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Using the Internet to Assist Smoking Prevention and Cessation in Schools: A Randomized, Controlled Trial

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Objective: To evaluate the impact of a classroom-based, Web-assisted tobacco intervention addressing smoking prevention and cessation with adolescents. ***Design:*** A two-group randomized control trial with 1,402 male and female students in grades 9 through 11 from 14 secondary schools in Toronto, Canada. Participants were randomly assigned to a tailored Web-assisted tobacco intervention or an interactive control condition task conducted during a single classroom session with e-mail follow-up. The cornerstone of the intervention was a five-stage interactive Web site called the *Smoking Zine* (http://www.smokingzine.org) integrated into a program that included a paper-based journal, a small group form of motivational interviewing, and tailored e-mails. ***Main Outcome Measure:*** Resistance to smoking, behavioral intentions to smoke, and cigarette use were assessed at baseline, postintervention, and three- and six-month follow-up. Multilevel logistic growth modeling was used to assess the effect of the intervention on change over time. ***Results:*** The integrated *Smoking Zine* program helped smokers significantly reduce the likelihood of having high intentions to smoke and increased their likelihood of high resistance to continued cigarette use at 6 months. The intervention also significantly reduced the likelihood of heavy cigarette use adoption by nonsmokers during the study period. ***Conclusion:*** The *Smoking Zine* intervention provided cessation motivation for smokers most resistant to quitting at baseline and prevented nonsmoking adolescents from becoming heavy smokers at 6 months. By providing an accessible and attractive method of engaging young people in smoking prevention and cessation, this interactive and integrated program provides a novel vehicle for school- and population-level health promotion.

Keywords: Internet, smoking prevention, smoking cessation, adolescents, school-based interventions

The interactivity, appeal, and wide reach of the Internet enables the delivery of targeted, tailored, and responsive interventions to prevent illness and promote health in ways that were once unimaginable. Technologies like the World Wide Web and wireless phones have wide reach, providing opportunities to engage diverse populations in health promotion and deliver both general and focused interventions on demand. While attractive in theory, the evidence base illustrating the efficacy of electronic health (or eHealth) interventions in real-world settings remains thin. Challenges in developing Internet-enabled intervention trials are myriad, including the following: access (how to give all participants a similar experience), security and privacy (how to limit the intervention to participants, protect their rights, and avoid contamination), sampling (how to recruit and retain participants), and follow-up (how to track participants over time). Furthermore, it is important to find ways to explore novel technologies using a theory and evidence base that supports effective health behavior change interventions in different contexts.

This article describes the evaluation of a Web-based program for smoking prevention and cessation conducted in schools. Our study targeted cigarette smoking, the most preventable cause of illness on a population level, with adolescents as our focus. Adolescents are large users of Internet technologies (Lenhart, Madden, & Hitlin, 2005) and consumers of online health information (Gray, Klein, Noyce, Sesselberg, & Cantrill, 2005) and thus, represent an important population for understanding the impact of information technology tools on health behavior and outcomes.

Adolescence is a developmental stage characterized by gains in independence and opportunities to make life choices, such as the choice to try cigarettes, a behavior that can quickly transform into a lifelong habit or addiction (O'Laughlin et al., 2003, 2004). To

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achieve success in smoking prevention, interventions must be accessible, efficacious, cost-effective, and transportable. The Internet is an ideal medium for this task. In both Canada and the United States, over 90% of adolescents have regular access to the Internet and many use it as a key source for health information (Gray et al., 2005; Hanson, Derry, Resnick, & Richardson, 2003).

While Internet-enabled interventions have the potential to support behavior change, only a small number of studies have examined their impact on health outcomes (Griffiths, Lindenmeyer, Powell, Lowe, & Thorogood, 2006). Web-assisted tobacco interventions (WATIs) are one of the few areas in which high quality evidence exists. Feil, Noell, Lichtenstein, Boles, and McKay (2003) evaluated an online self-treatment cessation program among adults that contributed to 18% of smokers quitting—rates comparable with conventional face-to-face programs. Similar positive results were observed in trials conducted on other stand-alone WATI programs (Cobb, Graham, Bock, Papandonatos, & Abrams, 2005; Lenert et al., 2003) and in randomized trials comparing multiple WATI formats (Etter, 2005; Pike, Rabius, McAlister, & Geiger, 2007). However, these studies all focused on adults, and no comparable studies with young people have been published (Bader, Travis, & Skinner, 2007).

Our goal was to develop an intervention that could be adapted for multiple contexts with teenagers—the critical developmental period in which cigarettes are often first tried and the stage prior to young adulthood where cigarette rates are highest (over 25%, Health Canada, 2007). Over a decade of experience by Youth Voices Research (www.youthvoices.ca) working with adolescents has taught us that Web-based programs for health promotion are more engaging and likely to be adopted when combined with other approaches (Norman & Skinner, 2007; Skinner, 2002; Skinner, Biscope, & Poland, 2003a, Skinner, Biscope, Poland, & Goldberg, 2003b; Skinner, Maley, & Norman, 2006; Skinner et al., 1997). Internet-enabled programs provide behavioral assessments and tailored feedback, while offline programs can aid in integrating information gleaned from these tools. An integrated approach is ideal for schools, where classroom lessons increasingly incorporate mixed media (Cowan et al., 2004). The decision to design a program that was delivered in schools addressed issues of the digital divide, or the gap between those with and without access to new technology, due to the fact that every Canadian high school is network-enabled, and over 85% of students have daily access to the Internet at home or school (Corbett & Willms, 2002). The challenge for eHealth is less about the digital divide represented by access to information technology and more about how these tools aid learning and the literacies required to fully utilize them to their potential (Norman & Skinner, 2006; Underwood, 2007; Valdez & Duran, 2007).

The Internet component of the intervention featured a five-stage Web site called the *Smoking Zine* (http://www.smokingzine.org), which combines interactive quizzes and self-assessments with tailored feedback aimed at fostering resistance to pressures to smoke and promoting self-efficacy (see Table 1). For the school intervention, the *Smoking Zine* Web site is supplemented by paper-based journals in which students record their assessment scores from the Web site and use them in a short, group-based form of motivational interviewing (Miller & Rollnick, 2002) in a single classroom session. The intervention is supplemented with tailored e-mails sent to participants for 6 months after the intervention to remind them of their scores and invite them to repeat the *Smoking Zine* program online as needed. Tailored e-mails have been used in other WATI trials (Etter, 2005; Etter, le Houezec, & Landfeldt, 2003), producing encouraging results. This integrated intervention was developed with students, teachers, and school board curricu-

