Tropical Medicine and International Health

VOLUME 9 NO 4 PP A16–A25 SUPPL APRIL 2004

Economic evaluation of Mectizan distribution

H. R. Waters, J. A. Rehwinkel and G. Burnham

Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

Summary The distribution of ivermectin has dramatically altered the nature of onchocerciasis control. Existing economic analyses of ivermectin distribution programmes show that these programmes have a highly beneficial impact. Most analyses have estimated the economic benefits in terms of increased labour productivity as a result of reductions in blindness, and in terms of additional land-availability because of a reduced transmission of the parasite. Economic evaluations of the Onchocerciasis Control Program (OPC) in West Africa have calculated a net present value – equivalent discounted benefits minus discounted costs – of $485 million for the programme over a 39-year period, using a conservative 10% rate to discount future health and productivity gains. The net present value for the African Program for Onchocerciasis Control (APOC) is calculated at $88 million over a 21-year time period, also using a 10% discount rate. Cost-effectiveness analyses of ivermectin distribution have found a cost of $14–$30 per disability-adjusted life-year prevented – estimates comparable with other priority disease control programmes. However, the economic success of ivermectin distribution is sensitive to the fact that the drug itself has been donated free of charge. The market value of Merck's donations to the APOC for just 1 year considerably outweighs the benefits calculated for both the OPC and the APOC over the life of these projects. Pending the development of an effective macrofilaricide, the distribution of ivermectin will remain a public health priority into the foreseeable future.

keywords economic evaluation, cost-effectiveness analysis, cost-benefit analysis, Mectizan, ivermectin, onchocerciasis

Introduction

In 1987, Merck Pharmaceuticals announced the beginning of the Mectizan Donation Program (MDP). Merck's contribution includes the production cost of the drug ivermectin (Mectizan), transport costs to the port of entry for recipient countries, and related clearing costs. Many of the recipient countries waive customs fees for ivermectin. Merck directly supports the MDP, which coordinates among Merck and relevant treatment programmes – the Onchocerciasis Control Program (OCP) until its closure in 2002, the African Program for Onchocerciasis Control (APOC), the Onchocerciasis Elimination Program of the Americas (OEPA), and the bilateral onchocerciasis health programme in Yemen (Merck 2002). In Africa, the MDP was expanded in 1999 to also target lymphatic filariasis. As this article shows, detailed economic analyses have been conducted for the OCP and APOC. But there has not yet been a thorough analysis conducted of the economic impact of the OEPA.*

A committee of tropical disease experts, non-voting World Health Organization (WHO) representatives, Centers for Disease Control and Prevention representatives, and Merck scientists together form the Mectizan Expert Committee, which independently oversees the functions of the MDP (Coyne & Berk 2001). The MDP has dramatically altered the nature of onchocerciasis control. Prior to the availability of Mectizan, the principal activities to control onchocerciasis were undertaken by the OCP in the 11 West African countries where it was actively working. These activities focused on relatively expensive efforts to control the black fly vector although aerial larvaciding operations. Ivermectin introduced a new option for preventing and treating the disease, and for interrupting its transmission. As this article shows, several economic evaluations have shown that ivermectin distribution has also resulted in positive economic returns.

Distribution strategies and their costs

Even with Merck donating Mectizan and paying related international shipping costs, in-country distribution can be expensive, particularly relative to the limited ability of governments and individuals in most of the affected countries to pay these costs. Distribution strategies for

* The OEPA has supported a strategy of biannual ivermectin treatment in onchocerciasis-affected countries in the Americas. This strategy has reached at least 85% of the targeted populations in endemic communities and may result in the elimination of onchocerciasis in the region (Dadzie *et al.* 2003).

Box 1 Comparison of distribution approaches

Passive distribution – general, clinic-based distribution. Drugs are delivered to health centres and are generally offered in support of mobile teams and community-based, active treatment. This type of distribution is particularly useful in hypoendemic areas – where the microfilarial loads indicate low or no risk for onchocerciasis – and for treating unstable populations (WHO 1991). Problems include low-coverage rates (Akpala *et al.* 1993), and wastage of unused drugs whose shelf-life expires (Amazigo *et al.* 1997).

Mobile teams (landrover) – mobile teams formed the nucleus of the first attempts at large-scale distribution. In this system, paid, local health professionals are trained to organize drug distribution points in the communities. Mobile teams have achieved high coverage in Onchocerciasis Control Program (OCP) countries; coverage reached 70% in 1996 (WHO 1996).

