USING DYNAMICS MODELING TO PROMOTE EFFECTIVE TOBACCO TREATMENT PRACTICES IN COMMUNITY-BASED PRIMARY CARE SETTINGS

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ABSTRACT

This paper describes formative field research to develop and test the utility of a system dynamics modeling intervention intended to promote evidence-based tobacco treatment practices in community-based primary care settings. Brief counseling interventions by primary care providers have been shown to effectively promote tobacco cessation among patients who smoke, yet many physicians are inconsistent in the way they intervene with their patients. Too little time, poor training, lack of third-party reimbursement, competing clinical problems, and the belief that their patients are not able to change explain, in part, why some physicians do not adhere to evidence-based guidelines for treating tobacco use and dependence. Via a protocol for conducting on-site office visits to small primary care practices located in medically underserved urban communities, we tested the hypothesis that providers exposed to the simulation tool would demonstrate better understanding and progress towards full implementation of the US Public Health Service Guideline for Treating Tobacco Use and Dependence. Results indicate that simulated output that reflects the dynamics of providers' unique practice environment is associated with stronger behavioral intent than other forms of feedback information, such as patient chart reviews.

INTRODUCTION

In this study, we examined the utility of system dynamics modeling as a means to develop a simulation tool to foster understanding about how to improve implementation of the PHS Guideline for Treating Tobacco Use and Dependence in primary care practices. We examine the dynamics of tobacco treatment in small primary care practices (1-5 physicians per practice). System dynamics models have been developed to study community and population impacts of varied public health problems and policies (Homer and Hirsch 2006), including tobacco policies (Feenstra, Hamberg-van Reenen et al. 2005; Levy, Bales et al. 2005; Cavana and Clifford 2006). However, these works have not modeled the dynamics of individual practice settings, nor have they used system dynamics models to directly educate and influence physician practices.

In the first stage of this research, we worked collaboratively with an expert advisory group to construct a working system dynamics model of the simulation tool. This version of the simulation tool is now being subjected to a formative assessment in an academic detailing intervention with a small sample of community-based primary care practices. Our formative assessment examines: (1) feasibility and acceptability of using the simulation tool in an academic detailing intervention, (2) changes in individual provider attitudes about and practices in tobacco treatment, (3) and implementation of new or improved office systems to improve tobacco treatment at the practice level. We hypothesized that system dynamics modeling of the practice environment will promote deeper understanding of and greater impetus to implement the PHS Guideline.

The specific aims of this project were as follows:

Aim 1. To develop a system dynamics simulation tool as a decision aid for promoting in-depth understanding about how best to implement currently recommended the clinical guidelines for the treatment of tobacco use and dependence in community-based primary care settings;

Aim 2. To conduct a formative assessment of the simulation tool, delivered as part of an academic detailing intervention to a cohort of small primary care practices in racially and ethnically diverse, urban communities with high rates of smoking and poverty.

BACKGROUND AND SIGNIFICANCE

The Efficacy of Academic Detailing to Change Provider Practices. Brief counseling intervention by primary care providers has been shown to effectively promote tobacco use cessation, yet many physicians do not consistently adhere to this practice for all patients at each appointment (Greco and Eisenberg 1993; Davis and Taylor-Vaisey 1995; Goldstein, DePue et al. 1998; Goldstein, Niaura et al. 2003). Significant barriers exist that can interfere with clinicians' assessment and treatment of smokers. Many clinicians lack knowledge about how to identify smokers quickly and easily, which treatments are efficacious, how treatments can be delivered, and the relative efficacies of different treatments (Orleans 1993). Even if clinical knowledge is strong, many physicians do not consistently use this intervention. Primary care physicians are more likely to report counseling patients about smoking cessation than other medical professionals, but are not more likely to refer them for counseling (Meredith, Yano et al. 2005). Too little time, poor training, lack of third-party reimbursement, competing clinical problems, and the belief that their patients are not able to change also explain why some physicians do not adhere to the guideline (Glynn and Manley 1989; Cabana, Rand et al. 1999; Adsit, Fraser et al. 2005).

Academic detailing interventions typically involved multiple components, including provision of written materials and sample supplies, didactic training, auditing (with feedback), 'reminder' systems, and one or more office-based consultations (Soumerai and Avorn 1990; Goldstein, Niaura et al. 2003; Gandjour and Lauterbach 2005). A recent Cochrane review by O'Brien and colleagues (O'Brien, Oxman et al. 2005) examined the effectiveness of educational outreach visits, or academic detailing, to promote changes in medical and health care provider practices. In 13 of 18 randomized trials examined, the targeted provider behavior was prescribing practices. Three studies addressed preventive practices, including brief counseling for smoking cessation (Avorn, Soumerai et al. 1992; Berings, Blondeel et al. 1994). Collectively, these efforts help detailers establish a rapport with providers that, in turn, can generate effective change in practices.

Although positive outcomes were observed in all studies in the review, interventions that provided one or more of the following, including individual instruction, used audit and feedback strategies, incorporated review by peers, and that successfully integrated 'reminder' systems, were among the most effective for medical professionals (Steele, Fors et al. 1989; Dietrich, O'Connor et al. 1992) (Wensing and Grol 1994; Yano, Fink et al. 1995; Weissman, Allison et al. 1999; Andrews, Tingen et al. 2001; Kiefe, Allison et al. 2001). Results did not reveal a clear relationship between the number of office visits by detailers and impact on the provider, although it was noted that interventions with as few as one or two visits had positive effects.

Overall, academic detailing appears to be a promising way to change provider behaviors, especially when the behavior was prescribing medications. However, additional research on interventions intended to change preventive practices, including tobacco treatment practices (Goldstein, Niaura et al. 2003), is needed. Although dissemination-only strategies (e.g., conferences and mailings) always demonstrated smaller effects than interventions involving outreach visits or peer review, such interventions had varying levels of effective impact (Oxman, Thomson et al. 1995).

We believe that the system dynamics modeling approach has the potential to transform how clinical guidelines and scientific reviews are disseminated to busy professionals. A well-designed simulation tool could greatly accelerate the rapport-building process between detailers and providers. We hypothesize that the capability to automatically simulate the dynamics of implementing practice changes during the course of either a didactic training session and/or an office-based consultation would help an academic detailer quickly learn about a provider's practice environment and help providers make practice-specific, cost-effective decisions about how to most efficiently and rapidly attain (and/or sustain) evidence-based standards of tobacco treatment for their patients. A tool with this capability would allow for quick comparison of alternative ways of changing office procedures by generating scenarios that simulate different combinations of role-sharing or resource exchange.

The system dynamics simulation tool we envision would be able to generate customized output, on the spot, in the form of easy-to-read behavior-over-time charts and data tables. Results would give a dynamic picture of demand on providers as well as patient outcomes over a specified period of time. It could show how, for example, adding tobacco treatment time during office visits will impact wait times over the course of a single day, or how combination NRT impacts relapse rates for heavy smokers over a three year period. More generally, our completed simulation tool would help providers answer critical questions such as: Which staff members should (and can) be involved in the practice's tobacco treatment strategies? How effective are minimal interventions, such as clinician advice to stop smoking, for our patients, or are more intensive interventions required? How does the duration of an intervention in number of treatment sessions or in total face-to-face contact time substantially influence efficacy for our patients? How much counseling time can we allocate during an office visit? What are the short-term and long-term costs of not effectively treating tobacco use, to the practice and to our patients? Which pharmacologic interventions will be easiest for our patients to adhere to and may lead to greater patient contact? How many times do patients relapse before they quit for good?

We expect that the capacity to address these types of questions with the simulation tool will help primary care providers visualize the implementation of various features of the tobacco treatment guidelines. In turn, we expect that providers will more quickly identify the mechanisms that will drive effective tobacco treatment in their own practices.

