Applying syndemic theory to women with and at-risk for HIV

Batchelder, A.W., Lounsbury, D.W., Palma, A., Schoenbaum, E., & Gonzalez, J.

Abstract

Women in the United States are increasingly affected by HIV/AIDS, most commonly through heterosexual contact. Together childhood sexual abuse, emotional distress, substance use, violence, and financial hardship have been hypothesized to represent a syndemic: a set of mutually reinforcing health and social problems that interact and impose an increased burden on vulnerable populations. To date, models of HIV-related syndemics have predominantly assessed the linear or 'additive' relationships between syndemic constructs and outcomes (e.g., HIV-related high risk behaviors). We applied system dynamics modeling to assess the simultaneous interdependencies and feedback processes among these constructs. Our model was informed by applicable research literature, qualitative input from members of the Bronx Community Research Review Board, and previously collected cohort data describing women with a history of HIV-related high-risk behaviors (n=620). The final model demonstrates the causal influence of violent events and substance use on self-worth, emotional distress, and HIV-related high-risk sexual behaviors. Simulation output displays changes in these constructs over a hypothetical period of 104 weeks (2 years) for selected clinically relevant profiles of women with and at-risk for HIV in the Bronx. Overall, the modeling fostered a critical understanding about patterns of interdependency among the syndemic variables unforeseen by general linear modeling.

Introduction

The vast majority of women affected by HIV/AIDS in the United States are African-American and Hispanic, low socioeconomic status, and dependent on public assistance for economic survival (Zierler & Krieger, 1997). Among women with HIV, an estimated 72% of cases are attributable to heterosexual sex with an infected partner (CDC, 2011). In New York City, an estimated 32,000 women are living with HIV/AIDS; over 9,200 of them live in the Bronx (New York City Department of Health and Mental Hygiene [NYC DOHMH], HIV Epidemiology & Field Services Semiannual Report, 2011). Almost 80% of HIV+ women in the Bronx are thought to have acquired the virus from heterosexual sex (NYC DOHMH, 2011). Therefore, increasing levels of sexual self-care among women with and at-risk for HIV continues to be an area in need of intervention.

However, the relationships between sexual self-care and psychosocial variables are complex. Engagement in sexual self-care is intimately and dynamically related to other psychosocial constructs directly and indirectly, including history of childhood sexual abuse, emotional distress, substance abuse, financial hardship, and violent encounters with others, particularly intimate partner violence (CDC, 2011; Brier & Runts, 1993; Simoni & Ng, 2000; Simoni & Ng, 20002; Whetten et al., 2006; Valverde et al., 2007; Cook et al., 2007; Zierler & Krieger, 1997). Therefore, to effectively understand and intervene on this complex problem, we must account for the interrelated nature of these linked psychosocial constructs and the social environment.

In the early-1990's Singer (1992) described a syndemic as the co-occurrence of two or more afflictions that synergistically contribute to an excess burden of disease in a population. Initially, Singer proposed the "SAVA" syndemic, involving substance abuse, violence, and AIDS (SAVA; 1992). Milstein (2008) later defined syndemic orientation as a way of thinking about public health that focuses on the connections between and among health- related problems. Although originally described on a population level, Stall et al. (2003) and others (e.g., Mustanski et al., 2007; Kurtz, 2008) wrote about individual-level syndemics involving the additive relationships between variables such as: substance abuse, emotional distress, adult victimization, and history of childhood sexual abuse in men who have sex with men (MSM). The majority of this literature has assessed the co-occurrence of syndemic constructs by demonstrating their bivariate and additive association with engagement in HIV-related high-risk behavior and HIV-status in MSM. More recently, similar syndemics have been identified in women (e.g., Senn, Carey, & Vanable, 2010; Myer et al., 2011).

The majority of these publications continue to use additive general linear methodologies (GLM), operationalized by summing the presence of co-occurring known risk factors and comparing the groups. The methods previously mentioned enable the use of cross-sectional data by creating a summative variable comprised of the number of proposed syndemic variables present for each individual. However, this method assumes equal weighting of each variable (e.g., emotional distress and substance abuse are equally associated with engagement in HIV-related high-risk behavior). Further, this approach neither enables the assessment of interactions between co-occurring variables, nor the

exploration of how these interactions change over time. Therefore, a GLM approach to analyzing individual level data is poorly equipped to identify changes in effects among these variables over time (i.e., dynamic interdependency). Systems-based methodologies, such as system dynamics modeling, are needed to assess these apparent dynamic interdependencies (Trochim, Cabrera, Milstein, Gallagher, & Leischow, 2006).