Community-based distribution – introduced as a distribution alternative offering higher and more cost-effective coverage. Africare, the International Eye Foundation and the Nigerian Ministry of Health were the first to demonstrate the potential efficacy of active community involvement (Amazigo *et al.* 1997).

Community-directed distribution – recently initiated by African Program for Onchocerciasis Control (APOC), builds on the initial successes of the community-based programme with greater involvement of the communities themselves.

ivermectin have evolved – starting with relatively costly mobile teams, moving to community-based distribution (CBD) and community-directed systems. Ivermectin was initially distributed via mobile, or 'Land-Rover' teams (see Box 1). In 1991, WHO recommended community-based distribution as a less costly alternative.

In community-based delivery systems, ivermectin treatment is provided by members of the communities living in endemic areas. Treatment may be provided by trained volunteers, known as community-based distributors, or through various organizational structures at the community level – ranging from women's cooperatives to traditional community structures (WHO 2002). In Mali, the costs of treatment through CBD were found to be less than one-eighth of costs of treatment through national mobile teams – $0.06 compared with $0.50 per person treated (WHO 1994).

However, the aggregate annual costs of CBD are still relatively high in the countries most affected by onchocerciasis. The costs of payments to distributors, and per diems and allowances for supervisors – generally covered by non-governmental organizations (NGOs) and reaching up to the US $5.00 per subject treated – are considered too high for Ministries of Health to sustain.† Greater involvement of the endemic communities themselves in distribution activities was promoted as a result (Amazigo *et al.* 1997).

An initial multicountry study of community-based approaches to distribution showed promise for further increasing the cost-effectiveness of ivermectin distribution through community involvement (WHO 1994). APOC subsequently adopted a policy of promoting community-directed distribution for ivermectin. Under this approach, the development and implementation of community-directed delivery plans are overseen by Ministries of Health and NGOs through special projects funded by APOC. As part of this effort, mapping of hyper-, meso- and hypoendemic areas is intended to make the distribution efforts more directed and thus more efficient.

The APOC, through community-directed distribution, has substantially lowered the per-dose cost of ivermectin treatment (Carter Center 2002).‡ A recent study from the villages of Nike and Achi in Nigeria (Onwujekwe *et al.* 2002) estimated treatment costs to be $0.17 and $0.13 per dose in the two villages, respectively. These estimates include the direct financial costs, opportunity costs, advocacy, mobilizing the community, training and distribution. A baseline survey showed that 93.3 and 92.6% of the households in Achi and Nike, respectively, were willing to pay for ivermectin distribution, with the mean willingness to pay per dose equalling $0.30 in Achi and $0.28 in Nike (Onwujekwe *et al.* 1998). As the level of willingness to pay reaches the cost of programme implementation, a sustainable onchocerciasis prevention and treatment programme becomes increasingly feasible.

Results of economic evaluations

Box 2 briefly describes the main types of economic analysis used for documenting the costs of disease and the payoff to public health disease control programmes. Economic analyses of onchocerciasis and programmes to control it have used all of these techniques to quantify the relationship between the programme costs and impacts. There remains a wide variety among studies in terms of categories

† All dollar figures in this paper are the US dollars.

‡ Excluding Sudan, where costs have been higher as a result of civil conflict.

Box 2 Types of economic analysis of disease control

Calculating the costs of illness – documentation of the costs of a disease is a key step in promoting treatment efforts. Costs can include lost wages, lost time, the costs of treating the illness, and the lost earnings of persons caring for sufferers of the disease.

Cost-benefit analysis (CBA) – provides information on both the costs of the intervention and the benefits, expressed in monetary terms. Results are generally expressed as the difference between discounted benefits and costs (net present value), the economic rate of return, or the ratio of benefits to costs.

Cost-effectiveness analysis (CEA) – provides information on the cost of the intervention and its effectiveness, where effectiveness is not expressed in monetary terms but rather by a defined metric. When results are expressed in terms of Quality Adjusted Life-Years (QALYs) or Disability Adjusted Life-Years (DALYs), CEA is sometimes referred to as cost utility analysis.

of costs included and techniques used to arrive at total cost estimates. Table 1, on the following page, provides an overview of the principal economic evaluation studies for onchocerciasis control; Tables 2–4 provide additional detail by type of study.

