

AIDS policy modeling by example

Edward H. Kaplan[†] and Margaret L. Brandeau*

AIDS 1994, 8 (suppl 1):S333-S340

Keywords: AIDS policy, mathematical modeling, program evaluation, policy analysis, resource allocation, HIV transmission

Introduction

Many interventions to slow or halt the AIDS epidemic have been proposed. Some, including needle-exchange programs, high school-based condom availability programs, mandatory contact tracing, screening programs targeted to specific population groups, and immigration bans on HIV-infected individuals, have been vigorously debated. Decision makers often do not have reliable information about the probable worth of a given intervention, or about the appropriate allocation of resources among competing programs. However, doing nothing also represents a policy decision—and possibly a costly one.

Policy modeling can provide important input to the AIDS decision-making process. Such models can provide quantitative estimates of the probable costs and outcomes of a given intervention. Where data are uncertain, policy models can be used to explore intervention effects under different possible scenarios, and to identify the most critical areas where further data are needed. The goal of AIDS policy modeling is not to provide precise valuations of costs and benefits but, rather, to help in determining good policy decisions. Policy modeling is also useful for making explicit the implicit value judgments underlying a given policy choice, and the implications following from such valuations. For example, Steven Grover and his colleagues [1] showed that in Canada, health-care costs attributable to HIV-infected immigrants (including costs associated with individuals they might infect after immigrating) are comparable to health-care costs for immigrants with coronary heart disease. Thus, those favoring a ban on HIV-infected immigrants should also favor banning

the immigration of people at risk for heart disease. That proposals for banning the latter group have not been voiced suggests that the arguments of those wishing to bar HIV-infected immigrants on the basis of avoiding additional health-care costs discriminate unjustifiably against HIV-positive immigrants.

In the past few years, policy models dealing with a range of AIDS-related issues have appeared [2,3]. For instance, in addition to Grover and colleagues' analysis of immigration policy [1], policy models have been developed to analyze counseling and testing programs [4,5], needle-exchange programs [6,7], protective screening of the blood supply [8,9], and policies for mitigating HIV transmission risks between health-care providers and patients [10]. Policy models have been applied to project future HIV/AIDS resource needs, both at the level of the individual health-care facility [11,12] and at the national level [13], to study the cost-effectiveness of zidovudine [14], and to analyze decisions on the design of clinical trials for testing antiretroviral drugs [15].

This paper will describe recent work in the area of AIDS policy modeling. Rather than attempting an exhaustive survey of all AIDS policy modeling research, we will demonstrate the value of policy modeling by presenting examples in a few illustrative areas pertaining to AIDS policy in the United States (some European applications can be found in [2]), while an in-depth study of AIDS scenarios for policy planning in The Netherlands was reported in [13]. First, we present four examples showing how simple 'back-of-the-envelope' models can lead to valuable insights. Forecasting is important for health-services planning and resource allocation, so we

From Yale University School of Organization and Management, Yale University School of Medicine, New Haven, Connecticut and the *Department of Industrial Engineering and Engineering Management, Stanford University, Stanford, California, USA. [†]Current address: Braun School of Public Health and Community Medicine, Hebrew University of Jerusalem, Jerusalem, Israel.

Sponsorship: E.H.K. acknowledges the National Institute on Drug Abuse for partial support under grant R01-DA07676-02, the Robert Wood Johnson Foundation for partial support under grant 20049, and the Lady Davis Fellowship Trust, Jerusalem, Israel. M.L.B. was supported in part by a grant from the California Universitywide AIDS Research Program.

Requests for reprints to Prof. Edward H. Kaplan, Yale School of Organization and Management, Box 208200, New Haven, CT 06520-8200, USA, or to Prof. Margaret L. Brandeau, Department of Industrial Engineering and Engineering Management, Terman Engineering Center, Stanford University, Stanford, CA 94305-4024, USA.

next describe a specific forecasting exercise designed to estimate the number of severely immunosuppressed HIV-infected people in the United States, and determine the change in the number of AIDS cases reported due to the recent expansion in the Centers for Disease Control and Prevention (CDC) definition of AIDS to include HIV-infected people with a CD4+ T-cell count less than $200 \times 10^6/l$. Following this, we highlight selected aspects of two instances of AIDS policy modeling in action: model-based evaluation of needle-exchange programs, and analysis of HIV counseling and testing programs. These applications demonstrate both modeling methodology and policy relevance. We conclude with a discussion of several general policy modeling issues that arise from the disparate analyses.

