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PROJECTING THE SPREAD OF AIDS IN THE UNITED KINGDOM: A SENSITIVITY ANALYSIS

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ABSTRACT

In AIDS Bulletins Nos. 1 to 4 the Institute of Actuaries AIDS Working Party presented projections of HIV infection and AIDS based on a model developed by Wilkie. This paper explores the sensitivity of those projections to the various different assumptions which have to be made and presents results on a number of alternative sets of assumptions.

KEYWORDS

AIDS; Projections; Models

1. INTRODUCTION

1.1 Since the first cases of AIDS were reported in June 1981 (Gottlieb *et al.*, 1981), the numbers affected have grown dramatically. Nearly 223,000 cases have been reported worldwide from 153 countries (W.H.O., 1989), but it is thought that the true figure could be 500,000 or more. AIDS has been shown not to be a disease in itself, but a collection of symptoms associated with an advanced stage of development following infection with the human immunodeficiency virus (HIV), which was first identified in 1983 (Barre-Sinoussi *et al.*, 1983; Gallo *et al.*, 1984).

1.2 HIV has a long incubation period, which can differ considerably from person to person, but probably has a mean and a median of around 8 to 10 years (Hessol *et al.*, 1988; Medley *et al.*, 1988). Recent studies suggest that a very high proportion of those infected with HIV will ultimately develop AIDS. Some drugs may be effective in delaying the onset of AIDS.

1.3 Once someone has been diagnosed as having AIDS, the prospects for survival are very poor, and the mean survival time is probably no more than two years, even with the various drug therapies that have so far been found to be helpful in controlling opportunistic infections and extending life expectancy (Lemp *et al.*, 1988; NH&MRC Special Unit, 1989).

1.4 HIV infection is transmitted sexually, from male to male, male to female and female to male, and also through blood and blood products. Other modes of transmission are theoretically possible, but, in practice, occur very rarely (Friedland & Klein, 1987; Lifson, 1988). Although heterosexual spread is common in Africa (Quinn *et al.*, 1986), by far the majority of cases so far in the United Kingdom and in most other industrialised countries have been the result of homosexual transmission. However, in certain southern European countries (Italy, Spain and parts of France) a larger role is attributed to intravenous drug use. Transmission may be facilitated by the presence of other sexually transmitted diseases (Greenblatt *et al.*, 1988; Piot & Laga, 1989) and by the practice of anal intercourse. Even when other sexually transmitted diseases are not present, infectivity may be higher immediately after becoming infected, and as AIDS develops (European Study Group, 1989).

1.5 The epidemiological characteristics of HIV, incubation time, survival, methods of transmission, etc., have been reviewed elsewhere (Daykin, 1990). However, practical requirements in insurance and other fields make it necessary to consider ways of modelling the possible future spread of HIV and the incidence of AIDS. Any attempt to model the complex dynamics of an epidemic must, of necessity, involve a simplistic characterisation of the processes, however complicated the mathematical formulation. Some of the many different attempts at modelling the HIV epidemic have been reviewed by Haberman (1990).

1.6 In AIDS Bulletins Nos. 1 and 4 the Institute of Actuaries AIDS Working Party presented projections based on a model developed by Wilkie (1988). The model is a deterministic approximation to a Markov stochastic process, with time varying transition intensities between states. It is a single sex model and is intended to represent only homosexual transmission of HIV. The model is age-related, but considers each generation, by year of birth, as a separate entity, with infection only taking place within each group. The model consists of a series of simultaneous differential equations, with appropriate initial conditions, which are solved numerically to give the proportions in each state at each duration. Similar models have been proposed by others considering the future spread of AIDS (Anderson *et al.*, 1986, 1988a; Hyman & Stanley, 1988).

2. ASSUMPTIONS REQUIRED FOR THE MODEL

2.1 A number of important assumptions have to be made in order to use the model. These include the following:

—initial population at risk of becoming infected with HIV,
—new entrants to population at risk,
—cessation of risk,
—infection of people at risk,
—AIDS incubation distribution for people infected with HIV, and
—survival distribution for people with AIDS.

2.2 Each of these factors can be stipulated by the user of the model. They may vary by age and in some cases by duration also. This provides the possibility of modelling a very wide range of different scenarios. Some of the assumptions can be compared with the results of medical and statistical research, to ensure that realistic values are adopted. Other assumptions cannot be calibrated directly, but a reasonable range of possible values can be proposed.

2.3 The overall effect of a complete set of assumptions must be assessed, to ensure that the projected numbers of cases of AIDS, deaths from AIDS and numbers of people infected with HIV are consistent with such information as is known about these items up to the present time. However, in making such comparisons, it is important to recognise the delays that occur in reporting cases of AIDS, the possible failure to identify some cases at all, the fact that some deaths from AIDS are not necessarily classified as such, and the general lack of information about the number of people currently infected.

2.4 In order to permit a useful analysis of the effect of alternative assumptions on the future development of HIV infection and the number of cases of AIDS, we adopt, for the purposes of this paper, a standard set of assumptions, from which we can measure the effect of individual changes.

2.5 The standard projection which we adopt corresponds to Projection R in AIDS Bulletin No. 4. This involves the following principal assumptions:

—an initial population at risk of $2\frac{1}{2}\%$ of males in the U.K. aged from 21 to 50, tapering to 1% at age 15 and to 0% at age 70, with 0% outside the range 15 to 70,

—new entrants to the at-risk population at the rate of 1% of males reaching the age of 15 in future years,

—transfers out of the at-risk population, to be no longer at risk ('clear'), with an instantaneous intensity of transfer of 0·1 from January 1987 onwards,

—infection of those in the at-risk population in proportion to those at risk and to those already infected, with an intensity of infection initially of 0·7 at the peak ages of 25 to 35, reducing to zero at ages 15 and 70 respectively, and with the profile of the force of infection reducing linearly at all ages to half of the initial values over the period from January 1987 to January 1992,

—the incubation period for the development of AIDS in those infected with HIV is treated as being independent of age, but dependent on duration since infection d, with an intensity of becoming sick with AIDS given by a modified Gompertz formula:

$$\mu = \exp(-8{\cdot}4 + 1{\cdot}4d) \text{ with a maximum value of } 0{\cdot}25, \text{ and}$$

—mortality of those sick with AIDS is represented by a constant intensity at all ages, initially of 0·7, but reducing linearly to 0·35 over the period from January 1987 to January 1992.

2.6 In the sensitivity analysis which follows, we look in turn at the effect of varying the assumptions regarding:

—the initial at-risk population,
—the cessation of risk,
—the infection of people at risk,
—the incubation period for the development of AIDS, and
—the survival of people with AIDS.

2.7 The projections have been calibrated against reported cases of AIDS and reported deaths from AIDS in the U.K. and the figures for future years, therefore, relate to reported figures for the U.K., unlike those produced by the Cox Working Group (Department of Health/Welsh Office) and Day *et al.* (1990), which were projected diagnoses for England and Wales.

2.8 The projections were started in 1983 and the initial proportion HIV positive was chosen so as to produce approximately 1,000 cumulative deaths recorded by the end of 1988 and an age distribution which corresponds reasonably with the actual experience.

3. THE INITIAL AT-RISK POPULATION

3.1 The nature of the model is that only those in the at-risk category at a particular moment can become infected with HIV at that moment, but that all those in the at-risk category at a particular age and at a particular moment have an equal chance of becoming infected. This is a very crude representation of the true situation, in which it can be assumed that there will be a distribution of the extent to which individuals are at risk of becoming infected with HIV, with some people highly at risk and others at relatively minimal risk.

3.2 Our model does not have the facility to explore the consequences of such heterogeneity, but it has been shown by others that heterogeneity leads to a rapid initial rate of spread of the epidemic of HIV infection, and a subsequent reduction in the rate of spread even in the absence of changes in sexual behaviour (Blythe & Anderson, 1988a). Indeed, the rate of infection may be insufficient to sustain the epidemic in low-risk segments of the population, or in particular geographical areas where there are relatively few people at risk.

3.3 To reflect the absence of any representation of heterogeneity, the assumption made for the size of the initial at-risk population should have regard to the possible numbers with a significant risk of exposure to the infective agent HIV. Since the model is concerned with the homosexual spread of AIDS, and is not suited to modelling the spread amongst heterosexual intravenous drug users or more general heterosexual spread, we are concerned to make an estimate of the size of the homosexual population in 1983, with a significant involvement in behaviours potentially liable to lead to infection with HIV, i.e. anal intercourse and the sharing of needles with other homosexuals who could themselves have become infected.

3.4 Little firm information is available on the size of the homosexual population, still less on the population which might be considered to be at risk.

The Kinsey study in the United States of America indicated that 10% of the male population may be involved in homosexual behaviours at some stage in their life, but the methodology of this report has been widely criticised. It is also now quite dated and may not reflect the current situation adequately.

3.5 Recent relatively small-scale surveys of sexual behaviour in the U.K. point to a figure of around 4% to 5% of the male population as actively homosexual. Some of these will have had an exclusive relationship with a single partner, with neither partner being exposed to the possibility of infection with HIV. Others will not have engaged in any high-risk behaviours.

3.6 Our standard assumption that $2\frac{1}{2}\%$ of males aged from 21 to 50 are at risk, with lower proportions at ages outside this range, may be regarded as fairly modest as a representation of the position in 1983. It would imply a total initial at-risk population of 430,000. Nevertheless, there is no degree of certainty that this assumption is appropriate, even as an order of magnitude.

3.7 As we might expect, a larger population assumed to be initially at risk leads to a larger epidemic. The results are not directly proportionate, since different starting conditions are required to generate an approximation to the known cases of AIDS so far in the U.K. Alternative projections are shown here for initial at-risk populations of respectively 5% and $1\frac{1}{4}\%$ of males aged from 21 to 50, and corresponding proportions at other ages (i.e. double the standard assumptions and half the standard assumptions). These projections are labelled R1A and R1B.

3.8 Figure 1 shows the total numbers projected to be HIV positive at the end of each year on these three projections (including the standard basis). Figure 2 shows the number of the new infections with HIV implied by the projection for each future year. Figure 3 shows the number of new cases of AIDS projected for each year and Figure 4 shows the number of deaths from AIDS projected for each year. Details of the projected numbers are given in Appendix 1 for the standard basis and Appendix 2 for the variant assumptions as to the initial at-risk population.

3.9 The three projections produce estimates for the numbers infected with HIV at the end of 1989 varying from about 57,000 to about 91,000 and a peak number infected varying from 66,000 in 1991 for the low assumption to 161,000 in 1994 for the high assumption. Deaths from AIDS reach a maximum of 17,400 in 2000 on the high assumption, with a cumulative total number of deaths of 233,000 by 2010, compared to a peak of 7,000 in 1997 and a cumulative total of 90,000 by 2010 on the low projection.

