omer, and M.Y. Sukkar. 1976. Physiological performance and work capacity of Sudanese cane cutters with Schistosoma mansoni infection. Am. J. Trop. Med. Hyg. 25:410-421.***

This study examined the physiological effects of S. mansoni infection on 194 Sudanese cane cutters. Six categories were defined based on age and diagnosis of schistosomiasis: *(A)* uninfected,16-24 years of age; *(B)* intestinal infection, ova in stool,16-24 years of age; *(C)* intestinal infection, ova in stool and clinical signs, 16-24 years of age; *(D)* uninfected, 25-45 years of age; *(E)* intestinal infection, ova in stool, 25-45 years of age; and *(F)* intestinal infection, ova in stool and clinical signs, 25-45 years of age. Physiological response to exercise was assessed by a stationary bicycle ergometer; thermoregulatory function was measured as sweat rates and acclimatization to heat in a controlled environment. Field studies of work capacity were conducted and productivity was assessed for habitual activity and for maximum efficiency (using a monetary bonus system as an inducement). Sociological factors suggested to be important to productivity were number of seasons experience (habitual skill) and the number of dependents (motivation). The authors found no statistically significant differences between infected and uninfected workers based on anthropometric measures, physiological response to work (bicycle ergometer), or heat stress. The uninfected men of both age groups had higher hemoglobin levels than infected men. The mean productivity was correlated with individuals' maximum aerobic capacity determined in the laboratory, but was not correlated with the degree of S. mansoni infection. The mean productivity varied by infection status as follows: (A+D) were the lowest producers, (B+E) the highest, and (C+F) intermediate. The number of seasons cutting experience was correlated with age, degree of infection, and mean productivity. These results are consistent with other research in that they show no clear evidence of any deleterious effect of schistosomiasis on productivity or physiological function. The authors explain the low productivity of the uninfected group by lack of experience -- many of them were in their first season of cane cutting. The authors also suggest that productivity in cane cutting requires the ability to sustain a high level of physiological performance over an extended period of time rather than achieve a maximal output.

4. ***Fenwick, A. 1972. The costs and a cost-benefit analysis of an S. mansoni control programme on an irrigated sugar estate in northern Tanzania. Bull. WHO 47:573-578.***

This article summarizes the costs of a long-term control program against schistosomiasis on an irrigated sugar estate--the costs of the current (1968-1970) program are calculated and the costs of future snail control in the same area estimated. An attempt is made to evaluate the cost-benefit ratio of schistosomiasis control in the irrigated sugar estate. In a 1963 study *[see Foster, 1967]*, the prevalence of infection was over 85% among workers who had been on the estate for at least 6 months. The control program, which began in 1968, decreased the overall prevalence of infection by 50% and the intensity of infection (measured as total egg output) by about 85%. The costs attributed to the current program are due to the following: *(1)* snail control requiring molluscicides, labor costs, transport costs, and capital equipment costs; and *(2)* mass diagnosis and treatment requiring labor, laboratory equipment, transport and drugs. Future expenditures that would be required to maintain control of S. mansoni infection consist of snail control and screening of new employees with immediate treatment of "imported" cases. It is

estimated that the net cost of the 3-year control program was about $24,000. The total amount spent on the 3-year control program was $60,581, but the cost of treatments for the estimated number of cases prevented (about 4,050 cases) was $35,875. The benefits from continuing the S. mansoni control program include: general improvement in health; reduction in the number of required courses of drug treatment; and improvement in worker productivity of about 2.5-5.0%. The author proposes that the annual cost of future snail control will be covered simply by the annual savings in drug treatments required--the increased productivity will be an added benefit. "Any savings derived from increases in productivity would be an extra advantage, as would be the goodwill involved in keeping the estate residents free from infection with presumably healthier wives and children (p.578)."

