A Dynamic Model of Client Recruitment and Retention in Community-Based HIV Prevention Programs

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The study used system dynamics modeling computer simulations to gain a better understanding of the process of delivering small-group, evidence-based HIV prevention programs in the community and to explore implications for public health practice. A model was developed to explain provider-reported challenges associated with recruiting, retaining, and graduating people from small-group workshop programs. The model simulations revealed the difficulty in sustaining high rates of recruitment and retention in small-group programs over time. The model simulations provided insight into what processes may lead to suboptimal numbers of people being recruited and positively influenced by these programs.

Keywords: *system dynamics modeling; HIV prevention; evidence-based programming; dissemination research*

In 2007, AIDS was responsible for approximately 2 million deaths around the world (UNAIDS, 2008). As of 2007, an estimated 33 million people were infected with HIV, the virus that causes AIDS (UNAIDS, 2008). In many nations, AIDS is a leading cause of death and disability among young adult populations and a principal source of strain on existing medical, treatment, and health care resources. A cure for AIDS is not yet on the horizon, nor is the much-talked-about vaccine. The high personal, economic, and social costs of AIDS highlights the importance of providing high-quality and effective AIDS prevention programs to populations at risk of exposure to HIV. In the absence of medical solutions to the prevention of HIV, behavioral approaches to prevention remain among the most important means to reduce individual exposure to HIV and slow the spread of the epidemic

Since the mid-1990s, social scientists have established through rigorous research the benefits of a select set of HIV prevention interventions (Albarracin, Gillette, Earl, Durantini, & Ho, 2005; Herbst et al., 2005; Johnson et al., 2005; Logan, Cole, & Leukefield, 2002; Mize, Robinson, Bockting, & Scheltema, 2002; Semaan & Sogolow, 2002). These interventions have been shown to increase condom use and improve skills to negotiate lower-risk sex in a variety of at-risk populations. Over the prior decade, interest in disseminating the HIV prevention programs that have been determined to be effective in scientific studies has dramatically increased and a number of these programs have undergone widespread dissemination (Collins, Harshbarger, Sawyer, & Hamdallah, 2006). As of 2006, more than 4,000 people representing over 2,000 agencies had been trained by Centers for Disease Control and Prevention (CDC) and its technical assistance contractors to deliver one or more of these select evidence-based programs.

Simultaneously, the practice of imposing select evidence-based intervention programs on service providing agencies has become commonplace in many

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health and social service arenas in the United States (Weiss, Murphy-Graham, & Birkeland, 2005). In the case of HIV prevention, state and city departments of health often strongly encourage, if not require, that organizations seeking funds select from the compendium of HIV prevention programs endorsed by the CDC. These programs, often referred to colloquially as "DEBIs" (named after CDC's Diffusion of Effective Behavioral Interventions Project), have been subject to at least one rigorous quasi-experimental or experimental test of efficacy. Few of these programs have benefited from a thorough examination of their effectiveness in communities (Lyles, Crepaz, Herbst, & Kay, 2006).

As the pace at which HIV prevention evidence-based programs are being disseminated to community providers through imposed and voluntary adoption has accelerated, so has interest in better understanding the processes associated with successful implementation of evidence-based programs following their initial adoption. For instance, over the prior decade the CDC has conducted several dissemination trials and expanded its efforts to increase the capacity of organizations to provide these programs (Harshbarger, Collins, O'Donnell, & Rebchook, 2006). As the field accumulates more experience of dissemination and implementation of HIV-related evidence-based programs in community settings, knowledge of the challenges associated with the implementation of these programs has slowly begun to accumulate (see, for example, Chng, Sy, Choi, Bau, & Asutdillo, 1998).

A growing body of anecdotal and empirical evidence suggests some success in transferring these programs into service delivery environments over the short term. At the same time, empirical and anecdotal evidence suggests that some providers struggle to implement many of these programs over time (Harshbarger, Simmons, Coelho, Sloop, & Collins, 2006; Rebchook, Kegeles, & Huebner, 2006) and are not always able to offer these programs with acceptable levels of fidelity to the original program design (Cotton, 2006). Many in the field express cautious optimism about the long-term success of current dissemination efforts. Yet it is also clear that the field has much to learn about the process of long-term implementation of these programs if dissemination efforts are ultimately likely to succeed.

In light of the importance of providing routine effective prevention programs to populations at risk, research specific to the context of community service provision of HIV-related prevention programs is needed to understand problems in implementing the processes that are integral to delivering HIV prevention services on an ongoing basis, such as identifying and attracting at-risk populations for receipt of services, recruitment of those individuals into prevention services, and acquiring, allocating, and maintaining resources for the provision of HIV prevention services. We know very little about how the service delivery context for HIV prevention programs and the characteristics of the various types of HIV prevention programs now being disseminated to providers might ultimately interact. To understand the dynamic complexity of implementing evidence-based programs, more research on the context of service delivery in HIV prevention is needed.

THE CURRENT RESEARCH

We present results from simulations of a system dynamics model developed to explore one aspect of the process of delivering programs in the community: the process of recruiting, retaining, and graduating people from a small-group intervention. We focus on the process of implementing a single type of intervention—the small-group workshop because the program represents a distinct and common approach to HIV prevention. Indeed, in a meta-analysis conducted by the CDC (Seeman & Sogolow, 2002), 71% of interventions studied were of this type. This small-group approach is also dominant among those interventions that have earned the label of *evidence based*. The processes associated with implementing a small-group workshop in a community are also distinct from those of other interventions, such as one-on-one, face-to-face outreach programs, community-level social marketing, or normative change interventions. By building a model specific to a common intervention type, it is our hope to gain insight into the unique challenges of offering this specific form of HIV prevention in the dynamic context of a community.