System Dynamics Modeling to Foster Practice Change. Experts in change management and health care quality improvement recommend that "rapid change" can be achieved by: (1) employing strategies that break large goals into a series of smaller goals (i.e., 'small wins'); (2) fostering interdisciplinary workgroups to intervene at multiple points in the process of care; and (3) conducting a series of pilot studies or projects to test and establish new practices. Through our planned intervention, we attempt to use our system dynamics model to bring together two types of knowledge to the problem of tobacco treatment in primary care: *Professional knowledge* (i.e., evidence-based medicine) and *knowledge for improvement* (i.e., a systematic approach to achieving change for improved care; informative feedback) (Headrick 2000).

In public health and health services research, system dynamics modeling and other simulation techniques have typically studied population-level problems (Lounsbury 2002; Feenstra, Hamberg-van Reenen et al. 2005; Levy, Bales et al. 2005; Bar-Yam 2006; Homer and Hirsch 2006). This work has examined cost-effectiveness of new treatment modalities (i.e., pharmacotherapies) (Halpern, Khan et al. 2000), new public resources (e.g., state administered tobacco ‘quit lines’) (Bentz, Bayley et al. 2006), as well as implementation of the PHS Guideline itself (Cromwell, Bartosch et al. 1997; Torrijos and Glantz 2006). These studies often use cost-benefit analytic techniques to assess cost of life-year, or quality-adjusted-life-year (QALY), saved, which have provided useful, though highly variable results across studies. A recent meta-analytic review of economic evaluations of smoking cessation determined that cost-effectiveness ratios in such policy studies were huge (ranging from 120% to 5600%) (Ronckers, Groot et al. 2005).

System dynamics modeling is a method that can help researchers and policy makers better understand why such variability exists. A recent policy study that used system dynamics to study the long term impact of implementing an excise tax on tobacco is a case in point. The authors used system dynamics to answer questions related to price, tobacco sales, government revenues, and smoking prevention (Cavana and Clifford 2006). The researchers reported that policy analysts engaged in the study found the model useful and exciting, and well-suited to society-level policy questions. Collaborating in the model-building process gave them insight into the structure behind the processes, and helped them understand how a specific policy aim could be achieved, or not. To our knowledge, system dynamics has not yet been applied to dynamics modeling of tobacco treatment at the level of the primary care practice (Homer and Hirsch 2006), though one simulation study, conducted in The Netherlands, examined the cost-effectiveness of face-to-face smoking cessation interventions by general practitioners (Feenstra, Hamberg-van Reenen et al. 2005; Homer and Hirsch 2006).

METHODS

Participating Practices. Twenty-five community based practices were recruited to the study. On average, these practices are staffed by two full-time primary care providers. The largest practice included five providers. The mean number of patient visits per week was 125 (minimum 30 per week; maximum 300 per week). Smoking prevalence, based on initial chart review data collected from each practice, was 18% (minimum 5%; maximum 33%). The average co-pay was $18.84 per visit (range $5 to $50), with an estimated average patient visit bill being $144 (range $50 to $500). A high proportion of patients were covered by Medicare and/or Medicaid in most practices. A substantial amount of time and effort was expended to recruit these practices (see Table 1). A total of 196 Queens-based practices were approached in order to secure the participation of 25 sites over recruitment period of 14 months. Recruitment efforts were focused on practices affiliated with MetroPlus, a low or no-cost health insurance provider to eligible people living in Manhattan, Brooklyn, the Bronx and Queens, through a variety of Federally-backed Medicaid and Medicare programs.

Participating providers’ awareness and use of patients support services, including the New York State Quit Line, the New York State Fax-to-Quit Service, or of local smoking cessation support groups, was limited (see Table 2). None of the participating practices had formal tobacco treatment policies in place; similarly, none had a designated ‘tobacco cessation champion’ available to patients who smoked.

Table 1 – Primary Care Practice Recruitment Results

Recruitment status	N	%
Targeted practices (Queens, NYC)	276	100%
Eligible MetroPlus Contacts	161	58%
Ineligible MetroPlus Contacts	80	29%
Cold calls	35	13%
Practice approached	196	100%
Visited; pending recruitment	107	55%
Recruited[1]	25	13%
Refused[2]	38	19%
Excluded[3]	13	7%
Unreachable[4]	13	7%

[1] includes 4 cold call practices.

[2] not interested, too busy, few patients who smoke.

[3] already a partner to Queens Quits.

[4] could not locate, closed for business, bad address.

Table 2 – Patient Support Services and Pharmacotherapy Prescription Practices

Patient Support Services (N =23)	% aware of resources	% often refer to the resources	% find resources very useful
NYS Quit Line	74%	13%	17%
NYS Fax-to-Quit	44%	4%	17%
Cessation support group - QHC	44%	0%	17%
Cessation support group - EHC	44%	0%	17%

Pharmacotherapy (N= 23)	% actively prescribing	% comfortable prescribing	% actively educating	% comfortable educating
Nicotine patch	61%	57%	44%	30%
Other NRT (Gums/Lozenges/Inhaler)	48%	48%	35%	22%
Zyban/Bupropion	52%	52%	44%	26%
Chantix/Varenicline	52%	39%	44%	30%

Model Development. The system dynamics method we have applied to develop the simulation tool is consistent with standard procedures and techniques described in texts by seminal system dynamicists such as Randers, Richardson, and Sterman (Randers 1980; Richardson and Pugh III 1981; Sterman 2000). All model development has been conducted using Vensim (Ventana Systems, Harvard, MA). Our finalized simulation tool is a theoretical representation of the dynamics of a single primary care office visit with a patient who uses tobacco.

Informed by the PHS Guideline for Treating Tobacco Use and Dependence, other published literature on managing primary practices, as well as input from participating primary care physicians, our model includes examines the dynamics of smokers visiting a given primary care practice over a period of two to four years. The problem to be modeled has multiple components, namely understanding: (1) How to facilitate a 'quit attempt'; (2) How tobacco treatment can stimulate growth of the practice; and (3) How practice treatment efforts impact patient outcomes and practice outcomes (e.g., reimbursement), over time.

The conceptual framework for the general model links three broad domains: (1) Provider Practices, (2) Patient Tobacco Use, and (3) Patient Health (see Figure 1). Tobacco use can be viewed as a mediator of patients' health and their use of primary care, in that everyone requires some level of primary care at some point (whether for an acute, chronic or preventive health matter)(Fetter, Averill et al. 1984; Ritzwoller, Goodman et al. 2005). Moreover, we know that tobacco users are more likely to have respiratory and other health problems and, therefore, are more likely to demand primary care services (Rigotti 2000; Rigotti 2002).

Figure 1 – Conceptual Framework for Model

To represent the interdependent nature of these domains, we have chosen to adopt Hornbrook's fundamental concept of *health care episodes* (Hornbrook, Hurtado et al. 1985). Hornbrook and his colleagues are economists and health services researchers whose work takes a theoretical approach to unitizing health care services and costs (Hornbrook and al. 2005). The concept of a health care episode is useful here because it "enables more appropriate assessment of costs of care and, in addition, lends itself to analysis of the processes as well as the outcomes of medical care" (Hornbrook, Hurtado et al. 1985)(p. 164).

