A MODEL FOR EXPLORING SCENARIOS SURROUNDING

THE SPREAD OF AIDS IN THE U.K.

Brian C Dangerfield & Carole A Roberts

Department of Business & Management Studies

University of Salford

SALFORD   M5 4WT

U.K.

STRUCTURE OF THE MODEL

FIGURE 1 illustrates the structure of the model.

People flow from a Susceptible Population after invasion by HIV and become members of the HIV population capable of infecting other susceptibles.

Then, infected people move either into a state of

   (i)   clinical AIDS (governed by the Symptoms Emergence Ratio, SER)

or into one of several other states:-

  (ii)   die from other unrelated causes

(iii)   retire altogether from sexual activity on account of their age

 (iv)   retire altogether from sexual intercourse as a reaction to knowledge of their condition

  (v)   acquire a medically non-infectious state

All these states render the host non-infectious since we assume that patients with clinical AIDS will no longer be sexually active.

FIGURE 1   Flow Diagram of the Model
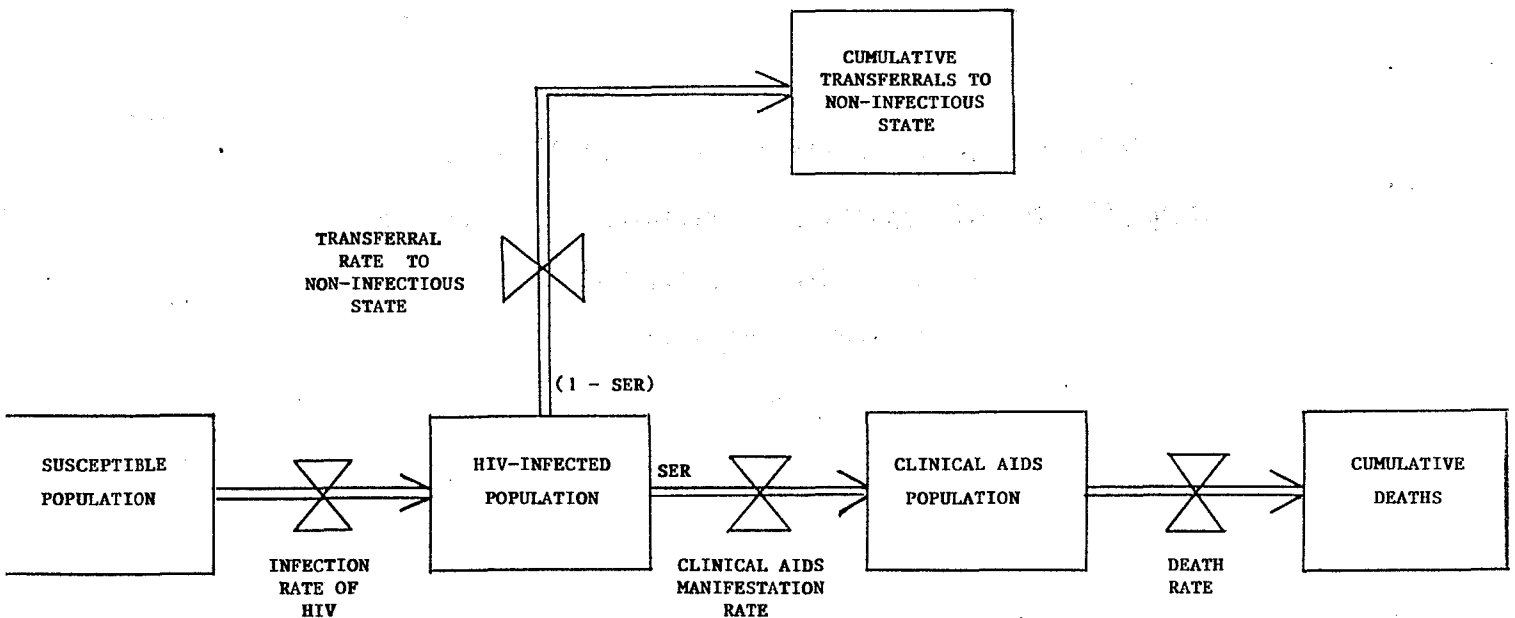
BASE MODEL

A base model was constructed. This provides a benchmark against which to compare various subsequent complications.