The small-group-workshop–type programs require that an organization offering such a program enroll a relatively homogenous group of users who can come to a set location and participate in a group session of 1 or more hours in duration. The number of program sessions may range from as few as 1 to as many as 24, according to the data provided in a recent meta-analysis characterizing these types of programs (Albarracin et al., 2005). Programs of this type typically include informational and skills-building sessions that are designed to accomplish aims such as promoting consistent condom use, improving partner communication and negotiation skills, and helping individuals to identify and avoid situations that place them at high risk of exposure to HIV. It is also typically the case that, to be effective, participants must participate in most, if not all, sessions. Meta-analyses appear to suggest that programs that occur over multiple sessions produce better results than those that have few sessions and that good attendance is positively related to an individual accruing knowledge, attitudinal, and behavioral program benefits (Herbst et al., 2005; Johnson et al., 2005). Our base model assumes a program that meets weekly over a period of 8 weeks, the average number of sessions reported in meta-analyses by Albarracin and her colleagues.

METHODS

System dynamics builds on diverse sources of data and on group process techniques to develop models that may be used to conduct virtual experiments via computer simulations (Hirsch, Levine, & Miller, 2007; Homer & Hirsch, 2006; Sterman, 2006). A model-building team develops a visual representation of a problem, specifying what processes they hypothesize give rise to it (e.g., low rates of recruitment). Model building may rely on an in-depth review of existing empirical and theoretical literature, collection of new qualitative or quantitative data, secondary data analyses, or on the experiences and opinions of people who are close to the process of interest. The team then develops a set of mathematical equations to represent the model, relying on a wide variety of data to do so. Next, the team explores the model's behavior via computer simulation (for a comprehensive introduction to system dynamics modeling methods, see Sterman, 2000).

Model-Building Process

We developed our model across a series of team meetings. Our team included a system dynamics expert and individuals with diverse experience and expertise in the design, delivery, and evaluation of HIV-related prevention and care services. The team began by discussing a conceptual model developed by Gericke, Kurowski, Ranson, and Mills (2005) describing the elements of an intervention that determine its complexity, the last of which concerns the user interface and maintenance of a base of clients. A principal task for any program delivery system is to insure that there is a steady stream of appropriate clients accessing and using the programs (Levin & Roberts, 1992). Programs must serve someone and processes must be in place to make sure that this is the case. In essence, for a program to have any hope of ameliorating the problem it is designed to effect, some set of mechanisms must exist to bring the program to the attention of its target population, recruit members of this population into the program and, once enrolled, maintain their enrollment long enough for some of them to benefit in the desired ways.

We focused our initial discussion on elaborating the interface between prospective clients and program activities. In these discussions, we also considered how this interface might change as a function of the type of program that was being delivered (e.g., small-group workshop, one-on-one outreach, social marketing), which ultimately confirmed our sense of the importance of focusing on a single program type, the small-group workshop. As our discussions evolved, our model-building meetings focused on decomposing each of the major phases in the user interface. We began to detail the processes by which a prospective client would be recruited, enrolled, retained, and helped to complete the program. We focused on identifying factors that would enable successful recruitment, retention, and graduation and on factors that would undermine success at each of these phases. During our meetings, we represented our thinking in causal loop diagrams, which show the basic causal loop structure in the system. As our thinking evolved these diagrams were continually refined.

As our articulation of a model progressed, we also began to identify reference modes, which are the typical patterns of behavior observed in the real world. We identified reference modes through informal discussions with technical assistance providers who work with the CDC's capacity building and dissemination program, informal discussions with service providers who were attempting to implement evidence-based workshops, reanalysis of data from prior studies (Miller, 1995, 2001), and a review of the studies that describe aspects of delivering HIV prevention in community-based settings (Barton-Villagrana, Bedney, & Miller, 2002; Cain, 1993, 1995, 1997; Casteneda & Collins, 1997; Chambre, 1995, 1999; Chng et al., 1998; Conner et al., 2005; DiFranciesco et al., 1999; Goldstein, Wrubel, Faigeles, & DeCarlo, 1998; Gomez, Hernandez, & Faigeles, 1999; Lesser et al., 2005; Miller, 2001, 2003; Miller & Greene, 2005; Miller, Klotz, & Eckholdt, 1998; Oliva, Rienks, Udoh, & Smith, 2005; Operario, Nemoto, Ng, Syed, & Mazarei, 2005; Wong, Chng, & Lo, 1998; Zibalese-Crawford, 1993). Our reference-mode