Table 1
Smoking Zine Web Site and Related Behavior Change Processes

Smoking Zine stage	Process/concept
1. Makin' Cents. Participants input the number of cigarette packs they smoke (or would smoke if they started) in one month. The market value of the cigarette packs is calculated into an annual total. Participants then spend this amount in a virtual shopping mall.	This stage is designed to raise consciousness of the cost of cigarettes purchases relative to other consumer goods.
2. It's Your Life. Participants complete a short assessment that asks about their smoking behavior (frequency, amount smoked), which enables the program's tailoring based on whether someone is a smoker, non-smoker, or an experimental/social smoker	This stage is both an assessment of smoking status and provides personalized feedback on the level of relative risk based on the results of the assessment, while increasing awareness of cigarette use behavior.
3. To Change or Not to Change. This quiz is tailored to the user's smoking status (identified in Step 2) and allows them to assess their readiness to change (quit or reduce smoking). In addition, youth assess the importance and their confidence in being able to change.	This stage assesses: (a) readiness (stage of change), (b) confidence (self-efficacy) and (c) importance (self-determination)
4. It's Your Decision. This section creates a decision balance that displays the pros and cons related to smoking and being smoke free. Upon completion users can see their thoughts about smoking and reasons to quit, reduce tobacco consumption or stay the same.	This stage examines the pros and cons of being a non-smoker versus being a smoker (Decision Balance). This process may help advance the user's readiness for change.
5. What Now? This section brings together the results from the previous stages in an easy to use and comprehensive format. For smokers ready to quit, the *Smoking Zine* will guide them in creating a personalized quit program. If the participant is not ready to quit, then the *Smoking Zine* will take them to the *Personal Forecast* quiz. The quiz looks at other areas of the person's life that may relate to their smoking behavior such as close relationships and availability of social support.	Identification of readiness, barriers and assets are core components for a successful change plan. This stage helps develop a quit plan including a specific date, method of cessation, support mechanisms, relapse prevention strategies and outcome rewards. (cognitive/behavioral change plan)

lum staff to meet Ontario provincial curriculum guidelines for both Health and Media Studies courses in grades 9, 10, and 11.

Multiple models and theories of health behavior change informed the intervention's design. Use of a multitheory approach has been shown to offer a more complete account for shifts in smoking behavior in adolescents (Collins & Ellickson, 2004) and better reflects the challenge of changing complex behaviors (Fishbein et al., 1992, 2001). The framework underlying this approach is called the Likelihood of Action Index (LAI) and is described in detail elsewhere (Skinner, 2002, chapter 7). The LAI posits that an individual is more likely to change as the number of behavior change conditions increase. These conditions include: a high perceived risk and susceptibility to health consequences; identification of more benefits than drawbacks to change; the knowledge and skills to change; and personal interest in change. It also included additional factors related to five key models of change: the Health Belief Model (Strecher & Rosenstock, 1997), Self-efficacy/Social–cognitive theory (Bandura, 1986, 1997), Self-determination theory (Deci, Eghrari, Patrick, & Leone, 1994; Deci & Ryan, 1985; Ryan & Deci, 2000), Transtheoretical Model and Stages of Change (Prochaska, DiClemente, & Norcross, 1992), and Theory of Reasoned Action/Planned Behavior (Montaño et al., 1997).

The intervention was evaluated by using a randomized trial, testing the hypotheses that those who complete the intervention, relative to a control condition, would report at posttest and three- and six-month follow-up:

(1) Increased *resistance* to smoking initiation/continuation

(2) Decreased behavioral *intentions* to smoke, and

(3) *Lower cigarette use* (30-day prevalence).

It was expected that participants exposed to the *Smoking Zine* intervention would report higher levels of resistance to cigarettes and smoking behavior, reduced intentions to smoke in the future, and report an overall reduction in cigarette use over the course of 6 months compared with those in the control condition. The aim of this study was to examine the short and midterm impact of an integrated, classroom-based program centered around an Internet module on adolescent smoking behavior.

Method

Participants

The study included 1,402 adolescents, with 211 (15%) assessed as smokers at baseline. Fifty-four percent ($N = 753$) were boys, due to a higher proportion of all-boys classes recruited into the study. Eighty-one classes were sampled from fourteen secondary schools in the Greater Toronto Area using a purposeful, stratified, and modified snowball sampling approach that included an initial strategic selection of schools to balance differences in school size, neighborhood (location), and unique characteristics (e.g., single-sex schools and special education programs) to reflect the diversity of the community and population. Schools that were interested in the study referred us to other schools that they believed fit our criteria, and this follow-up was conducted until an adequate sample was achieved. Schools received a modest stipend for participation.

Thirty-nine percent of students were in grade 9 ($N = 548$), 30% in grade 10 ($N = 418$), and 31% in grade 11 ($N = 436$). Participant ethno-cultural background was assessed by using a question modified from the Canadian census (Statistics Canada, 2006) that categorizes participants based on self-reported family heritage and geographic regions rather than racial background. As expected, our sample participants presented with a wide range of cultural identities with the highest number identifying as East Asian ($N = 220$, 16% of sample), Eastern European ($N = 218$, 16%), or Central Asian ($N = 172$, 12%). Two hundred thirty-five participants (17%) did not identify with any one cultural group. The distribution of cultural groups in the smoker sample was significantly different ($t(13) = 3.105$, $p < .001$) than the nonsmoker sample, with a higher proportion of smokers identifying with Eastern European or Mediterranean cultures. Those from Central Asian or African cultural groups were the least represented in the smoker sample.

Design and Procedures

A two-group repeated measures randomized control trial was conducted over six months (see Figure 1). Six months was the maximum amount of time permitted to conduct research over the school year due to the restrictions in access to schools during the start and end of the academic year. Participants were randomly assigned to each group by computer at the individual level with an algorithm using the PHP programming language. Smoking status was assessed at baseline by using a paper-based survey administered prior to randomization and the intervention. Smokers were categorized as those who had consumed more than two cigarettes in the past month and more than 100 cigarettes in a lifetime (Mills, Stephens, & Wilkins, 1994). The overall smoking rate in our sample was consistent with other population-based studies of adolescent smoking in the same region (Health Canada, 2004; Ontario Tobacco Research Unit, 2004).

Materials

Three key outcome variables were the focus of the analysis:

(1) *Resistance to smoking* a composite theoretical construct that includes measures of self-efficacy, attitudes toward smoking, readiness to change, and others;

(2) *Behavioral intention* to be smoke-free; and

(3) *Cigarette use*.

