A Comparison of the Stages of Smoking Acquisition versus Susceptibility as Predictors of Smoking Initiation in Adolescents

By

Minnie Victoria Huang, MD

A Masters Thesis

Presented to the Department of Public Health and Preventive Medicine
and Oregon Health & Science University School of Medicine
in partial fulfillment of the requirements for the degree of
Master of Public Health
December 2002

School of Medicine

Oregon Health & Science University

Certificate of Approval

This is to certify that the MPH thesis of

Minnie V. Huang, MD

Has been approved

[redacted]

Professor in charge of thesis

[redacted]

Member

[redacted]

Member

Table of Contents

ACKNOWLEDGEMENTS

Thanks to the following individuals who helped to make this study possible:

The committee members for their guidance and review of the thesis and defense: Donald Austin, MD, MPH, Jack Hollis, Ph.D., and Jodi Lapidus, Ph.D.

The Teen REACH study investigators for allowing me access to their data for this research project: Jack Hollis, Ph.D., Michael Polen, MA, Ed Lichtenstein, Ph.D., Evelyn Whitlock, MD, MPH.

David Hickam, MD, MPH and the Faculty of the Department of General Medicine at Oregon Health & Science University and the Portland Veterans' Affairs Medical Center for their support, guidance, and encouragement in this project.

Michael Polen, MA, Xiuhai Yang, MS, Kristine Funk, MS, Carla Green Ph.D., Selvi Williams, MD, and the staff of the Kaiser Permanente Center for Health Research for computer and program support.

My husband Michael Maris, MD, for his unwavering and enthusiastic support throughout this research project.

ABSTRACT

Tobacco use is the leading preventable cause of death and disease in the United States, with approximately 430,000 deaths attributed to cigarette smoking each year. Roughly 80% of adult smokers began smoking in adolescence. Many socio-demographic risk factors and behavioral models for smoking initiation in adolescence have been identified, but it is unclear which best predict the establishment of regular smoking patterns. The stage of change theory, which has been widely used in tobacco cessation efforts in adults, has been extended to involve smoking acquisition behaviors in adolescents. Its value in identifying adolescents who will become smokers remains unclear. Susceptibility to smoking has also been described in the literature as a predictor for subsequent smoking in adolescence. Susceptibility to smoking is defined as the absence of a firm decision not to smoke. It identifies adolescents who are cognitively predisposed to smoking. Recent research suggests that susceptibility and the stages of acquisition may be interrelated.

The purpose of this retrospective cohort study was to evaluate the socio-environmental factors associated with the stages of acquisition and susceptibility to determine which factors can best identify adolescents who will become smokers. I utilized data from a randomized controlled trial of a primary care based intervention to reduce the prevalence of smoking in a health maintenance organization. The subjects were adolescents (n=1955) ages 14-17 who reported never smoking cigarettes regularly. Independent variables included gender, demographics, susceptibility, stage of acquisition, a combined measure of susceptibility and the stages of acquisition, body mass index, educational aspirations, exercise frequency,

weight loss attempts, reported depressed mood, and number of friends/household members who smoke. The dependent variable was thirty-day smoking prevalence at two-year follow-up (89.6% response rate). When susceptibility and the stages of acquisition were combined into a single measure, logistic regression odds ratios (OR: 95% CIs) were as follows: precontemplation and susceptible (2.21: 1.57, 3.10), contemplation (6.24: 3.84, 10.13) or preparation (9.71: 5.51, 17.10) for smoking onset versus precontemplation and not susceptible. Depending upon the covariates used, the odds ratios for susceptibility ranged from two to three times that of nonsusceptible subjects. The odds ratios for the stages of acquisition ranged from three to nearly five for contemplation, and from nearly five to eight times for preparation, versus precontemplation. Other logistic regression predictors of smoking included race (white), having educational aspirations less than graduate school, and having friends who smoke. These findings suggest that acquisition stage and susceptibility are independent predictors of smoking onset that may be used together to target teens for smoking prevention efforts.

A Comparison of the Stages of Smoking Acquisition versus Susceptibility as Predictors of Smoking Initiation in Adolescence

BACKGROUND/SIGNIFICANCE

Tobacco use is the leading preventable cause of death and disease in the United States. Approximately 430,000 deaths are attributed to cigarette smoking each year (1). In addition, the direct medical costs associated with smoking were more than $50 billion, or about seven percent of the total cost of health care in the United States in 1997. Lost earnings and productivity cost an additional $47 billion annually (2). The prevalence of cigarette smoking nationwide among high school students increased during the 1990s, peaked in 1996-1997 at 36.4%, and then began a gradual decline to 28.5% by 2001 (3, 4, 5).

Based on data from the National Health Interview Surveys from 1965-1988, Pierce and Gilpin (6) estimated the median age of smoking cessation for young smokers born between 1975-1979 to be 33 years for males and 37 years for females. Thus, based on a median age of smoking initiation of 16-17 years, 50% of these adolescent males may smoke for at least 16 years and 50% of these adolescent females may smoke for at least 20 years. In addition, the vast majority of adult smokers (roughly 80%) started using tobacco as teenagers. This finding suggests that if adolescents can be kept tobacco-free, most will never start using tobacco. The CDC has estimated that 70% of smokers (33.2 million) want to quit, but only 2.5% (1.2 million) per year succeed in quitting smoking permanently (7).

The United States Department of Health and Human Services (USDHHS) aims to halve the prevalence of smoking in the United States as described in Healthy People 2010 (7). Suggested methods include: implementing effective prevention/cessation programs, changing physician behaviors, increasing coverage for the treatment of nicotine addiction, enforcing stringent clean indoor air regulations, increasing tobacco excise taxes, and changing the social environment to decrease cultural acceptance of tobacco abuse.

As the majority of adult smokers initiated smoking in their adolescent years, this population is worthy of further consideration and focus. Specifically, preventive efforts targeting adolescents who are at risk for becoming adult smokers might help to stem the tide of tobacco use and its concomitant morbidity and mortality. This is supported by a recent systematic assessment by Coffield *et al* assessing the values of clinical preventive services recommended for average risk patients by the United States Preventive Services Task Force (8). Coffield *et al* assessed services based on two dimensions---burden of disease prevented by each service and cost effectiveness. They found that offering adolescents an anti-tobacco message or advice to quit is one of the eight highest priority services with the lowest delivery rates ($\leq$50% nationally). Other services included providing tobacco cessation counseling to adults and counseling adolescents on alcohol and drug abstinence (8).

The 2000 Surgeon General's report noted that school-based social influences programs have significant and substantial short-term impacts on smoking behavior. Those

programs with more frequent educational contacts during the critical years for smoking adoption are more likely to be effective as are programs that address a broad range of educational needs. The smoking prevention effects of strong school programs can be extended through the end of high school or longer when combined with relatively intensive efforts directed through other powerful channels. Such channels include strategies that vigorously engage the influences of parents, the mass media, and other elements of adolescents' social environments (7, 9).

Identifying adolescents who are at greater risk for becoming regular smokers for more intensive prevention efforts may increase the effectiveness and cost effectiveness of these programs. The difficult task is identifying those adolescents who are at greater risk for initiation of regular smoking patterns that may persist into adulthood. If a "higher risk" population can be identified, then targeted educational, behavioral and social interventions may be enacted more efficiently in an effort to prevent tobacco use initiation and perpetuation.

Many investigators have undertaken the task of identifying "risk factors" for smoking initiation in adolescents. A review by Lamkin and Houston found that these include direct social influences from peers and family members and indirect social influences from media and tobacco advertising (10). Parental smoking, friends' smoking and cigarette offers from friends significantly predicted smoking among adolescents. To a lesser degree, both friends' and parental approval of smoking was predictive of varying levels of tobacco use among adolescents. Lower socioeconomic status and academic

achievement, peer/sibling use and approval of tobacco, adolescent's perceived prevalence of smoking and ease of access to cigarettes, lack of skills required to resist influences to use tobacco, and experimentation with any tobacco product were also found to be associated. Associated personal factors included a lower self-image and lower self-esteem than peers. Factors associated with decreased tobacco use included parental disapproval of smoking, involvement in children's free time, discussion of health matters with children and encouragement of children's academic achievement and school involvement. Flay *et al* showed that, in general, friends' smoking has a stronger effect on adolescents' smoking behavior than parental smoking influences, particularly on initiation (11).