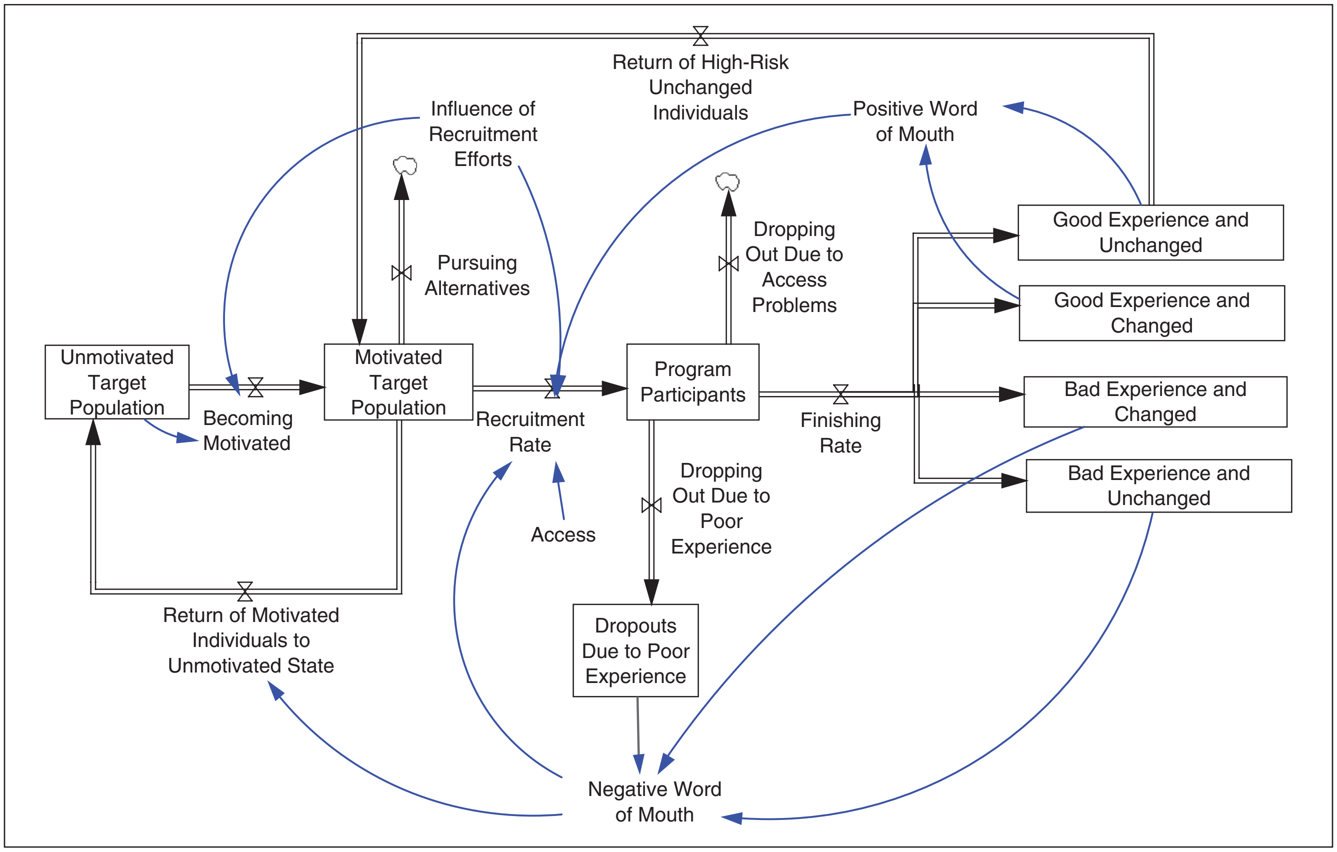

FIGURE 1 Simplified View of Entire Model

discussions focused on how patterns of recruitment, retention, and graduation typically proceeded over time (e.g., an initial high rate of recruitment followed by a steady decline; a long, slow, steady growth in clients that ultimately plateaus). The larger purpose of identifying reference modes was to be sure that the factors that we had identified in our model would have a reasonable likelihood of accounting for the various patterns typically observed and to generate dynamic hypotheses about how these trajectories might come about.

Developing the System Dynamics Simulation Model

Our next step was to convert our causal loop diagrams into a stock and flow diagram. In Figure 1, we display the basic structure of our system dynamics model.

The heart of the model is a chain of stocks of people at various stages of the process of flowing into, through, and out of the program. The initial two stocks contain the members of the target population whom a program intends to enroll. These stocks are disaggregated into two separate stocks of people: those who are currently unmotivated to pursue behavioral changes via our program and those who are currently motivated to change via a program such as ours. Following theory on the processes of individual change (Prochaska & DiClemente, 1992; Prochaska, DiClemente, & Norcross, 1992), we have subdivided our target population into these two stocks to recognize that not all of the people whom one might recruit are ready to take action to pursue behavior change. In our model, motivation to pursue change increases the probability that a person can be influenced to enroll in the program. In the full structure of the model (not represented here) we include inflows and outflows to and from these stocks to represent the constant addition and subtraction of members to each population resulting from factors such as migration into and out of the community, losing or gaining motivation to change, and electing to pursue behavior change without the aid of the program.

The next sets of stocks are of people who enroll in the program. We assume that those people who have a negative experience of the program have a higher probability of dropping out of it than those who have a positive experience and of doing so in the program's initial sessions. By contrast, those who have a positive experience of the program are assumed to have a low probability of dropping out. We have assumed that people in both groups would drop out as a result of life events, such as having a cold or missing the bus, with the same probability distribution. Those who drop out leave the system or return to the earlier stocks in the model (not shown for clarity of presentation).

The final set of stocks contains the people who complete the program. We have disaggregated the populations into four stocks to reflect the distinct processes associated with having a high- or low-quality experience of the program and have also disaggregated people by program outcome. We assume that quality of experience and benefiting from the program are not perfectly related; that is, it is possible to have a good experience and still not change one's behavior, just as it is possible to have an unpleasant experience and benefit. We have disaggregated these groups because each would have a different likelihood of reappearing in the stocks of motivated and unmotivated members of the target population and each would play a different role in influencing others to consider or avoid the program via word-of-mouth processes. We have included an outflow from the stock of people who have benefited from the program (not shown) so that people who are unable to maintain behavioral changes acquired with the help of the program can return to the initial stocks.