4. CESSATION OF RISK

4.1 Whatever the assumption may be about the initial population at risk, it is reasonable to suppose that, as knowledge about AIDS and HIV infection has become more widespread, a significant number of those in the 'at risk' group will have changed their behaviour, so as to reduce or eliminate the risk. On the

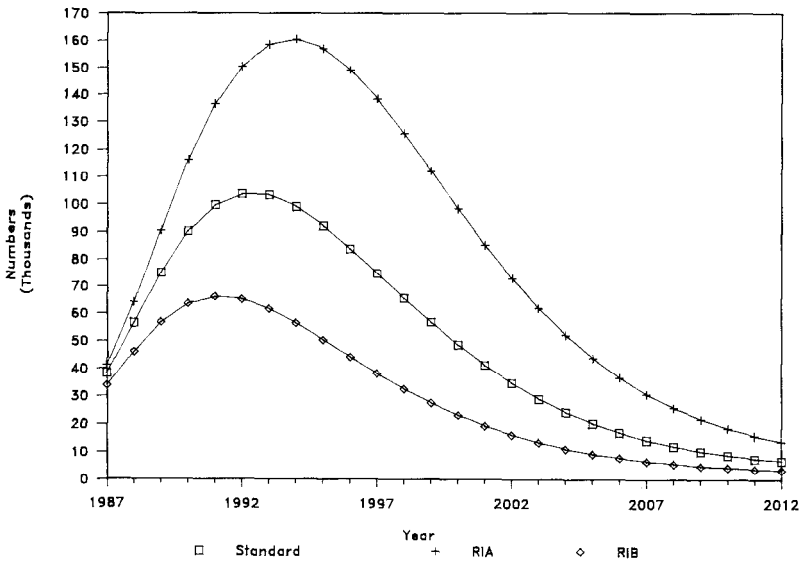

Figure 1. Projected numbers of HIV positives at end of each year.

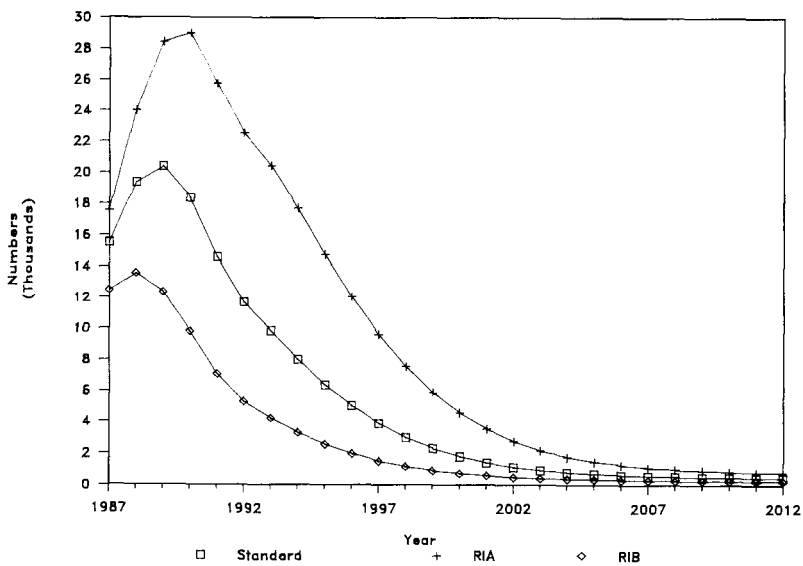

Figure 2. Projected numbers of new HIV positives.

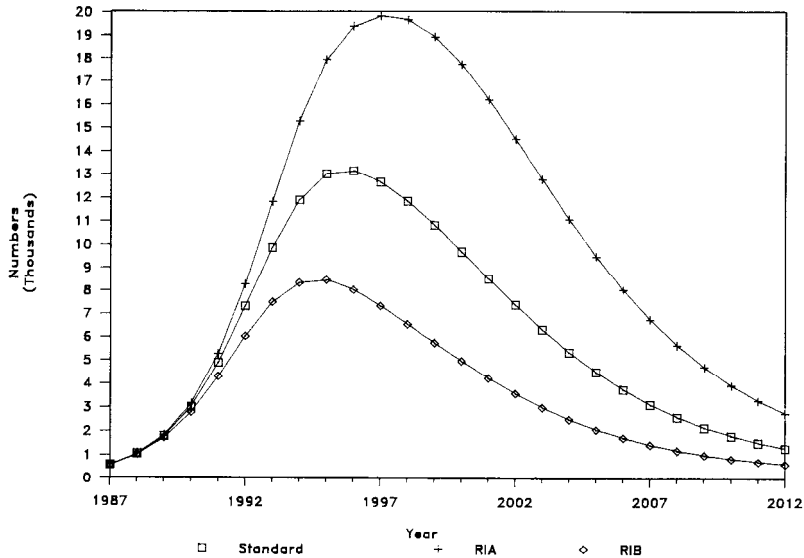

Figure 3. Projected numbers of new cases of AIDS.

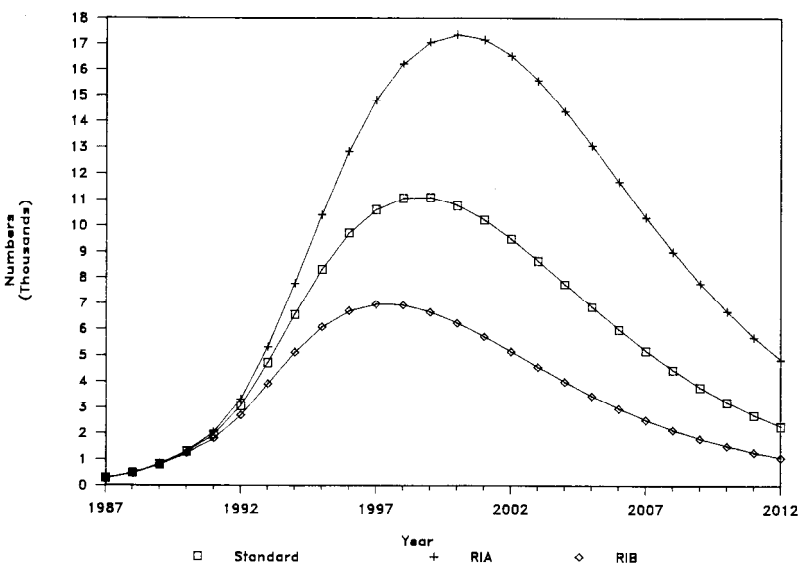

Figure 4. Projected numbers of deaths from AIDS.

standard basis we assume that this behavioural change began to take effect from the beginning of 1987 and that, with an intensity of transfer from the at-risk group to clear of 0·1, the size of the at-risk group would decrease by 40% in each successive 5-year period, leaving aside the impact of those becoming infected with HIV.

4.2 It is interesting to consider the effect of this reduction in the population at risk. The first variant (Projection R2A) assumes no transfers from at risk to clear. This results in a peak number infected with HIV of 128,000 in 1994 compared to a peak of 104,000 in 1992 on the standard basis, a peak number of deaths from AIDS of 14,000, compared with 11,000 and a cumulative number of deaths from AIDS by 2010 of 203,000 instead of 147,000.

4.3 A number of reports in the medical literature have suggested that there is good evidence to suppose that significant behavioural change in the homosexual community began as early as 1983 or 1984. Projection R2B assumes, therefore, that the transfer from at risk to clear, with an intensity of 0·1, began in January 1984 instead of January 1987. This reduces the projected number infected with HIV at the end of 1989 from 75,000 on the standard basis to 68,000, and the peak number infected with HIV to 86,000. The peak number of deaths from AIDS is little over 9,000, and the cumulative number of deaths from AIDS by 2010 is 123,000.

4.4 It might be argued that the degree of behavioural change implied by a constant intensity of transfer from at risk to clear from January 1984 onwards is unlikely to be sustained in practice. Projection R2C allows for some slowing down in the process of behavioural change with the intensity of transfer from at risk to clear reducing linearly to 0·05 over the period from January 1987 to January 1992, remaining at that level thereafter. This does not have a major effect on the projected figures, as compared to Projection R2B, but increases the cumulative number of deaths from AIDS by 2020 to 129,000.

4.5 Details of these projections are given in Appendix 3. Figures 5 to 8 show, respectively, the numbers HIV positive, the number of new infections, the number of new cases of AIDS and the number of deaths from AIDS for projections R2A to R2C and the standard basis.

5. THE INFECTION OF PEOPLE AT RISK

5.1 The projected number of new infections with HIV depends not only on the population at risk, but also on the rate at which infection is passed from those infected to those at risk but not infected. In a simple model, without assumptions about behavioural change, the intensity of infection determines the doubling rate of the epidemic in the early stages. Thus, an intensity of transfer from at risk to positive of 0·7 implies an annual doubling of the numbers infected, whilst that number remains small in relation to the size of the population at risk. The observed development of new cases of AIDS in the early stages of the epidemic would be consistent with such an intensity of infection, but this can be expected

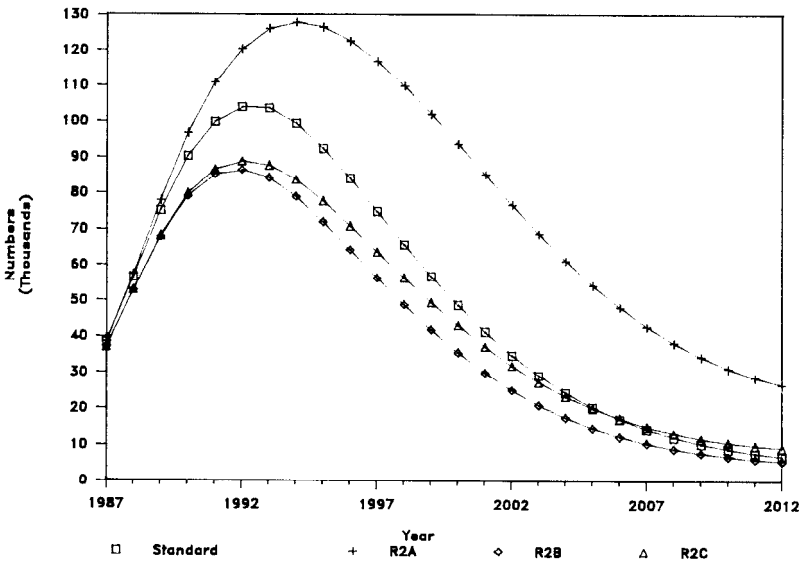

Figure 5. Projected numbers of HIV positives at end of each year.