AIDS policy modeling on the back of an envelope

AIDS policy models can be simple or complex depending upon the modeling purpose being served. Policy modeling does not always require elaborate mathematical formulations or computer solutions. To illustrate how even the simplest of modeling concepts can provide useful insights, consider the following four examples.

A simplified circulation model of needle exchange

Needle-exchange programs exist to slow the spread of HIV transmission among drug injectors who share injection equipment. Many studies of needle exchange have reported changes in risky behavior among drug injectors as evidence of program effectiveness (for a detailed review of these studies see [16]), but recent research suggests that rather mechanical changes in the behavior of *needles* take place as a direct result of the availability of needle exchange. A simple variant of this circulation theory [6,7] proceeds as follows: let λ represent the number of shared drug injections per drug injector per unit time, and let ν equal the per capita needle-exchange rate in a program, given by the number of needles exchanged per drug injector per unit time. Suppose that a drug injector possesses a used needle. Either the needle will be re-used, or the needle will be exchanged. A simple competing risks framework (which technically assumes that injection with used equipment and needle exchange occur in accordance with independent Poisson processes) predicts that the probability that a needle will be exchanged rather than re-used is equal to $\nu/(\lambda+\nu)$. Consequently, the rate with which injectors are exposed to used equipment will be reduced by $100 \times \nu/(\lambda + \nu)\%$ relative to pre-program levels, barring other changes.

This simple argument has proved very effective in assessing probable changes in HIV incidence

rates resulting from needle-exchange programs. For example, in the New Haven (Connecticut, USA) needle-exchange program, λ was estimated to equal roughly 246 shared injections per year, while ν was measured to be 122 exchanges per year, yielding approximately a 33% estimated reduction in exposure to used needles (and consequently a 33% estimated reduction in new infections via this route of transmission [6]). More recently, this simple model formed the heart of a detailed analysis conducted by San Francisco researchers investigating the cost-effectiveness of US needle-exchange programs [7]. Using the simplified formula discussed above, in conjunction with baseline incidence estimates, the researchers deduced the number of infections likely to be averted via needle exchange. Combined with the cost of operating such programs, it was then possible to compute the cost per HIV infection prevented under a variety of scenarios designed to mimic needle exchanges operating in different parts of the United States. As the cost per infection averted was much less than the actual cost of medical care alone per new HIV infection (estimated at US \$119 000 [7]), the researchers were able to argue persuasively that needle exchange is a cost-effective approach to slowing HIV transmission among drug injectors.

Estimating the prevalence of HIV from AIDS diagnosis rates

In order to detect HIV infection earlier, it has been proposed that hospitals in the United States should offer voluntary HIV screening programs [17]. There would be little value at potentially high cost if screening were encouraged in areas where HIV prevalence is negligible. However, without undertaking prevalence studies, how can HIV prevalence in hospitals be estimated from available data? To answer this question, Janssen *et al.* [17] correlated HIV prevalence from 20 hospitals in the US CDC sentinel system with AIDS diagnosis rates, defined as the number of newly diagnosed AIDS cases per discharge. The researchers discovered via linear regression that in the 20 hospitals studied, HIV prevalence was approximately 10.4 times the AIDS diagnosis rate.

We suggest that this result could have been anticipated from first principles. Let π equal the HIV prevalence in a hospital, D equal that hospital's discharge rate, α equal the probability that an HIV-infected person progresses to AIDS in a given year, and k be a constant of proportionality to be determined. In a given year, the fraction of all new hospital admissions who are diagnosed with AIDS will be very close to the product of the prevalence π and the AIDS progression probability α . Also, the number of hospital admissions will essentially equal the number of discharges over a 1-year period. Thus, the AIDS diagnosis rate as formulated in

the study cited is approximately equal to $D \times \pi \times \alpha$ (number of new AIDS diagnoses), divided by D (number of discharges), which simply equals $\pi\alpha$. Relating HIV prevalence to the AIDS diagnosis rate by the proportionality constant k yields the relationship $\pi = k \times (D\pi\alpha/D)$, which implies that $k = 1/\alpha$. Now, if α represents the probability of progression to AIDS in 1 year, then $1/\alpha$ equals the mean incubation time, which many have estimated to be approximately 10 years [18–21]. Thus, one would expect that $k \approx 10$, which is what the researchers discovered empirically.

