

Comparing Intervention Outcomes in Smokers Treated for Single Versus Multiple Behavioral Risks

Judith J. Prochaska
University of California, San Francisco

Wayne F. Velicer and James O. Prochaska
University of Rhode Island

Kevin Delucchi and Sharon M. Hall
University of California, San Francisco

This study examined treatment outcomes among smokers with single versus multiple behavioral risks. Data were drawn from smokers ($N = 2,326$) participating in 3 population-based, multibehavioral studies targeting cigarette smoking, high-fat diets, and high-risk sun exposure. Outcomes were compared for participants at risk for smoking only (13%), smoking plus 1 additional risk factor (37%), and smoking plus 2 additional risk factors (50%). The smoking only group tended to be female, older, more educated, lighter smokers, in the preparation stage of change for smoking, with more previous quit attempts and longer periods of abstinence. At 12 and 24 months follow-up, treatment of 1 or 2 coexisting risk factors did not decrease the effectiveness of smoking cessation treatment, and treatment for the coexisting factors was effective.

Keywords: multiple behavior change, smoking cessation, randomized controlled trial

Risky behaviors such as smoking, alcohol abuse, physical inactivity, and poor diet are detrimental to health and often co-occur. Analysis of data from the 2001 National Health Interview Study indicates the majority of adults in the United States meet criteria for two or more risk behaviors (Fine, Philogene, Gramling, Coups, & Sinha, 2004). Tobacco users, in particular, tend to have poor behavioral profiles, with about 92% of smokers having at least one additional risk behavior (Fine et al., 2004; Klesges, Eck, Isbell, Fulliton, & Hanson, 1990; Kronenfeld et al., 1988; Pronk et al., 2004). The health care burden is believed to multiply with an increasing number of risk factors with respect to both medical consequences and medical costs (Edington, Yen, & Witting, 1997; Shinton, 1997). To more comprehensively address the health needs of individuals and populations, greater knowledge is needed about interventions that target multiple risk behaviors.

The strategy of intervening in multiple behaviors concurrently became a focus of attention in the early 1970s with the goal of preventing cardiovascular disease (Labarthe, 1998). Interventions included the Multiple Risk Factor Intervention Trial (Multiple Risk Factor Intervention Trial Research Group, 1982), the North

Karelia Project (Puska, Nissinen, Salonen, & Toumilehto, 1983), the Stanford Three-City and Five-City Projects (Farquhar, et al., 1990), and the Pawtucket and Minnesota Heart Health Programs (Carleton, Lasater, Assaf, Feldman, & McKinlay, 1994; Luepker et al., 1994). Outcomes ranged from favorable to unfavorable. Individual studies reported significant effects on some but not all targeted behaviors (Emmons, Marcus, Linnan, Rossi, & Abrams, 1994; Sorensen et al., 1996). For tobacco use outcomes, meta-analysis estimated the net reduction in smoking prevalence at 4.2% across the trials (Ebrahim & Davey Smith, 2002).

In these large community-based interventions, multiple behavior change was promoted at the population level. Not all participants were at risk on all targeted behaviors. In the Multiple Risk Factor Intervention Trial, for example, only 59% of participants were current smokers (Ockene & Shaten, 1991). Changes in behaviors were examined overall, and success rates for individuals receiving intervention on a single versus multiple risk behaviors were not reported. Nevertheless, leaders of some of the projects, such as the Minnesota Heart Health Program, suggested that maybe they should have focused their interventions on a single behavior, like smoking, rather than multiple risks for heart disease (Luepker et al., 1994).

Within the primary care setting, a recent review concluded that “large gaps remain in our knowledge about the efficacy of interventions to address multiple behavioral risk factors” (Goldstein, Whitlock, & DePue, 2004, p. 61). The need for multiple-risk, transbehavioral research models and paradigms has been identified (Orleans, 2004). Specific research questions to be answered include “whether, or in which situations, multiple risk factor interventions are *more* effective or efficient at reducing risk than targeted single interventions” (Atkins & Clancy, 2004, p. 102). For example, some attribute the success of tobacco-cessation initiatives to a narrowly focused research and policy agenda. Research

Judith J. Prochaska, Kevin Delucchi, and Sharon M. Hall, Department of Psychiatry, University of California, San Francisco; Wayne F. Velicer and James O. Prochaska, Cancer Prevention Research Group, University of Rhode Island.

This work was supported by National Cancer Institute Grants CA 50087 and CA 27821, National Institute on Drug Abuse Grants DA 07250 and DA 016752, and a Postdoctoral Fellowship from the Tobacco-Related Disease Research Program (#11FT-0013).

Correspondence concerning this article should be addressed to Judith J. Prochaska, Department of Psychiatry, University of California, San Francisco, 401 Parnassus Avenue – TRC 0984, San Francisco, CA 94143-0984. E-mail: JProchaska@lppi.ucsf.edu

is needed to determine under what conditions multiple risk factors could be targeted without diminishing the effectiveness of smoking cessation interventions (Atkins & Clancy, 2004). The current analysis sought to examine the important issue of whether smokers at risk and treated for one, two, or three risk factors differed in their effectiveness with smoking cessation.

Data were drawn from three recent, parallel, population-based, multibehavioral studies targeting smoking cessation, high-fat diets, and high-risk sun exposure (J. O. Prochaska et al., 2005; J. O. Prochaska, Velicer, et al., 2004; Velicer et al., 2004). Participants in the three studies were randomized to an expert system intervention based on the transtheoretical model (TTM) of behavior change (J. O. Prochaska & DiClemente, 1983) or to an assessment-only control condition. The TTM is an evidence-based theory that conceptualizes the behavior change process as occurring in five stages reflecting one's intention and readiness to change (J. O. Prochaska, DiClemente, & Norcross, 1992). Individuals in the first three, or pre-action, stages are all identified as at risk on the basis of a behavioral criterion but vary in their intentions to change: These stages are precontemplation (not intending to change in the next 6 months), contemplation (intending to change within 6 months) and preparation (planning change within the next 30 days). Individuals meeting a behavioral criterion (e.g., quit smoking) for less than 6 months are in the action stage, whereas those meeting it for 6 months or more are in the maintenance stage. In contrast to action-oriented paradigms, which promote immediate action among all participants (including among those who are not ready to change), the TTM recommends tailoring of strategies to an individual's stage of change. For individuals in the precontemplation and contemplation stages, the strategies are more cognitively focused, whereas for individuals in the preparation and action stages, strategies are more active and behaviorally focused.