Estimates of the economic costs of onchocerciasis

The impacts of onchocerciasis include lost economic productivity, diminished earnings, adverse effects on the supply of labour, and reduced agricultural output due to exodus from arable land. Kim (1997) studied the effects of onchocerciasis on health and labour productivity among 425 workers at the Teppi coffee plantation in southwest Ethiopia (Tables 1 and 2). Permanent workers at the coffee plantation without onchocercal skin disease (OSD) earned, on average, 29.7 Birr ($5.32 in 2001 US dollars) more per month than workers with severe OSD. This difference was statistically significant ($P < 0.05$). The amount represents 5.2% of per-capita gross domestic product (GDP) in Ethiopia.§ Workers with OSD lost an average of 1.9 days of work per month in comparison with their non-OSD counterparts.

The World Bank (1997) conducted a multicountry study of the economic impact of OSD. The four sites included two in Nigeria and one in both Sudan and Ethiopia (Tables 1 and 2). With a matched-pair prospective design comparing OSD and non-OSD persons, this study included the costs of health-related expenditures at the individual and community levels, productivity, transportation, non-cash exchanges, and time spent in seeking health care and accompanying patients. The costs of health care services subsidized by the public providers were also estimated using cost information provided by health care facilities. On average, persons suffering from OSD were found to spend an additional $8.10 over a 6-month period in comparison with their non-OSD counterparts from the same community, and to spend an additional 6.75 h seeking health care over the same 6-month period. Average per-capita annual health expenditures in Nigeria, Sudan and Ethiopia are $23, $48 and $25 respectively (World Bank 2001).

Cost-benefit analyses

Several studies have used cost-benefit analysis to calculate the net present value (NPV) of onchocerciasis control (Tables 1 and 3). NPV is the difference between the discounted present value of benefits and the discounted present value of costs. For this review, NPV is estimated as the present value of the stream of net returns (benefits minus costs) of a project during its economic life. The net present value is determined by discounting expected future net returns at a rate which reflects the cost (interest rate) of borrowing funds or the likely return on a best alternative investment available for those funds (Boardman *et al.* 1996). A positive NPV is an indicator of a successful investment.

The cost-benefit analyses included in this review all also provide an economic rate of return (ERR), otherwise known as the internal rate of return. The ERR is most often calculated as the discount rate that sets the net present value of the stream of net benefits equal to zero. If the ERR is greater than the market interest rate or the cost of borrowing money, then the programme is determined to be an economically worthy investment. An ERR of 10% is considered by the World Bank and others as a standard for successful public health programmes (Kim & Benton 1995). The ERR will generally increase when longer time horizons are evaluated – because positive programme impacts such as reducing blindness will continue to accrue after the completion of a fixed period of programme inputs.

McFarland and Murray (1994) project costs for the OCP over 10 years, estimated at $195 million. They assume that the programme serves 16.8 million persons that 500 000 cases are prevented annually, and that the subsistence

§ Ethiopia's GDP is $103 per capita (World Bank 2001). Despite earning more money, workers without onchocercal skin disease (OSD) actually worked two fewer days than workers with severe OSD.

Table 1 Overview of studies

Source	Type	Location and population	Activities costed	Years costed	Year and currency of costs	Cost incurred by
African Program for Onchocerciasis Control (APOC) countries						
Benton (1997)	Cost-benefit analysis (CBA)	19 APOC countries with a total target population of 50 million	Mectizan distribution and research alone	1996–2007	1996 constant $US dollars with a 4% deflator	Donors, beneficiary governments, non-governmental organizations (NGOs), Merck
Haddix (1997)	CBA	19 APOC countries with a target population of 50 million	Mectizan distribution, country programmes, training and research	1996–2007	1996 constant $US	APOC, Merck
Onchocerciasis Control Program (OPC) countries						
Benton and Skinner (1990)	CBA	Onchocerciasis Control Program (OCP) countries	Not stated	1990–2024 (benefits); 1990–2024 (costs)	1985 constant $US dollars	Not stated
Kim and Benton (1995)	CBA	11 OCP countries with total average population of 25.9 million over life of programme	Programme expenditures, solely vector control until introduction of Mectizan Donation Program (MDP)	1974–1993 actual 1994–2000 projected	1987 constant $US with annual 2.5% deflator	22 donors, Merck
McFarland and Murray (1994)	CBA	16.8 million treated with ivermectin in the OCP	Entire programme	10 years	US$	OCP
Prost and Prescott (1984)	CEA	7 West African countries	Programme expenditures, solely vector control until introduction of Mectizan Donation Program (MDP)	1975–1994	Actual US$ as of 1981	OCP
Other countries						
Kim (1997)	Costs only	425 Workers in Teppi Coffee plantation in SW Ethiopia	Not stated	1996	Birr (1996 1US$ = 6.33 birr)	Not stated
World Bank (1997)	Costs only	Enugu, Ibadan Nigeria, one site in each Ethiopia and Sudan (406 cases and 409 controls evaluated)	Not stated	1997	US$	Not stated

