

GAO

Report to the Chairman, Committee on
International Relations, House of
Representatives

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INFECTIOUS DISEASES

Soundness of World Health Organization Estimates for Eradication or Elimination



**National Security and
International Affairs Division**

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The Honorable Benjamin A. Gilman
Chairman, Committee on International Relations
House of Representatives

Dear Mr. Chairman:

Infectious diseases place an enormous burden on the developing world, killing more than 17 million people a year and afflicting hundreds of millions of others. The World Health Organization (WHO) has identified seven diseases—dracunculiasis, polio, leprosy, measles, onchocerciasis, Chagas' disease, and lymphatic filariasis—as candidates for global eradication or elimination¹ and estimated the costs and time frames for achieving these goals. Appendix I provides a table summarizing some of the characteristics of each disease, and appendixes II through VIII provide descriptions of each disease and WHO's strategies to address them.

As you requested, we examined

- the soundness of the cost and time frame estimates developed by WHO for eradicating or eliminating these diseases,
- U.S. spending related to the seven diseases in fiscal year 1997 and any potential cost savings to the United States as a result of eradication or elimination,
- other diseases that international health experts believe pose a risk to Americans and could be candidates for eradication, and
- historical information on U.S. costs and savings from smallpox eradication and whether experts view smallpox eradication as a model for other diseases.

Background

Global disease eradication and elimination campaigns are initiated, primarily by WHO, to concentrate and mobilize resources from both affected and donor countries. WHO provides recommendations for disease eradication and elimination to its governing body, the World Health Assembly, based on two general criteria—scientific feasibility and the level of political support by endemic and donor countries. Formal campaigns were initiated against dracunculiasis and leprosy in 1991, and

¹Eradication reduces worldwide incidence of a disease to zero and obviates the need for further control measures. Elimination reduces the number of cases to zero in a defined geographic area and/or reduces morbidity to a level that does not constitute a major public health problem. Elimination still requires a basic level of control and surveillance.

against polio and lymphatic filariasis in 1988 and 1997, respectively. Regional or subregional campaigns are also underway against measles, onchocerciasis, and Chagas' disease. Disease eradication and elimination efforts are normally implemented by national governments of the affected countries. Developing countries typically receive assistance for these efforts from bilateral and multilateral donors, nongovernmental organizations, and the private sector.

In April 1997, WHO provided the House International Relations Committee with estimated costs and target dates for eradicating or eliminating the seven diseases. Subsequently, WHO revised some of the costs and time frames based on more recent information. We also made some adjustments for consistency among the figures. Our review focuses on the estimates that WHO provided to us as of December 1997. WHO officials estimated that about \$7.5 billion would be needed to eradicate or eliminate the seven targeted diseases. Developing costs and time frames for these efforts is difficult due to challenges in gathering and verifying data from countries with minimal health infrastructure. Unpredictable and unstable country conditions, such as civil unrest, further complicate efforts to project how much these efforts will cost and how much time is needed. Table 1 provides a breakdown of costs and time frames for eradicating or eliminating each disease.

Table 1: WHO Estimated Target Dates and Costs for Eradicating or Eliminating Selected Diseases as of December 1997

Dollars in millions			
Disease	Goal	Target date	Estimated cost ^a (1997 dollars)
Dracunculiasis	Eradication	2011 ^b	\$40
Polio	Eradication	2000 ^c	\$1,600
Leprosy	Elimination	2000	\$225
Measles	Eradication	2010	\$4,900
Onchocerciasis	Elimination	2010	\$143
Chagas' disease	Elimination	2010	\$391
Lymphatic filariasis	Elimination	2030	\$228

^aThese costs represent projected public expenditures by national governments and donor countries for eradication or elimination campaigns.

^bWHO expects that all but two countries will be free of dracunculiasis by 2005.

^cCertification is expected by 2005.

To assess the soundness of WHO's estimated costs and time frames, we met with the WHO officials responsible for preparing them and with other international health experts who discussed the factors that should be considered when estimating how much disease eradication or elimination will cost and how time frames are established. Following consultation with WHO and other experts, we determined five overall factors to be considered for estimating costs. These experts also provided information on how targets are developed and the variable circumstances that may affect time frames. We used this information to assess whether the data underlying WHO's estimates were sound. In addition to WHO, the experts we consulted included officials from the Pan American Health Organization (PAHO), the U.S. Agency for International Development (USAID), the U.S. Centers for Disease Control and Prevention (CDC), the Carter Center's Global 2000 health program, the Johns Hopkins University, and Emory University to obtain their views on WHO's estimates. Appendix IX contains a detailed description of our scope and methodology.

Results in Brief

The soundness of WHO's cost and time frame estimates for eradicating or eliminating the seven diseases varied for each disease. Cost and time frame estimates for dracunculiasis, polio, and leprosy were the most sound because campaigns against them have been underway for several years and are largely based on firm data about target populations and intervention costs from ongoing initiatives. For the other diseases, WHO's estimates are more speculative because data underlying the cost and time frame estimates are incomplete or unavailable. WHO officials acknowledge that the costs and time frames provided to the House Committee on International Relations are not exact and that they must continually be refined as new information becomes available.

The United States spent about \$391 million in 1997 on programs to combat these diseases. Potential savings to the United States if eradication or elimination of these diseases were achieved could be substantial. Most of the savings would result from eliminating the need to vaccinate U.S. children against polio and measles.

The experts we interviewed and our review of the literature identified several other diseases that pose health threats to the United States and that meet the scientific criteria for eradication used by health experts. Four diseases were frequently mentioned: rubella, mumps, hepatitis B, and Hemophilus influenzae type b (Hib). WHO officials stated that while it is technically possible to eradicate these diseases with existing vaccines, it is

unlikely that other diseases will be considered for eradication before achieving success with currently targeted diseases.

Using CDC data, we estimated that the United States has saved almost \$17 billion to date from the eradication of smallpox in 1977. The savings are due to the cessation of vaccinations and related expenditures such as surveillance, treatment, and loss of productivity. Experts agree that several lessons can be learned from the smallpox effort, but the primary lesson is that a disease can actually be eradicated. However, they also suggested that smallpox has limitations as a model for other diseases because it had characteristics that were uniquely amenable to eradication.

Soundness of Estimates Varies by Disease

WHO officials and other experts identified the following as the key factors to consider in estimating direct costs for eradicating or eliminating diseases: (1) the funds needed to purchase the required intervention products, such as vaccines, drugs, insecticides, or water filters; (2) the prevalence and incidence of the disease and the population targeted for intervention;² (3) the administrative costs for delivering products to the target population (for example, transportation, setting up local infrastructure, administering vaccines or treatment, spraying, and technical assistance); (4) the costs for surveillance activities, such as diagnosing the disease, testing blood or other specimens at laboratories, and monitoring and reporting disease incidence; and (5) for eradication, the costs of certifying that each country is free of the disease. We focused our assessment primarily on these five factors.

WHO addressed all five factors in developing its cost estimates, except for the measles estimate, which did not include certification costs. The completeness of the data underlying the estimates varies by disease. Estimates for those diseases with long-standing campaigns that are closest to eradication or elimination—dracunculiasis, polio, and leprosy—are more complete, and costs are based on actual experience in endemic countries. For the other diseases, WHO is still gathering data and refining its assumptions. For several diseases, products are donated and are not included in projected costs. Examples include nylon filters donated by Dupont Corporation and Precision Fabrics Group for controlling dracunculiasis, donations of ivermectin by the Merck Company for the onchocerciasis program, and donations of albendazole by SmithKline

²“Prevalence” is the number or percentage of existing cases of a disease, and “incidence” is the number of new cases in a defined period of time.

Beecham for treating lymphatic filariasis. The Nippon Foundation of Japan also funds the drugs used for leprosy treatment.

WHO establishes time frames primarily to gain commitment and mobilize resources from endemic and donor countries. WHO bases time frame estimates on the technical feasibility of reaching target populations over a period of time and an assessment of the commitment of endemic and donor countries. As part of that assessment WHO considers the economic and political conditions in endemic countries that could affect their ability to carry out disease campaigns. As with costs, time frames for diseases expected to be eradicated or eliminated within 5 to 10 years are considered more accurate than for those with later target dates because of the unavailability of data and the difficulty of predicting commitment levels and country conditions over time.

The following sections describe in more detail WHO's cost and time frame estimates for eradicating or eliminating each of the seven diseases.

Dracunculiasis (Guinea Worm Disease)

WHO's cost estimate for eradicating dracunculiasis included data on each of the five key factors and appears to be sound. The cost data associated with each element are based on historical data from community-based control programs underway since 1980. WHO had previously set target dates of 1995 and the year 2000 for eradication, but continuing civil unrest in some endemic areas precluded meeting those dates. WHO now expects that all countries except Nigeria and Sudan will be free of dracunculiasis by 2005 at the latest; assuming safe access to endemic areas and appropriate funding, WHO officials said this goal could be reached by 2002. WHO expects that transmission of the disease will be interrupted in Nigeria and Sudan by 2010, provided that safe access and funding conditions can be met. WHO has prepared a biennial estimate of the funds needed through 2011, including certification costs.

Experts we interviewed agreed that eradicating dracunculiasis is generally feasible within the time frame and cost estimate established by WHO. In fact, officials from CDC and the Carter Center's Global 2000 program believe that dracunculiasis will be eradicated in some countries even sooner than WHO estimated and costs will therefore be lower than WHO's projections. However, one expert cautioned that continuing instability in the region could extend the projected time frame.

Polio

WHO's cost estimate for eradicating polio is generally sound and included well-developed cost data on each of the five key factors based on historical experience in controlling the disease. The global effort to eradicate polio was formally launched in 1988,³ although many countries began polio vaccinations as part of the Expanded Programme on Immunization during the 1970s and 1980s.⁴ WHO relies on UNICEF for estimates of vaccine costs and uses its own estimates for the cost of vaccine delivery based on actual experience in countries around the world.

While the World Health Assembly originally targeted polio for eradication by the year 2000, most experts we consulted said that polio is on track for eradication by 2002 and certification by 2005. However, some experts raised concern about whether less developed countries will maintain the required level of commitment to polio vaccinations and surveillance until eradication is achieved. In addition, a 1997 WHO report raised concerns about some countries' progress in meeting performance indicators for detecting and reporting acute flaccid paralysis, a key component of polio surveillance.⁵ According to WHO, unless sufficient resources are mobilized to improve detection capability, eradication cannot be certified.

Leprosy

WHO's cost estimate for eliminating leprosy as a public health problem included well-defined data on all key cost elements and appears to be sound. The current elimination strategy is based on the multidrug therapy program begun in 1981, so cost information is well developed. Endemic countries have made significant progress toward eliminating leprosy since the 1980s. However, WHO officials noted that it is possible that some countries with concentrated pockets of leprosy might need to continue campaigns beyond the target date of the year 2000 to reach the global leprosy elimination target of less than 1 case per 10,000 people. Despite this caution, experts generally agreed that WHO's cost and time frame estimates for leprosy are reasonable.

³In 1985, PAHO launched a campaign to eradicate polio from the Western Hemisphere. The last indigenous case of polio was reported in Peru in 1991, and PAHO certified the eradication of polio from the Americas in 1994.

