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Predictors of 1-, 6- and 12-month smoking cessation among a community-recruited sample of adult smokers in the United States

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Abstract
Baseline socio-demographics, substance use and smoking history characteristics, as well as intra-treatment indicators (i.e. nicotine patch adherence and tobacco use during patch treatment) of smoking cessation were examined among 65 community-based adult male smokers recruited from a metropolitan area within the United States. All participants were recruited between 2009 and 2010 and were enrolled in an 8-week smoking cessation programme involving nicotine patch treatment and adjunctive counselling. Stepwise multiple regression analyses were performed to examine unique predictors of smoking status at 1-, 6- and 12-month follow-up. Abstinence rates at 1-, 6- and 12-month follow-up periods were 34%, 18% and 17%, respectively. Results indicated that less smoking during patch treatment, and particularly during weeks 1 through 3, was the most robust predictor of successful abstinence, and this predicted smoking status at all follow-up periods. These results underscore the importance of total abstinence during the cessation process, especially at the outset of treatment, which is paramount to ultimate cessation success. Study limitations and clinical implications are discussed.

Keywords: Smoking, smoking cessation, successful abstinence, predictors

Cigarette smoking is responsible for enormous health and economic burdens. In fact, each year, smoking is attributable to nearly half a million deaths in the United States, which translates to an estimated $97 billion in health-related economic losses (Centers for Disease Control and Prevention, 2008). Cigarette smoking is by no means a public health problem specific to the United States alone; tobacco use is responsible for approximately 5 million premature deaths annually worldwide (Global Youth Tobacco Survey Collaborative Group, 2003). This smoking-related mortality rate is expected to double by the year 2030 (Ezzati & Lopez, 2003).

It has been established that many of the deleterious health sequelae of cigarette smoking are reversible following a sufficient period of post-cessation abstinence (e.g. reduced risk of lung

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cancer (US Department of Health and Human Services, 1989), cardiovascular diseases (Perkins et al., 2007) and respiratory diseases (Anthonisen et al., 1994)). Given this evidence, there are now a number of effective pharmacological and adjunctive behavioural interventions to assist with initiating smoking abstinence. Although long-term cessation rates are improved among those who use nicotine replacement therapies (NRTs) compared to those who quit "cold turkey", the majority of individuals who attempt to quit either independently or with cessation aids still fail in this endeavour. In fact, the US National Health Interview Survey reported that only 4.7% of the 15.7 million smokers surveyed were able to maintain abstinence for 3–12 months following a quit attempt (Centers for Disease Control and Prevention, 2002). Given the intractable nature of smoking, combined with its public health consequences, understanding mechanisms responsible for successful long-term cessation is pivotal.

A growing body of literature, from both clinical trials and community- and population-based samples, has begun to identify a range of characteristics associated with smoking cessation success and failure. Some of the more robust predictors of unsuccessful abstinence following a quit attempt include younger age (Velicer et al., 2007), lower socio-economic level (Hymowitz et al., 1997), frequent alcohol (Humfleet et al., 1999) and illicit drug use (Stapleton et al., 2009), younger age at smoking initiation (Hymowitz et al., 1997), higher nicotine dependence (Ferguson et al., 2003) and smoking after the designated quit date (Higgins et al., 2006; Kenford et al., 1994).

Although a wide array of characteristics has been proposed as possible predictors of smoking cessation status, to date no consistent determinants have been identified. These heterogeneous findings may be a function of varying methodologies such as (1) length of follow-up period, (2) ways in which smoking status is defined (e.g. complete or partial abstinence and sustained smoking abstinence since the quit date versus abstinence during a 7-day point prevalence period), (3) methods of cessation (e.g. unaided, pharmacotherapy and/or counselling) and (4) the target population. Furthermore, few studies have systematically examined weekly concomitant smoking and NRT adherence, especially among interventions that provide adjunctive counselling that is intense and frequent such as this study. This is important, given that intensive and frequent counselling may help to buffer against the potential deleterious effects of smoking after the designated quit date. Additionally, examining week-by-week intra-treatment indicators as predictors of cessation enables a more nuanced exploration into the dynamic temporality of these behaviours and their association with cessation outcome.

The purpose of this study was to examine predictors of successful abstinence at 1, 6 and 12 months post-cessation among heavy smokers who participated in an 8-week smoking cessation programme combining both pharmacological (i.e. nicotine patch) and psychological (cognitive–behavioural therapy) interventions. In order to enhance the potential clinical utility of the results of this study, a number of variables were examined that could easily be assessed by health-care providers. Specifically, pre-treatment variables were evaluated (socio-demographics, substance use and smoking characteristics, as well as intra-treatment indicators, such as nicotine patch adherence and concomitant tobacco use during treatment).