Outcomes were assessed by using the Likelihood of Action Scale for Smoking–Adolescents (LASS-A) developed for this study based on Skinner's (2002) Likelihood of Action framework described earlier. Nonrational aspects of adolescent decision-making were incorporated into the framework by inclusion of items informed by the Behavioral Willingness theoretical construct proposed by Gibbons and colleagues (Gibbons et al., 1995, 1998a, 1998b). A set of 26 items comprised the LASS-A based on the three outcome variables. The Resistance to Smoking subscale was comprised of 20 items. Item analysis produced an internal consistency reliability score of $\alpha = .82$, with test–retest reliability values ranging from $r = .86$ to .87, while intraclass correlations for the

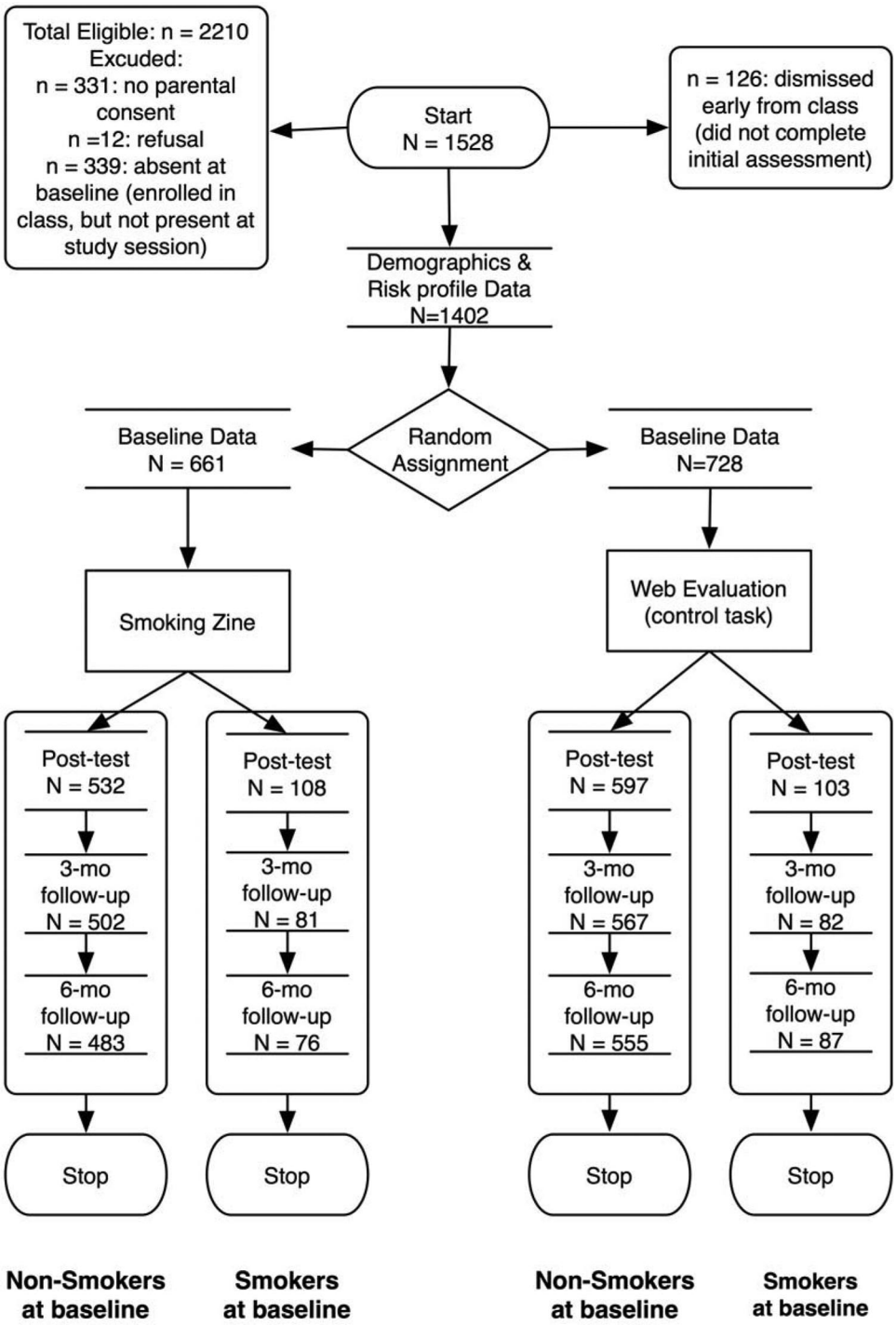

Figure 1. Participant allocation.

four measurements was $r = .72$, $F(576) = 11.11$, $p < .000$. Principal components analysis produced a strong single-factor structure accounting for 56% of the variance in the model with subscale to scale correlations ranging from .63 to .86. The three-item Behavioral Intention scale had an internal consistency of $\alpha = .81$, while test–retest reliability ($r = .83$ to .84) and the intraclass correlation coefficient on the four measures ($r = .65$) all indicated high levels of consistency within the scale. The three Cigarette Use items had correlations (Pearson's r) ranging from .66 to .80. Although the correlations among the items were high, the overall scale alpha was lower than the other two scales at $\alpha = .69$. Test–retest reliability regressions performed on the data from Time

1 to Time 3 and Time 3 to Time 4 responses produced *r* values of .73 and .78. The intraclass correlation coefficient on the cigarette use variable was .72.

In accordance with the a priori hypothesized structure of the likelihood of action model, a path analysis was conducted to determine the structural component of the model using MPlus (Muthén & Muthén, 2002). Structurally, it was hypothesized that the concept of resistance would act through behavioral intention to influence cigarette use behavior with some moderate direct influence between resistance and cigarette use. The model was fitted to the data as predicted. The fitted model and relationship between resistance, intention and cigarette use was consistent with our hypothesis, χ^2 (80) = 300.50, $p < .000$; see Figure 2). The measurement model had an excellent fit (comparative fit index [CFI] = 0.95).

Group Conditions

Intervention group. The intervention had four components designed around a central Internet program: (1) the *Smoking Zine* Web site, (2) accompanying paper journal, (3) small-group motivational interview, and (4) tailored follow-up e-mails. This intervention was designed to be a holistic program and thus, the influence of individual components was not evaluated. The first three components were delivered in a single 60-min class session, with e-mails sent once per month after the initial class. Table 1 summarizes the five interactive stages of the *Smoking Zine* Web site, which takes about 20 minutes to complete depending on adaptive branching. The *Smoking Zine* was originally developed in 1996 and has been enhanced several times using the Spiral Technology Action Research (STAR) process (Skinner et al., 2006), which incorporates participant feedback in iterative stages to elicit ideas, make program refinements, and evaluate outcomes throughout a program's life cycle.

Participants logged into the *Smoking Zine* with a unique, assigned username and password, which allowed us to track use of the Web site while providing a secure online environment restricted to registered users only. Participants recorded their Web site assessment scores in a paper-based journal, which was subsequently referred to during a 10-min small-group motivational interview after students completed the Web site. Groups were led by graduate-level counselors or public health nurses who had received two days of intensive training on the intervention protocol and motivational interviewing by the investigators (C.D.N. and H.A.S.).

Tailored e-mails were sent monthly between the initial classroom session and the three- and six-month follow-ups using a plain text e-mail sent by one of the investigators. Examples of the e-mail texts are located in the publications section of the Youth Voices Web site (www.youthvoices.ca). Tailoring was based on a participant's assessment results from the *Smoking Zine* including the following: participant's readiness to change, confidence to change, and reported intention to change scores. The e-mails were designed to support ongoing change and encourage return visits to the *Smoking Zine,* but were not expected to have a strong influence on behavior. Investigators were only able to determine whether an e-mail was delivered, not opened. Fewer than 5% of e-mail addresses were invalid.

