Forecasting the Personal Medical Care Costs of AIDS from 1988 Through 1991

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Synopsis

The personal medical care costs of those diagnosed with acquired immunodeficiency syndrome (AIDS) in 1988 are forecast to be $2.2 billion, an amount that will increase to $4.5 billion in 1991. This is the first study to include the cost of purchasing azidothymidine (AZT), also called zidovudine, a palliative treatment for AIDS. The forecasts of this study are lower than those reported by Rice and Scitovsky, and other researchers, because the data are more recent and AIDS patients are receiving more care on an outpatient basis and staying in the hospital fewer days. They are also lower because projections for the number of AIDS cases diagnosed in future years are lower than those made by the Centers for Disease Control (CDC).

This study projects that about 38,000 AIDS cases will be diagnosed in 1988 and 73,000 in 1991. The projections in this study are derived using data on the number of AIDS cases reported to CDC from January 1984 to October 1987, while the CDC projections employed by Rice and Scitovsky were derived using data from June 1981 to May 1986. It is also projected that the lifetime cost of treating an AIDS patient will increase from $57,000 in 1988 to $61,800 in 1991 due to the wider use of AZT.

IN FORECASTING the personal medical care costs of patients diagnosed with acquired immunodeficiency syndrome (AIDS) during the years 1988 through 1991, this is the first study to include the costs of purchasing azidothymidine (AZT), also called zidovudine. Personal medical care costs include hospital, physician, drug, and nursing home costs. They do not include nonpersonal medical care costs of AIDS such as the cost of testing, education, and support services, or the indirect costs of AIDS measured by lost productivity.

This study forecasts the personal medical care costs of those diagnosed with AIDS to be $2.2 billion in 1988, increasing to $4.5 billion in 1991. These forecasts are slightly lower than those reported by Rice and Scitovsky (*1,2*) and are based on projections of 38,000 AIDS cases diagnosed in 1988 and 73,000 in 1991. These case projections are lower than the Centers for Disease Control (CDC) projections used by Rice and Scitovsky (*3*). The case projections in this study are derived using data on the number of AIDS cases reported to CDC from January 1984 to October 1987, while the CDC projections used by Rice and Scitovsky were derived using data from June 1981 to May 1986. The forecasts of aggregate costs are also based on predictions that the lifetime costs of treating an AIDS patient will be $57,000 in 1988 and that this figure will rise to $61,800 in 1991 because of the wider use of AZT.

The introduction to this paper briefly examines the spread of AIDS through the population, the two types of models that have been used to project the number of AIDS cases, and evidence about the effects of AZT. The second section of this paper reviews several studies that estimate the cost of AIDS in the United States. The third section projects the costs of treating an AIDS patient, and

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the fourth section projects the number of AIDS cases; the last section projects aggregate costs.

The Spread of AIDS

The human immunodeficiency virus (HIV) responsible for AIDS was isolated in 1984. New information about the HIV indicates that it is more complex than originally thought and that the body's immune system is impaired soon after a person is infected by the HIV. The CDC definition of AIDS covers only the most severe manifestations of the HIV (*4*). The AIDS virus may be spread by sexual contact, by parenteral exposure to contaminated blood or blood products, and from an infected mother to her child. All but 3 percent of those who acquire AIDS may be identified as a member of a high-risk group.

The proportion of AIDS patients in each high risk group has remained stable since 1981: 65 percent are homosexual or bisexual; 17 percent are intravenous (IV) drug users; 8 percent are both; 3 percent are hemophiliacs or have received transfusions; 4 percent have had heterosexual contact with a person with AIDS or at risk for AIDS, or were born in a foreign country where heterosexual transmission of AIDS is common; and 3 percent could not be placed in one these categories based on available information (*5*). Strictly heterosexual transmission of AIDS between people not in these risk groups has been documented, yet it is rare and appears not to be increasing (*6*). Although risk group proportions have remained stable, the geographic distribution of AIDS has not remained stable (*7*). Before 1984, about half of all AIDS cases were found in New York City or San Francisco. During 1987, only about one-fourth of the AIDS cases reported were in New York City or San Francisco.

Forecasting the Number of AIDS Cases

To forecast the cost of AIDS, both the future number of AIDS cases and the future cost of treating an AIDS patient must be projected. Since 1981, when the first cases of AIDS were reported in five young homosexual men from Los Angeles, more than 50,000 AIDS cases have been reported to the CDC (*8*). The medical costs of treating these cases exceed $2 billion, and the indirect costs (that is, loss in productivity) are many times this amount because of the large percentage of young adults stricken by the disease.

