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RESEARCH REPORT

Addiction versus stages of change models in predicting smoking cessation

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Abstract

Prospective data from the California Tobacco Surveys (n = *2066) were used to perform a critical test of the Prochaska* et al. *(1991) stages of change model. When the stages of change model was used as a stand alone predictor, smokers in preparation at baseline were more likely to be in cessation at follow-up than smokers in pre-contemplation at baseline* ($OR_{adj} = 1.9$) *When stage membership was combined with baseline measures of addiction including smoking behaviors and quitting history, it was not a significant predictor of future cessation. A prediction equation that combined daily vs. occasional smoking, cigarettes per day smoked, life-time quits of at least a year, and quits of more than 5 days in the previous year discriminated smokers in cessation at follow-up of 1 to 2 years better than did the stages of change model. The area under the ROC curve for the equation based on addiction measures was 69.3% vs. 55.1% for the stages of change. Cessation rates ranged from 7.7% to 35.7% for the four-category addiction equation compared with 15.1% to 24.9% for stages of change model.*

Introduction

During the past decade the stages of change construct, derived from the transtheoretical model of change presented by Prochaska & DiClemente (1983), has become widely adopted among addiction researchers as the accepted model for understanding the process of achieving abstinence from smoking (Heather, 1992; Stockwell, 1992). Recently, other researchers have expressed concerns about the validity of the stages of change construct and its apparent lack of a solid theoretical basis (Davidson, 1992). Prochaska and colleagues offered in rebuttal that their model has been demonstrated to be robust across behaviors, that the model draws on Bandura's social learning and self-efficacy theories and on other motivational and relapse theories, and that it has been carefully validated (Prochaska *et al.*, 1992).

Even after reviewing the published papers on smoking cessation by Prochaska and colleagues since they introduced the stage of change construct (DiClemente, 1981; Prochaska & DiClemente, 1983; DiClemente, Prochaska &

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Gibertini, 1985; Prochaska *et al.*, 1985, 1991, 1992, 1993; Velicer *et al.*, 1985, 1992; Wilcox *et al.*, 1985; DiClemente *et al.*, 1991; Pallonen *et al.*, 1992), we find that an important gap in its validation remains. When used as the sole predictor, stage membership has been shown to be significantly associated with smoking cessation at follow-up intervals ranging from 1 to 18 months (DiClemente *et al.*, 1991; Prochaska *et al.*, 1993). However, we do not know the relative importance of stage membership as a predictor of cessation because of the absence in the literature of appropriate multi-variable analyses that include other known predictors of cessation, such as the other 14 components of the transtheoretical model of change.

Many studies have demonstrated that nicotine addiction is the main impediment to cessation (US Department of Health and Human Services, 1988). Current smoking measures, such as the number of cigarettes smoked per day and the latency to the first cigarette of the day (Fagerstrom, 1978; Fagerstrom & Schneider, 1989), are associated with cessation. Similarly, more indirect measures of addiction, such as the duration and ease of the most recent failed quit attempt (Ockene *et al.*, 1982), are also associated with cessation.

We will use data from a large longitudinal population-based survey of California smokers conducted in 1990 and 1992 to clarify whether (1) stage membership predicts smoking cessation because it shares a sizable amount of common variance with indicators of addiction level; (2) stage membership goes beyond addiction and is independently important for predicting smoking cessation; or (3) stage membership neither shares common variance nor acts as an independent predictor. Either of the first two outcomes would provide needed justification for use of stage membership both as a stand-alone predictor and as an interim outcome in smoking cessation studies (Velicer *et al.*, 1992). It would also shed light on whether stage-matching provides the optimal way of tailoring cessation interventions to specific smokers (Prochaska *et al.*, 1993). However, if stage membership neither shares considerable variance with other known predictors nor acts as an independent predictor, then it will be necessary to develop new approaches for predicting cessation.