It conforms to the flow diagram (FIGURE 1) and examines, over a period of 30 years, the effects of the spread of the infection in an estimated at risk population of 1 million homosexual males in the U.K.

The base model assumes a homogeneous sexual activity profile.

The rate of acquisition of HIV by susceptible people is a function of

- HIV Population (HIVPOP)

- Mean Number of Different Partners per Year (MNDP)

- Probability of Infection per Partner (PIPP)

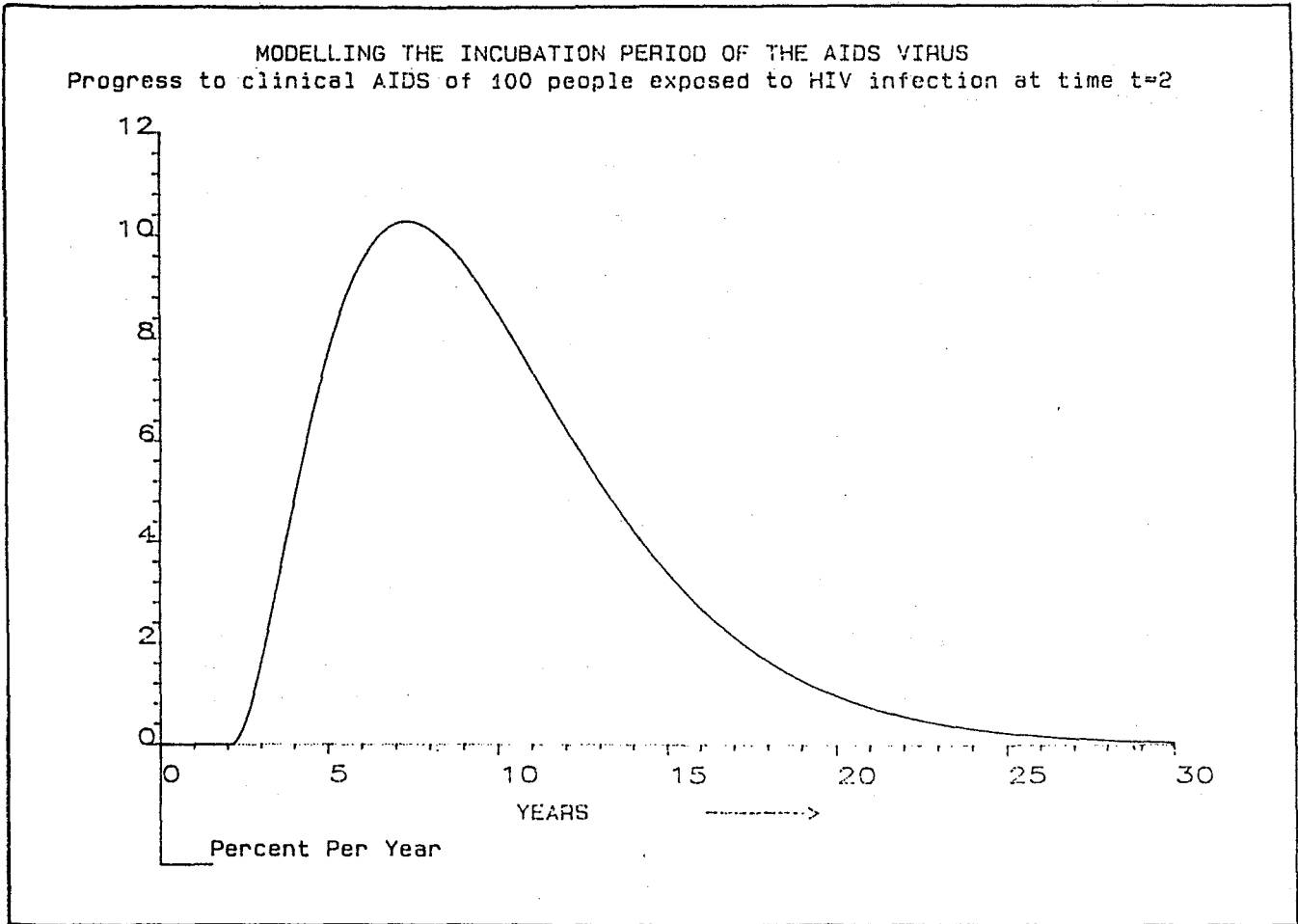- Proportion of susceptible people in the at risk population (SPR)

MNDP was set at 10.5, following publication by HMSO of British Market Research Bureau Survey (1). PIPP was set at 0.1 giving a value of MNDP x PIPP approximately equal to 1, an accepted value for the product of these two quantities (2).