Control group. Participants evaluated the quality of Web sites by using a tool developed by the investigators as the control task. The aim was to create an activity that would prompt similar levels of participant engagement without confounding the intervention. Participants reviewed three Web sites offering different perspectives on climate change. Like the *Smoking Zine* condition, participants used journals to record scores from the Web site task and also participated in small-group discussions on this topic. Care was taken to ensure that the external look and feel of the paper journals was identical between conditions. Control group participants received monthly generic follow-up e-mails discussing strategies for evaluating online information.

Implementation and Protocol Adherence

No serious implementation issues occurred during the trial. Three classes at one school were denied an opportunity to participate because of a server malfunction on the intervention day; otherwise, all other scheduled sessions proceeded problem-free. To ensure protocol adherence, the investigators or an appointed team leader monitored all aspects of the intervention implementation during each class session. Discussion group leaders completed a quality checklist after each group outlining how many points they covered in the 10-min discussions. Results indicate that nearly all of the seventeen recommended discussion points were covered in both smoker (M = 15.48, SD = 3.29) and nonsmoker groups (M = 16.01, SD = 1.65). The only substantive problem resulted from the suspension of expired air carbon monoxide (CO) measurements during the six-month follow-up when Toronto experienced the Severe Acute Respiratory Syndrome (SARS) outbreak (Basrur, Yaffe, & Henry, 2004; Varia et al., 2003), due to perceived health and safety concerns for participants and research

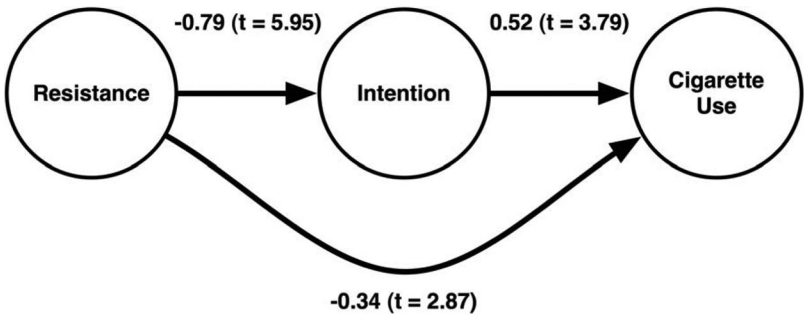

Figure 2. Likelihood of Action Scale for Smoking–Adolescents (LASS-A) measurement model.

Table 2
Summary of Key Significant Findings

	Resistance	Intention	Cigarette use
Nonsmokers at baseline	Maintained or increased the likelihood of high resistance for up to three-month follow-up (not significant)	Lower likelihood of high intentions to smoke at posttest (not significant)	Decreased likelihood of heavy cigarette use adoption at all follow-up measurements
Smokers at baseline	Increased likelihood of high resistance to continued cigarette use at all follow-ups	Lower likelihood of high intention to smoke at all follow-ups	No effect

staff alike. CO measurement served as a bogus pipeline for self-report and thus, discontinuation was not seen as a significant problem.

Study contamination was reduced through the use of an assigned, secure login to the *Smoking Zine* Web site for each participant. Participants could revisit the Web site at any time; however, server logs indicated that only 24 participants logged on to the Web site after the initial class session, with eight participants logging in on multiple occasions. This was not unexpected because students had little reason to revisit the site after the initial smoking message was received unless they felt their scores might change over time. Thus, even if intervention participants did share usernames and passwords with classmates from the control condition, the overall impact was minimal.

Data Collection and Management

The influence of missing data was minimized through an assertive tracking approach involving multiple visits to schools after scheduled data collection sessions, and working closely with teachers and school administrators who assisted the research team by contacting students in class or sending reminders home. Intensive procedures were used to find students absent at follow-up through collaboration with participating school officials, which resulted in high follow-up rates: 95% at postintervention, 89% at three-month follow-up, and 87% at six-month follow-up. The use of multilevel logistic regression models provided alternative strategies to deal with missing data that are comparable to estimation procedures, but rely on less data to effectively assess change over time (Little & Rubin, 1987).

The data formed a natural hierarchical structure with repeated measures on individuals, individuals as a part of classes, classes nested within grades, and grades within schools. Since other studies have found a strong effect of school and classroom or teacher (Cameron et al., 1999) on tobacco control interventions, these factors were taken into consideration in choosing the analytical strategy. It was hypothesized a priori that smokers and nonsmokers would have a different motivational structure with regard to cigarette use and its antecedents (resistance and intention), which were expected to produce a different response pattern and interaction with the intervention. Initial analysis of the data confirms such differences; the distributions between smokers and nonsmokers were not alike. The cigarette use scores and behavioral intention scores were highly skewed to the low end for nonsmokers but were spread more evenly across the entire range with more high scores among smokers. The resistance scores were skewed to the high end for nonsmokers while they were symmetrical distributed for smokers. The novelty of the intervention necessitated a detailed analysis of sex and grade-level

Table 3
Resistance and Behavioral Intention Two-Level Logistic Growth Models (All Four Time Points)

	Resistance		Intention	
	Estimate (*SE*)	Odds ratio	Estimate (*SE*)	Odds ratio
Level 1 (time)				
Constant	4.888 (1.104)*		−4.572 (1.247)*	
Time	−0.119 (0.045)*	0.887	0.264 (0.061)*	1.302
Level 2 (individual)				
Group (ref: control)	−0.157 (0.193)	0.854	0.489 (0.290)	1.630
Gender (ref: female)	−0.223 (0.111)*	0.800	−0.033 (0.128)	0.967
Smoker (ref: nonsmoker)	−3.340 (0.204)*	0.035	3.579 (0.203)*	35.837
Age	−0.241 (0.079)*	0.785	0.117 (0.089)	1.124
Grade 10 (ref: grade 9)	0.470 (0.153)*	1.599	0.330 (0.232)	1.390
Grade 11 (ref: grade 9)	1.113 (0.236)*	3.043	0.408 (0.386)	1.503
Group × Grade 10			−0.649 (0.301)*	0.522
Group × Grade 11			−0.768 (0.309)*	0.463
Intra-class interaction				
Group × Time	0.031 (0.065)	1.031	0.043 (0.079)	1.043
Grade11 × Time			−0.205 (0.086)*	0.814
Group × Smoker × Time	0.198 (0.097)*	1.2189	−0.202 (0.097)*	0.817

* Significant at $p < .05$.