Our model includes the multiple factors that alter the rates of flow of people from one stock to the next that are reflected in our dynamic hypotheses. In all stages of the model, some of these influences are within the direct control of agency personnel and others are less directly amenable to planned manipulations. For the initial stocks in the model, we have included positive (Bass, 1969; Bass, Krishnan, & Jain, 1994) and negative (Leonard-Barton, 1985) word of mouth, advertising and outreach recruitment efforts, referrals to the program, and ease of access to the program. For the later stocks in the model, we have included efforts to enhance the quality of the experience of participants and efforts to accelerate or decelerate participant throughput by changing the number of program sessions offered.

Dynamic Hypotheses

System dynamics focuses on the role of feedback loops to clarify and represent the processes that underlie the observed behavior of the system. These dynamic hypotheses convey the modeler's assumptions about the main loops that help explain the behavioral trends of interest. Loops are read as if all variables in the other loops are held constant.

Dynamic hypotheses are embedded throughout our model. Key hypothesized loop processes are associated with a set of loops that may underlie a decreasing demand for the program and a set of loops that are associated with different actions to recruit and graduate participants. Figure 2 shows the proposed underlying structure that may account for problems in recruitment, enrollment, and graduation. In the figure, Loop 1 could act as a reinforcing process if, for example, *total recruitment rate* were to increase. However, this positive loop may be problematic if *total recruitment rate* were to initially decrease. Holding all other variables in the loops constant, a decrease in *total recruitment rate* leads to a decrease in the *number of people finishing the program*. A decrease in this variable decreases the effects of *word of mouth*, which would in turn decrease the *total recruitment rate*, putting the system into collapse mode.

Loop 2 assumes that not everyone who completes the program will change their behavior and represents the effect of the recycling of people who had participated in the program and who at the moment are not practicing safer sex. A decrease in *total recruitment rate* decreases the *number of people finishing the program*, which in turn decreases the size of the *target population*. A decrease in *target population* would decrease the *total recruitment rate*.

Loops 3 and 4 focus on policies that agencies may follow to monitor and report to their funding sources that they are meeting the terms of their service provision contracts. Loop 3 represents a policy of monitoring the recruitment rate as an indicator of providing the required amount of service. We hypothesize that if the agency fails to meet its goals, the agency's main response is to put more emphasis and resources into recruitment efforts (Loop 3). Loop 3 describes a negative loop associated with reacting to not getting enough people enrolled. A decrease in *total recruitment rate* decreases the *perceived recruitment ratio*, which in turn increases the intensity of the agency's recruitment effort for the program. Finally an increase in the intensity of recruitment outreach increases *total recruitment rate*. Loop 4 represents a policy of monitoring the number of people completing the program. In Loop 4, agencies may try to increase the quality of the experience of the program to maintain participant satisfaction long enough to get them through the program.

Finally, our dynamic hypothesis includes a positive Loop 5 that affects the *total recruitment rate*. Going into collapse mode is problematic and conforms to our prior description of a reference mode in which recruitment and graduation declines over time. A decrease in the