⁴The Expanded Programme on Immunization, launched by WHO in 1974 and jointly carried out with the United Nations Children's Fund (UNICEF), aims to increase global vaccination coverage against childhood diseases through donor and technical assistance to national governments. The standard immunizations include polio, measles, diphtheria, neonatal tetanus, pertussis, and tuberculosis; immunizations against hepatitis B and yellow fever have been added in some countries.

⁵See *Polio: The Beginning of the End*, WHO, Global Programme for Vaccines and Immunizations (Geneva, Switzerland: WHO, 1997), p. 22.

Measles

WHO's measles eradication estimates are speculative. While vaccine costs are well known and based on UNICEF data, WHO officials told us that their estimates did not include the costs of certifying measles eradication and that cost estimates for other factors were low or incomplete. Specifically, WHO officials noted that

- information on the number of children to be vaccinated is incomplete;
- administrative costs may be underestimated and are in need of further refinement, and assumptions regarding the efficacy of mass campaigns may be overstated; and
- assumptions regarding the costs of surveillance and monitoring are low because WHO did not account for inadequate health systems in some countries.

Despite these limitations, WHO noted that the measles eradication estimates benefit from the experience of previous eradication efforts. The vaccine administration, surveillance, and certification costs utilize estimates from the polio eradication experience and are adjusted upward to account for difficulties in administering an injectable rather than an oral vaccine.

Experts we consulted, including WHO officials, noted that there are unique challenges to eradicating measles within the estimated time frames. Measles is highly contagious, requiring even higher routine vaccination coverage than smallpox and polio. Special campaigns in varying age groups are also necessary to catch those still susceptible after vaccination because the vaccine is not 100 percent effective. Outbreaks can occur even in areas with high routine vaccination coverage. Injection safety is also a concern in the large-scale campaigns required for eradication, particularly in areas where the risk of infection with human immunodeficiency virus and hepatitis is high. In addition, diagnosis is difficult because the symptoms can mimic other, less severe infections, and surveillance is difficult because the disease can spread rapidly while laboratory analysis and confirmation are undertaken. Finally, while measles is a major cause of mortality and morbidity for children in poorer countries, according to some experts we consulted, it is not perceived to be a major public health problem by some industrialized countries. As a result, unlike polio, some developed countries have not initiated the measles elimination efforts necessary to prepare for global eradication. More than half of the estimated cost of measles eradication is expected to be incurred by developed countries. WHO estimates that the lowest income countries will require up to \$1.8 billion in external funding for measles eradication.

At a February 1998 meeting in Atlanta, Georgia, over 200 disease eradication experts concluded that it is biologically plausible to eradicate measles with the current vaccine, noting that measles transmission appears to have been interrupted for variable time intervals in the Americas. According to a CDC summary of the meeting, participants recommended, among other things, that (1) developed countries proceed with measles elimination efforts as a step toward eradication; (2) less developed countries accelerate control efforts, particularly in areas with high mortality; and (3) experience from regional and country level interventions be used to refine the strategies for eventual eradication. Participants ranked measles as the disease most likely to be the next candidate for a global eradication effort. USAID officials told us that many participants, while agreeing on the technical feasibility of eradicating measles, also cautioned that further study should be undertaken to fully understand the magnitude of the effort and resources required for eradication.

According to WHO and CDC, some areas are beginning to set regional elimination goals. In addition to the PAHO elimination goal for the year 2000, over 50 countries encompassing Europe and the Newly Independent States are in the final stages of adopting a goal of regional elimination by 2007, and the Eastern Mediterranean region has adopted an elimination goal of 2010.

Onchocerciasis (River Blindness)

WHO's estimate for eliminating onchocerciasis is somewhat speculative. It incorporates data on all key cost elements—including the costs for larvicides and drug treatment, delivery, and surveillance—but data on the size of the target population are incomplete, which could affect the cost and time frame estimates. A control program covering 11 countries in West Africa has been in place for 24 years and has almost reached its elimination goal,⁶ and a program covering 6 countries in Latin America has been ongoing since 1991.⁷ Thus, the costs for these countries are well defined. However, WHO officials told us that the amount estimated for the other 19 endemic African countries of the African Programme for Onchocerciasis Control (APOC) is more speculative because WHO is still

⁶The Onchocerciasis Control Programme in West Africa includes Burkina Faso, Benin, Cote d'Ivoire, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Senegal, Sierra Leone, and Togo.

⁷The Onchocerciasis Elimination Programme in the Americas includes Brazil, Colombia, Ecuador, Guatemala, Mexico, and Venezuela.

mapping the prevalence of the disease in this area.⁸ WHO's early estimates of the population eligible for treatment, upon which the APOC cost estimate was based, are low for some areas. The latest estimate for the population eligible for treatment in the APOC program is 42 million compared to the original estimate of 35 million. Due to the political unrest in the Democratic Republic of the Congo (formerly Zaire), WHO does not have a reliable estimate of the number of people to be treated. However, according to WHO officials, this region is probably the first or second most infected area in the world. Experts generally agreed that the ongoing West Africa and Latin America programs are on schedule and onchocerciasis is likely to be eliminated as a public health problem within the cost and time frames estimated by WHO. The APOC program started its operations in 1996 and, according to WHO, it is too early to judge whether it will achieve elimination goals within the set time frame.

Chagas' Disease

Although WHO included data on all five cost factors, the estimates for eliminating Chagas' disease are understated because (1) not all countries have submitted estimates and (2) countries that are targeted for elimination of Chagas' disease by 2010 only submitted estimates through 2005. Like onchocerciasis, the cost and time frame estimates vary among several regional efforts. The program for the southern portion of South America⁹ has been underway since 1991, so data from this region are more complete and based on actual experience. However, the efforts in the Central American and Andean countries only began in 1997.¹⁰ Costs and time frames in these countries are less certain because three countries have not submitted cost estimates, and three countries have not submitted prevalence and incidence data. Experts generally agreed that the first program in South America is on track and will probably meet elimination goals by the target date of 2005. However, they believed that the estimates for some of the other countries are likely to increase.

Lymphatic Filariasis

Costs for eliminating lymphatic filariasis are very speculative. While all five direct cost factors were addressed in the estimates, WHO officials said that the data are very preliminary. Unlike its information for some of the

⁸The APOC area includes Angola, Burundi, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo (formerly Zaire), Ethiopia, Equatorial Guinea, Gabon, Kenya, Liberia, Malawi, Mozambique, Nigeria, Rwanda, Sudan, Tanzania, and Uganda.

⁹Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay.

¹⁰The Andean Countries Initiative includes Colombia, Ecuador, Peru, and Venezuela. The Central American Initiative includes Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama.

other diseases, WHO has limited historical data on costs because formal campaigns have only recently begun in some of the 73 countries in which lymphatic filariasis is known to be present. WHO extrapolated actual program costs from the first four country programs to other countries and is continuing to develop more accurate estimates of costs based on further experience. In addition, WHO officials said that they have not completed country assessments to establish the number of people who must be treated in identified countries and to determine whether there are other endemic countries. Quantitative targets for defining elimination have not yet been established, but WHO plans to prepare a draft document with elimination definitions to be reviewed by an expert working group by the end of 1998. According to WHO, initial control programs show such dramatic results in reducing disease transmission that WHO believes that elimination may occur in a number of endemic areas (particularly island populations) after 5 to 6 years of effective control efforts. Experts generally agreed that the disease was a good candidate for elimination but that the costs and time frames were speculative at best.

U.S. Spending on These Diseases and Potential U.S. Savings Associated With Their Eradication or Elimination

The United States currently spends about \$391 million a year on these diseases. This amount includes \$300 million a year on polio and measles prevention programs and leprosy treatment in the United States, and about another \$91 million abroad for all seven diseases (see table 2). Most of this amount would be saved if eradication and elimination goals were met and efforts to combat them ceased or were reduced. The United States does not currently track domestic costs related to Chagas' disease, but there have been discussions about implementing routine blood screening for it. An American Red Cross official estimated this screening could cost \$25 million a year.

Table 2: U.S. Spending on Diseases to Be Eradicated or Eliminated, Fiscal Year 1997 (excluding research spending by the National Institutes of Health)

Dollars in millions			
Disease	Domestic programs	Overseas programs	Total
Dracunculiasis	0	\$0.7	\$0.7
Polio	\$230	74.2	304.2
Leprosy	20	0	20.0
Measles	50	11.7	61.7
Onchocerciasis	0	3.5	3.5
Chagas' disease	0	0.4	0.4
Lymphatic filariasis	0	0.6	0.6
Total	\$300	\$91.1	\$391.1

Sources: USAID; CDC; and the U.S. Department of Health and Human Services, National Hansen's Disease Program.

Potential Cost Savings for Polio and Measles

Polio

The overall savings to the United States as a result of polio eradication are estimated to be at least \$304 million a year, including about \$230 million in public and private expenditures for controlling polio within U.S. borders and about \$74 million for the global eradication effort. This estimate does not include the costs of caring for about eight or nine vaccine-associated polio cases that occur in the United States each year. As a donor, the United States currently funds the global polio eradication effort through CDC and USAID and indirectly through support of the Expanded Programme on Immunization.

According to CDC, about 48 percent of domestic expenditures is for the cost of the oral polio vaccine and about 52 percent is for administrative costs. The U.S. polio schedule is four vaccine doses; until recently, most children received only the oral vaccine. For purposes of estimating savings to the United States with eradication, CDC estimates an additional \$20 million a year may be incurred due to a 1996 CDC recommendation to administer two doses of the more expensive injectable vaccine before administering two doses of oral vaccine. Unlike the injectable polio vaccine, the oral vaccine is a live, attenuated vaccine that causes disease in several people each year in the United States. Providing the injectable vaccine first in the vaccine schedule will lessen the possibility of provoking disease from the oral vaccine. However, the oral vaccine is the

vaccine of choice for eradication because, unlike the injectable vaccine, it prevents the wild poliovirus from readily multiplying in the gut and thus stops person-to-person transmission.

Measles

The overall savings to the United States as a result of eradicating measles are estimated at a minimum of \$61.7 million a year, including about \$50 million for domestic vaccine costs and about \$11.7 million for global measles control efforts. CDC estimates that it spent an additional \$1.3 million on domestic measles research in 1997. The \$50 million spent in the United States only includes the cost of the vaccine and not administration costs because immunization against measles is included in the vaccine for mumps and rubella, and the United States would continue administering mumps and rubella vaccines even if measles were eradicated. Therefore, projected savings are not as large as for the eradication of polio. Additional savings would be realized from preventing periodic measles epidemics in the United States; the last measles epidemic of 1989-91 cost \$150 million, not including costs associated with lost productivity.

U.S. Savings Associated With Achieving WHO's Goals on Other Diseases Are Limited

For the other tropical diseases we reviewed, U.S. savings from eradication or elimination are estimated at about \$25 million. The U.S. Department of Health and Human Services spends approximately \$20 million a year to treat a small number of leprosy patients in the United States. However, without eradication of the disease, it is likely that the United States would continue to have a small number of cases. USAID funds the dracunculiasis eradication effort at \$500,000 a year and the onchocerciasis effort at \$3.5 million a year. CDC spends about \$1 million for overseas efforts against dracunculiasis, Chagas' disease, and onchocerciasis. Eradicating dracunculiasis and eliminating onchocerciasis, Chagas' disease, and lymphatic filariasis will remove or reduce the need for U.S. assistance. In addition, as previously discussed, U.S. blood banks may begin screening donated blood for Chagas' disease due to a significant number of infected Latin American immigrants in certain areas of the United States. Screening requirements might be reduced or unnecessary at some point if a successful elimination effort diminished the threat to the U.S. blood supply.