Pierce *et al* have developed the concept of "susceptibility" to help identify nonsmoking adolescents who are cognitively predisposed to smoking. Susceptibility to smoking is defined as the absence of a firm decision not to smoke. Nonsusceptibility is defined by answers of "no" or "definitely not" to all of the following questions: "Do you think you will try a cigarette soon?" "If one of your best friends were to offer you a cigarette, would you smoke it?" "Do you think you will be smoking cigarettes one year from now/At any time during the next year do you think you will smoke a cigarette (12, 13)?"

In examining this construct, Pierce *et al* utilized data from the 1989 and 1993 Teenage Attitudes and Practices Survey (TAPS), a nationally representative longitudinal study of 4500 adolescents who reported that they were never smokers at baseline. This survey was designed to provide information on adolescent smoking behavior and was developed

under the direction of the National Center for Health Statistics and the Office on Smoking and Health, Centers for Disease Control. Overall, Pierce *et al* found that baseline susceptibility to smoking was a stronger independent predictor of experimentation with smoking than the presence of smokers among either family or the best friend network. Susceptibility to smoking, however, was not as important as exposure to smokers in distinguishing adolescents who progressed to established smoking from those who remained experimenters at follow-up (13).

Unger *et al* investigated the value of the susceptibility measure for predicting smoking initiation at one and two-year follow-up among 687 seventh-grade nonsmokers (14). They demonstrated that, compared to nonsusceptible adolescents, susceptible adolescents were two to three times more likely to experiment with cigarettes during the ensuing two years when controlling for the number of friends who smoke, the number of cigarette offers received, and one's beliefs in the positive consequences of smoking. This study was limited, however, by a high rate of attrition (60% follow-up at one year and 53% follow-up at two years). In addition, the data were collected more than 10 years prior to analysis and were not specifically collected to evaluate the susceptibility construct. Unger *et al* also utilized a slightly different measure of susceptibility than that examined by Pierce *et al*.

The Transtheoretical Model of Change provides a temporal framework for assessing addiction problems and applying interventions (15). It has been advocated for use in the clinical setting (16, 17). This theory was originally applied to smoking cessation in adults and views an individual's readiness to change a behavior, such as smoking, as

being composed of five stages--- precontemplation, contemplation, preparation, action, and maintenance. This model recognizes that subjects can move in both directions between stages or recycle several times through the stages. Each stage represents a time period as well as set of tasks needed for movement to another stage. This model was originally based on studies of adults, but has subsequently been shown to be applicable to adolescents (18). In addition, an integrated model of the stages of smoking acquisition and cessation has been described by Pallonen *et al* (19). The model has been envisioned to assist with understanding the patterns of uptake and continuation/cessation of adolescent cigarette smoking. The integrated model of the stages of acquisition/stages of change includes:

1. acquisition pre-contemplation (aPC)*: nonsmokers who are not thinking about smoking within the next six months
2. acquisition contemplation (aC)*: nonsmokers who are thinking about trying smoking within the next six months
3. acquisition preparation (aP)*: nonsmokers who are thinking about trying smoking within the next 30 days
4. recent acquisition (RA): people who have smoked cigarettes regularly less than six months (where "regular" is smoking cigarettes weekly or more)
5. precontemplation (PC): smokers who are not thinking about quitting in the next six months
6. contemplation (C): smokers who are thinking about quitting in the next six months
7. preparation (P): smokers who are thinking about quitting in the next 30 days
8. action (A): smokers who have quit smoking within the last six months
9. maintenance (M): smokers who have quit smoking more than six months ago

* denotes the components of the stages of acquisition.

Recent articles in the literature have evaluated the relationship between the stages of acquisition and susceptibility. Kremers *et al* conducted a cross-sectional study of 21,535 young people (mean age 13 years) from six European countries who had never smoked regularly. They examined the presence of three possible subtypes within the precontemplation stage of adolescent smoking acquisition: "progressives", "immotives", and "committers" (20). The "progressives" encompassed a subset of precontemplators that are ready to move to the contemplation stage. The "immotives" were those with no plans to move to contemplation but who also lacked a strong commitment not to smoke. The "committers" were the adolescents who were firmly committed to nonsmoking. Thus, distinguishing the subtype of committers from the immotives and progressives is the concept of susceptibility. Kremers *et al* found that the adolescents in the three subgroups of precontemplation differed from each other on every cognitive determinant tested (attitudes towards smoking, perceived social influences and self-efficacy to remain a nonsmoker). In addition, they found that progressives were more likely to start smoking than immotives, who in turn were more likely to start smoking than committers.

Prokhorov *et al* created and evaluated an integrated four-part measure combining the stages of acquisition and susceptibility using two school-based study populations: a one-year prospective study of 1,124 elementary through high school students and a cross-sectional study of 5,624 high school students (21). The subjects in this study were categorized as current nonsmokers, but included those who had experimented with smoking in the past or were former smokers. Prokhorov *et al* utilized Chi-square and

ANOVA tests in their analysis. They found that the prevalence of current smoking at one-year follow-up increased with increasing stage of smoking acquisition at baseline and was higher for students classified as susceptible than for students classified as nonsusceptible at baseline. They did not, however, report risk estimates. In addition, the integrated measure significantly differentiated smoking status one year later and demonstrated significantly better fit to the data than either the stages of smoking acquisition or susceptibility alone.

Pallonen *et al* assert that the proposed stage continuum will be especially useful in selecting and directing appropriate intervention measures to bring about the optimal behavior outcome in the entire target population according to a participant's readiness to change (19). Intensive primary prevention efforts should be aimed at the cohort of non-smokers who are in the acquisition contemplation and acquisition preparation stages and who have increased readiness to experiment with smoking (18). In addition, the work of Kremers *et al,* supported by the findings of Prokhorov *et al,* suggests that subtypes may exist within the precontemplation stage of acquisition that may be more or less likely to progress along the continuum of acquisition (20, 21).

Thus, identifying those adolescents who will progress to established smoking may be helpful in targeting preventive efforts. While clinicians should make it a high priority to counsel all teens about smoking (8), targeting high-risk teens for more intensive efforts may prove more effective and cost effective.

The stages of acquisition and susceptibility measures have both shown promise in identifying those adolescents who will become smokers. In addition, there is evidence that a combined measure that includes both the stages of acquisition and susceptibility may better identify those adolescents who will become smokers, as some precontemplators may be at greater risk for smoking initiation than previously thought. Given the work to date, this study examines the following question:

Are there combinations of the stages of smoking acquisition, susceptibility and socio-demographic factors that can predict smoking initiation in adolescence?

The specific aims of this project are:

1. To identify the individual socio-demographic factors associated with the stages of smoking acquisition and with susceptibility in an adolescent population.

2. To identify whether baseline stage of smoking acquisition, baseline susceptibility, and other socio-demographic factors can predict smoking initiation at two-year follow-up in a cohort of nonsmoking adolescents.

3. To compare the predictive utility of the different combinations of measures found to predict smoking status at two-year follow-up.

METHODS

Overview of Research Design

I examined whether baseline stage of smoking acquisition, baseline susceptibility, and other socio-demographic factors can predict smoking initiation at two-year follow-up in a cohort of nonsmoking adolescents. To accomplish this, I utilized data obtained from self-administered questionnaires completed by subjects enrolled in a randomized controlled trial of a computer-based tobacco prevention and cessation intervention. The variables included socio-demographics, baseline stage of smoking acquisition, baseline susceptibility, and smoking status at two-year follow-up. I first performed bivariate analyses to identify socio-demographic factors associated with the stages of smoking acquisition, susceptibility, and smoking status at two-year follow-up. I then performed multiple logistic regression analyses to control for treatment condition and to identify whether stage of smoking acquisition, susceptibility (individually or combined) and socio-demographic factors were independent predictors of adolescent smoking initiation at two-year follow-up.

Design

This was a retrospective cohort study utilizing data obtained from a cohort of adolescents who described themselves as nonsmokers at baseline and who participated in a randomized controlled trial of a computer-based tobacco prevention and cessation intervention with two years of follow-up.

