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HOMING IN ON HELMINTHS*

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I am honored to give this lecture dedicated to the memory of Dr. Fred Soper, whose pioneering efforts against the insect vectors of malaria and yellow fever are legendary. Soper and his colleagues also played key roles in restoring the concept of eradication to respectability after the collapse of earlier campaigns to eradicate hookworm and yellow fever. When Soper was himself invited to give the first of five Fred Soper Lectures to mark his retirement as regional director of the Pan American Health Organization in 1959, he entitled his lecture *Rehabilitation of the Eradication Concept in Prevention of Communicable Diseases.*[1] Ten years later, The World Health Organization (WHO)'s abandonment of the declared goal of malaria eradication marked another nadir in the acceptability of the concept of eradication, from which we are only now reemerging.

One measure of the change is that the Director-General of WHO in 1980 wrote that "Important lessons can be learned from smallpox eradication, but the idea that we should single out other diseases for worldwide eradication is not among them."[2] By 1988, the same Director-General had endorsed the goal of polio eradication.[3] Under sponsorship of a grant from the Charles A. Dana Foundation, there is now an International Task Force for Disease Eradication, the Secretariat of which is located at the Carter Center. That Task Force has developed criteria for systematically assessing the eradicability of candidate diseases, and has used those criteria to evaluate 15 diseases so far.[4,5] The Task Force plans to review 14 other diseases in 1992. Of the diseases reviewed to date, two—dracunculiasis and poliomyelitis—have been judged to be eradicable, while two others—rubella and mumps—were felt to be probably eradicable.

Dr. Soper would no doubt be pleased that the Pan American Health Organization (PAHO) and the region of the Americas have led so visibly in the campaigns to eradicate smallpox, polio, and other diseases. Despite the risk of failure in such efforts if they are not well conceived and executed, the onus of abetting unnecessary suffering by not exploiting the unique advantages of an eradication campaign when that is possible, must also be considered.

My main intention here is not to review the concept of eradication, however, but to consider progress and prospects of efforts to reduce the burden of certain helminthic diseases. Parasitic diseases are, after all, a major part of the tropical diseases with which the American Society of Tropical Medicine and Hygiene is concerned, and helminths are among the most ubiquitous of parasites.

A 1990 WHO listing of estimated annual deaths ranked six parasitic diseases, including three helminths, among the top 21 fatal diseases worldwide: malaria (1–2 million), schistosomiasis (200,000), amebiasis (40,000–110,000), hookworm (50,000–60,000), African trypanosomiasis (20,000), and ascariasis (20,000). Thus, in 1990 approximately as many people died of schistosomiasis as of acquired immunodeficiency syndrome (200,000), and about as many people died of ascariasis as of polio (20,000–25,000). In 1967, the estimated 13.2 million cases of smallpox that occurred that year would have killed over one million persons, perhaps about the level of mortality that malaria caused then. Smallpox has, of course, been stripped from this list forever. The global childhood immunization initiative, which raised infant immunization levels dramatically over the last decade, prevented measles (1.5 million deaths), neonatal tetanus (775,000 deaths), and whooping cough (500,000 deaths) from figuring even more prominently on WHO's list.

We must, however, avoid the common mistake of imagining that death is the only useful measure of a parasite's significance, especially when considering the helminths. A listing of major helminthic infections according to prevalence

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TABLE 1
Major helminthic infections

Parasitic infection	Estimated worldwide prevalence (millions)
Ascariasis	1,000
Hookworm	900
Trichuriasis	750
Enterobiasis	400
Schistosomiasis	200
Filariasis	90
Strongyloidiasis	80
Taeniasis	70
Clonorchiasis/ opisthorchiasis	>30
Onchocerciasis	18
Fascioliasis	17
Trichinosis	11
Diphyllobothriasis	9
Paragonimiasis	6
Dracunculiasis	3

adds another perspective (Table 1), but even that perspective is still inadequate, since it does not reflect the prevalence of associated disease, which affects only some of those who are infected. Of these estimates, the data for dracunculiasis are the only ones based on actual active surveillance; ten years ago, WHO estimated that approximately 10 million were infected by dracunculiasis annually.