Table 4
Cigarette Use Two-Level Logistic Growth Model (Posttest, Three Months, and Six Months)

	Cigarette use	
	Estimate (*SE*)	OR
Level 1 (Time)		
Constant	0.198 (0.506)	
Time	−0.177 (0.149)	0.837
Level 2 (individual)		
Group (ref: control)	−0.524 (0.621)	0.592
Gender (ref: female)	0.349 (0.178)	1.417
Nonsmoker (ref: smoker)	−7.358 (0.679)*	0.000
Grade 10 (ref: grade9)	0.413 (0.205)*	1.511
Grade 11 (ref: grade9)	0.863 (0.300)*	2.370
Intraclass interaction		
Group × Time	0.237 (0.203)	1.267
Nonsmoker × Time	1.298 (0.201)*	3.661
Group × Nonsmoker × Time	−0.242 (0.111)*	0.785
Nonsmoker × Grade 11 × Time	−0.345 (0.111)*	0.708

* Significant at $p < .05$.

effects and interactions given that age and gender effects can influence both Internet use and clinical response to an intervention. Analyses by ethno-cultural identity were not possible due to the small cell sizes of some populations and no reliable means of combining groups for further interpretation.

Model building. The descriptive analysis showed that scores on all three dependent variables deviated considerably from a normal distribution. Although the outcome variables were measured as continuous, the responses by the participants clearly showed distinct differences between the data distribution among those that smoked cigarettes and those that did not smoke at baseline, creating a distinct skew in the data set that could not be amended by transformation. To address this, scores were dichotomized at the midpoint for the behavioral score and the cigarette use score and at 0.8 for the resistance score to reflect high and low status. The rationale for using 0.8 for resistance rather than 0.5 reflected the skew of the data, for which 0.8 was a midpoint given the extent of the skew. Multilevel logistic regression models were used to handle the data using an iterative generalized least squares (IGLS) procedure with MLwiN 2.02 (Rasbash et al., 2000), which enabled parameter estimation with the proportion of variance explained at each level computed using formulas developed by Snijders and Bosker (1999). Using this approach, model development began with a null model, which allowed for the estimation of the proportion each level contributed to the total variation. The null model demonstrated the relative (unconstrained) influence of each potential level of the data on the outcome of interest. The additional levels corresponding to the influence at the individual, class and school were then developed from the null model to test the impact of *the Smoking Zine* program on the composite variable resistance, intention to smoke and cigarette use. Since there were only three grades, grade was not treated as a separate level. Instead, grade was included in the model as two indicator variables including grade 10 and grade 11 with grade 9 as the reference category.

Results

The initial modeling did not reveal a main effect attributed to the *Smoking Zine* program; however, multiple statistically significant cross-level interaction effects were detected. A test of the null model with four levels of structure (school, class, individual, and time) found no substantial influence of school and class on the model. Because these levels accounted for very little of the variance, they were dropped from further analyses. The absence of an effect in the null model indicated that any variability between classes or schools was attributable to differences between individuals rather than differences attributed to structural issues. Subsequent analyses only focused on individuals as a source of the difference attributed to the intervention.

Among the various models tested, a two-level model with Time (level 1) and Individual (level 2) provided the most parsimonious representation of the data, in which Time was treated as a continuous variable in models to control the overall longitudinal trends. This process did not reveal an overall main effect attributed to condition, but did detect specific cross-level interactions for smokers on resistance and behavioral intention and nonsmokers on cigarette use over the six-month period of the study. These interactions corresponded to specific tobacco use conditions, such as heavy smoking adoption (nonsmokers), or provided a booster effect with those who were most motivated to quit smoking (smokers). A synopsis of the key findings is given in Table 2. The reader is directed to additional tables, including the raw data scores and various other multilevel models tested at www.youthvoices.ca in the Publications section.

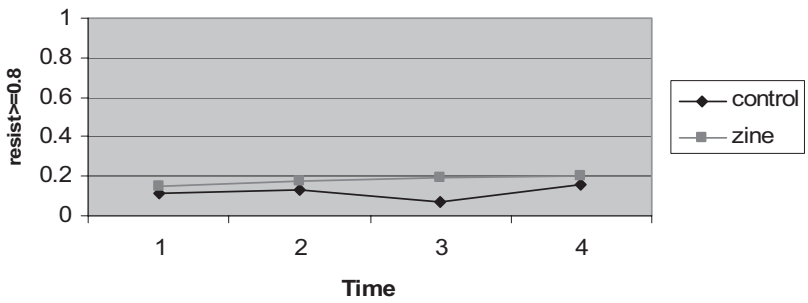

Figure 3. The overall proportion of high resistance (≥0.8) to continued cigarette use among all smokers at baseline over the course of the study.

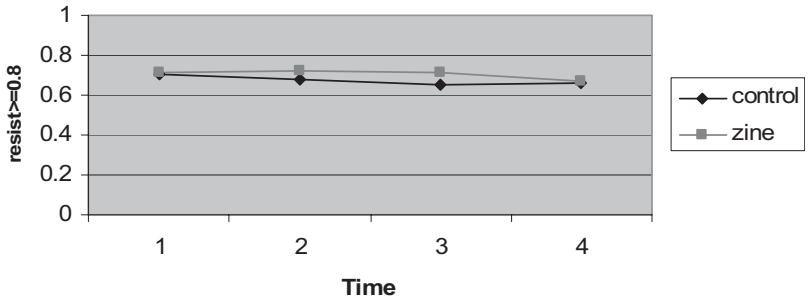

Figure 4. The overall proportion of high resistance (≥0.8) to continued cigarette use among grade 10 students over the course of the study.

Nonsmokers (85% of study participants). The intervention was successful at reducing the existing low levels of cigarette use over the course of the study. It decreased the likelihood of heavy cigarette use over the study period overall. No significant impact was detected on behavioral intention and resistance.

Smokers (15% of study participants). The intervention did not influence cigarette use but had a significant modifying effect on behavioral intention, which had an increasing trend over the course of six months, thus negatively influencing the likelihood of future cigarette use. The intervention also had a significant modifying effect on resistance to further tobacco use over the study period. The *Smoking Zine* had the greatest influence on those who reported a high level of intention to quit and resistance to smoking, which was most notable at three-month follow-up.

The significant findings are discussed further below with respect to the three dependent variables. Table 3 presents the findings of the logistic growth models for resistance and behavioral intention at each of the four measurement points, while Table 4 presents the models for cigarette use at each of the three measurement points where Time 2 (immediate postintervention) is used as the baseline measure given that no measurement was taken at Time 1 (preintervention).

1. Resistance to cigarette use. Table 3 illustrates the model building process and the significant effects of gender, age, grade and related interaction effects on both resistance and behavioral intention. Logistic growth modeling suggests that the intervention maintained the level of resistance to smoking throughout the study period among those who reported the highest baseline levels of resistance, compared with those in the control group for whom the proportion of high resistance decreased between posttest and three-month follow-up ($p < .05$) (see Figure 3). Students in grade 10 were the most influenced by the program (see Figure 4) relative to other grades indicating a potential effect of age on program response.

2. Behavioral intention to smoke. The intervention was most effective at influencing the intention to continue smoking among those classified as smokers at baseline compared with those in the control group for the duration of the study (see Figure 5). Notable differences in intention were evident at three-month follow-up, where there was a spike in the proportion of those with high intentions to smoke in the control condition and a continued decline among those in the *Smoking Zine* program condition. This difference was tested to be statistically significant ($p < .05$) in the model (see Table 3). No significant effects were detected among those classified as nonsmokers at baseline on intention to smoke.