Two types of models may be used to forecast the number of AIDS cases—the epidemiologic model and the statistical extrapolation model. Epidemiologic models begin by estimating the number of people at risk for AIDS and then the spread of the HIV through the population (*9*). Estimates using this model are based on information about the number of people with the HIV in each risk group, the risk of an infected person acquiring AIDS, the average number of sexual contacts or instances of needle sharing between infected persons and their partners, the risk of infection per sexual contact or instance of needle sharing, and the effect of educational efforts aimed at changing the behavior of persons in high-risk groups.

Reliable information on these parameters is generally unavailable. For example, there is still substantial uncertainty regarding the percentage of those infected with the HIV who will acquire AIDS. A recent article stated that, "For public health planning, the dominant unknown is the fraction infected who will eventually get AIDS. Estimates of this parameter have been increasing in recent years, but on present evidence the possibility cannot be ruled out that it is as low as 20 percent or as high as virtually 100 percent" (*9*). The Public Health Service has estimated that between 20 and 30 percent of the people infected with the HIV will develop AIDS within 5 years (*10*). Estimates of the penetration of the HIV in high-risk groups are generally about 60 percent for homosexuals and bisexuals and up to 70 percent of IV drug users in New York City (*11*). The percentage of infected IV drug users in other cities is less, but it is likely to increase. However, the rate of spread of the HIV in the homosexual community has lessened considerably during the past year.

An alternative to the epidemiologic model for predicting AIDS cases is the statistical extrapolation model based on the number of AIDS cases reported. The statistical extrapolation model has been used in studies by the CDC, the Department of Health Services in California, and the Minnesota Department of Health (*3,12,13*). These studies estimate polynomial equations to explain the num-

ber of AIDS cases as a function of time. They forecast by calculating the number of AIDS cases for periods beyond those used to estimate the equation. Although these models are simplistic and are not based on underlying epidemiologic phenomena, they have produced good forecasts.

AZT

AZT was approved by the Food and Drug Administration to treat AIDS patients in March 1987. In double-blind clinical trials, AZT was found to reduce mortality and the occurrence of opportunistic infections in the 145 people with AIDS manifested by *Pneumocystis carinii* pneumonia (PCP) who received AZT (*14*). For the most part, AIDS patients on AZT have PCP. Yet, AZT is being used for other types of AIDS patients and has been used to treat people who are seropositive. Preliminary evidence from an ongoing double-blind clinical trial of AZT shows that 83 percent of those treated with AZT were alive after 1 year, and 70 percent were alive after 18 months (personal communication, Margaret A. Fischl, MD, Director, Comprehensive AIDS Program, University of Miami School of Medicine, January 20, 1988). All of these patients have PCP. Of those alive after 18 months, about 50 percent are on a reduced dosage (generally one-half the full dosage), about 25 percent are unable to take AZT because of adverse side effects, and about 25 percent are taking a full dosage.

Efforts are continuing to learn how to reduce the toxicity of AZT. The drug regimen at Jackson Memorial Hospital, Dade County, FL, combines AZT with antibiotic therapy, while researchers at the National Institutes of Health are conducting clinical trials to treat AIDS patients with AZT and dideoxycytidine (DDC) in order to reduce toxic side effects (personal communication, Margaret A. Fischl, January 20, 1988) (*15*). In a double-blind clinical trial, Jackson Memorial Hospital is treating AIDS patients with Kaposi's sarcoma with AZT and interferon. Researchers at Jackson Memorial Hospital anticipate that AZT eventually may be used to treat 70 percent of AIDS patients.

Review of National AIDS Cost Studies

Hardy and colleagues presented the first national estimates for the costs of AIDS in January 1986 (*16*). They estimated the hospital cost of the first 10,000 cases of AIDS reported to CDC in May 1985 to be $1.4 billion. This cost estimate is based on the assumption that AIDS patients spend an average of 167 days in a hospital at an average cost of $878 per day, resulting in lifetime hospital costs per patient of $147,000. The 167-day estimate was derived from the experience of some New York City hospitals that treated early AIDS patients, and it is now regarded as too high.

Table 1. Estimated personal medical care costs of AIDS in 1985, 1986, and 1991 in 1984 dollars

Estimates	*1985*	*1986*	*1991*
Number of AIDS cases.....	18,720	31,440	172,800
	Expenditures in millions		
Low.....	$381	$640	$3,517
Medium	597	1,003	5,512
High	1,016	1,706	9,374

SOURCE: Scitovsky and Rice (*2a*).