5. ***Fenwick, A. and B.H. Figenschou. 1972. The effect of Schistosoma mansoni infection on the productivity of cane cutters on a sugar estate in Tanzania. Bull. WHO 47:567-572.***

This study attempts to quantify the effects of infection with S. mansoni on worker productivity. Foster (1967) had studied these effects on workers on the same plantation but had been unable to demonstrate differences in physiological work performance during work shifts between infected and uninfected workers. He did note higher rates of absenteeism for infected workers, as well as more hospital days. By the time of the present study, the labor force had become more stable on the estate and a snail control program had considerably reduced the transmission rates of the disease. In classifying men into the infected and uninfected categories, it was assumed that there were no self- cures and that there were no new infections during the 2 years. The study was conducted during 1968-1969. Uninfected men earned at least 11.0% more in bonuses in all but one 6-month period; these differences were significant at the 95% confidence level. Infected men who were treated for disease improved their earnings of bonuses by about 5.0-6.0%. Before treatment, infected men earned about 12.2% less than uninfected men; after treatment, they earned only 6.5-7.0% less. Because of the complicated scales for the bonuses, and the fact that different men worked different fields (different fields have different yields depending on how straight the cane grows), a separate productivity study was conducted. The purpose of the second study was to relate the bonus earned to the actual quantities of cane cut. The overall difference in productivity between infected and uninfected workers (measured as quantity of cane cut) was estimated to be about 3-5%.

6. ***Foster, R. 1967. Schistosomiasis on an irrigated estate in East Africa. III. Effects of asymptomatic infection on health and industrial efficiency. J. Trop. Med. Hyg. 70:185-195.***

This study investigates the economic burden of chronic schistosomiasis on a sugar cane plantation in 1962-1963. Approximately 200 workers, some cane cutters and some irrigators, were classified as infected or uninfected based on diagnosis of S. mansoni ova in the stool. No significant differences between infected and uninfected workers were observed based on weight, physique (weight adjusted to standard height), or hemoglobin levels. Significant differences were found in illness history. Among irrigators, infected workers were more likely to report sick; the annual cost of an additional 819 attendances was 5,163 shillings. Infected workers used more hospital days, even when admissions for schistosomiasis treatment were excluded; the annual cost of an additional 1,677 hospital days was 18,447 shillings. An additional annual cost of 73,715 shillings covered schistosomiasis treatments. Industrial efficiency was measured as attendance at work and, for the cane cutters, as output on the job (weight of cane cut per shift). The proportion of shifts lost for no apparent cause (absenteeism) was higher among infected workers than uninfected, and the difference was higher among irrigators than cane cutters. The rate of worker absenteeism rose from July to December coincident with an increasing prevalence of disease. The

annual cost to the estate was estimated to be 21,600 shillings, equivalent to 9 irrigators' salaries. Mean output per shift was the same for infected and uninfected cane cutters. The total yearly cost of the disease was 118,925 shillings or £5,946. With a control program of molluscicides and treatment of new labor, the yearly cost was estimated to be 70,656 shillings or £3,533 -- a savings of £2,413 for the estate. This cost-benefit analysis represents the minimum savings, as another class of workers, cultivators, were not studied; however, the effects of schistosomiasis observed in the irrigators would likely be found in the cultivators.

7. ***Hunter, J.M., L. Rey and D. Scott. 1982. Man-made lakes and man-made diseases: Towards a policy resolution. Soc. Sci. Med. 16:1127-1145.***

The risk of spread of parasitic infections associated with the development of water resources has been stressed many times. The conditions most frequently listed as being apt to spread in tropical zones are schistosomiasis, malaria, bacterial and helminthic intestinal infections and arbovirus infections. The pressure of population increase in the developing world demands an expansion of agricultural production that is achieved through intensification of water impoundment and irrigation. The typical sectoral dichotomy in which a department of agriculture creates a disease outbreak through its development activity, leaving its counterpart department of public health to cope on a curative basis, is strongly deplored. Disease prevention measures should be integrated with development projects from the beginning; infrastructural investment and operational costs for health maintenance should be incorporated into the total cost-benefit analysis. A communications network is proposed to create an international register of water development projects.

8. ***Prescott, N.M. 1979. Schistosomiasis and development. World Development 7:1-14.***

This paper evaluates evidence relating to the belief, long held by tropical health workers, that schistosomiasis control would contribute significantly to economic development. Macro estimates of the benefit of control have assumed that schistosomiasis impairs labor productivity in all infected cases and that its elimination would yield substantial productivity gains. These benefits have been generalized to the entire infected population without regard to its composition by age, sex and productive activity and implicitly have been assumed to accrue as a result of complete, instantaneous and costless eradication. Micro research on the effects of schistosomiasis on worker productivity has observed a small effect in some instances, but other determinants of productivity may not have been properly controlled. However, micro research on active workers most likely underestimates the impact of schistosomiasis because those with severe, debilitating illness are automatically excluded.