Evaluating contact tracing programs

The strategy of partner notification has been used in the attempt to contain the spread of sexually transmitted diseases (STD), and some have advocated its use to contain HIV transmission [22]. One group of researchers favoring contact tracing as a preventive tool has argued that such programs are inherently easy to evaluate as well: 'The partner notification procedure, consisting of case interview and tracing of named contacts, also conveniently contains a built-in measure of intervention efficacy: over time, the proportion of located contacts who are newly identified as positive should diminish, testifying to diminished HIV transmission. Should the opposite occur, it would demonstrate the failure of our behavior-modification messages to alter high-risk behavior' [23].

To assess the credibility of this argument, consider for a moment the following principles. First, people who have more sexual partners are more likely to be named in the early 'generations' of a contact tracing study. Worded differently, the more partners one has, the greater the number of potential referrals. Second, people who are more sexually active are more likely to be infected with HIV. As a consequence, the implicit snowball sampling that occurs in partner notification programs will cause the fraction of newly contacted people who test HIV-positive to fall even if no behavior change occurs. Thus, declining prevalence in successive generations during contact tracing is exactly what one should expect as a base case, and cannot be taken as evidence for the success of such programs.

Condom availability in schools

In debates surrounding sexual behavior, it is often difficult to separate reason from rhetoric. One highly charged issue concerns proposals to make condoms available in schools [24,25]. Opponents of such programs argue that making condoms available only serves to encourage sexual activity, and perhaps even leads to increases in STD transmission and teenage pregnancies.

Consider first the fear that condom promotion might increase sexual activity to the point of actually increasing the rate of unprotected sex. That condoms fail only rarely in industrial quality-control checks is

well known, although one would not expect sexually active youth (or adults) to use condoms appropriately in all sexual encounters [26]. Therefore, the degree of protection offered by condoms in the aggregate depends mainly upon the fraction of time condoms are used correctly. Suppose that following an educational program that includes instruction in the appropriate use of condoms, 10% of all sexual encounters in the target population remain unprotected because of misuse or non-use of condoms in addition to true condom failure. For the rate of unprotected sexual exposure following the program to equal the status quo rate that existed before the education program, the total amount of sex in the target population would have to increase by a factor of 10 over the pre-program rate of unprotected sex [27]. A condom failure rate of 20% would still require a five-fold increase in sexual activity to achieve the status quo level of unprotected sexual exposures. Sex educators claim that proper condom instruction embedded in health education might actually reduce the total number of sex acts, and not just the number of risky sex acts [28]. Even discounting this claim, it is difficult to believe that teenagers could increase the amount of sex they have by a factor of five to 10.

Of course, some people will be unwilling to accept any increase in sexual activity. Such people would rather maintain the status quo number of sex acts, total and risky, in favor of a program that, perhaps in the worst case, could raise the total number of sex acts while lowering the number of unprotected exposures. Such views imply disturbing tradeoffs. Imagine 1000 sexually active teenagers pursuing unprotected sex at the rate of one encounter per week. Following a condom availability program, suppose sexual activity increases by 10% to 1100 sex acts per week. However, an operational condom failure rate of 10% from breakage, misuse or non-use of condoms translates into a reduction in the number of unprotected sex acts from 1000 to 110. So, the 100 new sex acts can be associated with a reduction in the number of risky sex acts from 1000 to 110, an average of 8.9 risky sex acts averted per incremental sexual experience. A person favoring the status quo would be unwilling to accept a reduction of 8.9 risky acts for each new sexual encounter. Similar reasoning shows that, still assuming a 10% condom failure rate, a 20% increase in sexual activity results in a reduction of 4.4 risky acts per new encounter, while even a 50% increase in sexual activity leads to a reduction of 1.7 risky sex acts per new encounter. The above arguments show that it is possible to reveal the until now hidden tradeoffs between increased sexual activity on the one hand and reduced opportunities for unwanted pregnancies and STD transmission on the other that are implicit in such opposition. Confrontation with such tradeoffs may cause some (though not all) opponents of condom availability to re-think their position.