Experts Suggest Other Diseases as Possible Candidates for Eradication

International public health experts at CDC and Johns Hopkins University and a 1993 report by the International Task Force for Disease Eradication (ITFDE) revealed a number of diseases that pose threats to the United States and that are technically possible to eradicate.¹¹ Diseases commonly mentioned include rubella, mumps, hepatitis B, and Hib. The ITFDE concluded that mumps and rubella could probably be eradicated and that the transmission of hepatitis B could be eliminated by universal vaccination.¹² While these diseases generally meet the technical criteria for eradication, we discuss in the following paragraphs some of the challenges to initiating campaigns at this time and WHO's position on eradicating these diseases.

CDC officials suggested that rubella and mumps could be considered candidates for eradication as part of a measles eradication effort, since they are often included as part of a trivalent vaccine against measles, mumps, and rubella. Their inclusion would result in significant increased savings to the United States because, without the eradication of rubella and mumps, most of the cost of the measles vaccination—vaccine administration—would continue to be incurred after measles eradication. CDC estimated U.S. savings from eradicating measles, mumps, and rubella at about \$255.5 million a year. According to WHO and CDC officials, rubella constitutes a significant health burden in the form of birth defects and is being discussed as an elimination initiative for the Americas. As with polio and measles, a successful strategy in the Western Hemisphere would likely be a model for global eradication. Challenges to eradication are difficulties in diagnosis and the additional costs, particularly for developing countries. WHO said that, because the global burden of mumps is relatively low or unknown in some areas, the costs of an eradication effort would be difficult to justify.

According to WHO and CDC officials, the viral disease hepatitis B may be a candidate for eventual eradication because the vaccine is effective and relatively inexpensive—about 50 to 75 cents per dose. In addition, a good diagnostic tool is available and it appears that humans are the only reservoir for the disease. Hepatitis B is considered a major public health threat because it often progresses to cancer. Almost 1.2 million deaths

¹¹The ITFDE was a group of scientists from WHO, CDC, other health and development agencies, and academia. It was convened by the Carter Center of Emory University during 1989-92 to establish criteria for eradication and to use them to evaluate the potential for eradicating other diseases in the aftermath of the smallpox eradication campaign.

¹²Centers for Disease Control and Prevention: Recommendations of the International Task Force for Disease Eradication. MMWR 1993; 42 (No. RR-16) (Atlanta, Ga.: U.S. Department of Health and Human Services, Public Health Service), pp. 11-13.

result each year from hepatitis B, usually from liver cancer or chronic liver disease. The National Science and Technology Council and the National Institutes of Health estimate that the United States spends about \$720 million each year in direct and indirect costs related to hepatitis B. CDC estimates that U.S. public and private sectors spend from \$308 million to \$383 million a year for hepatitis B vaccines alone. According to CDC officials and the ITFDE report, the major barrier to eradication is that it would take decades to achieve because some people are chronic carriers and would have to die before the disease could be considered eradicated.

Hib is a bacterial infection that is the most common cause of childhood meningitis and, like hepatitis B, poses a serious global disease burden, including 400,000 to 700,000 deaths each year among children in developing countries. The U.S. public and private sectors spend about \$162 million a year on Hib vaccines. According to CDC officials, this disease has potential for eradication but more needs to be known about the vaccine before it could be an eradication candidate. WHO has made Hib a priority for introduction to routine childhood immunization, but cost is a barrier. The vaccine costs \$1 to \$2 per dose, which would substantially increase the vaccine costs of the Expanded Programme on Immunization.

According to WHO officials, due to the public health burden associated with rubella, hepatitis B, and Hib and the success in controlling the diseases in some parts of the world, these three diseases could be eventual candidates for eradication. However, WHO officials noted that, due to the high costs associated with eradication efforts, political will and popular support are as critical to any eradication effort as the technical ability to achieve success. As a result, they said that it is important to limit the number of ongoing efforts and that they do not support adding campaigns at this time. They noted that other diseases could be considered as eradication candidates after success with the currently targeted diseases is achieved.

Other infectious diseases pose a growing threat to the United States but do not have characteristics that make them amenable to eradication. During congressional testimony last year, a WHO official noted several other diseases—in addition to human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS)—that continue to be major public health problems, globally and in the United States.¹³ For example, malaria, which results in about 500 million infections and 2 million to 3 million deaths outside the United States each year, is being imported into the

¹³Statement by David L. Heymann, M.D., Director, Emerging and Other Communicable Diseases Surveillance and Control, WHO, before the Committee on International Relations, House of Representatives, 105th Cong., 1st session, July 30, 1997.

United States about 1,000 times each year. In some instances, malaria is then transmitted locally by mosquitoes present in the United States. During 1996, a tourist to Latin America returned to Tennessee with yellow fever. According to the WHO witness, if mosquitoes in Tennessee had become infected with yellow fever from this patient, they could have caused an epidemic in the United States similar to the one that caused high mortality in the southern United States at the beginning of the 20th century. Outbreaks of dengue fever, another mosquito-borne disease, have occurred in more than 100 tropical and subtropical countries, including recent epidemics in Central America. WHO reported 138,000 deaths from dengue in 1996. There are about 8 million new cases worldwide of tuberculosis each year, a new infection every second, and 3 million deaths in 1996. Finally, influenza, a viral disease, causes between 10,000 and 40,000 deaths each year in the United States alone.

These diseases are not likely candidates for eradication over the next generation for a variety of reasons, although it is possible to control disease transmission in some instances. According to the ITFDE, eradicating malaria has proven difficult due to the lack of an effective vaccine, resistance of some mosquitoes to insecticides, and resistance of some malaria parasites to treatment. Although an effective vaccine for yellow fever has been available for more than 50 years, it has only recently been standardized in freeze-dried form so that its stability, both in the freeze-dried and reconstituted form, resembles measles vaccine. According to WHO officials, the additional cost is proving a major constraint to having endemic countries include it in their routine childhood immunization programs. Yellow fever cannot be eradicated because humans are not the only reservoir for infection—an animal reservoir also exists. No effective treatment is available for dengue fever; the primary intervention is mosquito control—and a possible monkey reservoir for dengue infection is suspected. The need for improved diagnostic tests, chemotherapy, and vaccines is cited as obstacles to eradicating tuberculosis; emerging drug-resistant strains of the bacterium causing tuberculosis have complicated control programs. Finally, influenza reemerges worldwide each year in a new form and is highly infectious; the yearly vaccines are only partially effective. The ITFDE reported that an animal reservoir is also suspected for influenza.

Smallpox Eradication Showed That Success Was Possible

According to the literature and experts with whom we met, the primary lesson learned from the smallpox initiative was that disease eradication can be technically feasible. The smallpox campaign provided valuable institutional knowledge on the role of community, national, and

international mobilization. Eradicating smallpox also meant that costly programs for immunizations and treatment of infected cases were no longer needed. However, unlike most of the diseases that are currently candidates for eradication, smallpox had unique characteristics that made it particularly vulnerable to eradication and therefore has limitations as a model for current efforts.

As the first and only disease to be eradicated through human intervention, smallpox is used as evidence that disease eradication is technically feasible. According to some experts, the smallpox effort yielded lessons that have since been applied to other disease control and health care efforts, such as the role of surveillance and the ability to garner resources for massive campaigns.

The considerable amounts spent on smallpox prevention and treatment ceased after eradication, resulting in considerable savings. Using 1967 estimated smallpox costs¹⁴ as a baseline measure for savings from smallpox eradication and adjusting for annual birth rates, we estimated the cumulative present value global savings in 1997 dollars for the post-eradication period 1978-97 at \$168 billion. This amount included vaccinations, treatment, and loss of economic productivity for developing countries.¹⁵ For the United States, cumulative savings from smallpox eradication are estimated at \$17 billion. The United States spent about \$610 million in 1997 dollars for domestic smallpox control in 1968 and about \$130 million in 1997 dollars during 1968-77 on the overseas eradication effort. We estimated the annual real rate of return for the United States at about 46 percent per year since smallpox was eradicated.

Smallpox had the characteristics that experts consider desirable for eradication. The disease was easily diagnosed, and all infections resulted in visible symptoms. The smallpox vaccine was effective with only one dose, stable in heat, and inexpensive. Polio and measles share many of the desirable eradication characteristics of smallpox, including being viral agents with human-only reservoirs, having effective interventions available to interrupt transmission, and providing long-lasting immunity after vaccination. However, certain differences exist. For example, smallpox was less infectious than either polio or measles. Polio is difficult to diagnose without laboratory confirmation because the vast majority of infections show no symptoms, and the paralytic manifestations of polio

¹⁴F. Fenner, et al., *Smallpox and Its Eradication* (Geneva, Switzerland: WHO, 1988), pp. 1364-65.

¹⁵If cost savings are limited to vaccinations and their related costs, the cumulative global savings are estimated at \$41 billion.

can be due to other causes. In addition, while the oral vaccine is easy to administer and does not always require trained health workers, up to four doses are recommended, and the vaccine is sensitive to heat, requiring refrigeration until administered.

Similarly, measles is not as easily diagnosed as smallpox and is much more infectious. Because the measles virus spreads so easily and the diagnosis may present difficulties, the surveillance and containment strategies used for the smallpox eradication campaign are not as effective for measles, and a surveillance strategy uniquely tailored to measles is required. Even in the United States, where transmission of the measles virus has essentially been interrupted since 1993, occasional outbreaks still occur due to imported virus.

Dracunculiasis is very different from smallpox since it is a parasitic disease and not vaccine preventable. However, like smallpox, it is vulnerable to eradication efforts primarily because the interventions are inexpensive and effective, and the infection is easily diagnosed. Simply using a water filter and keeping infected persons out of the water supply can stop transmission of the disease. The main barriers to eradication within the time frames set by WHO are ongoing civil strife in the endemic regions of Africa and a potential lag in national and donor support for a disease that is found mostly in isolated rural areas.

Conclusions

The soundness of WHO's cost and time frame estimates for eradicating and eliminating these seven diseases varies for each disease. The estimates are most sound for diseases where eradication or elimination campaigns have been underway for several years. For the other diseases, complete data are unavailable so the estimates are more speculative. WHO officials acknowledge their estimates are a snapshot in time, based on the information then available. They also pointed out that they are continuously revising their assumptions and the data underlying cost factors to refine the estimates.

For some of the diseases, WHO indicated that obtaining good data will be difficult because many developing countries do not have good disease surveillance systems or the health infrastructure to collect and report the information. Moreover, WHO indicated that external factors, such as civil strife and government commitment to disease eradication and elimination, can influence the cost and time frame estimates.

The United States is spending a significant amount to combat these diseases domestically and overseas, most of which could be saved if eradication and elimination efforts are successful. In addition, other diseases posing significant public health problems and costs for the United States may be potential candidates for eradication and possible U.S. savings if the current strategies prove successful.

Agency Comments

WHO, the State Department, CDC, and USAID provided written comments on a draft of this report. Their responses and our evaluation, where appropriate, are printed in appendixes X through XIII. WHO, CDC, and USAID also provided technical comments, which we incorporated as appropriate.

