COST-BENEFIT ANALYSIS OF THE GLOBAL DRACUNCULIASIS ERADICATION CAMPAIGN (GDEC)

by

Aehyung Kim and Ajay Tandon[1]
The World Bank
and
Ernesto Ruiz-Tiben
The Carter Center

July 1997

ABSTRACT

This paper is a cost-benefit analysis of the Global Dracunculiasis Eradication Campaign (GDEC). Dracunculiasis (or Guinea worm disease) has been endemic in several African countries as well as in Yemen, Pakistan, and India. In the past decade, the incidence of dracunculiasis has seen a remarkable decline as a result of GDEC. This paper compares expenditure on GDEC activities with estimates of increased agricultural production due to reductions in infection-related morbidity resulting from the eradication program. Using a project horizon of 1987-1998, the Economic Rate of Return (ERR) is 29%, under conservative assumptions regarding the average degree of incapacitation caused by Guinea worm infection (5 weeks). In addition, our results indicate that eradication must be achieved in Sudan -- which is projected to be the sole endemic country after 1998 -- at the very latest by the year 2001 in order for economic returns there to be consistent with those obtained in other endemic countries.

[1] We would like to thank Pedro Belli, Jeffrey Hammer, Donald Hopkins and the participants of the consultation meeting at the Carter Center/Global 2000 for valuable comments. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors and should not be attributed in any manner to the World Bank, to its affiliated organizations, or to members of its Board of Executive Directors or the countries they represent.

Introduction

In 1986, there were over 2.25 million cases of dracunculiasis (Guinea worm disease) worldwide.[2] Ten years later, in 1996, the estimated worldwide incidence of dracunculiasis was close to 330,000 cases.[3] This remarkable decline in the incidence of dracunculiasis has been the result of the Global Dracunculiasis Eradication Campaign (GDEC). GDEC is spearheaded by national eradication programs and is supported by a coalition of agencies, institutions, organizations, and bilateral donors. As the numbers attest, as a result of GDEC, dracunculiasis has been virtually eliminated as a major public health problem and an impediment to socioeconomic development in several African countries as well as in India, Pakistan, and Yemen.[4] Dracunculiasis was eradicated from Pakistan in 1994.[5] In 1996, an overwhelming majority (78%) of a provisional total of 152,185 reported cases of dracunculiasis occurred in Sudan, where civil strife has complicated the successful operation of its national Guinea worm eradication program.

Dracunculiasis is caused by the nematode parasite *Dracunculus medinensis.* An individual becomes infected by drinking water containing tiny crustaceans (copepods) which harbor infective larvae and act as an intermediate host. After about one year, theife has c pawue f mate

2.01-0.11j - 88.8172 TF2 12 2.05(2) Tj 1030.11j -W as podher70 aed worldwibal patincidence of drac communities and by the application of the insecticide Abate (temephos) to selected unsafe sources of drinking water.

The objective of this paper is to report on a cost-benefit analysis of GDEC: expenditure on GDEC activities is compared with the economic benefit resulting from the campaign. The emergence of the Guinea worm is a painful and debilitating process causing serious disability in infected individuals for weeks -- thereby seriously constraining their income-generating capacity. Therefore, the major benefit of GDEC is considered to be the prevention of this period of infection-related economic incapacitation.[6] Based upon the resulting augmentation of agricultural production, this economic benefit is accorded a monetary value and then compared with the costs of the campaign. This “human capital” approach enables an assessment of the economic viability of large-scale public health programs such as GDEC which are demonstrably successful in controlling and/or eradicating disease incidence.

The economic assessment of GDEC entails the following. First, we examine the strategies for eradication under the auspices of GDEC and the associated costs of the campaign. Second, we elaborate the projected benefits from the eradication program, focusing specifically on the prevention of economic incapacitation resulting from incidence decline. Finally, we contrast the costs with the projected economic benefits in order to estimate the economic returns of the campaign.