Methods

Study design

These data were taken from a non-randomised intervention study examining the effects of smoking cessation on several health indices in men. More details are described elsewhere (Harte & Meston, 2011). In brief, during an initial telephone screening, a quit date was set,

which corresponded to the day after the first visit to the clinic. During the first visit and after providing written informed consent, self-report, anthropometric and physiological measures were collected. To increase the validity of self-reporting of cigarette consumption, participants provided saliva samples, and they were spuriously informed that these samples would be assayed for salivary nicotine content. Counselling was provided, and participants were asked to commence nicotine patch therapy the following morning. Nicotine patch treatment lasted 8 weeks in duration. Participants returned to the laboratory for second and third visits during week 4 of treatment, and at 1-month follow-up (week 12), respectively. The second and third visits were identical to the first experimental session. Participants received weekly prescheduled telephone contacts throughout the initial 12 weeks (8 weeks of treatment and throughout the month following discontinuation of the patch) to provide brief smoking cessation counselling and to assess self-reported smoking status. Participants were also contacted via telephone at weeks 26 and 52 for the purpose of assessing smoking status. The protocol was approved by the University of Texas at Austin Institutional Review Board.

Intervention

All participants received nicotine transdermal patch treatment (Habitrol®, Novartis Consumer Health Inc., Summit, NJ, USA) administered in a step-down fashion over 8 weeks (21 mg, weeks 1–4; 14 mg, weeks 5–6; 7 mg, weeks 7–8). The patch was applied once daily and was worn continuously for 24 h. Participants also received adjunctive counselling, which followed the tobacco use and dependence clinical practice guidelines (Fiore et al., 2000) and the protocols of the National Cancer Institute (Glynn & Manley, 1990). Individual counselling was intensive and emphasised brief assessment, education, behavioural modification, cognitive intervention and relapse prevention. Counselling occurred during each clinic visit and lasted 45 min in duration. During the initial 12 weeks (during the 8 weeks of patch treatment and during the subsequent month after patch discontinuation), participants also received a minimum of ten 10-min weekly telephone counselling contacts, which targeted topics that were relevant to the individual's place in the quitting process. The content was closely based on the Transtheoretical Model of Change (e.g. Stages of Change Model) (Prochaska & Velicer, 1997). In-person counselling interventions were conducted by the first author, and telephone counselling was performed by a trained research assistant supervised by the first author.

Participants

The total sample consisted of 65 self-referred, community-based, male participants from a metropolitan area within the United States recruited between 2009 and 2010. All participants were eligible for inclusion if they smoked at least 15 cigarettes per day for a minimum of five consecutive years and were motivated to quit smoking. Exclusion criteria included (1) use of NRTs and/or non-nicotine smoking cessation medications (bupropion and varenicline) within 3 months prior to enrolment, (2) use of non-cigarette tobacco products, (3) medical conditions that could make nicotine administration unsafe, (4) history of severe drug or alcohol abuse during the past 12 months ($\geq$16 points on the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993) and $\geq$6 on the Drug Abuse Screening Test (DAST-10) (Skinner, 1982)) and (5) a body mass index (BMI) (<18.5 kg/m^2 or >35 kg/m^2).

The sample had a mean age of 39.3 years (SD = 10.76), was predominantly White (86%), and reported an average of 15.1 years of education (SD = 2.23). Participants reported a mean of approximately 22.1 pack-years (SD = 16.17), and they were smoking an average of 22.3

cigarettes per day (SD = 7.89) at time of enrolment. The sample reported an average age of smoking onset of 17.3 years (SD = 4.56), and participants were moderately addicted to tobacco (mean total score on the Fagerström Test for Nicotine Dependence (FTND) was 5.5 (SD = 1.97)).

Measures

Self-reported data collected at baseline included socio-demographics (age, education and income), alcohol use (per the AUDIT (Saunders et al., 1993)) and illicit substance use (per the DAST-10 (Skinner, 1982)), nicotine dependence (per the FTND (Heatherton et al., 1991)), and pack years (calculated by multiplying the number of packs of cigarettes smoked per day by the number of years smoked). Additionally, a one-item measure developed by the authors was used to assess confidence in quitting. This was measured on a Likert scale from 0 to 10, where 0 denoted "not at all" and 10 denoted "extremely". Intra-treatment predictors included nicotine patch adherence (number of days used per week) and concomitant cigarette smoking (cigarettes smoked per week) during each week of the 8-week treatment.