The three initiatives to reduce or eradicate helminthic diseases that I wish to consider here are the Onchocerciasis Control Program (OCP), the Dracunculiasis Eradication Program, and a new project to provide mass chemotherapy and hygiene education to control schistosomiasis and several intestinal helminths among school children nationwide in Ghana. I am intimately involved in the last two initiatives, but I have had no personal involvement in the OCP. I include a discussion of the OCP here mainly for the sake of younger members of the Society, and because the OCP illustrates so well many aspects of the increased opportunities available to this generation for reducing some of the helminthic horrors of our world. Between them, these three initiatives address all of the 15 helminthic infections listed in Table 1 except trichinosis.

Onchocerciasis Control Program

Onchocerciasis affects about 18 million persons worldwide. Nearly all of these are in sub-Saharan Africa, with only about 100,000 cases

TABLE 2
*Geographic distribution of onchocerciasis**

Area	Case prevalence (%)	Main intervention
OCP region	2.3 million (13)	Vector control, ivermectin
Nigeria	7.0 million (39)	Ivermectin
Other areas of Africa	8.4 million (47)	Ivermectin
Americas	0.1 million (1)	Ivermectin

* OCP = onchocerciasis control program (in West Africa).

still extant in the American tropics (Table 2).[6] An estimated 340,000 persons are blind from the disease, including 15% or more of the entire population and up to 40% of the adult male workforce in some areas.[7] Although it rarely kills directly, this disease's socioeconomic effects are ruinous nonetheless, forcing rural populations seeking to escape the effects of the parasite and its biting blackfly vector to abandon some fertile river valleys altogether, and move to less arable land.

Control of the vector of onchocerciasis over a large part of West Africa was judged to be feasible at a meeting of representatives from the US Agency for International Development (USAID), the francophone West African public health organization OCCGE (Organisation de Coordination et de Cooperation pour la Lutte Contre les Grandes Endemies), and WHO at Tunis, Tunisia in 1968. The OCP was launched in parts of seven West African countries of the Volta River Basin (Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali, Niger, Togo) in January 1974. The original agreement signed by twelve donor agencies designated the World Bank as the administering agency for the program, and WHO as the executing agency, with all four sponsoring agencies (United Nations Development Program, Food and Agriculture Organization, World Bank, and WHO) sharing in policy making and oversight.[8]

The original commitment of the donor agencies, based on understanding of the lifespan of the adult worm, was for a program lasting 20 years, at an expected total cost of about $120 million in 1973 dollars.[8] The area covered by the project was expanded in 1986 to parts of four more countries (Guinea, Guinea-Bissau, Senegal, and Sierra Leone), currently embracing a total of 30 million persons at risk (versus 20 million previously), at an average cost of about $30 million per year in 1988–1990.[9] A significant im-

TABLE 3
Comparison of onchocerciasis and dracunculiasis

	Onchocerciasis	Dracunculiasis
Regions affected	Africa, Americas	Africa, southern Asia
Estimated prevalence	18 million	3 million
Human impact	Blindness	Crippling
Control efforts	Regional OCP*, ~$120 million, 1974–1997; mass ivermectin therapy, eradication in the Americas by 2000	Global eradication by 1995, ~$75 million, 1986–1995
Cost effectiveness†	$300 per healthy life-year gained (vector control)	$25 per healthy life-year gained (water supply)

* OCP = Onchocerciasis Control Program.
† World Bank estimates, 1991.

petus for initiating this program was the visit by then World Bank president Robert S. MacNamara to an endemic area of West Africa, which personalized for him the devastation caused by river blindness (William H. Foege, personal communication).

From the beginning, the program was based almost entirely on vector control, which was then the only practical intervention for onchocerciasis, using a fleet of helicopters and small fixed-wing aircraft to apply temephos (Abate) or other larvicides to breeding sites in the rivers. The program also made use of the most modern appropriate technology available, including satellite transmitted readings of river flow rates and levels, computer modeling of parasite transmission, and chromosome determinations of the *Simulium damnosum* species complex.

The results have been dramatic and impressive. According to the latest external review of the program in November 1990, "the disease has ceased to be a public health problem in all of the original program area."[10] About seven million children have been born virtually free of risk of onchocerchal blindness. An estimated 100,000 persons have been saved from blindness because of the program. According to Dr. Ebrahim Samba, the OCP director, in Burkina Faso, which used to be the most severely affected country, the highest prevalence rate of infection in the remaining affected villages is now only 2%, as compared with 80–90% when the program began (personal communication). The socioeconomic benefits of these results to the populations at risk are incalculable.