Method

Sample

The 1990 California Tobacco Survey (CTS) used a modified Waksberg random-digit dialed telephone methodology (Waksberg, 1978) and a two-stage sampling design. Interviewers conducted a 25-minute computer assisted telephone interview (CATI) on 24 296 adults on issues relating to tobacco use (Borland *et al.*, 1992). Westat Inc. completed fieldwork by following a protocol aimed at maximizing response rates and data quality (Pierce *et al.*, 1992; Pierce *et al.*, 1994).

A stratified random sample of 2066 current smokers who in 1990 answered "Yes" to the questions: "Do you smoke cigarettes now?" and "Have you smoked at least 100 cigarettes in your entire life?" were reinterviewed in 1992. The interval between surveys ranged from 437 to 751 days, with a median of 602 days. We assessed the representativeness of respondents in the longitudinal panel by comparing respondents with the potentially eligible participants from the 1990 California Tobacco Survey, who were not interviewed again. Socio-demographic differences between the final sample and the initial sampling frame (CTS 1990) were less than 5% for any subcategory of age, gender, race/ethnicity or educational level attained.

Measures of smoking status

On both the 1990 and the 1992 CTS, ever smokers who answered "Yes" to the question: "Do you smoke cigarettes now?" were classified as current smokers, whereas those who answered "No" to this question on the 1992 CTS were classified as former smokers. On both surveys, current smokers who answered "Every day" to the question: "Do you now smoke cigarettes every day or some days?" were classified as current daily smokers while those who answered "Some days" were classified as occasional smokers.

Measures of cigarette consumption, quitting history and intention to quit

In both surveys, daily smokers were asked the following two questions: "How many cigarettes on average do you smoke per day?" and "How soon after you awake in the morning do you usually smoke your first cigarette?" Occasional smokers were asked a slightly different question:

"During the past 30 days, on the days that you did smoke, about how many cigarettes did you usually smoke per day?"

All current smokers on the 1990 CTS who provided an age response to the question: "How old were you when you first began to smoke cigarettes on a regular basis?" and who answered "Yes" to: "Since then, have you ever stopped smoking cigarettes for a period of at least one year?" were credited with one quit attempt that lasted for at least 1 year. Only those smokers who answered "Yes" to the second question were asked the third question: "Before that, did you ever stop smoking cigarettes for a period of at least one year?" The third question was repeated until the respondent denied making any further quit attempts that lasted for at least 1 year.

In both surveys, a history of recent quit attempts was ascertained for all current smokers by asking from one to four questions. The first question was: "Were you smoking at all around this time 12 months ago?" Only those smokers who answered "Yes" to the first question were asked the second question: "During the past 12 months, have you quit smoking intentionally for one day or longer?" Only those smokers who answered "Yes" to the second question were asked the third and fourth questions: "How long did you actually stay off cigarettes that time?" and "Did you quit smoking intentionally for at least a day any time before that, within the past 12 months?" The third and fourth questions were repeated until the respondent denied making any further quit attempts.

In both surveys, intention to quit smoking was ascertained for all current smokers by asking one or two questions provided by Prochaska and colleagues. The first question was: "Are you planning to quit smoking in the next 30 days?" Only those smokers who answered "No" to the first question were asked the second question: "Are you contemplating quitting smoking in the next six months?" Based on these two questions, respondents were assigned to one of three intention groups: those who intended to quit in the next 30 days, those who intended to quit in the next 6 months, and those who did not intend to quit. Intention and recent quitting history were used to assign each smoker to a stage, according to the Prochaska & DiClemente stages of change model. Smokers with no intention to quit were assigned to the precontemplation stage, and those with intention to quit in the next 6 months were assigned to the contemplation stage. Those with an intention to quit in the next 30 days and with a recent history of a quit attempt that lasted for a day or longer were assigned to the preparation stage; the remainder, without such an attempt were assigned to the contemplation stage.