While the general linear operationalization of syndemic theory has been widely used, we believe that the synergistic interrelationships dictated by syndemic theory are best captured by a dynamic approach (Singer, 2003). Therefore, we believe simulating the dynamic interdependency among key individual-level constructs over time can increase our understanding of syndemic constructs beyond cross-sectional GLM. By simulating the interrelationships between variables, system dynamics modeling enables the identification of points of leverage and, therefore, points of potential intervention (Homer & Hirsch, 2006). Overall, we aimed to demonstrate that system dynamics modeling is a useful, appropriate methodology for exploring the interdependencies of the psychosocial syndemic (including childhood sexual abuse, emotional distress, substance use, violence, and financial hardship) as they relate to engagement in sexual high-risk behavior by an individual woman over a two-year (104 week) period. We believed that our systems dynamics model would enable an increased understanding of points of potential leverage for designing effective systems- and community-level psychosocial interventions for women living with and at-risk of HIV.

Methods

Following established methods for model development and validation (Barlas, 1990; 1996), we built a system dynamics model of this syndemic. Our model was informed by three sources of evidence: published literature, qualitative feedback from the Bronx Community Research Review Board (BxCRRB), and previously collected cohort data (Luna-Reyes & Anderson, 2003). The cohort data involved a four-year cohort study following women with and at-risk for HIV/AIDS in the Bronx ("MS Study"; PI Ellie Schoenbaum, R01DA13564). All participants endorsed a history of HIV-related high-risk behaviors (including unprotected sex, sex with multiple partners, and sex work; n=620).

Our final model included three psychological constructs (emotional distress, self-worth, perceived financial hardship), two behavioral constructs (drug use and sexual self care), and two contextual constructs (risk of violence and violent events). Emotional distress, self-worth, risk of adult violence, perceived financial hardship, and sexual self-care were all built as stocks. The presence of drug use and violent events were built as auxiliary episodic variables. HIV-status and history of childhood sexual abuse were exogenous variables as were initial levels of self-worth, emotional distress, perceived financial hardship, risk of violence, sexual self care, and type of drug user (frequent user, relapser, or non-user). All equations were linked using linear and differential equations based on our causal loop diagram (see Figure 1), following standard procedures, as described by Anderson et al. (1996) and Richardson (1998). The constructs that were not included in the longitudinal data were based exclusively on our other sources of data.

Structure Validity

In order to assess the validity of the model structure, we first evaluated our initial causal loop diagram by asking for qualitative feedback from the BxCRRB, made up of community members, similar to those involved in the cohort study. We inquired if the BxCRRB perceived the proposed syndemic constructs (childhood sexual abuse, emotional distress, substance abuse, perceived financial hardship, and violence) as being linked, and if so, how they felt the variables were related to one another. Members of the BxCRRB described feeling as though the proposed syndemic variables were related, although virtually all board members emphasized how low levels of "self-worth" or "self esteem" contribute to all presented constructs. We subsequently investigated the peer-reviewed published literature and identified the involvement of "self-worth" and "self-esteem" in bivariate (Jacobs & Kane, 2011; Sterk, Klein, & Elifson, 2004; Somlai et al., 2000) and in some cases multivariate relationships (Gutierres & Puymbroeck, 2006; Weaver & Clum, 1996) with the initially proposed syndemic constructs. We also identified literature that described changes in self-esteem over time (Orth et al., 2012). Based on the BxCRRB's emphasis on "self-worth," and the strong relationships identified in the literature between "self-esteem" and the proposed syndemic constructs, we added self-worth to the model. Consistent with system dynamics modeling methodology, we quantified self-worth using relevant published data (Homer, 1996). The final 'causal loop diagram,' as shown in Figure 1 visually depicts the final hypothesized interdependent relationships between the proposed syndemic variables and outcome variables of interest in the current study.

We then evaluated each relationship individually and compared it with available knowledge from the BxCRRB and published literature comparable to women with and at-risk for HIV in the Bronx. We outlined rationales and evidence for each relationship and equation. Self-worth was parameterized on a scale of 0-100, 100 being very high self-worth and 0 being no sense of self- worth and was affected by violent events and perceived financial hardship. History of childhood sexual abuse brought the initial level of self-worth down by two-points. Emotional distress was initially parameterized on a scale from 0-60, in accordance with the CES-D scale used in the aforementioned cohort study, and subsequently converted to a 0-100 scale to enable comparison to the other constructs. Self-worth, perceived financial hardship, and violent events contributed to changes in emotional distress. Perceived financial hardship was parameterized on a scale from 0-100. HIV-status and self-worth contributed to perceived financial hardship based the cohort data longitudinal data and the literature. Risk of adult violence was parameterized on a scale from 0-100 and was affected by self-worth, drug use, and perceived financial hardship. Notably, perceived financial hardship differentially contributed to risk of adult violence based on level of drug use: perceived financial hardship had a greater potential effect on risk of adult violence fornon-drug users compared to users. Violent events were parameterized as a frequency affected exclusively by risk of adult violence. Drug use was parameterized nominally (1=chronic drug user, 2=drug user prone to relapse, and 3= non-user). For former drug users who were prone to relapse, self-worth contributed to time to drug use episode. Chronic drug users were simulated to use at regular frequencies and non-users were simulated to not engage in drug use. Sexual self-care was parameterized on a 0-100 scale (0 = no sexual self-care

and 100 = abstinent), initially based on the previously described cohort data summary scale. Drug use, self-worth, and violence affected sexual self-care.