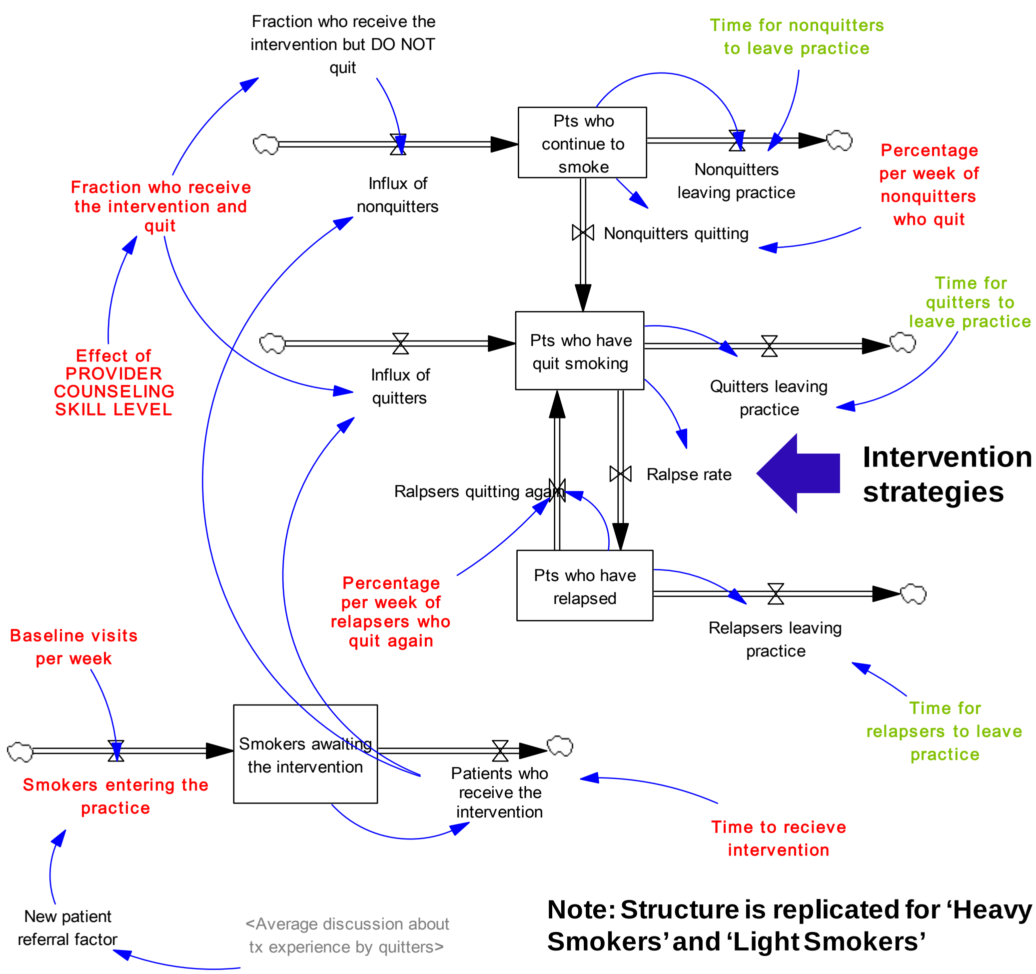
A health care episode is defined as a series of health-related events with a beginning, an end, and a course, all related to a given health problem that exists over a specific time period. For our study, there are four types of episodes, namely: (1) smoking episodes, (2) quitting episodes, (3) illness episodes, and (4) treatment episodes. Although an illness episode (e.g., the period of time someone is sick with the flu) may be unrelated to a patient's current smoking behavior, it nonetheless has the potential to bring the patient to the doctor's office, offering the opportunity to address their tobacco use (Thompson, Michnich et al. 1988; McBride, Plane et al. 1997; Sippel, Osborne et al. 1999; Easton, Husten et al. 2001; Katz, Muehlenbruch et al. 2002; Smith, Sheffer et al. 2003). In other words, the visit is an opportunity to initiate a quitting episode, and the system dynamics model is used to assess the dynamics of a quitting episode a function of Provider Practices, Patient Tobacco Use, and Patient Health.

In model runs, Provider Practices are presented in four modes, of ‘intervention strategies’ as follows:

1. **Counseling only** (which and be moderated by three levels of provider’s counseling skill – low – medium – high);
2. **Counseling with referral to Quit Line** (an external, unlimited telephone counseling and resource service);
3. **Counseling and Quit Line with prescription of a single pharmacotherapy** (e.g., nicotine replacement therapies (NRTs), including patches, lozenges, gum, and inhalers – or non-NRTs, including Bupropion [Zyban®/Wellbutrin®] and Varenicline [Chantix®]).
4. **Counseling and Quit Line with prescription of a combination pharmacotherapy** (e.g., NRT patches and gum).

A stock-and-flow diagram of patients who smoke entering a practice, being exposed to the provider’s intervention strategy is shown in Figure 2. These patients are funneled into three stocks according to their response to the intervention: Patients who continue to smoke, Patients who have quit smoking, and Patients who quit, but then relapsed (i.e. resumed smoking). quitter, quitting and relapsing, or simply not quitting (see Figure 2).

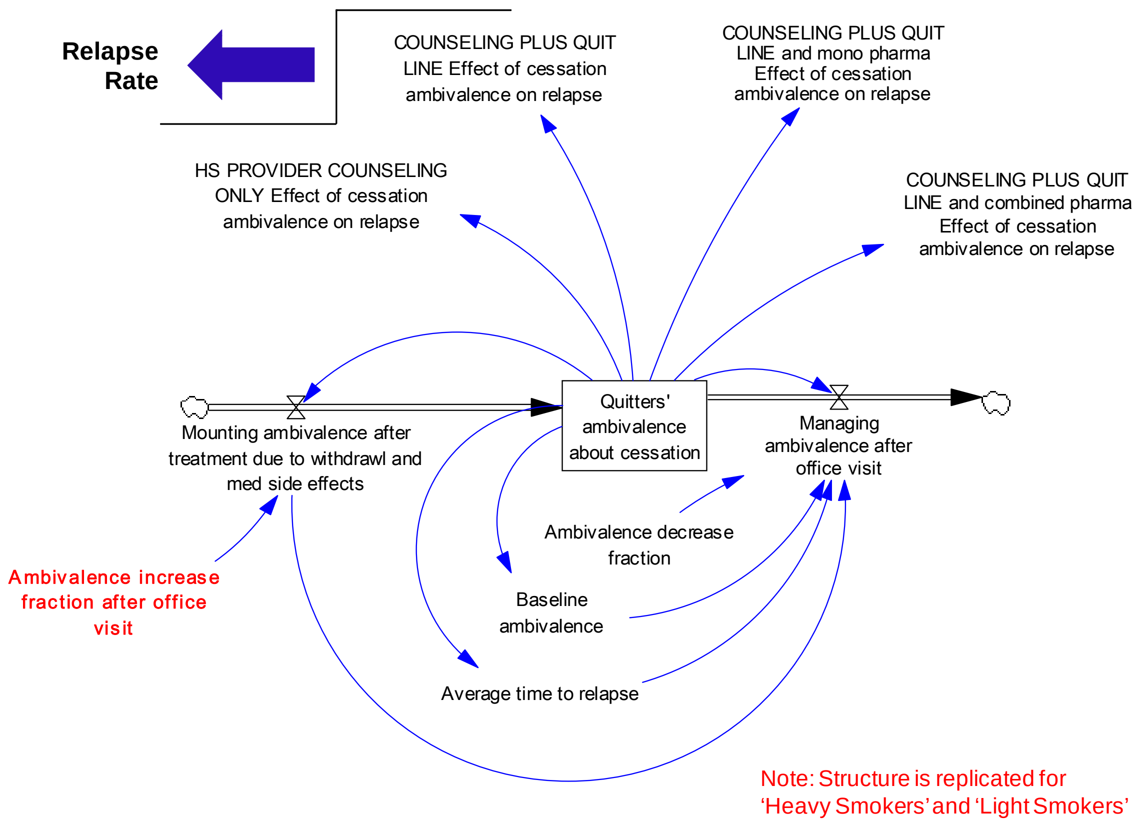
Figure 2 – Stock-and-Flow of Patients’ Response to an Intervention Strategy



Note: Structure is replicated for ‘Heavy Smokers’ and ‘Light Smokers’

Patients' relapsing is simulated via a construct we defined as 'quitting ambivalence,' the discomfort of quitting due to either nicotine withdrawal, side effects of cessation medication use, or other psychological or behavior symptoms that can accompany a patient's quit attempt. A stock-and-flow diagram of this structure is shown in Figure 3. Quitters' Ambivalence drives patient relapse for patients who are successful at making a quit attempt.