WHO stated that the report fairly reflects the processes it is using to estimate the costs and time frames associated with global eradication or elimination of the seven diseases. WHO pointed out that, as we state in our report, such estimates are most complete for those diseases with long-standing campaigns and closer target dates and that all estimates are refined as new information becomes available. WHO noted that successful campaigns against a disease must build on and build up strong national and international health infrastructure, such as routine immunization, disease reporting systems, trained health workers, and laboratory capacity. WHO stated that the explanations in the report appendixes about the unique challenges faced by each campaign should prove useful to decisionmakers in focusing on these important contextual dimensions.

The State Department stated that our report provides a comprehensive analysis of WHO's estimates. State noted that estimates are inexact and should not become an unrealistic yardstick for measuring costs. State also said that the value of investments in eradication and control should provide support for U.S. investment in bilateral and multilateral programs associated with campaigns against diseases. However, State pointed out that it is important to maintain a balance between eradication and elimination programs and other vital health care programs. State indicated that resources should not necessarily be diverted to eradication programs from other important health activities because, while the results may not be as dramatic, they are nonetheless essential.

CDC discussed the benefits of eradication programs, citing the 46 percent annual return on investment we estimated for smallpox and the \$300 million that could be saved by the United States as a result of polio eradication. CDC added that these costs will be saved in perpetuity. CDC

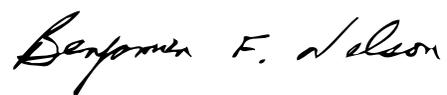
also noted that it appreciated our “recognition of the value of disease eradication and elimination programs.” However, we did not assess the value of eradication or elimination programs. Rather, our work focused on WHO’s estimates of program costs and potential U.S. savings based on current expenditures.

USAID commented that in general our report was comprehensive and informative. However, USAID expressed concern that we did not fully consider the costs and concerns regarding disease eradication and as a result we imply that there is global consensus on the eradication potential of the seven diseases reviewed. In particular, USAID said that we did not consider the financial and opportunity costs to health systems of eradication campaigns and that we implied a consensus on the feasibility and soundness of measles eradication. USAID said that eradication campaigns can be disruptive to primary health care systems and may result in an unfortunate reduction in efforts to prevent other diseases. As recognized by USAID, our report clearly states that our objective was to assess the soundness of WHO’s estimates. We did not assess the potential impacts of eradication or elimination campaigns on national health care systems. In addition, we do not imply that there is a global consensus on measles. In fact, our report specifically discusses many of the experts’ views and the challenges facing eradication and elimination campaigns, particularly for measles.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies of this report to the Director General of WHO, the Secretary of State, the Director of CDC, the Administrator of USAID, and other interested congressional committees. Copies will be provided to others upon request.

Please contact me at (202) 512-4128 if you or your staff have any questions concerning this report. Major contributors to this report are Lynne Holloway, Audrey Solis, Ann Baker, and Bruce Kutnick.

Sincerely yours,

A handwritten signature in black ink that reads "Benjamin F. Nelson". The signature is written in a cursive style with a large initial 'B' and a long, sweeping tail on the 'n'.

Benjamin F. Nelson
Director, International Relations
and Trade Issues

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Abbreviations

AIDS	acquired immunodeficiency syndrome
APOC	African Programme for Onchocerciasis Control
CDC	Centers for Disease Control and Prevention
DEC	Diethylcarbamazine
HIV	human immunodeficiency virus
ITFDE	International Task Force on Disease Eradication
PAHO	Pan American Health Organization
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
WHO	World Health Organization

Summary Descriptions of Seven Diseases Proposed for Eradication or Elimination

Disease	Type of infection	Mode of transmission	Characteristics	Endemic countries/regions
Dracunculiasis (guinea worm disease)	Parasitic	Drinking water contaminated with water fleas that carry the larvae of the parasite.	Adult worm (up to 1 meter in length) migrates through the body, usually emerging painfully through the foot and causing illness and incapacitation for weeks or months.	16 countries in Africa, plus Yemen
Polio	Viral	Human to human, via contact with feces of an infected person.	Usually no or mild symptoms; attacks the central nervous system and may cause aseptic meningitis (in 5%-10% of cases), paralysis or reduced breathing capacity (in less than 1% of cases), or death.	Originally throughout the world; still endemic in 61 countries in Africa, Asia, and Europe
Leprosy	Bacterial	Believed to be primarily human to human, via droplets from respiratory tract of a severely infected person, but exact mode of transmission is not fully understood.	Slowly affects skin, nerves, and mucous membranes; can lead to permanent damage to nerves, bones, eyes, and other organs and deformities of face and extremities after many years.	55 countries throughout the world, with most cases in Southeast Asia
Measles	Viral	Human to human, via droplets from respiratory tract of an infected person.	High fever, malaise, conjunctivitis, congestion, and cough, followed by rash; may lead to serious complications or death, especially from secondary infections.	Throughout the world
Onchocerciasis (river blindness)	Parasitic	Bite of blackflies that carry the larvae from human to human.	Adult worms lodge in nodules under the skin; immature worms move through the body, causing intense itching, skin disease, swollen genitals, and visual impairment or blindness.	36 countries in Africa and the Americas, plus Yemen (99% of cases are in Africa)

**Appendix I
Summary Descriptions of Seven Diseases
Proposed for Eradication or Elimination**

Estimated number of new cases per year	Estimated global health burden (selected data)	Primary interventions	Progress	Challenges to eradication or elimination
152,814 reported cases ^a (1996)	Temporary illness and incapacitation in every case.	Water filters or other water safety measures to prevent ingestion of parasite; prevention of persons with emerging worms from entering drinking water supply.	Global prevalence reduced by 97% between 1986 and 1996. Eradication certified in Pakistan in 1997.	Civil unrest in Sudan, where about 75% of cases now occur.
35,000 (1997)	Deaths: 1,750 (1997). Paralysis: 10 million-20 million total cases.	Vaccine	Elimination of the wild virus in the Americas certified in 1994. Global prevalence reduced by over 90% since 1988.	Need to maintain vaccination coverage of 90% in all countries until eradication effort is complete. Inadequate surveillance of acute flaccid paralysis in some countries.
566,604 (1997)	Deaths: 2,000 (1996). Disabilities: 1 million-2 million total cases.	Drug treatment	Global prevalence reduced by 84% since 1985 with the introduction of multidrug therapy.	Need to detect hidden cases and reach patients in remote and underserved areas.
31.077 million (1997)	Deaths: 961,000 children (1997).	Vaccine	Incidence reduced 99% since 1990 in the Americas. Transmission interrupted briefly in some countries, including the United States.	High infectiousness requires very high vaccination coverage (95% or higher). Measles is not perceived as a major burden by many developed countries, which results in poor surveillance and lack of willingness to improve control.
Data not available	Deaths: 47,000 (1996). Blindness: 270,000 cases. Other visual impairment: 500,000 cases. Skin disease: 6 million cases. (Above are totals.)	Drug treatment; insecticide spraying to control blackflies.	In West Africa, near elimination in original program area (seven countries), 1.5 million cured, and blindness prevented in 185,000.	Need to sustain implementation of long-term, community-based drug treatment. Possibility of development of resistance to drug.

(continued)

Appendix I
Summary Descriptions of Seven Diseases
Proposed for Eradication or Elimination

Disease	Type of infection	Mode of transmission	Characteristics	Endemic countries/regions
Chagas' disease	Parasitic	Contact with feces of certain parasite-carrying insects that bite humans; also transmitted through blood transfusions and congenitally.	Initial acute phase may cause illness or, rarely, death; possibly fatal damage to heart and digestive tract may occur in chronic phase many years after infection.	18 countries in Central and South America
Lymphatic filariasis	Parasitic	Bite of mosquitoes that carry the larvae from human to human.	Adult and immature worms damage the lymphatic ducts, causing gross swelling and sores on limbs, genital areas, and breasts and damage to lymphatic and renal systems.	At least 73 countries in Africa, Asia, South and Central America, and the Pacific islands

**Appendix I
Summary Descriptions of Seven Diseases
Proposed for Eradication or Elimination**

Estimated number of new cases per year	Estimated global health burden (selected data)	Primary interventions	Progress	Challenges to eradication or elimination
500,000 (1997)	Deaths: 45,000 per year. Chronic complications: 2 million-3 million total cases.	Insecticide treatment of houses to control insects; blood screening to prevent transmission through blood supply; drug treatment for acute and congenital cases.	Transmission interrupted in Uruguay in 1997. Significant reductions in house infestation and prevalence of human infection in Argentina, Brazil, and Chile.	Insect carriers in Andean and Central American countries cannot be controlled by household insecticides and will require development of new strategies.
Data not available	Swollen limbs and genitals and lung disease: 44 million total cases. Preclinical damage to organs: 76 million total cases.	Drug treatment or regular use of drug-fortified table salt to kill immature worms; limited control of mosquito populations; hygiene measures, antibiotics, and antifungal agents to treat effects of the disease.	A few national control programs are underway. SmithKline Beecham recently agreed to donate one drug (albendazole) to all endemic countries.	National and international funding commitments are uncertain.

^aThe number of reported disease cases is generally less than the number of actual cases. For dracunculiasis, the World Bank estimated that the total number of cases in 1996 was 330,000.

Sources: WHO and other data sources.

Dracunculiasis (Guinea Worm Disease)

Disease Characteristics

Dracunculiasis is caused by the parasite *Dracunculus medinensis*, or guinea worm. Infection occurs by drinking water contaminated with the intermediate hosts (water fleas) of the parasite. Once a person is infected, the worm migrates throughout the body, growing to a length of up to 1 meter. About a year after infection, the worm emerges from the body, normally through the foot, causing an intensely painful swelling and blister. Perforation of the skin is accompanied by fever, nausea, and vomiting. Secondary infections are common and can cause permanent deformity of the joints. Although the infection rarely kills, it inflicts intense suffering and sickness for at least several months, and a small percentage of victims may become permanently disabled. The diagnostic tools for dracunculiasis are visual and testimonial. Health workers and trained villagers can see the emerging worms or the scars from previous infection and take the testimony of the victim.

In endemic countries, the disease typically appears during the agricultural season, with farmers in particular being affected. A United Nations Children's Fund (UNICEF) study of an area in Nigeria with 1.6 million people found that rice farmers lost about \$20 million a year due to the effects of the disease on their ability to harvest. A World Bank study showed an economic rate of return of 29 percent for the eradication program for 1987-98, acknowledging a conservative assumption of 5 weeks for the average disability period caused by infection.¹ According to the World Bank study and a Carter Center expert on dracunculiasis, the average period of disability is about 8 weeks.

Dracunculiasis is present in Yemen and 16 countries in Africa, 10 of which are considered least developed countries. Last year, Pakistan was the first endemic country to be certified free of dracunculiasis; India and Kenya recently reached zero cases. The number of endemic villages decreased from about 23,000 in 1992 to 9,900 in 1996; reported cases during the same period fell from 422,555 to 152,814, according to the World Health Organization (WHO).

Strategy for Eradication

Dracunculiasis eradication has been divided into three major phases—interruption of transmission in endemic countries, surveillance in formerly endemic countries, and certification that countries are free of the disease. Because no vaccine or drugs exist to prevent dracunculiasis or to kill the worm inside the body, interrupting transmission of the disease is

¹Cost-Benefit Analysis of the Global Dracunculiasis Eradication Campaign, The World Bank, Africa Human Development Department (Washington, D.C.: Oct. 1997).

the basis of eradication. The strategy promoted in endemic countries combines several approaches, including community-based surveillance, case containment measures, and targeted interventions such as provision of safe water, health education, community mobilization, distribution of filters, and treatment of selected water sources.

