Modeling the HIV/AIDS Epidemic in the English-speaking Caribbean[1]

ELIZABETH A. C. NEWTON,[2] FRANKLIN M. M. WHITE,[2]
DAVID C. SOKAL,[3] TIMOTHY D. N. KING,[3] & STEVEN S. FORSYTHE[4]

♦♦♦

The study reported here examines the past and potential future impact of HIV/AIDS in 19 nations of the primarily English-speaking Caribbean. The authors use DemProj, a demographic projection model, to explore two different HIV scenarios. In the low scenario adult HIV prevalence stabilizes at 2% in the year 2000, and in the high scenario adult HIV prevalence stabilizes at 5%. By the year 2010, annual AIDS incidence exceeds 11 000 cases in the low scenario and 28 000 in the high scenario. In both scenarios, 70% of the cases are in young adults 20–45 years old and 12% are in children 0–15. Age-specific mortality is more than doubled in the 20–40 age range in the low scenario, and more than quadrupled in the high scenario. The impact on death rates is also severe among children 0–10. In assessing the economic impact, the authors estimate that the total annual costs of the epidemic will approach US$ 500 million (in constant 1989 US$) or 2% of GDP in the low scenario, and will exceed US$ 1 200 million or 5% of GDP in the high scenario.

INTRODUCTION

Mathematical models are an important tool in the effort to anticipate the future impact of the AIDS epidemic and the effects of intervention strategies. The long and variable incubation period of AIDS makes understanding the present course of the epidemic and predicting its future course particularly difficult, because it is hard to estimate the number of people who are presently infected but asymptomatic. It also impedes assessment of the effects of intervention measures. Mathematical modeling provides a means of experimenting with a hypothetical population under different sets of assumptions. As Roy Anderson and Robert May have stated, "mathematical models of the transmission of infectious agents within human communities can help to interpret observed epidemiological trends, to guide the collection of data towards further understanding, and to design programmes for the control of infection and disease" (*1*).

Mathematical models cannot provide exact forecasts of future events. They are only as accurate as the assumptions underlying them and the translation of those assumptions into mathematical constructs. However, they do allow us to explore the implications of these assumptions, which may not be obvious and in some cases may be unexpected (*2, 3*).

The Caribbean Epidemiology Center (CAREC) in Port of Spain, Trinidad, is developing models of the HIV/AIDS epidemic for the Caribbean. Administered by the Pan American Health Organization

---

[1]This article will also be published in Spanish in the *Boletín de la Oficina Sanitaria Panamericana*, Vol. 117, No. 4, October 1994. Reprint requests and other correspondence should be sent to Franklin M.M. White, Director, Caribbean Epidemiology Center, PO Box 164, Port of Spain, Trinidad, West Indies.

[2]Caribbean Epidemiology Center (CAREC/PAHO/WHO), Port of Spain, Trinidad, West Indies.

[3]Family Health International, Research Triangle Park, North Carolina, U.S.A.

[4]Family Health International, Arlington, Virginia, U.S.A.

Table 1. Reported AIDS cases and deaths in each of CAREC's members, to December 1992.

Country or political entity	Cases	Deaths	1990 population	Case rate per 100 000
Anguilla	4	3	7 000	57.1
Antigua and Barbuda	6	5	76 000	7.9
Bahamas	1 093	662	253 000	432.0
Barbados	328	251	255 000	128.6
Belize	67	60	187 000	35.8
Bermuda	218	177	58 000	375.9
British Virgin Islands	6	3	13 000	46.2
Cayman Islands	15	12	25 000	60.0
Dominica	24	23	82 000	29.3
Grenada	35	27	85 000	41.2
Guyana	390	102	796 000	49.0
Jamaica	431	299	2 456 000	17.5
Montserrat	1	0	12 000	8.3
Saint Kitts and Nevis	37	23	44 000	84.1
Saint Lucia	42	35	150 000	28.0
Saint Vincent and the Grenadines	46	36	116 000	39.7
Suriname	139	107	422 000	32.9
Trinidad and Tobago	1 228	779	1 281 000	95.9
Turks and Caicos Islands	28	23	10 000	280.0
Total	4 138	2 627	6 328 000	65.4

Source: Data provided to CAREC by each member.