Dracunculiasis Eradication: Strategies and Costs

There are several characteristics of dracunculiasis transmission that make the disease amenable to eradication[7]: there is no human carrier state beyond the one-year incubation period; there is no known animal reservoir; transmission is seasonal; active detection of individuals with worms protruding from skin lesions is a sensitive means of assessing the presence of the disease in villages; and the methods for controlling transmission (as subsequently elaborated) are relatively simple. Beginning in 1986, 1987, and 1988, the Global 2000 Project of the Carter Presidential Center, in collaboration with the Center for Disease Control (CDC), assisted national Guinea worm eradication campaigns in Pakistan,

[6] este ehe Guinea wormtifls4( ) T.n9qu si (Bae) Tj 0 -14.16 TD .32.onomicmaitatioono-ud

Ghana, and Nigeria, respectively.[8] The strategies for eradication in these three countries

Measuring the Costs of Eradication

The estimated expenditures of GDEC for the above-mentioned eradication activities include costs incurred by Global 2000, UNICEF, as well as WHO in the time horizon 1987-1996.[10] Table 1 reports the annualized expenditure figures. In nominal terms, actual

Number of Cases of Guinea Worm Prevented in Productive Age Group

Based upon epidemiological studies, the estimated total number of cases of Guinea worm in the period 1986-1996 is known. A sharp reduction in the number of cases of Guinea worm infection as a result of GDEC activities has been observed. By 1996, only 329,521 cases (including those in Sudan) were estimated to have occurred.[16] Global 2000 projections indicate that, by 1998, it is likely that dracunculiasis could be eradicated from all countries except for Sudan. The total number of cases of Guinea worm infection prevented as a result of GDEC in any given year is computed as the difference between the projected number of cases of Guinea worm *without* GDEC and the number of cases *with* GDEC. We make the following assumptions regarding the number of cases of Guinea worm infection: (a) in the absence of GDEC, the total annual number of cases of Guinea worm would have remained at 1986 levels (around 2.2 million every year in the entire region), (b) two-thirds of all cases reported (or estimated) represent those among the "economically productive" age group of 15-44, and, as mentioned in a previous subsection. Table 3 reports the total number of cases of Guinea worm infection prevented in a given year, based upon the above-mentioned information and assumptions.

Table 3. Number of Cases of Dracunculiasis (1986-1998).

Year	Total Cases of Dracunculiasis (with GDEC)	Total Cases of Dracunculiasis Prevented[a]	Cases Prevented In Productive Age Group[b]
1987	2,178,272	0	0
1988	2,118,368	59,904	39,936
1989	2,061,543	116,729	77,819
1990	1,523,540	654,732	436,488
1991	1,202,351	975,921	650,614
1992	997,016	1,181,256	787,504
1993	1,118,829	1,059,443	706,295
1994	521,365	1,656,907	1,104,605
1995	408,742	1,769,530	1,179,687
1996	329,521	1,848,751	1,232,501
1997	315,000	1,863,272	1,242,181
1998	300,000	1,878,272	1,252,181

a. Assuming the annual incidence without GDEC in the productive age group is 1,452,181 out of 2,178,272 for all age groups.
b. Assuming cases in productive age group represent two-thirds of total cases.

As can be seen from Table 3, by 1998, as a result of GDEC, an estimated total of almost 13 and 9 million cases of dracunculiasis would have been prevented in total and in the productive age group, respectively. This implies a unit cost of about $5 and $8 per case prevented in 1997 constant dollars for all age group and in productive group, respectively over the life of the program.

Productivity Loss Per Case

16 This is a Global 2000 estimate.

It is important to note that the benefits accruing from the availability of more productive labor days (as a result of reduction in the number of cases of Guinea worm) is not easily estimated. Since transmission occurs seasonally, usually coinciding with the period of peak agricultural labor demand, there is a significant adverse impact on agricultural productivity. The methodology for computing the enhanced productivity of labor as a result of GDEC is as follows. We assume that production of agricultural output is represented in the form of a Cobb-Douglas production function: $Y = AE^aK^b$.[17] Denote E as the effective labor force (in efficiency units[18]) without GDEC. One non-infected worker is assumed to supply one year of productive labor in any given year. An infected worker, due to disease-related incapacitation, is assumed to provide *less than* one year of productive labor in any given year.[19] The prevention of the loss in productive labor time due to Guinea worm infection is the estimated benefit accruing from GDEC.