We utilized a smooth system dynamics structure to simulate five of the main constructs in the model: self-worth, emotional distress, perceived financial hardship, risk of adult violence, and sexual self-care. Each equation was tested using structure and parameter confirmation tests that entailed comparing the form of the equations of the model with the relationships that exist in the real system (Forrester & Senge, 1980; based on the cohort data, when applicable, published literature, and qualitative feedback from the BxCRRB). This test was also carried out as a theoretical structure test, by comparing the model equations with the generalized knowledge in the literature and qualitative data from the BxCRRB.

We evaluated the constant parameters against knowledge of the real system both conceptually (with the BxCRRB) and numerically (comparing constants to the literature and the cohort data). All constructs were validated using direct extreme-conditions testing, which involves evaluating the validity of the model equations under extreme conditions. This enabled assessing the plausibility of the resulting values against the knowledge/anticipation of what would happen under a similar condition in real life (Forrester &Senge, 1980). Additionally, dimensional consistency tests were conducted.

We also evaluated the constant parameters against knowledge of the real system both conceptually (with the BxCRRB) and numerically (based on the cohort data), when possible. We tested direct extreme-conditions testing, which involves evaluating the validity of the model equations under extreme conditions, by assessing the plausibility of the resulting values against the knowledge/anticipation of what would happen under a similar condition in real life (Forrester & Senge, 1980). Sensitivity tests were also conducted by varying the value of selected variables, to assess model behavior under selected conditions, including testing the model's response to extreme or limiting conditions, ensuring consistency with cohort and epidemiological data, and evaluating plausible sensitivity to parameter changes over wide ranges (Peterson & Eberlein, 1994). The dimensional consistency test was also conducted, which involves checking the right-hand side and left-hand side of each equation for dimensional consistency.

Behavior Validity

Patterns of change in model constructs were simulated over a hypothetical time horizon of two years (104 weeks). The unit of analysis was an individual woman living in the Bronx with or at-risk for HIV/AIDS. All constructs depicted in the model were mathematically simulated using Vensim software (Ventana Systems, Inc.).

Once the simulation model was iteratively developed and validated, the model was calibrated to replicate trends identified in the three forms of data (Luna-Reyes & Anderson, 2003). The model was then used to simulate three scenarios believed to evidence clinically relevant profiles by the interaction of the variables in the system being modeled (Sterman, 2000).

After completion of the structural validity tests, we moved on to assessing the structure-oriented behavioral tests, which involved simulation. We evaluated the simulated output from the entire model as well as to isolated components of the model to ensure behavioral accuracy. These behavioral tests helped uncover structural flaws (Barlas, 1989; Forrester & Senge, 1980). For example, this portion of model validation identified the problematic direct link between substance and violence. As women who engage in substance use do not cause their own victimization, we added "risk of adult violence" as a mediating construct between drug use and adult violent events. We subsequently added "risk of adult violence as a mediating construct between perceived financial hardship and violent events. This restructuring of the model enabled violent events to become an episodic variable, which mimicked the quantitative and qualitative data we obtained from our three sources.

Behavior sensitivity test consisted of determining which parameters the model is highly sensitive to and asking if the real system would exhibit similar high sensitivity to the corresponding parameters. During this portion of validation, we identified that the model was highly sensitive to the two episodic variables: drug use and violent events. This test involved calibrating equations linking drug use and violent events (e.g., Effect of Violence on Self- worth) to have more realistic effects on related constructs based on our three forms of data. After the validity of the model structure was evaluated, we began applying tests designed to measure how accurately the model reproduced the major behavior patterns exhibited in the syndemic literature (described in detail in the results section).

We tested the behavioral patterns of the model after several iterations of the structure tests. We based the three clinically relevant profiles on the cohort data (using cluster analysis) and qualitative data from the BxCRRB. Cluster analysis revealed that extent of drug use and endorsed history of violent events typified subgroups of participants in the cohort study. Over 75% of participants in the cohort study reported enrolling in treatment to treat addiction to one or more illicit drugs (crack, cocaine, heroin, or speedball). A little over a quarter endorsed using illicit drugs in the past 6 months. To capture clinically relevant profiles of women, we simulated three substance use patterns: non-use, relapse, and chronic use. To capture the identified association in the cluster analysis between drug use and violence, we simulated higher initial levels of risk of violence for the profiles prone to relapse or chronic drug use. Among those who endorsed recent drug use, we identified two groups: those with baseline CESD scores below the cut-off for emotional distress (mean=13.60) and those with CESD scores above the cut-off for emotional distress. Therefore, we simulated the relapse profile (B) as a baseline emotional distress score of 25 and the chronic user profile (profile C) to have a baseline emotional distress score of 10. Based on qualitative feedback from the BxCRRB, we simulated that the profiles of women who were using drugs or who had higher initial levels of risk of violence had lower levels of initial self-worth. We evaluated the steady-state constructs (e.g., perceived financial hardship) by comparing trends between variations of the profiles. For the constructs that changed significantly throughout simulations (e.g., self-worth or emotional distress) we compared the graphical simulations between profiles to ensure they were consistent with our clinical profiles and three sources of information (Barlas, 1996).