Statistical analysis

For percentages and crosstabulations in the tables and text, we have provided 95% confidence intervals (CIs) and χ^2-square statistics (Wald or Mantel–Haenszel) where appropriate. We used an automated procedure to test the predictor power of the stages of change model (Efron, 1982). Smokers were randomly assigned to one of 10 test samples. The 90% of smokers not in a given test sample were used as the training sample in a stepwise logistic analysis to generate a prediction equation. We included as independent variables sets of dummy coded variables for intention to quit, stage, long-term quitting history, recent quit durations, daily or occasional smoking and addiction (four categories defined by cigarette consumption <15 or $\geqslant 15$ cigarettes per day, and latency to smoke upon awakening $\leqslant 30$ or >30 minutes). For some factors, we included alternative sets so that the stepwise procedure could chose the best categorization. For instance, we considered different frequency cut-points for long-term quits, whereas we considered different duration cut-points for short-term quits. We examined variables selected by each analysis (significance level $p<0.05$); variables that appeared in all or most of the analyses were selected for inclusion in the final equation estimated for the full sample. We also used the stage variables by themselves to generate an alternate equation on the full sample.

We generated response operator characteristic (ROC) curve areas using the probabilities of smoking cessation generated from the two equations in the full sample and the actual outcomes (smoking or not smoking at follow-up). Doing so provided a measure of the predictive power of the two equations (Hanley & McNeil, 1982). Since these ROC curve areas are biased because they are based on coefficients applied to the sample from which they were derived, we computed ROC curve areas for each of the 10 test

Table 1. *Addiction level and quitting history at baseline and cessation at follow-up* (n = 2066)

Variables	*n*	% Quit at follow-up	Adjusted OR**	95% CI+	Wald χ^2	*p*-value
Addiction level*						
15+ Cigarettes & ⩽30 minutes	933	10.8	—	—	—	—
15+ Cigarettes & >30 minutes	390	14.4	1.1	0.8–1.7	0.57	NS
<15 Cigarettes & ⩽30 minutes	157	21.7	1.9	1.2–3.0	8.46	<0.005
<15 Cigarettes & >30 minutes	586	27.8	1.8	1.3–2.6	12.00	<0.001
Frequency of smoking						
Daily	1768	14.1	—	—	—	—
Non-daily	298	35.2	1.9	1.3–2.7	12.18	<0.001
Longest quit attempt in the previous year (days)						
<6	1495	13.9	—	—	—	—
6+	571	25.7	1.5	1.2–2.0	10.87	<0.005
One or more year quits since start of regular smoking						
No	1432	13.2	—	—	—	—
Yes	634	26.0	1.9	1.5–2.4	26.81	<0.001

*Determined by number of cigarettes consumed on the days smoked and time to the first cigarette after awakening; the occasional smokers were included with smokers who waited >30 minutes.
**Odds ratios adjusted for the remaining variables in the table.
+ Confidence interval.

samples using the coefficients from the 90% training sample for that particular test sample. We then computed the mean and standard error of differences in the ROC areas for the 10 pairs of test and training samples. The mean difference between these areas is an estimate of bias in the prediction equations. The standard error of this mean was used to calculate the 95% CI for the bias. Finally, we tested the mean curve areas for the two equations to determine if they differed statistically (Hanley & McNeil, 1983).

Results

Factors related to cessation at follow-up

Table 1 shows the variables selected by the logistic regression. The same variables of addiction level, smoking frequency (daily vs. occasional) and long-term quit of at least a year entered all 10 cross-validation analyses. Recent quitting history variables also entered each analysis, but with somewhat different cut-points; five of the analyses selected a recent quit of more than 5 days while the others chose 4 or 7 days. In all but one analysis, smokers not smoking at all a year before the baseline interview were included in the group with 4 to 7 or more days of recent cessation. In none of the 10 analyses did the stepwise procedure select stage membership or intention to quit as an independent predictor of smoking cessation.

Applied to the full sample of 2066 smokers, Table 1 shows that smokers who smoked fewer than 15 cigarettes per day at baseline were about 80% more likely to be in cessation at follow-up than were those who smoked 15 or more cigarettes per day at baseline. This was the case regardless of whether those who smoked fewer than 15 cigarettes had short or long latency ($OR_{adj} = 1.9$ vs. $OR_{adj} = 1.8$, respectively). Even after we adjusted for addiction level, the occasional smokers at baseline were still about 90% more likely to be in cessation at follow-up than were daily smokers. In addition, smokers who reported making at least one quit attempt that lasted for a year since becoming a regular smoker were also about 90% more likely to be in cessation at follow-up than were smokers who had never made a year-long quit attempt. Smokers whose longest recent quit attempt lasted for more than 5 days were about 50% more likely to be in cessation at follow-up than those without a quit attempt or whose longest quit lasted for less than 6 days.