According to WHO, the most powerful tools in monitoring eradication of dracunculiasis are village-based surveillance and case containment strategies. For effective surveillance, cases should be identified prior to worm emergence or within 24 hours after the worm appears. Due to the intense pain as the worm emerges, victims often put their foot in the nearest water source, thereby releasing the larvae back into the water to reproduce and continue the contamination. Once a case is identified, containment measures are initiated, the wound is bandaged to help prevent further transmission, and the patient is advised to avoid contact with stagnant water. The community is educated regarding prevention and containment and encouraged to filter or boil drinking water. According to WHO, this strategy has proven very effective and has been implemented in almost all endemic villages, except in Sudan. Other methods to provide safe drinking water include digging bore-hole wells and treating water sources with larvicide. Wells are considered the best option because they provide protection against diarrheal diseases. However, such interventions are more expensive.

Challenges to Eradication

Experts agree that eradication of dracunculiasis is feasible and no technical obstacles exist. The relatively simple interventions for interrupting transmission and the community-based surveillance network are effective. Potential obstacles to achieving eradication within the time frames set by WHO include ongoing civil unrest and unanticipated upheavals in health, communications, and transportation infrastructure. Some experts are concerned about sustaining donor and national support for eradicating a disease rarely seen outside rural and often remote areas; they caution that such support must be maintained to achieve eradication.

Polio

Disease Characteristics

Polio is an infectious disease caused by any of three related types of poliovirus that mostly affect children under three. The virus usually enters through the nose or mouth and multiplies in the throat and intestines. Poliovirus can enter the bloodstream and invade the central nervous system. As it multiplies, the virus destroys the motor neurons that activate muscles. These nerve cells cannot be regenerated, and the affected muscles no longer function. Muscle pain, spasms, and fever are associated with the rapid onset of acute flaccid paralysis. In the most severe cases, poliovirus attacks the motor neurons of the brain stem, reducing breathing capacity and causing difficulty in swallowing and speaking. Without adequate respiratory support, this type of polio can result in death by asphyxiation.

Although paralysis is the most visible sign of polio infection, less than 1 percent of polio infections result in paralysis. About 90 percent of cases produce either no or mild symptoms and usually go unrecognized. The remaining cases involve mild, flu-like symptoms common to other viral infections but do not result in paralysis. About 5 to 10 percent of all polio infections result in aseptic meningitis, a viral inflammation of the outer covering of the brain. There are no animal or insect reservoirs or long-term human carriers. Once deprived of its human host, poliovirus will rapidly die out.

While most people are unaware of their infection, they can shed the virus intermittently in feces for several weeks. This enables the rapid spread of poliovirus, especially in areas with poor sanitation and hygiene, but also in any environment in which young children, not yet fully toilet trained, are a ready source of poliovirus transmission. Poliovirus circulates “silently” at first—possibly infecting up to 200 people before the first case of polio paralysis emerges. Due to this silent transmission and the rapid spread of the virus, WHO considers a single confirmed case of polio paralysis to be evidence of an outbreak.

Protective immunity against polio is established through immunization or as a result of natural infection with the virus. Polio infection provides lifelong immunity to the disease but the protection is largely limited to the particular type of poliovirus involved and may fail to protect against the other two types. Immunization provides protection against all three types of poliovirus.

The last case of indigenous polio in the Western Hemisphere was reported in Peru in August 1991; the Pan American Health Organization (PAHO)

certified the eradication of polio from the Americas in 1994. In 1996, 155 countries and territories reported zero cases of polio. Polio is still considered endemic in 61 countries, mostly in Africa and Asia. Before 1996, India accounted for over half the world's polio cases every year; however, India's polio eradication strategy has recently decreased this portion to about 25 percent of worldwide polio cases.

It is estimated that about 10 million to 20 million people of all ages are living with paralysis due to polio. The number of reported cases was 4,074 in 1996—a decline from 35,251 reported in 1988. However, due to incomplete epidemiological surveillance in many countries, WHO estimates that approximately 35,000 to 40,000 cases of paralytic polio occurred in 1996. Before the development of polio vaccines, it is estimated that about 500,000 people a year were paralyzed or died after contracting the disease.

Strategy for Eradication

WHO's strategy for polio eradication has four components: routine immunization coverage, supplemental immunization in the form of mass campaigns or national immunization days, effective surveillance, and door-to-door campaigns ("mop-ups") in the final stages in areas where the virus persists.

According to WHO, routine coverage with four doses of oral vaccine is needed among infants to reduce the incidence of polio and make eradication feasible. Unless high routine coverage is maintained, pockets of nonimmunized children accumulate, creating ideal conditions for the spread of the virus. National immunization days are intended to supplement routine immunization. In polio endemic countries, this usually means organizing two rounds of national immunization days a year, 1 month apart, over at least 3 years or until circulation of the virus is interrupted in the country. For the poorest endemic countries, where health, communications, and transportation systems are most deficient, WHO estimates that 5 years of national immunization days may be necessary.

Surveillance is needed to pinpoint where and how the wild poliovirus is still circulating and to verify when it has been eradicated. Health care workers are asked to report every case of acute flaccid paralysis in any child under 15. The number of cases reported each year is used as an indicator of the effectiveness of a country's surveillance system. Because it is often difficult to tell whether a case of acute flaccid paralysis is caused by polio, WHO recommends laboratory-based surveillance in

addition to collecting clinical and epidemiological information. Early detection and testing are essential because the highest concentrations of the virus are found during the first 2 weeks after the onset of paralysis. Precise information on the patterns of poliovirus spread is considered essential in developing strategies for global eradication. Finally, following up on surveillance data, mop-up campaigns are conducted door to door to provide two doses at 1-month intervals to immunize all children under 5 in high-risk districts regardless of the child's immunization status.

Challenges to Eradication

As the more developed countries reach eradication goals, the least developed countries are just beginning to conduct national immunization days and increase routine coverage. The poorest countries are least able to support vaccine programs. In the countries of the Americas, national funding averaged 80 percent of the costs, and campaigns were started in countries with generally higher routine vaccine coverage than in most African countries. WHO estimates that the poorest countries fund about 25 to 75 percent of the costs and, in countries affected by conflict, 100 percent of the costs may need to be funded from external resources. Many of the least developed and most unstable countries are unable to reach the majority of their population with even the most basic health services. Some academic experts also state that, while local mobilization for supplemental campaigns can be sustained for 2 or 3 years, the volunteer spirit dissipates as the disease appears to be under control. At that point, supplemental campaigns tend to become more expensive.

At the same time, WHO fears that "donor fatigue" may set in and the competing needs for funds to combat other infectious diseases—some more widespread and life-threatening than polio—will slow the eradication momentum. According to the U.S. Agency for International Development (USAID) officials and several academic experts, eradicating polio is not a priority for developing countries compared to controlling malaria, tuberculosis, acquired immunodeficiency syndrome (AIDS), and diarrheal and respiratory diseases. These experts assert that, if eradication is to be achieved, industrialized countries, which will enjoy greater benefits from eradication, need to assume a substantial part of the cost.

Developing a surveillance system is a long-term process that must be maintained until eradication is certified. Surveillance of acute flaccid paralysis poses special difficulties in countries with inadequate health, transportation, and communication infrastructures. According to WHO, of the 61 countries where polio is endemic, less than 10 percent are meeting

the essential criterion of reporting at least 1 case of acute flaccid paralysis for every 100,000 children under 15. Moreover, by the end of 1996, 25 polio-endemic countries had not officially established a surveillance system for acute flaccid paralysis, a crucial requirement for certifying eradication.

In some countries, infrastructures have been destroyed by war and neglect, vaccine supply lines cut off, and immunization programs suspended, setting the stage for an upsurge in polio and other vaccine-preventable diseases. War-related outbreaks of polio occurred in Chechnya in the Russian Federation in 1995, in Iraq during 1992 and 1993, and in Sudan in 1993. Today, emerging polio-free areas are threatened by continuing unrest in Afghanistan, Angola, Iraq, Liberia, Somalia, Sudan, and the Democratic Republic of the Congo (formerly Zaire). However, as some officials have pointed out, unrest existed in several countries near the end of the smallpox eradication effort, yet political pressure and massive, military-style campaigns allowed health workers to deliver the vaccine.

Leprosy

Disease Characteristics

Leprosy is a chronic infection caused by a bacillus that multiplies very slowly and mainly affects the skin, nerves, and mucous membrane; infection may lead to permanent disfigurement, disability, and deformity. Humans are the primary reservoir for leprosy, although some wild animals, such as the armadillo in the southwestern United States, may also serve as reservoirs. The transmission cycle of the disease is not fully defined, but it is generally accepted that infected humans serve as the source for all human infections, most likely through droplets spread from more severe cases. Leprosy cases are diagnosed through existing health facilities. Minimum diagnostic procedures include clinical examination and a skin smear. Detection of leprosy remains a challenge because leprosy patients are often ostracized from society or they are ashamed of the disease and hide themselves from public view.

Leprosy remains a public health problem in 55 countries, but only 16 of these are considered seriously endemic, accounting for 91 percent of the cases.¹ At the beginning of 1997, there were about 1.15 million leprosy cases, a significant decrease from the 10 million to 12 million estimated cases in 122 countries in 1985.

Strategy for Elimination

The overall strategy for eliminating leprosy is to ensure cases are identified and patients have access to treatment. Leprosy cases are divided into two general categories. Paucibacillary cases are those that have fewer bacteria—normally less than 1 million bacilli in a gram of skin tissue. Multibacillary cases—the most serious and infectious cases—may have more than 100 billion bacilli. Leprosy is curable with a combination of drugs—dapsones, rifampin, and clofazimine—known as multidrug therapy. This combination has prevented the bacillus from becoming resistant to any one of the three drugs. According to the Centers for Disease Control and Prevention (CDC), for paucibacillary patients, the treatment is six doses of rifampin within a 6-month period plus daily dapsones. Until recently, multibacillary patients received 24 doses within a 24 to 36 month period. In June 1997, however, the Expert Committee on Leprosy recommended reducing treatment for multibacillary patients to monthly doses of rifampin for 12 to 18 months plus daily dapsones.

In most countries, multidrug therapy services have reached patients who have easy access to the health care system. However, certain areas in some endemic countries have patients who have not been reached

¹These countries, in order of number of estimated cases, are India, Brazil, Indonesia, Bangladesh, Myanmar, Nigeria, Nepal, Democratic Republic of Congo (formerly Zaire), Mozambique, Ethiopia, Madagascar, Sudan, Philippines, Cambodia, Tanzania, and Guinea.

because there is no health infrastructure to deliver multidrug therapy, the present geographical coverage is poor, or the health services for delivering multidrug therapy are not operating properly. To reach these patients, leprosy elimination campaigns and special action projects have been established so that elimination goals can be achieved. Campaigns are based on three elements: diagnosing and treating patients, increasing community awareness and participation, and establishing capacity-building measures for health workers.