Every case of dracunculiasis prevented is projected to add k worker-years of productive labor input time in a given year. This degree of incapacitation k may be expressed in terms of the percentage of labor days per year not worked as a result of infection. As mentioned earlier, a review of twelve published studies yielded an average duration of disability from infection of about 8 weeks, with estimates ranging from 2 to 16 weeks. This implies that over 20% of annual work-time is lost per case of infection.[20] In order to be conservative, we assume that on average 5 weeks of production time is lost per case of Guinea worm: a loss of 12.5% of annual work time. We elect a conservative estimate as a benchmark to allow for the possibility that other members belonging to the households of infected individuals may pick up some of the slack in income generation during the period of disability. Furthermore, there may be attempts at long-term intertemporal coping such that infected individuals are later able to make up (to some extent) for lost production time. In a later section, we assess the sensitivity of our results

---

17 See footnote 13 for additional details.

18 We are measuring the labor force E in terms of the labor service inputs (i.e., time worked) instead of in terms of natural units (i.e., number of workers).

19 The framework is similar to that in Cuddington (1993). The effective labor force, in the absence of GDEC, may therefore be decomposed as the sum of the labor input supplied by infected and non-infected individuals in any given year. If z is the proportion of the labor force L that is infected in any given year then the effective labor force E may be characterized as: $E = (1-z) L + z (1-k) L$, where $(1-z) L$ is the labor supplied by non-infected workers and $z (1-k) L$ is the labor supply of infected workers; k (taking a value between 0 and 1) represents the fraction of work year *lost* per Guinea worm-stricken worker. In the presence of GDEC, the effective labor force E_G is similarly given by: $E_G = (1-z_G) L + z_G (1-k) L$, where z_G is the fraction of the labor force infected with dracunculiasis in a given year. With GDEC, z_G is progressively lower than z. The incremental labor input available as a result of GDEC is given by $(E_G - E)$ or $k(z- z_G)L$, where $(z- z_G)L$ is simply the number of cases of Guinea worm prevented due to GDEC in the productive segment of the population. Therefore, $(z- z_G)L$ times k gives us the additional productive labor input available as a result of reducing the incidence of dracunculiasis.

20 This is assuming a 40 week work-year, given the seasonality of agricultural production and its coincidence with disease transmission.

to variations in this parameter. In order to estimate the additional output produced, the

Table 4. Net Present Value (NPV) and Economic Rates of Return (ERR) of GDEC.
Project Horizon: 1987-1998.
Percent of Work-Year Lost Per Case of Dracunculiasis: 12.5% (5 weeks out of 40).

Discount Rate	Net Present Value (NPV)
3%	$7,235,744
10%	$6,257,928
Economic Rate of Return (ERR):	29%

As can be seen from Table 4, even under relatively conservative assumptions of infection-related disability and limiting the calculation of benefits to the productive age group, GDEC appears to represent an efficacious use of resources. The ERR is very respectable at 29% and the NPV at a 10% discount rate is almost US$6.3 million in constant dollars. These economic returns compare very favorably with those from other health-sector projects. Typically, institutions such as the World Bank consider ERRs in excess of 10% to represent sound economic investments in "productive" sectors such as transport, energy, and agriculture.[26]

Switching Value

We calculate the switching value (

We assume a range of values against the benchmark assumption of 5 weeks loss per case in order to assess the sensitivity of our results. As mentioned earlier, the average degree of incapacitation caused by Guinea worm infection -- as chronicled several studies -- is about 8 weeks. Thus, our benchmark assumption of 5 weeks of work-time loss is quite conservative in that it is more representative of the lower bound estimate of the dracunculiasis-related duration of disability reported in most studies. Table 5 reports the results of a sensitivity analysis with regard to changes in this parameter. As can be seen, the results are quite sensitive. In any case, even at a relatively low estimate of a 4 week loss of productivity per case of infection, the NPVs are substantial.

Table 5. Sensitivity of NPV and ERR: *Productivity Loss Per Case*
Project Horizon: 1987-1998.