3. Cigarette use. Multilevel analyses for cigarette use were based on posttest, three-month follow-up, and six-month follow-up only due to the fact that no shift was possible between baseline and postintervention. Among nonsmokers at baseline, some did initiate regular cigarette use over the course of the study. However, those who completed the intervention were less likely to adopt heavy smoking behavior than those in the control condition ($p < .05$), thus mediating the influence of current tobacco use (Table 4, Figure 6). Consistent with the findings on resistance and intention, students in grade 10 in the *Smoking Zine* condition were the most likely to respond to the intervention (see Figure 7).

In summary, the integrated *Smoking Zine* program provided a protective factor by significantly reducing the likelihood of smok-

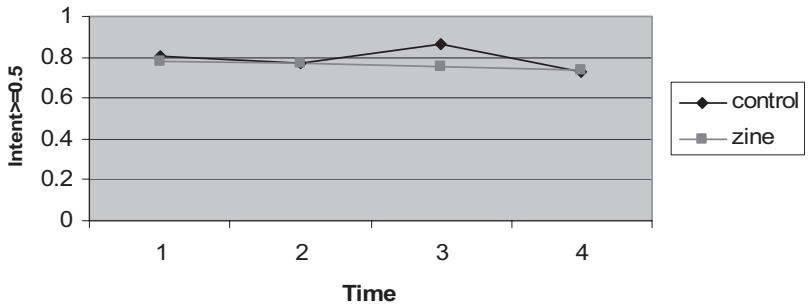

Figure 5. The overall proportion of those reporting high intentions to smoke (≥0.5) among smokers at baseline over the course of the study.

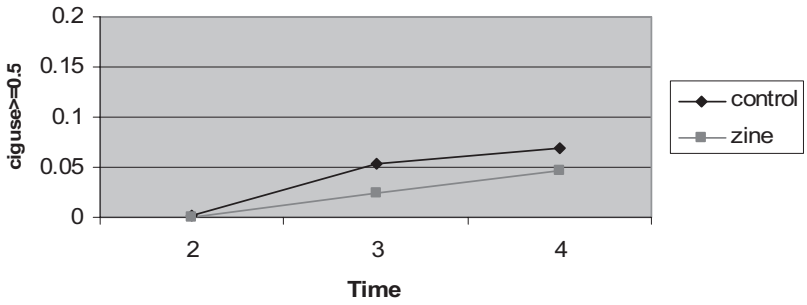

Figure 6. The overall proportion of heavy cigarette use adoption (≥0.5) among nonsmokers at baseline over the course of the study.

ers having high intentions to smoke and increasing the likelihood of high resistance to continued cigarette use. The program had a significant preventive effect for nonsmokers against heavy cigarette adoption throughout the study period.

Discussion

This study demonstrates that an intervention designed around a Web site supported by additional motivational components can be integrated into schools to support smoking cessation and prevention in an engaging manner. Through the use of multiple learning channels, the *Smoking Zine* was able to significantly reduce the likelihood that an adolescent would take up smoking over 6 months when compared with similar students in the control condition, especially with regard to adoption of heavy smoking. For cigarette users at baseline, the greatest benefit of the program was in sustaining motivation to resist further smoking and lowering intentions to smoke in the future. An intervention that has wide reach and efficacy, appeals to teachers and students alike, and is easy to implement and adapt to individual needs provides the greatest opportunity to influence population health (Glasgow, Vogt, & Boles, 1999). The free, Web-based format allows the *Smoking Zine* to contribute to population-level chronic disease prevention, school health, and tobacco control strategies immediately at virtually no cost to schools or public health officials if used independently.

This study adds to an emergent evidence base supporting the use of WATIs in advancing tobacco control (Japuntich et al., 2006; Mermelstein & Turner, 2006). By evaluating this intervention in Toronto, one of the most ethnically diverse cities in the world (http://www.toronto.ca/toronto_facts/diversity.htm, accessed 05/04/08), the results suggested that this intervention approach could be used with different cultural groups, although more research is necessary to investigate this possibility. To further enhance the program, the investigators have created the Virtual Classroom on Tobacco Control that integrates the *Smoking Zine* within an educational framework designed to promote learning about tobacco broadly (http://www.tiged.org/tobacco) as an option to the standalone Web site.

While the findings from this study of an integrated eHealth intervention are promising, certain limitations should be noted. School-based trials typically randomize classes; we chose to randomize participants at the individual-level because of the personalized nature of the intervention. Doing so introduced the possibility that students would share lessons learned with their peers, although randomization should control for this. Integrating the intervention into regular classroom activities potentially reduced its novelty and the likelihood of extramural discussion. Treating the program as an integrated whole limits our understanding of the contributions of the separate components of the program (Web site, booklet, discussion group, e-mail) on behavior. Another area worthy of consideration is the fact that fewer smokers completed the six-month trial compared with nonsmokers. A potential reason could be attributed to complications arising from increased engagement in risk behaviors among the smokers. Data not presented in this manuscript found that smokers engaged in higher risk health activities than nonsmokers (e.g., drug use) ($p < .05$), consistent with other studies

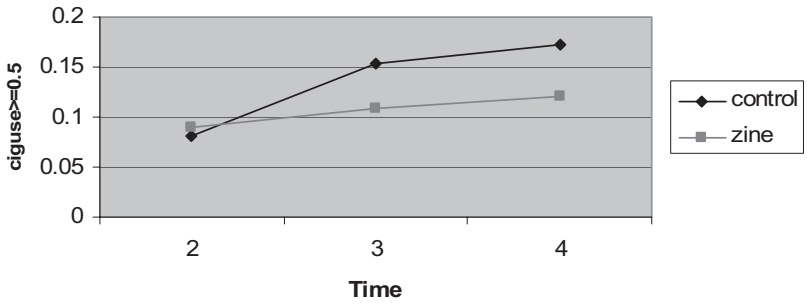

Figure 7. The overall proportion of heavy cigarette use adoption (≥0.5) among grade 10 students at baseline over the course of the study.

that suggest smoking may be part of a constellation of risk behavior (Allison, 1999; Crockett & Petersen, 1993; U.S. Centers for Disease Control and Prevention, 1999). These risk behaviors may have contributed to an increased absenteeism rate at school, making follow-up more difficult.