9. ***Warren, K., F. Bundy, R. Anderson, A.R. Davis, J.A. Henderson, D.T. Jamison, N. Prescott and A. Senft. 1992. Helminth infections. In: Health Sector Priorities Review, edited by Jamison, D.T. and W.H. Mosley. World Bank, Oxford University Press, New York. (In Prep)***

This chapter reviews the public health significance and approaches to control for helminthic infections. Special attention is paid to chemoprophylaxis as a primary strategy. Important drugs are the benzimidazoles, praziquantel and ivermectin. Programs need to consider distribution of two or three anthelminthic agents.

10. ***Wright, W.H. 1972. A consideration of the economic impact of schistosomiasis. Bull. WHO 47:559-566.***

This study attempts to estimate the economic cost of schistosomiasis to the world, although the paucity of data precludes an accurate estimate. Moreover, the prevalence rates of schistosomiasis are exceedingly variable, even in the same locality; infections are highly focal in seemingly homogenous populations. Gross inadequacy of reporting for morbidity and mortality is evident in the available data (WHO information, public health reports from individual countries and a 1957 NAS tropical disease survey) -- less than 600 deaths per year are estimated for the whole world. In 1966, only 3,127 cases of schistosomiasis were reported to the Pan American Health Organization; more cases were reported for New York City than for all of Brazil.

The economic consequences of disease are divided into three categories: *(1)* resource use, or the costs of the nation's resources (both manpower and materials) for providing health services, and the materials used by those services; *(2)* resource transfer, the costs represented by the transfer of income from the healthy to the sick in public and private efforts to mitigate the burden of illness; and *(3)* resource loss, or the costs reflected in the reduced national production of all goods and services. This study is restricted to resource loss. Severe cases are assumed to be completely disabled and such patients are considered to contribute nothing to the GNP. Moderately severe cases are considered to have a reduced productive capacity of 10%. The economic loss from decreased productive capacity is expressed as GNP per capita in US dollars based on the 1967 World Bank Atlas. Separate estimates for the totally disabled and the partially disabled are calculated. The estimated annual losses in 1972 are $446 million in Africa, $755 thousand in Mauritius, $17 million in southwest Asia, $118 million in southeast Asia and $60 million in the Americas. The total annual loss is estimated to be $642 million.

ECONOMIC DEVELOPMENT AND METHODOLOGY

1. ***Barlow, R. and L.M. Grobar. 1986. Cost and Benefits of Controlling Parasitic Diseases. Population, Health and Nutrition Department, World Bank, Washington, DC.***

This paper is a review of the literature on the costs and benefits of control programs designed to combat major parasitic diseases. Over 100 studies containing information on costs, health and/or economic effects of disease control are reviewed. Four principal definitions of cost-effectiveness are used in the literature: cost per person protected, per death averted, per case-year prevented and per healthy year gained. The cost per case-year prevented and per healthy year gained are most useful when discussing parasitic diseases. The main findings are: *(1)* substantial gaps exist in our knowledge about cost- effectiveness and benefit-cost ratios of parasitic disease control projects; *(2)* there are large differences in cost-effectiveness between alternative techniques of control; and *(3)* a given technique is subject to wide variations in cost-effectiveness. The authors recommend that when undertaking a new project of control, health authorities need to know whether they can expect a performance at the high or low end of the broad range covered by experience elsewhere. Understanding the sources of variation (e.g., differences in the rate of taxation or subsidy applied to a given input) is very important.

2. ***Barnum, H. 1987. Evaluating healthy days of life gained from health projects. Soc. Sci. Med. 24:833-841.***

This paper reviews the Ghana Health Assessment Project Team's application of healthy