Figure 3 – Stock-and-Flow of Quitters' Ambivalence about Cessation

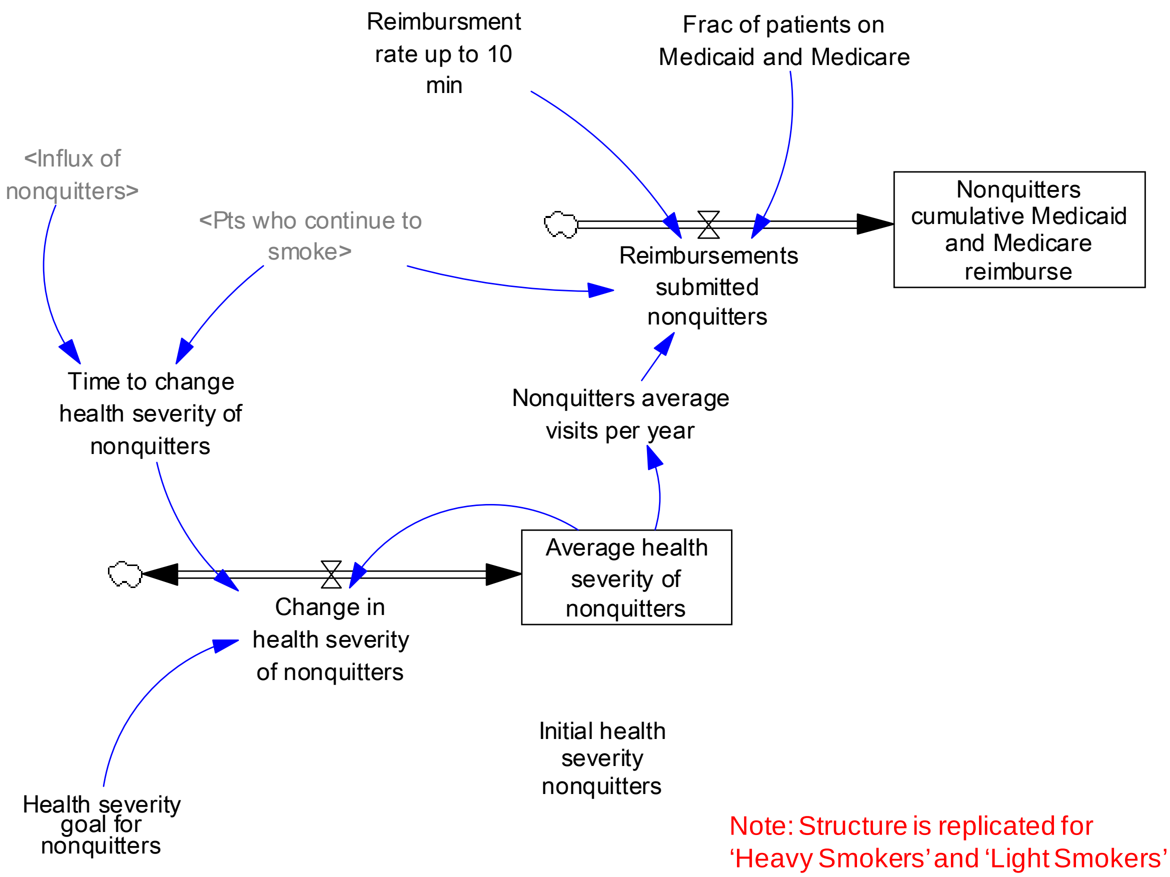


The dynamics of Quitters' Ambivalence are a function of the treatment mode that is employed by the provider. Simulated output shows how a more intensive intervention strategy fosters more patients quitting and extends the quitting episode (see Appendix: Ratio of Quitters to Relapsers by Strategy; Proportion of Quitter to Relapsers by Strategy).

Other features of the model include structures to simulate patients' change in 'health severity' as a function of their tobacco use status and the tendency for successful patients (i.e., those who have quit) to bring in new patients to the practice, via word of mouth. Finally, the model also simulates reimbursement via new Medicaid and Medicare provisions, for time spent counseling patients (see Figures 4 and 5).

These structures represent important feedback loops in the model that impressed participating physicians. The lesson learned was that helping patients quit was good for business, as patients who quit were more likely to remain under their care for a longer period of time, and, more importantly, ushered in new patients (see Appendix: Effect of New Patient Referrals by Quitters). More new patient visits translated into more stable practice environments, over time.

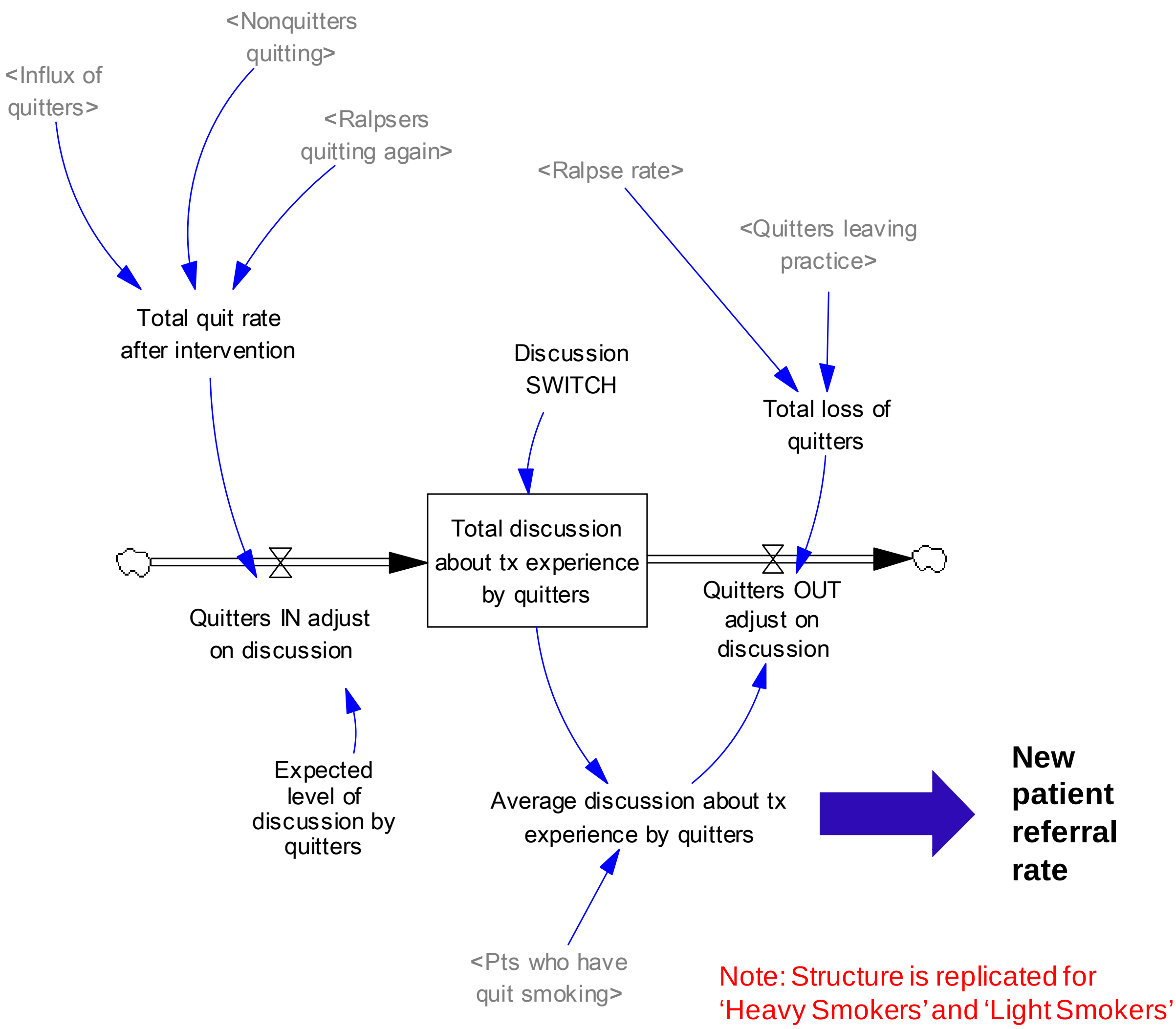
Figure 4 – Stock-and-Flow of Average Health Severity of Patients, Visits per Year, and Reimbursement from State-sponsored Medicaid and Medicare Programs



Simulation analyses of expected reimbursement from State-sponsored Medicaid and Medicare services in New York State were also modeled. Simulated output called attention to the fact that non-quitters and relapsers (see Appendix: Status of Patients who are Receiving Treatment; Reimbursement Rate Comparison), who comprised the largest numbers of tobacco patients in a practice, accounted for most of the reimbursement revenue generated for the practice. In addition, the model indicated that the health severity of patients who did not successfully quit was worse than those who did quit successfully. Hence, physicians inferred that health problems would likely translate into more office visits per year. The take home message here was that providers can benefit financially from working consistently with all tobacco patients.