Protocol monitoring

Participants were contacted by telephone during weeks 1–12 (weekly during the first 8 weeks of intervention and weekly for the following month) to assess both nicotine patch adherence (i.e. number of days used per week) and tobacco use (number of cigarettes smoked per day during the previous 7 d), and additionally during week 26 (6-month follow-up) and week 52 (12-month follow-up) to assess cigarette consumption.

Statistical analysis

Efficacy of smoking cessation at 1, 6, and 12 months post-treatment were the primary outcome measures. At each time point, participants reporting zero cigarettes during the previous 7 d were classified as being successfully quit, whereas individuals reporting smoking one or more cigarettes during those days were classified as being unsuccessfully quit. Initial analyses were conducted on an intent-to-treat basis, with those unavailable for follow-up classified as smoking (unsuccessfully quit). Per-protocol analyses were additionally employed using only those individuals who provided data at each time point. Comparisons between successful and unsuccessful quitters at each follow-up period were initially examined using independent samples *t*-tests, and associated effect sizes were reported. Significant predictors identified in the univariate analyses were included into a multivariable logistic regression model by performing both forward and backward stepwise selection and calculating the χ^2 from the difference in –2 log-likelihood estimates for each subsequent model. Adjusted odds ratios (AORs) with their 95% confidence intervals (CIs) were calculated accordingly. All variables that significantly improved the model fit were retained. All statistical tests were two-sided and an alpha <0.01 was considered statistically significant. Analyses were performed using SPSS statistical software version 19.0 (SPSS Inc., Chicago, IL, USA).

Results

Of the 65 participants who were enrolled in this study and received the initial dose of nicotine patch treatment, 33 (51%), 29 (45%) and 20 (31%) participants provided data at the 1-, 6- and

12-month follow-ups, respectively. Using the intent-to-treat approach (coding those lost to follow up as unsuccessfully quit), 22/65 (34%) were classified as successfully quit at the 1-month follow-up and 12/65 (18%) and 11/65 (17%) were classified as successful quitters at the 6- and 12-month follow-up periods, respectively. For additional details pertaining to participant flow, we refer the reader to the parent study, which describes data using Consolidated Standards of Reporting Trials (CONSORT) guidelines (Harte & Meston, 2011).

Univariate intent-to-treat analyses of predictors of successful abstinence

Univariate comparisons between successful and unsuccessful quitters at all follow-up periods are shown in Table 1. With respect to smoking status at the 1-month follow-up time period, successful quitters, compared to unsuccessful quitters, demonstrated significantly higher nicotine patch compliance during week 2 ($d = 0.81$, $p < 0.001$) and week 3 ($d = 0.67$, $p < 0.001$), as well as significantly less concomitant smoking during week 2 ($d = 0.68$, $p < 0.001$), week 3 ($d = 0.98$, $p < 0.001$) and week 4 ($d = 0.81$, $p < 0.001$) of patch treatment. Regarding smoking status at the 6-month follow-up time period, the following predictors were significant: lower baseline smoking frequency ($d = 0.50$, $p < 0.01$), higher confidence in quitting smoking ($d = 0.22$, $p < 0.01$) and less concomitant smoking during week 1 ($d = 0.80$, $p < 0.001$), week 2 ($d = 0.73$, $p < 0.001$), week 3 ($d = 0.96$, $p < 0.001$) and week 6 ($d = 0.66$, $p < 0.01$) of the patch intervention. Finally, the significant predictors of successful quitting at the 12-month follow-up were higher confidence in quitting smoking ($d = 0.19$, $p < 0.001$), higher nicotine patch compliance during week 5 ($d = 0.48$, $p < 0.001$) and week 6 ($d = 0.93$, $p < 0.001$), as well as less concomitant smoking during week 1 ($d = 0.74$, $p < 0.01$), week 2 ($d = 0.75$, $p < 0.001$) and week 3 ($d = 01.05$, $p < 0.001$) of the patch intervention.

Multivariate intent-to-treat analyses of predictors of successful abstinence

Predictors independently associated with successful abstinence at all follow-up periods are shown in Table 2. After controlling for significant predictors identified in the univariate analyses, the stepwise multiple logistic regression model revealed that predictors of 1-, 6- and 12-month successful cessation were less concomitant smoking during week 3 (AOR = 0.97; 95% CI = 0.96–1.00), week 1 (AOR = 0.41; 95% CI = 0.15–1.11) and week 3 (AOR = 0.92; 95% CI = 0.84–1.02), respectively.