Results

Finalized Feedback Structure

The final causal loop diagram presents three reinforcing loops and two outcome variables (emotional distress and sexual self-care). The first reinforcing loop involves four constructs: self-worth, drug use, risk of violence, and violent events. Given the categorical nature of the type of drug use construct, this loop is only activated when the baseline characteristic of frequent drug user or woman prone to relapse are programmed. This cycle demonstrates that incremental changes in self- worth over time lead to incremental changes in drug use, in the opposite direction (i.e., as self- worth increases, drug use decreases). As drug use increases, risk of violence also increases. As risk of violence increases, the rate of violent events increases. Finally, as violent encounters increase, self-worth incrementally decreases. This reinforcing loop indicates the presence of potential vicious cycle: increasing drug use and violence contributing to a progressive decrease of self- worth.

The second reinforcing loop represents causal influences of risk of violence for women who are not using drugs (i.e., non-users and women prone to relapse when they are not using drugs). This loop involves four constructs: self-worth, perceived financial hardship, risk of violence, and violent encounters. This cycle demonstrates how an incremental change in self- worth leads to an incremental change in the opposite direction in perceived financial hardship (e.g., as self-worth increases, perceived financial hardship decreases). It is of note that this feedback structure is not suggesting that actual financial hardship is caused by self-worth; rather, we suggest level of self-worth incrementally contributes (albeit minutely) to perception of the severity of financial hardship. An incremental change in perceived financial hardship can then lead to an incremental change in the same direction in risk of violence (e.g., as perceived financial hardship increases, risk of violence increases). An incremental change in risk of violence can then lead to an incremental change in the same direction in violent events (e.g., as risk of violence decreases, the number of violent events decreases), which then leads to an incremental change in the opposite direction in self-worth (e.g., as the number of violent encounters increases, self-worth decreases). As this loop contains two positive and two negative links, the loop has an overall positive sign and is, therefore, reinforcing.

The third, and final, reinforcing loop involves self-worth and perceived financial hardship. Incremental changes in self-worth lead to changes in the opposite direction in perceived financial hardship (e.g., as self-worth increases, perceived financial hardship also decreases). Similarly, as perceived financial hardship decreases, self-worth increases. This loop contains two negative links, resulting in a positive loop, or a reinforcing feedback process.

Simulation of Clinically Relevant Profiles

We present output in three clinically relevant profiles (A-C; Figures 2-4), each with and without HIV. The output for each of these profiles conveys the complex interrelationships and patterns that result from the synergism between constructs. While

we do not claim that the simulated outputs are strictly empirical, we do believe that the general quantification of the constructs and patterns depicted in the output represent interrelationships that are helpful in starting to understand the complex nature of syndemics on an individual level.

Profile A represents a woman with no reported history of childhood sexual abuse, moderately high self-worth, no depression, low perceived financial hardship, low risk of violence, and no reported drug use. Profile B represents a woman with no reported history of childhood sexual abuse, moderate self-worth, depression, high-perceived financial hardship, moderately low risk of violence, and reported history of drug use and relapse. Profile C represents a woman with no reported history of childhood sexual abuse, low self-worth, clinically significant distress, moderate perceived financial hardship, moderate risk of violence, and reported current drug use. The clinical profiles were developed based on the three sources of information and included: frequency tabulations and cluster analysis using the baseline data from the cohort study described above, qualitative information obtained from the BxCRRB, and empirically supported published research (Meyers et al., 2011).