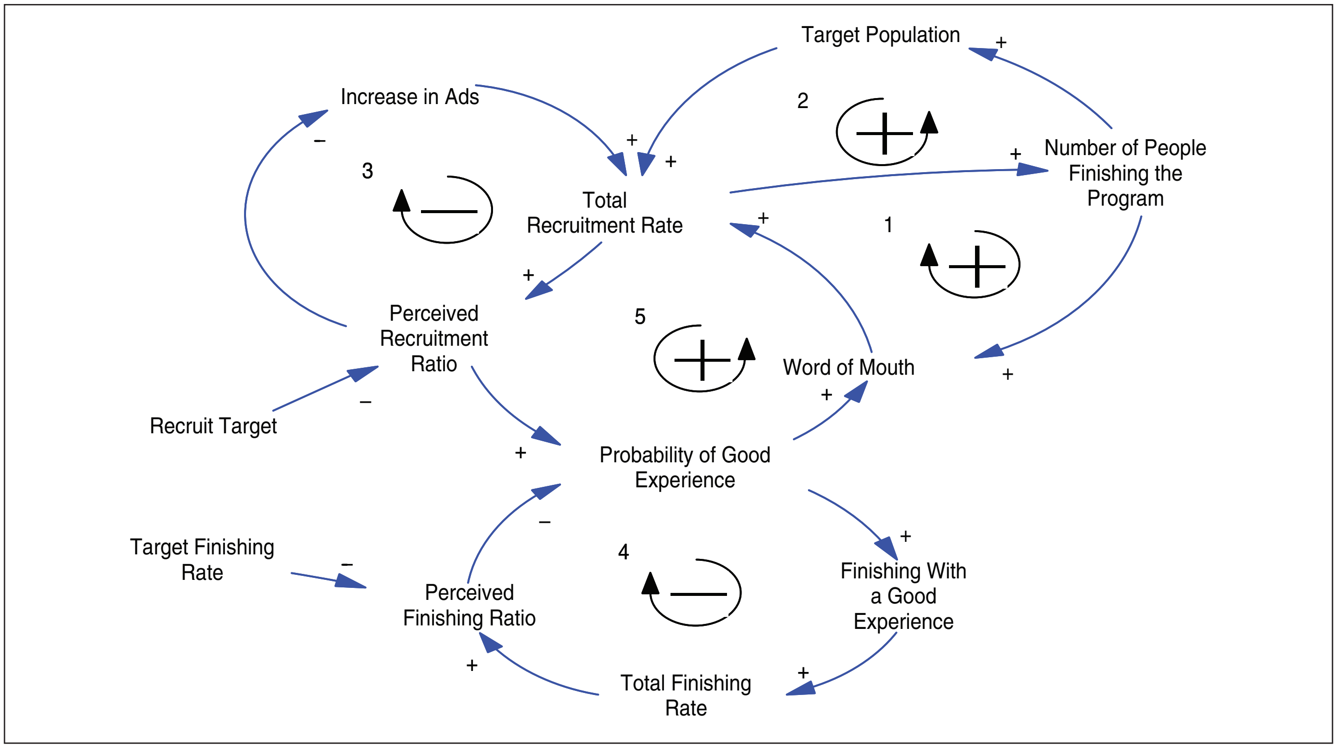

FIGURE 2 Dynamic Hypotheses

total recruitment rate decreases the *perceived recruitment ratio*, which in turn decreases the *probability of good experience* by participants. *Probability of good experience* decreases because staff effort toward recruitment must increase to close the gap between the actual and ideal recruitment rate, so effort is diverted from maintaining the quality of the experience. A decrease in this probability decreases the impact of *word of mouth* by decelerating positive word of mouth and accelerating negative word of mouth (not depicted here for clarity of presentation), which in turn would decrease the *total recruitment rate*, thus completing the loop. By contrast, if this loop operates in growth mode, as the *total recruitment rate* increases, the *perceived recruitment ratio* increases, closing the gap between the program's recruitment goals and actual recruitment. As the ratio increases, the *probability of good experience* increases, which accelerates positive word of mouth and decelerates negative word of mouth. In turn, the rate of recruitment improves.

Model Calibration

We converted the stock and flow diagram into a mathematical simulation model that could be used to pose "what if?" questions about different strategies for recruiting, retaining, and graduating clients. The model's parameters were calibrated on the basis of estimates from the scientific literature on HIV prevention programming and service provision. To set the initial values, determine ranges, and plot graphs for model parameters such as the average effectiveness of a group-based workshop by its number of sessions, we relied on data from the meta-analytic literature (Albarracin et al., 2005; Herbst et al., 2005; Johnson et al., 2005; Semaan & Sogolow, 2002). For data topics such as typical rates of client satisfaction, program dropout, and levels of motivation to change in communities, we relied on evaluations of community-delivered HIV prevention programs (CDC AIDS Community Demonstration Projects Research Group, 1999; Conner et al., 2005; Gomez et al., 1999; Lesser et al., 2005; Miller, 1995, 2003; Miller, Klotz, & Eckholdt, 1998; Oliva et al., 2005; Operario et al., 2005). These data were supplemented by qualitative studies on service provision (Barton-Villagrana et al., 2002; Cain, 1993, 1995, 1997; Miller, 2001). These qualitative data were used to develop rough plots of the shapes of relationships among variables as they unfolded over time to produce approximate functions.

In our baseline parameterization of the model we assumed the program had an annual goal of recruiting

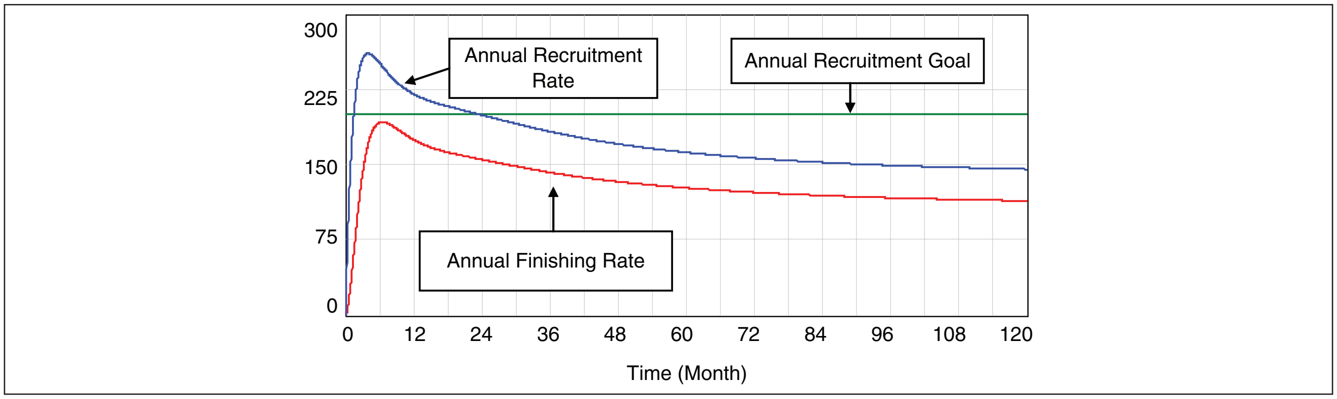

FIGURE 3 Annual Recruitment and Finishing Rates at Baseline

200 people. We assumed a program lasting 8 weeks, which, as noted earlier, was typical of the most effective programs in the meta-analyses conducted by Albaraccin and colleagues (2005), Herbst and colleagues (2005), and Johnson and colleagues (2005). We set no enrollment limit on the number of participants per 8-week session. We assumed that the probability of participants having a good experience was high, .85 on a scale of 0 to 1.0 (0 = *no participant was satisfied* to 1.0 = *all participants were satisfied*). We set the probability of a participant changing his or her behavior in desired ways at .35 for the 8-week-length program. The function we set for the probability of behavior change initially declines gradually from .35 for shorter programs, with a more dramatic decline in effectiveness as the number of sessions becomes fewer than four. We assumed high probabilities of dropout for those who had a poor experience (.75) and low dropout for those who had a positive experience (.05). Finally, we assumed that 20% of the target population was motivated to change their at-risk behavior through a program such as ours. We also assumed that about 50 new people (more unmotivated than motivated) join the target population each month. We set the initial size of the target population in the community at 4,000.