days of life lost for evaluating health programs *[see Nimo et al., 1981]*. Several criticisms of the Ghana study are: *(1)* the method does not account for qualitative differences among different morbidity states; *(2)* the method does not consider the interaction among diseases; and *(3)* the method has substantial data requirements. Cost-effectiveness analysis is deemed applicable only in situations in which the outcomes are similar or comparable--broader policy choices cannot be compared in similar units of outcome effects. Cross-sectoral choices require that a dimension of social welfare be included in the outcome measure for programs, not simply measures of health status. The use of unweighted healthy days of life lost is useful only in comparisons of narrowly-defined projects, such as alternative child immunization programs. The author makes a good point: "It is important to note that use of unweighted healthy days of life lost to evaluate a health program or policy having wide effects on morbidity and fatality throughout the population implies comparability across age groups and assumes indifference to adult productivity." The author reviews the findings of the Ghana project using productivity weighted healthy days of life added as the outcome measure. The ranking of diseases varies with the discount rate employed. With a 0% rate, diseases having the greatest cost in lost production are primarily childhood diseases; as the discount rate rises, adult diseases increase in importance and childhood diseases are less significant. It may be appropriate to analyze groups of diseases with similar control strategies. Barnum points out two considerations regarding data quality: *(1)* a substantial proportion of the causes of mortality must be included, in the range of 80-85%; and *(2)* the use of single average incidence and case-fatality rates and age at onset to cover the entire population distorts the results by concentrating on morbidity and mortality in childhood. Finally, the author states that economic productivity does not in itself provide an index of social welfare; health status also contributes to the welfare of a society and should be included in the social objectives of a national policy.

3. ***Creese, A. 1985. Economic aspects of tropical disease: What is better health worth? Trans. R. Soc. trop. Med. Hyg. 79:143-148.***

The value of gains in health from a reduced level of tropical diseases may be assessed in two broad fashions and these may result in quite different monetary values and quite different policy implications. Human capital methods, valuing expected output gains from reduced morbidity and mortality, will understate the total welfare gain by ignoring those changes in health status which do not result in higher future income. The use of valuations derived from demand patterns has the advantage that actual preferences for particular types of services can be observed and the relevant notion of health status involved is that of patient perceived morbidity. A conceptual framework embracing both approaches is beginning to emerge in the context of theoretical developments in household economics *[see Popkin, 1982]*. For the immediate future, an increased recognition of community preferences and demands seems likely to accompany the implementation of more accessible primary health care and offers an alternative basis for assessing whether such initiatives are judged worthwhile by the target populations.

4. ***Dunlop, D. 1984. Theoretical and empirical issues in benefit identification, measurement, and valuation related to parasitic disease control in poor countries. Soc. Sci. Med. 19 1031-1037.***

This paper reviews the theoretical and empirical rationales employed in cost-benefit and cost-effectiveness studies of programs to control or eradicate parasitic diseases. The traditional benefits specified are: *(1)* direct benefit, i.e., the reduction in medical care services used to treat a disease as a result of lower incidence or prevalence of the disease; *(2)* indirect benefit, i.e., reduction in foregone output as a result of reduction in mortality and morbidity attributed to a disease; and *(3)* public good benefit which accrues to all members of society when a particular

disease has been eradicated. Empirical studies of benefit do not usually include the third category. Methodological difficulties in measuring benefits are discussed. The larger context of developmental changes in population, housing, water supply, education, income and roads complicate the evaluation of benefits from disease control. The assignment of monetary value to healthy life lost on the basis of average wages or a marginal product has several conceptual problems: *(1)* the value of the foregone output would probably have changed if the additional labor supply had been produced; *(2)* most labor markets in developing countries are not competitive so that average wages do not reflect the opportunity cost of labor; and *(3)* benefits based on productive output do not incorporate the values others may attribute to life and improved health. Willingness-to-pay approaches should become more widely used because long run sustainability of programs depends on public support. Multidisciplinary efforts are important for future research.

5. ***Hughes, C.C. and J.M. Hunter. 1970. Disease and "development" in Africa. Soc. Sci. Med. 3:443-493.***

This paper reviews the meaning of the term "development". The authors stress the fact that development is a relative term which cannot be absolutely defined. A functional definition is offered: "a purposive action to alter sets of conditions, whether these be economic, as in attempts to improve the food supply; or in any other institutional area of human life, as in the establishment of new settlement patterns, educational systems, forms of governance, or whatever." This paper focuses on the disease consequences of development activities. Although the improvement of health is one of the implicit goals of many development programs, the prevalence of some diseases may actually increase with development. The paper contains a comprehensive review of disease in Africa and cites cases in which development projects resulted in heavy losses in human life. Diseases were introduced into areas previously unaffected. New strains of pathogens or more virulent strains were introduced into regions in which humans did not have adequate immunity to protect them from disease. Six types of activities which have resulted in these unexpected consequences are as follows: *(1)* overall changes in human habitat relationships; *(2)* increased population movements, mixing, and concentration; *(3)* changes in patterns of water flow and use; *(4)* changes in vegetation cover; *(5)* changes in micro-environmental conditions; and *(6)* changes in value systems and social sanction systems. The coordination of development activities within a comprehensive ecologic framework is necessary if social and economic conditions of life are to improve.