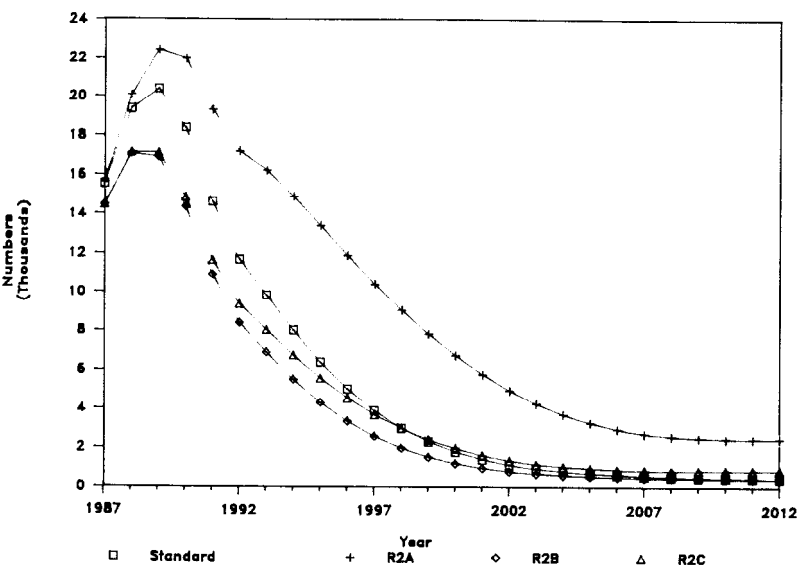

Figure 6. Projected numbers of new HIV positives.

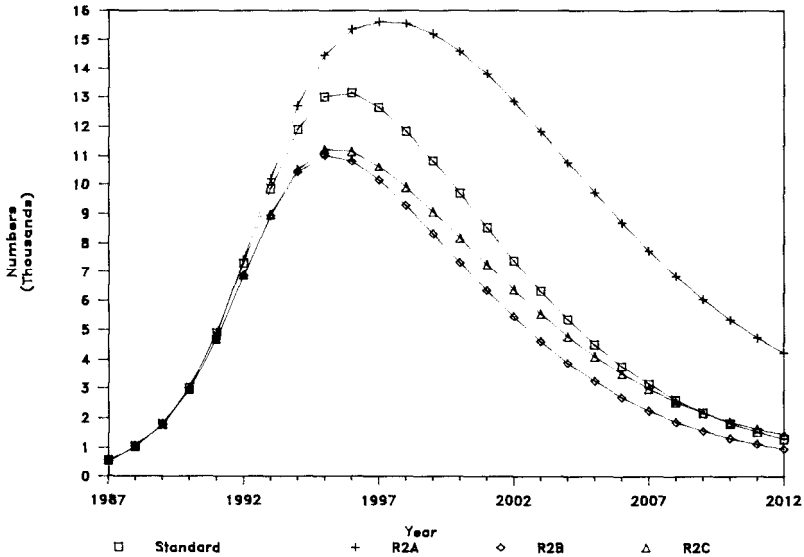

Figure 7. Projected numbers of new cases of AIDS.

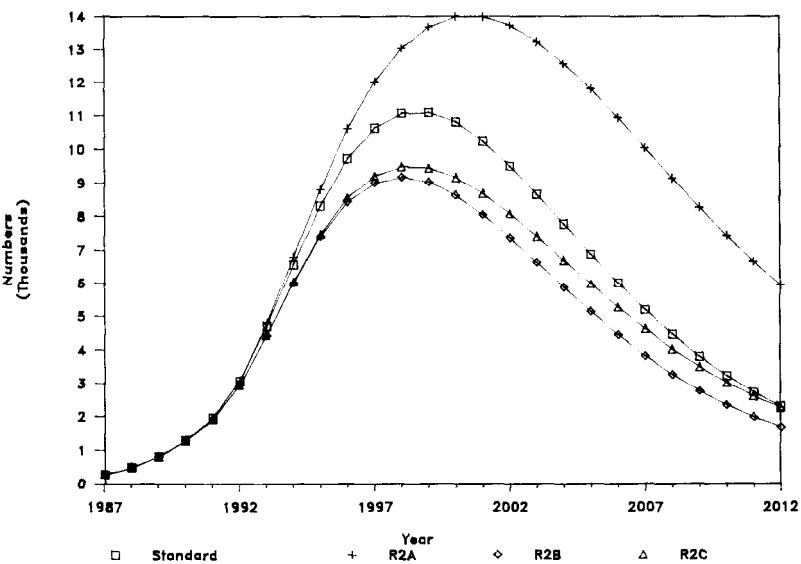

Figure 8. Projected numbers of deaths from AIDS.

to reflect the transmission of infection amongst a relatively high-risk part of the homosexual population during a period before any significant behavioural changes had begun to take place.

5.2 The standard assumptions allow for the combined effect of heterogeneity of risk and behavioural change, by allowing the intensity of transfer from at risk to positive to reduce from 0·7 to 0·35 (implied doubling time of 2 years) over the period from January 1987 to January 1992. In Projection R3A, we examine the effect of not reducing the intensity of transfer from at risk to positive. This results in a projected number infected at the end of 1989 of 89,000 instead of 75,000 and a peak number infected of 146,000 compared with 104,000. The peak number of deaths from AIDS is increased from 11,000 to 15,000 and the cumulative number of deaths from AIDS by 2010 is 187,000 compared with 147,000.

5.3 As mentioned in § 4.3, there is evidence that significant behavioural change began to take place among male homosexuals from 1983 or 1984. This, combined with the natural reduction of the intensity of new infections which can be expected as a result of the spread of infection to lower risk parts of the population, supports alternative assumptions which allow for earlier reduction in the transition intensity.

5.4 Projection R3B takes the intensity of infection as reducing linearly over the period from January 1984 to January 1986, stabilising thereafter at half the initial level (i.e. at 0·35). Projection R3C adopts the same pattern of reducing intensity of infection from January 1984 to January 1986, but allows for a further linear decrease over the period from January 1986 to January 1991, to reach an ultimate level of 0·175, one quarter of the initial level.

5.5 These assumptions of earlier behaviour change substantially reduce the impact of the epidemic. Projections R3B and R3C imply a projected number infected at the end of 1989 of 26,000 and 20,000 respectively, compared to 75,000 on the standard basis and a peak number infected of 57,000 on Projection R3B and 23,000 on Projection R3C compared to 104,000. The peak number of deaths from AIDS is reduced from 11,000 to 6,000 in Projection R3B and 2,600 in Projection R3C and the cumulative numbers of deaths from AIDS by 2010 are 89,000 and 45,000 respectively. The effect of the earlier changes in infection intensity in Projection R3B is not only to reduce the size of the ultimate epidemic, but also to defer the peak by several years. Projection R3C results in a very flat profile of numbers of people with HIV.

5.6 A further aspect of the spread of HIV infection is the possible variability of infectiousness of those who have become infected with HIV. There are indications that many of those infected with HIV may not be particularly infectious, in the absence of specific co-factors, such as other sexually transmitted diseases, except in the first few weeks after infection and in the period close to the development of AIDS. This could have an appreciable effect on the speed of spread of the infection (Blythe & Anderson, 1988b). In Projection R3D allowance is made for variable infectivity by duration since the acquisition of HIV infection. The assumptions follow those of Projection U in AIDS Bulletin

No. 4. The infection intensity in the model is determined by the product of 3 factors relating to calendar year, age and duration since becoming infected. In Projection R3D the duration factor is taken as the sum of two exponentials, one decreasing with duration, the other increasing, but with the sum of the two limited to a maximum value of 1·0. Thus:

Duration factor $= \text{Min} \cdot \{[A \cdot \exp(Bd) + C \cdot \exp(Dd)], 1 \cdot 0\}$

where d is the duration from becoming infected,

$A =$ 10·0,
$B = -2 \cdot 302585$,
$C =$ 0·031623,
$D =$ 0·575636.

5.7 The effect of the variable duration factor is to give a much reduced level of infectivity between durations 1 and 6 years, with a minimum of about one-sixth of the peak level at duration $2\frac{1}{2}$ years. The resulting projected numbers HIV positive are 22,000 at the end of 1989 and a peak number of 29,000 in 1996. The peak number of deaths from AIDS is reduced to just over 3,000 and the cumulative number of deaths from AIDS by 2010 to 55,000. The profile of numbers of people with HIV is also rather flat on these assumptions, with similar results to Projection R3C.

5.8 Projecting future infections with HIV is one of the most uncertain aspects of the modelling process. It is of interest, therefore, to explore what the consequences might be if there were *no* further infections. The date chosen as the cut-off point is clearly critical. Projection R3E assumes that new infections cease in the first quarter of 1987. This leads to a projected number HIV positive at the end of 1989 of 22,000, which in this scenario would be already past the peak of about 25,000 which was reached at the end of 1987. New cases of AIDS would continue rising slowly to a peak of 3,600 in 1991, deaths from AIDS would peak at nearly 2,400 in 1993 and cumulative deaths from AIDS by 2010 would total only 24,000.

5.9 If new infections ceased from the first quarter of 1986 (Projection R3F), the number HIV positive would peak at 14,000 in 1986, falling to 11,000 at the end of 1989. New cases of AIDS would continue rising slowly to a peak of 2,100 in 1990, deaths from AIDS would peak at around 1,300 a year in 1993 and cumulative deaths from AIDS by 2010 would total only 14,000.

5.10 The assumption that new infections ceased altogether in 1986 is perhaps somewhat extreme, but it serves to illustrate how low a projection can be obtained if dramatic behavioural change is postulated from a relatively early date. With the Department of Health reporting a cumulative total of 10,794 positive HIV tests to the end of June 1989, of which at least 5,254 are thought to be male homosexuals, projections which imply a maximum of around 10,000 male homosexuals affected by the epidemic at any time seem fairly optimistic.

5.11 It is difficult to know by how much the published HIV test results understate the true position, but it is thought that many male homosexuals, who

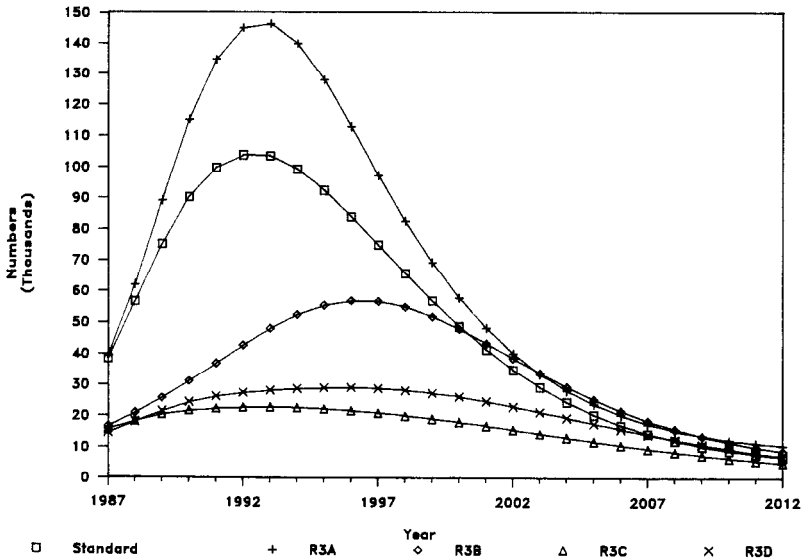

Figure 9. Projected numbers of HIV positives at end of each year.