Results

Simulations are done by starting with a specified set of initial conditions, using the equations to calculate changes that occur over the first time interval, updating the state of the system to reflect those changes, and then using the new system to calculate the changes over the next time interval.

In Figure 3, we present the baseline simulation output for the annual recruitment and finishing rate in a target population of 4,000 people over 10 years. As the figure illustrates, the model reproduces a pattern in which the rate of recruitment reaches or exceeds the recruitment goal for a brief period before it falls below the desired level. Recruitment begins to fail by the 24th month of program operation. Initially, the program enrolls about 27 people per month. By the end of the simulation run, the monthly number of participants has fallen to about 12 people per month. Overall, the number of people who are recruited represents a small proportion of those who might participate; the number who finish is even smaller. The same pattern is produced when we increase the size of the target population to 10,000 people. In a population of this size, recruitment problems occur later at about 72 months (6 years). For a smaller population of 400 and a lower target of 80 people annually, the recruitment rate never reaches the target. Real world drop-out levels could make this picture worse.

Interventions to Improve Recruitment and Graduation

We undertook a series of simulation policy experiments designed to understand what caused recruitment problems and how the recruitment and program completion rates might be improved. In the first experiment, we changed a single input to the model, access, holding all other input values constant. In the baseline scenario, we assumed that 40% of the target population would have easy access to the program. In our simulation experiment we increased access to 60% and then to 80%. In real life, this might mean offering the program at multiple times and locations, offering transportation or child care, or offering the program primarily to people who are already engaged in and accessing services at the same site as the program.

In the second experiment, we changed the proportions of motivated and unmotivated members of the target population so that the proportion of those who are initially motivated is increased from 20% to 50% and, in a second trial, from 20% to 80%. Shifts in the initial proportions of motivated to unmotivated people to 50% might result from focused social marketing designed to increase motivation or use of motivation-enhancing outreach prior to initially offering a program. Shifts to 80% might result from initially targeting only populations that are already high in motivation to change, such as an existing client population that is ready for the program.

In our third experiment, we compare two policy actions. The first policy action involves intensifying or decelerating efforts at recruitment in response to the size of the gap between the recruitment goal and the actual rate of recruitment. For this policy, recruitment effort increases as the gap enlarges and decreases as the gap closes. The second policy action involves increasing effort to raise the quality of the experience provided to participants in response to the size of the gap between goals for the number of people finishing the program and the actual rate of program completion. In this action, staff members try to improve the quality of the experience to reduce attrition when too few people are finishing the program; they attend to other matters, such as recruitment, if the finishing rate is satisfactory. We assume that staff cannot increase the intensity of their efforts in any one direction without decreasing it in the other. That is, given limited resources, increased recruitment effort necessarily limits effort devoted to quality of the experience and vice versa. The trade-offs between allocation of effort to recruitment and satisfaction is achieved technically by introducing a nonlinear function that has a multiplicative effect and amplifies allocation of resources toward one effort and concurrently dampening the other effort.

The final experiment involves manipulating the length of the program to increase the rate of throughput. Specifically, rather than require that people attend 8 sessions to graduate, we decrease the length of the program from 8 sessions to 4 sessions and to 2 sessions. In real life, agencies might drop sessions or collapse or omit content to reduce the burden of program attendance on participants and decrease opportunities for dropping out. We assume that decreasing length requires some decrement to the program's probability of being effective, so that changes in length will affect the finishing rate and the numbers of people flowing into each of the final stocks.

The results of these four experiments on the estimated annual rates of recruitment and completion are presented in Figure 4. For each experiment, we show how the intervention compares with the baseline scenario.

Improving access. This policy experiment produces dramatic improvements in rates of recruitment compared with the baseline scenario. As displayed in Figure 4a, at the baseline setting of .40, the program initially exceeds its recruitment goals, albeit modestly, but recruitment rates then immediately decline. By 30 months of operation recruitment rates have fallen below recruitment goals. By contrast, increasing access by 50% to a probability of .60 causes the recruitment rate to overshoot the goal and to remain above it for the 10-year period we simulated. The pattern for increasing access to 80% produces an even more extreme overshoot, followed by a collapse in recruitment. In both cases, the pattern of recruitment over time parallels that of the baseline scenario, with recruitment gradually declining over time. However, all other things held constant, simply improving the recruitment rate by increasing access ultimately doubles the pool of people who complete the HIV prevention program and benefit from it. Although increasing access allows the program to meet and exceed its recruitment goals, improving access creates a new problem, capacity, and creates the need to manage excess enrollment by waiting lists or other means.