The primary study was a two-arm randomized trial of a clinic-based behavioral intervention to reduce the prevalence of smoking in adolescents aged 14-17. Adolescents presenting for routine primary care clinic visits from October 1997 through August 1999 in pediatric/family practice clinics at Kaiser Permanente Northwest, a prepaid, group practice health maintenance organization, were eligible for participation in this study. Research staff in the waiting rooms of the clinics approached every age-eligible adolescent possible presenting for primary care visits for recruitment. They enrolled 2,526 subjects as a result of 5,179 encounters occurring on one or more occasions between 3,747 adolescents and research staff. This represents 67.4% of all possible subjects since each subject may have been approached on more than one occasion. Of those individuals approached, 4.1% were ineligible by study protocol, 14.8% refused (including 1.1% parent refusals), and 15.6% were unable to participate on that day, but agreed to be re-contacted at a later medical visit. Of the 70 teens who were successfully re-contacted at a later time, 12% subsequently enrolled. No further information was available for adolescents who declined to participate.

Subjects in the intervention arm received three elements delivered during routine primary care office visits: brief (less than one minute) physician advice to not smoke; a session with an interactive computer program administered on laptop computers and designed to deliver tobacco interventions individually tailored to the teen's stage of smoking initiation/cessation and other factors; and a five-minute session with a health counselor. Up to two "booster" computer and counselor sessions were offered during the 11 months after the visit, usually by phone. Subjects in the control arm received usual care via the

physician visit and a five-minute motivational interview from health counselors at the intake office visit about increasing consumption of fruits and vegetables. Subjects completed baseline self-administered questionnaires in private while waiting for their medical appointments.

One-year and two-year follow-up self-administered questionnaires assessed smoking prevalence, smoking initiation/cessation behaviors, socio-demographic factors and dietary habits. A combination of mailed questionnaires and telephone interviews (for those who did not respond to the mailing) provided outcome data. The study investigators mailed questionnaires with a cover letter to the teen one month prior to each annual anniversary of the teen's enrollment. A second questionnaire was mailed two weeks later if the first had not been returned. Two weeks after the second mailing, if necessary, study staff attempted contact by telephone. Blinded study personnel conducted all follow-up assessments. The second annual follow-up was truncated by two to three weeks for the last 140 participants enrolled in the study as the study investigators extended the recruitment period beyond original plans. The mean length of follow-up from study enrollment was 12.4 months (sd=0.84) for the first assessment and 24.4 months (sd=0.80) months for the second assessment. Follow-up assessment was completed by the end of September 2001 (22).

Written informed consent was obtained from all participants. Parental consent was not required, but the study was explained to interested parents accompanying the teens. Both

parental and teen wishes were respected. The study was reviewed, approved, and monitored by the Kaiser Permanente Institutional Review Board.

The data analyzed for this study involved the smaller subset of 1955 subjects who reported that they never smoked cigarettes (n=1307) or had tried smoking only a few times at baseline (n=647).

Measures

For this analysis, I utilized data from the baseline and two-year follow-up questionnaires incorporated as part of the primary randomized controlled trial.

The response rate for the two-year follow-up pencil and paper questionnaires was 89.6% for this cohort. The baseline and follow-up questionnaires were identical with the exception of additional questions added to the two-year follow-up questionnaire assessing subjects' beliefs regarding the "pros" and "cons" of smoking. Most questions were multiple choice or "yes" or "no" questions. A complex skip pattern allowed respondents to answer questions tailored to their experience with smoking. For example, those respondents who were current smokers were not asked questions assessing their susceptibility to smoking or their stage of smoking acquisition.

The contents of the questionnaires included: socio-demographic factors (age, gender, ethnicity, body mass index computed as weight in kilograms/height in meters squared, grade, educational aspirations), health behavior/psychosocial characteristics (exercise frequency, weight loss attempts in the last year), and reported depressed mood (positive

on a three-item depression screener) (23). Subjects also reported: the number of days they smoked in the past 30 days, their self- described smoking status ("never smoked", "tried smoking a few times", "smoked regularly but quit", "smoke now"), other forms of tobacco used in the last month, proportion of friends who smoke cigarettes, and the number of people in the household who smoke cigarettes.

Baseline stage of smoking acquisition included "acquisition precontemplation" (those who did not intend to start smoking within the next six months), "acquisition contemplation" (those who were considering smoking within the next six months, but not within the next 30 days), and "acquisition preparation" (those who were planning to start smoking in the next 30 days).

Baseline susceptibility to smoking was defined as the absence of a firm decision not to smoke. Nonsusceptibility was defined by answers of "no" or "definitely not" to all of the following questions: "Do you think you will try a cigarette within the next six months/next thirty days?" "If one of your best friends were to offer you a cigarette, would you smoke it?" "Do you think you will be smoking cigarettes one year from now?" An answer of "yes" to any of the above questions yielded a designation of susceptibility.

Data from the questionnaires were entered at the Kaiser Permanente Center for Health Research and stored on a computer data network protected by network access privileges and by password. This analysis utilized a masked data set that contained the measures of interest (sociodemographic/health behavior factors, one-year and two-year smoking

status) but no traceable identifiers. Data management and analysis were conducted using SPSS version 11.0.

Data Analysis

I used descriptive statistics to describe the baseline measures and covariates. I manually imputed the mode value for any missing data for the predictor variables, with the exception of body mass index (BMI), which had 115 observations missing. For all the variables except BMI, the missing data represented less than 1% of the total data. Due to the larger number of missing data for BMI, the missing observations were placed into a separate "missing" category for BMI to avoid any misclassification bias (Table 1). Thus, the categories for BMI were "missing", "normal weight or less", or "at risk for overweight or overweight". Due to small numbers in many response categories, and to make the variables more meaningful for subsequent analyses, I collapsed several variables into two or more categories. The race variable was dichotomized into "white" or "nonwhite" because there were too few subjects in the ethnic categories of "Native American or Alaskan Native", "Asian or Pacific Islander", "Black or African-American", and "Hispanic/Latino". The subject's highest level of schooling planned was divided into "less than high school/high school", "two-year college or technical/vocational school", "four-year college", and "graduate school". The proportion of friends who smoke was divided into "none", "few or less than 1/2", and "1/2 or greater". The number of people who smoke in the home was divided into "none", "one", or "two or more". Exercise frequency was dichotomized into "one time per week or less" or " more than once per week".

I used Chi-square tests of independence to identify significant associations ($p \leq 0.05$) between socio-demographic, health behavior and psychosocial factors and the baseline stages of smoking acquisition, baseline susceptibility and two-year follow-up smoking status. The unadjusted odds ratio (OR) between each characteristic and two-year smoking status was calculated using simple logistic regression to examine the relationship between two-year follow-up smoking status and each variable.

All characteristics with significance of $p \leq 0.25$ were included in the initial multiple logistic regression models to avoid missing any significant associations when grouped together in the model (24). Variables from each model were then excluded from the model if the p value was greater than 0.05 in order of decreasing association with baseline stage of acquisition/susceptibility as determined by gamma statistic (25). The gamma statistic is a measure of correlation for categorical variables similar to the correlation coefficient for continuous variables. This eliminated the variables more highly associated with the stages of acquisition/susceptibility to reduce the effect of collinearity. I monitored the influence of collinearity by examination of the ORs in the models with and without a particular variable of concern. A diminished OR, as well as very large estimated slope coefficients and estimated standard errors in the presence of a highly correlated variable, could identify the presence of collinearity. I developed multiple models containing various combinations of the measures of interest and associated variables for comparison of ORs adjusted for the other variables. Once the remaining variables met significance criteria of $p \leq 0.05$, each discontinued variable was

re-entered into the model to reassess whether it was significant when added back to the model. No variables were significant after reentry.

I included age, race, and gender in each multiple logistic regression model regardless of significance to control for any confounding effects from these socio-demographic characteristics. I also included treatment condition as a control variable as the subjects for this analysis were drawn from both the treatment and control arms of the primary study. I used these multiple logistic regression models to calculate adjusted ORs to identify whether baseline stage of smoking acquisition and baseline susceptibility, independently or combined, were associated as protective or risk factors for adolescent smoking status at two-year follow-up, controlling for significant covariates.