Additional research exploring the impact of the integrated *Smoking Zine* program on special populations, particularly with respect to smoker and nonsmoker differences, is required. One explanation for the differences we found between the two groups may be that the unique, nontraditional nature of this intervention disrupts the motivational system in those young people who may be most conditioned to seeing smoking prevention and cessation messages given that these "high-risk" youth are a target of much public health programming (Cameron et al., 1999). In providing a markedly different engagement strategy from other tobacco control programs, both in terms of style (Internet and mixed methods) and substance (promoting autonomous decision making vs. delivering an antismoking message), it is possible that the intervention was more likely to resonate with those who may have become desensitized to messages from other media. This cognitive "disruption" may align an individual's thinking with the larger set of social changes around tobacco use, strategies reflected in the emerging work on complex adaptive systems and human health (c.f., Glouberman, Enkin, Groff, Jadad, & Stern, 2006; Plsek & Greenhalgh, 2001), which include viewing addictive behavior itself as a system (West, 2006). The strongest impact with those in grade 10 may be attributed to the fact that this is the grade and age range (13–15 years) in which students have both wide exposure to cigarette use and sufficient income to purchase cigarettes, increasing the likelihood of smoking initiation (Statistics Canada, 2000).

Although it has been suggested that school-based prevention interventions are ineffective over the long-term (Glantz & Mandell, 2005; Wiehe, Garrison, Christakis, Ebel, & Rivara, 2005), our study suggests that a single-session intervention can influence behavior for at least six months, equivalent to two-thirds of a regular school year. By demonstrating an effect at six months, this research suggests that an integrated, technology-based intervention holds promise in delivering tobacco-related curriculum content for the duration of the school year, while providing a mechanism for preventing smoking in young people at the same time. The effect of the intervention was most noticeable at Time 3, when there was an increase in intentions to smoke and a lowering of resistance. This may have been attributed to the time of the three-month follow-up, which was within three weeks of first semester final exams; a time when stress is most likely elevated, which could influence resistance and smoking-related intentions. Although the overall effect size was small, the portability and low cost of the intervention makes for a higher likelihood of adoption (e.g., Rogers, 2003) and thus, a translation into a large population health effect.

This study demonstrates the importance of engaging students in health promotion strategies that go beyond traditional classroom instruction and school clinics, to an approach that involves media that students already use for health information (e.g., the World Wide Web) in a manner consistent with their values and interests (Skinner et al., 2006). It also provides evidence for the use of an integrated approach to behavioral eHealth programming in general and may encourage new ways of viewing how the Internet can aid tobacco control and health promotion programming more broadly. The integration of online and offline health behavior change tools, in formats that can be adapted to suit different contexts, moves us one step further toward creating a transportable, evidence-based approach to promoting population health; an approach that has the reach we desire and the cost savings we need to widely impact adolescent smoking adoption and cessation.

References

Allison, K. R. (1999). Predictors of health risk behaviours among young adults: Analysis of the National Population Health Survey. *Canadian Journal of Public Health, 89,* 85–89.

Bader, P., Travis, H., & Skinner, H. A. (2007). Knowledge synthesis of smoking cessation among employed and unemployed young adults. *American Journal of Public Health, 97,* 1434–1443.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Basrur, S. V., Yaffe, B., & Henry, B. (2004). Sars: A local public health perspective. *Canadian Journal of Public Health, 95,* 22–24.

Cameron, R., Brown, K. S., Best, J. A., Pelkman, C. L., Madill, C. L., Manske, S. R., et al. (1999). Effectiveness of a social influences smoking prevention program as a function of provider type, training method and school risk. *American Journal of Public Health, 89,* 1827–1831.

Cobb, N. K., Graham, A. L., Bock, B. C., Papandonatos, G., & Abrams, D. B. (2005). Initial evaluation of a real-world Internet smoking cessation system. *Nicotine & Tobacco Research, 7,* 207–216.

Collins, R. L., & Ellickson, P. L. (2004). Integrating four theories of adolescent smoking. *Substance Use & Misuse, 39,* 179–209.

Corbett, B. A., & Willms, J. D. (2002). Information and communication technology: Access and use. *Education Quarterly Review, 8,* 8–15.

Cowan, C., Ennis-Cole, D., & Hudson, J. (2004). Successful technology integration: Critical themes and practical illustrations. *Teacher Education and Practice, 17,* 14–28.

Crockett, L. J., & Petersen, A. C. (1993). Adolescent development: Health risks and opportunities for health promotion. In S. G. Millstein, A. C. Petersen, & E. O. Nightingale (Eds.), *Promoting the health of adolescents: New directions for the twenty-first century* (pp. 13–37). New York: Oxford University Press.

Deci, E., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: The self-determination theory perspective. *Journal of Personality, 62,* 119–142.

Deci, E., & Ryan, R. (1985). The general causality orientation scale: Self-determination in personality. *Journal of Research in Personality, 19,* 109–134.

Etter, J.-F. (2005). Comparing the efficacy of two internet-based, computer-tailored smoking cessation programs: A randomized trial. *Journal of Medical Internet Research, 7,* e2.

Etter, J-F., le Houezec, J., & Landfeldt, B. (2003). Impact of messages on concomitant use of nicotine replacement therapy and cigarettes: A randomized trial on the internet. *Addiction, 98,* 941–950.

Feil, E. G., Noell, J., Lichtenstein, E., Boles, S. M., & McKay, H. G. (2003). Evaluation of an internet-based smoking cessation program: Lessons learned from a pilot study. *Nicotine & Tobacco Research, 5,* 189–194.

Fishbein, M., Bandura, A., Triandis, H. C., Kanfer, F. H., Becker, M. H., & Middlestadt, S. E. (1992). *Factors influencing behavior and behavior change: Final report—a theorist's workshop.* Rockville, MD: NIMH.

Fishbein, M., Hennessy, M., Kamb, M., Bolan, G. A., Hoxworth, T., Iatesta, M., et al. (2001). Using intervention theory to model factors

influencing behavior change: Project respect. *Evaluation and the Health Professions, 24,* 363–384.

Gibbons, F. X., & Gerrard, M. (1995). Predicting young adults' health risk behavior. *Journal of Personality and Social Psychology, 69,* 505–517.

Gibbons, F. X., Gerrard, M., Blanton, H., & Russell, D. W. (1998). Reasoned action and social reaction: Willingness and intention as independent predictors of health risk. *Journal of Personality and Social Psychology, 74,* 1164–1180.

Gibbons, F. X., Gerrard, M., Ouellette, J. A., & Burzette, R. (1998). Cognitive antecedents to adolescent health risk: Discriminating between behavioral intention and behavioral willingness. *Psychology and Health, 13,* 319–339.

Glantz, S. A., & Mandell, L. L. (2005). Since school-based tobacco prevention programs do not work, what should we do? *Journal of Adolescent Health, 36.*

Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: The RE-AIM framework. *American Journal of Public Health, 89,* 1322–1327.

Glouberman, S., Enkin, M., Groff, P., Jadad, A. R., & Stern, A. (2006). Entrenched health care practices and complex systems. *Australian Health Review, 30,* 7–11.

Gray, N. J., Klein, J. D., Noyce, P. R., Sesselberg, T. S., & Cantrill, J. A. (2005). Health information-seeking behaviour in adolescence: The place of the internet. *Social Science & Medicine, 60,* 1467–1478.

Griffiths, F., Lindenmeyer, A., Powell, J., Lowe, P., & Thorogood, M. (2006). Why are health care interventions delivered over the Internet? A systematic review of the published literature. *Journal of Medical Internet Research, 8,* e10.