Per-protocol analyses of predictors of successful abstinence

Per-protocol analyses were additionally employed in an attempt to buffer against the possibility that the intent-to-treat approach introduced statistical bias. Univariate results were generally the same as those derived from imputation. Specifically, higher nicotine patch compliance during week 2 ($d = 0.72$, $p < 0.001$) and less concomitant smoking during week 2 ($d = 0.79$, $p < 0.001$) and week 3 ($d = 1.07$, $p < 0.001$) of the intervention predicted successful abstinence at 1-month follow-up. Regarding smoking status at the 6-month follow-up, lower baseline smoking frequency ($d = 0.44$, $p < 0.01$) and less concomitant smoking during week 1 ($d = 0.59$, $p < 0.01$) of the intervention predicted successful abstinence. Less concomitant smoking during week 2 ($d = 0.64$, $p < 0.01$) and week 3 ($d = 0.94$, $p < 0.01$) predicted successful abstinence at 12-month follow-up.

Results of the stepwise multiple logistic regression model using per-protocol analyses were similar to those generated from the full imputed data set and are presented in Table 2.

Table 1. Univariate intent-to-treat analyses of predictors of smoking status at 1-, 6- and 12-month follow-ups ($N = 65$)

	1-Month follow-up			6-Month follow-up			12-Month follow-up		
Characteristic	Successful quitters ($n = 22$)	Unsuccessful quitters ($n = 43$)	d	Successful quitters ($n = 12$)	Unsuccessful quitters ($n = 53$)	d	Successful quitters ($n = 11$)	Unsuccessful quitters ($n = 54$)	d
Age (years)	36.73 (11.51)	39.74 (10.35)	0.27	35.67 (9.37)	39.42 (11.02)	0.37	34.09 (9.68)	39.67 (10.81)	0.58
Education (years)	15.45 (1.97)	14.12 (2.27)	0.63	15.67 (2.18)	14.32 (2.21)	0.62	15.09 (2.55)	14.46 (2.19)	0.25
Income (US dollars)	46,590 (20,112)	58,430 (34,688)	0.42	50,000 (19,217)	55,424 (33,027)	0.20	46,590 (19,438)	56,018 (32,644)	0.35
Alcohol use severity[†]	6.36 (3.01)	4.21 (3.39)	0.67	5.58 (3.08)	4.79 (3.47)	0.24	6.27 (3.35)	4.67 (3.37)	0.46
Illicit drug use severity[‡]	0.73 (1.12)	0.58 (0.66)	0.16	0.75 (1.14)	0.60 (0.77)	0.15	0.82 (1.17)	0.59 (0.77)	0.20
Age of smoking onset (years)[¶]	17.50 (5.41)	16.04 (4.02)	0.31	16.58 (3.12)	16.53 (4.85)	0.01	16.55 (2.21)	16.54 (4.92)	0.01
Smoking duration (years)[¶]	18.45 (10.91)	22.57 (11.16)	0.37	17.92 (9.94)	21.90 (11.39)	0.38	16.09 (9.03)	22.21 (11.35)	0.60
Smoking frequency (cigarettes per day)[¶]	19.61 (6.91)	22.68 (8.24)	0.40	18.96 (3.28)	22.24 (8.51)	0.50*	17.68 (4.26)	22.44 (8.24)	0.72
Nicotine dependence severity[¶,§]	5.27 (1.78)	5.55 (2.07)	0.15	5.08 (1.67)	5.54 (2.03)	0.25	4.82 (1.66)	5.58 (2.01)	0.41
Number of lifetime quit attempts[¶]	3.14 (2.75)	3.64 (2.66)	0.18	3.33 (2.71)	3.50 (2.70)	0.06	3.09 (3.02)	3.55 (2.63)	0.16
Duration of prior abstinence (days)	360.73 (775.34)	362.07 (886.39)	0.01	556.92 (1017.93)	317.40 (804.61)	0.26	590.73 (1055.88)	314.94 (798.34)	0.30
Confidence in successfully quitting[¶,‖]	7.27 (1.64)	7.45 (1.90)	0.10	7.67 (1.07)	7.33 (1.94)	0.22*	7.27 (1.01)	7.42 (1.94)	0.19**
Nicotine patch adherence (days per week)									
Week 1	6.55 (1.59)	5.93 (2.17)	0.33	6.42 (2.02)	6.08 (2.02)	0.17	6.36 (2.11)	6.09 (2.00)	0.15
Week 2	6.50 (1.50)	4.60 (2.97)	0.81**	5.67 (2.67)	5.15 (2.73)	0.18	6.00 (2.09)	5.09 (2.81)	0.17
Week 3	5.27 (2.69)	3.30 (3.21)	0.67**	5.08 (3.11)	3.72 (3.15)	0.45	5.36 (2.80)	3.69 (3.19)	0.56
Week 4	4.82 (2.92)	2.98 (3.15)	0.61	4.92 (3.09)	3.30 (3.15)	0.52	5.36 (2.80)	3.24 (3.15)	0.71
Week 5	4.41 (2.94)	2.65 (3.10)	0.58	4.75 (3.02)	2.91 (3.09)	0.58	4.36 (2.54)	3.02 (3.22)	0.48**
Week 6	4.50 (3.14)	2.53 (3.15)	0.63	5.08 (3.09)	2.77 (3.17)	0.74	4.82 (2.64)	2.87 (1.27)	0.93**