(PAHO), CAREC provides epidemiology and laboratory reference services to 19 member nations (listed in Table 1) with a total 1990 population of 6 328 000, comprising the English-speaking Caribbean and Suriname. This article reviews the history of AIDS in these CAREC members and then describes projections developed for all of them taken as a whole. Projections for a hypothetical Caribbean nation are discussed in Hospedales et al. (4).

AIDS in CAREC Member Countries (CMCs)

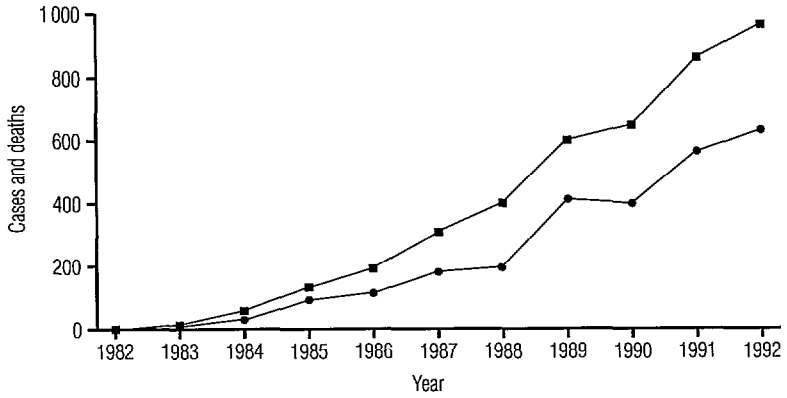
Data on AIDS cases is supplied to CAREC by each of the CAREC member countries (CMCs). The first case of AIDS in a CMC was reported in 1982. By 31 December 1992, 11 years later, a total of 4 138 cases and 2 627 deaths had been reported, yielding a case-fatality ratio of 63.5%. As indicated in Figure 1, the annual incidence of AIDS cases has risen steadily each year, with 858 cases being reported for 1991 and 969 for 1992.

The extent of underreporting is unknown, though underreporting as high as 50% has been estimated in some Latin American countries (5). We expect that in the smaller island CMCs most cases are reported, but in the larger countries some cases may be missed.

As Table 1 shows, cumulative AIDS rates vary considerably in different CMCs. Cumulative rates exceeding 100 cases per 100 000 have been reported in the Bahamas (432.0), Barbados (128.6), Bermuda (375.9), and the Turks and Caicos Islands (280.0). The precision of these estimates is limited by the fact that the populations of some CMCs are quite small, 10 of the 19 having populations under 100 000.

The mode of transmission has shifted substantially over the course of the epi-

Figure 1. Reported AIDS cases and deaths in CAREC member countries, 1982–1992.



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Cases	1	8	24	132	192	307	403	592	652	858	969
Deaths	1	6	15	95	114	189	200	410	402	557	638

demic. The earliest cases reported were all among homosexual males. However, the percentage of heterosexual cases has been rising steadily, from 12% of the cases with an identified mode of transmission in 1985 to 78% in 1992. This was accompanied by a change in the sex ratio, so that of the cases reported in 1992 in adults (those age 15 or older), 31% occurred in women.

There has also been a shift in the age distribution of AIDS cases. AIDS has affected primarily the young adult population, with 76% of the cases of known age reported in people 20–44 years old in 1985 and 73% in 1992. However, the number of cases reported in older age groups (over 44 years) has increased steadily, accounting for 19% of total cases in 1992 as compared to only 9% in 1985.

While the number of cases among children (those under age 15) has increased over the course of the epidemic, the percentage of all cases in this age group has declined—from 13% in 1985, when the first pediatric case was identified, to 7% in 1992. This may be a reflection of the more rapid progression from HIV infection to AIDS among children (*3, 5*). However, we expect to see a rise in the proportion of cases in this age group as the epidemic becomes increasingly heterosexual.

HIV Incidence and Prevalence

HIV incidence is the number of new HIV infections occurring in a particular population during a specified period of time, frequently 1 year. HIV prevalence is the number of infected people in a population at a particular point in time. HIV prevalence is frequently expressed as the number (or percent) of adults (those age 15 or older) who are infected—partly because, in general, only adults transmit infection, and also because the duration of infection is much shorter in children (*5*). Both HIV incidence and prevalence are difficult to measure directly (*6*) and must be inferred from seroprevalence levels in selected populations.