Scitovsky and Rice produced the first rigorous and comprehensive study of the cost of AIDS for CDC (*1,2*). Their study estimated personal and nonpersonal medical care costs, as well as the indirect costs of AIDS. Scitovsky and Rice used estimates of the number of AIDS cases produced by CDC analysts, W. Meade Morgan and James Curran, adjusted up by 20 percent to account for underreporting. CDC estimated the number of people alive with AIDS each year between 1985 and 1991 and divided these estimates into three categories—those diagnosed prior to the year and who lived through the year, those diagnosed during the year and who lived through the year, and those who died of AIDS during the year. Each group was broken down further into patients with PCP, Kaposi's sarcoma, and other manifestations of AIDS. It was assumed that the proportion of AIDS patients alive in each of these nine categories remained constant over time. Scitovsky and Rice used data from AIDS patients at San Francisco General Hospital (SFGH) in 1984 to derive estimates of the cost of treating a patient in each of the nine categories. These estimates were then adjusted up to derive medium and high estimates (table 1). The SFGH data were used to generate low estimates because the costs of treating AIDS patients in San Francisco are lower owing to the large percentage of homosexual AIDS patients with Kaposi's sarcoma and the extensive social support network for AIDS patients that helps reduce hospital stays.

In May 1987, a Rand study by Pascal on the cost of AIDS was published (*17*). Pascal estimated

Table 2. Estimates of the cumulative medical costs for AIDS treatment for 1986–91

Factor	Range of estimates		
	Low	Medium	High
Number of cases	220,000	400,000	750,000
Lifetime cost per case	$70,000	$94,000	$150,000
National cost estimates in billions of dollars	$15.4	$37.6	$112.5

SOURCE: Pascal (*17a*).

the personal medical care costs of AIDS between 1986 and 1991 using varying assumptions about the projected number of AIDS cases and about the future costs for treating an AIDS case (table 2). Scitovsky and Rice used CDC projections of future AIDS cases for all of their estimates.

Pascal's estimates are substantially higher than those made by Rice and Scitovsky. Pascal's low case estimate corresponds closely with Scitovsky's and Rice's intermediate estimate. CDC estimated that about 220,000 new cases of AIDS (Pascal's low estimate) would be diagnosed between 1986 and 1991. Pascal derived his high estimate of 750,000 cases from the Institute of Medicine's high estimate of 1.5 million seropositives and Johnstone's estimate that 50 percent of seropostives will acquire AIDS within 5 years (*18, 19*). Pascal's intermediate estimate for the number of cases is 400,000, which is one-third of the way between the low and high estimates. Pascal moves only one-third of the way between the low and high estimates because the low estimate is the most widely cited caseload projection, and the high estimate is based on highly speculative assumptions (*17b*). The low estimate for lifetime costs per case is $70,000. It comes from a study by Scitovsky and coworkers that used all data sources available in the middle of 1986 (*20*). The intermediate cost estimate of $94,000 was obtained from an early study by Kizer and coworkers of charges for AIDS patients in California (*21*). The high estimate for lifetime costs per case of $150,000 was obtained from a study by Hardy and coworkers (*16*). Each of these estimates included $2,000 to $4,000 to cover non-inpatient costs of treatment.

The only national survey of AIDS costs for hospital care was conducted by the National Association of Public Hospitals and the Association of Medical College's Council of Teaching Hospitals in 1985. In September 1987, Andrulis and coworkers reported that study, which used data from 169 hospitals that accounted for almost one-third of the AIDS cases treated in 1985 (*22*). They found that the average hospital cost per AIDS patient per year was $20,320, equivalent to about $37,400 for lifetime costs (table 3). Scitovsky and Rice (*1a*) found that the average AIDS patient alive during 1984 at SFGH lived 6.527 months, so that the cost of 1 year of life is 1.839 ($12 \div (6.527)$) times the cost per patient per year. The study by Rothenberg and coworkers of 5,800 AIDS cases in New York City revealed that the average AIDS patient lived about 1 year after diagnosis, so that the cost of treating an AIDS patient for 1 year is equal to the average lifetime cost (*23*).

The average hospital cost per patient per year in the survey by Andrulis and coworkers varied from $23,421 in the Northeast to $14,858 in the West. The geographic variations are almost entirely a result of variations in the average length of stay (24 days per admission in the Northeast and 14 days in the West). The cost per patient day and the number of admissions per patient year varied little across census regions. Andrulis and coworkers multiplied the $20,320 estimate of the average cost per patient per year by 18,720 (the CDC estimate of the number of people alive during 1985 with AIDS) to obtain their estimate of $380 million for the inpatient cost of AIDS in 1985. This is similar to the low estimate for both inpatient and outpatient hospital costs made by Scitovsky and Rice.

Estimates derived from an epidemiologic model for forecasting AIDS costs, constructed by Harris, were published in July 1987 (*24*). Using 1948 estimates from Kinsey that 4 percent of the male population are homosexual and estimates that about 15 percent of these men are infected, Harris estimated that 750,000 homosexual men were infected with the HIV. Harris used estimates of 500,000 IV drug users in the United States and assumed that 20 percent were infected to obtain the estimate of 100,000 infected IV drug users. Other groups were estimated to comprise 50,000 infected persons, resulting in a total of 900,000 infected persons in the United States. From a variety of sources Harris concluded that, "AIDS will develop in 4 percent of all infected people after 3 years and 40 percent after 7 and a half years. The median incubation period is 5 and a half years" (*24a*). These figures imply that there will be 210,000 more AIDS victims in 1991 than in 1987. Harris estimated the lifetime cost of AIDS at $50,000 and that the cumulative burden of AIDS will exceed $10 billion by 1991.