Table 1. (*Continued*)

Characteristic	1-Month follow-up			6-Month follow-up			12-Month follow-up		
	Successful quitters ($n = 22$)	Unsuccessful quitters ($n = 43$)	*d*	Successful quitters ($n = 12$)	Unsuccessful quitters ($n = 53$)	*d*	Successful quitters ($n = 11$)	Unsuccessful quitters ($n = 54$)	*d*
Week 7	4.23 (3.34)	2.07 (3.02)	0.68	4.58 (3.06)	2.40 (3.21)	0.70	4.09 (3.36)	2.54 (3.22)	0.48
Week 8	2.86 (3.32)	2.07 (2.99)	0.25	3.58 (3.34)	2.06 (3.01)	0.50	3.45 (3.36)	2.11 (3.03)	0.42
Concomitant cigarette smoking during patch treatment (cigarettes per week)									
Week 1	13.27 (34.27)	28.00 (49.88)	0.34	0.17 (0.58)	28.19 (48.90)	0.80**	1.55 (4.50)	27.39 (48.70)	0.74**
Week 2	8.95 (30.04)	46.70 (72.99)	0.68**	4.25 (14.10)	40.64 (69.09)	0.73**	3.27 (7.40)	40.17 (68.74)	0.75**
Week 3	10.23 (30.06)	65.05 (72.61)	0.98**	6.75 (15.84)	55.49 (70.46)	0.96**	2.82 (5.81)	55.39 (69.85)	1.05**
Week 4	21.73 (48.48)	73.42 (75.50)	0.81**	29.92 (53.73)	61.81 (74.16)	0.49	27.82 (55.69)	61.65 (73.49)	0.52
Week 5	32.27 (60.96)	80.21 (72.85)	0.71	28.50 (54.46)	72.02 (73.80)	0.67	29.55 (55.07)	71.00 (73.76)	0.64
Week 6	29.41 (61.75)	85.63 (75.34)	0.83	31.33 (54.07)	74.58 (77.71)	0.66	26.82 (56.14)	74.70 (76.73)	0.70
Week 7	25.64 (56.39)	80.81 (72.77)	0.85	31.33 (54.07)	67.51 (73.71)	0.56	27.45 (55.82)	69.20 (73.52)	0.64
Week 8	45.64 (68.12)	95.26 (73.19)	0.70	43.92 (64.46)	86.28 (75.32)	0.60	40.18 (64.28)	86.26 (74.93)	0.66

Notes: Data depict means and standard deviations in parentheses.
[†]Assessed with the Alcohol Use Disorders Identification Test (Saunders et al., 1993). Higher scores represent increased levels of problematic drinking.
[‡]Assessed with the Drug Abuse Screening Test, 10-item (Skinner, 1982); higher scores represent increased levels of problematic drug use.
[¶]Data were missing for one participant.
[§]As per the Fagerström Test for Nicotine Dependence (Heatherton et al., 1991); higher scores represent increased levels of nicotine dependence.
[‖]Assessed on a scale from 0 to 10, where 0 denoted "not at all" and 10 denoted "extremely".
*$p < 0.01$; **$p < 0.001$.