Participants assigned to the TTM-tailored intervention in each of the three studies received treatment for the behavior(s) for which they were identified as being at risk on the basis of their baseline stage of change. The studies used common measures administered at an identical assessment schedule. In all three studies, across all three behaviors, treatment effects were significant at 12 and 24 months follow-up, with the exception of smoking in the work site study (Velicer, et al., 2004), which had a relatively small number of smokers. Averaging across studies, we found that the self-reported cessation rates were 24% in the intervention and 18% in the control condition at 24 months follow-up ($p < .01$). The primary study outcomes for each of the three trials have been described in separate articles (J. O. Prochaska et al., 2005; J. O. Prochaska, Velicer, et al., 2004; Velicer et al., 2004). Outcomes, however, have not been analyzed by the number of behaviors that were treated within individuals.

The purpose of the present research was to compare treatment outcomes in individuals who were at risk and treated for smoking only versus those at risk and treated for one or two additional risk behaviors. The question of interest was whether treatment of coexisting risk factors decreases the effectiveness of smoking cessation treatment. In addition, the effectiveness of treating the coexisting risk factors was examined. Combining samples of smokers across the three trials provided sufficient sample size to conduct this analysis. The number of behavioral risks within individuals is a variable that cannot be determined randomly.

Therefore, the analysis had to control for potential confounding differences in the three risk factor groups.

Method

Study Design

The present research analyzed data from three randomized controlled trials conducted as part of a center grant from the National Cancer Institute. Though the trials were conducted with participants drawn from very different settings—patients from primary care practices ($N = 5,407$), parents of ninth graders from high schools ($N = 2,460$), employees from work sites ($N = 1,906$)—common interventions, procedures, measures, and assessment schedules were used. In each trial, participants were randomized to one of two groups: an expert system intervention or an assessment-only control condition. The stage-based expert system used tailored communications for treating the cancer-related risk behaviors of cigarette smoking, high-fat diet, or high-risk sun exposure. Separate, stand-alone intervention materials were developed for each risk behavior, and intervention participants received materials only for the behaviors for which they were identified as being at risk at baseline. Assessments were conducted by mail and phone at 0, 12, and 24 months. A 6-month assessment, completed only with the intervention group to create the expert system reports, was not included in the outcome analysis.

Participants

Inclusion criteria for all three studies were adult age, English speaking, association with one of the recruitment sites, and currently having at least one of the targeted cancer-risk behaviors. Recruitment rates were 69%, 84%, and 86% for the patient, parent, and employee trials, respectively. For the current analysis, data were drawn only from the 2,326 participants who were identified as current smokers at baseline (24% of all trial participants).

Treatment Conditions

Expert system intervention. The intervention in all three studies included behavior-specific, stage-matched, self-help manuals and expert system feedback reports mailed at 0, 6, and 12 months. Intervention materials were provided to participants for only the behaviors for which they were identified as being at risk at baseline (e.g., individuals reporting a low-fat diet did not receive intervention materials on dietary change). The expert system program analyzed participants' responses to mail and phone surveys for each of the three behaviors to calculate scale scores associated with important TTM variables, which were then used to generate and print individualized feedback reports. The reports included (a) a description of the person's current stage of change, (b) information on the overuse or underuse of key processes of change appropriate for that stage, (c) feedback on his or her personal decisional balance regarding the risk behavior (e.g., the pros and cons), (d) information about personal high-risk situations and appropriate responses; and (e) a section on strategies for taking small steps to progress to the next stage. The baseline reports contained feedback on normative comparisons, that is, comparing the individual's scores on each of the key TTM variables to the norms of those who have made progress in the program. In the follow-up reports, both normative and ipsative feedback were provided; that is, comparisons were made to the person's previous scores. For smokers in the precontemplation stage, intervention strategies included increasing the salience of the cons of smoking, reducing the perceived importance of the pros, and promoting use of the experiential processes of change (e.g., obtaining information on the hazards of smoking). For facilitating progress from contemplation to preparation, the processes of self-liberation (e.g., making a commitment to quit), stimulus control (e.g., removing smoking paraphernalia from the

home), and counterconditioning (e.g., engaging in alternative behaviors) were emphasized. The report referred participants to sections of the stage-matched, self-help manual that were most relevant to their progress. Further details on the expert system and manuals are available in Velicer et al. (1993) and Velicer and Prochaska (1999) articles.

Control condition. Participants randomized to the assessment-only condition in all three studies were assessed at 12-month intervals and did not receive any feedback.

Measures

Demographic characteristics. Demographic variables included age, gender, marital status, years of education, race or ethnicity, and annual household income.

Smoking characteristics. Participants reported the number of cigarettes they smoked in the 7 days prior to baseline assessment, the time to first cigarette smoked in the morning, the number of quit attempts made in the past year, and the longest duration of any previous quit attempt.

Risk factor status. Risk factor status was determined on the basis of stages of change measures for smoking, high-fat diet, and high-risk sun exposure completed at baseline. The smoking stage of change measure assessed behavioral intentions and actions to quit smoking (DiClemente et al., 1991). The sun stage of change measure assessed behavioral intentions and actions to protect oneself from the sun by (a) avoiding sun exposure, (b) wearing protective clothing, and (c) using Sun Protection Factor 15 sunscreens (Weinstock, Rossi, Redding, Maddock, & Cottrill, 2000). The stage of change measure for dietary fat reduction involved a five-item behavioral criterion assessment of low-fat dietary practices (e.g., removing skin from chicken, eating reduced or low-fat cheese; Greene, Rossi, Reed, Willey, & Prochaska, 1994). Individuals meeting the criteria for low-fat diet were categorized as being in either the action or the maintenance stage depending on how long they had met the criteria. Individuals not meeting the criteria were placed in a pre-action stage depending on their intentions to change to meet the criteria. For each of the behaviors, being at risk was defined as being in a pre-action stage, which means that they were smoking, not practicing safe-sun behaviors, and/or consuming a high-fat diet. Baseline data were used to classify participants into three mutually exclusive risk factor categories: (a) smoking only, (b) smoking plus one additional risk factor, or (c) smoking plus two additional risk factors.