Challenges to Elimination

While WHO and other experts agreed that the elimination program has been largely successful, they noted several factors that may affect achieving elimination by the year 2000. In densely populated countries with significant numbers of infected people, large declines in cases, even as much as 95 percent, may not be enough to reach the elimination target. Civil unrest and difficult conditions in countries such as Sudan, Nigeria, Sierra Leone, and the Democratic Republic of the Congo (formerly Zaire) may delay detection, treatment, and surveillance. Complacency may also become a problem as some countries believe they have done a good job and cease conducting campaigns. Finally, leprosy patients are often ostracized and hidden, making case identification difficult and possibly slowing progress toward elimination of leprosy.

Measles

Disease Characteristics

Measles is a highly contagious viral disease that mostly affects children. Before vaccines were available, almost everyone eventually acquired measles, usually as a young child. The virus is transmitted by droplets or airborne spray from the respiratory tract of infected individuals to mucous membranes in the upper respiratory tract or eyes of susceptible persons. Secondary attack rates among susceptible household members are reported to be more than 80 percent. Humans are the only known reservoir for measles infection, although some primates can be infected. Protective immunity against measles is established either through immunization or as a result of natural infection with the virus. Global immunization coverage of infants is estimated at about 80 percent; in WHO's Africa region, the rate is only about 56 percent. The virus is not expected to develop a resistance to the vaccine.

The clinical diagnosis of measles can be difficult, particularly as incidence decreases, making surveillance a challenge. Measles symptoms develop approximately 10 days after exposure. The early symptoms of high fever, malaise, conjunctivitis, upper respiratory congestion, and cough are followed after 2 to 4 days by a rash that lasts several days. The patient is most infectious during the earlier phase but can transmit the virus during the first 3 to 4 days after the rash appears. Communicability generally decreases rapidly after the appearance of the rash. Rashes due to other causes, such as other viruses and drug reactions, and accompanied by similar symptoms, are easily confused with measles.

About 1 million deaths each year are attributed to measles, the vast majority of them children under age 5 in developing countries. About another 30 million cases survived the illness in 1997. Complications, such as ear infections, pneumonia, croup, and diarrhea are common in young children, and acute encephalitis occurs in about 1 of every 1,000 cases. Measles is more severe among malnourished children in developing countries. For the most part, measles transmission has been interrupted in the Americas and the United Kingdom. According to CDC, measles reached record low levels in the United States during 1997, with a provisional total of 135 cases reported. However, measles outbreaks may still occur in the United States and other developed countries that have maintained high immunization coverage.

Strategy for Elimination and Eventual Eradication

Measles elimination refers to the interruption of transmission of the virus in a sizable geographic area in which vaccination would nevertheless need to continue because reintroduction of the virus is an ongoing threat. Eradication is the global interruption of measles transmission,

representing the sum of successful elimination efforts in all countries. Once eradication is achieved, vaccinations could be stopped without risk of future measles outbreaks.

Estimates of the appropriate level of population immunity needed to stop transmission of the virus vary. Many variables affect transmission, such as population density, living patterns, and temperature and humidity, but the consensus is that transmission is very efficient. Outbreaks have been reported in populations in which as few as 3 to 7 percent of individuals were susceptible. Current estimates of the routine coverage needed range from 90 to 95 percent or higher, and some experts suggest that 97 percent may not be enough under certain conditions.

WHO is using PAHO's measles elimination strategy as guidance in developing a possible global measles eradication initiative. This strategy aims to (1) rapidly interrupt measles transmission by initially conducting mass campaigns and (2) maintain interruption of transmission by sustaining high population immunity through vaccination of infants at routine health services facilities supplemented by periodic mass campaigns. Surveillance of both symptoms and virus transmission is to be a key part of this strategy.

Challenges to Eradication

Many countries have made significant progress in decreasing the transmission of the measles virus; in the Americas, measles incidence decreased by 99 percent from 1990 to 2,109 cases in 1996. However, the nature of measles presents several challenges to an elimination or eradication campaign. It is highly contagious and requires high immunization coverage rates that are difficult to achieve, even in the most developed countries. The accumulation of susceptible persons over time is considered the most serious impediment to the elimination or eradication of measles. However, experts at WHO, PAHO, and CDC believe that strategies that provide at least two doses of vaccine to each child can overcome this challenge.

The timing of immunization also presents special difficulties. Vaccinating infants under 12 months is less effective due to the presence of maternal antibodies and hastens the accumulation of susceptible preschool aged children. The PAHO strategy and experience in the United States demonstrate that vaccinating at 12 to 15 months or switching to a two-dose schedule provides immunity more effectively. However,

vaccinating those under 12 months has substantially reduced measles incidence in this group, in which mortality from this disease is the highest.

Some experts express concern that use of the PAHO strategy as a model may not work globally or will require modifications to allow for less favorable country conditions. They point out that high immunization coverage and surveillance have been successful in the Americas due to the relatively advanced state of the health, transportation, and communications infrastructure in these countries compared with the infrastructure of the least developed countries. Good surveillance systems allow PAHO countries to calculate the number of susceptible children and target campaigns accordingly. Some experts remain doubtful that such high coverage and good surveillance can be achieved in the least developed countries with much weaker infrastructure. WHO officials agreed that sustaining a measles eradication campaign in the poorest countries will be a challenge.

In addition to technical challenges, political commitment in selected industrialized countries and adequate donor support for low-income countries remain uncertain. While measles is a major childhood killer among the poor, it is often perceived as a mild illness, and many industrialized countries do not consider the disease a major public health threat. This perception can inhibit the public and political support for allocating the resources needed for a successful eradication effort. Accordingly, immunization coverage and surveillance systems in many areas, including industrialized countries, are inadequate to interrupt transmission. The measles strains that enter the United States, for example, largely do not originate in less developed countries. Most measles strains imported into the United States come from France, Germany, Japan, and Italy, according to CDC. However, according to WHO and CDC officials, support for measles eradication is increasing. For example, the more than 50 countries encompassing WHO's region for Europe and the former Soviet Union are in the final stages of adopting a goal of regional elimination by 2007, and WHO's Eastern Mediterranean region has adopted an elimination goal by 2010.

Despite the challenges to measles eradication, WHO and CDC officials believe that a global measles eradication strategy should be pursued based on the burden of the disease and the technical feasibility of eradication. They point out that similar skepticism existed before and during the early years of the smallpox and polio eradication initiatives. Several global meetings on measles, sponsored primarily by WHO, PAHO, UNICEF, and CDC,

have been held in recent years to discuss challenges and build consensus on eradication. At the most recent meeting of about 200 public health experts in February 1998, measles was identified as the leading candidate for the next global eradication initiative due to its biological feasibility, high mortality and complications among children, effective interventions, demonstrated feasibility in the Americas, increasing global support, and potential cost benefits. According to USAID, participants also agreed that further study should be undertaken regarding operational feasibility and possible costs to the development of sustainable primary health care systems before a global campaign is launched.

Onchocerciasis

Disease Characteristics

Onchocerciasis, also known as river blindness, is a chronic parasitic disease that causes blindness and severe skin conditions. The clinical manifestations of the disease include formation of nodules under the skin, changes in skin pigmentation, loss of skin elasticity, debilitation, severe itching, visual loss, and blindness. A World Bank study for calculating the net benefits of the Onchocerciasis Control Programme in West Africa assumed that people who become blind due to the disease live another 8 years with blindness and die 12 years prematurely, thus indicating that preventing one case of blindness can add 20 years of productive life.¹

Humans are the only known host for the disease. The parasite is transmitted between humans by the bite of blackflies, which breed in streams and rivers. When a fly bites an infected human host, the fly becomes infected with the larvae of *Onchocerca volvulus*. When the infected fly bites another human, the larvae may develop into adult worms (macrofilariae) in the human, producing offspring, or microfilariae. These microfilariae may in turn be ingested by other blackflies, thus continuing the transmission. A human is infectious to the blackfly only when microfilariae are present; the adult worm is not transmitted. However, the adult worms usually live about 12 to 15 years inside the body and generally keep reproducing microfilariae for much of that time if not treated.

Although onchocerciasis is considered nonfatal, it is the second leading cause of infectious blindness and the source of enormously debilitating skin disease. WHO estimates that 120 million people are at risk and that 18 million are infected. Blindness afflicts about 270,000 persons, and about 500,000 suffer visual impairment. Severe itching and dermatitis affect about 6 million. Onchocerciasis is suspected to be endemic in 30 countries of sub-Saharan Africa, in Yemen, and in 6 countries in Latin America. Because the disease is endemic in fertile river valleys, it has had significant socioeconomic impact over the years as residents have abandoned villages with arable land and moved to more arid areas. The first onchocerciasis control program in West Africa has resulted in people beginning to resettle in lands that have been deserted for as long as 50 to 100 years, resulting in increased income levels. Twenty-five million hectares have been opened for resettlement and cultivation, an area that can feed a population of about 17 million people.

¹Aehyung Kim and Bruce Benton, *Cost-Benefits Analysis of the Onchocerciasis Control Programme*, World Bank (Washington, D.C.: Nov. 1994).

Strategy for Elimination

Two specific elimination strategies have been implemented: controlling the vector (blackfly) in endemic areas and treating infected persons with ivermectin. Vector control is accomplished through the use of larvicide in rivers and streams, mostly by helicopter spraying, and aims at interrupting disease transmission. The drug ivermectin kills the microfilariae, thus arresting further development of the disease. It has a very limited effect, if any, on killing the adult worms. Treatment with ivermectin once a year is considered sufficient to prevent blindness. Ivermectin treatment reduces transmission of the parasite but does not appear to halt it. Annual, large-scale treatment will therefore have to continue for a long time. Current predictions based on a simulation model indicate that annual treatment at the current level of coverage may have to continue for about 1-1/2 to 2 decades, although elimination of the disease as a public health problem is likely to occur before the full treatment regimen is complete. A third treatment option, not widely used, is removing the nodules under the skin in which the microfilariae are lodged.

Challenges to Elimination

Sustainability of community-directed ivermectin distribution systems is a potential concern. Cost estimates assume that community-based programs will be independent within 5 years, but this may be modified as these systems are evaluated. One issue is whether community volunteers will continue to work without compensation. Another unknown is whether people will continue to come for treatment after their condition improves, but WHO officials do not see this as a problem at this time. It is also uncertain whether the parasite will develop resistance to ivermectin. A final challenge to eliminating onchocerciasis within estimated costs and time frames is the fact that WHO is still mapping the prevalence of the disease in the area of the African Programme for Onchocerciasis Control, where the population to be treated appears to be greater than originally estimated.

Chagas' Disease

Disease Characteristics

Chagas' disease is a parasitic disease with both acute and chronic complications. It is caused by a parasite, *Trypanosoma cruzi*, contained in the feces of reduviid insects. More than 100 species of mammals have been found infected. Normally, humans become infected following the insect's bite, but the contaminated feces may also enter through the mucous membrane when a child rubs or scratches a bite then touches his or her eyes or mouth. The parasite may also be transmitted from human to human through transfusions of contaminated blood or through congenital transmission from an infected mother to the fetus. The insect favors poverty conditions, normally living in the cracks of poorly built or decaying housing.