Discussion

Our results indicate that violence and substance use result in rapidly decreasing self-worth and sexual self-care and increasing emotional distress. While emphasizing the need for violence and substance use reduction interventions may seem intuitive, our system dynamics model, built based on our causal loop diagram, indicates that self-worth influences both of these constructs. However, few interventions have concurrently focused on psychosocial and contextual risk factors that are known to be associated with engagement in HIV-risk behaviors, including trauma, distress, substance abuse, risk reduction, and economic empowerment (Logan, Cole, & Leukefeld, 2002). Interventions aimed at reducing symptoms of trauma, including a history of childhood sexual abuse, were associated with increased sexual self-care (Gore-Felton et al., 2002; Sikkema et al. 2008; Wyatt et al. 2004). However, interventions that included elements of drug treatment and addressed risk factors such as traumatic stress, low self-esteem, and self-efficacy have demonstrated greater effectiveness compared to single focused interventions among similar populations (Amaro et al. 2007; Exner et al. 1997; Meade & Sikkema, 2005). Similarly, women who received integrated trauma treatment and substance abuse treatment engaged in significantly fewer sexual risk behaviors (Amaro et al., 2007). For example, three hundred and forty-five randomized women with PTSD and substance use disorders were found to engage in fewer unprotected sexual behaviors after 12 sessions of a cognitive behavioral intervention compared to an attention control psychoeducational group (Hien et al., 2010). This finding suggests that women with co-occurring trauma and addiction may benefit from psychological interventions aimed at increasing coping skills and addressing trauma in order to reduce engagement in high-risk sexual behaviors. Case management, housing support, and gender-specific programming all have been reported to help women with and at-risk for HIV improve access to social services and health care (Kenagy et al., 2003; Sikkema, Hansen, Meade, Kochman, & Lee, 2005; Simoni, Montoya, Huang, &Goodry, 2005).

The traditional methods of collecting empirical data have several limitations. For example, when collecting empirical data pertaining to highly stigmatizing variables (e.g., history of childhood sexual abuse, being the victim of a violent act, etc.) validity is frequently threatened, given the potential for reporting biases (Ellsberg, Heise, Pena, Agurto, &Winkvist, 2001; Faulkner, 1996). Further, we were only able to assess variables that were collected in the original research project. We identified self-worth as a relevant construct based on the BxCRRB and the literature but were unable to include it in our general linear analyses, as it was not asked in the original interviews and we, therefore, did not have empirical data.

Limitations

The system dynamics model developed for this project is intentionally simplified, as system dynamics models are methodologically as parsimonious as possible, while meeting the goal of the model (Homer & Hirsch, 2006). Yet, it is a powerful representative of the dynamic interdependency of core psychosocial constructs in syndemic theory. While all of the included constructs are clearly multifaceted and involve contextual and historical qualifications, we intentionally excluded constructs we conceptualized as non-essential to conveying the interrelationships of the proposed syndemic. For example, we did not include the expected projected length of time of emotional distress, including the expected reduction in symptoms after a certain amount of time. Additionally, we did not distinguish between specific types of violence (e.g., intimate partner violence, random acts of violence, violence associated with transactional sex).

We excluded representation of the role perpetrators play in violence. This model, in no way aims to suggest that women who are violently victimized cause the violence that is inflicted upon them. Given the profound racial and ethnic disparities among women at-risk for and living with HIV/AIDS, we questioned whether to include history of disempowerment as a contributing exogenous variable in the system dynamics model to account for the racial and ethnic disparities evident, even when controlling for SES (Lillie-Blanton, Parsons, Gayle, & Dievler, 1996).

System dyanamics modeling, given its constructivist epistemology, enabled the use of both qualitative and quantitative longitudinal information, thus being able to account for limitations in the empirical data. While we did not account for expected reporting biases, in order to remain conservative, we did add the unmeasured construct of self-worth, based on an extensive literature review (Dietz, 1996; Orth, Robins, & Widaman, 2012).

Future Directions

The development of this system dynamics model brought attention to the deficit nature of syndemic theory. Certain behaviors have been associated with increased coping strategies and improved levels of self-worth. These include religiosity, family support, and mental health care among others. Religiosity, particularly among African Americans and

individuals with low socioeconomic status has been associated with higher levels of self-esteem and self-worth (Thompson, Thomas, & Head, 2012). Similarly, Gecas and Seff (1990) found that when family was central to self-evaluation, family variables, compared to other variables such as socioeconomic status, had stronger effects on self-esteem. Further, reported self-worth significantly increased among women with a history of emotional distress and violence after engaging in psychological treatment (Elklit, 2009).

Post-hoc, we considered what naturally occurring balancing feedback loops exist and what should be added to the model to increase accuracy. Using a system dynamics archetype, the eroding goals structure (Braun, 2002), we added two balancing loops to the causal loop diagram (Figure 5). The first balancing loop depicts how an individual woman may recognize a deficit in self-worth, below what she would like, and engage in actions to increase her self-worth (e.g., seek out social support from family or friend(s), engage in spiritual or religious practice, or pursue mental healthcare). The second balancing loop depicts how a perceived deficit in self-worth could lead to internal pressure to adjust one's perceived acceptable level of self-worth, resulting in a decrease in one's sought level of self- worth. These two balancing loops move beyond the model's depiction of syndemic theory and portray a more realistic account of how some individuals are able to balance the reinforcing interrelationships. We aim to pursue this more comprehensive model in future work.