Forecasting the AIDS epidemic

Credible predictions of the course of the AIDS epidemic are crucial for the planning of health services and the allocation of public resources devoted to controlling the further spread of HIV and AIDS. Indeed, many quantitative analysts were first drawn to the study of AIDS by the need to both forecast the future spread of the epidemic and to estimate the number of people currently infected with HIV. This gap led to the development of novel statistical methodologies, most notably the backcalculation procedure for reconstructing HIV incidence rates from AIDS incidence data corrected for reporting delays [29,30]. It is perhaps a testimony to this modeling approach that commonly cited HIV infection statistics are the outputs of such models. For example, many readers are familiar with statements such as 'there are approximately 1 million HIV-infected persons in the United States', but how does one know? No one has ever counted! The most credible estimates are those derived from statistical backcalculation models as exemplified in [29,30]. In the absence of systematic HIV surveillance, such models offer the best available guide to the near future.

Estimating the number of immunosuppressed HIV-infected people

The backcalculation technique was used recently in a careful (and unusually well documented) study that estimated the number of HIV-infected people in the United States with CD4+ T-cell counts less than $200 \times 10^6/l$, an indicator of severe immunosuppression [31,32]. Such estimation becomes possible by staging the incubation time from HIV infection up to the development of AIDS according to CD4+ counts. For planning purposes, the number of severely immunodepressed people is important to know, for such people might benefit from clinical interventions to delay the onset of disease and/or to treat disease once it develops.

In January 1993, the CDC expanded the AIDS case definition to include HIV-infected people with CD4+ counts less than $200 \times 10^6/l$. To estimate the number of newly diagnosed AIDS cases among the severely immunosuppressed, the researchers created a stochastic model tracing severely immunosuppressed HIV-infected people up to possible AIDS reporting endpoints, accounting for whether or not health care was received before an AIDS diagnosis, and whether CD4+ counts were taken for those already receiving health care. These different circumstances lead to different distributions for the length of time from the onset of severe immunosuppression up to a diagnosis of AIDS. The flows of severely immunosuppressed people into the system were chosen to be consistent with the numbers estimated via backcalculation (following adjustment for people diagnosed with AIDS before their CD4+

counts dropped below $200 \times 10^6/l$, in addition to adjustment for non-reporting of AIDS).

The results showed that the expansion of the AIDS case definition can be expected to increase the number of new AIDS cases reported during 1993 in the United States by roughly 75%. Perhaps more importantly, however, the results suggest that less than half of the estimated 115 000–170 000 people with severe immunodeficiency were known to have CD4+ counts below $200 \times 10^6/l$ and to be under medical care for HIV disease [31,32].

AIDS policy modeling in action

The use of models for evaluating existing AIDS intervention programs and for *a priori* analysis of proposed policies is on the rise [2,3,33]. Two areas that received considerable modeling attention in the past year are the evaluation of needle-exchange programs and the cost-effectiveness of alternative HIV counseling and testing proposals. As both of these applications demonstrate modeling methodology and policy relevance, we will now highlight selected aspects of these two examples.

Model-based evaluation of needle-exchange programs

This section concerns the circulation theory of needle exchange developed over the past 2 years in conjunction with the evaluation of New Haven's legal needle exchange [6,34,35]. The theory suggests that even if drug injectors persist in sharing needles, the physical exchange of needles may be sufficient to slow (though not eliminate) the spread of HIV among drug users participating in the program.

Needle exchange may be thought of as a mechanism that operates directly on the periods of time during which needles circulate among a population of drug injectors. In areas where needle possession is illegal without a medical prescription, needles become a scarce resource, and will be re-used for as long as possible. Needle exchange is an opportunity for more rapid circulation of needles (because of the opportunity for frequent exchange of used equipment for new). Thus, the introduction of a needle-exchange program will probably lead to a decline in needle circulation times. However, if needles circulate for shorter periods of time, they are less likely to be used multiple times. In short, needles will share fewer people. This being the case, it stands to reason that fewer needles will be rendered infectious, and consequently even those seronegative drug injectors who persist in needle sharing (perhaps via shooting gallery attendance) are less likely to encounter infectious equipment. Worded differently, if presented with the choice between injecting with a needle that has been in circulation for 1 day ver-

sus injecting with a needle that has circulated for 1 week, most would agree that injecting with the former carries a lower risk of HIV transmission than the latter. As HIV transmission via needle sharing requires injection with an infectious needle, it is reasonable to assume that the HIV transmission rate is proportional to the fraction of circulating needles that are contaminated with HIV.