No large-scale HIV seroprevalence studies have been conducted in CAREC member countries. However, HIV seroprevalence levels in blood donors and

prenatal clinic attenders provide some indication of levels in the general population. These levels vary widely, both among and within countries; but in most cases they are currently less than 1%. Seroprevalence levels among prenatal clinic attenders may overestimate those in the general population, because young sexually active women are at high risk of contracting the disease. On the other hand, because blood donors are screened, levels among blood donors most likely underestimate those in the overall population.

HIV seroprevalence levels in selected high-risk populations can be quite high and have been rising in recent years. For example, one 1990 study found that 25% of a group of female sex workers were HIV-positive. Another 1991 study found that 33% of a group of STD clinic patients were HIV-positive (unpublished CAREC data provided by member countries).

Future Prospects

It has been observed in countries with a longer history of epidemic AIDS, particularly in Africa, that the adult HIV prevalence does not continue to climb indefinitely. In fact, the epidemic can frequently be divided into three phases: an early phase with a prevalence of less than 1%, a steeply rising epidemic phase, and then an endemic phase in which the adult HIV prevalence stabilizes at a certain level (*7*). This level may be very high, as high as 25% or 30% in certain African cities (*8*). In Port-au-Prince, Haiti, a plateau of approximately 7% may have occurred (*9*).

On the basis of the limited HIV prevalence information available, and also the number of AIDS cases reported, we infer that in 1993 most CMCs were still in the early phase, with adult prevalences in their general populations still being less than 1%. However, the high rates in certain high-risk populations, as well as rates starting to appear in prenatal clinics (CAREC, unpublished data), indicate that CMCs in general are currently at the start of the epidemic phase and may face sharply rising seroprevalence levels. On the other hand, we do not expect the epidemic in the Caribbean to become as severe as it is in certain parts of Africa and Asia. Rather, seroprevalence levels are unlikely to exceed those seen in Port-au-Prince, which we expect, given the level of poverty and lack of access to education and health care, is a worst-case scenario for the Caribbean. These observations have led us to explore the implications of HIV seroprevalence levels up to 5% in our modeling efforts.

METHODS

In seeking to anticipate the epidemic's impact, we have developed projections of the course of the epidemic, assuming strictly heterosexual transmission, for all CAREC member nations taken as a whole. (The term "CMN" is used to refer to this composite of the CAREC member nations.) The projections were made using the demographic projection model DemProj (*10*). APM, an AIDS projection model developed at CAREC (*11*) which is similar in its calculations to the WHO EpiModel (*12*), was used for validation.

Input Parameters

The models require the input of certain demographic and HIV/AIDS-related information in order to formulate the projections.

Demographic Characteristics

The 1980 population of the CMN is based on population estimates published by the United Nations (*13*, *14*) for all of the CMCs. Other demographic features

are extrapolated from figures published by the UN for the five largest CMCs: Jamaica (1980 population 2 133 000), Trinidad and Tobago (1 082 000), Guyana (759 000), Suriname (352 000), and Barbados (249 000). In 1980 the total CMN population was 5 549 000, with 61.6% being adult (15 years of age or older). The crude birth rate was 27.6; the crude death rate was 7.3; the infant mortality rate was 30.6; the population growth rate was 1.18%; and the total fertility rate was 3.51. Male life expectancy was 66.0 years, and female life expectancy was 70.8 years.

For making future projections, the age distribution of fertility was taken from the UN Sub-Saharan Africa Table; of the three tables built into DemProj, this one is the closest to figures published for Trinidad and Tobago in 1989 (*15*). Age-specific survival rates were calculated from UN projections for life expectancy and the default Coale-Demeny North Life Table. International migration rates were assumed to be zero, based on UN projections for most CMCs indicating that net migration will reach zero by the mid-1990s.

The per capita gross domestic product for all years was taken to be US$ 2 429 (in constant 1989 US dollars) based on World Bank estimates for Latin America and the Caribbean (*16*). This figure is important for assessing the epidemic's economic impact.