Projecting Treatment Costs

Data compiled recently by researchers at the University of California at San Francisco (UCSF) Institute for Health Policy Studies show that lifetime hospital charges for AIDS patients average about $41,000 (*25*). Unexpectedly, the highest lifetime charges for hospital services ($70,000) were found in California. These figures were obtained from the 1987 report by Kizer and colleagues on Medi-Cal lifetime hospital costs for AIDS patients (*12*). Lifetime Medi-Cal hospital costs averaged $44,000 per patient with AIDS, and Kizer and colleagues used a charge-to-cost ratio for Medi-Cal patients of 1:6 to obtain the $70,000 estimate.

Perhaps the best source of data on hospital costs is the national survey described by Andrulis and coworkers (*22*). They found that the average hospital cost per patient year was $20,320, or about $37,400 in lifetime hospital costs. This estimate is consistent with the charge data reported by UCSF. (Cost estimates are expected to be less than charge estimates.) The data used by both the UCSF and Andrulis and coworkers cover only hospital services. Outpatient drugs, long-term care, ambulatory physician visits, and diagnostic tests performed outside the hospital are excluded. Data from a study of Medi-Cal patients with AIDS reveal that nonhospital-associated medical costs account for about 10 percent of direct medical care costs (*12a*); 6 percent was attributable to physician services and the remaining 4 percent to pharmacy, visiting nurses, home health care services, nursing home care, and other services.

There is substantial evidence that the cost of treating an AIDS patient has decreased over the past 3 years. In April 1987, Kizer and coworkers reported that, "The cost experience consistently showed lower Medi-Cal costs than earlier studies, by significant amounts" (*12b*). They found that the average cost of medical care for all Medi-Cal AIDS cases through September 1985 was $90,000 and that the average cost of all cases through September 1986 was $70,000. Since the 1987 study contained three times as many cases as the 1986 study, this implies that the lifetime cost of treating an AIDS patient during the State's 1986 fiscal year was $60,000. Scitovsky and Rice stated, "We know that, in the course of the epidemic to date, changes in treatment have already occurred. There is considerable evidence that the average length of stay has declined" (*2b*). In her recent review article, Sisk noted that, "There are reports that AIDS patients are less likely to be admitted to intensive care units than they were when less was known about the course of the disease and that the average length of stay has declined. Seage's preliminary data from Massachusetts . . . suggest such a decline in hospital treatment costs" (*26*).

Table 3. Hospital costs of patients with AIDS, 1985

Costs	Amount
Per day	$635
Per admission	12,065
Per patient per year	20,320

SOURCE: Andrulis and coworkers (*22a*).

Phillip Lee, president of the city of San Francisco's Health Commission, reported that the average length of stay has dropped from 18 to 11 days because of increased treatment in outpatient settings. Donald Abrams, assistant director of the AIDS clinic at San Francisco General Hospital, stated that, "AIDS is essentially an outpatient disease" (*27*). San Francisco has developed a comprehensive coordinated program of AIDS treatment that relies heavily on volunteer help for such services as cooking and cleaning for AIDS victims in their homes, counseling, financial support, and legal assistance.

The cost of treating an AIDS patient has fallen because physicians have learned how to treat patients more efficiently, and because numerous coordinated systems of care have been developed that are less dependent on hospital services. Gordon Nary, executive director of the AIDS Medical Resource Center in Illinois, stated, "By having a coordinated system of care, and paying for nonacute care services that are not currently being covered, we've found we can substantially reduce hospital days, usually by about 50 percent" (*25a*). Andrulis and coworkers stated that, "Less reliance on the hospital as *the* primary or sole source of care could reduce the burden and mitigate costs. In particular, developing community-based services and changing public attitudes towards AIDS could facilitate the creation of more cost-effective alternatives" (*22b*).

It is difficult to predict whether increasing knowledge about AIDS will decrease or increase the cost of treatment in the future, but it is likely that the movement toward coordinated AIDS treatment systems will help lower costs. The Health Resources and Services Administration (HRSA) of the Public Health Service is currently funding 13 health organizations to develop coordi-

nated systems of treatment based on close working relationships among health agencies (personal communication, Richard Schulman, HRSA, AIDS Service Demonstration Program, January 15, 1988). There are also several private foundations that are providing funds for this purpose.