income level is $150 (1985 dollars) – resulting in economic benefits of $75 million annually. Additionally, land-related benefits for the OCP are estimated at $205 million over a 50 year project life horizon (1974–2023) with a 5% discount rate, resulting in a net present value of $85 million over a 10 year project time period.

Land-related benefits include positive effects on the supply of labour as fewer workers are affected by onchocerciasis, and increased agricultural output as unusable arable land is reclaimed.

Kim and Benton's (1995) cost-benefit analysis of the OCP is the most extensive economic analysis carried out since the initiation of the programme. This study takes into consideration the sum of expenditures incurred from 1974 to 1993 and projected expenditures from 1994 to 2002. The costs include all donor and government programme

Table 2 Results of studies documenting the costs of onchocerciasis

Source	Years	Year and currency of costs	Types of costs	Results
Kim (1997)	1996	Birr (1996 $US1 = 6.3 Birr)	Reduced earnings and lost work days for permanent workers	Loss of 1.9 work days and 29.7 birr per month in wages
World Bank (1997)	1997	1997 $US	Health expenditures and lost time	Average increase of US$8.10 in treatment costs and 6.75 h of time over a 6-month period

costs – including those for the vector control programmes that preceded Mectizan distribution – but not Merck's costs in producing and distributing Mectizan. The total costs for 1974–2002 are $571 in 1987 constant dollars. For sensitivity analysis, Kim and Benton (1995) use several different discount rates, labour force participation percentages, and agricultural land use rates.

The following values taken from Kim and Benton's (1995) analysis use a discount rate of 3%, with labour force participation at 85% of eligible workers in rural areas and an agricultural land use rate of 85% of potential land. A comparison of programme costs with just the labour-related benefits – not counting benefits from increased land use – results in an NPV of $192 million (1987 US dollars) over the 39-year horizon with a corresponding ERR of 6% for the OCP programme. A shorter horizon of 29 years results in an NPV of $37 million and a corresponding ERR of 2% for the OCP, also including only increased labour productivity among the benefits. The net present value of increased agricultural land use is estimated at $3.2 billion over the 39 year horizon, resulting in a programme ERR of 18%.

Kim and Benton (1995) estimate the total net present value of the OCP – including both land and labour benefits – to be $3.7 billion over a 39 year programme life and using a 3% discount rate – or $485 million using a 10% discount rate. Both estimates result in a programme ERR of 18%. A shorter project horizon of 29 years results in an ERR of 16%.

The 1997 economic impact analysis of the APOC, also led by Benton (1997), estimated the APOC Programme's costs over the time period 1996–2007 to be $161 million in nominal dollars and $131.2 million in 1996 constant dollars, using an annual deflator of 4%. These figures include all costs incurred by the donors, the beneficiary governments, and NGOs, but exclude the costs incurred by Merck. The APOC, active in 19 countries, focuses on ivermectin distribution and does not include vector control – in contrast to the OCP. Benton's (1997) analysis calculated the value of preventing blindness as an increase of 20 productive healthy life-years discounted at 3%. He used a disability weight of 1.0 for blindness – in other words assuming that blindness completely prevents productivity. He found an NPV of $15.5 million and ERR of 6% at a 10% discount rate for the 1996–2009 project horizon, while for the 1996–2017 project horizon the NPV was $53.7 million and the ERR was 17%.

Haddix (1997) also evaluated of the APOC programme – using the same cost values as Benton (1997), and also excluding the costs of Merck. One difference between the two studies is that Haddix (1997) includes the benefits of both land and labour instead of solely focusing on labour. Haddix (1997) estimated the long-term NPV using a 3% societal discount rate to be $307 million, for an ERR of 24%, and a corresponding NPV of $87.6 million with a 10% discount rate. Haddix (1997) also calculated that the NPV was $9 million when using a 3% discount rate and limiting the time period under consideration to the investment period.