HIV/AIDS Parameters

The AIDS incubation distributions for adults and for children are based on Bacchetti and Moss (*17*) and Chin (*5*) respectively. Among adults, approximately 50% develop AIDS within 10 years. However, among children the rate of progression is thought to be much faster, so that 50% develop AIDS within 3 years. On the basis of published estimates (*8, 18–21*), the perinatal transmission rate is taken to be 30%. The age distribution of HIV incidence was surmised from the age distribution of reported AIDS cases; the highest incidence rates are for males between the ages of 20 and 29, and for females between the ages of 15 and 24.

It is difficult, if not impossible, to predict the future of any epidemic accurately. In the absence of dramatic changes in the dynamics of the HIV epidemic, such as might result from the introduction of an effective vaccine, we feel that adult HIV seroprevalence in the CMCs is likely to stabilize in the vicinity of 2% by the year 2000. This is based on published (*4*) and unpublished CAREC surveillance data and on observations in other countries, as mentioned above. Even in the worst case, however, the HIV seroprevalence is unlikely to exceed 5%. We therefore decided to examine the impacts of two different HIV prevalence scenarios, a "low" scenario in which the adult HIV prevalence rate stabilizes at 2% starting in the year 2000, and a "high" scenario in which the prevalence rate stabilizes at 5% in that year.

In both scenarios the prevalence rate starts at 0.01% in 1980, rising to 0.13% in 1985 and 0.25% in 1990. In the low scenario it climbs to 1.25% in 1995 and 2% in 2000. In the high scenario it reaches 3% in 1995 and 5% in 2000. The levels through 1990 were chosen to approximate the AIDS incidence already observed in the CMCs.

The projection of adult and child AIDS cases follows from the assumptions about seroprevalence, incubation periods, and vertical transmission rates. DemProj, APM, and EpiModel all compute AIDS incidence from HIV incidence, which in turn is derived from the input HIV prevalence assumptions. DemProj is far more structured than the other two, however, with stratification of the population into 5-year age categories.

RESULTS AND DISCUSSION

HIV Population

Since we have assumed that the HIV prevalence rate stabilizes in the year 2000, the absolute number of HIV-positive people rises in proportion to the growth of the total population. In the low scenario, the HIV-positive population reaches 135 558 by the year 2010, and in the high scenario it reaches 330 104.

AIDS Incidence and Effects on Population Growth

The projected AIDS incidence is depicted in Figure 2. By the year 2000, the annual incidence reaches 7 776 cases in the low scenario and 19 080 in the high scenario. By 2010, these figures rise to 11 666 cases per year in the low scenario and 28 854 in the high scenario.

The epidemic does affect population growth. By the year 2010, the population in the low scenario is approximately 98% of what it would have been in the absence of AIDS, while in the high scenario it is 95%. These figures drop to 97% and 92% by the year 2020.

These DemProj results are very close to those generated by APM. Except for the earliest years, when AIDS incidence is low, the models agree to within 6% in estimates of both adult and child AIDS incidence. Using the same input adult HIV prevalence scenario, APM and EpiModel yield identical results for adult AIDS incidence.

Age Distribution of AIDS Cases

The age distribution of new AIDS cases in the low scenario in the years 2000 and 2010 is represented in Figure 3. As has been observed in the CMCs, the model epidemic affects primarily young adults, with 70% of the AIDS cases occurring between the ages of 20 and 44. In the year 2000 a peak of approximately 1 560 cases occurs in the 25–29 year age bracket, whereas in 2010 the peak is spread over the broader 25–34 age range, with close to 2 100 cases occurring in each of the

Figure 2. Annual AIDS incidence (1980–2010) in the CMN projection (low and high scenarios).