In addition to examining models containing both the stages of acquisition and susceptibility, I also analyzed a "combined new measure" that incorporated the stages of acquisition and susceptibility into a single measure. This measure divided the individuals in the precontemplative stage of acquisition into: "precontemplative/nonsusceptible" and "precontemplative/susceptible." This grouping is similar to Kremers' "committers" and "immotive"/"progressives" subtypes, respectively, within the precontemplative stage of acquisition. It is also similar to Prokhorov's integrated measure. In addition, this new measure effectively examined an interaction between the precontemplative stage of acquisition and susceptibility. Very few subjects in this data set were nonsusceptible/contemplative or

nonsusceptible/preparation. As a result, an interaction could not be examined between susceptibility and the contemplation or preparation stages of acquisition.

I then examined interactions between each characteristic and a binary version of the stages of acquisition ("collapsed stages") and susceptibility using forward conditional stepwise regression. Because there were only 74 adolescents in the preparation stage, I collapsed subjects into two categories: "precontemplation" or "contemplation/preparation."

The main outcome variable was self-reported smoking status at two-year follow-up. Current smoking status was defined by smoking at least one cigarette in the past 30 days. This definition has commonly been used in national surveys such as Youth Risk Behavior Survey 1995, National Household Survey, and Monitoring the Future. Because follow-up data were missing on 203 (10.4%) of the 1955 subjects, and because failure to respond at follow-up may be associated with smoking status, I ran separate multiple logistic regression models imputing two potential conditions ("smoker" or "nonsmoker") for the missing outcomes. The model that ignores the missing outcome data likely represents the true association if there is little change in the significant associations described by this model in comparison to the models imputing smoker and nonsmoker status for the missing outcomes. In addition, since no further data on the nonresponders were available for analysis, I used forward conditional stepwise multiple logistic regression to identify covariates that appeared to be associated with missing status at two-year follow-up to shed further light upon any potential biases contributing to this attrition.

I examined the overall goodness of fit for each model utilizing Hosmer and Lemeshow's Goodness of Fit test (24). This test divides the study sample into deciles of risk based on the estimated probabilities from the logistic regression model and calculates the number of expected "cases" for that decile based on a weighted average of estimated probabilities for the decile. The number of expected "cases" for each decile is then compared to the number of observed "cases" from the study sample. The null hypothesis is that there is no difference between the observed and the expected values. Rejecting the null hypothesis implies that the model does not fit well. Accepting the null hypothesis implies that the model fits the data well. Only those models that demonstrate an overall goodness of fit were included in the RESULTS section of this study.

The models were also compared using the Deviance statistic as a measure of goodness of fit. The lower the deviance value, the better the model fits the data. For the purposes of this comparison, the models were run with either the stages of acquisition, susceptibility or both and the following covariates: gender, age, race, highest level of schooling planned, proportion of friends who smoke, positive depression screen, BMI and treatment condition. This facilitated comparison of similar models with the exception of the stages of acquisition, susceptibility or both. This allowed for the comparison of the model containing either the stages of acquisition or susceptibility to be compared to the model containing both the stages of acquisition and susceptibility since the former was "nested" within the latter. Only the unaltered main effects models could be compared using this

statistic due to uniformity of the variables (i.e. interaction terms and the combined measure could not be entered into all models for uniformity purposes).

Finally, I used Receiver Operating Characteristic curves (ROC curves) to compare the models to one another to identify which model best fits the observations. The model that maximizes the area under the curve (closest to one) is the model that best fits the data. Unlike the Deviance statistic as a measure of goodness of fit, the ROC curves can be compared across models, regardless of component variables.

RESULTS

Descriptive statistics demonstrating the frequencies of the baseline characteristics and baseline stages of acquisition and susceptibility are shown in Table 1. Twenty-seven percent of subjects in this cohort were susceptible whereas only nine percent of subjects were in either acquisition contemplation or acquisition preparation. Twenty-one percent of acquisition precontemplators were also susceptible to smoking onset (not shown). Associations between baseline susceptibility, baseline stages of acquisition and the other covariates are presented in Table 2. Proportion of friends who smoke was the socio-environmental factor most strongly correlated with both susceptibility and the stages of acquisition. Other factors positively associated with both susceptibility and the stages of acquisition included weight loss attempt in the past year, increasing number of smokers in the home, and a positive depression screen. Male gender was the only factor negatively associated with both susceptibility and the stages of acquisition. Increasing age was also positively associated with the stages of acquisition, but negatively associated with susceptibility. White race and higher educational aspirations were negatively associated with susceptibility. In addition, the stages of acquisition and susceptibility were strongly associated with one another ($p<0.01$), with a gamma score of 0.93 (not shown).

Table 1: Baseline frequencies of sociodemographics, health care behaviors, stages of acquisition and susceptibility in a cohort of 1955 adolescents ages 14-17

Characteristics	N	%	n missing*
Gender			0
Female	1110	56.8	
Male	845	43.2	
Age (years)			0
14	607	31.0	
15	524	26.8	
16	443	22.7	
17	381	19.5	
Race			12
Nonwhite	419	21.4	
White	1536	78.6	
Highest level of schooling planned			4
High school or less	111	5.7	
Two-year college or technical school	244	12.5	
Four-year college	976	49.9	
Graduate/professional school	624	31.9	
Body mass index			N/A**
Missing	115	5.9	
Normal weight or less	1250	63.9	
At-risk of overweight or overweight	590	30.2	
Exercise frequency			1
One time per week or less	416	21.3	
More than one time per week	1539	78.7	
Tried to lose weight in the past year?			1
No	1099	56.2	
Yes	856	43.8	
Proportion of friends who smoke cigarettes?			2
None	520	26.6	
Few to less than ½	1079	55.2	
½ or more	356	18.2	
Number of smokers in the home?			3
None	1338	68.4	
One	383	19.6	
Two or more	234	12.0	
Positive depression screen			3
No	1060	54.2	
Yes	895	45.8	
Acquisition stage			15
Precontemplative	1784	91.2	
Contemplative	97	5.0	
Preparation	74	3.8	
Susceptibility			2
Nonsusceptible	1434	73.4	
Susceptible	521	26.6	
Treatment condition			0
Treatment	971	49.7	
Control	984	50.3	

* Mode value assigned for missing data.

** Not applicable as a separate category was created for missing data for this variable.

Table 2: Bivariate associations between stages of acquisition, baseline susceptibility and social-environmental factors in a cohort of 14-17 year-old adolescents (n=1955)

Characteristics	% susceptible	Correlation with susceptibility (gamma statistic)	%aPC*	%aC*	%aP*	Correlation with stages of acquisition (gamma statistic)
Gender		-0.12 **				-0.22 **
Female	28.6		89.7	6.0	4.2	
Male	24.0		93.3	3.6	3.2	
Age, years (categorized)		-0.11 **				0.19 **
14	31.0		93.9	3.6	2.5	
15	26.0		91.2	4.4	4.4	
16	23.5		91.0	5.4	3.6	
17	24.4		87.4	7.3	5.2	
Race		-0.15 **				0.05
Nonwhite	31.5		91.9	4.5	3.6	
White	25.3		91.1	5.1	3.8	
Highest level of schooling planned		-0.17 **				-0.05
High school or less	37.8		88.3	7.2	4.5	
Two-year college or technical school	31.1		90.6	5.3	4.1	
Four-year college	27.4		91.6	4.7	3.7	
Graduate or professional school	21.8		91.5	4.8	3.7	
Body mass index		0.07				-0.12
Normal weight or less	25.8		90.5	5.4	4.1	
At-risk of overweight or overweight	27.3		92.7	3.7	3.6	
Missing	33.0		92.2	6.1	1.7	
Exercise frequency		-0.02				-0.05
One time per week or less	27.4		90.6	5.3	4.1	
More than once per week	26.4		91.4	4.9	3.7	
Tried to lose weight in past year?		0.13 **				0.29 **
No	24.4		93.4	3.5	3.0	
Yes	29.6		88.4	6.8	4.8	
Proportion of friends who smoke cigarettes?		0.48 **				0.69 **
None	11.3		98.8	0.6	0.6	
Few to less than ½	28.4		92.4	4.9	2.7	
½ or more	43.8		76.7	11.5	11.8	
Number of Smokers in the home?		0.25 **				0.22 **
None	22.9		92.6	4.4	3.0	
One	35.2		88.3	6.8	5.0	
Two or more	34.2		88.5	5.1	6.4	
Positive Depression Screen		0.35 **				0.30 **
No	20.1		93.6	3.7	2.7	
Yes	34.4		88.5	6.5	5.0	
Treatment condition		0.06				0.07
Treatment	25.5		91.8	4.9	3.3	
Control	27.7		90.8	5.0	4.3	