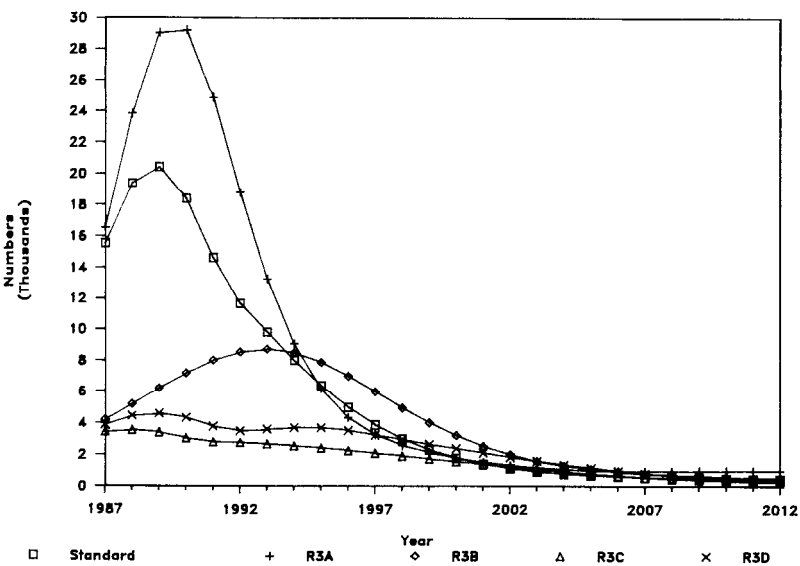

Figure 10. Projected numbers of new HIV positives.

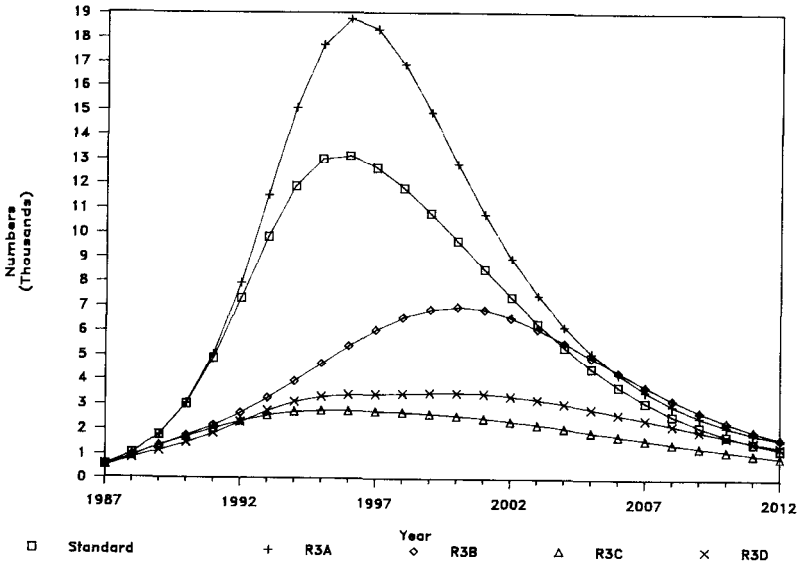

Figure 11. Projected numbers of new cases of AIDS.

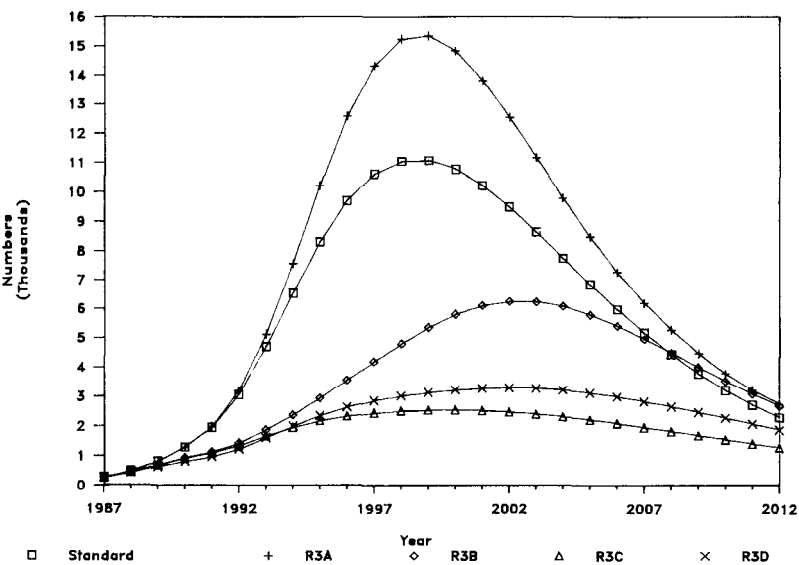

Figure 12. Projected numbers of deaths from AIDS.

consider themselves to be at possible risk from AIDS, have been reluctant to have a test. Some doctors and organisations representing the homosexual community have also positively discouraged people from having the test. The report of the Cox Working Group estimated that there might have been 13,000 to 31,000 male homosexuals infected with HIV in 1987 (Department of Health/Welsh Office, 1988). Day *et al.* (1990) revised these estimates down to between 7,000 and 14,000 male homosexuals infected with HIV at the end of 1988.

5.12 Details of these further projections are given in Appendix 4. Figures 9 to 12 show respectively the numbers HIV positive, the number of new infections, the number of new cases of AIDS and the number of deaths from AIDS for Projections R3A to R3D and the standard basis.

6. THE INCUBATION PERIOD FOR AIDS

6.1 The assumed incubation period for AIDS determines the rate at which new cases of AIDS will emerge from the numbers projected to be infected by HIV. A large number of studies have sought to estimate the distribution of the incubation period and some measure of consensus seems to be emerging that few, if any, of those infected with HIV can be regarded as immune from the development of AIDS. Within 9 to 10 years from the date of infection, some 50% can be expected to have developed AIDS. The mean period of incubation cannot be directly estimated, since the shape of the tail of the distribution remains unknown, but a number of epidemiologists have suggested a Weibull form for modelling the distribution and this seems, so far, to provide the possibility of a reasonable fit to the available data.

6.2 The assumption of a modified Gompertz distribution for our standard basis corresponds to the assumption made in Projections A, BC and F in AIDS Bulletin Nos. 1, 2 and 3 and Projections P, Q and R in AIDS Bulletin No. 4. The distribution is not unlike a Weibull distribution in shape but gives a rather lower proportion developing AIDS in the first three or four years than the Weibull distributions with a median of some 8 to 10 years which are now being proposed by some authors.

6.3 Projection R4A uses the Weibull distribution which was adopted for Projection T of AIDS Bulletin No. 4. This was designed to give a reasonable fit to the data from the San Francisco City Clinic Cohort study (Hessol *et al.*, 1988) and is characterised by the parameters $b=2{\cdot}35$ and $c=0{\cdot}004$, where the cumulative distribution function is given by:

$$G(d)=1-\exp\{-cd^b\} \text{ for } d>0.$$

It implies that 16% will develop AIDS in the first 5 years after infection and 59% within 10 years (c.f. 16% and 76% on the standard basis).

6.4 Projection R4A reduces the estimate of people infected with HIV at the end of 1989 from 75,000 on the standard basis to 63,000. New cases of AIDS peak at 10,400 in 1999 and deaths from AIDS peak at 9,300 in 2001.

6.5 Projection R4B uses a somewhat similar Weibull distribution which corresponds to a distribution derived by Medley *et al.* (1988) from U.S. transfusion-associated AIDS case data. This is characterised by the parameters $b = 2{\cdot}383$ and $c = 0{\cdot}006$ and implies that 15% will develop AIDS in the first 5 years and 76% within 10 years.

6.6 Projection R4B reduces the estimate of people infected with HIV at the end of 1989 to 45,000. The peaks of new cases of AIDS and AIDS deaths are slightly lower than in Projection R4A and the cumulative number of AIDS deaths by 2010 is 125,000, compared to 138,000 on Projection R4A and 152,000 on the standard basis.

6.7 Projection R4C uses yet another Weibull distribution, as proposed in the work of the Modelling Subcommittee of the Canadian Institute of Actuaries Task Force on AIDS (1988). This is characterised by the parameters $b = 2{\cdot}5$ and $c = 0{\cdot}002192$ and implies that $11\frac{1}{2}\%$ will develop AIDS in the first 5 years and 50% within 10 years.

6.8 Projection R4C produces higher estimates initially than the standard basis, implying 84,000 infected with HIV at the end of 1989. However, the peak number of new cases of AIDS is rather later, in 1999, and slightly lower, at 11,500, and the peak number of deaths from AIDS is also later, in 2002, and lower, at 10,300. The cumulative number of AIDS deaths by 2010 is 152,000, as on the standard basis.

6.9 One possibility is that the shape of the incubation period distribution will change over time, possibly as drugs such as zidovudine are prescribed to symptom-free HIV carriers, with the effect of lengthening the period taken for AIDS to develop. Projection R4D explores such a scenario, starting with the same Weibull distribution as in Projection R4A, but allowing the parameter b to change linearly from 2·35 to 1·85 over the period from January 1987 to January 1992. This gives a progression of the incubation distribution, which may be illustrated as in Table 1:

Table 1. *Assumed shape of Weibull incubation distribution for projection R4D*

	Year					
	1987	1988	1989	1990	1991	1992 & later
Weibull parameter $b =$	2.35	2·25	2·15	2·05	1·95	1·85
Average incubation period	9·3	10·3	11·5	13·1	15·0	17·5
Standard deviation of incubation period	4·1	4·7	5·6	6·6	8·0	9·7
% sick after 5 years	16·1	13·9	12·0	10·3	8·8	7·6
% sick after 10 years	59·2	50·9	43·1	36·2	30·0	24·7
% sick after 15 years	90·2	83·0	74·1	64·3	54·4	45·1
% sick after 20 years	99·0	96·6	91·9	84·4	78·0	64·0
% sick after 25 years	100·0	99·6	98·3	94·7	88·1	78·6

Note: The parameter c is held at 0·004 throughout.