The acute phase of Chagas' disease appears shortly after infection and often has no distinctive symptoms. It can be characterized by inflammation at the site of the infection and flu-like symptoms. If the parasite is introduced into the eye, conjunctivitis and swelling of the eye area develops. A characteristic lesion may also develop, but often the disease goes unnoticed and undiagnosed during this period. However, it is during the early phase of the infection—lasting only a few weeks—that the parasite can be seen in the blood and that the disease may be curable with the drugs nifurtimox or benznidazole. Once the acute phase has passed, the parasite moves into tissue and cannot be treated. About one-third of those infected will develop chronic conditions, especially heart disease. Chronic cardiopathy occurs in 27 percent of those infected, chronic digestive lesions in 6 percent, and neurological disorders in 3 percent. Patients with severe chronic disease become progressively sick and ultimately die, usually from heart failure.

Prevalence of Chagas' disease is limited to the Americas. WHO estimates that about 100 million people in 18 countries are at risk in Latin America. The Caribbean region has not reported any cases. Up to 18 million are currently infected, with about 2 million to 3 million of these suffering from chronic complications. Various estimates place the number of infected persons in the United States at up to 100,000, due mostly to immigration. The World Bank has characterized Chagas' disease as a major public health burden in Latin America.

Strategy for Elimination

Control and eventual elimination of Chagas' disease centers on two overall strategies to interrupt transmission of the parasite—vector control and blood bank screening. Vector control includes insecticide spraying, insecticidal paints, fumigant canisters, housing improvement, and health

education. The blood screening strategy aims to screen all blood donors in and from endemic countries for antibodies and to strengthen existing health service infrastructure for multiple blood screening. Serological testing is also conducted to treat the disease in its acute phase and for surveillance purposes.

Distribution of Chagas' disease may be divided into two areas: the Southern Cone countries of Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay; and the areas of northern South America and Central America. The insects that transmit Chagas' disease differ in these two areas; this has implications for disease control strategies. In the Southern Cone countries, the insect mainly lives in the cracks of poorly constructed housing and not outside the home. In these countries, the use of insecticides and other vector control measures are reducing infection significantly. In northern South America and in Central America, the insect can live in housing and outside in other diverse habitats. Because vector control measures have limited effectiveness, the initial strategy in these countries is to interrupt transmission through blood screening measures.

Challenges to Elimination

As noted, the vectors carrying the parasite that transmits Chagas' disease differ between the Southern Cone countries and the endemic areas in the Andes and Central America. Because the vector in the latter areas is less easily controlled, the elimination strategy currently relies on blood screening to interrupt transmission. The Andean and Central American elimination initiatives were launched only last year, and serological testing for donated contaminated blood has not yet been undertaken in all countries. Moreover, it is not yet clear that this strategy will eliminate Chagas' disease as a public health problem because humans will still be vulnerable to being bitten by the vector.

Lymphatic Filariasis

Disease Characteristics

Lymphatic filariasis, a parasitic disease transmitted by mosquitoes, is the world's second leading cause of permanent and long-term disability. Like onchocerciasis, the infected vector takes blood from a human and passes on the infection. The adult worms, or macrofilariae, settle into the lymphatic system and mature over a period of 3 to 15 months. When fertilized, female adults produce large numbers of larvae known as microfilariae, which invade the blood stream. Mosquitoes can then ingest them when they bite an infected human and transmit the microfilariae to other people, in whom they pass through a larval sequence to become new adults. The vast majority of microfilariae remain in the body as immature forms for 6 months to 2 years, growing up to a third of a millimeter in length and doing immense damage. The adult macrofilariae can grow to several centimeters long, damaging the lymphatic ducts. Humans are the only hosts of the most common forms of filariasis.

The infection causes a very severe pathology of the lymph system. This can result in elephantiasis, a condition in which one or more limbs becomes grossly swollen and covered with sores; in hydrocele, a grotesque enlargement of the male scrotum; or in lymphoedema in women, in which their breasts or genitals are grossly swollen. Other internal damage and related infections can also occur, but the effects are often hidden. The disease can have serious social and psychological consequences, including sexual dysfunction and social exclusion.

Diagnosis of lymphatic filariasis used to be difficult—blood samples had to be taken between 9:00 p.m. and 3:00 a.m. because the parasite remained in the organs during the day and entered the bloodstream at night. Diagnostic tools were improved, and now a test of a drop of blood on cardboard can detect the infection from blood taken at any hour because the test detects a specific antigen, not the parasite itself. Another new diagnostic tool detects deoxyribonucleic acid of the parasite in infected mosquitoes or in human blood.

WHO estimates that at least 120 million people in 73 endemic countries worldwide are infected with filarial parasites. The percentage infected is about 49 percent in Southeast Asia, 34 percent in Africa, and 16 percent in the western Pacific. There is some, but very little, incidence of the disease in Europe and the Americas. The prevalence of the disease is growing in some endemic areas, due in large part to rapid unplanned urbanization. The mosquitoes carrying this parasite tend to breed in dirty urban water, making this disease more prevalent in dense urban slums.

Strategy for Elimination

The strategy for eliminating lymphatic filariasis is to interrupt the transmission between mosquitoes and humans. In the past, the strategy was to control the mosquito population, but this proved difficult, expensive, and ineffective, according to WHO. While limited vector control activities may continue, the recent development of treatment options based on drugs that are inexpensive (diethylcarbamazine, or DEC) or donated (ivermectin and albendazole), safe, easily administered, and broadly effective has changed the strategy to mass distribution of medication to entire at-risk populations. The optimal treatment regimens that result in almost complete elimination of microfilaria-stage parasites from the blood (thus blocking transmission by vector mosquitoes) involve two drugs administered concurrently (either albendazole or DEC plus ivermectin) given once yearly over a period of 4 to 6 years. According to WHO, experimental observations in the field indicate that such yearly regimens are effective in interrupting transmission. An alternative treatment is the substitution of regular table salt with DEC-fortified salt for 1 to 2 years. This strategy also decreases blood microfilaria numbers to very low levels and has been shown in large-scale control programs to be effective in interrupting transmission.

The treatment programs are largely community based. Techniques for identifying communities in need of treatment include estimating infection rates from existing health records, assessing the presence of hydrocele in adult men, examining mosquito vectors for infection, and evaluating daytime finger-prick blood samples from selected groups. Geographical information systems for mapping public health resources and disease patterns are now available for use in planning and monitoring lymphatic filariasis control programs.

Challenges to Elimination

National and international funding commitments through 2030 are uncertain. Although there is some possibility that the parasites will develop resistance to the drugs, this is less likely because the drugs are being used in combination and taken only once a year, according to WHO officials.

Objectives, Scope, and Methodology

Our objectives were to examine (1) the soundness of WHO's cost and time frame estimates for eradicating or eliminating seven infectious diseases, (2) U.S. spending related to these diseases in fiscal year 1997 and any potential U.S. savings as a result of eradication or elimination, (3) other diseases that may pose a risk to Americans and that could be candidates for eradication, and (4) historical information on U.S. costs and savings from smallpox eradication and whether experts view smallpox eradication as a model for other diseases.

To assess the soundness of the WHO's cost and time frame estimates for the seven diseases, we met with epidemiologists and health economists to understand the key elements of estimates and with cognizant WHO officials to understand the information on which their estimates were based. We also reviewed the criteria that WHO set forth to identify candidates for eradication or elimination and assessed how the diseases fit the criteria. We conducted a search of the medical and scientific literature on these diseases to identify studies and research by other experts on the costs and time frames associated with disease control efforts and other factors relevant to eradication or elimination. We also met with epidemiologists at the PAHO, CDC, and the Carter Center and with epidemiologists, economists, and other experts at the Johns Hopkins University, Emory University, USAID, and Abt Associates (a USAID health project contractor that conducted a cost study for child survival initiatives) to discuss the characteristics of the diseases and the bases for cost and time frame estimates developed by WHO. We used the information to assess whether the data underlying WHO's estimates were sound.

We did not develop independent estimates of the costs and time frames for eradicating or eliminating these diseases nor did we verify the accuracy of the data underlying the estimates. However, we adjusted some of the numbers to ensure consistency across diseases, particularly to express all estimates as cumulative totals in 1997 dollars. For dracunculiasis, measles, and Chagas' disease, no adjustments were necessary because WHO's estimates had been calculated in 1997 dollars with no annual inflation adjustments. For polio and onchocerciasis, we took out WHO's inflation adjustments. Because WHO's leprosy estimate covered 2 years prior to this review, we recalculated for the period 1998-2000. We subtracted \$72 million from the lymphatic filariasis estimate for the cost of treating symptoms for infected cases since treatment was not included in the other estimates.

To determine past and current U.S. spending on these diseases and any likely savings that may be gained by the United States as a result of reaching these goals, we obtained public and private expenditure data and projections from CDC and USAID, including information on U.S. contributions to WHO. We discussed the incidence of the diseases and their potential threat to the United States. We also spoke with an official of the American Red Cross to determine projected spending for screening donated blood for Chagas' disease.

To identify other diseases that pose threats to the United States and that could be candidates for eradication, we reviewed the medical and scientific literature and consulted experts in epidemiology and international public health at WHO, CDC, and USAID. Finally, we obtained information from CDC on global and U.S. spending for smallpox; adjusted estimated savings to reflect inflation, birth rates, and present value in 1997 dollars; and estimated the annual real rate of return on the U.S. investment in smallpox eradication. We discussed with public health officials and epidemiologists at WHO, CDC, USAID, and the Johns Hopkins University how that undertaking could be applied for ongoing efforts.

We conducted our review from August 1997 to December 1997 in accordance with generally accepted government auditing standards.

Comments From the World Health Organization

WORLD HEALTH ORGANIZATION



ORGANISATION MONDIALE DE LA SANTE

Téléphone Central/Exchange: 791 2111
Direct: 791 2411

In reply please refer to:
Prière de rappeler la référence: ADG

Your reference:
Votre référence:

Mr Henry L. Hinton, Jr.
Assistant Comptroller General
National Security and International Affairs
Division US General Accounting Office
Room 4964
441 G Street, NW
Washington, DC 20548
USA

23 March 1998

...

Dear Mr Hinton,

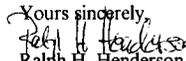
Thank you for your letter of 12 March 1998 providing for WHO's review a copy of the GAO's draft report entitled Infectious Diseases: Soundness of World Health Organization Estimates to Eradicate or Eliminate Seven Diseases.

...

WHO staff commend the effort that has gone into this review, which represents a serious study and eminently fair summary of the processes WHO is using for estimating the costs and time frames associated with current global eradication and elimination campaigns for these seven diseases.

As is noted in the report, such estimates are most complete and precise for those disease with longstanding campaigns that are closest to eradication or elimination because future cost estimates can be based on substantial actual experience of what is required for successful efforts in endemic countries. Estimates for all campaigns are constantly being refined as new data becomes available.

Any successful global campaign against a disease does not occur in a vacuum. It must build on and build up strong national and international health infrastructure, such as routine immunization, disease reporting systems, trained health workers, and laboratory capacity. The success of any global campaign to eradicate and eliminate a disease necessarily reflects sustained commitment from many partners including national governments, international organizations, community groups, and the private sector. The explanations in the report's appendices about the unique challenge faced by each of these campaigns against a disease should prove useful to decision makers in focusing on these important contextual dimensions as well.