* aPC = acquisition precontemplation; aC=acquisition contemplation; aP=acquisition preparation

** Significantly associated by Chi Square Test of Independence (p value ≤ 0.05)

Table 3 includes the results from simple logistic regression analyses to assess the unadjusted association between smoking status at two-year follow-up and each potential predictor variable. Unadjusted predictors of two-year follow-up smoking status included race (white), educational aspirations less than graduate school, having a missing BMI, increasing proportion of friends who smoke, increasing number of smokers in the home, positive depression screen, increasing stage of acquisition, and being susceptible. The combined stage/susceptibility measure showed that susceptible precontemplators, contemplators, and those preparing to start smoking were all at increased risk of smoking onset. Overall, the highest unadjusted ORs belonged to the measures of interest (susceptibility and the stages of acquisition) whether examined independently or as an integrated measure. Smoking status at two-year follow-up was not associated with gender, age, exercise frequency, attempted weight loss in the past year, or treatment condition.

Table 3: Simple logistic regressions of two-year follow-up smoking status on stages of acquisition, baseline susceptibility and socio-environmental factors

Characteristic	OR	95% CI Lower	95% CI Upper	p value
Gender (Female*)				0.23
Male	0.85	0.65	1.11	
Age (14 years*)				0.12
15	1.37	0.97	1.94	0.08
16	1.41	0.98	2.02	0.07
17	1.51	1.03	2.21	0.03
Race (White*)				0.03
Nonwhite	0.69	0.49	0.97	
Highest level of schooling planned?** (Graduate or professional*)				<0.001
High school or less	3.47	2.04	5.88	<0.001
Two-year college or technical school	2.95	1.97	4.42	<0.001
Four-year college	1.51	1.09	2.09	0.01
Exercise frequency (One time per week or less*)				0.10
More than one time per week	0.78	0.57	1.05	
Body mass index (Normal weight or less*)				0.03
At-risk of overweight or overweight	0.90	0.67	1.21	0.50
Missing	1.78	1.10	2.87	0.02
Tried to lose weight in the past year?** (No*)				0.14
Yes	1.21	0.94	1.57	
Proportion of friends who smoke?** (None*)				<0.001
Few to less than ½	2.18	1.50	3.16	<0.001
½ or more	4.29	2.83	6.50	<0.001
Number of smokers in the home?** (None*)				0.02
One	1.38	1.01	1.90	0.05
Two or more	1.58	1.08	2.30	0.02
Positive depression screen? (No*)				<0.001
Yes	1.68	1.30	2.18	
Acquisition stage** (Precontemplative*)				<0.001
Contemplative	5.86	3.74	9.19	<0.001
Preparation	9.15	5.42	15.45	<0.001
Susceptibility (Nonsusceptible*)				<0.001
Susceptible	3.68	2.81	4.81	
Combined measure** (Precontemplative and nonsusceptible*)				<0.001
Precontemplative and susceptible	2.41	1.74	3.32	<0.001
Contemplative	7.35	4.63	11.66	<0.001
Preparation	11.48	6.73	19.57	<0.001
Treatment condition (Treatment*)				0.15
Control	1.21	0.93	1.57	

* Reference category

** Significant trend based upon Linear-by-Linear Association ($p \leq 0.05$)

Multiple logistic regression models of the predictors of smoking status at two-year follow-up demonstrated predictive power for susceptibility and the stages of acquisition regardless of the potential confounding variables included in the models. Table 4 contains the ORs and 95% confidence intervals for susceptibility and the stages of acquisition when included in various multiple logistic regression models. Regardless of the covariates included, the ORs remained significant for susceptibility versus nonsusceptibility and both contemplation and preparation versus precontemplation.

When susceptibility and the stages of acquisition were combined, the ORs, relative to nonsusceptible precontemplators, remained significant for susceptible precontemplators, contemplators, and those preparing for smoking onset. Generally, susceptibility to smoking increased the risk of being a smoker at two-year follow-up from at least two to three times that of being nonsusceptible. This is similar to the findings of Unger *et al* (14). This risk estimate held true even when susceptibility and the stages of acquisition were combined into a single measure, as the OR (95% CI) for being a smoker at two-year follow-up for those who were precontemplative/susceptible was 2.21 (1.57, 3.10) compared to those who were precontemplative/nonsusceptible. In addition, the contemplation stage of acquisition increased the risk of being a smoker at two-year follow-up from three to nearly five times that of being in the precontemplation stage of acquisition. The preparation stage of acquisition increased the risk from almost five to eight times that of being in precontemplation. When combined into a single measure with susceptibility, these general relationships held true, as the OR for contemplation was

6.24 and the OR for preparation was 9.71, relative to the precontemplation/nonsusceptible stage of acquisition.

I used forward conditional stepwise regression to test for interactions in the above models. This method identified two possible interactions in the Collapsed Stages of Acquisition with Interactions Model and the Combined Susceptibility and Collapsed Stages of Acquisition with Interactions Model: 1) an interaction between race and collapsed stage of acquisition (Table 4) and 2) an interaction between age and proportion of friends who smoke cigarettes (not shown). The proportion of friends who smoke cigarettes drove this interaction rather than age. Specifically, the risk associated with age overall increased by less than 50% from age 14 to age 17. The risk associated with proportion of friends who smoke, however, increased by more than two times from those individuals who had no friends who smoke to those who had one-half or more of their friends who smoke (not shown). The interaction between race and collapsed stage of acquisition demonstrated increased risk for those who were white contemplator/preparers, ranging from greater than four to almost seven times that of white precontemplators. Nonwhite contemplator/preparers were at 1.5 to 2.5 times the risk for smoking than nonwhite precontemplators, though the 95% CI included one.

Table 4: Odds ratios and 95% confidence intervals for susceptibility and the stages of acquisition as predictors of smoking status at two-year follow-up in a cohort of 14-17 year old adolescents based on multiple logistic regression analyses

	New measure model (1)	Susceptibility model (1)	Stages of acquisition model (2)	Combined susceptibility and stages of acquisition model (1)	Collapsed stages of acquisition with interactions model (3)	Combined susceptibility and collapsed stages of acquisition with interactions model (4)
Susceptibility (Nonsusceptible*)		3.27 (2.46, 4.36)		2.16 (1.56, 3.00)		2.03 (1.46, 2.83)
Stages of acquisition (Precontemplative*)						
Contemplative			4.88 (3.03, 7.85)	3.13 (1.88, 5.22)		
Preparation			7.78 (4.46, 13.58)	4.86 (2.69, 8.76)		
Collapsed stages of acquisition interaction with race:						
White contemplator/preparer (White precontemplator*)					6.98 (4.55, 10.69)	4.56 (2.86, 7.26)
Nonwhite contemplator/preparer (Nonwhite precontemplator*)					2.44 (0.97, 6.14)	1.53 (0.59, 3.95)
Combined new measure (Precontemplative/nonsusceptible*)						
Precontemplative/susceptible	2.21 (1.57, 3.10)					
Contemplative	6.24 (3.84, 10.13)					
Preparation	9.71 (5.51, 17.10)					

* reference category

(1) adjusted for gender, age, race, highest level of schooling planned, proportion of friends who smoke, treatment condition

(2) adjusted for positive depression screen, BMI, and variables in (1)

(3) adjusted for gender, interaction between age and proportion of friends who smoke, highest level of schooling planned, positive depression screen, BMI and treatment condition

(4) adjusted for variables in (3) except BMI

An example of the full multiple logistic regression model for the Combined New Measure Model is displayed in Table 5 to give further insight into the magnitude of the ORs for the control variables. Multiple logistic regression predictors of smoking at two-year follow-up in this model included: being white, educational aspirations less than graduate or professional school, proportion of friends who smoke cigarettes, and the combined new measure. In this model, the combined new measure had the highest OR overall, with increasing ORs for those in precontemplation/susceptible, contemplation, and preparation relative to those who were in precontemplation/nonsusceptible. Educational aspirations had the next highest OR overall. Having an increasing proportion of friends who smoke increased one's risk for being a smoker at two-year follow-up. Being nonwhite relative to white demonstrated a protective effect. Though not significant, gender, age and treatment condition were included in the model to account for any confounding effects. The Hosmer and Lemeshow Goodness of Fit test for this model was nonsignificant (p=0. 95), suggesting that this model overall fits the data. No interactions were found for this model using a "collapsed combined measure" via forward conditional stepwise regression. This measure collapsed those in the contemplation and preparation categories into a single group because of small numbers in the preparation category.