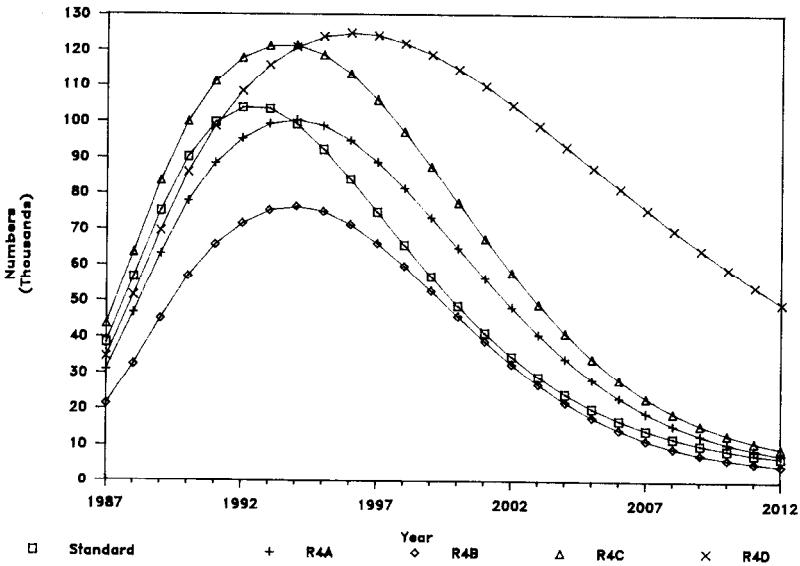

Figure 13. Projected numbers of HIV positives at end of each year.

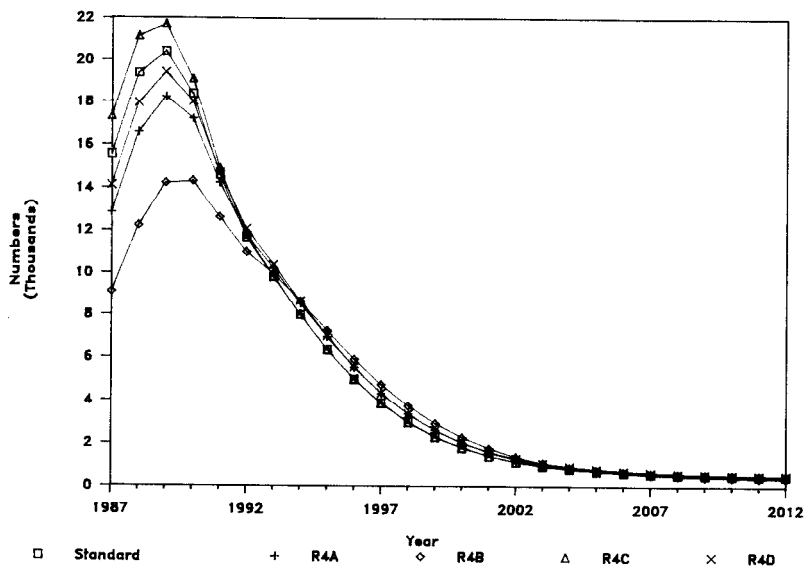

Figure 14. Projected numbers of new HIV positives.

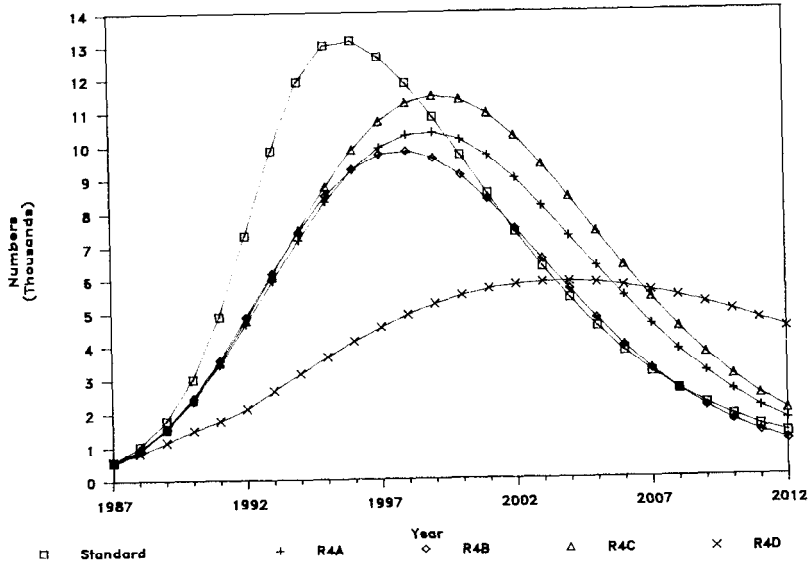

Figure 15. Projected numbers of new cases of AIDS.

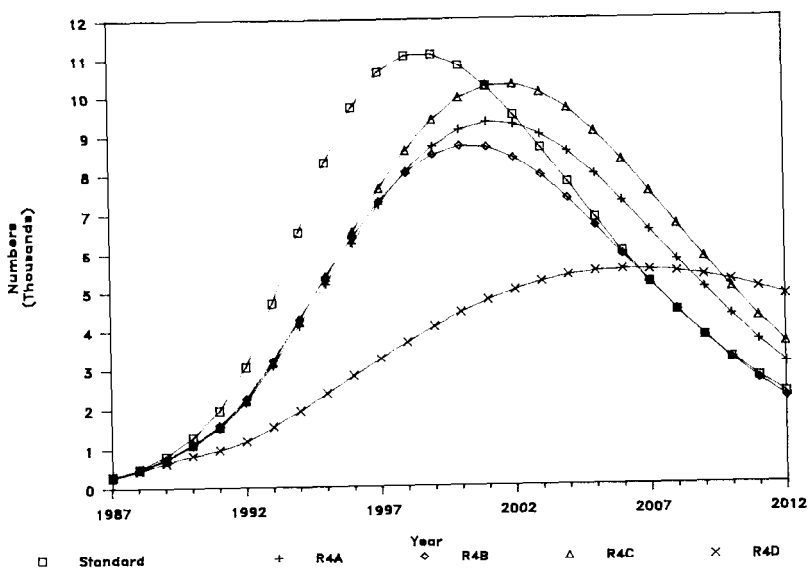

Figure 16. Projected numbers of deaths from AIDS.

6.10 Projection R4D implies 70,000 people infected with HIV at the end of 1989. The progression to AIDS is, however, considerably slowed down, with a peak number of new cases of AIDS of 5,900 in 2004 and a cumulative number of AIDS deaths by 2010 of 92,000.

6.11 Details of these projections are given in Appendix 5. Figures 13 to 16 show respectively the numbers HIV positive, the number of new infections, the number of new cases of AIDS and the number of deaths from AIDS for projections R4A to R4D.

7. THE SURVIVAL OF PEOPLE WITH AIDS

7.1 A number of studies have indicated that the median survival time of people with AIDS is of the order of 1 year from the date of diagnosis. If the data is properly adjusted for underreporting and late reporting of deaths, it seems probable that the true median survival time has been nearer 10 or 11 months. However, there is evidence that treatment of people with AIDS with the drug zidovudine (AZT) will increase their probability of survival. Some lengthening of survival times, for this or for other reasons, is suggested by some of the more recent U.K. data. The standard basis assumes that the force of mortality from AIDS, taken initially as a constant 0·7 at all ages and durations, reduces linearly, over the period from January 1987 to January 1992, to a constant 0·35 at all ages and durations from then on.

7.2 This assumption seems to make reasonable provision for improving mortality of people with AIDS. Projection R5A shows what the effect is of assuming no such improvement (as in Projections A, BC, P and Q of AIDS Bulletins Nos. 1 to 4). This projection is identical to the standard basis as regards numbers of new infections, numbers of people with HIV and numbers of new cases of AIDS. The projected number of deaths from AIDS peaks at just over 12,000 in 1997 compared to 11,000 in 1999 on the standard basis, and the number of people sick with AIDS at any particular time is substantially fewer, peaking at nearly 18,000 in 1997 as compared to nearly 32,000 (in 1998) on the standard basis.

7.3 Details of this projection are given in Appendix 6. Figures 17 and 18 show the number of people sick with AIDS and the number of deaths from AIDS for Projection R5A and the standard basis.

8. CONCLUSION

8.1 It is not the intention of this paper to indicate which of the many projections illustrated is the most likely to occur. The future prospects remain highly uncertain. The aim has been to illustrate the impact of assumptions about different factors on the resulting projections of people HIV positive, sick with AIDS, etc. The standard basis was chosen as a convenient benchmark and should not be interpreted as a central projection with the other assumptions as variants.

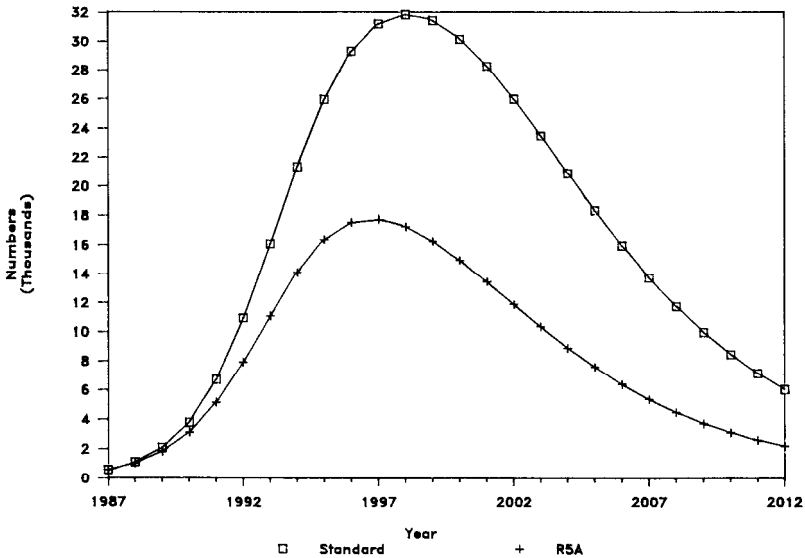

Figure 17. Projected numbers sick with AIDS at end of each year.