PARAMETER AND DISTRIBUTIONAL ASSUMPTIONS

- Proportion acquiring clinical AIDS 0.7

- Mean incubation time to develop AIDS ....8 years

- Incubation period modelled using a third order delay, equivalent to an Erlang Type 3 probability distribution (see FIGURE 2)

- Mean time before death from AIDS occurs ....1 year

- Death rate modelled using a ninth order delay, equivalent to an Erlang Type 9 probability distribution

All these parameter and distributional assumptions can be varied with ease to accommodate revised opinion as more time-based data becomes available.

FIGURE 2

MODELLING THE INCUBATION PERIOD OF THE AIDS VIRUS
Progress to clinical AIDS of 100 people exposed to HIV infection at time t=2

VARIATIONS ON THE BASE MODEL I

PROPORTION OF THE HIV POPULATION ACQUIRING AIDS

FIGURE 3 shows the effect on the clinical AIDS population of varying values of the proportion acquiring AIDS, as modelled by the Symptoms Emergence Ratio.

EPIDEMIOLOGY DYNAMICS: THE SPREAD OF AIDS IN THE U.K.
Clinical Aids Population

Top Line: Symptoms Emergence Ratio (SER) = 1.0
Second line: SER = 0.9
Third line: SER = 0.8
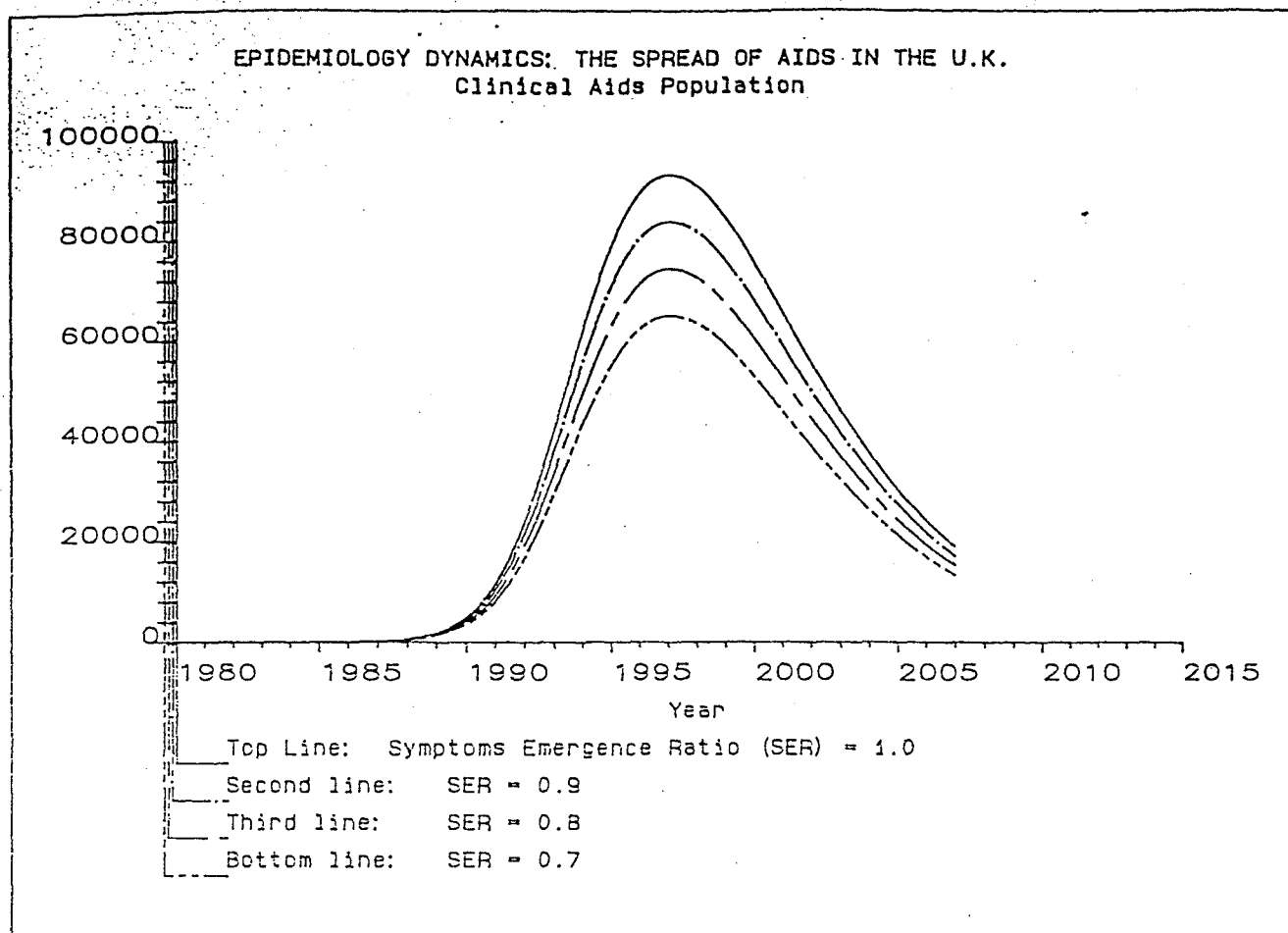Bottom line: SER = 0.7