A host of factors affects the costs of treating an AIDS patient. If the proportion of patients with specific AIDS manifestations (for example, with PCP or Kaposi's sarcoma) changes, it will affect the cost of treatment because it costs more to treat patients with PCP than Kaposi's sarcoma (*20a*). CDC data as of December 21, 1987, reveal that the percentage of AIDS patients with Kaposi's sarcoma has fallen since 1981 (*28*). The percentage of AIDS patients with PCP was 61 percent during 1987 and 63 percent for all cases since 1981; the percentage with Kaposi's sarcoma was 9 percent during 1987 and 11 percent for all cases since 1981. (Cases with both PCP and Kaposi's sarcoma were reported under PCP.)

Changes in the geographic distribution of AIDS cases could also affect the average costs of treating an AIDs patient because patients in the Northeast are more costly to treat (*22b*). Recent data from CDC reveal that the proportion of cases reported in the Northeast has dropped as a result of a drop in the proportion of cases reported in New York. In 1985, 30.2 percent of the AIDS cases were reported in New York State (*29*); in 1986, it was 27.5 percent, and in 1987, 19.0 percent (*30*). Data on the percentage of cases diagnosed in the New York standard metropolitan statistical area (SMSA) confirm this trend. In 1985, 25.6 percent of all AIDS cases were diagnosed in the New York SMSA; in 1986, this figure was 22.8 percent, and in 1987, 17.4 percent (*28*). It is too early to determine the effect of this change on the cost of treatment, and there is little information indicating why this shift has occurred.

Projecting the cost of treating a patient with AIDS is difficult because there is no way of knowing how future scientific advances will affect the way AIDS patients are treated. For example, analysts before 1985 had no way of predicting that a drug that lowers the morbidity and mortality rate of AIDS patients would be approved by FDA and would be used by almost half of all AIDS patients in early 1988. Originally, the cost of a year's supply of the recommended amount of AZT approached $12,000; now it is about $8,000 per year (*31*). AZT represents a significant proportion of the cost of treating an AIDS patient. However, prior studies have been unable to account for the costs of AZT because it has been widely available for only a short time. This paper assumes that AZT will be the drug of choice to treat AIDS through 1991.

Evidence suggests that increased knowledge about AIDS, development of new coordinated systems of care that depend less on hospital care, and a decrease in the proportion of AIDS cases from the Northeast have lowered, and may continue to lower, the costs of treating an AIDS patient. In developing projections of the costs of treating an AIDS patient, the assumption is that any cost reductions experienced because of the previously mentioned factors will be offset by the increased costs of treating the side effects of AIDS patients who receive AZT. To the extent that these factors persist and result in future costs being lower by an amount greater than the costs of treating the side effects of AZT, the projections of this study are overestimates.

Unfortunately, there is no information available on the overall treatment costs of a patient on AZT. It may be that the reduced occurrence of opportunistic infections for patients on AZT offsets the cost of treating the side effects of AZT (*14*). In any case, one is left in the position of having to quantify the monetary effects of treatment regimens that provide less emphasis on hospital care, but provide patients with AZT that is sometimes toxic to the bone marrow, often necessitating blood transfusions. The approach in this paper is to add the cost of the drug AZT to current estimates of the cost of treating an AIDS patient.

Some analysts might reasonably assume that treatment costs will fall as a result of the increased use of outpatient care and that the cost of treating the side effects of AZT is more than offset by the reduction in opportunistic infections. Yet, until more information is available, it is not possible to determine the net effects of these factors on the costs of care. The approach here is to overestimate rather than underestimate the costs of care.

Because knowledge about how to treat AIDS is rapidly evolving, projecting costs requires that problematic assumptions about the future be made. Indeed, it is difficult to estimate the current costs of treating an AIDS case because of the speed with which new methods of treatment are developed and made known. Currently available cost data describe how AIDS patients were treated several years ago, not how they are treated today or how they will be treated a year or two from now. For example, there are no cost studies that

reflect the increasing treatment of PCP on an outpatient basis by drugs administered orally or in aerosol form (*32*). There are also no studies that examine the treatment costs of AIDS patients with PCP who receive prophylactic therapy to reduce the likelihood of future episodes (*33*) or studies that examine cost savings attributable to IV administration of drugs at home rather than in a hospital (*27*).

In this study, the estimated lifetime hospital costs incurred by the average AIDS patient receiving no AZT are $41,000. Two primary sources were used to come to that conclusion: the review of hospital charges for AIDS patients compiled by the University of California at San Francisco (*25*) and data on hospital costs obtained in a survey of 169 hospitals described by Andrulis and coworkers (*22*).

Preliminary information from an ongoing study of the cost of AIDS patients of community physicians in San Francisco suggests that nonhospital costs presently account for 20 to 25 percent of the medical care costs of AIDS and that the increased use of nonhospital services has significantly lowered hospital costs (personal communication, Anne A. Scitovsky, Palo Alto Medical Foundation, February 29, 1988). It is unknown whether nonhospital services have supplanted hospital services outside San Francisco to the extent found in San Francisco. If other regions follow the lead of San Francisco, nonhospital costs will become a more significant portion of total medical care costs. For this study, the finding by Kizer and coworkers that 10 percent of total charges are attributable to nonhospital services is used to obtain an estimate of $45,000 for the total lifetime direct medical costs of treating an AIDS patient not receiving AZT (*12a*).