Cost-effectiveness analyses

There are very few analyses evaluating the cost-effectiveness of onchocerciasis control. McFarland and Murray (1994) calculated that on an annual basis in Africa onchocerciasis accounts for 640 000 Disability-Adjusted Life-Years (DALYs) – healthy life-years lost due to disability and mortality. This represents 0.22% of the total disease burden for the region. They estimate that a programme to effectively address onchocerciasis on the continent would cost $19.5 million annually, which would result in a cost per DALY of $30.47 if all onchocerciasis-related DALYs were eliminated (Tables 1 and 4).¶

¶ In the calculation of DALYs, life-years lost because of disability are computed by adjusting age-specific life expectancy for loss of healthy life due to disability. The value of a year of life at each age is weighted, as are decrements to health from disability from specific diseases and injuries and future life-years are discounted.

Table 3 Cost-benefit results

Source	Time period and programme	Year and currency of costs and benefits	Total costs	Value of health gains	Value of land	Benefits minus costs (net present value, NPV)	Economic rate of return (ERR)
Benton (1997)	1996–2017 (African Program for Onchocerciasis Control, APOC)	Constant 1996 $US with annual deflator of 4%	$131.2 million	Preventing one case of blindness results in an increase of 20 productive healthy years		For 1996–2017 at 10% discount rate: $53.7 million	For 1996–2017, ERR is 17%
Benton and Skinner (1990)	1974–2004 (costs); 1974–2023 (benefits) (Onchocerciasis Control Program, OCP)	Constant 1985 $US	$571 million	Blindness results in complete loss of producti-vity – valued at subsistence wage	From $57 million (10% discount rate) to $205 million (5% rate)	From $8 million (10% discount rate) to $312 million (5% rate)	With land benefits, minimum of 11–13%
Haddix (1997)	1996–2007 (APOC)	1996 constant $US	$108.5 million	Total number of additional years of labour available	Measured as the increase in agricultural output made available by increased productive labour	For the 1996–2017 horizon at 3% discount rate: $307.4 million and at 10% discount rate, $87.6 million	For 1996–2007 (6%) For 1996–2017 (24%)
Kim and Benton (1995)	1974–2002 (Onchocerciasis Control Program, OPC)	1987 US$ with annual deflator of 2.5%	$571 million	Figured as an increase of 20 productive healthy years discounted at 3%	25 million hectares new land – at 85% agricultural output and at 3% discount rate value is $380 million	For 39 year horizon at discount of 3%: $3729 million For 39 year horizon at discount of 10%, $485 million	For 39 year horizon with discount rate of 3 and 85% land use and labour force participation rates – ERR of 6% for labour and 18% for land
McFarland and Murray (1994)	10 years (OPC)	1994 US$	$195 million	$75 million annually for an estimated 50 000 averted cases	$205 million for 50 year project length	$85 million at discount of 5%	Not given

Prost and Prescott (1984) calculated that the activities of the OCP in seven West African countries could add 1.1 million healthy life-years added over 20 years, at a cost of $20 per healthy life-year added. They assumed that one case of blindness resulted in 23 healthy life-years lost. Benton (1997) calculated that the APOC's activities would result in 10 million discounted healthy life-years being added in the time horizon of 1996–2017, equal to a programme cost of $13.52 per DALY prevented (1996 US dollars). By way of comparison, cost-effectiveness studies of other priority disease control interventions have found similarly wide ranges of estimates – from $12 to $30 for immunization programmes; $1–$25 for micronutrient fortification; $25–$75 for distribution of oral rehydration salts; and $20–$50 for treatment of acute respiratory infections.

Table 4 Cost-effectiveness results

Source	Years and programme	Year and currency of costs	Total costs	Value of health gains	Value of land	Cost-effectiveness ratio
Benton (1997)	1996–2017 (African Program for Onchocerciasis Control, APOC)	1996 $US	$53.7 million	10 million discounted health life-years added		$13.52 per healthy life-year added
McFarland and Murray (1994)	1994 (Onchocerciasis Control Program, OPC)	$US	$195.5 million (not discounted)	Increased labour force with assumed $150 annual wages and 500 000 cases averted is $75 million, 640 000 DALYS lost annually	Increased land availability over 50 year horizon is $205 million at 5% discount	$30.47 per healthy life-year added
Prost and Prescott (1984)	1977 (OPC)	Actual US$ as of 1981	$22.1 million	One blindness as 23 years healthy life lost in hyperendemic areas; 20 in mesoendemic. 1 098 095 healthy life-years added over 20 years; 147 294 annually		$20 per healthy life-year added; $150 per discounted healthy life-year added