FIGURE 3   The effect on the clinical AIDS population of increasing,
from 0.7 to 1.0 in steps of 0.1, the proportion of HIV-infecteds
who translate to clinical AIDS.

VARIATIONS ON THE BASE MODEL II

AVERAGE TIME BEFORE DEATH OCCURS

FIGURE 4 shows the effect on the clinical AIDS population of increasing the average time before death from AIDS occurs, for example, by the widespread administration of drugs like AZT.
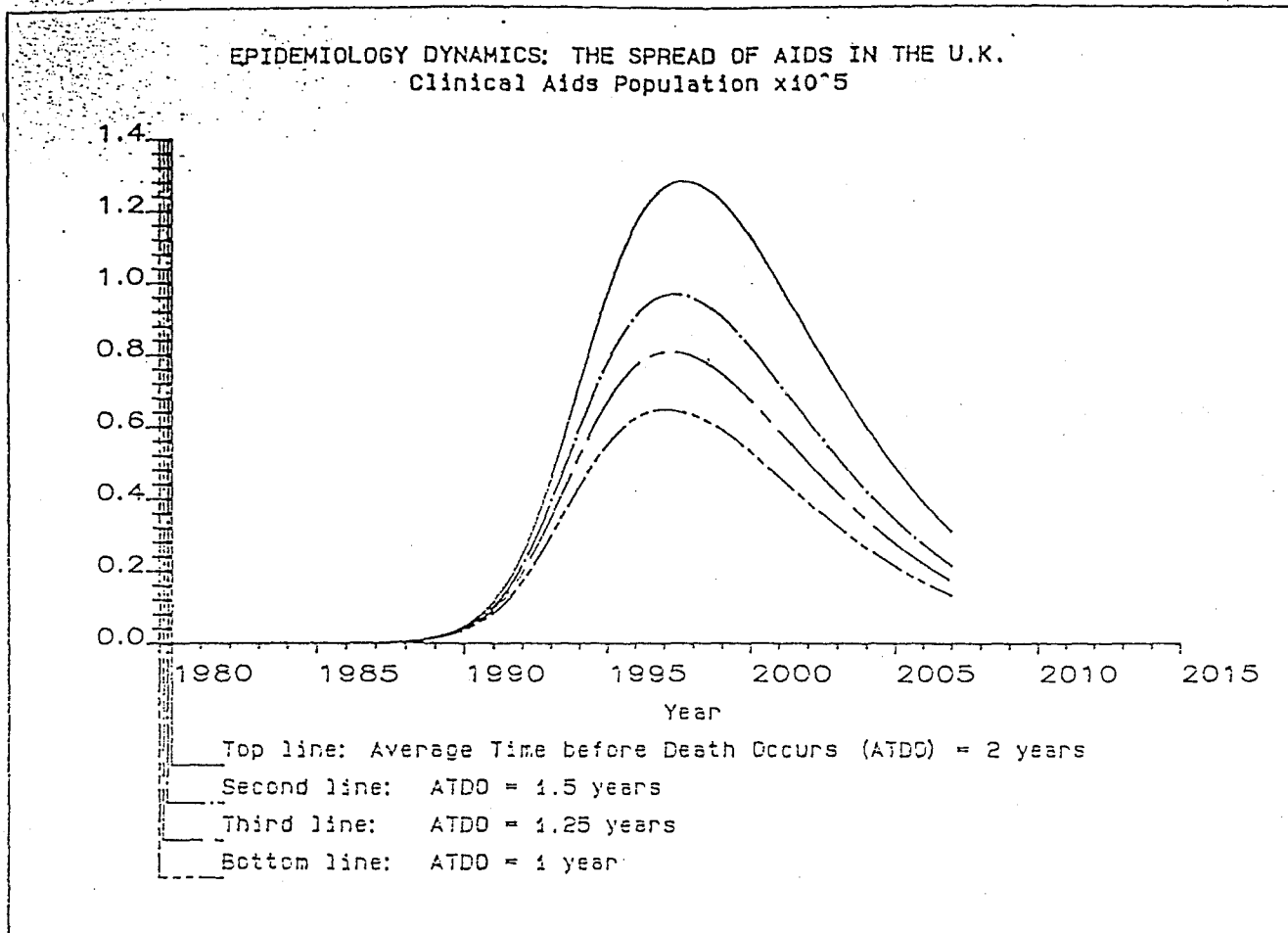
-46-