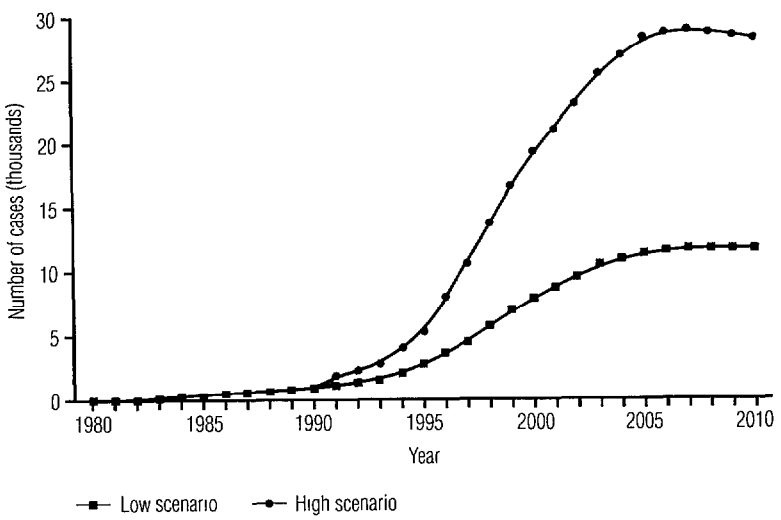
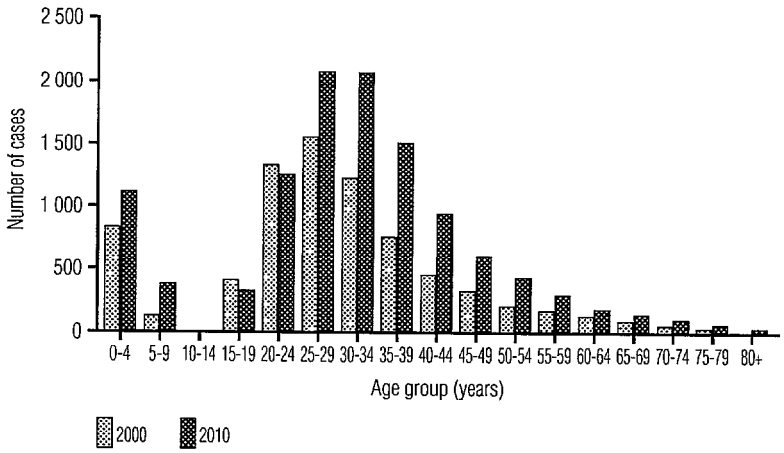


Figure 3. New AIDS cases by age in 2000 and 2010 in the CMN projection (low scenario).



two 5-year age brackets involved. The average age in 2010 is 32, and there is actually a decrease in the number of cases seen in the 15–19 and 20–24 year age brackets as the epidemic stabilizes.

In the high scenario the pattern is very much the same, but the peak in the 25–29 year age bracket is near 3 900 cases in the year 2000, and in 2010 close to 5 200 cases occur in both the 25–29 and 30–34 year age brackets.

Since this is a model of strictly heterosexual transmission, the percentages of child cases are higher than the percentages observed currently in the CMCs (12% as compared to 6%). However, as transmission patterns shift to a primarily heterosexual epidemic, we can expect to see more pediatric cases in the future. Indeed, in some areas of the world pediatric AIDS cases constitute even more than 12% of the total (*20*, *21*).

Age-specific Mortality

In estimating the impact of AIDS on age-specific mortality, baseline or non-AIDS death rates were taken from published figures for 1989 in Trinidad and Tobago (*15*). These figures may underestimate true rates for this country in 1989 (due to underreporting), but may be more accurate for projections into the future, as longevity increases.

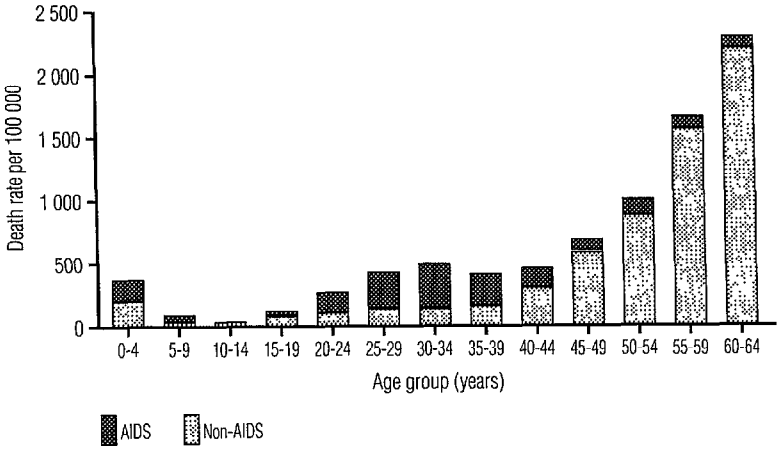
Figure 4 depicts the impact of AIDS on age-specific mortality in the low scenario in the year 2010. The effect on young adults is particularly pronounced. Death rates are more than doubled in the age brackets from 20 through 39. Among children, death rates are increased by 65% in the 0–4 age group and by twice that in the 5–9 age group.