6. ***Hunter, J.M., L. Rey and D. Scott. 1982. Man-made lakes and man-made diseases: Towards a policy resolution. Soc. Sci. Med. 16:1127-1145.***

The risk of spread of parasitic infections associated with the development of water resources has been stressed many times. The conditions most frequently listed as being apt to spread in tropical zones are schistosomiasis, malaria, bacterial and helminthic intestinal infections and arbovirus infections. The pressure of population increase in the developing world demands an expansion of agricultural production that is achieved through intensification of water impoundment and irrigation. The typical sectoral dichotomy in which a department of agriculture creates a disease outbreak through its development activity, leaving its counterpart department of public health to cope on a curative basis, is strongly deplored. Disease prevention measures should be integrated with development projects from the beginning; infrastructural investment and operational costs for health maintenance should be incorporated into the total cost-benefit analysis. A communications network is proposed to create an international register of water development projects.

7. ***Jamison, D.T. and W.H. Mosley. 1991. Disease control priorities in developing countries: Health policy responses to epidemiological change. Am. J. Pub. Health 81:15-22.***

Health systems in developing countries are facing major challenges in the 1990s and beyond because of a growing epidemiological diversity as a consequence of rapid economic development and declining fertility. The infectious and parasitic diseases of childhood must remain a priority at the same time the chronic diseases among adults are emerging as a serious problem. Health policymakers must engage in undertaking an epidemiological and economic analysis of the major disease problems. The cost-effectiveness of alternative intervention strategies must be evaluated. It will be important but difficult to reduce investments of public funds in health care activities that are clearly not cost-effective. The most important advance in health policy formulation is a willingness to go beyond the direct provision of health services. Public health may also be affected by the judicious use of regulation, legislation, taxation and subsidies. There is a critical need for national and international investment in building up the capacity of developing countries to undertake a broad assessment of health policies.

8. ***Mooney, G. and A. Creese. 1992. Cost and cost-effectiveness analysis of health intervention. In: Health Sector Priorities Review, edited by Jamison, D.T. and W.H. Mosley. World Bank, Oxford University Press, New York. (In Prep)***

Priority setting means developing analyses and procedures to insure that those policies that get priority (i.e., get a higher call on extra resources) are those providing the greatest benefits per additional dollar spent. Measuring the burden of illness is part of the process of setting priorities. The burden of illness, however, is not a particularly useful concept if it is assessed separately from the question of how effective and how costly different forms of treatment, care or prevention are in dealing with the illnesses being considered. In order to measure the effectiveness of health interventions, addressing issues of cost and its measurement is the first step. Fo[illegible] principles of costing are: *(1)* measure the opportunity costs, which are the benefits foregone in the best alternative use of resources; *(2)* the relevant cost is the marginal cost, i.e., the cost of the change being considered; *(3)* cost should include all resource use no matter who is reponsible for payment; and (4) transfer payments (sickness benefits, pensions,etc.) are considered redistributions rather than costs. In order to determine effectiveness, health status must be measured. A major problem in establishing health indices is the issue of combining mortality and morbidity into one measure. The Ghana Health Assessment Team calculated healthy days of life lost due to either temporary disability, permanent disability, or death. However, if different rates of discounting the future are used, the ranking of diseases by impact will change *[see Barnum (1987)]*. Another problem of the Ghana study is that the value of a death prevented is based on the average years of life extended by the program; however, variability among subgroups in the population may be important. Finally, measures of healthy days of life added by a control program have been adjusted by a measure of the quality of life. Many questions are raised by the prospect of this index: *(1)* who does the valuing?; *(2)* how does one life compare to another?; and *(3)* is the only output of health services improved health status? Another problem is assigning a monetary value to health outcomes. The three major approaches are: *(1)* human capital theory, based on productive output; *(2)* willingness-to-pay, based upon individuals' willingness to pay for a specified reduction of risk; and (3) implied values, based upon what is actually paid for health.