An analogy to the spread of malaria is instructive. Imagine the effect that replacing infectious mosquitos with newborn mosquitos free of disease would have on the spread of malaria. Needle exchange achieves this effect by replacing infectious needles with clean ones.

The intuition embodied in the above discussion has been formalized mathematically and tested against 20 months of data collected in New Haven [33,34]. One finding shows that the needle removal rate from the population, given by the reciprocal of the mean needle circulation time, grows linearly with the needle exchange rate per participating drug injector per unit time. Figure 1 shows the relationship between needle removal and exchange rates observed over 20 months in the New Haven program. It is clear that increasing needle exchange frequency strongly predicts increasing needle removal rates, explaining the drop in needle circulation times observed in New Haven. Decreasing the mean needle circulation time effectively reduces the fraction of needles in circulation that are infected. A 33% decline in the prevalence of HIV among needles was observed [34,36], suggesting an equivalent reduction in needle-borne HIV transmission.

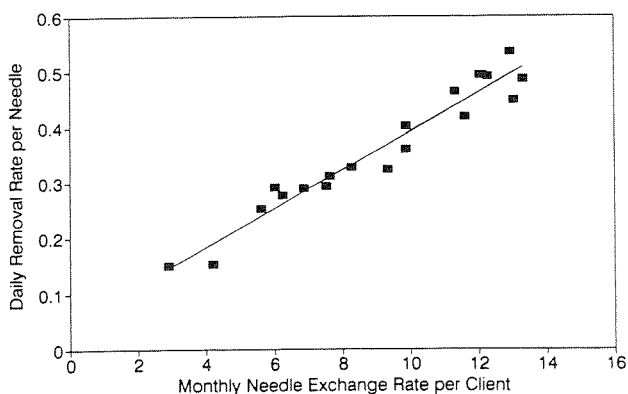


Fig. 1. Needle exchange and removal rates in the New Haven needle-exchange program (Connecticut, USA).

It is important to note that the above arguments are conservative, in that other aspects of needle exchange services (such as placement of clients in drug treatment programs, counseling and education, and the provision of bleach and condoms) have not been considered. Nor have changes in injection behavior beyond participation in the needle-exchange pro-

gram. Thus, the true reduction in HIV incidence is likely to be greater, and perhaps much greater, than reported above.

Earlier, we briefly discussed the needle-exchange modeling exercise conducted by San Francisco researchers in their detailed study of needle-exchange programs in the United States and abroad [7]. Several different modeling approaches were considered, including a model that focused on changes in injecting behavior rather than the changes in needle kinetics we have emphasized until now. Conservatively using data describing changes in injecting behavior derived from many studies, the researchers demonstrated that the expected reduction in HIV transmission caused by behavioral changes is quite comparable to the reduction in HIV transmission estimated via circulation modeling. That similar results have been obtained from different modeling assumptions adds to the overall credibility of needle-exchange policy modeling.

In the United States, the results discussed above have had the effect of moving some public officials towards greater acceptance of needle exchange as a valid public health intervention. For example, the Connecticut legislature repealed the statewide prohibition against possessing unauthorized needles on the basis of the results of the New Haven needle-exchange evaluation, while that same study proved influential in enabling needle exchanges to operate with official blessings in New York City [6]. Given that it is virtually impossible to conduct a controlled trial pitting the HIV incidence rate among drug injectors participating in a needle exchange against a probably equivalent group of drug injectors not exchanging needles, modeling has proved to be a particularly useful approach to policy analysis in the case of needle exchange.

Modeling counseling and testing programs

The issue of HIV counseling and testing has received a great deal of attention, with debate on the likely costs and benefits associated with screening different population groups, as well as discussion of such issues as confidentiality of test results, potential discrimination, and individual rights. For some groups, such as military applicants in the United States, HIV screening is mandatory; other HIV screening programs are voluntary. Many different population groups, such as high-risk men, those applying for marriage licenses, and pregnant women, have been targeted by special screening programs.