In the high scenario the impact is considerably more severe, as shown in Figure 5. Overall death rates are at least doubled in every age bracket from 15 through 44, and are more than quadrupled in the age brackets from 20 through 39. Among children, death rates are more than doubled in the 0–4 age group and quadrupled in the 5–9 age group.

Economic Impact

In assessing the economic impact of HIV/AIDS, it is necessary to determine the direct costs (the costs of caring for

Figure 4. AIDS and non-AIDS age-specific mortality in 2010 in the CMN projection (low scenario).

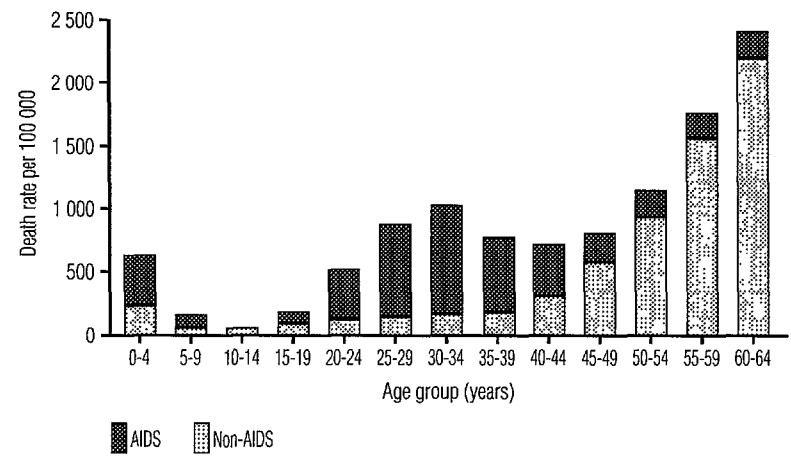


AIDS patients) and the indirect costs, which are defined here as losses in productivity due to increased mortality of the working population (*8, 22*).

In this study we have endeavored to express direct and indirect costs as functions of the per capita gross domestic product (PCGDP). To estimate direct costs, we examined costs found in other studies in 15 countries located primarily in Africa, the Caribbean, and Europe (22). As might be expected, there appears to be a direct linear relationship between resources available, as measured by PCGDP, and expenditures for the care of AIDS patients. Fitting a regression line of per person direct costs on PCGDP, we estimate direct costs as 1.75 times PCGDP. This result agrees with an estimate for Trinidad and Tobago when the costs of AZT are not included (*23*).

A similar approach is used to assess

Figure 5. AIDS and non-AIDS age-specific mortality in 2010 in the CMN projection (high scenario).



indirect costs. Here we examined costs assessed for six countries in Africa, Asia, and the Caribbean (*24*), and again found a linear relationship between lost productivity costs and PCGDP. Fitting a regression line, indirect costs per AIDS case are estimated as 15.6 times PCGDP.

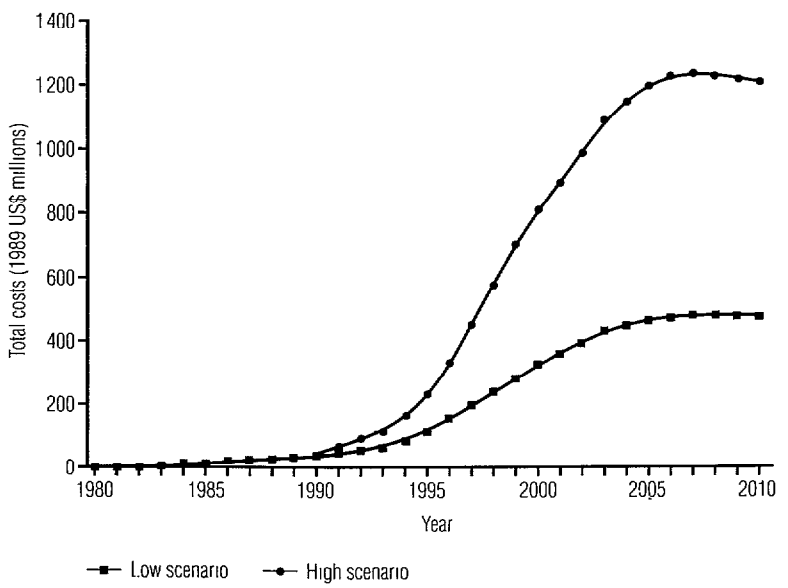
Another approach to estimating indirect costs is as follows: the income level of persons with AIDS is unknown; but if, for example, it is assumed that each person succumbing to the disease at an average age of 32 loses 30 years of productive life earning an annual income equivalent to the PCGDP, and these future earnings are discounted to their present value at 5% (*25*), then each AIDS case results in a loss to the economy of 16.14 times the PCGDP. This alternative method yields an estimate which is smaller than estimates of lost productivity costs found in several countries including the United States (*26, 27*). However, in this article the still more conservative figure of 15.6 times the PCGDP is used.