Current expenditures on onchocerciasis control

In the year 2000, the OCP spent a total of $13.9 million in 11 countries in West Africa. $9.2 million of this amount was for vector control, consisting primarily of aerial operations, larvicides and personnel costs. An additional $1.9 million was spent on planning, evaluation, and transfer costs for the programme – including travel and training. $0.7 million was spent on the Macrofil Chemotherapy Project, and 1.7 million on administrative costs. The APOC, with 19 member countries throughout Africa, spent $9.4 million in 2000.** $5.9 million of this amount was spent on national ivermectin distribution projects. The share of APOC's budget going to ivermectin distribution was projected to increase in 2001 and 2002. While a significant portion of OCP expenditures were for vector control, vector control represents a minimal portion of APOC's activities.

These expenditure levels are somewhat less than those projected by earlier studies. Kim and Benton (1995) had predicted total OCP expenditures of $571 million over 28 years, or $20.4 million per year (1987 US dollars). McFarland and Murray (1994) used an estimate for the OCP of $19.5 million per year.

The OPC and APOC programme expenditures, while significant, are dwarfed by the value of Merck's contributions through the MDP. In the year 2001, the value of the ivermectin contributed by Merck – calculated at $1.50 per tablet†† – was $28.1 million for the OCP, $143.6 million for APOC and $3.0 million for the OEPA. The additional costs of the MDP paid by Merck – shipping the ivermectin from France where it is produced to the destination countries, customs clearance, and programme management and administration – amount to just 1.1% of total programme costs.

The future cost structure will change further as the OCP is in the process of officially closing. An inter-country unit called the Special Intervention Team (SIT) will plan and conduct control activities in special intervention zones (Kale *et al.* 2002). A plan of action and corresponding 5-year budget has been prepared for the 2003–2007 time period – anticipating $14.2 million in expenditures during this time period, 32.9% of which is for aerial operations (JPC 2002; Kale *et al.* 2002). After this period, any other special efforts will be the responsibility of national authorities.

Discussion and conclusions

The available economic analyses of ivermectin distribution programmes show that the programmes have a

** Currently, large-scale ivermectin distribution is being carried out in 13 of 19 endemic countries in Africa in the APOC area.

†† $1.50 is the unitary value of ivermectin production cited by the MDP.

highly beneficial impact. The range of results is highly dependent, however, on assumptions regarding the time period, the discount rate used, and the benefits included – generally labour productivity and the value of increases in available agricultural land. There is also variability in the costs included. All of the cost-benefit analyses analysed here include research, training, overhead and distribution costs. In the OCP analyses, vector control costs are also included. None of the studies included the production and distribution costs incurred by Merck, but all did include the costs of the 22 donors for the OCP and the donors, beneficiary governments, and NGOs in the case of APOC.

The cost-benefit analyses of the OCP (Kim & Benton 1995) and the APOC (Benton 1997) are two of the most comprehensive economic analyses of ivermectin distribution available. The OCP has an estimated total target population of 25.9 million people, with costs calculated as $571 million in 1987 constant dollars for the 1974–2012 time horizon (38 years). On the contrary, the APOC, with a target population of 50 million in its 19 member countries, has costs calculated as $131.2 million in constant 1996 dollars for the 1996–2002 time horizon (6 years). The cost per person to be treated is thus nearly an 8.5-fold higher in the OCP relative to the APOC.

The difference in the costs of the two programmes can be partially attributed to the considerably longer project horizon for the OCP. However, given the life cycles of the parasite and its vector, APOC's activities would also likely need to be sustained for approximately 20 years to have a substantial permanent impact. The cost differences are also due to the cost of vector control included in the OCP programme. In the year 2000, the OCP spent 66% of its $13.9 million budget on vector control efforts.

The estimated absolute difference between benefits and costs (net present value) is calculated by these studies to be $485 million for the OCP over a 39 year project horizon, and $53.7 million for APOC over a 21 year project horizon – both calculated using a conservative 10 year discount rate.‡‡ The corresponding ERR is 20% for the OCP and 24% for the APOC in the specified time periods (Kim & Benton 1995; Haddix 1997). The evaluation of the OCP included the total costs incurred by the 22 donors, the benefits of 'new land', and an increase of productive labour to 85% of the potential work force, over a 39 year horizon.

The APOC evaluation used a 21 year horizon, and did not factor in the worth of 'new land'; only the value of increased labour productivity. Prevention of one case of blindness was considered to be worth 20 productive, healthy years. When the APOC was re-evaluated to include increased agricultural output as new land is available, the long-term net present value rose to $87.6 million at a 10% discount rate (Haddix 1997).