Table 5: Combined New Measure Model: Multiple logistic regression model predicting smoking status at two-year follow-up in a clinic based cohort of 14-17 year old adolescents

		95% CI		
	OR	Lower	Upper	p value
Male (Female*)	0.94	0.71	1.26	0.68
Age, years (14*)				0.43
15	1.27	0.87	1.85	0.22
16	1.36	0.92	2.02	0.13
17	1.29	0.85	1.96	0.24
Race, Nonwhite (White*)	0.65	0.45	0.95	0.02
Highest level of schooling planned (Graduate or professional school*)				<0.01
High school or less	3.08	1.73	5.46	<0.01
Two-year college or technical school	3.05	1.97	4.71	<0.01
Four-year college	1.49	1.05	2.11	0.02
Number of friends who smoke (None*)				0.01
Few to less than ½	1.55	1.04	2.30	0.03
½ or more	2.02	1.27	3.21	<0.01
Combined new measure (Precontemplative and not susceptible*)				<0.01
Precontemplative and susceptible	2.21	1.57	3.10	<0.01
Contemplative	6.24	3.84	10.13	<0.01
Preparation	9.71	5.51	17.10	<0.01
Treatment condition, Control (Treatment*)	1.13	0.86	1.50	0.39

* reference category

Effects of Missing Data and Outliers

Two hundred three cases (10.4%) were missing for the smoking status outcome at two-year follow-up. To assess for any potential biases due to missing outcome data, I performed multiple logistic regression analyses utilizing three different assumptions: ignoring the missing observations; imputing a "nonsmoker" status for all missing data; and imputing a "smoker" status for all missing data. Logistic regression models with the above imputations revealed few differences among the models. The main differences occurred between the race and age variables when "smoker" status was imputed for the missing outcome. For example, when "smoker" status was imputed for the missing outcome data in the Combined Susceptibility and Stages of Acquisition Model, the Stages of Acquisition Model, and the Susceptibility Model, race became nonsignificant at $p \geq 0.05$. The age variable became significant ($p \leq 0.05$) because of the 17 year-old category in both the Combined Susceptibility and Stages of Acquisition Model and the Susceptibility Model. None of the other age categories were significant. In addition, none of the other covariates demonstrated a change in significance.

I assessed the presence of outlying values for the models described in Table 4 using Cook's residuals, leverage residuals and deviance residuals. These analyses revealed anywhere from three to seven potential outlying values dependent upon the model under examination. No significant changes occurred in the p value or ORs of any variables when I reran each model excluding each potential outlier. Thus, I did not exclude any data points.

The deviance statistic (-2 log likelihood) for the Susceptibility Model was 1352.90. The deviance for the Stages of Acquisition Model was 1331.69. The deviance for the Combined Susceptibility and Stages of Acquisition Model was 1314.09. These results suggest that the Combined Susceptibility and Stages of Acquisition Model better fits the data than a model containing either the stages of acquisition or susceptibility alone.

Receiver Operating Characteristic (ROC) Curves

Table 6 summarizes the areas under the ROC curves for the measures of susceptibility, the stages of acquisition, and the combined new measure without associated covariates. Combining susceptibility and the stages of acquisition (by including them separately in the same model or incorporating them into an integrated measure) equally maximized the area under the curve. The 95% CIs all overlapped, suggesting that the measures had similar predictive power. It is notable, however, that the stages of acquisition measure had the smallest area under the curve.

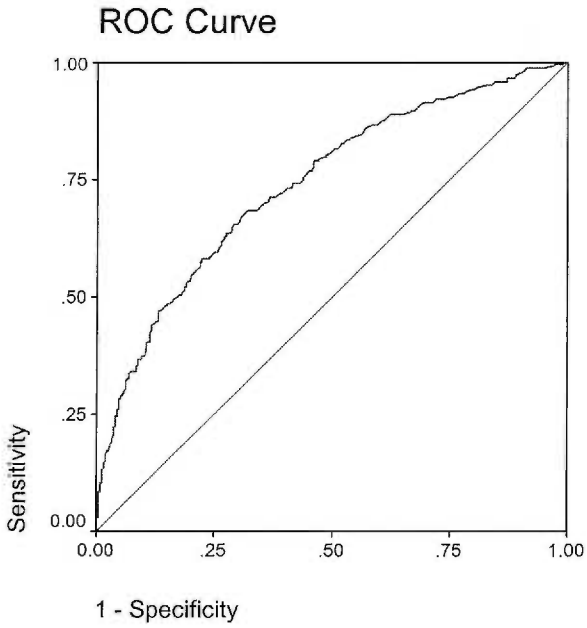
Table 6: Summary of ROC curves (areas under the curves) for susceptibility, the stages of acquisition, both measures combined, and combined new measure

Measure	Area Under the Curve	95% CI
Susceptibility	0.64	0.61, 0.68
Stages of Acquisition	0.61	0.57, 0.65
Combined Susceptibility and Stages of Acquisition	0.67	0.63, 0.71
Combined New Measure	0.67	0.63, 0.71

Figure 1 contains an example of a ROC curve for the Combined New Measure Model previously described and summarized in Table 5. The diagonal line from the left lower

portion of the graph to the right upper portion represents the operating characteristics of a test in which the true-positive rate is the same as the false-positive rate, regardless of the cutoff point chosen to define a positive test.

Figure 1: ROC Curve for Combined New Measure Model



Area under the curve 0.74
95% CI (0.71, 0.77)

The predictive power for the different multiple logistic regression models was nearly identical as shown by the similar areas under the ROC curves in Table 7. The Combined Susceptibility and Collapsed Stages of Acquisition with Interactions Model had the largest area under the curve. Overall, however, there is little to no difference in the area under the curve amongst the models and there is overlap among the confidence intervals.

Table 7: Summary of ROC Curves (areas under the curves) from multiple logistic regression models of two-year smoking status on susceptibility, the stages of acquisition and associated socio-environmental factors

Model	Area Under the Curve	95% CI
Susceptibility	0.72	0.70, 0.76
Stages of Acquisition	0.74	0.70, 0.77
Combined Susceptibility and Stages of Acquisition	0.74	0.71, 0.77
Collapsed Stages of Acquisition with Interactions	0.75	0.71, 0.78
Combined Susceptibility and Collapsed Stages of Acquisition with Interactions	0.75	0.72, 0.79
Combined New Measure	0.74	0.71, 0.77

LIMITATIONS

The generalizability of this study may be limited as the study subjects were recruited from the population of patients receiving medical care from the prepaid group practice health maintenance organization Kaiser Permanente Northwest rather than the general population. Freeborn and Pope reported a comparison of the age and sex distribution of Kaiser Permanente Northwest members with the census data for the population in the surrounding area (26). With some exceptions, the Kaiser Permanente membership is generally similar in age and sex composition to the local community population. In addition, Kaiser Permanente subscribers are similar to subscribers in other plans. The main differences are that significantly more Kaiser Permanente Northwest subscribers have no more than a high school education, fewer are employed in entrepreneurial and managerial positions, and more are employed in the blue collar jobs. Thus, this population of subjects does differ to a small degree from the general population in the surrounding area, but not to such a large extent that the findings will be completely inapplicable to a larger population.