Recently focus groups were conducted among young African American women and community leaders in two southern states to assess perceptions of a micro-enterprise HIV- prevention intervention aimed at reducing HIV/STD transmission among unemployed and underemployed African American women at risk for HIV (Prather et al., 2012). Results from this study suggest that interventions should aim to increase self-esteem, enhance employability and job sustainability and decrease financial dependence. Together this evidence outlines the profound need for coordinated psychosocial and socioeconomic programs in order to increase sexual self-care among women with and at-risk for HIV in the Bronx. Given the known associations between the previously identified psychosocial constructs (including history of trauma, emotional distress, substance abuse, perceived financial hardship, and interpersonal violence) and their known relationship to sexual self-care as well as the acquisition and spread of HIV, an increased understanding of how these constructs are interrelated is needed.

Participatory action research has been particularly successful in identifying potential interventions aimed at financial hardship reduction, including more systems-level interventions (e.g., Smith & Romero, 2010). However, microcredit programs, although found to be effective internationally (Salt, 2011), have not be systematically evaluated in the United States. Future research will need to look at the multifaceted interventions needed to address to complex nature of the synergistically linked syndemic variables (e.g., interventions addressing psychosocial as well as socioeconomic variables). When asked what might be helpful in addressing these related problems, the BxCRRB suggested a peer intervention. One board member described benefits of speaking with others who have experienced similar hardships. Another described the benefits of being able to reach out to a peer in a social context, without the barriers present in medical or mental health contexts. Another board member noted that in a support group context very

serious issues regarding self-worth can surface, requiring a professional. The board agreed that asupport group with one mental health professional, such as a psychologist, would work well for those interested in pursuing care. Board members also stated that they felt an intervention that addressed all of the proposed issues (childhood sexual abuse, emotional distress, substance abuse, financial hardship, and violence) would be most helpful, rather than the more traditional single-focused groups (e.g., a emotional distress group or a substance abuse group).

Additionally, future research will need to evaluate the efficacy and cost-effectiveness of ecological interventions. System dynamics modeling is uniquely suited to conduct cost-benefit analysis that incorporates feedback. This work could initially be simulated, using the validated model made for this project. By allotting dollar estimates to potential emergency room visits associated with violent events, HIV-care, and estimated cost of emotional distress and drug use cost could be calculated before and after various simulated intervention effects. Subsequently,actual interventions will need to be implemented and assessed in order to evaluate the actual efficacy and cost-effectiveness of successfully simulated interventions.

Conclusion

System dynamics modeling moves beyond general linear associations of cross-sectional data to include nonlinear relationships and feedback structures over time. The deterministic nature of this methodology facilitates the inclusion of multiple sources of data (e.g., quantitative and qualitative data), enabling movement beyond limitations in classically collected empirical data (e.g., attrition or response bias). System dynamics modeling is built on a constructivist epistemology, in that the development of a simplified perception of reality is a purposeful abstraction aimed at conceptualizing constructs to increase understanding of a specified problem. Ontologically, system dynamics is both realist and relativist (Vasquez, Liz, & Aracil, 1996), in that system dynamics models represent one reality, that include the most realistic content possible, while maintaining parsimony and ideally offering an explanation or understanding of a proposed problem and to formulate empirically oriented hypotheses. Based on this demonstration, we believe that system dynamics modeling is a valid and useful way to depict syndemic theory.

References

Amaro H., Larson M.J., Zhang A., Acevedo A., Dai J., & Matsumoto, A. (2007). Effects of trauma intervention on HIV sexual risk behaviors among women with co-occurring disorders in substance abuse treatment. *Journal of Community Psychology, 35(7),* 895-908.

Andersen, D., Richardson, G. P., & Vennix, J. (1997). Group model building: Adding more science to the craft. *System Dynamics Review, 13(2),* 187-201.

Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review, 12(3),* 183-210.

Barlas, Y. (1990). Multiple tests for validation of system dynamics type of simulation models. *European Journal of Operational Research, 42(1),* 59-87.

Braun, W. (2002). The System Archetypes. *The Systems Modeling Workbook.* Retrieved from http://wwwu.uni-klu.ac.at/gossimit/pap/sd/wb_sysarch.pdf.

Brier J. & Runts M. (1993). Childhood sexual abuse: Long-term sequelae and implications for psychological assessment. *Journal of Interpersonal Violence, 8,* 312-330.

Center for Disease Control. (2011). HIV among Women. National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Division of HIV/AIDS Prevention. Retrieved from http://www.cdc.gov/hiv/topics/women/pdf/women.pdf

Cook, J.A., Grey, D.D., Burke-Miller, J.K., Cohen, M.H., Vlahov, D., Kapadia, F., … Goparaju, L. (2007). Illicit drug use, negative affect and their association with highly active antiretroviral therapy in HIV-positive women. *Drug & Alcohol Dependence, 15(89),* 74-81.

Elklit, A. (2009). Traumatic stress and psychological adjustment in treatment-seeking women sexually abused in childhood: A follow-up. *Scandinavian Journal of Psychology, 50(3), 251-257.*

Ellsberg, M., Heise, L., Pena, R., Agurto, S., & Winkvist, A. (2001). Researching domestic violence against women: Methodological and ethical considerations. *Studies in Family Planning, 32(1*), 1-16.