Table 2. Significant predictors of successful smoking cessation at 1-, 6- and 12-month follow-ups using multivariate logistic regression models

Characteristic	B	AOR	95% CI
Intent-to-treat analyses			
1-Month follow-up*			
Concomitant smoking during week 3 of treatment (cigarettes per week)	−0.03	0.97	0.96–1.00
6-Month follow-up†			
Concomitant smoking during week 1 of treatment (cigarettes per week)	−0.89	0.41	0.15–1.11
12-Month follow-up‡			
Concomitant smoking during week 3 of treatment (cigarettes per week)	−0.08	0.92	0.84–1.02
Per-protocol analyses			
1-Month follow-up¶			
Concomitant smoking during week 2 of treatment (cigarettes per week)	−0.11	0.89	0.82–0.99
6-Month follow-up§			
Concomitant smoking during week 1 of treatment (cigarettes per week)	−1.27	0.28	0.08–1.02
12-Month follow-up‖			
Concomitant smoking during week 3 of treatment (cigarettes per week)	−0.58	0.93	0.82–1.05

B, unstandardised beta; CI, confidence interval; AOR, adjusted odds ratio.

*Multivariate model adjusted for patch adherence during weeks 2 and 3 of treatment, and concomitant cigarette smoking during weeks 2 through 4 of treatment.

†Multivariate model adjusted for baseline smoking frequency, confidence in successful cessation and concomitant cigarette smoking during weeks 1 through 3 and week 6 of treatment.

‡Multivariate model adjusted for confidence in successful cessation, patch adherence during weeks 5 and 6 of treatment and concomitant cigarette smoking during weeks 1 through 3 of treatment.

¶Multivariate model adjusted for patch adherence during week 2 and concomitant cigarette smoking during weeks 2 and 3 of treatment.

§Multivariate model adjusted for baseline smoking frequency and concomitant cigarette smoking during week 1 of treatment.

‖Multivariate model adjusted for concomitant cigarette smoking during weeks 2 and 3 of treatment.

Predictors of 1-, 6- and 12-month successful cessation were less concomitant smoking during week 2 (AOR = 0.89; 95% CI = 0.82–0.99), week 1 (AOR = 0.28; 95% CI = 0.08–1.02) and week 3 (AOR = 0.93; 95% CI = 0.82–1.05), respectively.

Discussion

This study examined predictors of failed abstinence at 1, 6 and 12 months post-cessation among US male community volunteers who participated in an 8-week smoking cessation intervention combining both pharmacological and cognitive–behavioural therapy interventions. Abstinence rates at 1-, 6- and 12-month follow-up periods were 34%, 18% and 17%, respectively, and were similar to those of large, randomised clinical trials (6-month abstinent rates of approximately 22%) (Fiore et al., 1994). Of the 14 socio-demographics, substance use, smoking and intra-treatment variables considered as potential associated factors of successful abstinence, only smoking after the designated quit date (during the 8-week NRT intervention) was independently associated with successful abstinence. Specifically, smoking fewer cigarettes during weeks 2 and 3 of the NRT intervention was associated with successfully quitting at 1-month follow-up, whereas smoking fewer cigarettes during weeks 1 and 3 was associated with successful abstinence at 6- and 12-month follow-up, respectively. These results held irrespective of NRT adherence and despite receiving intensive and frequent

empirically based counselling. These findings are in line with other studies, demonstrating the relationship between post-cessation smoking and abstinence (Gourlay et al., 1994; Higgins et al., 2006; Heffner et al., 2010; Kenford et al., 1994), and particularly concomitant smoking shortly after the designated quit date (Heffner et al., 2010; Kenford et al., 1994).

This investigation had both strengths and limitations. Strengths included the use of several follow-up periods (to capture a more comprehensive understanding of how baseline characteristics influence the trajectory of smoking behaviours) and the broad use of predictor variables, including baseline characteristics as well as several intra-treatment variables. A number of limitations warrant mention. The sample of participants may not generalise to the population of individuals in the United States for several reasons. First, given that the analyses of this study were secondary in nature, the data were taken from a study assessing men only. Therefore, it is possible that these results do not generalise similarly to women. Second, the data indicate that African-American individuals were under-sampled compared to the general population of the United States (US Bureau of the Census, 2000). Third, the sample was comprised entirely of community volunteers enrolled in a university-based research study, and results may differ from those obtained within medical or clinic-based populations. Fourth, all participants enrolled in this study with the understanding that they would participate in a comprehensive intervention programme combining both NRT and counselling. It is possible that predictive associations may differ between those who quit on their own and those who engage in formal treatment programmes. Finally, more than half of the sample dropped out before completing the 6- and 12-month follow-ups, a problem that is notorious in longitudinal smoking research (Lichtenstein & Glasgow, 1992). Several steps were taken to enhance the reliability of the reported effects. First, all missing data were imputed using a baseline observation carried forward approach, whereby those lost to follow up were coded as being unsuccessfully quit. This is a standard approach to missing data in smoking cessation trials, and there are empirical data to support its superiority to traditional strategies (e.g. listwise deletion) (Foulds et al., 1993). Furthermore, it should be noted that analyses using intent-to-treat and listwise deletion produced nearly identical results, indicating consistency between estimated and non-estimated missing data approaches.