As mentioned above, the PCGDP is taken to be \$2 429 per year (in constant 1989 US dollars), so that annual total costs become US\$ 2 429 × (1.75 + 15.6) × AIDS incidence, with direct costs accounting for approximately 10% of the total. As shown in Figure 6, annual total costs of the epidemic for the CMN approach US\$ 500 million, or approximately 2% of GDP, in the low scenario, and exceed US\$ 1 200 million, or approximately 5% of GDP, in the high scenario.

CONCLUSIONS

Even in the relatively conservative adult HIV prevalence scenarios modeled in this study, the effects of the HIV/AIDS epidemic are substantial. With 70% of the AIDS cases occurring between the ages of 20 and 44, a significant proportion of

Figure 6. The cost of AIDS (1989 US$) in the CMN projection (low and high scenarios), 1980–2010. Total costs include direct (cost of care) and indirect (lost productivity) costs. Direct costs are approximately 10% of the total.



the working and child-rearing population will be affected. AIDS will account for more than half of the deaths in this age range in either scenario. More than 10% of the cases will be in children, accounting again for at least half of the deaths in children under 5 and having an even greater impact on deaths among children 5–9.

Economic impacts, both in terms of caring for AIDS patients and lost productivity, will also be significant, possibly approaching 5% of GDP. If other indirect costs including (1) losses on societal investment in persons dying prematurely; (2) the cost of caring for orphans left by parents succumbing to AIDS; (3) the additional health care costs resulting from the increased incidence of other diseases; (4) the cost of ensuring the safety of the blood supply; (5) the cost of laboratory and hospital precautions; (6) the cost of health education and other preventive measures; (7) the cost of lost tourism revenue; and (8) the enormous psychological toll imposed on AIDS victims, their families, and society as a whole, are taken into account, estimates of total costs will be considerably higher.

In sum, the HIV/AIDS epidemic will markedly alter morbidity and mortality patterns with formidable social and economic consequences. It will be important for each CAREC member country to anticipate and, to the extent possible, mitigate these effects. This circumstance has immediate implications for the design of institutional and community health services and other social support systems.

Acknowledgments. We wish to thank each of the CAREC member countries for supplying the data on which this article was based. CAREC was supported for this work by grants from the United States Agency for International Development (USAID) and the Canadian International Development Agency (CIDA). Partial support was provided by Family Health International (FHI) with funds from USAID. The views expressed in this work do not necessarily reflect those of USAID or CIDA. FHI is an international nonprofit organization that conducts research and provides technical assistance in reproductive health, family planning, sexually transmitted diseases, and AIDS whose headquarters is in Research Triangle Park, North Carolina, USA.