9. ***Moore, D.G., G.G. Tappan, S.M. Howard, R.W. Lietzow, C.A. Nadeau, W. Renison, J. Olsson and R. Kite. 1991. Geographic modelling of human carrying capacity from rainfed agriculture: Senegal case study. EROS Data Center, U.S. Geological Survey Technical Report.***

USAID/Dakar needed to evaluate the agricultural potentials of Senegal by crop and by region to support their Agricultural Sector Analysis, as part of their Country Program Strategic Plan. The analysis was limited to rainfed cereal and cash crops. The development alternatives considered for increasing rainfed agricultural production were to increase the cropped area, to increase technology (and thereby crop yields), and a combination of both. The alternatives were evaluated as forecasts of agricultural production in terms of human carrying capacity and gross domestic product. A geographic information system (GIS) was used to link knowledge and databases and to provide for their institutional memory. The GIS approach provides a base for evaluating diverse sectoral and cross-sectoral issues, shaping USAID investment programs and monitoring their field impact.

10. ***Morrow, R.H., jr. 1983. A primary health care strategy for Ghana. In: Practising Health for All, edited by Morley, D., Rohde, J. and Williams, G. Oxford University Press, Oxford, pp. 272-299.***

This paper describes a process of establishing priorities for health programs based on loss of healthy days of life due to various diseases. "The three most important effects that a disease may have in a community are as causes of illness, disability, and death. With some exceptions, other social and economic effects of a disease are directly related to its severity as measured by these three factors." Data that would provide a measure of these three factors were collected from sources such as: a national census, cause of death from death certificates (available on abut 12% of the population), in-patient and out-patient statistics, special surveys, and interviews with experienced clinicians. The annual incidence of disease, disability caused by the disease, and the case fatality rate of the disease were measured and expressed in terms of the number of healthy days of life lost due to disease. Once the relative importance of diseases are established, then the cost-effectiveness of various interventions must be determined using a ratio of healthy days of life saved per monetary unit expended.

11. ***Morrow, R.H.,jr. 1984. The application of a quantitative approach to the assessment of the relative importance of vector and soil transmitted diseases in Ghana. Soc. Sci. Med. 19:1039-1049.***

The Health Planning Unit of Ghana (HPU) developed a quantitative method of assessment of the health impact of several different diseases in order to provide information for decisions regarding resource allocation to various health improvement programs. Estimates of healthy days of life lost through illness, disability, and death are used to determine the relative importance of diseases and to set health priorities. The data needed for the assessment of these effects are: *(1)* annual incidence of disease, *(2)* disability caused by the disease, and *(3)* case-fatality rate of the disease. The paper contains sample calculations of days of healthy life lost due to disease, as well as a ranking of the top 25 diseases in Ghana. The next step after determining the relative importance of diseases is to estimate the benefits of each intervention in terms of healthy days of life saved. Finally, one must determine the cost of each intervention and calculate benefit to cost ratios in healthy days of life saved per unit expenditure. *[See also Morrow (1983)]*

12. ***Morrow, R.H., jr., D.W. Dunlop, P.L. Rosenfield and A. Wouters. 1992. Cost-effectiveness analysis: An essential tool for health-related decision making in developing countries. (UnPub)***

"Essential national health research" as used by the Commission on Health Research for Development encompasses that research which every country must be able to conduct in order to make informed decisions concerning health policy, management and resource allocations. The

most important information that health sector decision-makers should have for making choices among alternative uses of health resources is that which relates resource inputs for health interventions to health status outcome resulting from those interventions. However, such information for the health sector is lacking not only in developing countries but everywhere. The research tools most needed for acquiring this information are cost-benefit and/or cost-effectiveness analyses (CEA). Only recently have such techniques been applied in developing countries, but even in the few studies carried out so far, substantial differences occur among them in terms of their purposes, scope, methods, and criteria for determining effects and costs. This paper examines methods for identifying, measuring and valuing benefits/effects as compared to costs of health investments directed toward reduction of disease in developing countries. The viewpoint taken is that the central purpose of such CEA studies is to assist decision-makers in reaching better resource-allocation decisions. A major conclusion is the urgent need to identify and conduct a consistent set of empirical studies that address the identified methodological issues in CEA and that provide real data on the outcome (effects) of health programs and their costs as they are actually carried out.