A final limitation is with respect to the method by which smoking status was assessed. Smoking abstinence was determined by self-report rather than by objective biochemical verification, and therefore, the validity of this outcome measure cannot be determined with certainty. However, it should be noted that during the initial 12 weeks, all participants provided a saliva sample at each experimental visit (baseline, 1 month after treatment initiation, 1-month follow-up), and they were spuriously told that these samples would be assayed for cotinine content (a by-product of nicotine). This "bogus pipeline" technique has been shown to produce reliable and accurate estimates of smoking (Murray et al., 1987). This procedure would have likely positively affected the validity of self-reporting with respect to intra-treatment variables, as well as smoking status at 1-month follow-up, but would not likely have directly influenced reporting at the later follow-up periods. However, in a meta-analysis that examined the concordance between self-reported smoking and biological verification of smoking activity ($N = 36\ 830$), it was determined that self-reports of smoking are generally quite accurate (Patrick et al., 1994).

It is an important goal to advance knowledge regarding particular characteristics that predict smoking cessation success and failure. Delineating factors that could distinguish successful quitters from unsuccessful quitters has the potential to facilitate a process whereby treatment decisions could be made on a more rational basis (Kenford et al., 1994). That is, health-care providers could determine a smoker's level of risk for relapse by comparing that

individual's set of characteristics to a risk profile, which could dictate the course of treatment (e.g. changes in type, potency and/or breadth of treatment (i.e. adding adjunctive counselling to pharmacotherapy)). Additionally, improving rates of sustained abstinence has important public health implications. Considering that smoking rates are increasing in many areas around the world (Steptoe et al., 2002), combined with the fact that the World Health Organization anticipates that tobacco will become the largest single health problem by the year 2020 (Vainio et al., 2001), understanding mechanisms responsible for successful long-term cessation is pivotal.

Conclusions

In conclusion, the findings of this study indicate that concomitant cigarette smoking during nicotine patch treatment was the most robust predictor of successful abstinence, and this predicted smoking at all follow-up periods (1, 6 and 12 months). These results underscore the importance of total abstinence during the cessation process, especially at the outset of treatment, which is paramount to ultimate cessation success.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

References

Anthonisen, N. R., Connett, J. E., Kiley, J. P., et al. (1994). Effects of smoking intervention and the use of an inhaled anticholinergic bronchodilator on the rate of decline of FEV1. *JAMA: The Journal of the American Medical Association*, 272(19), 1497–1505. doi: 10.1001/jama.272.19.1497

Centers for Disease Control and Prevention. (2002). Cigarette smoking among adults – United States, 2000. *Morbidity and Mortality Weekly Report*, 51, 642–645.

Centers for Disease Control and Prevention. (2008). Smoking-attributable mortality, years of potential life lost, and productivity losses – United States, 2000–2004. *Morbidity and Mortality Weekly Report*, 57(45), 1226–1228.

Ezzati, M., & Lopez, A. D. (2003). Estimates of global mortality attributable to smoking in 2000. *Lancet*, 362(9387), 847–852.

Ferguson, J. A., Patten, C. A., Schroeder, D. R., Offord, K. P., Eberman, K. M., & Hurt, R. D. (2003). Predictors of 6-month tobacco abstinence among 1224 cigarette smokers treated for nicotine dependence. *Addictive Behaviors*, 28(7), 1203–1218.

Fiore, M., Bailey, W., Cohen, S., et al. (2000). *Clinical practice guideline: Treating tobacco use and dependence.* Rockville, MD: US Department of Health and Human Services, Public Health Service.

Fiore, M. C., Smith, S. S., Jorenby, D. E., & Baker, T. B. (1994). The effectiveness of the nicotine patch for smoking cessation: A meta-analysis. *Journal of the American Medical Association*, 271(24), 1940–1947.

Foulds, J., Stapleton, J., Hayward, M., Russell, M., Feyerabend, C., Fleming, T., & Costello J. (1993). Transdermal nicotine patches with low-intensity support to aid smoking cessation in outpatients in a general hospital. A placebo-controlled trial. *Archives of Family Medicine*, 2(4), 417–423.