Formative Assessment of the Simulation Tool. Testing of the model is on-going, although the current version has passed basic Verification tests, which are concerned with verifying that the structure and the parameters of the system have been correctly incorporated into the model; Legitimation tests, which affirm that the model follows commonly accepted principles or rules of system structure and dimensional checks (i.e., units of measurement or quantification of the variables on each side of equations are the same); and (3) Validation tests, which address the extent to which the simulated behavior of the model is like the actual 'real world' problem behavior it is intended to represent (Forrester and Senge 1980; Sterman 2000).

Figure 5 – Stock-and-Flow of ‘Word-of-Mouth’ Effect on Generation of New Patients Referrals by Patients who were Successful Quitters



We used a mixed (qualitative and quantitative) one-arm, pretest-posttest design to assess the utility of the tool for participating providers. Note that involvement by any given practice lasted approximately four months. To assess baseline level of implementation of office systems, we completed a practice profile with assistance from the practice administer during our initial planning meeting (M zero). In addition, at M1 Baseline and M3 Follow-up we asked the practice administrator or other staff member to conduct a rapid patient chart review to obtain objective evidence of tobacco screening and treatment practices among providers.

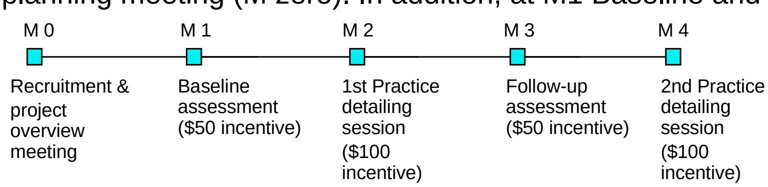
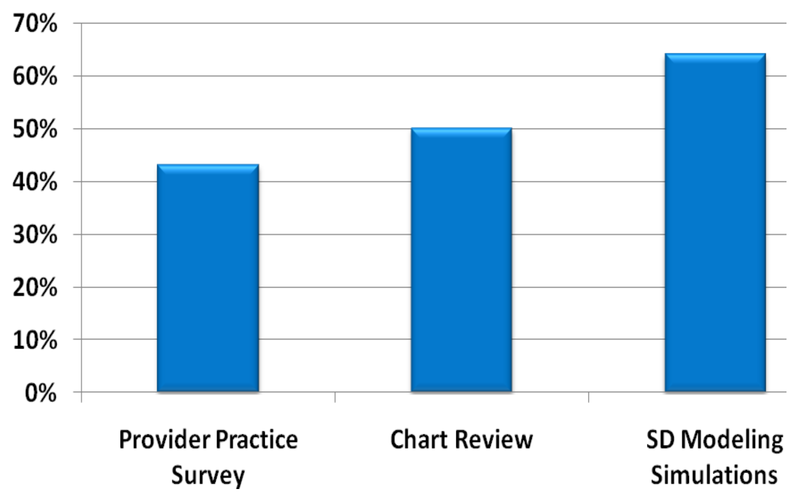


Figure 6 – Intervention Design

To determine the feasibility and acceptability of using the simulation tool, we analyzed discourse from each practice's academic detailing session (collected at M2 and M4) and from our project logbook entries throughout the study. An evaluation of the detailing sessions was completed by providers after each one was completed (see Figure 6).

Figure 7 – Comparison of Participating Providers' Preference for Feedback Format during Academic Detailing Sessions



Results indicate that providers found tailored simulation output to be a greater source of motivation than feedback about their self-reported practices or independent chart reviews (see Figure 7). The large majority of participating providers (93%) indicated that our office-based feedback sessions fostered a strong behavioral intent to enhance the way they addressed the needs of patients who used tobacco in their practice (see Table 4).

Our field experience indicates that simple behavior-over-time graphs easily capture the interest of participating providers. Moreover, results support that these graphs, when accompanied with brief explanatory text, appear to foster effective communication. We found that presentation of the stock-and-flow diagrams that comprise the system dynamics model were difficult to explain to participants, and time dedicated to this – which was on average limited to less than 20 minutes – seemed to dampen enthusiasm about the simulated output. However, some found that the graphs shown with a tiny, partial stock-and-flow figure overlay would be the most effective way to share results and build an understanding of the model structures that produce specific simulated data.

Table 3 – Preliminary Assessment of Intent to Enhance Tobacco Treatment Practices

Post Academic Detailing Session Evaluation (N=14)	%	N
Provider motivated to make changes in the practice	93%	13
Increased motivation to provide follow-up and counseling	57%	8
Increased motivation to encourage relapsers	50%	7
Encouraged to ensure that patients have easy access to tobacco treament	41%	6
Increased motivation to document use at every visit	36%	5
Encouraged to prescribe pharmacotherapy	36%	5
Motivated planning to educate staff	36%	5
Informed about ways to obtain reimbursement for counseling	29%	4
Promoted use of dedicated staff time for patient counseling/follow-up	29%	4
Encouraged to spend more time counseling patients	21%	3
Encouraged to generate own practices performance data	21%	3

Future Directions. Additional model development is under consideration, per input from our participating providers, such as: (1) Further disaggregation of patients (e.g., by ‘chronic’ vs. ‘non-chronic’ medical conditions or by adherence to meds); (2) Examination of the effect of subsequent ‘booster’ office visits (as the effect of only one visit is featured in the current model); (3) Examination of the effect of longer-term treatment sequelae (e.g., weight gain); (4) Examination of the effect of integrating other behavioral treatments (e.g., diet, exercise, alcohol consumption). The key question regarding whether or not to embellish on the existing version of the model is the following: How much complexity is sufficient to motivate practice change?

Based on the results of this formative fieldwork with urban, primary care providers, we conclude that system dynamics models are effective tools for communicating complexity to busy health care providers. There is a need for further research that assesses actual practice change, as the current study design was not able to detect more than an effect on behavioral intent to change. Also, time and effort required to facilitate office visits suggests the need to explore alternative ways to expose providers to the model, such as web-based platforms and more structured user interfaces.