FIGURE 4 The effect on the clinical AIDS population of changes to the average time before death occurs.

VARIATIONS ON THE BASE MODEL III

HETEROGENEITY IN SEXUAL BEHAVIOUR AND CHANGING BEHAVIOUR – REDUCING NUMBER OF PARTNERS

A more realistic model is achieved by disaggregating the susceptible population to reflect heterogeneity in sexual behaviour.

Approximately based on the data from the British Market Research Bureau Survey (1), a crude split of the at-risk population was made, such that

    30 per cent had 1 partner per year
    50 per cent had 6 different partners per year
    20 per cent had 36 different partners per year

giving an average of 10.5 partners but for epidemiological purposes, an effective mean of 26.4 — mean + variance/mean (2).

To maintain MNDP x PIPP at approximately 1, PIPP was set to 0.04

Further the BMRB survey indicated a reduction in the average number of partners from 10.5 in February 1986 to 4.8 in February, 1987.

FIGURE 5 shows a comparison plot (co-plot) of the prevalence of clinical AIDS for

  (i)   a homogeneous profile of sexual activity
 (ii)   a heterogeneous profile of sexual activity
(iii)   a heterogeneous profile incorporating changing behaviour

A heterogeneous profile reduces the size and intensity of the epidemic since the more active individuals are removed relatively quickly from the system and stop contributing to the spread of the disease.