Another limitation of this study is the fact that adolescent self-reported smoking status was used as the outcome measure. As a result, some under-reporting may have occurred. Though under-reporting is a valid concern, Benuck *et al* evaluated the use of a short questionnaire in identifying adolescent smokers in a pediatric practice in comparison to urinary cotinine levels. The questionnaire alone was able to identify 92% of regular smokers (27). Thus, self-report is reasonably accurate in identifying smoking status in an adolescent clinic population.

Loss to follow-up is a potential threat to the validity of any study, though the overall response rate of 89.6% was excellent in this case. Stepwise forward conditional multiple logistic regression analyses identified a set of factors that predicted which subjects were more likely to be missing at follow-up. These factors included being male (OR 1.54; 95%CI 1.14, 2.07), being 17 years old (OR 2.24; 95%CI 1.50, 3.34), having educational aspirations of high school or less (OR 2.40; 95%CI 1.36, 4.22), being susceptible (OR 1.41; 95%CI 1.02, 1.94), and being in the treatment group of the primary study (OR 1.50; 95% CI 1.11, 2.01).

The missing values for BMI (6% of all subjects) also represented a potential bias in the data. I utilized Chi-square tests of independence as well as forward stepwise conditional multiple logistic regression to further examine potential bias, and found no variables associated with the missing BMI values. This suggests that these values were missing at random or due to another factor not measured by this study. In addition, including BMI in the multiple logistic regression models did not have significant effects on the ORs for susceptibility and the stages of acquisition.

Alternate analyses assuming that nonresponders were either smokers or nonsmokers resulted in little change in the significance or ORs for the main variables of interest: susceptibility and the stages of acquisition. The age variable became significant and the race variable became nonsignificant when "smoker" status was imputed for the missing outcome data, but no changes were noted when "nonsmoker" status was imputed for the

missing data. This again indicates that the effects of susceptibility and the stages of acquisition cannot be completely or even mainly accounted for by confounding variables such as age and race. Given that only 16% of these initial nonsmokers started smoking at follow-up, it seems inappropriate to assume that all those lost to follow-up were smoking. Since no changes occurred in the significance of variables between the models that ignored the missing observations versus the models with "nonsmoker" status imputed for the missing observations, these two models more likely represent the true association between the covariates and the outcome. Thus, the results of the models that ignored the missing outcome data are reported here.

DISCUSSION AND CONCLUSIONS

Both susceptibility and the stages of acquisition were effective independent screening measures to identify adolescents at increased risk for smoking initiation over a two-year follow-up. The relationships held true when controlling for other covariates and when the measures were considered individually, jointly, or in the form of an integrated measure. This replicates Prokhorov's *et al* findings showing the value of an integrated measure of the stages of acquisition and susceptibility in two school-based cohorts (one cross-sectional and one prospective) (21). These findings expand the generalizability of this approach as it utilizes a cohort of adolescents from a clinical, rather than school-based, setting.

A key finding was that 27% of adolescents in this cohort were susceptible whereas 91% were in acquisition precontemplation. Twenty-one percent of acquisition precontemplators were also susceptible to smoking onset suggesting smoking prevention efforts should target not only those adolescents in the contemplation and preparation stages of acquisition, but also those who are precontemplative and susceptible to smoking. Adolescents who were susceptible to smoking were approximately two to three times more likely to be smokers at two-year follow-up. Adolescents who were in the acquisition contemplation and acquisition preparation stages were anywhere from three to five and five to eight times more likely, respectively, to be smokers at two-year follow-up compared to those in acquisition precontemplation. When combined into a single measure, the OR for being precontemplative/susceptible was 2.21, for being

contemplative was 6.24, and for being preparative was 9.71 when compared to being precontemplative/nonsusceptible.

These findings for the combined measure of susceptibility and the stages of acquisition further supports Kremers' *et al* concept that susceptibility distinguishes the "committer" and "immotive" subtypes of the precontemplation acquisition stage. Committers are firmly committed to nonsmoking (akin to nonsusceptible precontemplators) and immotives are those adolescents with no plans to move to contemplation, but who also lack a strong commitment not to smoke (akin to susceptible precontemplators). These findings also support the work of Prokhorov *et al* by demonstrating the added value of an integrated measure that combines susceptibility and the stages of acquisition.

Susceptibility and the stages of acquisition do not appear to be merely a proxy for other psychosocial variables predictive of smoking, such as the proportion of friends who smoke or one's educational aspirations. This suggests that assessing susceptibility and the stages of acquisition, in addition to other associated psychosocial variables, may result in more accurate identification of adolescents who are at-risk for smoking.

The interaction between race and collapsed stage of acquisition deserves special note. Stage of acquisition appeared far more predictive of smoking onset for whites than nonwhites. White contemplator/preparers had four to seven times the risk for smoking initiation compared to white precontemplators. Nonwhite contemplator/preparers were at 1.5 to 2.5 times the risk for smoking than nonwhite precontemplators, though the 95%

confidence interval included one. This finding may be limited, however, by a lack of power due to the small number of nonwhite contemplator/preparers (n=28) in this cohort. If stage is a better predictor for whites than nonwhites, this finding may have implications for tailoring future screening tools and intervention approaches.

The ROC curves do not clearly identify the single best model of those described. While the Combined Susceptibility and Collapsed Stages of Acquisition with Interactions Model has the highest area under the curve, there is much overlap between the confidence intervals for this estimate and those of the other models. The main effects model that combines susceptibility and the stages of acquisition into a single measure should be explored further as it combines the best of theory and practical application. This model takes into account the interrelationship between the stages of acquisition and susceptibility, and has potential for use in the clinical setting as a screening tool since it incorporates only a few straightforward and easy to answer questions that could be administered in the clinical setting.

Identifying adolescents in clinical settings who are at-risk for smoking is an important step for meeting the goals of Healthy People 2010. School-based programs alone have not yielded sustained and lasting effects and interventions in other settings are clearly needed. Better use of clinical interventions may help to buttress the effects of school-based and other broad-based interventions as adolescents routinely interact with the health care system. For example, O'Connor *et al* found that, in a managed care setting, most teens have clinic visits and opportunities for advice from their health care provider:

62% of adolescents ages 14-17 enrolled in an HMO were seen within a one-year time period; almost 83% of the adolescent membership was seen within two years (28). Little conclusive research, however, exists regarding the effectiveness of clinic-based interventions to prevent smoking in adolescents. For example, a randomized controlled trial utilizing mailed information from primary care teams reinforcing nonsmoking behavior in adolescents ages 10-15 demonstrated success in the United Kingdom. The OR for smoking initiation was 1.6 (95% CI 1.1-2.2) for controls relative to the intervention group, and the effect was more pronounced with boys than with girls (29). Another study utilizing an office systems' approach in pediatric primary care offices, however, found no effect for an intervention targeting alcohol and tobacco use (30).

Though further research is needed to identify the most effective clinic-based interventions, the clinic setting clearly provides a venue for smoking prevention. Unfortunately, the screening and counseling of adolescents regarding smoking prevention is not routinely performed. This is highlighted by the finding of Coffield *et al* that offering adolescents an anti-tobacco message or advice to quit is one of the eight highest priority services with the lowest delivery rates (8). Further highlighting these missed opportunities, Hollis *et al* found that 67% of the adolescents approached for participation in a clinic-based intervention to reduce the prevalence of tobacco use were willing to extend their visit to receive tobacco and/or dietary educational interventions as part of the study (31). Thus, physicians have both an opportunity and an obligation to deliver anti-tobacco messages to the vast majority of adolescents who seek routine medical care each year.

A practical and standardized screening tool is needed to make the most of screening and counseling opportunities for both smoking prevention and cessation. Simply asking "Are you a smoker?," the common screening question used in clinical practice, will miss those individuals who are experimenting with cigarettes but do not yet consider themselves smokers. For example, Alfano *et al* found that weekly regular smokers were nearly three times more likely to disclose their smoking than experimental smokers, who may not identify themselves as smokers (32). Hollis *et al* found that 23% of teens in their study were willing to report smoking one or more cigarettes in the past 30 days, while only 14% of teens reported that they "currently smoke" (31). Thus, how one asks the question is important; otherwise, many at-risk teens may be overlooked for counseling and preventive interventions.