Smoking outcome. Stage of change for smoking cessation was reassessed at 12 and 24 months. Being in the action or the maintenance stage is equivalent to a measure of 24-hr point-prevalence abstinence (i.e., nonsmoking status for 24 hr or more). Seven-day point-prevalence abstinence also was measured, and the two measures have been found to correlate at $r = .99$ (Velicer & Prochaska, 2004). Biochemical validation measures of smoking abstinence were not incorporated. A consensus has emerged that biochemical validation is not necessary or even advisable in population-based smoking cessation trials (Society for Research on Nicotine and Tobacco Subcommittee on Biochemical Verification, 2002).

Sun and dietary outcomes. Stages of change for high-risk sun exposure and dietary fat were reassessed at 12 and 24 months. Being in the action or maintenance stages equated with no longer being at risk for high-risk sun exposure or high-fat dietary consumption.

Analyses. Descriptive statistics were used to describe the full sample. Analysis of variance F tests and Pearson chi-squares were run to examine differences in baseline characteristics by risk factor group status. Differences identified between the three risk groups on demographic and smoking variables were included as covariates in model building to control for potential confounding with risk factor status. We conducted the model building using Generalized Estimating Equations (GEE) in SAS Version 8.2. GEE is a powerful and versatile procedure for analyzing discrete and continuous longitudinal data under minimal assumptions about time dependence (Zeger & Liang, 1986). The logit link function was used to assess the dichotomous outcome of moving into the action or the maintenance stage at follow-up for smoking cessation. An autoregressive correlation

matrix was specified because this assumes diminishing correlations as the time between observations increases. The initial model examined the main effects of time, treatment, and risk factor group, controlling for identified covariates. Interaction effects for time, risk factor status, and treatment condition were tested. A categorical variable for the study from which the data were drawn (i.e., patient, parent, employee) was created and examined as a class variable in SAS for main effects and interaction with treatment and risk factor group. Nonsignificant interaction terms were dropped from the final model.

GEE allows for the modeling and evaluation of patterns of missing data. Of the 2,326 smokers at baseline, 1,506, or 65%, completed the 12-month assessment and 1,356, or 58%, completed the 24-month assessment. Analyses were run with the 1,686 participants (73%) who completed at least one of the two follow-up assessments. A parameter for missing none, one, or two assessments was included in the model as a main effect and as an interaction with treatment and risk factor group. Parallel models were run to examine changes in sun and dietary outcomes.

Results

Sample Descriptive Characteristics

Combining across the three trials, the sample of 2,326 smokers was 69% female, 94% non-Hispanic Caucasian, with a mean age of 42 years ($SD = 10.4$); 66% were married or living with a partner. Mean years of education was 13 ($SD = 3.1$); 83% were employed; 54% reported annual household incomes of less than \$40,000. The number of cigarettes smoked per day averaged 17 ($SD = 11.4$). Over half (52.5%) the sample smoked within 30 min of waking; 59% had made a quit attempt in the past year. The longest previous quit attempt averaged 12 months ($SD = 20.3$). The stage distribution for smoking cessation was 35.6% precontemplation, 43.8% contemplation, and 20.6% preparation. The percentages at risk for high-risk sun exposure and high-fat diet were 71.4% and 71.8%, respectively, determined by the baseline stage of change.

Risk Group Comparisons

The proportion of the sample in each of the three risk factor groups was 13% smoking only, 37% smoking plus one additional risk factor, and 50% smoking plus two additional risk factors. The three risk groups were found to differ significantly by gender, age, educational level, smoking rate, quit attempts in the past year, and longest previous quit attempt (all $ps < .01$). The smoking only group was more likely to be female, older, and better educated. These participants smoked fewer cigarettes per day, had made more prior quit attempts in the past year, and had longer periods of abstinence. Smoking stage of change also differed significantly for the risk factor groups ($\gamma = -.096, p = .001$). The proportion in the precontemplation stage increased, whereas the proportion in the preparation stage decreased with additional risk behavior targets. Table 1 summarizes demographic and behavioral data for the three risk groups. Additionally, although 87% of the sample had a risk behavior in addition to smoking, only 8.4% of participants were in the preparation stage for both smoking and for another risk behavior (i.e., sun exposure or diet).

Smoking Cessation by Treatment Condition and Risk Factor Group

Figure 1 displays the point-prevalence abstinence rates for each of the three risk factor groups (smoking only, smoking plus one

Table 1
Descriptive Characteristics by Risk Factor Group Status

Characteristic	Smokers only	Smokers +1 risk factor	Smokers +2 risk factors
Female (%)**	80.3	76.2	61.4
Caucasian (%)	94.4	93.9	93.3
Married/cohabitating (%)	64.5	67.5	64.2
Employed (%)	81.5	81.3	84.4
Income < \$40,000 (%)	56.9	53.1	54.6
Age**	44.9 (11.6)	42.8 (10.2)	41.4 (10.0)
Education*	13.5 (2.6)	13.3 (2.6)	13.1 (2.5)
Cigarettes per day**	15.4 (10.9)	16.4 (10.7)	18.6 (11.8)
Quit attempt past year (%)**	66.6	61.9	55.6
Time to 1st cigarette (hours)	1.7 (2.6)	1.5 (2.5)	1.3 (2.4)
Longest prior quit attempt (months)**	13.5 (23.1)	13.1 (21.5)	9.9 (18.4)
Smoking stage (%)**			
Precontemplation	28.2	35.2	37.9
Contemplation	47.6	43.1	43.3
Preparation	24.3	21.8	18.8

Note. Numbers in parentheses indicate standard deviations. Numbers preceding them indicate means.
* Group comparison $p < .05$. ** Group comparison $p < .01$.

risk factor, smoking plus two risk factors) separately by treatment assignment (intervention vs. control). Abstinence rates were observed to increase over time for all groups, with greater increases among groups receiving the intervention. An increasing proportion of individuals in the intervention condition moved from pre-action stages of change to the action or the maintenance stage over time. It takes time for individuals to progress through the stages of change, and therefore the effects of stage-based treatment are often found to increase over time as participants progress to the action or the maintenance stage. This pattern of increasing treatment effects is in contrast to the relapse curves characteristic of most smoking cessation interventions in which abstinence rates are highest soon

after the intervention and decline thereafter. Among participants receiving the intervention, the smoking only group had the highest abstinence rates at 12 and at 24 months.