Kim and Benton (1995) calculated the economic rate of return for the OCP to be 6% for labour and 18% for land with a 3% discount rate and a 39-year horizon. In comparison, they found an ERR of 17% with a 10% discount rate and with benefits of increased labour but not land. Haddix's (1997) re-evaluation including the value of new land increased the APOC ERR to 24%.

The economic success of ivermectin distribution is largely based on the fact that the drug itself has been donated free of charge. If the costs of the Mectizan were included, calculated at $1.50 per tablet, the economic evaluations would not be positive. The value of Merck's donations to the APOC for just 1 year – $143.6 million in 2001 – considerably outweighs not just the operational budgets of the OPC and the APOC but also the net present values reported above for the programme over the long-term horizon. In other words, the economic value of Mectizan itself for 1 year is greater than the projected economic benefits of its distribution over a period of 20 years or more.

On the contrary, the public health impacts of ivermectin distribution may be significantly underestimated by using blindness as the only health-related outcome. The drug can reverse weight loss and musculoskeletal complaints associated with onchocerciasis.§§ The effects of ivermectin on other parasites causing geohelminth infection, scabies, and lymphatic filariasis represent additional benefits to individuals and populations covered by distribution programmes – benefits that are not captured in the economic analyses reviewed here.

When vector control is included in these economic analyses, costs are considerably increased and the ERR is

‡‡ The US Panel on Cost-Effectiveness in Health and Medicine has recommended using a real rate of 3% for cost evaluations in health care (Gold *et al.* 2001). This rate reflects a wide range of studies documenting individuals' preferences for present consumption compared with future consumption, and the marginal rate of returns – the interest rate – for private investment. In theory, both of these factors influence the discount rate for future costs and benefits in the context of both financial and health-related gains and losses. By using a rate of 10%, the studies reported here tend to undervalue the future benefits of ivermectin distribution.

§§ Onchocerciasis can result in a wide range of symptoms that are reversed with effective treatment using ivermectin. These symptoms include disfiguring skin changes, musculoskeletal complaints, weight loss and growth arrest (Burnham 1998).

consequently reduced. But vector control, if successful, clearly conveys a set of benefits not counted in these calculations. Ultimately, eliminating transmission would end the need for a long-term disease control programme. During its closing-out period, the OCP will continue aerial operations, covering a maximum 2835 km of rivers. The APOC is also considering increased eradication efforts with selected foci in Burundi, Equatorial Guinea, Malawi, Tanzania and Uganda.

An effective macrofilaricide could change the economics of onchocerciasis control. Alley *et al.* (2001) used the ONCHOSIM model to simulate the dynamics of onchocerciasis transmission and to explore the potential of a hypothetical macrofilaricidal drug to eliminate onchocerciasis. With a high vector biting rate and poor coverage, a very effective macrofilaricide, with high coverage rates, shows a higher potential for achieving elimination of the parasite than does ivermectin.

As the MDP celebrates its 17th anniversary, it is appropriate to focus on the future financial sustainability of ivermectin distribution. In Africa, distribution of the drug will likely need to be sustained for the foreseeable future (Carter Center 2002). The OEPA seeks to terminate transmission of the *Onchocercal volvulus* parasite in the Americas, but the time frame for doing so is uncertain. Presenting a clear picture of the costs and benefits of ivermectin distribution helps global efforts for onchocerciasis control in terms of planning future activities and demonstrates the large economic benefits that such distribution has already achieved.

Acknowledgements

This document is based on work funded by Merck Pharmaceuticals Company. The authors are grateful to anonymous referees for constructive comments and suggestions.

References

Akpala D, Okonkwo PO, Nwagbo D & Nwakoby D (1993) Comparison of three strategies for mass distribution of ivermectin in Achi, Nigeria. *Annals of Tropical Medicine and Parasitology* **87**, 399–402.

Alley WS, van Oortmarssen GJ, Boatin BA *et al.* (2001) Macrofilaricides and onchocerciasis control – mathematical modeling of the prospects for elimination. *BMC Public Health* **1**, 12.

Amazigo U, Noma M, Boatin BA *et al.* (1997) Delivery systems and cost recovery in Mectizan treatment for onchocerciasis. *Annals of Tropical Medicine and Parasitology* **92** (Suppl. 1), S23–S31.