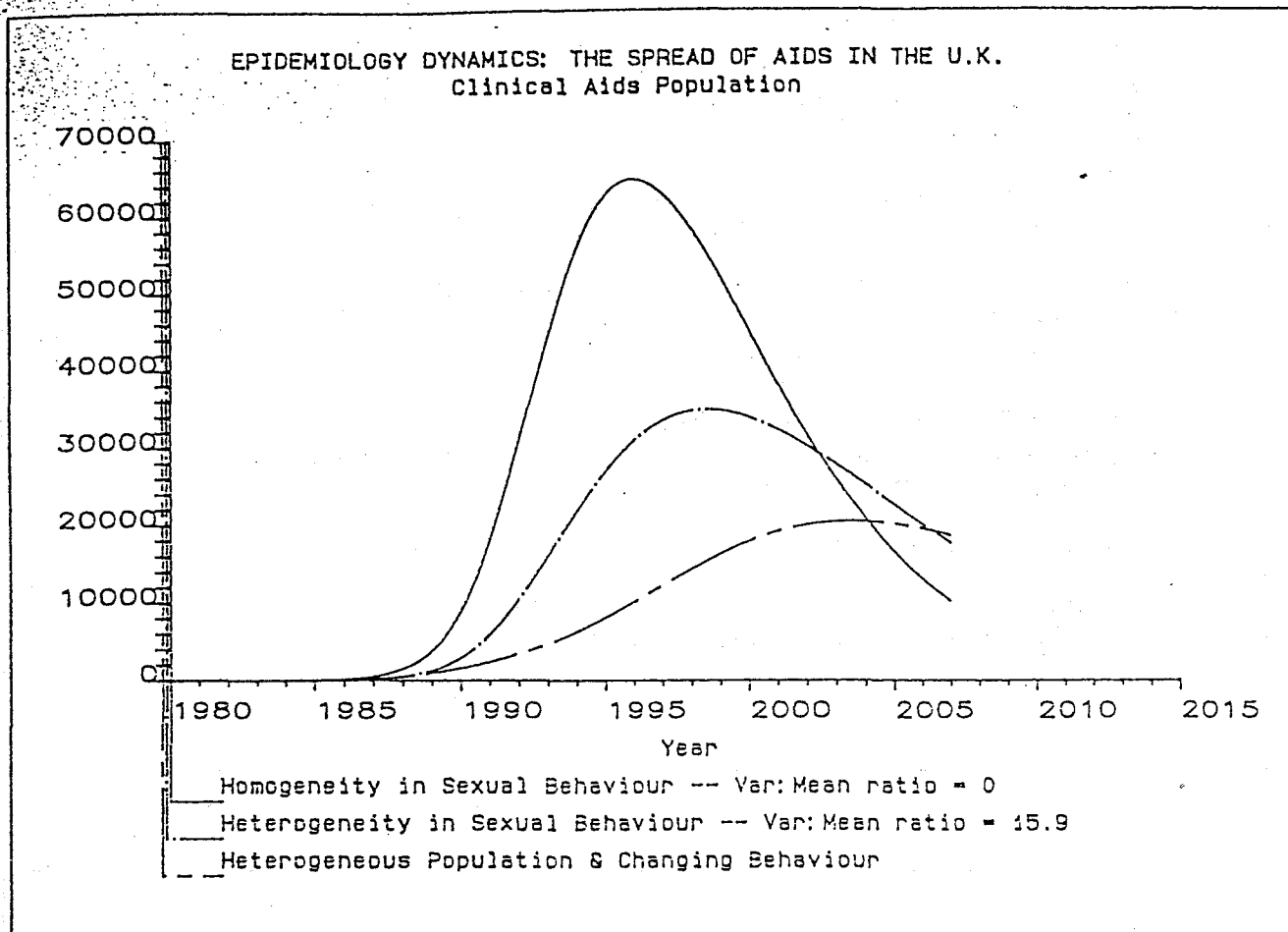EPIDEMIOLOGY DYNAMICS: THE SPREAD OF AIDS IN THE U.K.
Clinical Aids Population

FIGURE 5 Comparison of the effect on the clinical AIDS population as between (i) the homogeneous (base) model (highest peak), (ii) a heterogeneous sexual profile model (middle peak) and (iii) the model in (ii) augmented by changing sexual behaviour (lowest peak).

VARIATIONS ON THE BASE MODEL IV

EFFECTS OF A VACCINE COMPARED WITH A DRUG TO REDUCE INFECTIVITY

FIGURE 6 shows the effect of two possible interventions

- A vaccine for seronegative members of the at-risk population available in 1992, possibly an optimistic scenario

- A drug to reduce infectivity by 50% for seropositive members of the at-risk population available in 1990

A drug to reduce infectivity is likely to be produced earlier than a vaccine (3).

There will be a point in time when a vaccine will be too late to affect the size of the epidemic for the at-risk population. In our model this date is 1995.