Motivating people. This experiment, in which the proportions of motivated people in the initial pools are increased, provides clear initial advantages (see Figure 4b). Increasing the proportion of motivated people to 50% generates excess demand for the program in its initial months, as does increasing the proportion of motivated people to 80%. The baseline condition, in which 20% of the population is motivated, is least advantageous in the early months, with recruitment rates hovering just around the target and then rapidly falling below the target level. However, the advantages of starting with a large pool of people who are motivated to change their high-risk behavior are lost between 18 and 24 months. During that period, recruitment rates begin to look nearly identical to those in the baseline condition, in which far fewer people were initially motivated to address their HIV-risk-related behavior. By 34 months, any advantage to starting with a more motivated pool is no longer evident. One reason for the loss of advantage concerns the other ways in which people may leave the pool of motivated people besides being recruited into the program. When the size of the stock of people is increased, so is the flow of people out of the system as a result of having pursued options for changing their HIV-related risk behaviors other than

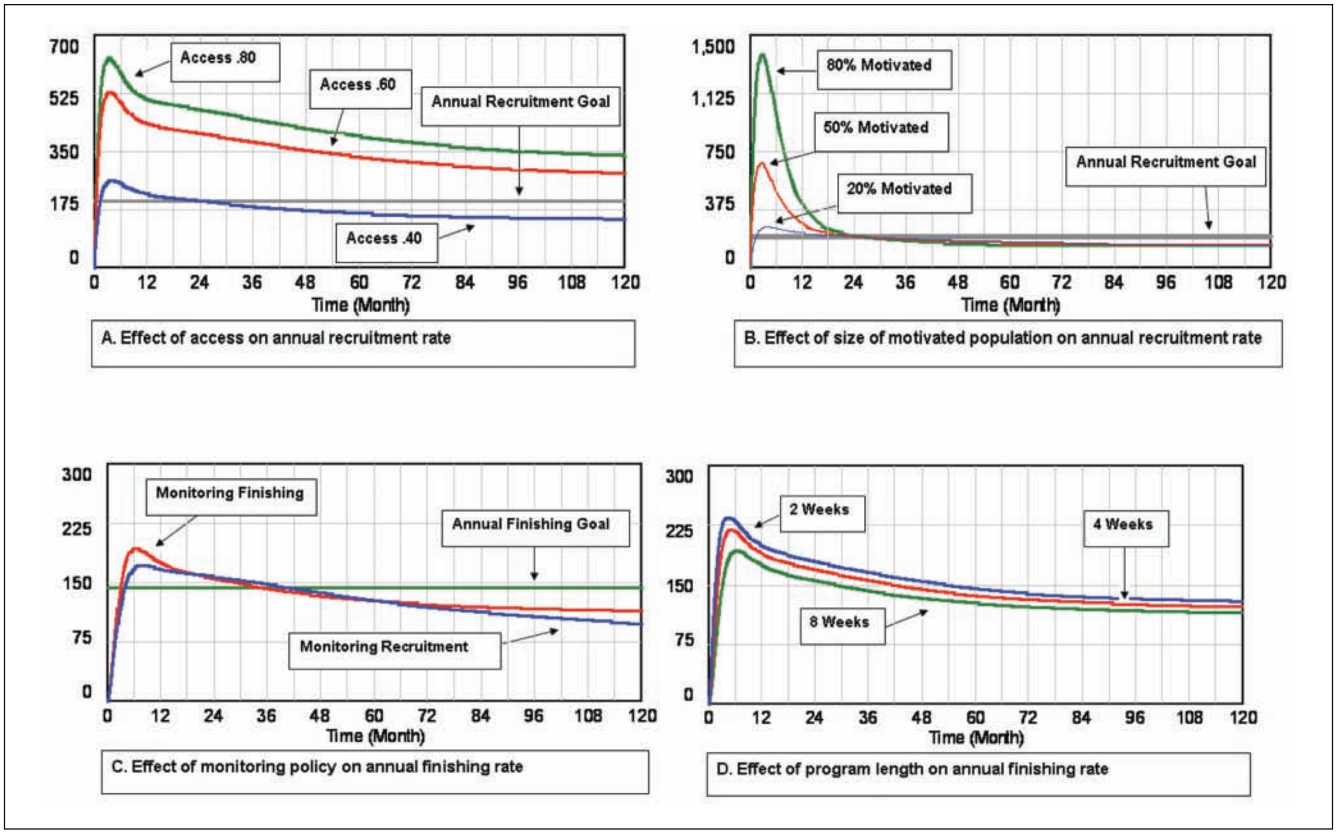

FIGURE 4 Results of Simulation Experiments on Annual Recruitment and Finishing Rates

the particular program. That is, given a world of more motivated people to reduce their risk of exposure to HIV, motivated people pursue other ways of having their needs met (see Figure 1). The size of the motivated pool rapidly shrinks without any special efforts in place to keep large proportions of people motivated. By 36 months, all three scenarios result in nearly the same numbers of people who have changed their HIV risk behavior.

Monitoring recruitment or graduation. The two monitoring policies, one in which staff respond to recruitment gaps by increasing recruitment effort and the other in which staff respond to program completion gaps by improving the quality of the experience, achieve modest initial differences in the annual rates of recruitment and program completion, favoring the policy of monitoring completion rates. During the initial 12 months of program operations, monitoring program completion rates provides its initial advantage as a function of the benefit of generating positive word of mouth about the program. Over the longer term, the policy fares only slightly better than monitoring recruitment because the initial probability of having a good experience is high enough that there is a natural ceiling on how much recruitment advantage can be gained by it. The impact of these policies on the total completion rate is shown in Figure 4c. As illustrated here, attending to the finishing rate produces better annual rates of completion for about the first 24 months of program operation, after which it produces similar results to a policy of attending to the recruitment rate.