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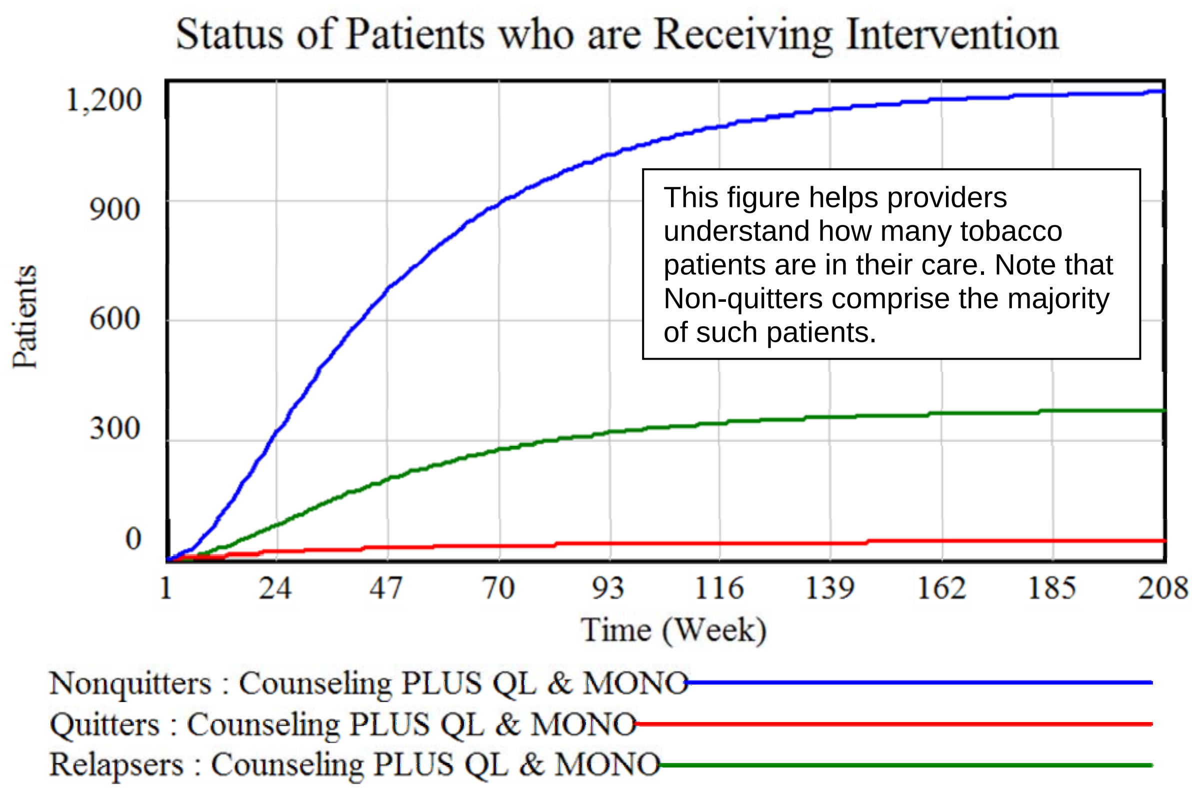
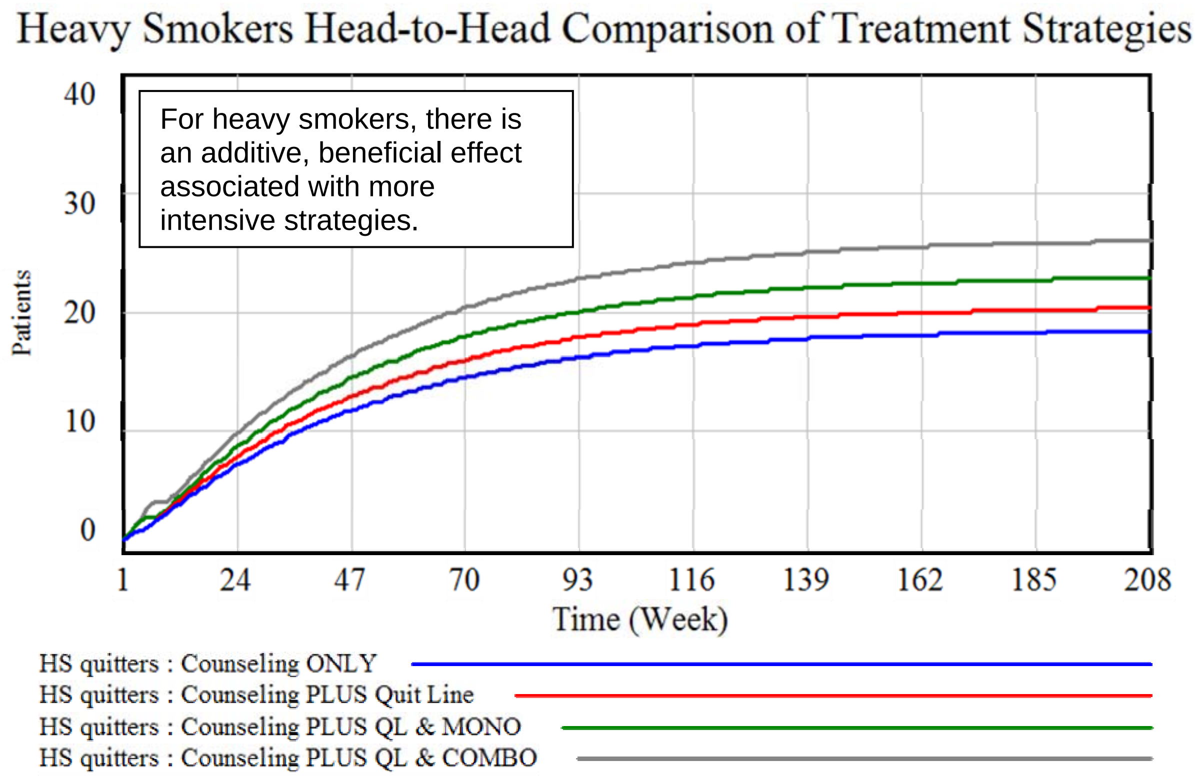
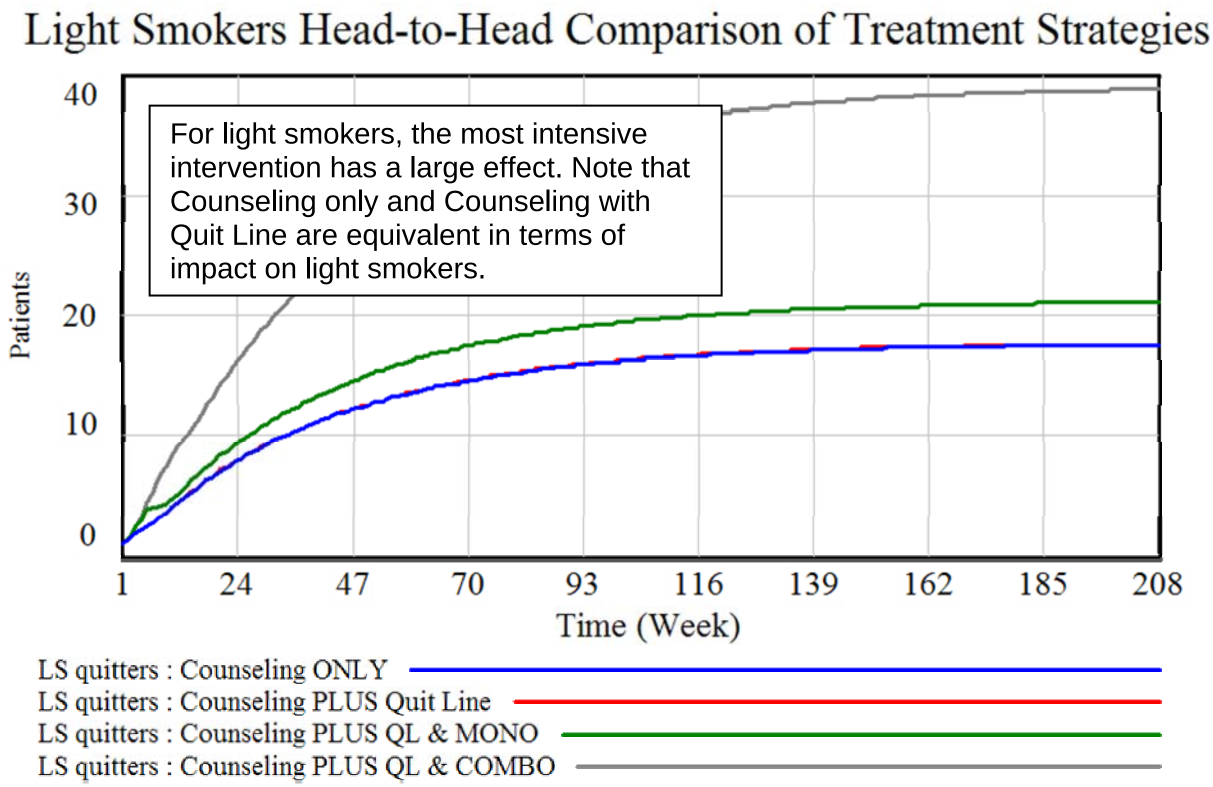
APPENDIX – Sample simulation output – Typical participating primary care practice