Yours sincerely,

Ralph H. Henderson, M.D.
Assistant Director-General

cc: Dr Nelle Temple Brown, WHO Liaison Office in Washington

CH-1211 GENEVA 27-SWITZERLAND Telégr.: UNISANTE-GENEVE Telex: 415416 OMS Fax 791.07.46 CH-1211 GENEVE 27-SUISSE Télégr.: UNISANTE-GENEVE

Comments From the Department of State



United States Department of State

Washington, D.C. 20520

March 31, 1998

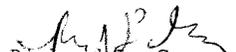
Dear Mr. Hinton:

The Department of State has reviewed your draft report "INFECTIOUS DISEASES: Soundness of World Health Organization Estimates to Eradicate or Eliminate Seven Diseases," GAO Job Code 711258.

We appreciate the opportunity to comment and hope that you will incorporate our observations into your final report to Congress.

If you have any questions concerning this response, please contact Ms. Nancy Carter-Foster, Director of the Office of Emerging Infectious Diseases and HIV/AIDS at (202) 647-2435.

Sincerely,


Richard L. Greene

Enclosure:

As stated.

cc:

GAO/NSIAD - Ms. Lynne Holloway
STATE/OES/E/EID - Ms. Carter-Foster

Mr. Henry L. Hinton, Jr.,
Assistant Comptroller General,
National Security and International Affairs,
U.S. General Accounting Office.

Comments From the Centers for Disease Control and Prevention



DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
and Prevention (CDC)
Atlanta GA 30333

MAR 30 1998

Mr. Jess T. Ford
Associate Director
International Relations and Trade Issues
United States General Accounting Office
441 G Street Northwest, Room 4938
Washington, D.C. 20548

Dear Mr. Ford:

This is in response to the U.S. General Accounting Office (GAO) draft report, "INFECTIOUS DISEASES--Soundness of World Health Organization Estimates to Eradicate or Eliminate Seven Diseases." The Centers for Disease Control and Prevention (CDC) appreciates the GAO's recognition of the value of disease eradication and elimination programs and the significant potential of the program to save lives and resources in the United States and around the world.

GENERAL COMMENTS

Eradication programs save significant amounts of money. As estimated by GAO, the annual real rate of return for the United States on its investment in smallpox eradication is approximately 46 percent per year. GAO also appropriately noted that polio eradication will save the United States more than \$300 million a year once polio vaccination can be stopped worldwide. It is important to remember that such savings will continue in perpetuity.

Eradication programs are an established and powerful global public health strategy. The smallpox model proved that disease eradication is achievable and provided valuable knowledge on how to accomplish eradication of a disease. Further knowledge has been provided by the ongoing polio and guinea worm eradication efforts.

In addition to the permanent termination of a disease, eradication programs, such as that for polio, produce many other benefits including development of the disease surveillance and global laboratory network infrastructure to address other diseases of public health importance that threaten the health of the public. Additional benefits of the polio eradication

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Comments From the Centers for Disease
Control and Prevention**

Page 2 - Mr. Jess T. Ford

initiative include: (1) increased enthusiasm and high level political support for national immunization programs; (2) increased international donor support for immunization; (3) improved managerial and epidemiologic skills of national, provincial, and district level health staff; (4) strengthened communications systems as a result of rapid reporting and follow up of cases; and (5) improved collaboration between ministries of health, education and defense.

A March 3, 1998, Congressional hearing on Global Health Issues, held by the Senate Subcommittee on Public Health and Safety, highlighted issues about global infectious diseases. The Subcommittee Chairman, Senator Bill Frist, noted that we must, as a Nation, be concerned about the threat to our citizens' health through the spread of infectious diseases, and Dr. David Brandling-Bennett, M.D., Deputy Director of the Pan American Health Organization, testified that we must not fail to complete the "unfinished business" of eradicating or eliminating diseases which have already been targeted by the international community, including polio, guinea worm disease, leprosy, neonatal tetanus and Chagas disease to be closely followed by measles and onchocerciasis.

Polio

CDC has a proud history of working with other U.S. agencies, international organizations, individual nations, and private-sector partners. By using the lessons of smallpox eradication, global reported cases of polio have declined by 90 percent since 1988. As GAO reports, more than \$300 million a year in public and private sector spending can be stopped with the eradication of polio. The support provided by Rotary International has been unprecedented in this effort, including anticipated Rotary contributions of \$400 million by the year 2005.

Measles

The worldwide disease burden of measles is staggering. Measles accounts for approximately 1 million deaths and 36.5 million cases in children under five years old each year. Despite the availability of safe and effective vaccines for 35 years, it is the eighth leading cause of death worldwide, accounting for approximately 10 percent of global mortality for children under five years old. Thus, while measles eradication may be more costly than other elimination/eradication programs, the global benefits would be greater.

While challenges do exist to measles eradication, many experts agree that measles eradication is biologically feasible. Two WHO regions have already established regional measles elimination targets: The Americas/PAHO (by year 2000) and the Eastern Mediterranean Region (by year 2010), and an elimination target is being discussed by the European Region (by year 2007).

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Comments From the Centers for Disease
Control and Prevention**

Page 3 - Mr. Jess T. Ford

Smallpox

We agree with GAO that smallpox eradication has provided many valuable lessons for eradication programs. While smallpox had characteristics that were particularly amenable to eradication, the smallpox initiative provided valuable experience that has been used and extended by the polio and other global eradication programs. For example, polio and measles eradication apply the same general approaches as used in the smallpox programs, i.e., the critical role of disease surveillance in developing strategies and monitoring impact. Also, the smallpox initiative documented the significant financial savings that result from eradication programs.

In conclusion, CDC appreciates the opportunity to comment on the draft report and requests that the non-technical text of this letter be included in the final report. Enclosed are technical comments in response to the draft report.

Sincerely,



Claire V. Broome, M.D.
Acting Director

Enclosure

Comments From the U.S. Agency for International Development

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



U.S. AGENCY FOR
INTERNATIONAL
DEVELOPMENT

APR 1 1998

Mr. Henry L. Hinton, Jr.,
Assistant Comptroller General
National Security and International
Affairs Division
United States General Accounting
Office (GAO)
Washington, D.C. 20548

Dear Mr. Hinton:

I am pleased to provide the U.S. Agency for International Development's (USAID's) formal response on the draft GAO Report entitled "INFECTIOUS DISEASES: Soundness of World Health Organization Estimates to Eradicate or Eliminate Seven Diseases" (March 12, 1998).

In general, the draft report is very comprehensive and provides concise information on the potential eradication/elimination of key diseases. It is well-written, succinct and informative. However, we are concerned about some major omissions in the draft report and believe that as a result, the full costs and concerns regarding disease eradication are misrepresented.

We understand the report's mandate was to assess the soundness of eradication financing, and to take a neutral position on whether eradication should be recommended or not recommended. However, the draft implies that there is global consensus on the eradication potential of the seven diseases reviewed, and makes no reference to an existing debate among public health experts. In fact, there is not a global consensus on the "eradicability" of these diseases, with the exception of polio and perhaps guinea worm. A number of public health experts have serious technical, financial and operational reservations about the feasibility of eradication and the potentially adverse impacts on sustainable health development in developing countries.

The draft does not fully consider the real financial and opportunity costs to the overall health system that eradication campaigns may entail. Eradication campaigns can be very disruptive to the routine primary health care system, can draw human and financial resources away from on-going health care activities, and may result in an unfortunate reduction in efforts

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See comment 1.

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Comments From the U.S. Agency for
International Development**

2

to prevent other diseases and improve health while attention is focused on eradication of one disease.¹

Measles, arguably the "next candidate" for eradication, requires intense scrutiny by the international community prior to embarking on a global eradication effort. Contrary to the implications in the draft report, measles eradication remains a major international issue, and there is not a consensus on either the feasibility or soundness of eradication at this time. While it is biologically plausible to eradicate measles with the present vaccine, there are serious operational issues that call into question the possibility of doing so. Because it is more infectious than smallpox or polio, and highly prevalent, measles requires repeated campaigns to immunize large segments of the population, and requires a strong primary health care system to ensure high routine immunization rates -- strong systems that do not exist in many countries. Surveillance systems must be extremely sensitive to differentiate measles' "rash with fever" from a number of other prevalent diseases with similar symptoms. There are also concerns about injection safety in the large scale campaigns required for eradication, particularly where the risk of infection with HIV and Hepatitis B is high. Lastly, it is unclear that the success in the Americas can be replicated in other regions.

Dr. Donald A. Henderson, Emeritus Dean of the Johns Hopkins University School of Hygiene and Public Health, remains cautious about measles eradication. He implies that there are serious operational issues which did not exist with the smallpox eradication program.² Furthermore, it is widely agreed that routine coverage should be at least 90% for measles (due to its high communicability) before eradication is possible.³ (In 1996, routine coverage in Africa was only 56%.) UNICEF supports this tenet in their 1997 message to the field recommending efforts to achieve 90% sustainable measles coverage in all their immunization programs. UNICEF paraphrased a conclusion reached in the August 1997 international meeting in Atlanta by stating: "the meeting concluded that global measles eradication using the currently available vaccine is technically feasible, but the programmatic and financial feasibility of eradication still needs

¹Taylor, C.E., Cutts, F., Taylor, M.E., 1997. Ethical dilemmas in current planning for polio eradication, *American Journal of Public Health*, 87(6): 922-925:97

²Henderson, D.A., 1998. Eradication: Lessons Learned from the Past. Conference on Global Disease Elimination and Eradication as Public Health Strategies, Atlanta GA, February 24, 1998, 8pp.

³de Quadros, C., et. al., January 17, 1996, "Measles Elimination in the Americas", *Journal of the American Medical Association*, 275:(3):224-229:96

See comment 2.

**Appendix XIII
Comments From the U.S. Agency for
International Development**

3

to be addressed before one could propose the eradication of measles as a target. It was also agreed that measles can be eliminated from a country only if routine immunization coverage is high."⁴

The draft report aptly points out that reasonable estimates of cost exist only for smallpox, polio, guinea worm and leprosy. It should clearly note that because of the lack of data on other diseases, cost savings estimates should be viewed with extreme caution. The draft should also highlight the fact that more work needs to be done on cost estimates and cost-benefits prior to embarking on eradication strategies for the other diseases, notably measles.

We appreciate the opportunity to read and comment on the draft GAO report. Page specific comments are contained in the enclosure. We hope these issues can be adequately addressed so that the operational and opportunity costs associated with eradication are appropriately represented, in addition to the excellent analysis undertaken by your staff.

Thank you for the courtesies extended by your staff in the conduct of this review.

Sincerely,



Terrence J. Brown
Assistant Administrator
Bureau for Management

Enclosure: a/s

⁴Rasheed, S., 1997. Headquarters Programme Instructions: Measles Control, CF/PD/PRO/97-008; November 4, 1997.

See comment 3.

The following are GAO's comments on USAID's letter dated April 1, 1998.

GAO Comments

1. We do not imply global consensus on the eradication of all seven diseases. As we noted in our draft report, the World Health Assembly, which is composed of health ministers from WHO member countries, voted to initiate formal eradication campaigns against dracunculiasis and polio in 1988 and 1991, respectively. The only other disease being discussed for possible eradication is measles, for which we outline the challenges to eradication.

2. We discuss many of the operational challenges facing measles eradication raised by USAID. We have clarified the text to reflect USAID's concern about injection safety.

3. The basis for our estimates of cost savings to the United States is the current level of U.S. spending on those diseases. It is not based on WHO's cost estimates for disease eradication and elimination. Thus, the fact that some of the estimates are speculative does not affect the potential U.S. cost savings, only whether or when they might be forthcoming.

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