This initiative has benefited greatly from the timely, fortuitous discovery of the microfilaricidal effects of ivermectin (Mectizan), and the equally unprecedented decision of its manufacturer, Merck, to donate the drug for treatment of onchocerciasis patients worldwide beginning in 1987. This has provided more security against recrudescence of onchocerciasis after spraying is halted in the OCP area. More importantly, the availability of this new intervention has now made feasible the control of onchocerciasis in the other 87% of the endemic area, such as Nigeria, where another OCP-type program was never a realistic option because of its great cost.[11–13] Mass ivermectin therapy for onchocerciasis also simultaneously provides effective treatment of acariasis, trichuriasis, enterobiasis, filariasis, and strongyloidiasis.

The chairman of the Mectizan Expert Committee and the most recent previous Soper Lecturer, Dr. William Foege, reports that 1.3 million treatments of ivermectin were provided in 1990, and that 1.4 million treatments have already been provided in the first half of 1991.[14] The availability of mass treatment with ivermectin has also increased speculation about the potential eradicability of onchocerciasis, a goal that the endemic states of the Americas and PAHO have already resolved to achieve by the year 2000. Most observers, including the International Task Force for Disease Eradication, agree that if onchocerciasis is not now eradicable, discovery of a suitable macrofilaricide capable of destroying the adult parasites, would surely make it eradicable.[7]

Among the major lessons of the OCP that are cited by that multi-country program's leaders are that the existence of a clear, well-defined objective helped the program and its backers to focus on technical and not political considerations, the importance of the donors' long-term commitment, from the beginning, to a realistic time frame based on the 15–18-year lifespan of the worm, choice of appropriate technology and under-

TABLE 4
Status of dracunculiasis eradication by country, December 1991

Country	Status
Gambia, Guinea, Saudi Arabia, Yemen	Ready to be considered for certification of elimination
Cameroon, Kenya, Pakistan	Intensive case containment strategy now appropriate
Ghana, India, Nigeria	Nationwide reductions evident
Benin, Burkina Faso, Cote d'Ivoire, Niger, Mauritania, Senegal, Togo	Completed nationwide search
Chad, Mali, Uganda	Nationwide search underway
Central African Republic	Preliminary survey done
Ethiopia, Sudan	Search not yet begun

standing of the disease's epidemiology, support for relevant applied research to address operational problems encountered in the field, organizational autonomy that "sheltered [the program] from competition with other WHO priorities," and a "sense of urgency to act and to succeed."[10]

Dracunculiasis

As we leave the OCP to consider the campaign to eradicate dracunculiasis, it is instructive to compare these two diseases and control efforts directly (Table 3).[12] Both diseases rarely kill their victims, but each exerts a negative effect on the development of endemic communities that is disproportionately greater than the numbers of deaths caused, a grim reality that often is hidden from urban policy makers by the remoteness of the villages concerned. By crippling large proportions of adults and school children simultaneously for weeks or months at critical periods of the agricultural year, dracunculiasis attacks the health, education, and agricultural productivity of rural populations. It is still found in an endemic zone that now involves mainly sub-Saharan Africa, with a relatively small remaining extra-continental focus in India and Pakistan. Over 100 million persons are still at risk of this infection.[15, 16]

Dracunculiasis is now destined to become the first parasitic disease of humans to be eradicated. The World Health Assembly explicitly endorsed the 1995 goal for dracunculiasis eradication for the first time in a resolution (WHA44.5) adopted in May 1991. African Ministers of Health had already set that target date for themselves in 1988.

This global initiative began at the Centers for Disease Control (CDC) in October 1980, and was linked to the then imminent launching of the International Drinking Water Supply and Sanitation Decade (1981–1990).[17] Dr. M. I. D. Sharma had just persuaded his colleagues in India to undertake a program to eliminate dracunculiasis from that country in followup to the successful smallpox eradication program there.[18] The Global 2000 project of the Carter Center and former US President Jimmy Carter became involved late in 1986, when Pakistan agreed to establish an eradication program. Global 2000 is now assisting dracunculiasis eradication programs in Ghana, Nigeria, and Uganda, in close cooperation with CDC, and we shall soon begin working similarly with the government of Ethiopia, by virtue of a grant we have just received for that purpose from the Conrad N. Hilton Foundation. Our project in Pakistan ended on November 1, 1991.

Since dracunculiasis was the subject of a symposium at last year's annual meeting in New Orleans, and was recently reviewed in the Society's journal,[15] I need only mention here the latest reports from the frontlines.[19] Thanks largely to the financial support of the United Nations International Children's Education Fund (UNICEF) over the past two and a half years, most of the endemic countries, except for Sudan and Ethiopia, have now completed or will soon complete nationwide, village-by-village searches for cases (Table 4). Thus, the scope of the remaining endemic areas is being revealed for the first time. The numbers of endemic villages found in each endemic country range from a mere two dozen in Cameroon to over 5000 villages each in Ghana and Nigeria.