Benton B (1997) Economic impact of onchocerciasis control through the African Programme for Onchocerciasis Control: an overview. *Annals of Tropical Medicine and Parasitology* **92** (Suppl. 1), S33–S39.

Benton B & Skinner ED (1990) Cost-benefits of onchocerciasis control. *Acta Leidensia* **59**, 405–411.

Boardman A, Greenberg D, Vining A & Weimer D (1996) *Cost-benefit Analysis: Concepts and Practice*. Prentice Hall, Upper Saddle River, NJ.

Burnham G (1998) Onchocerciasis. *The Lancet* **351**, 1341–1346.

Carter Center (2002) *Summary 2001 Program Review for the Carter Center/Lions SightFirst Riverblindness Programs*. Document Carter Center, Atlanta.

Coyne P & Berk D (2001) *The Mectizan (Ivermectin) Donation Program for Riverblindness as a Paradigm for Pharmaceutical Industry Donation Programs*. The World Bank, Washington, DC.

Dadzie YK, Neira M & Hopkins D (2003) Final report of the conference on the eradicability of onchocerciasis. *Filaria Journal* **2**. http://www.filariajournal.com/content/pdf/1475-2883-2-2.pdf

Gold MR, Siegel JE & Weinstein MC (2001) *Cost-effectiveness in Health and Medicine*. Oxford University Press, UK.

Haddix A (1997) *An Economic Re-Evaluation of the African Programme for Onchocerciasis Control*. Department of International Health, Rollins School of Public Health of Emory University, Atlanta, GA.

Joint Programme Committee (JPC) (2002) Onchocerciasis Control Programme in West Africa. Onchocerciasis Control in Special Intervention Zones Including Sierra Leone in the OCP Area: Plan of Action and Budget. 23rd Session, Ougadougou, 4–6 December 2002.

Kale O, Grunewald J, Koulischer G, Massougbodji A & Sachndeva P (2002) *Onchocerciasis Control Programme External Evaluation*. External Evaluation Team (EET), Onchocerciosis Control Programme, Ouagadougou, Burkina Faso.

Kim A (1997) *Health and Labor Productivity: the economic impact of onchocercial skin disease*. The World Bank, S1 (#WP 1836).

Kim A & Benton B (1995) *Cost-Benefit Analysis of the Onchocerciasis Control Program (OCP)*. The World Bank, Washington, DC.

McFarland D & Murray J (1994) *A Review of the Economic Impact of Treatment with Ivermectin for Onchocerciasis*. Emory University School of Public Health and the International Health Program Office at the Centers for Disease Control and Prevention, Atlanta.

Merck (2002) *The Story of Mectizan*. Available at: http://www.merck.com/about/cr/mectizan/p17.htm (Accessed: August 2002).

Onwujekwe O, Shu E, Nwagbo D, Akpala C & Onkonkwo P (1998) Willingness to pay for community-based ivermectin distribution: a study of three onchocerciasis endemic communities in Nigeria. *Tropical Medicine and International Health* **3**, 802–808.

Onwujekwe O, Chima R, Shu E & Onkonkwo P (2002) Community-directed treatment with ivermectin in two Nigerian

communities: an analysis of first year start-up processes, costs and consequences. *Health Policy* **62**, 31–51.

Prost A & Prescott N (1984) Cost-effectiveness of blindness prevention by the Onchocerciasis Control Programme in Upper Volta. *Bulletin of the World Health Organization* **62**, 795–802.

World Bank (1997) *Economic Impact of Onchocercal Skin Disease – Report of a Multi-Country Study*. Onchocerciasis Coordination Unit, The World Bank.

World Bank (2001) *World Development Report 2001*. Washington, DC.

World Health Organization (1991) *Strategies for Ivermectin Distribution through Primary Health Care Systems*. Document WHO/PBL/91.24. WHO, Geneva.

World Health Organization (1994) Progress Report of the World Health Organization for 1996: Onchocerciasis Control Programme in West Africa. Document OCP/JPC/17. Onchocerciasis Control Programme in West Africa, Ouagadougou.

World Health Organization (2002) Website: http://www.who.int/ocp/apoc/ocp. Accessed: November 2002. Copyright 1997 Onchocerciasis Control Programme.

Authors

Hugh R. Waters (corresponding author), **Julia Ann Rehwinkel** and **Gilbert Burnham**, Department of International Health, Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe St., Room 8132, Baltimore, MD 21205, USA.
E-mail: gburnham@jhsph.edu