GEE was used to examine the significance of risk factor group and treatment condition in predicting abstinence over 12 and 24 months, controlling for identified covariates. All interaction terms tested were nonsignificant, their entry had no effect on the parameter estimates of the main effects, and they were dropped from the model. The final model is summarized in Table 2. The significant main effects of time and treatment indicated abstinence increased from 12 to 24 months and was greater among smokers who received the expert system intervention compared with those in the

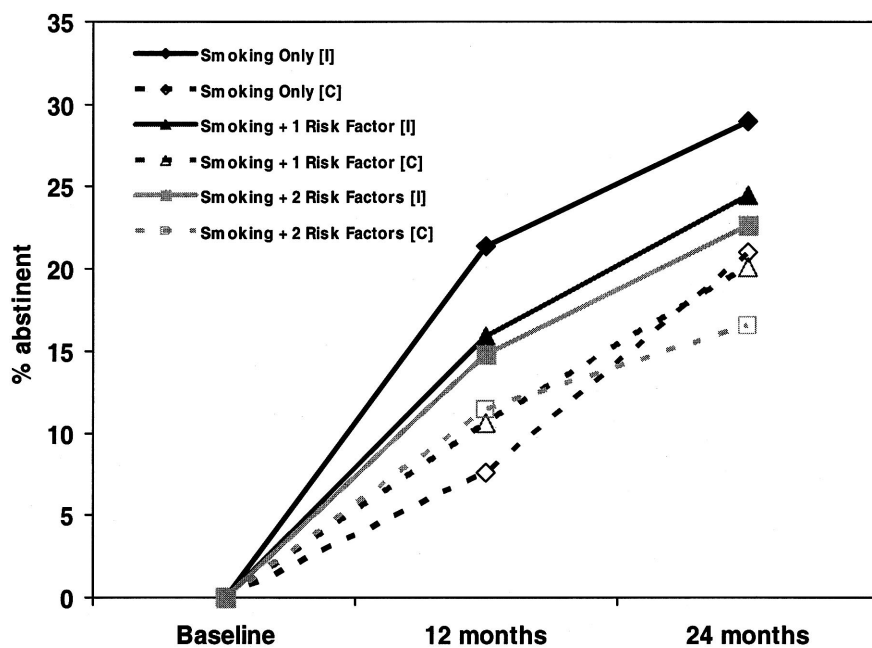


Figure 1. Unadjusted smoking abstinence rates by risk group and treatment condition. I = intervention; C = control condition.

Table 2
Generalized Estimating Equations Model Predicting Smoking Abstinence

Parameter	Odds ratio	95% confidence interval	Z	p
Intercept			-0.66	.507
Female	0.81	0.62, 1.07	-1.45	.146
Age	0.87	0.76, 0.99	-2.09	.036
Education	1.01	0.97, 1.07	0.59	.559
Stage of change at baseline				
Preparation vs. precontemplation	2.42	1.71, 3.42	4.96	< .001
Preparation vs. contemplation	1.79	1.32, 2.42	3.81	< .001
Cigarettes per day at baseline	0.97	0.95, .99	-3.64	< .001
Quit attempts past year	1.00	0.96, 1.05	0.21	.833
Longest previous quit attempt (years)	1.08	1.02, 1.15	2.55	.011
Time				
24 months vs. 12 months	1.68	1.45, 1.95	6.87	< .001
Treatment group				
Intervention vs. control	1.47	1.15, 1.88	3.05	.002
Risk group				
Smoking only vs. smoking +1 risk factor	1.21	0.81, 1.79	0.93	.351
Smoking only vs. smoking +2 risk factors	1.34	0.90, 2.00	1.44	.149
Study				
Employee vs. patient	1.14	0.79, 1.65	0.68	.496
Parent vs. patient	0.97	0.73, 1.29	-0.20	.844
Missing parameter (complete data)	1.52	1.11, 2.08	2.62	.009

Note. Age was divided by 10 years to aid interpretation of the odds ratio.

assessment-only control condition. The covariates of age, baseline smoking stage of change, cigarettes per day, and longest previous quit attempt were significant and indicated greater abstinence among younger participants, in the preparation stage of change, who smoked fewer cigarettes at baseline, and had lengthier prior quit attempts. Gender, education, number of previous quit attempts, and study were nonsignificant predictors in the model. Controlling for these covariates, risk factor group no longer had any significant relation to treatment outcome, indicating there were comparable rates of quitting smoking among the smokers who received only the cessation intervention and the smokers who also were treated for one or two additional risk factors. The main effect for missing status was significant and indicated greater rates of abstinence among participants with complete data.

Changes in sun and dietary behaviors by treatment condition. Sun and dietary outcomes also were examined to assess whether smokers treated for multiple risks were successful in changing these additional health behaviors. Analyses were restricted to those at risk for the behavior of interest at baseline (high-risk sun exposure, low-fat diet, or both). Model building was parallel to that for smoking except for the following changes: Demographic variables for identified risk factor group differences were maintained, but tobacco-related covariates were dropped, and behavior specific stage of change and missing status parameters were entered.

For the model predicting changes in high-risk sun exposure, gender, age, baseline sun stage of change, and treatment condition were significant effects ($p < .05$). Women (odds ratio [OR] = 1.84), older adults (OR = 1.22), individuals in the preparation (OR = 7.14) or the contemplation (OR = 2.26) stages of change, and intervention participants (OR = 1.43) were more likely to reach the action or the maintenance stage for high-risk sun exposure prevention. All interaction effects as well as the main effects for risk factor group, time, study, education, and missing status

were nonsignificant. Similar patterns of change to that observed for smoking cessation were observed: The proportion reaching action or maintenance increased over time, with greater increases among participants receiving the expert system intervention for high-risk sun exposure.