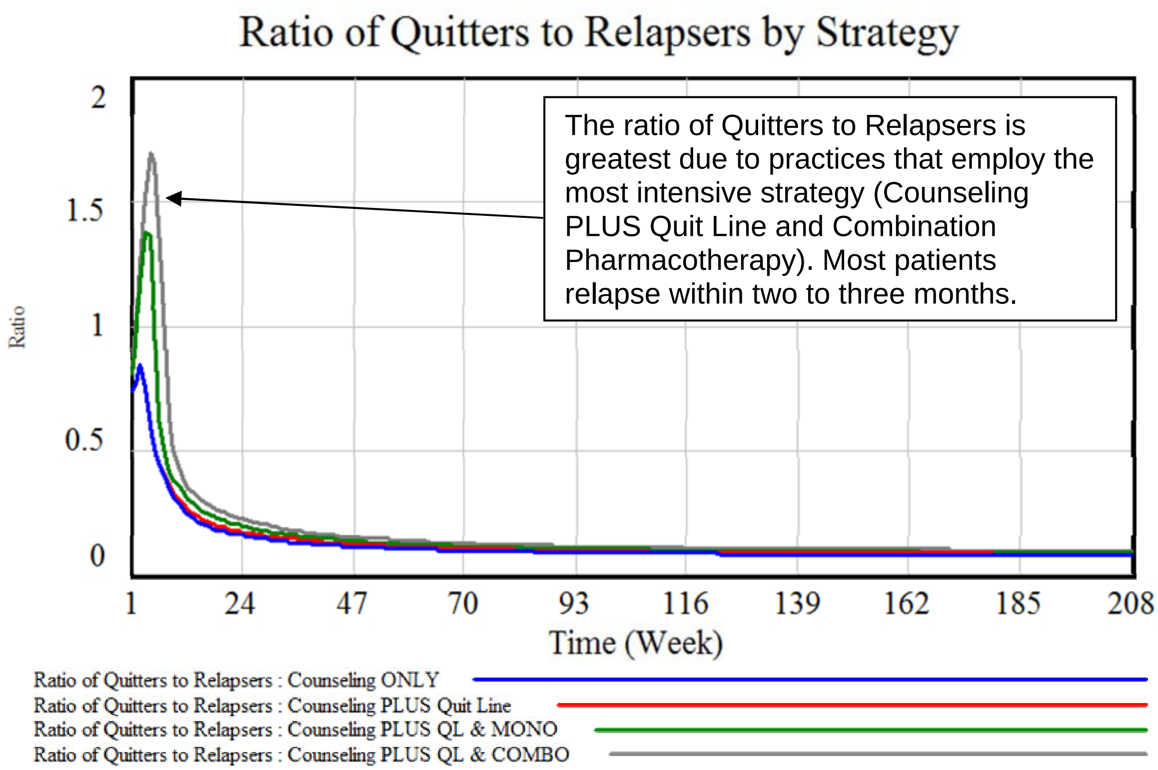
<u>Sample Simulation Output</u>: A Typical Primary Care Practice (18% smoking prevalence among new patients)



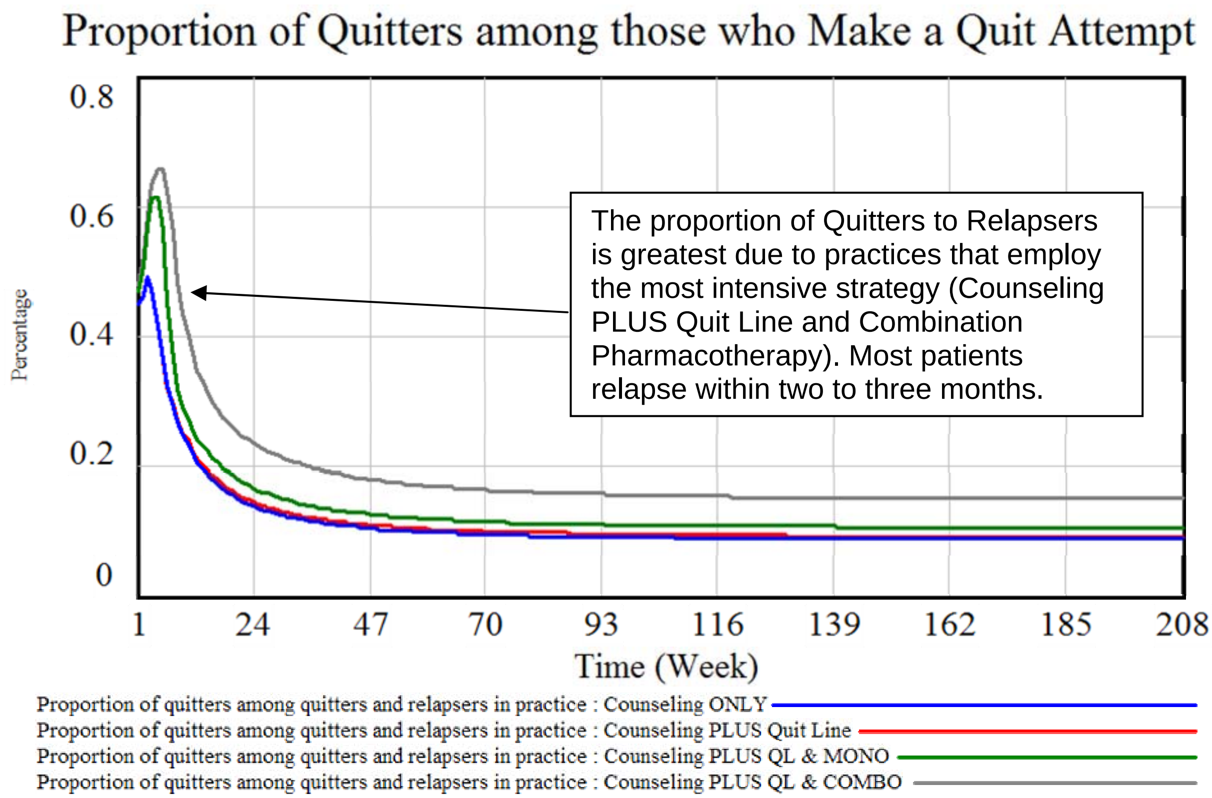
Sample Simulation Output: A Typical Primary Care Practice (18% smoking prevalence among new patients)



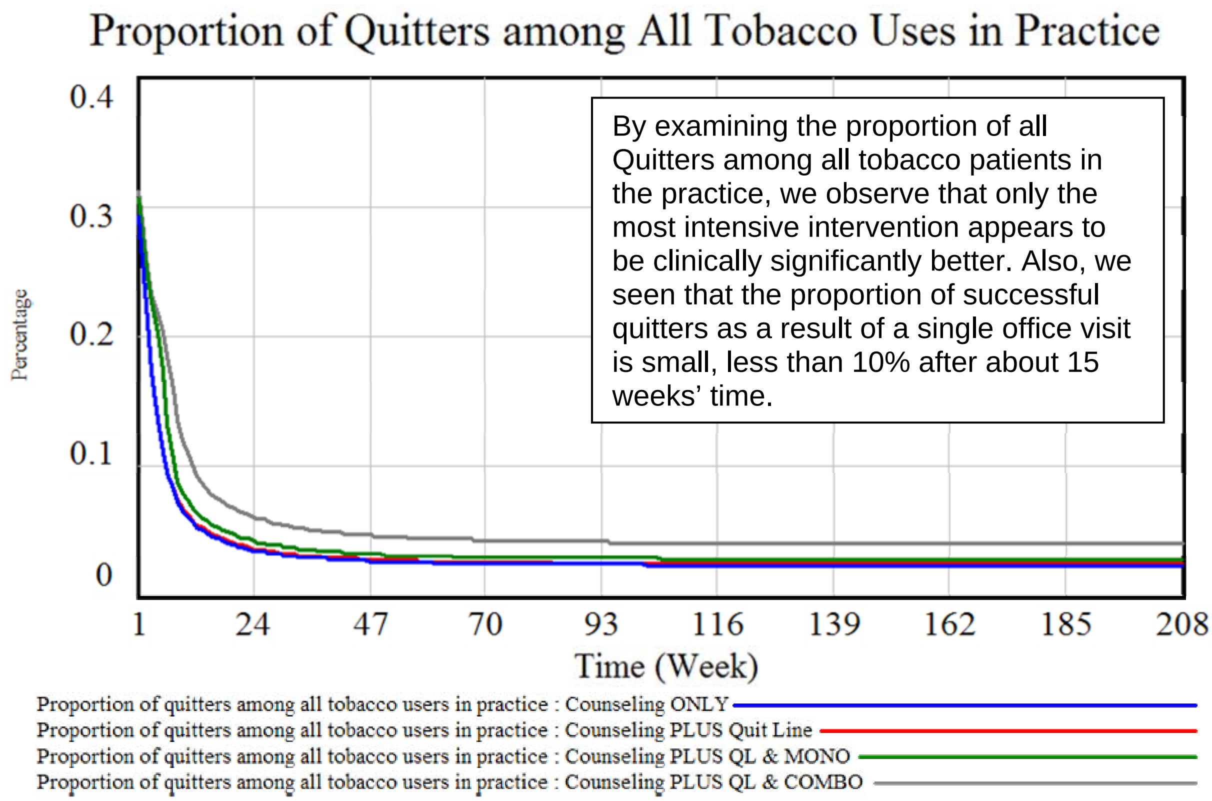
<u>Sample Simulation Output</u>: A Typical Primary Care Practice (18% smoking prevalence among new patients)