13. ***Nimo, K.P., V. Agadzi, R. Asante, R. Biritwum, C. Jones, R.H. Morrow jr., A. Neill, K. Nelson, J. Owusu, K. Saakwa-Mante, P.G. Smith and F. Wurapa. 1981. A quantitative method of assessing the health impact of different diseases in less developed countries. Int. J. Epi. 10:73-80.***

The impact of disease in a community is measured by the number of healthy days of life lost through illness, disability, and death. This measure requires estimates of the following for each disease: incidence rate; case fatality rate; average age at onset and death and expectations of life at these ages; and extent and duration of illness and disability. Multiple sources of data are used in the analysis: census data, cause of death as recorded on death certificates, inpatient and outpatient statistics, and special surveys. The above measures were estimated for about 50 causes of death deemed important in Ghana by the Ghana Health Assessment Project team. The diseases and health problems were then ranked in importance based on the healthy days of life lost. Malaria accounted for 10.2% of healthy days of life lost, the largest percentage for any single disease. Although the ranking is useful information, decisions regarding priorities should favor programs which most reduce the burden of illness, disability, and death for a given unit of cost. A program may simultaneously reduce the effects of more than one disease, and a particular disease may be affected by more than one program. This point is illustrated by a comparison of two programs to treat measles--vaccinations and outpatient care for patients with measles. Sixteen times as many days of healthy life are saved by the immunization program.

14. ***Popkin, B.M. 1982. A household framework for examining the social and economic consequences of tropical diseases. Soc. Sci. Med. 16:533-543.***

This paper attempts to show how social science methods used by economists can provide a framework for designing tropical disease impact research. Broadly defined dimensions of individual and household activity are felt to be more useful for understanding the causal pathways through which tropical disease affects behavior. The New Home Economics (NHE) framework emphasizes the value of time, the allocation of goods and time within the household, and the importance of considering nonmarket aspects of behavior in assessing household effects.

15. ***Prescott, N.M. 1979. Schistosomiasis and development. World Development 7:1-14.***

This paper evaluates evidence relating to the belief, long held by tropical health workers,

that schistosomiasis control would contribute significantly to economic development. Macro estimates of the benefit of control have assumed that schistosomiasis impairs labor productivity in all infected cases and that its elimination would yield substantial productivitly gains. These benefits have been generalized to the entire infected population without regard to its composition by age, sex and productive activity and implicitly have been assumed to accrue as a result of complete, instantaneous and costless eradication. Micro research on the effects of schistosomiasis on worker productivity has observed a small effect in some instances, but other determinants of productivity may not have been properly controlled. However, micro research on active workers most likely underestimates the impact of schistosomiasis because those with severe, disabling illness are automatically excluded.

16. ***Rosenfield, P.L., F. Golladay and R.K. Davidson. 1984. The economics of parasitic diseases: Research priorities. Soc. Sci. Med. 19:1117-1126.***

The purpose of this paper is to review the state of research on social and economic consequences of malaria, schistosomiasis, filariasis, trypanosomiasis, leishmaniasis and leprosy -- the six diseases that are the focus of the Special Programme of Research and Training in Tropical Diseases at WHO. The Special Programme confronts two major questions regarding priorities for resource allocation. *(1)* How much effort should be devoted to improving the methods available for preventing each of the six diseases? *(2)* What are the probable net gains from control activities that use either existing or emerging technologies? A conceptual framework is presented for examining the effect of disease in terms of: *(1)* the availability and productivity of home and market time; *(2)* the demand for various subsistence commodities (nutrition and health); and *(3)* demand for goods that are inputs in the production of better health (health services, improved housing, improved water supplies). Results of studies about social and economic consequences of parasitic diseases should be used to inform decision-makers and strengthen support for increased investment in the reduction of the parasitic disease burden in developing countries.

17. ***Rosenfield, P.L., C. Widstrand and A.P. Ruderman. 1981. Social and economic research in the UNDP/World Bank Special Programme for Research and Training in Tropical Diseases. Soc. Sci. Med. 15A:529-538.***

This paper describes the early planning stages of a Social and Economic Research Scientific Working Group as part of the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases. The agenda stresses evaluation of the economics of alternative existing and planned control measures (e.g., cost-effectiveness analyses); analysis of the interaction between disease transmission and economic development activities; and examination of social, cultural and behavioral aspects of disease transmission and control. Special effort is given to developing collaborative research projects among medical and social scientists from countries where tropical diseases are present.