Ethiopia, one of the two main remaining endemic countries that have not yet begun a national search for cases, held its first national workshop on dracunculiasis on December 6,

1991. Nigeria and Ghana, which conducted their first national searches for cases in 1988 and 1989, respectively, and which have more cases of dracunculiasis than any other country, are well-advanced in their programs to eradicate the disease. These two highly endemic countries reduced the combined total of their cases by more than 30% between 1989 and 1990, from about 820,000 cases to approximately 520,000 cases.[20]

In the Nanumba District of Ghana's Northern Region, over 70% of all villages had at least one case of dracunculiasis in 1989. A Japanese rural water supply project provided 159 wells in the endemic villages of this district in 1988–1989, in combination with intensive health education that included lectures on dracunculiasis prevention delivered in some of the villages by the head of state himself during his tour of 21 endemic villages in 1988. As a result, the incidence of dracunculiasis was reduced by 77% in the entire Nanumba district in one year, from 14,200 cases in 1989 to 3,241 cases in 1990.[19] The resultant increase in agricultural productivity in this district in 1991 was so great that the market price of the major local crop, yams, fell dramatically. When he was asked about that, one of the farmers replied that "even though the low price of yam was not in the interest of farmers, they were happy about improvement in their health which enables them to make more yam mounds and enjoy life to its fullest."[21]

Both Ghana and Nigeria appear likely to report similar annual reductions in incidence of the disease in 1991 as they did in 1990. Already, Nigeria's Anambra State, which reported the highest number of cases of dracunculiasis of all states in Nigeria in the past two years, has recorded a reduction of cases from a little over 95,000 in the year ending June 30, 1990 to just under 65,000 in the year ending June 30, 1991. One of the Local Government Areas of Cross River State reduced its number of cases over the same period from 1,341 to 25. Massive social mobilization, use of cloth filters in some endemic villages, and prioritization of endemic villages for rural water supply projects account for the significant decreases in incidence in Ghana and Nigeria.

Donations of temephos announced in 1990 by American Cyanamid and of nylon cloth for filtering drinking water by the DuPont Corporation and Precision Fabrics Group, and the donation this year of materials and printing for health education posters and other paper products by Georgia-Pacific and the Communicorp Company have encouraged the internal efforts of several African countries. Some endemic countries are now using the presence of dracunculiasis to successfully solicit more external assistance for providing safe water supplies to rural populations. The main needs in Africa now are to achieve similar levels of public awareness and urgency about dracunculiasis prevention in the endemic francophone countries as now exist in Ghana and Nigeria, and to attain an end to the civil war in Sudan.

India and Pakistan continue to progress toward eradication of the disease at a deliberate pace that although it is slower than desired, leaves the outcome in Asia not at all in doubt. Dr. Karl Kappus has already described at this annual meeting the occurrence of 103 cases of dracunculiasis in 35 villages in Pakistan in 1991. Forty percent of the 1991 Pakistani cases were from one village, while 22 of the other villages had only one case each. India now has a provisional total of less than 1,500 cases in only 374 villages, as compared with nearly 5,000 cases last year, and nearly 45,000 cases in 1983 (Ashok Kumar, unpublished data).

It will cost an estimated $75 million to eradicate dracunculiasis, not including the cost of providing safe drinking water to endemic villages. About half of that funding has already been secured. A study conducted for the World Bank recently estimated that even the most expensive intervention of providing safe drinking water to prevent dracunculiasis is over five times more cost effective, in terms of healthy life years gained, than is vector control to reduce onchocerciasis, even without considering the other benefits of safe water.[22] Fortunately, West African villagers are being helped to free themselves of both diseases, not one or the other, exactly as you or I would want if we were in their place.

The $75 million that is required to eradicate dracunculiasis and the projected $120 million that is needed to control onchocerciasis in the original OCP area may be compared with the reported $50 million that was spent in recent years to eradicate the threat posed to African cattle by imported screw worms in Libya since 1988, or with the more than $75 million that was reportedly required for a successful cam-

paign against the same pest when it threatened livestock in Mexico.[23] Humans deserve at least as much protection as cattle.