Exner, T.M., Seal, D.W., & Ehrhardt, A.A. (1997). A review of HIV interventions for at-risk women. *AIDS and Behavior, 1*, 93-124.

Faulkner, N. (1996). Pandora's box: The secrecy of child sexual abuse. *Sexual Counseling Digest.* Retrieved from: http://www.prevent-abuse-now.com/pandora.htm.

Forrester, J.W. & Senge, P.M., (1980). Tests for building confidence in system dynamics models. In Legasto, A.A., Forrester, J.W., & Lyneis, J.L. (Eds.), System Dynamics. Amsterdam: North-Holland.

Gecas, V. & Seff, M.A. (1990). Social class and self-esteem: Psycholigical centrality, compensation, and the relative effects of work and home. *Social Psychology Quarterly, 53(2),* 165-173.

Gore-Felton, C., Koopman, C., Turner-Cobb, J.M., Duran, R., Israelski, D., Spiegel, D. (2002). The influence of social support, coping, and mood on sexual risk behavior among HIV-positive men and women. *Journal of Health Psychology, 7,* 713-722.

Gutierres, S.E. & Puymbroeck, V.C. (2006). Childhood and adult violence in the lives of women who misuse substances. *Aggression and Violent Behavior, 11(5),* 497-513.

Hien, D.A., Campbell, A.N., Killeen, T., Hu, M.C., Hansen, C., Jiang, H., ... Nunes, E.V. (2010). The impact of trauma-focused group therapy upon HIV sexual risk behaviors in the NIDA Clinical Trials Network "Women and trauma" multi-site study, *AIDS Behavior, 14(2),* 421-430.

Homer J.B. (1996). Why we iterate: scientific modeling in theory and practice. *System Dynamics Review, 12,* 1–19.

Homer, J. & Hirsch, G. (2006). System Dynamics Modeling for Public Health: Background and Opportunities. *American Journal of Public Health, 96(3),* 452-458.

Jacobs, R.J. & Kane, M.N. (2011). Psychosocial predictors of self-esteem in a multiethnic sample of women over 50 at risk for HIV. *Journal of Women & Aging, 23(1*), 23-39.

Kenagy, G.P., Linsk, N.L., Bruce, D., Warnecke, R., Gordon, A., Wagaw, F., & Densham, A. (2003). Service utilization, service barriers, and gender among HIV-positive consumers in primary care. *AIDS Patient Care STDS, 17(5),* 235-244.

Kurtz, S.P. (2008). Arrest histories of high-risk gay and bisexual men in Miami: unexpected additional evidence for syndemic theory. *Journal of Psychoactive Drugs, 40(4),* 513-21.

Lillie-Blanton, M., Parsons, P.E., Gayle, H., & Dievler, A. (1996). Racial differences in health: Not just black and white, but shades of gray. *Annual Review of Public Health, 17,* 411-448.

Logan, T.K., Cole, J., & Leukefeld, C. (2002). Women, sex, and HIV: social and contexual factors, meta-analysis of published interventions, and implications for practice and research. *Psychological Bulletin, 128(6),* 851-885.

Luna-Reyes, L.F. & Anderson, D.L. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review, 19(4),* 271-296.

Meade, C.S. & Sikkema, K.J. (2005). HIV risk behavior among adults with severe mental illness: a systematic review. *Clinical Psychology Review, 25(4)*, 433-457.

Milstein, B. (2008). Hygeia's Constellation: Navigating Health Futures in a Dynamic and Democratic World. Center for Disease Control, Syndemic Prevention Network. Retrieved from http://www.cdc.gov/syndemics/monograph/sections/systemdynamics.htm

Mustanki, B., Garofalo, R., Herrick, A., & Donenberg, G. (2007). Psychosocial Health Problems Increase Risk for HIV Among Urban Young Men Who Have Sex With Men: Preliminary Evidence of a Syndemic in Need of Attention. *Annals of Behavioral Medicine, 34(1),* 37-45.

Myers, H.F., Wyatt, G.E., Loeb, T.B., Carmona, J.V., Warda, U., & Longshare, D. (2006). Severity of childhood sexual abuse, post-traumatic stress and risky sexual behaviors among HIV-positive women. *AIDS and Behavior, 10(2),* 191-199.

New York City Department of Health and Mental Hygiene. (2011). New York City HIV/AIDS Annual Surveillance Statistics 2010; HIV Epidemiology and Field Services Program. Retrieved from http://www.hptn.org/web%20documents/HPTN065/TrgPrsntns12_2010/MSweeney_Bronx6_Dec_2010

Peterson, D., & Eberlein, R. (1994). Reality check: A bridge between systems thinking and systems dynamics. *System Dynamics Review, 10(2-3),* 159-174.