There are obvious difficulties - both practical and ethical - in identifying the qualifying recipients of either a vaccine or a drug to reduce infectivity. Hence the model, which assumes all qualifying members are identified, produces an optimistic scenario of the impact of either intervention.
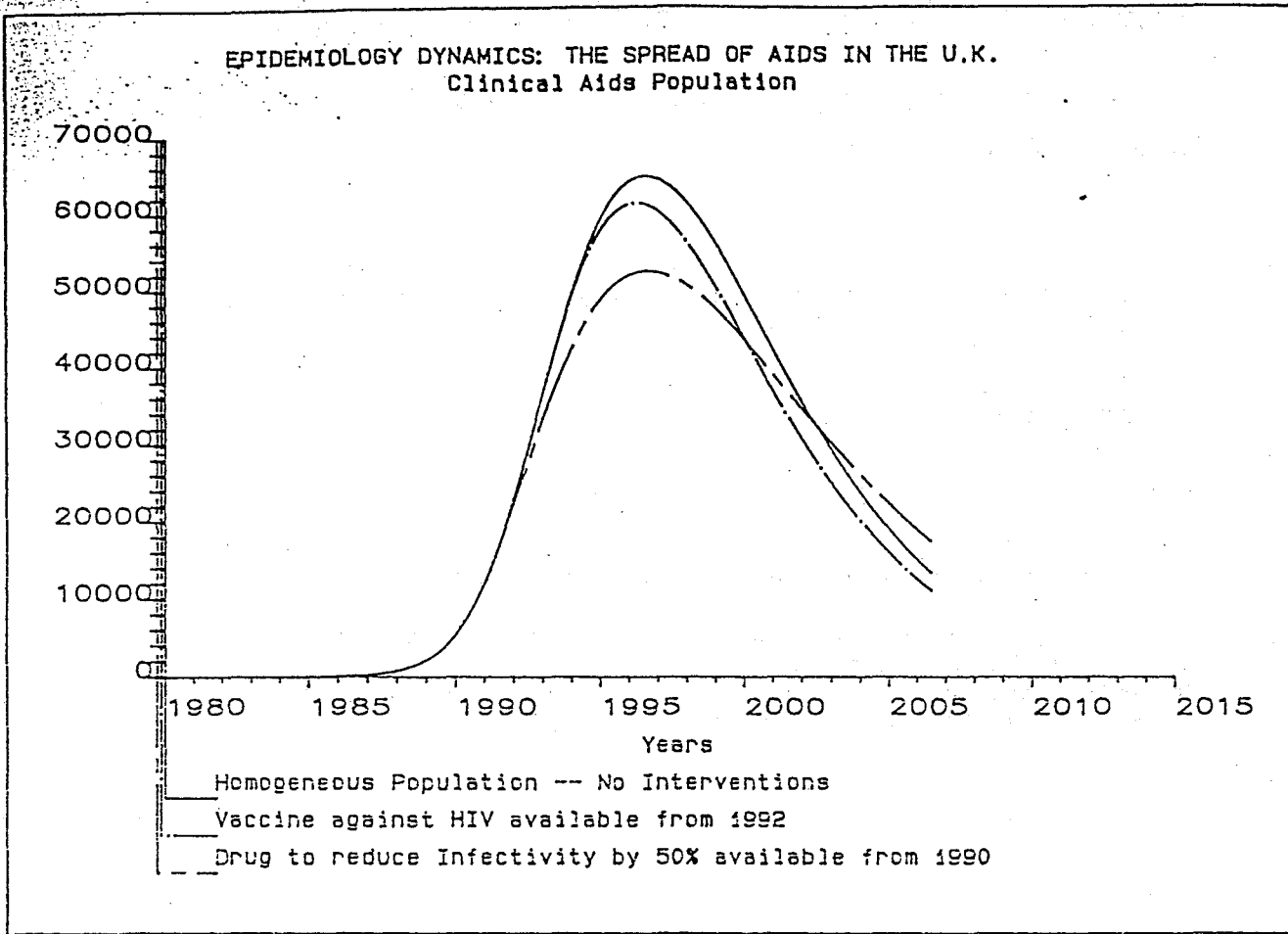
EPIDEMIOLOGY DYNAMICS: THE SPREAD OF AIDS IN THE U.K.
Clinical Aids Population

FIGURE 6 Comparison of the effect on the clinical AIDS population as
between (i) the homogeneous (base) model (highest peak), (ii) intro-
duction of a vaccine against HIV in 1992 (lower peak) and (iii)
introduction of a drug to reduce infectivity by 50% in 1990 (lowest
peak). For the at-risk population involved (male homosexuals), the
drug to reduce infectivity is more effective in attenuating the
peak of the epidemic, since if a vaccine arrives as early as 1992
it is still at a stage when the spread of HIV through this population
is almost complete.

REFERENCES

1. Department of Health & Social Security AIDS : Monitoring Response to
    the public education campaign February 1986 – February 1987 H.M.S.O.
    (1987)

2. Anderson R.M. Nature 326   137–142 (1987)

3. Hall M. Speaking at British Association for the Advancement of Science,
    Belfast (1987)