Shortening the program. This policy experiment, which involves shortening the program, does increase the total number of individuals who finish the program, but at a significant cost. Figure 4d shows the estimated annual finishing rate for programs of 2, 4, and 8 weeks in duration. A 2-week program is consistently superior in its finishing rate than a 4-week program; both produce better results than an 8-week program. However, a comparison of the final stocks in the model for each duration (results not displayed) shows that the 8-week program is vastly superior to the shorter programs in contributing to the stock of people who have had a good experience and who have benefited by changing their high-risk behavior. In an ideal world, having a large pool of these people complete the program is desired, as they provide the best source of positive word of mouth and are engaging in reduced HIV risk behavior. At 12 months, this stock of people contains about 10 more people per month for the 8-week version of the program than does the 2-week version. By contrast, the 2-week version contributes about 30 more people per month to the stock of people who enjoyed the experience but are unchanged by it than does the 8-week version and produces the largest number of people who have had a poor experience of the program. Therefore, although the 2-week program produces more finishers overall, it produces the fewest graduates who have changed their behavior. These findings highlight the deceptive nature of simply monitoring program output and the problems that arise when goals are based on quantity of services delivered rather than on a balance between quantity and quality.

DISCUSSION AND CONCLUSIONS

We developed a system dynamics simulation model to gain an improved understanding of the challenges associated with recruiting, retaining, and graduating clients from an HIV prevention small-group workshop. The model that we developed highlights several processes that may play an important role in real-world efforts to recruit at-risk individuals into such programs. Our model points to the importance of (1) opportunities that people may have to "drain out" of the recruitment system prior to becoming enrolled by pursuing alternatives, losing motivation, facing access challenges, and routine out-migration from the community; (2) time delays between program entry and graduation which increase opportunities for dropout; and (3) sorting that results from the probability that not everyone will care for or benefit from the program. In combination, these processes may cause a relatively small proportion of an intended target population to be effectively reached by such a program over the long term. Comparing strategies to improve recruitment, we find that the most effective solution among those we assessed—making the program more readily accessible to those who are motivated—creates new problems in program capacity. Alternatively, we found that speeding up the time it takes recruits to graduate by shortening the program succeeds in getting more people through, but fewer of them have reduced their risk behavior.

Recruitment and output processes do not settle into a state of equilibrium during the 10-year period that we simulated. Indeed, a stable system does not emerge until nearly 20 years have passed, far longer than most organizations would offer the same program. The lengthy duration required to reach a state of equilibrium suggests that HIV prevention providers may spend the entirety of a program's life in a state of unpredictability regarding how many people might be recruited and will graduate during any particular window of time and that prior experience is not necessarily a good indicator of future experience. Operating HIV prevention programs in a constant state of uncertainty may be all the more frustrating if the overshoots and collapses that we see in some of our simulations occur for real-world programs. Except in the case of improved access, the recruitment overshoots in our simulations have collapsed below target levels within 12 to 18 months. Realistically, by the time an HIV prevention organization would have mounted a response to the excess demand that we see during the periods of overshoot, the system would have already descended into decline. In an unstable system, given the nature of the time required to respond to its state at any particular moment, an organization would chronically over- or under-adjust to conditions and be challenged to perform effectively as a result.

The process of building the model itself and working through the logic of how people might flow through a system such as this produced insights absent conducting any simulation experiments. Among these is that an individual's cognitive readiness to change HIV risk behavior is strongly related to the probability of his or her being recruited into and enrolled in a program. This seemingly obvious point may be missed when recruitment goals are based on an estimate of the size of an at-risk target population in a given area. Our recognition that it is only a subset of people who will be motivated to pursue a program such as this, an even smaller subset of which will find the program accessible, enroll, and complete it, points to a potential limitation of a program predicated on these kinds of estimates. Other strategies, predicated on entirely different assumptions, are required to complement programs such as this.

As with any effort in which system dynamics modeling is employed, important caveats regarding our work bear mentioning. First, any attempt at modeling a system such as service delivery will fail to reflect its true complexity. Models will always be incomplete and wrong in some aspects and ours is no exception. We make no claim that this model provides a complete representation of this aspect of delivering a small-group HIV prevention workshop. However, we believe that by specifying the dynamics of the process and rendering these in a simple but not overly simplified fashion, we have achieved a primary goal of using a system dynamics modeling approach: insight into the features of a system that may give rise to a specific problem.

Second, as is the case with most system dynamics models, our model contains structures and processes that may be viewed as generic to service delivery in a wide variety of substantive arenas and to other types of programs. Our model emerged from specific consideration of providing HIV prevention programs using a small-group-workshop mode of delivery, but a very similar model might have easily emerged from consideration of an alternative program. From the vantage point of system dynamics, movement from a specific problem to the identification of the underlying generic processes in that system's context that give rise to that problem is the goal and considered unproblematic (Lane & Smart, 1996; Wolstenholm, 2004). More important, if people who are intimately engaged with the system believe the model adequately represents how things happen, then the generic features of the model need not be considered divested of the specific problem and context that gave rise to their origin, in our case HIV prevention in community-based organizational settings. To date, we have only vetted the model informally with a small set of individuals who play a variety of technical assistance roles in working with organizations attempting to adopt and implement the HIV prevention evidence-based programs that provided our initial inspiration. We have been rewarded by these initial conversations because they have perceived that our model fits well with their real-world experience in HIV.

More work remains in the expansion of the model and in testing alternative scenarios. We are currently exploring how monitoring program effectiveness as a policy may fare relative to monitoring recruitment and graduation and how contextual features, such as patterns of in- and out-migration in the area, service competition, and resource availability influence recruitment and graduation. Nevertheless, even from the simulation we present here, we can better understand the factors that may limit and improve the odds of particular prevention services having widespread impact on people at risk of exposure to HIV.

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