Gender, education, dietary stage of change, time, and study were significant effects ($p < .05$) for the model of dietary risk behavior change. The effect for the expert system intervention was OR = 1.28 ($p = .064$). Women (OR = 1.92), the more highly educated (OR = 1.06), and those in the preparation (OR = 1.73) stage of change were more likely to meet the behavioral criterion for healthy dietary practices. The proportion meeting the behavioral criterion increased from the 12 to 24 month follow-up (OR = 1.22), and the findings indicated greater success among the employee sample versus the patient sample (OR = 1.64). All interaction effects as well as the main effects for age, risk factor group, and missing status were nonsignificant. Similar patterns of change to those observed for smoking cessation were observed: The proportion reaching the action or the maintenance stage increased over time, with greater increases among participants receiving the expert system intervention for high-fat diet.

Comparison with previous smoking cessation only population trials. Four previous trials demonstrated the efficacy of the expert system intervention for smoking cessation (J. O. Prochaska, DiClemente, Velicer, & Rossi, 1993; J. O. Prochaska, Velicer, Fava, Rossi, & Tsoh, 2001; J. O. Prochaska, Velicer, Fava, Ruggerio, et al., 2001; Velicer, Prochaska, Fava, Laforge, & Rossi, 1999). These trials differ from the current set of studies in that they targeted a single health behavior for change: All participants were current smokers at baseline and received intervention only for smoking cessation (additional risk behaviors were not assessed or treated). Intervention smoking cessation rates for the four trials were in the narrow range of 21.6% to 25.6% at 18–24 months

long-term follow-up. Combining across the trials yielded 2,143 intervention participants, with an overall cessation rate of 23.6% (95% confidence interval: 21.80, 25.40). Figure 2 compares the abstinence rates at 24 months for smokers in the intervention condition in the current research with the intervention participants in the four previous trials of smoking cessation. The 95% confidence intervals overlap the point estimates, indicating no significant difference in rates of abstinence for the three risk groups, examined individually or collectively, relative to the previous expert system intervention trials.

Discussion

This article reports on data drawn from smokers participating in three large multibehavioral intervention trials. Findings indicate that there was no reduction in smoking cessation success when additional behavioral risks were treated. The smoking cessation expert system intervention resulted in significantly enhanced abstinence rates at long-term follow-up, with similar treatment effects among individuals at risk and treated only for smoking

compared with persons at risk and treated for smoking plus one or two additional risk behaviors. Comparison with data from previous expert system intervention trials for smoking provided further support, demonstrating replication of abstinence rates within a narrow range even when individuals had and were treated for additional risk behaviors.

An initial examination of abstinence rates and treatment effects by risk factor group suggested an advantage among the group treated for the single risk of smoking (see Figure 1). Participants, however, were not randomly assigned to risk factor groups. Rather, the groups were determined on the basis of participants' baseline risk profiles, and it might be expected that smokers with additional risk behaviors would be more difficult to treat. To identify potential confounding variables, we examined differences in demographic and smoking variables between these risk factor groups. Participants who were at risk for smoking only were found to differ significantly from those with additional risk behaviors and on variables shown previously to be related to successful cessation: They tended to be older, more educated, lighter smokers, in