To project future treatments costs, this paper assumes that AZT extends the average life expectancy of an AIDS patient from 1 to 2 years and that the added cost of the extra year of life is $24,000. Thus, the lifetime cost of care is $69,000 ($24,000 + $45,000). The $24,000 estimate for the added year of life is derived from a study by Kizer and coworkers showing the lifetime cost of AIDS is U-shaped, and the cost of care during the middle months is about $1,000 per month or $12,000 for an extra year of life (*12*). The estimate also assumes the cost of AZT will average $12,000 per patient; AZT is estimated to cost an average of $8,000 for the first year and $4,000 for the second year. During the second year, about 50 percent of the patients are on reduced dosages (assumed to be equal to half the full dosage), and 25 percent do not take AZT. It is estimated that about 50 percent of AIDS patients now use AZT and that the average lifetime cost of treating an AIDS patient diagnosed in 1988 is $57,000 ((.5)($69,000) + (.5)($45,000)). It is projected that 60 percent of AIDS patients will receive AZT in 1989, that the average lifetime cost of treating an AIDS patient diagnosed in 1989 is $59,400 ((.6)($69,000) + (.4)($45,000)), and that the average lifetime cost of treating an AIDS patient diagnosed in 1990 or 1991 is $61,800 ((.7)($69,000) + (.3)($45,000)). All of these estimates are in 1985 dollars because base estimates of treating an AIDS patient were obtained from the 1985 survey described by Andrulis and colleagues.

Projecting the Number of AIDS Cases

In this section, the number of AIDS cases that will be reported during the 4-year period from 1988 through 1991 is projected, and these estimates are translated into estimates of the number of AIDS cases that will be diagnosed. A quadratic polynomial is estimated to explain the number of AIDS cases reported each month from January 1984 to October 1987. Forecasts for the future number of AIDS cases are obtained by using the coefficient of the estimated polynomial and time period designations for 1988 through 1991. Time periods are numbered consecutively. Time period 1 is the first 4 weeks in 1984, time period 2 is the second 4 weeks in 1984, and so on until time period 49 is the 10th 4-week period of 1987. The forecast of the number of cases reported in 1988 is the sum of the estimated number of cases for time periods 53–65; for 1989 it is the sum of time periods 66–78; for 1990 it is the sum of time periods 79–91; and for 1991, the sum of time periods 92–104.

CDC used a quadratic polynomial by estimating a linear regression on adjusted case counts as transformed by a modified Box-Cox method (*3*). In this study, a linear model was estimated in which the dependent variable is the square root of the number of cases and the independent variable is the time period. This model is equivalent to a constrained quadratic polynomial regression model where the constant term and coefficient for the squared time term are positive, and the coefficient of the linear time term is equal to twice the product of the square roots of the coefficients for the constant term and the squared time term. Because the coefficient of the squared time period

Table 4. Projected number of AIDS cases diagnosed during each year from 1988 through 1991

Model	1988	1989	1990	1991
A	29,932	37,657	46,028	51,080
B	31,468	41,167	52,756	60,760
C	33,000	45,000	58,000	74,000

is positive, this model results in higher projections for future cases than projections derived from the unconstrained quadratic polynomial.

Other models tested were one with a lagged dependent variable, a model explaining the projected number of cases with higher-order terms (for example, time^2 and time^3), and a model explaining the square root of the projected number of cases with higher-order terms. None of these models worked well. The logistic model and the model with lagged dependent variables explained almost none of the variation in the number of reported cases between January 1984 and October 1987, while the models with the higher-order terms provided forecasts for the number of cases in the future that were negative by 1991.

CDC projections for 1986 and 1987 are within the bounds of what can be determined to be reasonable, given information available through 1987. CDC projected that 15,800 cases of AIDS were diagnosed in 1986 (*3*). As of January 4, 1988, 15,088 cases have been reported that were diagnosed during 1986. CDC also estimated that 23,000 cases of AIDS were diagnosed in 1987. To date, 15,184 cases have been reported that were diagnosed during 1987 (*30*). Yet, it is not unreasonable to expect that this number will increase to 23,000. The number of cases reported as of January 5, 1987, that were diagnosed in 1986, was 10,211. The number reported as of January 4, 1988, and diagnosed in 1986 is 15,088, so that the number diagnosed rose 48 percent during 1987, from 10,211 to 15,088. If the number of cases diagnosed during 1987 increases 48 percent during 1988, the total number diagnosed in 1987 will increase from 15,184 to 22,300.