Some lessons of the dracunculiasis eradication campaign are already apparent. They include the power of relatively inexpensively acquired data to focus attention on a neglected disease and to obtain additional resources to combat it, as well as the unique power of the idea of eradication to help marshall resources. Dracunculiasis has also demonstrated the ability of a disease-specific program to contribute significantly to achievement of other primary health care targets, in this case including childhood immunization, surveillance of schistosomiasis, training of village-based health workers, provision of safe drinking water, and helping villagers to improve their own lives in ways that are important to them. This program has demonstrated again the potential effectiveness of personalizing a problem: UNICEF provided $1.5 million to support national searches for cases of dracunculiasis in Africa starting one month after its executive director, Mr. James Grant, visited an endemic village in Ghana. Another important lesson has been this initiative's demonstration of the relevance of public health programs to rural development.

Expanded program of chemotherapy

This initiative to reduce the impact of schistosomiasis and some intestinal helminths in school children in Ghana was spawned by a meeting convened at the Edna McConnell Clark Foundation in July 1990, and by a presentation that Dr. Ken Warren made to the International Task Force for Disease Eradication a month later. With start-up funding provided by the Clark Foundation and the Charles A. Dana Foundation, the Carter Center expanded our collaborative efforts with the government of Ghana in 1991 to include this new effort.

Schistosomiasis, especially schistosomiasis hematobium, and intestinal helminthiases, especially ascariasis, hookworm, trichuriasis, and strongyloidiasis are known to be significant causes of morbidity and some mortality in Ghana. Prevalence rates of urine samples positive for *Schistosoma hematobium* eggs range from approximately 13% found in 10–19-year-old individuals in the greater Accra Region by the Danfa Project in the 1970s,[24] to maximum prevalence rates of approximately 25–31% among 10–24-year-old individuals in the Upper Western Region in the late 1960s,[25] to rates of over 70% among 10–20-year-old individuals in a village of Volta Region surveyed in 1979–1980.[26] In general, schistosomiasis hematobium is widely distributed in Ghana, with transmission tending to be more intensive in the northern part of the country and along the shores of Lake Volta. *Schistosoma mansoni* infections appear to be much more limited and focal in distribution.

Ascariasis is usually the most commonly reported geo-helminth in Ghana, according to official reports to the Ministry of Health. A 1973 survey found evidence of ascaris in the stools of 51% of 5–14-year-old persons in the Greater Accra Region,[24] while a study of preschool children in 1982 found prevalences of 41.9% and 76.2% in two villages near the Atlantic coast, as compared with prevalences of 0% and 32.9% in two villages in the forest zone across the middle of the country.[27] Ascariasis, like strongyloidiasis and trichuriasis, appears to be more prevalent in the southern parts of the country.

Hookworm is usually the second most commonly diagnosed geo-helminth in laboratory reports to the Ministry of Health. Similar to schistosomiasis hematobium, it is more prevalent in the northern part of Ghana.

Adequate current baseline data on these diseases is not yet available in Ghana. Although the true extent of the burden they represent is thus not known, it can reliably be assumed to be substantial. In an intensive nationwide study of school children in Cameroon, on the West African coast about 600 miles east of Ghana, Ratard and others recently documented similar gradients of increased urinary schistosomiasis in the arid northern region, whereas ascariasis and trichuriasis were relatively more prevalent in the more equatorial southern part of this country.[28, 29]

Ghana has long recognized the importance of these diseases. The Ministry of Health imported one million tablets of metrifonate and a 100,000 doses of praziquantel at a total cost of $85,000 in hard currency in 1989. That same year, the Ministry of Education imported $159,000 worth of piperazine to treat a million primary school children for ascaris in a program that was discontinued because of a lack of funds and other reasons. The main objectives of this new initia-

TABLE 5

Comparison of Expanded Program on Immunization (EPI) and Expanded Program of Chemotherapy (EPC)

	EPI	EPC
Target diseases	Measles Polio Pertussis Tetanus Diphtheria	Schistosomiasis Ascariasis Hookworm Strongyloidiasis Trichuriasis
Target population	Nationwide <2 years old	Nationwide 5–14 years old
Distribution	Clinic based	School based
Benefits	Reduced deaths Reduced crippling Indirect herd effect	Improved nutrition Improved growth and development Indirect community effect
Logistics	Injections Cold chain 3 times/year Life-long effect	Oral administration No cold chain Once/year Limited duration
Cost	Vaccines, <$1/child	Drugs, <$0.50/child/year

tive are 1) to improve the health and nutrition of Ghanaian school children by means of mass oral chemotherapy against schistosomiasis and intestinal helminthiases, 2) to increase school children's awareness and use of hygienic practices by providing appropriate educational instruction, 3) to document the major problems, costs, and benefits of such a program, and investigate ways to extend coverage beyond school children and for other oral therapies, such as iodine and iron supplementation, and 4) to provide a model of a sustainable national "Expanded Program of Chemotherapy" that may be adapted by other countries.