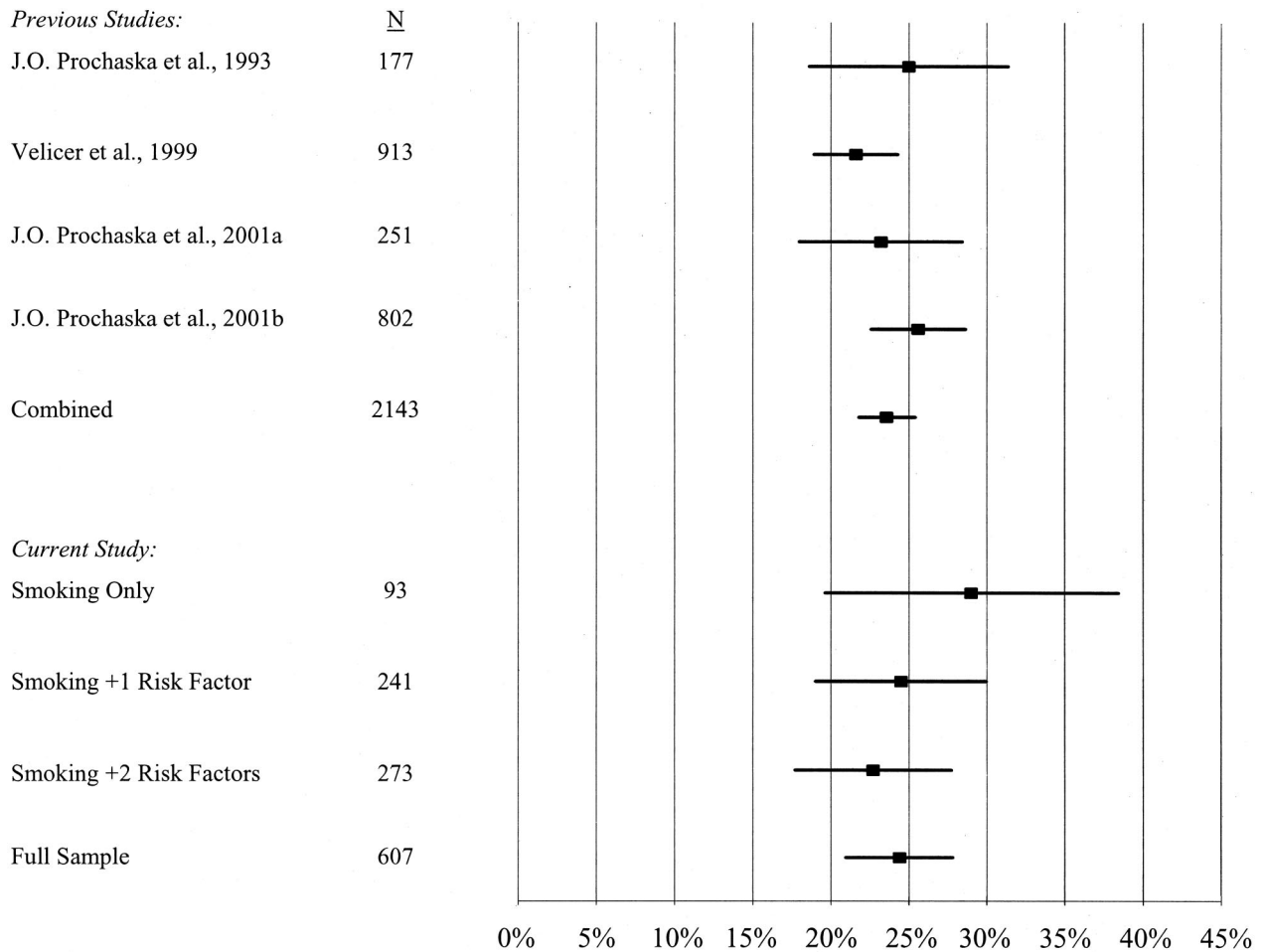


Figure 2. Comparison of point-prevalence abstinence rates at 24 months to previous expert system smoking only studies. The squares indicate the sample point-prevalence abstinence rate, and the bars indicate the 95% confidence intervals. J. O. Prochaska et al., 2001a, corresponds to Prochaska, Velicer, Fava, Rossi, and Tsoh (2001) and J. O. Prochaska et al., 2001b, corresponds to Prochaska, Velicer, Fava, Ruggiero, et al., 2001.

the preparation stage for quitting smoking. On the surface it appeared that the smoking only group did better than the other groups. However, when the advantages in this group on age, education, smoking rate, length of previous quit attempts, and stage of change were controlled in model testing, differences in cessation rates were nonsignificant. Further, the Treatment \times Risk Group interaction was nonsignificant, indicating no difference in treatment efficacy by risk factor group status. What this suggests is that being at risk and treated for multiple risk behaviors did not decrease success with quitting smoking. Rather, differences in demographic characteristics and smoking variables between the risk groups accounted for any differences in success with quitting smoking.

The findings of comparable outcomes when treating the single behavior of smoking in multibehavioral trials are especially important given that the vast majority of smokers have multiple behavioral risk factors. In the current study, for example, 87% of smokers also were at risk for high-fat diet or high-risk sun exposure. The results indicate that interventions can be more ambitious by effectively treating the multiple risks of smokers without reducing the efficacy of treatment for smoking.

Results for measures of sun exposure and dietary behaviors showed processes similar to those found for smoking. Treatment condition and baseline stage of change were consistent predictors of outcomes across all three behaviors. However, the number of risk behaviors that individuals had and were treated for was not a significant predictor of intervention success for any of the three behaviors. These results indicate that the expert system intervention was successful in promoting changes in multiple risk behaviors within individuals. Further, treatment efficacy for each behavior was not affected by the number of risk factors individuals had and were treated for.

Several demographic variables were related to sun and dietary changes. Women had a greater likelihood of improvement than did men on diet and sun behaviors, older age was associated with greater change in high-risk sun exposure, and more education was predictive of greater dietary changes. It is unclear why the employee sample outperformed the patient sample on dietary change. The patterns of changes observed were similar for smoking, sun, and dietary outcomes and indicated an increasing proportion of individuals in the intervention condition reached the action or the maintenance stage of change over time. The pattern of increasing treatment effects over time of the expert system intervention has been demonstrated previously and is a function of individuals progressing over time through the stages of change (J. O. Prochaska et al., 1993; J. O. Prochaska, Velicer, Fava, Rossi, & Tsoh, 2001; J. O. Prochaska, Velicer, Fava, Ruggerio, et al., 2001; Velicer et al., 1999). This pattern differs from the relapse curves common in action-based interventions that typically treat motivated smokers who are prepared to quit immediately.

Comparison of Findings With the Research Literature

The patient, parent, and employee data sets analyzed in the current study are unique in allowing for examination of multiple risk behavior change within populations and individuals, because treatment effects at the population level were significant. In examining changes at the individual level, the current findings provide additional support for multiple risk behavior interventions. In

the literature, a few studies have examined the impact of treating smoking along with additional risk behaviors. The findings have been mixed. For example, a smoking cessation program with an added weight management component demonstrated increased relapse rates as compared with a standard quit-smoking program (Hall, Tunstall, Vila, & Duffy, 1992). The focus on weight control issues was believed to have detracted from motivations to quit smoking. In contrast, participation in a vigorous exercise program was found to increase short- and long-term smoking cessation among women when combined with a cognitive-behavioral smoking cessation program (Marcus et al., 1999). Additional benefits included improved exercise capacity and delayed weight gain. A follow-up study, however, demonstrated less success with cessation (Marcus et al., 2003). A recent meta-analysis of tobacco cessation interventions with substance abusing populations found that smoking cessation interventions offered during substance abuse treatment were associated with significant short-term tobacco cessation as well as enhanced long-term sobriety from drugs and alcohol (J. J. Prochaska, Delucchi, & Hall, 2004). Treatment effects for smoking cessation, however, were not maintained at long-term follow up. More research clearly is needed to better understand the potential benefits and limitations of multibehavioral interventions within individuals.

The lack of success of prior multiple risk factor interventions may be due to the action-based paradigms used. Interventions that promote simultaneous action in multiple risk factors are likely to overwhelm participants. Analysis of data from 3,616 current smokers with three other risk factors (diet, sun, and exercise) indicated less than 10% were prepared to take action on two or more behaviors (J. O. Prochaska, Velicer & Rossi, 2002). In the current study, only 8.4% of smokers with additional risk factors were prepared to take action on smoking plus an additional risk behavior. The positive findings for multiple risk behavior change in individuals in the current study, and in populations reported elsewhere for the three trials, is likely related to the theoretical approach guiding the intervention strategies. Expert system TTM interventions are purposefully designed for individuals in all stages of change and not just for the minority who are ready to take action. The stage-based approach has proven useful for single behavior change within populations and may be even more appropriate when intervening on multiple risk behaviors within individuals.