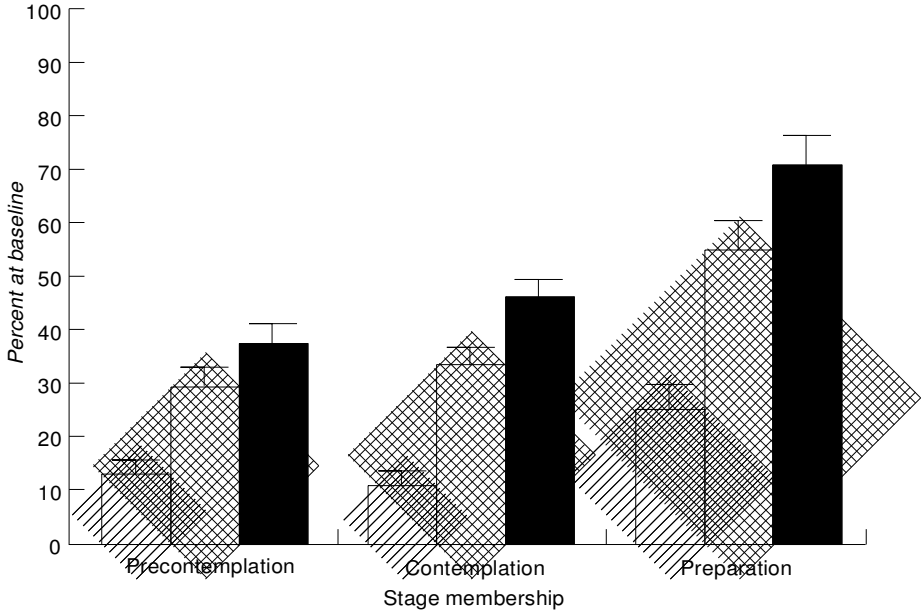

Figure 1. *Rates of non-daily smoking, consumption of less than 15 cigarettes per day, and quitting history (either a life-time quit of a year's duration or a 5+ day quit in the previous year) as a function of baseline stage of change (▨ non-daily, ▩ < 15 cigarettes per day, ■ quitting history).*

Stages of change and presence of behaviors that predict cessation

The lack of independent contribution for stages of change in the multivariable analyses suggests that stage may share common variance with the indicators of addiction level. Fig. 1 shows the prevalence of occasional smoking, low cigarette consumption (< 15/day), and quitting history (a prior year-long quit or a quit of more than 5 days in the previous year) among smokers in each of the stages of change at the initial interview. The only factor in which smokers in the contemplation stage differed from those in the precontemplation stage was quitting history (46.5% vs. 36.7%, respectively, $\chi^2 = 16.83$, df = 1, $p < 0.001$). However, smokers in the preparation stage differed from those in contemplation on all three factors (25.4% vs. 11.6% for occasional smoking, $\chi^2 = 37.60$, df = 1, $p < 0.001$; 55.6% vs. 33.9% for low consumption, $\chi^2 = 49.75$, df = 1, $p < 0.001$; and 71.6% vs. 46.5% for quitting history, $\chi^2 = 64.17$, df = 1, $p < 0.001$). Thus, the preparation stage captures a group of smokers with more of the characteristics that are positively related to the likelihood of future cessation.

