considerations that the decline will not be wholly symmetrical. Rather, it will probably be slower. We have not included any allowance for a continuing endemic incidence although from considerations already mentioned we expect it to be low. The important point is that if Farr's Law has any reasonable validity, the epidemic should crest at an early date and then progressively decline. The total number of projected cases will be about 150,000, approximately half the figure of most projections that have been made so far. Time will tell.

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Projection of AIDS Cases, USA

James Chin[1]

Since the initial recognition of AIDS in 1981, this worldwide epidemic (pandemic) has been beset by some extreme misconceptions. Among the first of these misconceptions was the belief that AIDS would only be a disease of homosexual/bisexual men and intravenous drug users. When this was shown not to be true, some "scientists" began to spread the alarming misconception that within a couple of decades AIDS would kill almost every man, woman, and child on this planet. That extreme view, based more on social-political motivation than fact, has been dismissed as science fiction by the medical and scientific communities.

Although the ultimate dimensions of the AIDS pandemic are not yet known, our current solid knowledge of HIV transmission and our understanding of the first five to ten years of the natural history of HIV infections enables us to begin to forecast the general scope of the AIDS problem with increasing confidence for up to the next five years.

Virtually all AIDS researchers and public health epidemiologists are predicting that in most areas of the world there will be a five- to tenfold AIDS case increase within the next five years. However, one solitary yet highly respected voice has been raised to challenge this mainstream scientific thinking regarding the future increase. Dr. Alexander Langmuir, former chief epidemiologist for the United States Centers for Disease Control (CDC), has predicted that the AIDS epidemic in the United States will peak in mid-1988 and virtually disappear as a public health problem by 1995. This paper will critique Dr. Langmuir's prediction and provide a simple model that projects an AIDS case increase in the United States similar to that estimated by the current AIDS staff at CDC.

PROBLEMS ASSOCIATED WITH THE USE OF REPORTED AIDS CASE DATA

In countries where clinical diagnosis and reporting of AIDS cases are relatively accurate and complete, the observed pattern and prevalence of the reported cases can be used as a reasonable approxima-

tion of the actual number of cases that have occurred. However, even with the best of surveillance systems the pattern and number of reported cases must be interpreted with extreme caution. In the United States, which probably has the most accurate and complete reporting system for AIDS cases, there are strong indications that during the last year or two there have been changes in diagnostic procedures and in reporting delays that could greatly distort the true temporal pattern of the actual occurrence of AIDS. It must be fully understood that although reported AIDS cases may to some extent represent the pattern of AIDS occurrence, this pattern is overlaid to varying degrees by vagaries of diagnosis and reporting. Thus, when the curve of *reported* AIDS cases is used to project future *occurrence* of AIDS cases, the accuracy of such projections must be seriously questioned.

Even if some "adjustments" are made for reporting delays, based on calculations of average *past* reporting delays, there is no assurance that such adjustments will adequately correct for *current* or *future* reporting delays or changes in diagnostic procedures. Any statistical projection or "curve-fitting" must also be consistent with what is known about the epidemiology and natural history of HIV infections.

LANGMUIR AND BREGMAN'S AIDS PREDICTION AND THEIR PREDICTION MODEL

Doctors Langmuir and Bregman used a Gaussian curve fitted to the log of *reported* AIDS cases for projecting the future incidence of AIDS in the United States. They did not comment on whether such a projected normal, bell-shaped curve was consistent with what is now known about HIV infections and AIDS. They admitted that their first attempt at fitting such a curve grossly underestimated the average AIDS incubation period. Their first prediction, that the AIDS epidemic in the USA would crest in "mid-summer of 1986," was wrong. Now they are confident that they have adequately adjusted for reporting lags, and they believe the incubation period for most AIDS cases is about eight to ten years. Based on experience from their prior attempts, they predict the crest will occur in 1988. In addition, they project that the total number of AIDS cases in the United States by 1995 (when they also predict the disease will virtually disappear) will be approximately 150,000.

If Doctors Langmuir and Bregman are correct, it will not be because of their use of Farr's Law, which is inconsistent with current epidemiologic thinking on HIV infections and AIDS. Farr's Law may have been applicable to smallpox and cattle plague epidemics that, when introduced into a population, spread rapidly, peaked, and then dissipated with no new incident infections because all the susceptibles were "consumed." Farr's Law does not apply to those diseases that are most similar to AIDS, such as hepatitis B, gonorrhea, and other sexually transmitted diseases that have reached high endemic levels in many human populations throughout the world.

HIV infections are presumably life-long, and the infected person is potentially infectious until death—a death that may not occur for a decade or two. Since most AIDS modelers now believe that the average incubation period from infection to the development of AIDS is some eight to nine years, Dr. Langmuir and Dr. Bregman, if they persist in applying Farr's Law to AIDS, should reset their predicted cresting to the early 1990s, and should readjust the right side of their projected curve to increase the number of total AIDS cases well beyond 200,000.