We are working with the Ministries of Health and Education to begin operations in the Volta region in March 1992, followed by the first annual nationwide distribution of drugs and educational materials in October 1992. The program hopes to use praziquantel and albendazole, if sufficient external support can be obtained, along with health educational materials developed in Ghana. Each of the drugs will be administered to children in a single oral dose without individual testing, once a year, free of charge. Between them, these two drugs could effectively treat schistosomiasis, taeniasis, clonorchiasis, fasciolliasis, diphyllobothriasis, and paragonimiasis (praziquantel), as well as ascariasis, hookworm, trichuriasis, enterobiasis, strongyloidiasis and taeniasis (albendazole), although not all of these diseases occur in Ghana.

The main target population initially will be the 2.3 million 6–14-year-old children enrolled in primary and secondary schools, representing about two-thirds of all Ghanaian children in this age group (Ghana's total population is approximately 14 million persons). The decision to target school children was judged to be the most cost-effective approach, since all the target diseases except hookworm, which reaches a maximum at slightly older ages, are most prevalent in 6–14-year-old children; this age group is often the one most responsible for contaminating the environment and thus maintaining transmission, and many of those children are accessible in the schools.[22,30] The Government of Ghana plans to begin the project in the Volta Region because that region is highly endemic for schistosomiasis, it has one of the best public health infrastructures in the country, some studies of schistosomiasis are already being conducted there, and that region has the second highest rate of school enrollment (77.3%) of the ten regions.

Pilot studies conducted in other countries by Dr. Don Bundy of London's Imperial College and by Dr. Lani Stephenson of Cornell University and their collaborators, as well as others, lead us to believe that the direct benefits expected from this program to reduce the intensity of infections with schistosomes and intestinal helminths in Ghanaian school children will include significant improvements in the children's growth, physical development, nutrition, learning ability, and school attendance.[31–39] Indirect reductions in transmission may also accrue in communities where a large proportion of school age children are enrolled and participate in the program.

In keeping with the program's objective to reduce the intensity of infection, parasitologic evaluation will stress the extent and duration of reduction in prevalence of quantified heavy egg burdens of urinary schistosomes (> 50 eggs/ml of urine), ascaris (> 50,000 eggs/g of feces), hookworm (> 5,000 eggs/g of feces), and trichuris (> 10,000 eggs/g of feces), and not a reduction in the overall prevalence of infections. Appropriate baseline and followup studies will be conducted on a small number of sentinel pop-

ulations for these and other expected outcomes. Additional studies of safety and efficacy of the drug combinations used, and their timing and sequencing may also be necessary before the drugs are administered as widely as planned.

We call this project using broad spectrum anthelmintics an Expanded Program of Chemotherapy (EPC) to emphasize the parallel to WHO's Expanded Program on Immunization (EPI) (Table 5), which administers vaccines. I believe the EPC will prove to be as popular, effective, and adaptable in years to come as the EPI has been.

CONCLUSION

Over the past decade, with the leadership of WHO, UNICEF, and other members of the Task Force for Child Survival and Development, the immunization rates of infants in developing countries have been increased from approximately 20% in 1980 to 80% at the end of 1990. When the EPI began in 1974, the comparable rates were less than 5%. The successful global childhood immunization program, the eradication of smallpox in 1977, and the intended eradication of polio by the year 2000, made possible by the discovery and use of vaccines against viruses and bacteria, will stand as three important legacies to the 21st century. By eradicating dracunculiasis, controlling onchocerciasis, and reducing the burden of schistosomiasis and intestinal helminths in school children by means of the new broad spectrum anthelmintics and other measures, we can add to these legacies in a way that will do honor to those who have pursued them and do justice to those who are their beneficiaries. Each advance against any of these causes of preventable suffering is cause for celebration by all.

In the words of Nigerian Professor Adebayo Adedeyi, the recently retired former Executive Secretary of the Economic Commission for Africa: "Improving the human condition of individual people, of families, of communities and of societies is the only ultimate objective, justification and validation of development."[40]

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