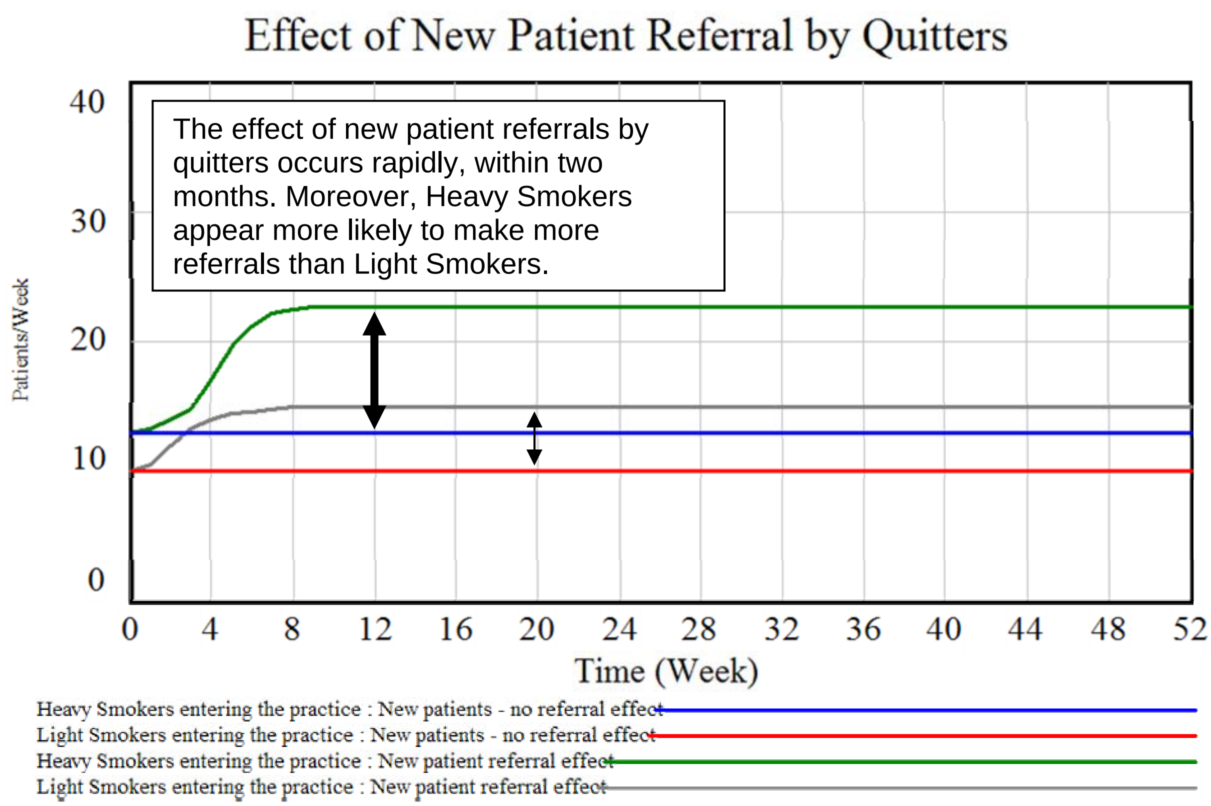
Sample Simulation Output: A Typical Primary Care Practice (18% smoking prevalence among new patients)



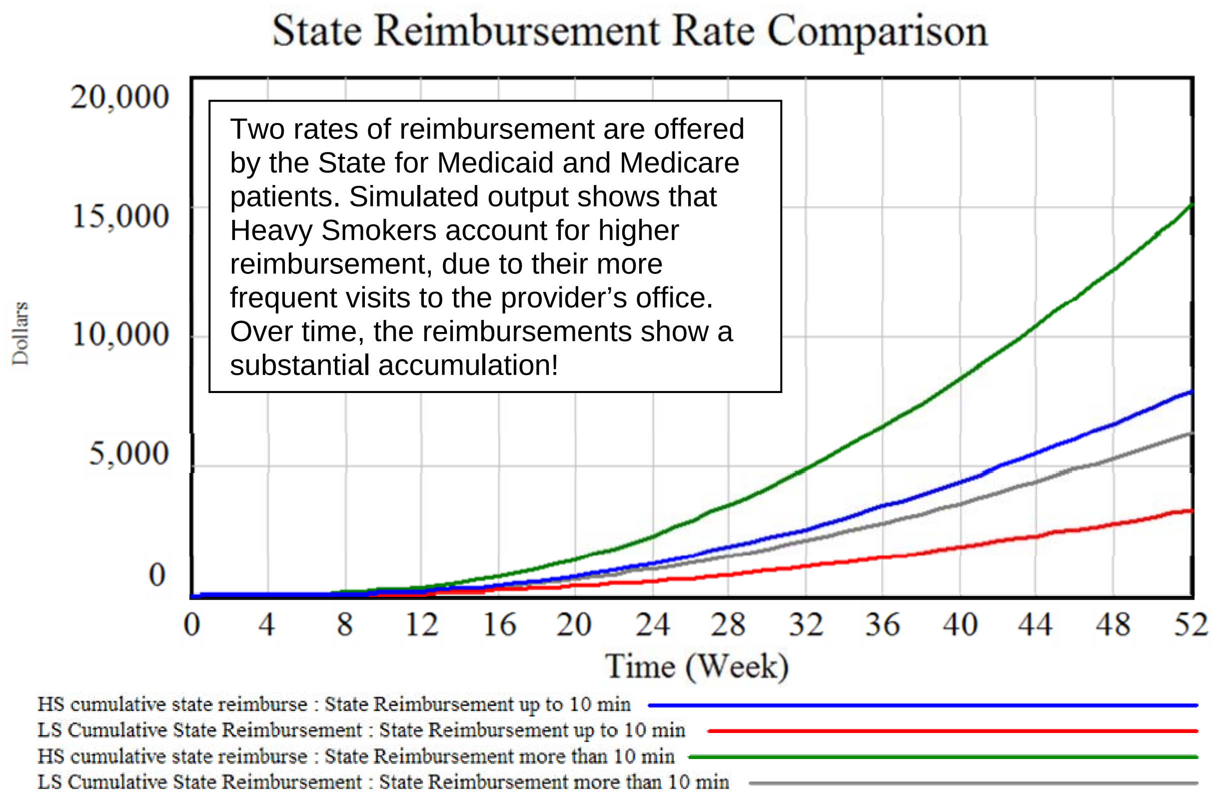
Sample Simulation Output: A Typical Primary Care Practice (18% smoking prevalence among new patients)



Sample Simulation Output: A Typical Primary Care Practice (18% smoking prevalence among new patients)



Sample Simulation Output: A Typical Primary Care Practice (18% smoking prevalence among new patients)



<u>Sample Simulation Output</u>: A Typical Primary Care Practice (18% smoking prevalence among new patients)