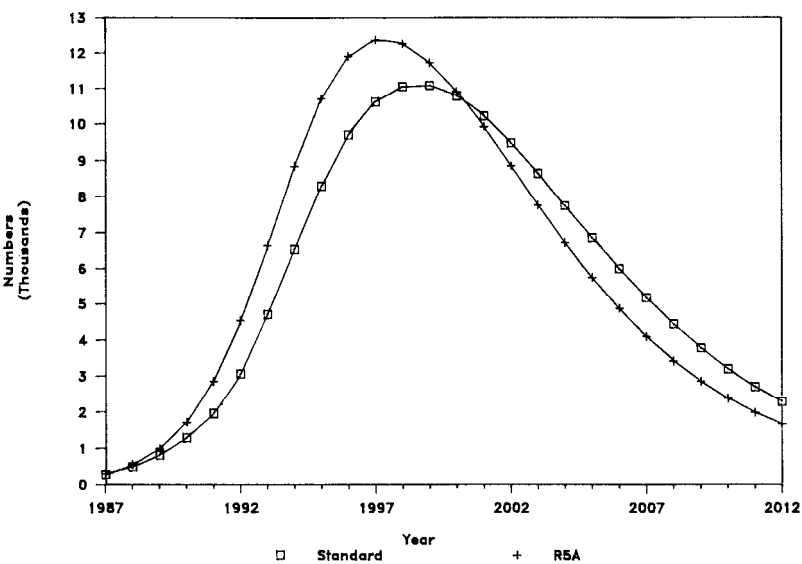

Figure 18. Projected numbers of deaths from AIDS.

Table 2. *Reported cases of AIDS and deaths from AIDS in the United Kingdom, 1982–1989*

Year	Reported cases of AIDS	Reported deaths from AIDS
1982	3	1
1983	26	14
1984	77	40
1985	160	85
1986	308	153
1987	653	404
1988	755	362
1989	848	553

8.2 The actual numbers of reported cases of AIDS and deaths from AIDS in the U.K. are as shown in Table 2.

8.3 The evidence now seems to point towards relatively early behavioural change amongst male homosexuals, to variable infectivity and to an incubation period for the development of AIDS distributed approximately as a Weibull form, but none of the projections shown here specifically take into account the spread of HIV infection amongst intravenous drug users and heterosexuals. Suitable combinations of the alternative parameter assumptions discussed here would enable a closer fit to the data to be obtained.

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APPENDIX 1

PROJECTIONS OF THE SPREAD OF AIDS—STANDARD BASIS (PROJECTION RO)

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	10,253	300	148	23,531	294	236
1987	15,544	575	281	38,441	587	517
1988	19,378	1,052	495	56,673	1,141	1,012
1989	20,403	1,798	824	75,142	2,108	1,837
1990	18,387	3,017	1,302	90,333	3,813	3,139
1991	14,612	4,890	1,965	99,832	6,721	5,104
1992	11,662	7,330	3,064	103,906	10,958	8,168
1993	9,820	9,865	4,713	103,576	16,065	12,881
1994	8,007	11,902	6,554	99,373	21,348	19,435
1995	6,382	13,013	8,308	92,424	25,964	27,743
1996	5,009	13,150	9,710	83,958	29,295	37,453
1997	3,891	12,652	10,623	74,874	31,193	48,076
1998	3,003	11,842	11,060	65,718	31,827	59,136
1999	2,313	10,828	11,091	56,897	31,401	70,227
2000	1,790	9,699	10,789	48,698	30,136	81,016
2001	1,403	8,535	10,233	41,292	28,256	91,249
2002	1,125	7,399	9,498	34,764	25,970	100,747
2003	928	6,333	8,654	29,126	23,461	109,401
2004	790	5,365	7,760	24,340	20,881	117,161
2005	692	4,507	6,862	20,334	18,346	124,024
2006	622	3,764	5,996	17,022	15,942	130,020
2007	570	3,133	5,186	14,309	13,726	135,206
2008	531	2,606	4,449	12,102	11,731	139,655
2009	502	2,171	3,791	10,320	9,970	143,446
2010	481	1,815	3,216	8,888	8,441	146,662
2011	467	1,527	2,720	7,743	7,133	149,381
2012	457	1,296	2,298	6,833	6,027	151,679

APPENDIX 2

VARIATION ACCORDING TO THE INITIAL AT RISK POPULATION

Table 2.1. *Projection R1A—5% initially at risk*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	6,151	154	68	13,843	143	88
1986	10,932	300	148	24,440	295	236
1987	17,578	578	282	41,379	589	518
1988	24,034	1,062	498	64,249	1,150	1,016
1989	28,454	1,840	836	90,711	2,149	1,852
1990	29,030	3,154	1,339	116,373	3,954	3,191
1991	25,783	5,279	2,065	136,599	7,151	5,255
1992	22,547	8,279	3,321	150,529	12,079	8,576
1993	20,445	11,822	5,320	158,759	18,532	13,896
1994	17,699	15,283	7,773	160,735	25,969	21,669
1995	14,787	17,941	10,405	157,102	33,401	32,074
1996	12,036	19,388	12,850	149,243	39,803	44,923
1997	9,614	19,844	14,824	138,489	44,654	59,748
1998	7,573	19,666	16,238	125,863	47,881	75,986
1999	5,904	18,925	17,084	112,311	49,493	93,070
2000	4,574	17,725	17,378	98,639	49,584	110,447
2001	3,540	16,210	17,171	85,468	48,345	127,618
2002	2,757	14,523	16,542	73,224	46,033	144,160
2003	2,180	12,786	15,586	62,168	42,928	159,746
2004	1,765	11,091	14,402	52,425	39,307	174,147
2005	1,472	9,502	13,081	44,013	35,417	187,229
2006	1,264	8,057	11,704	36,872	31,465	198,932
2007	1,115	6,778	10,334	30,896	27,613	209,266
2008	1,006	5,671	9,021	25,952	23,979	218,288
2009	926	4,731	7,800	21,900	20,643	226,088
2010	867	3,945	6,691	18,604	17,648	232,779
2011	823	3,297	5,705	15,941	15,010	238,484
2012	792	2,768	4,844	13,800	12,725	243,329

Table 2.2. *Projection R1B—1·25% initially at risk*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,614	153	68	13,177	143	88
1986	9,081	299	148	21,926	294	236
1987	12,479	571	280	33,779	584	515
1988	13,588	1,033	490	46,251	1,124	1,006
1989	12,373	1,726	805	56,785	2,040	1,810
1990	9,810	2,795	1,241	63,658	3,583	3,052
1991	7,073	4,306	1,809	66,260	6,064	4,860
1992	5,265	6,037	2,690	65,304	9,386	7,550
1993	4,213	7,507	3,909	61,814	12,944	11,459
1994	3,304	8,348	5,106	56,570	16,131	16,566
1995	2,558	8,471	6,080	50,456	18,453	22,646
1996	1,965	8,039	6,706	44,187	19,702	29,352
1997	1,506	7,332	6,967	38,173	19,972	36,319
1998	1,158	6,548	6,924	32,604	19,493	43,243
1999	901	5,749	6,657	27,587	18,476	49,900
2000	714	4,973	6,234	23,172	17,103	56,134
2001	583	4,249	5,714	19,363	15,524	61,847
2002	491	3,592	5,143	16,132	13,860	66,990
2003	427	3,012	4,560	13,431	12,202	71,550
2004	381	2,510	3,990	11,199	10,616	75,541
2005	348	2,083	3,454	9,372	9,144	78,995
2006	323	1,727	2,963	7,889	7,813	81,959
2007	305	1,433	2,524	6,692	6,635	84,483
2008	291	1,193	2,139	5,731	5,610	86,622
2009	281	999	1,806	4,963	4,732	88,428
2010	274	843	1,522	4,352	3,988	89,950
2011	270	718	1,284	3,869	3,365	91,234
2012	268	619	1,085	3,489	2,849	92,318

APPENDIX 3

VARIATION ACCORDING TO CESSATION OF RISK

Table 3.1. *Projection R2A—no transfers to clear*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	10,253	300	148	23,531	294	236
1987	15,646	575	281	38,542	587	517
1988	20,094	1,052	495	57,490	1,141	1,012
1989	22,421	1,799	825	77,974	2,110	1,837
1990	21,979	3,023	1,303	96,742	3,819	3,141
1991	19,307	4,918	1,971	110,894	6,750	5,111
1992	17,188	7,439	3,086	120,359	11,074	8,197
1993	16,222	10,206	4,793	126,048	16,442	12,990
1994	14,889	12,701	6,776	127,870	22,300	19,766
1995	13,386	14,472	8,800	126,386	27,881	28,566
1996	11,858	15,357	10,602	122,463	32,519	39,168
1997	10,396	15,618	12,018	116,794	35,976	51,186
1998	9,043	15,555	13,033	109,818	38,330	64,218
1999	7,816	15,204	13,676	101,955	39,666	77,894
2000	6,725	14,599	13,978	93,601	40,073	91,873
2001	5,770	13,795	13,974	85,097	39,661	105,847
2002	4,950	12,854	13,706	76,721	38,560	119,553
2003	4,263	11,832	13,220	68,690	36,909	132,773
2004	3,706	10,776	12,567	61,174	34,846	145,340
2005	3,274	9,724	11,791	54,297	32,499	157,131
2006	2,954	8,706	10,938	48,139	29,986	168,069
2007	2,730	7,746	10,044	42,741	27,406	178,113
2008	2,586	6,859	9,143	38,111	24,846	187,256
2009	2,505	6,059	8,261	34,226	22,375	195,517
2010	2,472	5,353	7,420	31,040	20,049	202,936
2011	2,472	4,744	6,637	28,489	17,907	209,573
2012	2,497	4,231	5,924	26,501	15,978	215,497

Table 3.2. *Projection R2B—transfers to clear 0·1 from 1984*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,912	153	68	13,555	143	88
1986	9,950	300	148	23,171	294	236
1987	14,477	575	281	37,015	587	517
1988	17,079	1,048	494	52,956	1,137	1,011
1989	16,889	1,783	821	67,935	2,094	1,832
1990	14,355	2,960	1,288	79,165	3,756	3,120
1991	10,886	4,712	1,922	85,141	6,529	5,042
1992	8,392	6,875	2,945	86,431	10,431	7,987
1993	6,884	8,952	4,428	84,117	14,912	12,415
1994	5,500	10,424	5,997	78,935	19,278	18,412
1995	4,317	11,020	7,398	71,968	22,821	25,809
1996	3,348	10,816	8,425	64,237	25,113	34,234
1997	2,580	10,146	9,001	56,412	26,142	43,236
1998	1,982	9,285	9,172	48,860	26,126	52,408
1999	1,529	8,325	9,018	41,826	25,294	61,426
2000	1,193	7,332	8,616	35,463	23,864	70,042
2001	952	6,359	8,040	29,848	22,032	78,082
2002	783	5,445	7,355	24,995	19,971	85,437
2003	669	4,613	6,614	20,877	17,819	92,051
2004	592	3,875	5,862	17,437	15,686	97,913
2005	540	3,235	5,130	14,603	13,650	103,043
2006	506	2,691	4,443	12,295	11,765	107,486
2007	482	2,236	3,814	10,433	10,062	111,300
2008	466	1,862	3,253	8,944	8,556	114,553
2009	456	1,559	2,760	7,760	7,248	117,314
2010	448	1,314	2,336	6,824	6,131	119,650
2011	443	1,120	1,976	6,089	5,188	121,626
2012	441	965	1,674	5,515	4,403	123,300