Once the teen's smoking status, susceptibility and stage of change are clarified, tailored interventions can be provided. Smokers and experimenters may be given cessation advice and assistance. A tool incorporating susceptibility and the stages of acquisition might be used to further identify the risk of smoking onset in nonsmokers and to assess the need for follow-up counseling and interventions. Those individuals in the higher stages of acquisition (e.g. contemplation or preparation) need more intensive support from their health care provider, and, ideally, a trained health counselor. Those who are precontemplative but susceptible should also receive proactive counseling to prevent them from progressing down the continuum towards regular smoking. Those who are precontemplative and nonsusceptible should receive reinforcing advice and support

against smoking, including tips on how to improve their refusal skills. Finding effective and practical ways to target and tailor smoking prevention efforts for adolescents will help us achieve the ultimate goal of reducing smoking in the United States.

CONCLUSION

In conclusion, these results show that susceptibility and the stages of acquisition predict risk of smoking initiation over a two-year follow-up and provide estimates of the magnitude of effects associated with each measure. This study also replicates prior work and expands the generalizability of these measures as it utilizes a cohort of adolescents from the clinical, rather than school-based, setting.

Susceptibility and the stages of acquisition were independent predictors of smoking initiation. These measures also demonstrated continued predictive utility when combined into an integrated measure. Stage was a better predictor for whites than for nonwhites. In addition, 21% of precontemplators were susceptible to smoking, and these susceptible precontemplators were at increased risk of smoking onset. The findings indicate that smoking prevention efforts should target not only adolescents in the contemplation and preparation stages of acquisition, but also those who are precontemplative and susceptible to smoking.

The clinical setting currently represents an underutilized venue for smoking prevention interventions. Though future research is needed to further evaluate the racial differences for the stages of acquisition measure and to identify the most effective clinical interventions, the Combined New Measure Model incorporates both stage and susceptibility theory into a simple tool that could be applied in the clinical setting. Ultimately, incorporating these measures into routine screening may help to achieve the goal of Healthy People 2010 to decrease the prevalence of smoking.

REFERENCES

1. McGinnis JM, Foege WH. Actual causes of death in the United States. *Journal of the American Medical Association* 1993; 270(18):2207-2212.

2. Centers for Disease Control and Prevention. Youth tobacco surveillance—United States, 1998-1999. *MMWR Morbidity Mortality Weekly Report* CDC Surveillance Summary 2000; 49(10):1-94.

3. Centers for Disease Control and Prevention. Tobacco use among high school students --- United States, 1997. *MMWR Morbidity Mortality Weekly Report* 1998; 47(12):229-33.

4. Johnston LD, O'Malley PM, Bachman JG. (December 1999). *Cigarette smoking among American teens continues gradual decline*. University of Michigan News and Information Services: Ann Arbor, MI. [On-line]. Available: www.monitoringthefuture.org; accessed 10/21/01.

5. Centers for Disease Control and Prevention. Trends in cigarette smoking among high school students --- United States, 1991-2001. *MMWR Morbidity Mortality Weekly Report* 2002; 51(19):409-412.

6. Pierce JP, Gilpin E. How long will today's new adolescent smoker be addicted to cigarettes? *American Journal of Public Health* 1996; 86:253-256.

7. U.S. Department of Health and Human Services. *Reducing Tobacco Use: A Report of the Surgeon General----Executive Summary*. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2000.

8. Coffield AB, Maciosek MV, McGinnis M, Harris JR, Caldwell MB, Teutsch SM, Atkins D, Richland JH, Haddix A. Priorities among recommended clinical preventive services. *American Journal of Preventive Medicine* 2001; 21(1):1-9.

9. U.S. Department of Health and Human Services. Preventing Tobacco Use Among Young People: A Report of the Surgeon General. Atlanta, Georgia: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 1994.

10. Lamkin L, Houston TP. Nicotine dependency and adolescents: preventing and treating. *Adolescent Medicine* 1998; 25(1):123-35.

11. Flay BR, Hu FB, Siddiqui O, Day LE, Hedeker D, Petraitis J, Richardson J, Sussman S. Differential influence of parental smoking and friends' smoking on adolescent initiation and escalation of smoking. *Journal of Health and Social Behavior* 1994; 35:248-265.

12. Pierce JP, Farkas AJ, Evans N, Gilpin E. An improved surveillance measure for adolescent smoking? *Tobacco Control* 1995; 4(1):S47-S56.

13. Pierce JP, Choi WS, Gilpin EA, Farkas AJ. Validation of susceptibility as a predictor of which adolescents take up smoking in the United States. *Health Psychology* 1996; 15(5):355-361.

14. Unger JB, Johnson CA, Stoddard JL, Nezami E, Chou CP. Identification of adolescents at risk for smoking initiation: validation of a measure of susceptibility. *Addictive Behaviors* 1997; 22(1):81-91.

15. Prochaska JO, DiClemente CC. *The Transtheoretical Approach: Crossing Traditional Boundaries of Therapy*. Homewood, IL: Dow Jones-Irving, 1983.

16. Rustin TA. Assessing nicotine dependence. *American Family Physician* 2000; 62(3):579-584.

17. Stein RJ, Haddock CK, O'Byrne KK, Hymowitz N, Schwab J. The pediatrician's role in reducing tobacco exposure in children. *Pediatrics* 2000; 106(5):E66.

18. Pallonen UE. Transtheoretical measures for adolescent and adult smokers: similarities and differences. *Preventive Medicine* 1998; 27(5 Pt 3):A29-38.

19. Pallonen UE, Prochaska JO, Velicer WF, Prokhorov AV, Smith NF. Stages of acquisition and cessation for adolescent smoking: an empirical integration. *Addictive Behaviors* 1998; 23(3):303-324.

20. Kremers SP, Mudde AN, de Vries H. Subtypes within the precontemplation stage of adolescent smoking acquisition. *Addictive Behaviors* 2001; 26(2):237-51.

21. Prokhorov AV, de Moor CA, Suchanek Hudmon K, Hu S, Kelder SH, Gritz ER. Predicting initiation of smoking in adolescents: evidence for integrating the stages of change and susceptibility to smoking constructs. *Addictive Behaviors* 2002; 27:697-712.

22. Hollis JF, Polen MR, Whitlock EP, Lichtenstein E, Mullooly J, Velicer WF, Redding CA. Teen REACH: Outcomes from a randomized controlled trial of a tobacco reduction program among teens seen in primary medical care. (Manuscript in preparation.)

23. Rost K, Burnam MA, Smith GR. Development of screeners for depressive disorders and substance disorder history. *Medical Care* 1993; 31(3):189-200.

24. Hosmer DW, Lemeshow S. *Applied Logistic Regression* (Second Edition). New York, NY: John Wiley & Sons, Inc., 2000.

25. Agresti A. *Categorical Data Analysis*. New York, NY: John Wiley & Sons, Inc., 1990.

26. Freeborn DK, Pope CR. *Promise and Performance in Managed Care: The Prepaid Group Practice Model*. Baltimore, MD: The Johns Hopkins University Press, 1994.

27. Benuck I, Gidding SS, Binns HJ. Identification of adolescent tobacco users in a pediatric practice. *Archives of Pediatric Adolescent Medicine* 2001; 155(1):32-35.

28. O'Connor EA, Hollis JF, Polen MR, Lichtenstein E. Adolescent health care visits: opportunities for brief prevention messages. *Effective Clinical Practice* 1999; 2(6):272-276.

29. Fidler W, Lambert T. A prescription for health: a primary care based intervention to maintain the non-smoking status of young people. *Tobacco Control* 2001; 10:23-26.

30. Stevens MM, Olson AL, Gaffney CA, Tosteson TD, Mott LA, Starr P. A pediatric practice-based, randomized trial of drinking and smoking prevention and bicycle helmet, gun and seatbelt safety promotion. *Pediatrics* 2002; 109(3):490-7.

31. Hollis JF, Polen MR, Lichtenstein E, Whitlock EP. Tobacco use patterns and attitudes among teens being seen for routine primary care. *American Journal of Health Promotion*, in press.

32. Alfano CM, Zbikowski SM, Robinson LA, Klesges RC, Scarinci IC. Adolescent reports of physician counseling for smoking. *Pediatrics* 2002; 109(3):E47