REFERENCES

1. Anderson RM, May RM. *Infectious diseases of humans, dynamics and control.* Oxford: Oxford University Press; 1991.
2. Newton EAC, Reiter P. A model of the transmission of dengue fever with an evaluation of the impact of ultra-low volume (ULV) insecticide applications on dengue epidemics. *Am J Trop Med Hyg* 1992;47:709–720.
3. González JJ, Koch MG. On the role of "transients" (biasing transitional effects) for the prognostic analysis of the AIDS epidemic. *Am J Epidemiol* 1987;126:985–1005.
4. Hospedales J, White F, Gayle C, Newton E, Francis C, Poumerol G. Epidemiology of HIV/AIDS in the Caribbean. In: Lamptey P, White F, Figueroa JP, Gringle R, eds. *Handbook for AIDS prevention in the Caribbean.* Research Triangle Park, North Carolina: Family Health International; 1992.
5. Chin J. Current and future dimensions of the HIV/AIDS pandemic in women and children. *Lancet* 1990;336:221–224.
6. Chin J. Public health surveillance of AIDS and HIV infections. *Bull World Health Organ* 1990;68:529–536.
7. Sokal DC, Buzingo T, Nitunga N, Kadende P, Standaert B. Geographic and temporal stability of HIV seroprevalence among pregnant women in Bujumbura, Burundi. *AIDS* 1993;7:1481–1484.
8. Mann J, Tarantola D, Netter T. The HIV pandemic: status and trends. In: Mann J, Tarantola D, Netter T, eds. *AIDS in the World.* Cambridge: Harvard University Press; 1992:11–108.
9. Health Studies Branch, Center for International Research, US Bureau of the Census. *Trends and patterns of HIV/AIDS infec-*

tion in selected developing countries. Washington, DC: US Government Printing Office; 1992.

10. Stover J. *DemProj: a demographic projection model for development planning.* Glastonbury: Futures Group; 1990.
11. Newton EAC. *Modeling the HIV/AIDS epidemic in the Caribbean: final report.* Port of Spain: CAREC; 1993.
12. Chin J, Lwanga SK. Estimation and projection of adult AIDS cases: a simple epidemiological model. *Bull World Health Organ* 1991;69:399–406.
13. United Nations Population Division, Department of International Economic and Social Affairs. *World population prospects 1990.* New York: United Nations; 1991.
14. United Nations Population Division, Department of International Economic and Social Affairs. *Sex and age distributions of population.* New York: United Nations; 1991.
15. Republic of Trinidad and Tobago, Central Statistical Office. *Population and vital statistics report 1988/1989.* Port of Spain: Ministry of the Economy; 1991.
16. International Bank for Reconstruction and Development/World Bank. *World Development Report 1992.* New York: Oxford University Press; 1992.
17. Bacchetti P, Moss AR. Incubation period of AIDS. *Nature* 1989;358:251–253.
18. Preble EA. Impact of HIV/AIDS on African children. *Soc Sci Med* 1990;31:671–680.
19. Pape JW, Johnson W. Perinatal transmission of the human immunodeficiency virus. In: *AIDS, profile of an epidemic.* Washington, DC: Pan American Health Organization; 1989.
20. Piot P, Plummer FA, Mhalu FS, Lamboray JL, Chin J, Mann JM. AIDS: an international perspective. *Science* 1988;239:573–579.
21. Quinn TC, Narain JP, Zacarias FRK. AIDS in the Americas: a public health priority for the region. *AIDS* 1990;4:709–724.
22. Forsythe S, Sokal D, Lux L, King T, Johnston A. *An assessment of the economic impact of AIDS in Kenya.* Research Triangle Park, North Carolina: Family Health International; 1992.
23. Henry R, Newton EAC. HIV/AIDS costs in Trinidad and Tobago. *Stud Comp Int Dev.* [In press].
24. Nyamuryekung'e K. The direct and indirect cost of HIV infection in developing countries. In: Fleming AF, Carballo M, Fitzsimmons DW, Bailey MR, Mann J, eds. *The global impact of AIDS: proceedings of the First International Conference on the Global Impact of AIDS.* New York: Alan R Liss; 1988.
25. Over M, Bertozzi S, Chin J, N'Galy B, Nyamuryekung'e K. The direct and indirect cost of HIV infection in developing countries: the cases of Zaire and Tanzania. In: Fleming AF, Carballo M, Fitzsimmons DW, Bailey MR, Mann J, eds. *The global impact of AIDS: proceedings of the First International Conference on the Global Impact of AIDS.* New York: Alan R Liss; 1988.
26. Hardy AM, Rauch K, Echenberg D, Morgan WM, Curran JW. The economic impact of the first 10,000 cases of acquired immunodeficiency syndrome in the United States. *JAMA* 1986;255:209–211.
27. Scitovsky AA, Rice DP. Estimates of the direct and indirect costs of acquired immunodeficiency syndrome in the United States, 1985, 1986, and 1991. *Public Health Rep* 1987;102:5–17.