Productivity Loss				
4 weeks *NPV*	@3%		$4,927,370	
		@10%		$4,233,999
	ERR			11%
5 weeks ***NPV***	**@3%**		**$7.235,744**	
		@10%		**$6,257,928**
	ERR			**29%**
6 weeks *NPV*	@3%		$9,544,119	
		@10%		$8,281,857
	ERR			44%

Annual Incidence without GDEC

For our benchmark analysis, we have assumed that in the absence of GDEC the annual incidence of Guinea worm would remain at the level of approximately 2.2 million over the course of the time horizon in our study. We now assess the sensitivity of our results to this assumption. We assume growth rates of -1.5% and 1.5% -- in addition to the benchmark of 0% -- in the annual incidence of dracunculiasis in the absence of GDEC.[27] Values of other parameters are the same as in the benchmark. Table 6 reports the results. As can be seen, the ERRs again are quite sensitive to this parameter. Not surprisingly, any projected increases in dracunculiasis infection (due to population growth, for instance) significantly augment the economic returns from the program.

27 A negative growth in annual incidence growth is also assumed since, arguably, general socio-economic development can sometimes lead to incidence declines even in the absence of any intervention.

Table 6. Sensitivity of NPV and ERR: *Annual Incidence without GDEC*
Project Horizon: 1987-1998.
Percent of Work-Year Lost Per Case: 12.5% (5 weeks out of 40).

Growth in Annual Incidence			
-1.5%	*NPV*	@3%	$5,185,570
		@10%	

This study has assessed the economic efficacy of GDEC in terms of comparing the costs of the campaign to the benefits that have resulted from the decline in the incidence of dracunculiasis. We have developed a methodology by which we are able to estimate the extent to which additional output is produced as a result of the prevention of infection-related economic incapacitation. It has been widely reported in the literature that a case of dracunculiasis results in some degree of work time lost. As a result of GDEC, this loss in productive potential is prevented. The additional output produced as a result -- derived using techniques that involve the use of the Cobb-Douglas production function -- represent the quantifiable economic benefits of the campaign. Based upon this methodology, we determine that the economic returns of GDEC are sensitive to assumptions regarding the average degree of economic incapacitation, in terms of percent of work year lost, caused by a case of dracunculiasis. Nevertheless, even under conservative assumptions we find highly respectable ERRs that range from 11% to 44%, depending upon whether an average case leads to 4 weeks or 6 weeks of economic incapacitation. A sensitivity analysis was also conducted to assess the variance caused by changes in key parameters. One key implication of the analysis is that eradication efforts in Sudan must be completed as soon as feasible in order for the economic returns there to be consistent with those obtained in other GDEC countries.

Appendix

This appendix elaborates on the methodology utilized for the estimation of the additional output produced as a result of an augmentation of productive labor time available from dracunculiasis eradication. Basically, we are interested in estimating the marginal product of labor, or how much additional agricultural output (*Y*) is available from additional labor time (*E*), where labor input is measured in efficiency units. Assuming agricultural production may be characterized by a Cobb-Douglas production function of the form:

$$Y = A\, E^{a} K^{b}$$

where *Y* is agricultural value-added; *A* is a technology parameter; *E* is labor input in time (equals total working population for a healthy labor force); *K* is land/capital; and *a* and *b* are the elasticities of output with respect to the two inputs. Hence, we have:

$$a = (dY/Y)/(dE/E)$$

or,

$$dY = a\,(dE/E)\,Y$$

The additional output (*dY*) available from disease control in any given year can be approximated by the output elasticity of labor *a* (assumed equal to 0.66) times the percentage increase in labor time (*dE/E*) times the agricultural value-added (*Y*).

References

Adeyeba, O.A. and O.O. Kale (1991), "Epidemiology of Dracunculiasis and Its Socio-economic Impact in a Village in South-west Nigeria," *West African Journal of Medicine* 10(3):208-215.

Aron, J.L. and P. Davis (1993), "A Comparative Review of the Economic Impact of Selected Infectious Diseases in Africa," *USAID Technical Paper No. 2*.

Belcher, D.W., F.K. Wurapa, W.B. Ward, and I.M. Lourie (1975), "Guinea Worm in Southern Ghana: Its Epidemiology and Impact on Agricultural Productivity," *American Journal of Tropical Medicine and Hygiene* 24:243-249.