Comparison of addiction and stages of change as predictors of cessation

Fig. 2 shows the ROC curves for the prediction equations based on addiction variables versus the stages of change, which we computed using the full sample; the areas under these curves were 69.3% and 55.1%, respectively. The mean areas computed for the test samples were 68.4% and 53.8%, respectively. The estimated bias was less than 1.0% with a confidence limit of ±3.1%. The 15% difference in the mean curve areas for the addiction variables and the stages of change was highly significant ($z = 9.02$; $p < 0.001$)

To evaluate further the predictive ability of these models, we contrasted cessation rates at follow-up for smokers with none, 1, 2 or 3 or more of the important addiction variables at baseline (< 15 cigarettes per day, a long-term quit of a year or more, a recent quit of more than 5 days, and occasional smoking) with cessation rates for smokers in each of the three stages of change. As can be seen in Fig. 3, the number of addiction factors present at baseline was strongly associated with cessation 1 to 2 years later (Mantel–Haenszel $\chi^2 = 145.86$, df = 1, $p < 0.001$). Compared with the smokers with no cessation indicators ($n = 818$), nearly twice as many of the

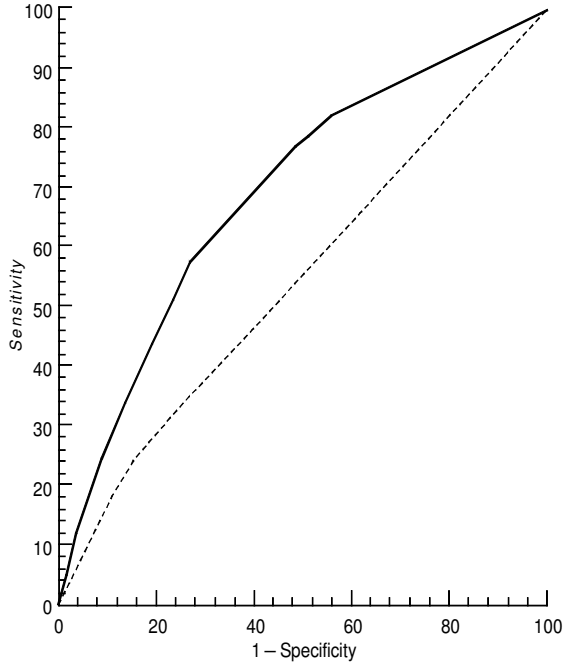

Figure 2. *Receiver operating characteristic (ROC) curves for cessation at follow-up for the addiction model (—) of smoking cessation and the stages of change (- - -) model.*

smokers with one indicator ($n = 596$) were in cessation at follow-up (7.7% vs. 15.1%; $OR_{adj} = 2.1$, Wald $\chi^2 = 18.91$, df = 1, $p < 0.001$); more than four times as many of the smokers with two indicators ($n = 372$) were in cessation at follow-up (7.7% vs. 27.2%; $OR_{adj} = 4.5$, Wald $\chi^2 = 72.75$, df = 1, $p < 0.001$); and more than six times as many of the smokers with three or more indicators ($n = 280$) were in cessation at follow-up (7.7% vs. 35.7%; $OR_{adj} = 6.7$, Wald $\chi^2 = 109.73$, df = 1, $p < 0.001$).

Overall, the stage of change at baseline was also associated with cessation at follow-up (Mantel–Haenszel $\chi^2 = 12.22$, df = 1, $p < 0.001$). Contrary to our expectations, the smokers in the contemplation stage ($n = 974$) did not show a significantly higher rate of cessation at follow-up than the rate observed for the smokers in the pre-contemplation stage ($n = 750$; 16.0% vs. 15.1%; $OR_{adj} = 1.1$, Wald $\chi^2 = 0.29$, df = 1, NS); however, the smokers in the preparation stage ($n = 342$) did show a higher rate of cessation at follow-up than smokers in the precontemplation stage (24.9% vs. 15.1%; $OR_{adj} = 1.9$, Wald $\chi^2 = 14.88$, df = 1, $p < 0.001$).