We use CDC data reported in various issues of the Morbidity and Mortality Weekly Report (MMWR) from January 1984 to October 1987 on the number of AIDS cases. Beginning in January 1984, the MMWR began providing data on the number of AIDS cases reported on a weekly basis. The January 13, 1984, issue of the MMWR stated, "In accordance with the recommendations passed by the Conference of State and Territorial Epidemiologists at its annual meeting in May 1983, acquired immunodeficiency syndrome (AIDS) has been added to the list of notifiable diseases reportable to CDC and will be reported in Tables I and III beginning with this issue" (*34*). We compiled data on 49 4-week periods beginning with the first week of 1984 and ending with the 44th week of 1987. This is the last time period before figures using the new CDC definition of AIDS cases were reported. Thus, our projections are comparable to the CDC estimates, but are underestimates of the number of AIDS cases that meet the new definition, which includes the wasting away syndrome and dementia.

There is often a long lag between the time a case is diagnosed and when it is reported. Harris stated that, "Only about 5 percent of AIDS cases are reported in the same period they are diagnosed. About 11 percent take over a year" (*24b*). To translate estimates of the number of cases reported during a year to estimates of the number of cases diagnosed during the year, we examined the ratio of the number of cases reported during 1984 to the number of cases diagnosed in 1984 that were reported by December 7, 1987. The year 1984 was used because many cases diagnosed during 1985 and 1986 have not yet been reported. The ratio of the number of cases diagnosed in 1984 and reported by December 7, 1987, to the number of cases reported in 1984, is 1.28 (5,681 ÷ 4,444). This is an underestimate of the true ratio because the estimates for the number of cases diagnosed in 1984 will increase with time. We estimate that the actual ratio of diagnosed to reported cases in 1984 is about 1.35.

During the past few years, reporting has become less timely. The percentage of cases reported in a year that were diagnosed in that year has decreased the past 2 years. The mean delay from diagnosis to report for cases reported in 1986 was 3.47 months; for 1987, the mean delay was 4.57 months (personal communication, W. Meade Morgan, CDC, February 28, 1988). To translate the projected number of reported cases into projections of the number of diagnosed cases in a given year, the assumption was that the ratio of cases diagnosed in a year to the number of cases reported in a year will be 1.25 for 1988–91. If anything, 1.25 is likely to be an overestimate because the AIDS epidemic is not growing exponentially.

Our first equation (Model A) estimates an unconstrained quadratic polynomial where the dependent variable is the number of cases reported during a 4-week period, and the independent

variables are a constant term and the designated number of the time period. Estimates for our quadratic equation are

$$\text{Model A: } C_T = \underset{(2.35)}{183} + \underset{(2.95)}{21.16}\,T + \underset{(.84)}{.118}T^2$$

where C_T is the number of cases reported during the T^{th} 4-week period, T is the number of the time period, and the values in the parentheses are the T-ratios of the coefficient above them. The square of the correlation coefficient for this equation is .84.

The estimates for the coefficients of our linear equation that explain the square root of the number of cases reported (Model B) are

$$\text{Model B: } C_T^{1/2} = \underset{(19.33)}{15.16} + \underset{(18.01)}{.49}\,T$$

The square of the correlation coefficient for this equation is .87. Projections for the number of cases reported may be obtained by squaring the right side of Model B and summing over the time period designations for a given year. (Squaring the right side produces a quadratic equation with positive coefficients for the constant term and the T^2 term.)

Table 4 presents estimates of the number of AIDS cases that will be diagnosed during 1988, 1989, 1990, and 1991 using Models A, B, and the CDC estimates (Model C). We obtained estimates of the number of cases diagnosed each year for Models A and B by forecasting the number of cases for time periods 53–104 and multiplying the number of reported cases for each year by 1.25.

From table 4, we see that Models A and B produce lower projections than the CDC Model C. Models A and B were estimated using data from January 1984 to October 1987, while the CDC model was estimated using data from June 1981 to May 1986. In regressions not reported here, we estimated Models A and B using data through May 1986 and found that estimates using this truncated data set were 5 to 7 percent higher than estimates using the more recent data set.

The estimates in table 4 are increased in table 5 to reflect the underreporting of AIDS cases. Scitovsky and Rice also increased CDC estimates by 20 percent to account for underreporting. Morgan and Curran of CDC suggested that estimates be increased by at least 20 percent to account for the 10 percent of cases that are diagnosed but not reported to CDC and the 10 percent of cases which did not fit the CDC definition of AIDS (for example, at that time the wasting away syndrome was not included in the CDC definition of AIDS). Recent data for New York City, Boston, Washington, DC, and Chicago showed that 11 percent of the deaths from AIDS were unreported (*35*). This is consistent with the 10 percent estimate by Morgan and Curran for the number of cases that are diagnosed but not reported.