Cleary *et al.* [4] presented a first-order analysis of the likely costs and benefits of compulsory premarital screening in the United States. Using data on age and sex cohorts of those applying for marriage licenses and probable HIV prevalence rates among those cohorts, the authors estimated the number of infected individuals who would be screened. These numbers were combined with estimates of screening test sen-

sitivity and specificity to yield an estimate of the number of infected men and women who would be identified by the screening program. To determine the number of individuals who might be saved from infection as a result of identifying these infected people, the authors considered the marriage partners of the newly identified individuals (either male or female) and the future offspring of all couples with at least one infected partner. The number of spouses who could potentially be saved from infection (i.e. those not yet infected) was estimated as the number of newly identified individuals minus the number of partners to whom transmission had already taken place (estimated from the fraction of couples likely to already have had sexual intercourse before marriage multiplied by the chance of HIV transmission per relationship); then, the estimated number of spouses saved from infection was calculated as 10% of the number of uninfected spouses of newly identified infected partners. The number of children who could be saved from infection was estimated as 50% of the future offspring of infected women; the number of women infected (in the absence of screening) was calculated as the number of infected women at the time of marriage plus 50% of the women with an infected husband.

The analysis showed that compulsory premarital screening of the general United States population is not likely to be an effective use of public health resources, since the prevalence in the screened population is low, and the number of individuals saved from infection small relative to the number of individuals screened. In 1988, the State of Illinois instituted compulsory premarital screening. In defense of the program, one state legislator said, 'If we find just 100 people that could have possibly infected another 100 people, it will have been worth it', but also stated that 'We don't know what this will cost' [37]. The program was abandoned within a year; after 11 months, 150 000 people were screened, but only 23 HIV-positive individuals were identified, at a cost per case found of US \$228 000 [38]. The finding of Cleary *et al.* was corroborated by the Illinois experience. Despite these observations, the State of Alabama has considered instituting a compulsory premarital screening program in response to growing HIV prevalence among women and injection drug users [39].

The analysis of Cleary *et al.* does not consider the full effects of screening on the epidemic. For example, the analysis ignores cases of HIV infection that would be prevented in the non-spousal adult contacts of newly identified cases, and ignores potential changes in HIV prevalence in the population that might be caused by such screening. Nevertheless, the simple model indicates that the costs of such a program are likely to be quite large compared to the benefits.

Because of the increasing prevalence of HIV among women and the rise in the number of HIV-infected newborns, much attention has focused on the issue of screening women of childbearing age for HIV [40–44]. Brandeau *et al.* [5,45] used a 28-compartment dynamic epidemic model, combined with a detailed economic model, to calculate the monetary costs and benefits of such screening. The epidemic model (illustrated schematically in Fig. 2) divides the population into seven classes (children, and high-, medium-, and low-risk men and women) and four disease stages (uninfected; infected and unidentified; infected, asymptomatic, and identified by screening; and infected, symptomatic). The arrows represent transitions from one population class to another; such transitions might occur due to maturation of children into adult groups, or due to changes in behavior (for example, from a high-risk class to a low-risk class).

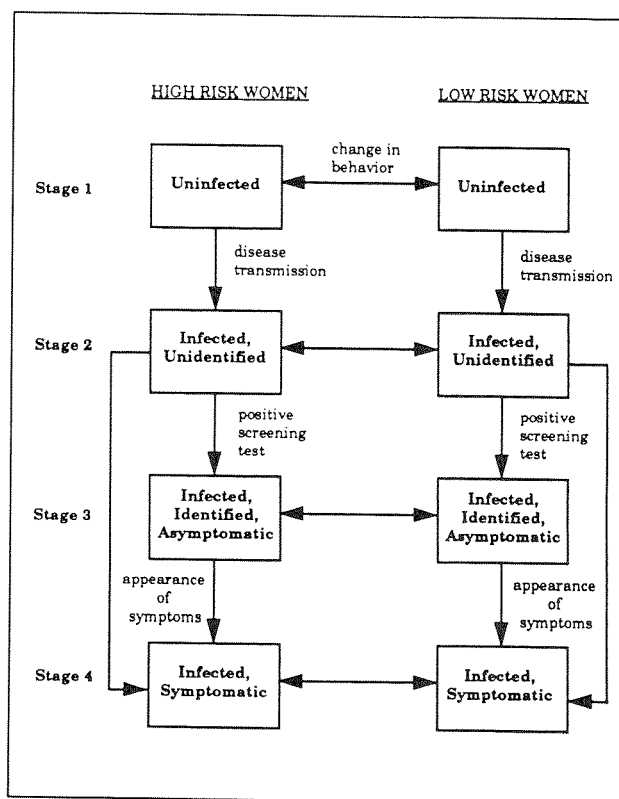


Fig. 2. Schematic of model: an example with two population classes.