Joint effects of stages of change and number of addiction model variables on cessation

In Table 2, we have assigned smokers to one of 12 groups on the basis of their stage of change and the number of addiction variables that they reported at baseline. For smokers in the preparation stage (first row of Table 2), the rate of cessation increased from a low of 11.1% to a high of 37.1% as the number of cessation indicators increased. Among smokers in the contemplation stage (second row of Table 2) the rate of cessation increased significantly from a low of 8.0% to a high of 27.8%; among smokers in the pre-contemplation stage (third row of Table 2) the rate of cessation increased significantly from a low of 7.0%, for those with none of the cessation indicators, to a high of 43.6% for those with three or more of these indicators.

This is in stark contrast to the stages of change model variables within each level of addiction. No significant differences were identified for the stages of change at any level of addiction. Among the most-addicted, the range of quitting for the stages of change varied from 7.0% to 11.1%; among those with one cessation indicator, the

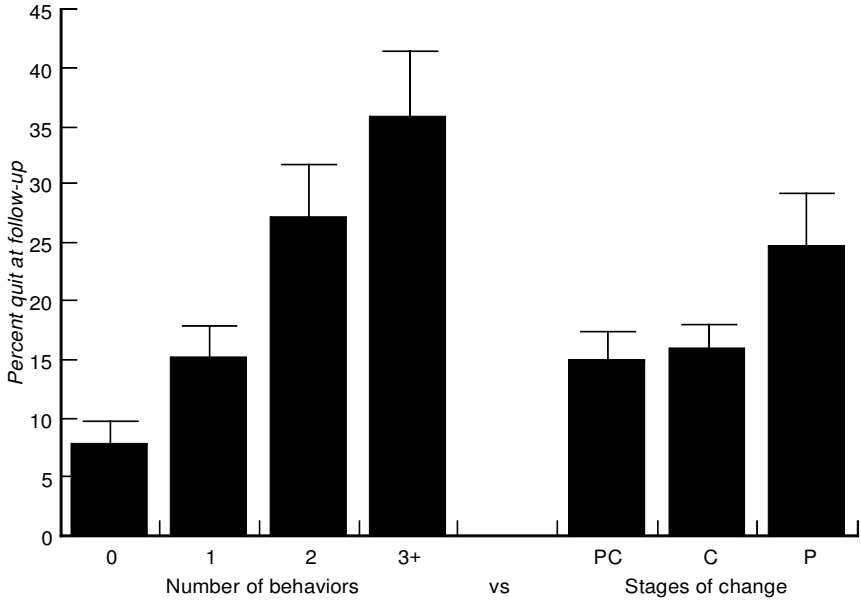

Figure 3. *Rates of cessation associated with the number of cessation-related behaviors present at baseline vs. baseline stages of change [pre-contemplation (PC), contemplation (C), preparation (P)].*

range of the stages of change was 12.0% to 17.1%; among those with two indicators, the range was 26.1% to 30.1%; among those with 3 or more indicators, the change was 27.8% to 43.6%.

Discussion

Our results question the utility of the stages of change construct as a predictor of smoking cessation. Although smokers in the preparation stage at baseline showed higher rates of cessation 1–2 years later, we observed no difference in follow-up cessation rates between those in the contemplation stage and those in the precontemplation stage at baseline. Furthermore, stage of change was not an independent predictor when used in an multivariable analysis with other factors. Smokers in the preparation stage do have a higher prevalence of the factors shown to be independently related to cessation at follow-up. However, the other predictive factors do a much better job of discriminating who will be in cessation at follow-up than does stage membership.

Our results suggest that an addiction model is a more appropriate theoretical basis for designing cessation intervention programs. We suggest that reduction in the level of addiction can be used as a measure of progress toward cessation. We developed the addiction model using a sample of more than 2000 smokers who were randomly selected from the population of California smokers. The results showed that the four variables included in the model (< 15 cigarettes per day, a long-term quit of a year or more, a recent quit of 6 days or more, and occasional smoking) were all robust predictors of cessation 1–2 years later.

The limitation in our data is the relatively crude measure of nicotine exposure: the number of cigarettes per day. In our randomly selected sample of smokers drawn from the population, this crude measure showed significant predictive power. We may dramatically increase the predictive power of the addiction equation by including other indicators of nicotine exposure, such as serum nicotine level (Foxx & Axelroth, 1983; Glasgow, Klesges & Vasey, 1983; Berecz, 1984; Burling *et al.*, 1989).