Brieger, W.R. and J. Guyer (1990), "Farmers' Loss Due to Guinea Worm Disease: A Pilot Study," *Journal of Tropical Medicine and Hygiene* 93:106-111.

Carter Center (1995), *Let Not the Sinuous Worm Strike Me*.

Chippaux, J.P., A. Banzou, and K. Agbede (1992), "Social and Economic Impact of Dracunculiasis," *Bulletin of the World Health Organization* 70(1):73-82.

Cuddington, J.T. (1993), "Modeling the Macroeconomic Effects of AIDS with an Application to Tanzania," *World Bank Economic Review* 7(2):173-190.

Edungbola, L.D. (1983), "Babana Parasitic Disease Project II: Prevalence and Impact of Dracontiasis in Babana District, Kwara State, Nigeria," *Transactions of the Royal Society of Tropical Medicine and Hygiene* 77(3):310-315.

Feachem, R.G.A., T. Kjellstrom, C.J.L. Murray, M. Over, and M.A. Phillips (1992), *The Health of Adults in the Developing World*, New York: Oxford University Press.

Hopkins, D.R. and E. Ruiz-Tiben (1991), "Strategies for Dracunculiasis Eradication," *Bulletin of the World Health Organization* 69(5): 533-540.

Hopkins D.R., M. Azam, E. Ruiz-Tiben, and K.D. Kappus (1995), "Eradication of Dracunculiasis from Pakistan," *The Lancet* 346(8975):621-624.

Ilegbodu, V.A., A.E. Ilegbodu, R.A. Wise, B.L. Christiansen, and O.O. Kale (1991), "Clinical Manifestations, Disability and Use of Folk Medicine in Dracunculiasis in Nigeria," *Journal of Tropical Medicine and Hygiene* 94:35-41.

Kale, O.O. (1977), "The Clinico-Epidemiological Profile of Guinea Worm in the Ibadan Journal of Tropical

Epidemiology and Socio-Economic Impact of the Disease," *Annals of Tropical Medicine and Parasitology* 76(2):187-200.
Over, M. (1992), "The Macroeconomic Impact of AIDS in Sub-Saharan Africa," *World Bank Technical Paper No. 3*.
Over, M., R.P. Ellis, J.H. Huber, and O. Solon (1992), "The Consequences of Adult Ill-Health." In Feachem, R.G.A. *et al.* (1992).
Rohde, J.E., B.L. Sharma, H. Patto, C. Deegan, and J.M. Sherry (1993), "Surgical Extraction of Guinea Worm: Disability Reduction and Contribution to Disease Control," *American Journal of Tropical Medicine and Hygiene* 48(1):71-76.
Ruiz-Tiben, E. (1992), "Dracunculiasis and Its Impact on Agriculture," Global 2000, Inc., The Carter Center.
Shulman, M.H. (1982), "On Correlations Between Dracunculiasis and Malnutrition in West Africa," *Workshop on Opportunities for Control of Dracunculiasis*, Washington, DC.
Smith, G.S., S.R.A. Huttly, D. Blum, N. Okeke, B.R. Kirkwood, and R.G. Feachem (1989), "Disability from Dracunculiasis: Effect on Mobility," *Annals of Tropical Medicine and Parasitology* 83(2):151-158.
Suleiman, M.M. and K. Abdullahi (1989-90), "Guinea Worm Infection in Kiri-Manai Village, Sokoto," *The Nigerian Journal of Parasitology* 9-11(13-16).
Vandemoortele, J. (1991), "Employment Issues in Sub-Saharan Africa," *Africa Economic Research Consortium Special Paper No. 14.*
Watts, S.J. (1987), "Dracunculiasis in Africa in 1986: Its Geographic Extent, Incidence, and At-Risk Population," *American Journal of Tropical Medicine and Hygiene* 37(1):119-125.
Watts, S.J. (1989), "Guinea Worm: An In Depth Study of What Happens to Mothers, Families, and Communities," *Social Science and Medicine* 29(9):1043-1049.
World Health Organization (1996), *Weekly Epidemiological Record*, 10 May.