Vertical arrows represent disease transmission and progression. Transition from the uninfected stage to the infected, unidentified state is due to infection with HIV. Infection occurs by interaction of people in the uninfected groups with people in the infected groups (Stages 2, 3, and 4, in all population classes). The model incorporates a standard assumption of epidemic models [46–48]: that the rate of infection is related to the product of the size of the infected group and the size of the uninfected group (account-

ing for all possible individual interactions between members of the first group with members of the second), leading to a non-linear rate of change. Transition from the infected, unidentified stage (Stage 2) to the infected, identified, asymptomatic stage (Stage 3) can only result from a true positive HIV-antibody screening test. Transition from the asymptomatic, infected stage (Stage 3) to the symptomatic stage (Stage 4) occurs when symptoms of HIV infection develop.

The effects of a screening (and associated counseling and education) program are modeled by changes in the rates of transition between different population compartments. For example, the identification of infected people by screening is modeled mathematically as an increased rate of transition from Stage 2 (the infected, unidentified stage) to Stage 3 (the infected, identified, asymptomatic stage). The change in behavior resulting from education and counseling is modeled by a decreased rate of transition from Stage 1 (uninfected) to Stage 2 (infected, unidentified). If screened women reduce their childbearing rate, this is modeled by a lower entry rate into the compartment of infected children.

The population dynamics of the model are captured by a set of simultaneous non-linear differential equations describing the relative change in the size of each population compartment over time. Brandeau *et al.* [5,45] implemented the model numerically using data for the State of California. They estimated the following outcomes from the epidemic model: number of screening tests administered, number of women identified as HIV-infected, number of men and women saved from infection, and number of infected and uninfected children not born. These outcomes were evaluated monetarily from a societal perspective that includes direct costs such as medical care, and indirect costs such as the future earnings of an uninfected child. The analysis showed that under a broad range of assumptions about changes in behavior among screened positive women, voluntary screening of medium- and high-risk women (i.e. those who are injecting drug users, sex partners of injecting drug users, or who have many sex partners) is likely to be cost-beneficial, while screening that reaches a more general population of women (such as those applying for marriage licenses) is not likely to be cost-beneficial.

Concluding remarks

The specific examples discussed in this paper highlight more general AIDS policy modeling issues. First, AIDS intervention research requires procedures for translating the results of behavioral studies into meaningful epidemic outcomes. Some readers may protest that the AIDS policy modeling approach, which is grounded in many years of

research in mathematical epidemiology (and economics, operations research, and statistics), requires too many unverifiable assumptions about the relationship between risky behavior and HIV transmission, and that such models improperly extrapolate observed behavioral data beyond what can be defended scientifically. However, we believe that such a view fails to recognize a fundamental fact of AIDS (and public health) policy: decision makers make decisions in the absence of complete information all the time. Failing to explain one's thinking on how to understand the results of behavioral studies may lead to reliance on implicit models of truly questionable value. For example, consider an educational intervention designed to reduce the incidence of unprotected sexual intercourse in some target population. Imagine discovering that the intervention reduces the rate with which targeted individuals engage in unprotected sex by 80%. It is easy to conjecture that this is a successful intervention. However, what if the relative reduction in risky sexual activity were 75, 50, 25, 10, or 1%? At what point would one decide to declare the program ineffective and undeserving of scarce public health resources? In our view, the most reasonable approach is to attempt to infer the likely number of infections prevented by the program contrasted against the resources expended.

Second, policy making often must occur over time scales that are very short relative to the natural time scale of the AIDS epidemic. For example, the Connecticut legislature required an evaluation study of the New Haven needle exchange within 1 year of passage of the enabling legislation, despite the obvious fact that the best possible controlled incidence trial would be incapable of producing definitive results in such a short period of time. Policy modeling enabled credible estimation of HIV incidence reduction, demonstrating how such models help join the time scale faced by decision makers with the time scale of the epidemic.

The important point to remember is that the goal of policy modeling is to help policy makers make better decisions. Given that societal resources devoted to controlling the AIDS epidemic are limited and will remain so, greater attention must be devoted to policy analysis and the evaluation of AIDS intervention programs. AIDS policy modeling is, and will continue to be, critical to these efforts.

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