Table 5. Projected number of AIDS cases diagnosed each year from 1988 through 1991 adjusted up by 20 percent for underreporting

Model	1988	1989	1990	1991
A	35,918	45,188	55,233	61,296
B	37,761	49,400	63,307	72,912
C	39,600	54,000	69,600	88,800

Table 6. Projected costs for treating AIDS patients diagnosed each year from 1988 through 1991 (in billions of dollars)

Model	1988	1989	1990	1991	Total, 1988–91
A	2.047	2.684	3,413	3.788	11.932
B	2.152	2.934	3.913	4.506	13.505
C	2.257	3.208	4.301	5.488	15.254

Projected Cumulative Costs and Final Remarks

Table 6 presents our estimates of the cost of treating AIDS patients diagnosed in 1988, 1989, 1990, and 1991. These are not prevalence-based yearly costs, because the costs of treating AIDS patients diagnosed during a given year will be borne during the year of diagnosis and for several years in the future. In addition, prevalence-based yearly costs include the cost of treating AIDS patients diagnosed in previous years who receive care during the given year. Our estimates increase considerably from 1988 to 1991, reflecting the greater number of projected cases and our projections that the cost of treating an AIDS patient will increase from $57,000 in 1988 to $61,800 in 1990 and 1991 because of the wider use of AZT.

Study estimates are substantially lower than those made by Pascal. They also are slightly lower than the prevalence-based yearly cost estimates made by Scitovsky and Rice. The fact that study estimates are lower than those made by Pascal and by Scitovsky and Rice is noteworthy because study

'Our forecasts include the personal medical care costs of AIDS and not costs for research, education, and testing services related to AIDS. Indirect costs (that is, lost productivity) also are excluded from our estimates.'

estimates are the first to include the cost of AZT. Part of the difference between the estimates in this study and estimates by Rice and Scitovsky is explained by the fact that this study estimates costs in 1985 dollars and Scitovsky and Rice estimated costs in 1984 dollars. Pascal estimated the range of costs of AIDS cases diagnosed from 1986 through 1991 to be between $15.4 and $112.5 billion. Pascal's medium estimate is $37.6 billion, which averages more than $6 billion per year. This is considerably higher than our middle estimate from Model B, which averages about $3.4 billion per year for the last 4 years estimated by Pascal. Pascal estimated costs in 1986–87 dollars.

This study estimates only the costs of AIDS using the CDC definition of AIDS before August 1987; consequently, it does not include the cost of patients with the wasting away syndrome or dementia. With the inclusion of the wasting away syndrome and dementia, most persons with HIV-related illnesses not included under the CDC definition of AIDS suffer from persistent generalized lymphadenopathy (personal communication, Donald Abrams, MD, SFGH, February 16, 1988). The term ARC (AIDS-related complex) has been used to describe those persons treated for HIV-related illnesses who are not included under the CDC definition. Very little is known about the number of people or cost of treating people with the wasting away syndrome, dementia, and other manifestations of HIV. Because data on the number of people with wasting away syndrome and dementia have been collected by CDC since October 1987, it is still unknown how inclusion of these groups will affect the number and cost of people with AIDS. Data on the number and cost of treating patients with HIV who are not included under the CDC definition of AIDS also are needed to calculate current costs and forecast future costs of those with HIV-related illnesses.

Another important issue not specifically addressed in this study is pediatric AIDS. Our estimates do include the cost of pediatric AIDS, but separate estimates of the future number of pediatric AIDS cases and the future costs of treating pediatric AIDS patients were not derived. (The study by Andrulis and coworkers did include pediatric AIDS patients.) As of December 21, 1987, 736 cases of pediatric AIDS had been reported to CDC. Forty-three percent of these cases (316) were reported during 1987 (*28*). Although pediatric AIDS cases comprise only 1.5 percent of all AIDS cases, the proportion is increasing, and CDC estimates that 4,000 infants and children may have AIDS by 1991 (personal communication, W. Meade Morgan, CDC, February 28, 1988). Little is known about the cost of pediatric AIDS, and better information about how pediatric AIDS patients are treated is needed to improve forecasts of the total cost of AIDS.

Our forecasts include the personal medical care costs of AIDS and not costs for research, education, and testing services related to AIDS. The Federal Government alone will spend over $1 billion in 1988 for these services (*36*). Indirect costs (that is, lost productivity) also are excluded from our estimates. Rice and Scitovsky estimated that the indirect costs of AIDS were about $7.0 billion for 1986 and will exceed $30 billion in 1991 (*2c*). Consequently, our cost estimates constitute only a fraction of the total cost of AIDS to society. Personal medical care costs are, however, an important fraction of the total costs because a large percentage of them are borne directly by the public through Medicaid, and because these costs involve physician, hospital, and nursing home services. It is necessary to understand the magnitude of the future demand for these medical resources in order to provide for the needs of all who will require medical services in the future.

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