Hanson, D. L., Derry, H. A., Resnick, P. J., & Richardson, C. R. (2003). Adolescents searching for health information on the internet: An observational study. *Journal of Medical Internet Research, 17,* e25.

Health Canada. (2004). Canadian tobacco use monitoring survey (ctums): Summary of results 2003. Retrieved April 3, 2008, from http://www.gosmokefree.ca/CTUMS

Health Canada. (2007). *Canadian Tobacco Use Monitoring Survey (2006*). Retrieved April 3, 2008, from http://www.gosmokefree.ca/CTUMS

Japuntich, S. J., Zehner, M. E., Smith, S. S., Jorenby, D. E., Valdez, J. A., Fiore, M. C., et al. (2006). Smoking cessation via the Internet: A randomized clinical trial of an Internet intervention as adjuvant treatment in a smoking cessation intervention. *Nicotine & Tobacco Research, 8,* S59–S68.

Lenert, L., Munoz, R. F., Stoddard, J., Delucchi, K., Bansod, A., Skoczen, S., et al. (2003). Design and pilot evaluation of an Internet smoking cessation program. *Journal of the American Medical Informatics Association, 10,* 16–20.

Lenhart, A., Madden, M., & Hitlin, P. (2005). *Teens and technology: Youth are leading the transition to a fully wired and mobile nation.* Washington, DC: Pew Internet & American Life Project.

Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data.* New York: Wiley.

Mermelstein, R., & Turner, L. (2006). Web-based support as an adjunct to group-based smoking cessation for adolescents. *Nicotine & Tobacco Research, 8,* S69–S76.

Miller, W. R., & Rollnick, S. (2002). *Motivational interviewing: Preparing people for change* (2nd ed.). New York: Guilford Press.

Mills, C., Stephens, T., & Wilkins, K. (1994). Summary report of the workshop on data for monitoring tobacco use. *Chronic Diseases in Canada, 15,* 105–110.

Montaño, D. E., Kasprzyk, D., & Taplin, S. h. (1997). The theory of reasoned action and the theory of planned behavior. In K. Glanz, F. M. Lewis & B. K. Rimer (Eds.), *Health behavior and health education* (pp. 85–112). San Francisco, CA: Jossey-Bass.

Muthén, B. O., & Muthén, L. K. (2002). *Mplus* (Version 2.14). Los Angeles: Muthén & Muthén.

Norman, C. D., & Skinner, H. A. (2006). eHealth literacy: Essential skills for consumer health in a networked world. *Journal of Medical Internet Research, 8,* e9.

Norman, C. D., & Skinner, H. A. (2007). Engaging youth in eHealth promotion: Lessons learned from a decade of TeenNet Research. *Adolescent Medicine: State of the Art Reviews: E-Health, 18(2).* Washington, DC: American Academy of Pediatrics.

Ontario Tobacco Research Unit. (2004). *OTS progress and implications, 2002–3*. Toronto, ON: Ontario Tobacco Research Unit.

O'Laughlin, J., DiFranza, J., Tyndale, R. F., Meshefedjian, G., McMillan-Davey, E., Clarke, P. B., et al. (2003). Nicotine-dependence symptoms are associated with smoking frequency in adolescents. *American Journal of Preventive Medicine, 25,* 219–225.

O'Laughlin, J., Paradis, G., Kim, W., DiFranza, J., Meshefedjian, G., McMillan-Davey, E., et al. (2004). Genetically decreased CYP2A6 and the risk of tobacco dependence: A prospective study of novice smokers. *Tobacco Control, 13,* 422–428.

Pike, K. J., Rabius, V., McAlister, A. L., & Geiger, A. (2007). American Cancer Society's QuitLink: Randomized trial of Internet assistance. *Nicotine & Tobacco Research, 9,* 415–420.

Plsek, P. E., & Greenhalgh, T. (2001). Complexity science: The challenge of complexity in health care. *British Medical Journal, 323,* 625–628.

Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of how people change: Applications to addictive behaviors. *American Psychologist, 47,* 1102–1114.

Rasbash, J., Browne, W., Goldstein, H., Yang, M., Plewis, I., Healy, M., et al. (2000). *MLwiN* (Version 2.14) [statistical software]. London: Multilevel Models Project.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55,* 68–78.

Skinner, H. A. (2002). *Promoting health through organizational change.* San Francisco: Benjamin Cummings.

Skinner, H. A., Biscope, S., & Poland, B. (2003a). Quality of internet access: Barrier behind internet use statistics. *Social Science & Medicine, 57,* 875–880.

Skinner, H. A., Biscope, S., Poland, B., & Goldberg, E. (2003b). How adolescents use technology for health information: Implications for practitioners. *Journal of Medical Internet Research, 5,* e32.

Skinner, H. A., Maley, O., & Norman, C. D. (2006). Developing internet-based ehealth promotion programs: The spiral technology action research (STAR) model. *Health Promotion Practice, 7,* 1–12.

Skinner, H. A., Morrison, M., Bercovitz, K., Haans, D., Jennings, M. J., Magdenko, L., et al. (1997). Using the internet to engage youth in health promotion. *International Journal of Health Promotion & Education, IV,* 23–25.

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic and advanced multilevel modeling.* London: Sage.

Statistics Canada (2000). *Canadian Community Health Survey.* Ottawa, ON: Government of Canada.

Statistics Canada (2006, April). Canada's ethnocultural portrait: The changing mosaic. Retrieved October 10, 2007 from http://www12.statcan.ca/english/census01/products/analytic/companion/etoimm/canada.cfm

Strecher, V. J., & Rosenstock, I. M. (1997). The health belief model. In K. Glanz, D. Lewis, & B. K. Rimer (Eds.), *Health behavior and health education: Theory, research and practice* (2nd ed., pp. 41–59). San Francisco: Jossey-Bass.

Underwood, J. D. M. (2007). Rethinking the digital divide: Impacts on student-tutor relationships. *European Journal of Education, 42,* 213–222.

U.S. Centers for Disease Control and Prevention. (1999). *Youth Risk Behavior Surveillance Survey.* Atlanta, GA: Author.

Valdez, J. R., & Duran, R. (2007). Redefining the digital divide: Beyond access to computers and the Internet. *The High School Journal, 90,* 31–44.

Varia, M., Wilson, S., Sarwal, S., McGeer, A., Gournis, E., Galanis, E., et al. (2003). Investigation of a nosocomial outbreak of severe acute respiratory syndrome (SARS) in Toronto, Canada. *Canadian Medical Association Journal, 169,* 285–292.

West, R. (2006). *Theory of addiction.* Oxford, United Kingdom: Blackwell Publishing & Addiction Press.

Wiehe, S. E., Garrison, M. M., Christakis, D. A., Ebel, B. E., & Rivara, F. P. (2005). A systematic review of school-based smoking prevention trials with long-term follow-up. *Journal of Adolescent Health, 36,* 162–169.