The poor cessation prediction of the stages of change model in our study may be due to any of several reasons. First, the algorithm used to stage smokers may not represent the best operational definition of stage membership. In light of our

Table 2. *Cessation rates at follow-up as a joint function of the smoker's baseline stage of change and number of cessation indicators*

	Number of cessation indicators								
	0		1		2		3+		
Stage of change	*n*	Quit (%)	*n*	Quit (%)	*n*	Quit (%)	*n*	Quit (%)	χ^2*
Preparation	54	11.1	88	17.1	95	26.3	105	37.1	16.63**
Contemplation	390	8.0	303	16.5	184	26.1	97	27.8	41.06**
Pre-contemplation	374	7.0	205	12.2	93	30.1	78	43.6	81.23**
χ^2*	1.00		1.70		0.34		0.52		

*Mantel–Haenszel χ^2 tests with 1 degree of freedom on the rates of cessation at follow-up.
**$p < 0.001$.

results, an algorithm seems less than optimal when that algorithm assigns a smoker who has made a serious quit attempt in the previous year that lasted for a week or more to the pre-contemplation or contemplation stage rather than to the preparation stage because the smoker does not intend to quit in the next 30 days. Secondly, stage membership is only one of the 15 constructs (i.e. the 10 coping strategies, the temptation and confidence components of smoking self-efficacy and the beliefs about the pros and cons of smoking) included in the transtheoretical model (Prochaska *et al.*, 1992). It is possible that if all 15 constructs were used simultaneously to predict cessation, the full transtheoretical model might perform better than the stages of change model alone. Unfortunately, we were not able to test this possibility because stage membership was the only component of the transtheoretical model measured on the CTS.

Another reason for the relatively poor performance of the stages of change model may, in part, stem from the nature of the subjects used in its development. The stages of change model was developed and validated using self-selected smokers recruited for a smoking cessation intervention study. This resulted in a sample in which daily smokers with higher levels of consumption who intended to quit were over-represented (DiClemente *et al.*, 1991). In the self-selected sample, 34.5% of the smokers were in the preparation stage, whereas in our random population sample of California smokers only 16.6% were in the preparation stage. In the self-selected sample, only 11.3% expressed no intention to quit, whereas in our population sample 36.6% expressed no intention to quit. Finally, in the self-selected sample, the mean number of cigarettes smoked per day was 29, whereas in our population sample the mean was only 18 cigarettes per day.

These results confirm and complement the findings of Ockene *et al.* (1982) concerning the importance of quitting history in determining the success of future quit attempts. A recent meta analysis of 10 prospective studies on smoking cessation found no relationship between the *number* of prior quit attempts and cessation (Cohen *et al.*, 1989). Taken at face value, this finding might lead to the erroneous conclusion that prior quitting history is not a significant predictor of subsequent cessation. The results from both the MRFIT study (Ockene *et al.*, 1982) and our present study show that the *duration* of recent quit attempts is the important determinant of future cessation. Quitters who are able to get through the worst of the withdrawal syndrome during the year prior to baseline before relapsing are more likely to be in cessation 1–2 years later. Our data show that life-time quits of a year or more also increase the odds of future cessation.

The level of addiction has clear implications for the clinical treatment of smoking addiction. The initial therapeutic goal should be to reduce addiction level. The means to achieve this goal need not be limited to reducing the number of cigarettes smoked, but could include other changes, such as switching to cigarettes that contain less nicotine, waiting longer for the first cigarette of the day, smoking less of the cigarette, and avoiding increases in the depth and duration

of smoke inhalation. The second therapeutic goal should be to achieve a week-long quit, as has been demonstrated by Zhu *et al.* (1996). This is especially important among smokers with limited quitting history. Further, smokers who relapse after achieving a week-long quit should be strongly encouraged not to return to high levels of cigarette consumption. Our data suggest that the combination of reduced addiction and more extensive quitting history should triple the odds of a smoker achieving cessation in the next 1–2 years.

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