Table 3.3. *Projection R2C—transfers to clear 0·1 from 1984, 0·05 from 1987*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,912	153	68	13,555	143	88
1986	9,950	300	148	23,171	294	236
1987	14,482	575	281	37,021	587	517
1988	17,144	1,048	494	53,026	1,137	1,011
1989	17,135	1,783	821	68,252	2,094	1,832
1990	14,871	2,961	1,288	79,996	3,757	3,120
1991	11,640	4,714	1,923	86,720	6,532	5,043
1992	9,352	6,887	2,947	88,956	10,443	7,990
1993	8,032	8,990	4,436	87,745	14,954	12,426
1994	6,741	10,526	6,023	83,691	19,396	18,449
1995	5,567	11,225	7,461	77,755	23,079	25,911
1996	4,551	11,152	8,550	70,871	25,580	34,461
1997	3,695	10,625	9,210	63,660	26,877	43,671
1998	2,989	9,909	9,483	56,462	27,171	53,154
1999	2,417	9,076	9,440	49,532	26,663	62,595
2000	1,963	8,181	9,150	43,054	25,541	71,745
2001	1,612	7,272	8,676	37,148	23,977	80,420
2002	1,350	6,386	8,074	31,879	22,126	88,494
2003	1,162	5,551	7,395	27,274	20,117	95,890
2004	1,035	4,785	6,681	23,325	18,058	102,571
2005	953	4,098	5,964	19,998	16,033	108,535
2006	904	3,494	5,270	17,244	14,103	113,805
2007	878	2,974	4,618	15,000	12,312	118,423
2008	869	2,535	4,020	13,203	10,688	122,444
2009	871	2,170	3,483	11,787	9,246	125,927
2010	880	1,874	3,011	10,690	7,989	128,938
2011	893	1,636	2,603	9,857	6,913	131,542
2012	909	1,449	2,257	9,239	6,007	133,798

APPENDIX 4

VARIATION ACCORDING TO THE TRANSFER OF INFECTION

Table 4.1. *Projection R3A—no reduction in infection intensity*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	10,253	300	148	23,531	294	236
1987	16,574	575	281	39,470	587	517
1988	23,836	1,053	496	62,154	1,142	1,013
1989	29,035	1,807	827	89,229	2,117	1,839
1990	29,232	3,058	1,311	115,182	3,854	3,151
1991	24,845	5,061	2,000	134,672	6,897	5,151
1992	18,773	7,957	3,197	145,124	11,628	8,348
1993	13,264	11,542	5,140	146,422	17,980	13,488
1994	9,077	15,111	7,581	139,917	25,436	21,069
1995	6,191	17,717	10,217	127,890	32,830	31,286
1996	4,356	18,778	12,599	112,955	38,866	43,885
1997	3,263	18,354	14,340	97,353	42,701	58,225
1998	2,596	16,902	15,259	82,551	44,131	73,484
1999	2,136	14,924	15,376	69,291	43,438	88,860
2000	1,786	12,804	14,837	57,834	41,142	103,698
2001	1,519	10,788	13,838	48,162	37,816	117,536
2002	1,322	9,001	12,570	40,118	33,966	130,106
2003	1,180	7,478	11,189	33,495	29,974	141,296
2004	1,081	6,205	9,807	28,086	26,098	151,103
2005	1,018	5,150	8,495	23,706	22,492	159,597
2006	984	4,282	7,292	20,194	19,236	166,889
2007	972	3,574	6,219	17,411	16,364	173,109
2008	975	3,001	5,282	15,232	13,876	178,391
2009	984	2,541	4,476	13,546	11,756	182,866
2010	992	2,176	3,794	12,255	9,973	186,660
2011	999	1,890	3,224	11,274	8,495	189,884
2012	1,005	1,669	2,755	10,536	7,285	192,639

Table 4.2. *Projection R3B—infection intensity halves from 1984 to 1986*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	3,067	153	68	10,173	143	88
1986	3,309	294	147	13,164	290	234
1987	4,214	548	273	16,799	563	507
1988	5,204	938	463	21,024	1,036	970
1989	6,217	1,368	705	25,820	1,693	1,675
1990	7,181	1,765	945	31,171	2,506	2,620
1991	8,001	2,167	1,145	36,923	3,517	3,764
1992	8,553	2,669	1,440	42,707	4,730	5,204
1993	8,728	3,272	1,889	48,044	6,092	7,093
1994	8,487	3,954	2,395	52,436	7,623	9,489
1995	7,874	4,679	2,959	55,471	9,308	12,448
1996	6,998	5,398	3,569	56,891	11,094	16,017
1997	5,992	6,048	4,199	56,640	12,890	20,215
1998	4,975	6,563	4,812	54,842	14,578	25,027
1999	4,032	6,887	5,364	51,769	16,026	30,391
2000	3,213	6,991	5,812	47,767	17,119	36,203
2001	2,536	6,875	6,119	43,205	17,777	42,322
2002	2,000	6,565	6,268	38,420	17,966	48,590
2003	1,592	6,108	6,254	33,693	17,703	54,844
2004	1,291	5,554	6,090	29,227	17,042	60,934
2005	1,072	4,953	5,801	25,156	16,065	66,735
2006	912	4,346	5,417	21,545	14,863	72,152
2007	793	3,766	4,971	18,409	13,528	77,123
2008	703	3,234	4,492	15,731	12,140	81,615
2009	634	2,760	4,007	13,472	10,767	85,623
2010	581	2,349	3,537	11,586	9,458	89,160
2011	540	1,998	3,096	10,023	8,248	92,255
2012	510	1,704	2,692	8,737	7,154	94,947

Table 4.3. *Projection R3C—As for R3B, with further halving 1986/91*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	3,067	153	68	10,173	143	88
1986	3,119	294	147	12,975	290	234
1987	3,455	548	273	15,852	563	507
1988	3,566	936	462	18,445	1,034	969
1989	3,422	1,361	703	20,461	1,686	1,673
1990	3,049	1,733	937	21,727	2,474	2,610
1991	2,803	2,049	1,119	22,425	3,393	3,729
1992	2,770	2,343	1,359	22,791	4,362	5,088
1993	2,688	2,581	1,684	22,834	5,241	6,772
1994	2,570	2,728	1,968	22,608	5,978	8,739
1995	2,425	2,776	2,195	22,187	6,532	10,934
1996	2,264	2,767	2,357	21,611	6,912	13,291
1997	2,092	2,745	2,465	20,883	7,157	15,756
1998	1,914	2,706	2,532	20,013	7,295	18,288
1999	1,732	2,649	2,564	19,019	7,341	20,852
2000	1,553	2,571	2,565	17,921	7,304	23,417
2001	1,379	2,474	2,539	16,746	7,195	25,956
2002	1,214	2,360	2,489	15,521	7,019	28,445
2003	1,060	2,232	2,417	14,271	6,786	30,862
2004	919	2,092	2,327	13,020	6,502	33,189
2005	791	1,945	2,220	11,792	6,177	35,409
2006	678	1,793	2,100	10,604	5,819	37,509
2007	578	1,639	1,970	9,473	5,437	39,479
2008	490	1,487	1,834	8,410	5,039	41,313
2009	415	1,339	1,693	7,424	4,634	43,006
2010	350	1,197	1,551	6,518	4,231	44,557
2011	295	1,063	1,411	5,696	3,834	45,968
2012	249	939	1,275	4,956	3,452	47,243

Table 4.4. *Projection R3D—variable infectivity*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	2,332	152	68	8,574	142	87
1986	3,027	290	145	11,292	286	232
1987	3,889	530	267	14,627	547	499
1988	4,462	866	441	18,189	969	941
1989	4,626	1,166	639	21,608	1,491	1,580
1990	4,343	1,469	815	24,430	2,138	2,395
1991	3,788	1,853	976	26,306	3,005	3,371
1992	3,502	2,309	1,235	27,432	4,066	4,606
1993	3,628	2,761	1,619	28,225	5,190	6,225
1994	3,732	3,125	2,010	28,752	6,283	8,235
1995	3,705	3,344	2,370	29,027	7,229	10,605
1996	3,531	3,420	2,663	29,045	7,954	13,268
1997	3,259	3,433	2,879	28,772	8,471	16,147
1998	2,959	3,457	3,035	28,168	8,852	19,182
1999	2,667	3,486	3,151	27,239	9,142	22,333
2000	2,388	3,494	3,238	26,020	9,347	25,571
2001	2,117	3,456	3,293	24,563	9,456	28,865
2002	1,852	3,367	3,312	22,930	9,452	32,177
2003	1,601	3,232	3,290	21,180	9,331	35,467
2004	1,368	3,063	3,228	19,367	9,100	38,695
2005	1,159	2,870	3,130	17,540	8,771	41,825
2006	976	2,660	3,000	15,743	8,360	44,825
2007	818	2,441	2,844	14,012	7,884	47,670
2008	684	2,216	2,669	12,375	7,358	50,338
2009	571	1,993	2,478	10,855	6,799	52,816
2010	477	1,775	2,279	9,464	6,222	55,095
2011	401	1,569	2,076	8,210	5,643	57,172
2012	339	1,376	1,875	7,094	5,074	59,047

Table 4.5. *Projection R3E—no infection after the first quarter of 1987*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	10,253	300	148	23,531	294	236
1987	1,637	573	281	24,546	585	517
1988	0	1,035	491	23,459	1,126	1,008
1989	0	1,719	805	21,687	2,035	1,813
1990	0	2,692	1,226	18,944	3,491	3,039
1991	0	3,614	1,695	15,283	5,395	4,733
1992	0	3,366	2,134	11,877	6,605	6,867
1993	0	2,619	2,371	9,224	6,827	9,238
1994	0	2,033	2,342	7,163	6,491	11,580
1995	0	1,578	2,168	5,562	5,872	13,748
1996	0	1,224	1,928	4,320	5,140	15,677
1997	0	949	1,668	3,355	4,395	17,345
1998	0	736	1,414	2,606	3,693	18,759
1999	0	571	1,180	2,026	3,061	19,938
2000	0	442	973	1,576	2,511	20,911
2001	0	343	794	1,227	2,041	21,706
2002	0	266	644	957	1,648	22,349
2003	0	206	518	748	1,322	22,867
2004	0	160	414	586	1,055	23,282
2005	0	124	330	462	839	23,612
2006	0	97	262	366	664	23,874
2007	0	76	207	292	525	24,081
2008	0	59	164	235	414	24,244
2009	0	47	129	191	326	24,373
2010	0	37	101	157	256	24,475
2011	0	30	80	131	202	24,555
2012	0	24	63	111	159	24,617