Prather, C., Marshall, K., Courtenay-Quirk, C., Williams, K., Eke, A., O'Leary, A., & Stratford, D. (2012). Addressing poverty and HIV using microenterprise: Findings from qualitative research to reduce risk among unemployed or underemployed African American women, *Journal of Health Care for the Poor and Underserved, 23,* 1266-1279.

Richardson, G.P. (1998). Problems in causal loop diagrams revisited. *System Dynamics Review, 13(3),* 247-252.

Salt, R. (2011). Microcreidt and the social determinants of health: a conceptual approach. *Public Health Nursing, 28(3),* 281-290.

Senn, T., Carey, M., & Vanable, P. (2010). The intersection of violence, substance use, negative affect, and STDs: Testing of a syndemic pattern among patients attending an urban STD clinic. *Journal of the National Medical Association, 102(7),* 614-620.

Sikkema, K.J., Wilson, P.A., Hansen, N.B., Kochman, A., Neufeld, S., Ghebremichael, M.S., & Kershaw, T. (2008). Effects of a coping intervention on transmission risk behavior among people living with HIV/AIDS and a history of childhood sexual abuse. *Journal of Acquired Immune Deficiency Syndrome, 47(4),* 506-513.

Sikkema, K.J., Hansen, N.B., Ghebremichael, M., Kochman, A., Tarakeshwar, N., Meade, C.S., & Zhang. (2006). A randomized control trial of a coping group intervention for adults with HIV who are AIDS bereaved: Longitudinal effects on grief. *Health Psychology, 25(5),* 563-570.

Simoni, J.M., Montoya, H.D., Huang, B., Goodry, E. (2005). Social support and depressive symptomatology among HIV-positive women: the mediating role of self-esteem and mastery, *Women Health, 42(4),* 1-15.

Simoni, J.M. & Ng, M.T. (2000). Trauma, coping, and negative affect among women with HIV/AIDS in New York City. *AIDS Care, 12(5),* 567-80.

Simoni, J. & Ng, M. (2002). Abuse, Health Locus of Control, and Perceived Health Among HIV-Positive Women. *Health Psychology, 21 (1),* 89-93.

Singer M. (1992). A dose of drugs, a touch of violence, a case of AIDS: Conceptualizing the SAVA Syndemic. *Free Inquiry in Creative Sociology, 24(2),* 99-110.

Smith, L. & Romero, L. (2010). Psychological interventions in the context of poverty: Participatory Action Research as Practice. *American Journal of Orthopsychiatry, 80(1),* 12-25.

Somalai, A.M., Kelly, J.A., Heckman, T.G., Hackl, K., Runge, L., & Wright, C. (2000). Life optimism, substance use, and AIDS-specific attitudes associated with HIV risk behavior among disadvantaged inner-city women. *Journal of Women's Health-Gender Based Medicine, 9(10),* 1101-1111.

Stall, R., Mills, T., Williamson, J., Greenwood, G., Paul, J., Pollack, L., … Catania, J. (2003). Association of co-occuring psychological health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *American Journal of Public Health, 93(6),* 939-942.

Sterk, C.E., Klein, H., Elifson, K.W. (2004). Predictors of condom-related attitudes among at-risk women. *Journal of Women's Health, 13(6*), 676-688.

Sterman JD. Business Dynamics:Systems Thinking and Modeling for a Complex World. Boston, Mass: Irwin/ McGraw-Hill; 2000.

Thompson, M.S., Thomas, M.E., & Head, R.N. (2012). Race, socioeconomic status, and self-esteem: The impact of religiosity. *Sociological Spectrum, 32(5),* 385-405.

Trochim, W.M., Cabrera, M.A., Milstein, B., Gallagher, R.S., & Leischow, S.J. (2006). Practical challenges of systems thinking and modeling in public health. *American Journal of Public Health, 96(3),* 538-546.

Vazquez, M., Liz, M., & Aracil, J. (1996). Knowledge and reality: some conceptual issues in system dynamics modeling, *System Dynamics Review, 12(1),* 21-37.

Whetten, K., Lesserman, J., Lowe, K., Stangl, D., Thielman, N., Swartz, M., … Van Scoyoc, L. (2006). Prevalence of childhood sexual abuse and physical trauma in an HIV-positive sample from the deep south. *American Journal of Public Health, 96(6),* 1028-1030.

Wyatt, G.E., Longshore, D., Chin, D., Carmona, J.V., Loeb, T.B., Myers, H.F., ... Rivkin, I. (2004). The efficacy of an integrated risk reduction intervention for HIV-positive women with child sexual abuse histories. *AIDS Behavior, 8(4),* 453-462.

Zierler, S. & Krieger, N. (1997). Reframing Women's Risk: Social Inequalities and HIV Infection, *Annual Reviews of Public Health, 18*, 401-436.