The current analysis focused on naturally occurring groups—the number of behaviors that individuals had could be determined only by baseline risk status and not by random assignment. Identified group differences in demographic and baseline tobacco use characteristics had to be statistically controlled for in model testing. This type of design is inherent when comparing outcomes in individuals who are at risk and treated for single versus multiple behaviors. This study was not designed to compare treatment outcomes in individuals who have all three risk behaviors but are randomly treated for one, two, or three behaviors. Future randomized trials are needed to address the important issue of single versus multiple behaviors treated within individuals who have the same multiple risk behaviors.

Statistical analyses controlled for effects related to retention rates. Standard statistical methods for handling missing data have been shown to be much more accurate than previous ad hoc procedures (Graham, Cumsille, & Elek-Fisk, 2003; Schafer &

Graham, 2002). In the models for sun and diet, missing data were unrelated to behavioral outcomes. The model for smoking, however, indicated an increased likelihood of missing data among participants who were unsuccessful in quitting smoking. Although the attrition was not completely at random, it appeared to be a function of something measured (i.e., abstinence status), and including this variable in the model statistically controlled for it. One of the strengths of intention-to-treat analysis is preventing the introduction of bias in group membership that may occur if participants with missing data are excluded.

Study Implications

The current findings support the strategy of treating multiple rather than single behaviors within individuals and populations that have multiple risks. The results indicate that smokers who do have and are treated for multiple risks will be just as effective at quitting smoking as those who have and are treated only for smoking. Further, treatment also produced significant treatment effects on their additional risk behaviors. By addressing multiple health risks within individuals and populations, these interventions have the potential for increasing significant impacts on public health.

Measures for assessing impact, however, will need to take into account the number of behaviors treated effectively. To date, impact has been measured only for treatment of a single behavior such as smoking. Impact (I) has been measured as intervention efficacy (E) times participation (P) or $I = E \times P$ (Velicer & Prochaska, 1999). With smoking, the stage-based expert system intervention for smoking cessation has consistently demonstrated efficacy of around 24% point-prevalence abstinence at long-term follow-up (see Figure 2). Recruitment rates have approximated 80%, leaving little room for improvement. A revised formula for impact may be considered as intervention efficacy times participation summed over the multiple behavioral targets, $I = \sum_{\# \text{ of behaviors}(b)} (E_b \times P_b)$. Here, P would be the proportion of at risk individuals participating in the intervention for each behavior. E would be the estimate of efficacy for each behavior. Use of a common metric, such as the percentage no longer at risk (i.e., the percentage reaching the action or the maintenance stage), would allow for summation across behaviors. This revised impact equation would provide a measure for assessing the impact of interventions in individuals and populations with multiple behavior risks.

References

- Atkins, D., & Clancy, C. (2004). Multiple risk factors interventions: Are we up to the challenge? *American Journal of Preventive Medicine*, 27(Suppl.), 102–103.
- Carleton, R. A., Lasater, T. M., Assaf, A. R., Feldman, H. A., & McKinlay, S. (1995). The Pawtucket Heart Health Program: Community changes in cardiovascular risk factors and projected disease risk. *American Journal of Public Health*, 85, 777–785.
- DiClemente, C. C., Prochaska, J. O., Fairhurst, S. K., Velicer, W. F., Velasquez, M. M., & Rossi, J. S. (1991). The process of smoking cessation: An analysis of precontemplation, contemplation, and preparation stages of change. *Journal of Consulting and Clinical Psychology*, 59, 295–304.
- Ebrahim, S., & Davey Smith, G. (2002). Multiple risk factor interventions for primary prevention of coronary heart disease. *Cochrane Database of Systematic Reviews*, 2, CD001561(4)
- Edington, D. W., Yen, L. T., & Witting, P. (1997). The financial impact of changes in personal health practices. *Journal of Occupation and Environmental Medicine*, 39, 1037–1046.
- Emmons, K. M., Marcus, B. H., Linnan, L., Rossi, J. S., & Abrams, D. B. (1994). Mechanisms in multiple risk factor interventions: Smoking, physical activity, and dietary fat intake among manufacturing workers. Working Well Research Group. *Preventive Medicine*, 24, 481–489.
- Farquhar, J. W., Fortmann, S. P., Flora, J. A., Taylor, C. B., Haskell, W. L., Williams, P. T., et al. (1990). Effects of communitywide education on cardiovascular disease risk factors. The Stanford Five-City Project. *Journal of the American Medical Association*, 264, 359–365.
- Fine, L. J., Philogene, G. S., Gramling, R., Coups, E. J., & Sinha, S. (2004). Prevalence of multiple chronic disease risk factors; 2001 National Health Interview Survey. *American Journal of Preventive Medicine*, 27(Suppl.), 18–24.
- Goldstein, M. G., Whitlock, E. P., & DePue, J. (2004). Multiple behavioral risk factor interventions in primary care: Summary of research evidence. *American Journal of Preventive Medicine*, 27(Suppl.), 61–79.
- Graham, J. W., Cumsille, P. E., & Elek-Fisk, E. (2003). Methods for handling missing data. In J. A. Schinka, W. F. Velicer, & I. B. Weiner (Eds.), *Handbook of psychology: Research methods in psychology* (Vol. 2, pp. 87–114). New York: Wiley.
- Greene, G. W., Rossi, S. R., Reed, G. R., Willey, C., & Prochaska, J. O. (1994). Stages of change for reducing dietary fat to 30% of energy or less. *Journal of the American Dietetic Association*, 94, 1105–1110.
- Hall, S. M., Tunstall, C. D., Vila, K. L., & Duffy, J. (1992). Weight gain prevention and smoking cessation: Cautionary findings. *American Journal of Public Health*, 82, 799–803.
- Klesges, R. C., Eck, L. H., Isbell, T. R., Fulliton, W., & Hanson, C. L. (1990). Smoking status: Effects on the dietary intake, physical activity, and body fat of adult men. *American Journal of Clinical Nutrition*, 51, 784–789.
- Kronenfeld, J. J., Goodyear, N., Pate, R., Blair, A., Howe, H., Parker, G., et al. (1988). The interrelationships among preventive health habits. *Health Education Research*, 3, 317–323.
- Labarthe, D. R. (1998). *Epidemiology and Prevention of Cardiovascular Disease: A Global Challenge*. Gaithersburg, MD: Aspen Publishers.
- Luepker, R. V., Murray, D. M., Jacobs, D. R., Jr., Mittelmark, M. B., Bracht, N., Carlaw, R., et al. (1994). Community education for cardiovascular disease prevention: Risk factor changes in the Minnesota Heart Health Program. *American Journal of Public Health*, 84, 1383–1393.
- Marcus, B. H., Albrecht, A. E., King, T. K., Parisi, A. F., Pinto, B. M., Roberts, M., et al. (1999). The efficacy of exercise as an aid for smoking cessation in women: A randomized controlled trial. *Archives of Internal Medicine*, 159, 1229–1234.
- Marcus, B. H., Lewis, B., Hogan, J., King, T., Albrecht, A., Block, B., et al. (2003). The efficacy of moderate intensity physical activity for smoking cessation among women [Abstract]. *Annals of Behavioral Medicine*, 25(Suppl.), S047.
- Multiple Risk Factor Intervention Trial Research Group. (1982). Multiple risk factor intervention trial. Risk factor changes and mortality results. *Journal of the American Medical Association*, 248, 1465–1477.
- Ockene, J. K., & Shaten, B. J. (1991). Cigarette smoking in the Multiple Risk Factor Intervention Trial (MRFIT). Introduction, overview, method, and conclusions. *Preventive Medicine*, 20, 552–563.
- Orleans, C. T. (2004). Addressing multiple behavioral health risks in primary care: Broadening the focus of health behavior change research and practice. *American Journal of Preventive Medicine*, 27(Suppl.), 1–3.
- Prochaska, J. J., Delucchi, K., & Hall, S. M. (2004). A meta-analysis of smoking cessation interventions with individuals in substance abuse treatment or recovery. *Journal of Consulting and Clinical Psychology*, 72, 1144–1156.

- Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology, 51*, 390–395.
- 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.
- Prochaska, J. O., DiClemente, C. C., Velicer, W. F., & Rossi, J. S. (1993). Standardized, individualized, interactive, and personalized self-help programs for smoking cessation. *Health Psychology, 12*, 399–405.
- Prochaska, J. O., Velicer, W. F., Fava, J. L., Rossi, J. S., & Tsoh, J. Y. (2001). Evaluating a population-based recruitment approach and a stage-based expert system intervention for smoking cessation. *Addictive Behaviors, 26*, 583–602.
- Prochaska, J. O., Velicer, W. F., Fava, J. L., Ruggiero, L., Laforge, R. G., Rossi, J. S., et al. (2001). Counselor and stimulus control enhancements of a stage-matched expert system intervention for smokers in a managed care setting. *Preventive Medicine, 32*, 23–32.
- Prochaska, J. O., Velicer, W. F., Redding, C. A., Rossi, J. S., Goldstein, M. G., DePue, J., et al. (2005). Stage-based expert systems to guide a population of primary care patients to quit smoking, eat healthier, prevent skin cancer, and receive regular mammograms. *Preventive Medicine, 41*, 406–416.
- Prochaska, J. O., Velicer, W. F., & Rossi, J. S. (2002). [Number of risk factors in preparation among 3,616 current smokers]. Unpublished raw data.
- Prochaska, J. O., Velicer, W. F., Rossi, J. S., Redding, C. A., Greene, G. W., Rossi, S. R., et al. (2004). Multiple risk expert systems interventions: Impact of simultaneous stage-matched expert system interventions for smoking, high-fat diet, and sun exposure in a population of parents. *Health Psychology, 23*, 503–516.
- Pronk, N. P., Anderson, L. H., Crain, A. L., Martinson, B. C., O'Connor, P. J., Sherwood, N. E., et al. (2004). Meeting recommendations for multiple healthy lifestyle factors; Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *American Journal of Preventive Medicine, 27*(Suppl.), 25–33.
- Puska, P., Nissinen, A., Salonen, J. T., & Toumilehto, J. (1983). Ten years of the North Karelia Project: Results with community-based prevention of coronary heart disease. *Scandinavian Journal of Social Medicine, 11*, 65–68.
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods, 7*, 147–177.
- Shinton, R. (1997). Lifelong exposures and the potential for stroke prevention: The contribution of cigarette smoking, exercise, and body fat. *Journal of Epidemiological Community Health, 51*, 138–143.
- Society for Research on Nicotine and Tobacco Subcommittee on Biochemical Verification. (2002). Biochemical verification of tobacco use and cessation. *Nicotine and Tobacco Research, 4*, 149–159.
- Sorensen, G., Thompson, B., Glanz, K., Feng, Z., Kinne, S., DiClemente, C., et al. (1996). Work site-based cancer prevention: Primary results from the Working Well Trial. *American Journal of Public Health, 86*, 939–947.
- Velicer, W. F., & Prochaska, J. O. (1999). An expert system intervention for smoking cessation. *Patient Education and Counseling, 36*, 119–129.
- Velicer, W. F., & Prochaska, J. O. (2004). A comparison of four self-report smoking cessation outcome measures. *Addictive Behaviors, 29*, 51–60.
- Velicer, W. F., Prochaska, J. O., Bellis, J. M., DiClemente, C. C., Rossi, J. S., Fava, J. L., et al. (1993). An expert system intervention for smoking cessation. *Addictive Behaviors, 18*, 269–290.
- Velicer, W. F., Prochaska, J. O., Fava, J. L., Laforge, R. G., & Rossi, J. S. (1999). Interactive versus noninteractive interventions and dose-response relationships for stage-matched smoking cessation programs in a managed care setting. *Health Psychology, 18*, 21–28.
- Velicer, W. F., Prochaska, J. O., Redding, C. A., Rossi, J. S., Sun, X., Greene, G. W., et al. (2004). Efficacy of expert system interventions for employees to decrease smoking, dietary fat, and sun exposure [Abstract]. *International Journal of Behavioral Medicine, 11*(Suppl.), 277.
- Weinstock, M. A., Rossi, J. S., Redding, C. A., Maddock, J. E., & Cottrill, S. D. (2000). Sun protection behaviors and stages of change for the primary prevention of skin cancers among beachgoers in southeastern New England. *Annals of Behavioral Medicine, 22*, 286–293.
- Zeger, S. L., & Liang, K. Y. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics, 42*, 121–130.