Table 4.6. *Projection R3F—no infection after the first quarter of 1986*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	971	299	148	14,257	293	236
1987	0	564	278	13,664	577	514
1988	0	997	480	12,637	1,091	994
1989	0	1,567	764	11,041	1,888	1,758
1990	0	2,101	1,081	8,913	2,899	2,840
1991	0	1,961	1,259	6,930	3,587	4,099
1992	0	1,526	1,304	5,385	3,794	5,403
1993	0	1,185	1,310	4,185	3,653	6,714
1994	0	920	1,225	3,253	3,331	7,939
1995	0	714	1,097	2,529	2,931	9,036
1996	0	554	953	1,968	2,517	9,989
1997	0	430	811	1,532	2,121	10,800
1998	0	334	679	1,194	1,763	11,479
1999	0	259	561	933	1,449	12,040
2000	0	201	459	730	1,181	12,499
2001	0	156	373	573	955	12,871
2002	0	122	301	452	768	13,172
2003	0	95	241	358	615	13,413
2004	0	74	193	286	490	13,606
2005	0	58	153	230	390	13,759
2006	0	46	122	187	309	13,881
2007	0	36	97	154	245	13,977
2008	0	29	77	129	194	14,054
2009	0	24	61	110	154	14,115
2010	0	19	48	95	123	14,163
2011	0	16	38	84	98	14,201
2012	0	13	31	75	79	14,232

APPENDIX 5

Table 5.1. *Projection R4A—Weibull incubation period (Hessol* et al., *1988)*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	4,794	167	75	10,850	156	97
1986	8,313	305	157	18,831	304	254
1987	12,858	543	279	31,098	567	534
1988	16,584	939	463	46,667	1,040	996
1989	18,244	1,544	736	63,255	1,845	1,732
1990	17,218	2,387	1,102	77,933	3,122	2,834
1991	14,264	3,448	1,535	88,555	5,024	4,369
1992	11,798	4,663	2,179	95,459	7,489	6,548
1993	10,242	5,943	3,105	99,491	10,298	9,653
1994	8,568	7,195	4,130	100,564	13,322	13,783
1995	6,968	8,327	5,201	98,876	16,393	18,984
1996	5,549	9,260	6,257	94,814	19,324	25,241
1997	4,353	9,932	7,231	88,867	21,935	32,472
1998	3,378	10,305	8,065	81,562	24,066	40,537
1999	2,607	10,371	8,709	73,418	25,599	49,246
2000	2,012	10,145	9,130	64,910	26,466	58,377
2001	1,567	9,665	9,314	56,449	26,652	67,691
2002	1,242	8,982	9,264	48,363	26,190	76,955
2003	1,010	8,158	9,000	40,891	25,156	85,955
2004	848	7,254	8,553	34,188	23,656	94,508
2005	733	6,324	7,964	28,328	21,810	102,472
2006	650	5,416	7,276	23,321	19,745	109,749
2007	589	4,566	6,532	19,134	17,576	116,281
2008	544	3,798	5,771	15,698	15,408	122,052
2009	511	3,124	5,025	12,929	13,322	127,077
2010	486	2,550	4,319	10,734	11,381	131,395
2011	469	2,072	3,670	9,023	9,624	135,066
2012	457	1,683	3,091	7,707	8,073	138,157

Table 5.2. *Projection R4B—Weibull incubation period (Medley* et al., *1988)*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	3,296	175	80	7,369	164	103
1986	5,757	315	164	12,792	315	267
1987	9,097	557	288	21,301	583	555
1988	12,225	960	475	32,515	1,066	1,030
1989	14,242	1,583	754	45,097	1,891	1,783
1990	14,339	2,462	1,132	56,869	3,214	2,915
1991	12,623	3,580	1,584	65,778	5,198	4,500
1992	10,992	4,858	2,259	71,750	7,777	6,759
1993	9,969	6,181	3,227	75,350	10,703	9,986
1994	8,658	7,429	4,287	76,369	13,806	14,273
1995	7,265	8,491	5,373	74,914	16,871	19,645
1996	5,936	9,276	6,406	71,333	19,674	26,051
1997	4,755	9,727	7,309	66,112	22,007	33,360
1998	3,752	9,826	8,020	59,785	23,713	41,380
1999	2,929	9,595	8,493	52,871	24,700	49,872
2000	2,271	9,083	8,708	45,818	24,946	58,580
2001	1,757	8,359	8,670	38,989	24,494	67,250
2002	1,365	7,498	8,403	32,645	23,439	75,653
2003	1,074	6,570	7,947	26,955	21,907	83,600
2004	865	5,639	7,348	22,007	20,040	90,948
2005	716	4,750	6,656	17,820	17,977	97,604
2006	612	3,936	5,919	14,362	15,841	103,523
2007	538	3,218	5,174	11,568	13,738	108,697
2008	485	2,602	4,456	9,354	11,746	113,153
2009	446	2,088	3,787	7,631	9,921	116,940
2010	418	1,671	3,182	6,311	8,294	120,122
2011	397	1,339	2,649	5,314	6,879	122,771
2012	382	1,080	2,191	4,572	5,676	124,962

Table 5.3. *Projection R4C—Weibull incubation period (CIA, 1988)*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	6,805	165	74	15,603	154	95
1986	11,597	306	156	26,855	303	251
1987	17,324	549	280	43,562	570	531
1988	21,131	950	467	63,636	1,052	998
1989	21,699	1,565	744	83,613	1,868	1,742
1990	19,109	2,422	1,117	100,092	3,166	2,859
1991	14,930	3,509	1,558	111,254	5,105	4,417
1992	11,798	4,773	2,218	117,974	7,638	6,635
1993	9,880	6,132	3,176	121,373	10,563	9,811
1994	8,028	7,496	4,251	121,515	13,763	14,062
1995	6,381	8,771	5,396	118,701	17,076	19,459
1996	4,991	9,868	6,548	113,371	20,316	26,007
1997	3,863	10,713	7,640	106,047	23,286	33,647
1998	2,973	11,253	8,606	97,280	25,809	42,253
1999	2,290	11,462	9,388	87,619	27,735	51,641
2000	1,782	11,344	9,943	77,573	28,965	61,584
2001	1,413	10,926	10,244	67,592	29,454	71,828
2002	1,152	10,257	10,286	58,041	29,212	82,114
2003	969	9,399	10,082	49,193	28,299	92,195
2004	839	8,420	9,660	41,228	26,819	101,855
2005	745	7,386	9,060	34,239	24,896	110,915
2006	675	6,356	8,331	28,249	22,671	119,245
2007	623	5,376	7,519	23,225	20,281	126,765
2008	584	4,480	6,672	19,096	17,849	133,437
2009	556	3,688	5,830	15,766	15,480	139,267
2010	536	3,009	5,023	13,127	13,252	144,290
2011	523	2,441	4,277	11,072	11,221	148,567
2012	515	1,979	3,605	9,496	9,418	152,172

Table 5.4. *Projection R4D—Weibull incubation period with changing parameters*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,360	187	85	12,166	176	110
1986	9,235	342	176	21,028	341	286
1987	14,130	563	305	34,543	597	591
1988	17,956	837	458	51,577	974	1,049
1989	19,414	1,174	640	69,692	1,504	1,690
1990	18,018	1,516	830	86,022	2,184	2,519
1991	14,734	1,790	986	98,746	2,980	3,506
1992	12,084	2,142	1,201	108,419	3,911	4,707
1993	10,422	2,656	1,555	115,866	4,997	6,262
1994	8,671	3,168	1,955	120,998	6,190	8,217
1995	7,020	3,662	2,384	123,932	7,442	10,602
1996	5,570	4,126	2,826	124,899	8,708	13,428
1997	4,357	4,547	3,266	124,179	9,947	16,694
1998	3,377	4,916	3,689	122,059	11,122	20,383
1999	2,610	5,229	4,085	118,810	12,203	24,468
2000	2,029	5,480	4,443	114,683	13,164	28,911
2001	1,600	5,668	4,756	109,896	13,988	33,667
2002	1,292	5,794	5,018	104,636	14,661	38,685
2003	1,074	5,860	5,226	99,059	15,177	43,911
2004	919	5,867	5,379	93,290	15,532	49,289
2005	805	5,822	5,475	87,429	15,730	54,764
2006	720	5,727	5,517	81,559	15,774	60,282
2007	656	5,588	5,507	75,752	15,674	65,789
2008	608	5,411	5,449	70,068	15,442	71,238
2009	573	5,202	5,346	64,558	15,089	76,584
2010	548	4,967	5,204	59,265	14,630	81,787
2011	531	4,710	5,027	54,223	14,081	86,814
2012	521	4,439	4,821	49,460	13,457	91,635

APPENDIX 6

Table 6.1 *Projection R5A—no improvement in mortality from AIDS*

Year	New infections with HIV during year	New cases of AIDS during year	Deaths from AIDS during year	Numbers HIV positive at end of year	Numbers sick with AIDS at end of year	Total dead from AIDS by end of year
1985	5,964	153	68	13,612	143	88
1986	10,253	300	148	23,531	294	236
1987	15,544	575	295	38,441	574	531
1988	19,378	1,052	559	56,673	1,063	1,090
1989	20,403	1,798	1,001	75,142	1,855	2,091
1990	18,387	3,017	1,717	90,333	3,147	3,807
1991	14,612	4,890	2,864	99,832	5,160	6,671
1992	11,662	7,330	4,544	103,906	7,925	11,215
1993	9,820	9,865	6,653	103,576	11,106	17,868
1994	8,007	11,902	8,854	99,373	14,112	26,721
1995	6,382	13,013	10,717	92,424	16,353	37,438
1996	5,009	13,150	11,916	83,958	17,521	49,354
1997	3,891	12,652	12,379	74,874	17,719	61,733
1998	3,003	11,842	12,261	65,718	17,220	73,994
1999	2,313	10,828	11,730	56,897	16,233	85,724
2000	1,790	9,699	10,919	48,698	14,926	96,643
2001	1,403	8,535	9,934	41,292	13,439	106,577
2002	1,125	7,399	8,865	34,764	11,886	115,442
2003	928	6,333	7,781	29,126	10,354	123,223
2004	790	5,365	6,735	24,340	8,904	129,958
2005	692	4,507	5,761	20,334	7,576	135,718
2006	622	3,764	4,880	17,022	6,390	140,598
2007	570	3,133	4,103	14,309	5,357	144,701
2008	531	2,606	3,432	12,102	4,472	148,134
2009	502	2,171	2,863	10,320	3,728	150,996
2010	481	1,815	2,387	8,888	3,110	153,383
2011	467	1,527	1,994	7,743	2,603	155,377
2012	457	1,296	1,673	6,833	2,190	157,050