SHORT-TERM FORECASTING OF AIDS

What are reasonable estimates and projections for AIDS cases in the United States? A simple model is proposed here to forecast the number of AIDS cases expected in any given population for up to five years. Four basic assumptions and estimates, based on our current understanding of the epidemiology and natural history of HIV infections, are needed to operate this model. These are as follows:

(1) *The number of HIV infections in the population must be estimated.* Using a variety of methods and assumptions, the CDC has estimated that as of 1987 there were at least one million HIV-infected persons in the United States. This conservative estimate is used in the proposed model.

(2) *The year when HIV infection probably began to spread extensively in the population has to be estimated.* This model takes the year 1980 as the likely period when HIV infection began to spread extensively in the United States.

(3) *The number of people infected each year (in the case of the United States, from 1980 through 1987) needs to be estimated.* The available epidemiologic cohort data indicate a majority of the HIV infections in the United States were transmitted before 1985. Thus, the cumulative HIV infection curve from 1980 to 1987 was not exponential or linear but asymptotic in shape. Using this latter assumption, the one million HIV infections estimated to have occurred in the United States as of 1987 can be distributed into annual infected cohorts back to 1980, as has been done in Table 1.

Table 1. An estimate of the annual numbers of new and cumulative HIV infections in the United States in 1980–1987, accepting the estimate of 1,000,000 infected persons as of 1987 and distributing those cumulative cases on an appropriate asymptotic curve.[a]

Year	HIV infections	
	New infections	Cumulative infections
1980	5,000	5,000
1981	25,000	30,000
1982	70,000	100,000
1983	175,000	275,000
1984	250,000	525,000
1985	225,000	750,000
1986	150,000	900,000
1987	100,000	1,000,000

[a]Data are insufficient to allow choice of a specific asymptotic curve, but for a short-term forecast the number of cases projected would be about the same regardless of the asymptotic curve selected.

(4) *The annual rate of progression after HIV infection to the development of AIDS needs to be estimated.* This progression has been estimated at about 15–20% after five years and up to 50% within 10 years. The specific annual progression to AIDS has been documented for a relatively large San Francisco cohort of homosexual men, and has reached about 40% after almost eight years. The annual rate of progression to AIDS after HIV infection for this model (Table 2) has been adapted and extrapolated from these data (San Francisco City Clinic cohort study, G. W. Rutherford, personal communication).

By applying these annual progression rates to the development of AIDS for each of the HIV-infected cohorts starting in 1980, the number of AIDS cases can be estimated by year up to 1991 (Table 3). These calculations indicate that, at a minimum, close to 250,000 AIDS cases can be expected in the United States by the end of 1991. It needs to be noted that this simple model does not take account of new

Table 2. Estimated annual rates of progression to AIDS following HIV infection. The figures shown have been adapted and extrapolated from progression curves reported for HIV-infected homosexual men.

Years after infection	% annual rate of progression to AIDS
0	0.0
1	0.5
2	2.0
3	3.0
4	4.0
5	6.0
6	7.0
7	8.5
8	9.0
9	9.5
10	10.0
11	11.0

Table 3. A projection of AIDS cases in the United States in 1980–1991 based on the assumptions and figures shown in Tables 1 and 2.

	Projected AIDS cases	
Year	New cases	Cumulative cases
1980	0	0
1981	25	25
1982	224	249
1983	993	1,242
1984	3,186	4,430
1985	7,996	12,426
1986	15,527	27,953
1987	24,803	52,756
1988	35,252	88,006
1989	45,634	133,642
1990	54,044	187,686
1991	59,890	247,576

HIV infections occurring after 1987, nor does it consider the probability that progression to AIDS could increase markedly above 50% of those infected after 15 to 20 years.

Obviously, the assumptions and estimates in this model will need to be changed when and if additional data warrant any change. Also, the model should be of greatest utility in those countries where the reporting system is not considered sufficiently reliable to attempt statistical extrapolation from the local pattern of reported cases.

CONCLUSIONS

To sum up, Dr. Langmuir and Dr. Bregman will be proven wrong again in their prediction. The incidence of HIV infection in the United States has probably decreased in recent years; but, because of the very long incubation period for the development of AIDS, the peak or cresting of AIDS cases will, at the earliest, occur in the early 1990s. Thereafter, AIDS cases will continue to occur at a relatively high endemic level well beyond the year 2000. HIV infection and AIDS in the United States will probably continue to be primarily concentrated among homosexual/bisexual men and I.V. drug users. However, heterosexuals with multiple sexual partners are at a low but measurable risk now; if they persist in their behavior, they will be placing themselves at increasing risk of HIV infection in the future.

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