Global Youth Tobacco Survey Collaborative Group. (2003). Differences in worldwide tobacco use by gender: Findings from the Global Youth Tobacco Survey. *Journal of School Health*, 73(6), 207–215.

Glynn, T. J., & Manley, M. (1990). *How to help your patients stop smoking: A National Cancer Institute manual for physicians* (NIH publication 90-3064). Washington, DC: Smoking and Tobacco Control Program, Division of Cancer Prevention, National Cancer Institute, US Department. of Health and Human Services.

Gourlay, S. G., Forbes, A., Marriner, T., Pethica, D., & McNeil, J. J. (1994). Prospective study of factors predicting outcome of transdermal nicotine treatment in smoking cessation. *BMJ*, 309(6958), 842–846.

Harte, C. B., & Meston, C. M. (2011). Association between smoking cessation and sexual health in men. *BJU International*, 109, 888–896. doi: 10.1111/j.1464-410X.2011.10503.x

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerström, K. O. (1991). The Fagerström test for nicotine dependence: A revision of the Fagerström tolerance questionnaire. *British Journal of Addiction*, 86(9), 1119–1127.

Heffner, J. L., Lee, T. C., Arteaga, C., & Anthenelli, R. M. (2010). Predictors of post-treatment relapse to smoking in successful quitters: Pooled data from two phase III varenicline trials. *Drug and Alcohol Dependence*, 109(1–3), 120–125.

Higgins, S. T., Heil, S. H., Dumeer, A. M., Thomas, C. S., Solomon, L. J., & Bernstein, I. M. (2006). Smoking status in the initial weeks of quitting as a predictor of smoking-cessation outcomes in pregnant women. *Drug and Alcohol Dependence*, 85(2), 138–141.

Humfleet, G., Muòoz, R., Sees, K., Reus, V., & Hall, S. (1999). History of alcohol or drug problems, current use of alcohol or marijuana, and success in quitting smoking. *Addictive Behaviors*, 24(1), 149–154.

Hymowitz, N., Cummings, K., Hyland, A., Lynn, W., Pechacek, T., & Hartwell, T. (1997). Predictors of smoking cessation in a cohort of adult smokers followed for five years. *Tobacco Control*, 6(Suppl. 2), S57–S62.

Kenford, S. L., Fiore, M. C., Jorenby, D. E., Smith, S. S., Wetter, D., & Baker, T. B. (1994). Predicting smoking cessation: Who will quit with and without the nicotine patch. *Journal of the American Medical Association*, 271(8), 589–594.

Lichtenstein, E., & Glasgow, R. E. (1992). Smoking cessation: What have we learned over the past decade? *Journal of Consulting and Clinical Psychology*, 60(4), 518–527.

Murray, D., O'Connell, C., Schmid, L., & Perry, C. (1987). The validity of smoking self-reports by adolescents: A reexamination of the bogus pipeline procedure. *Addictive Behaviors*, 12(1), 7–15.

Patrick, D., Cheadle, A., Thompson, D., Diehr, P., Koepsell, T., & Kinne, S. (1994). The validity of self-reported smoking: A review and meta-analysis. *American Journal of Public Health*, 84(7), 1086.

Perkins, K., Conklin, C., & Levine, M. (2007). *Cognitive-behavioral therapy for smoking cessation: A practical guidebook to the most effective treatments.* New York: Routledge.

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, 12(1), 38–48. doi: 10.4278/0890-1171-12.1.38

Saunders, J., Aasland, O., Babor, T., de la Fuente, J., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction*, 88(6), 791–804.

Skinner, H. A. (1982). The drug abuse screening test. *Addictive Behaviors*, 7, 363–371.

Stapleton, J. A., Keaney, F., & Sutherland, G. (2009). Illicit drug use as a predictor of smoking cessation treatment outcome. *Nicotine & Tobacco Research*, 11(6), 685–689.

Steptoe, A., Wardle, J., Cui, W., Baban, A., Glass, K., Tsuda, A., & Vinck, J. (2002). An international comparison of tobacco smoking, beliefs and risk awareness in university students from 23 countries. *Addiction*, 97(12), 1561–1571.

US Bureau of the Census. (2000). *Native resident population estimates of the United States by sex, race, and Hispanic origin: April 1, 1990 to July 1, 1999*. Washington, DC: Author. Retrieved from http://www.census.gov/population/estimates/nation/nativity/nbtab003.txt (accessed 5 February 2010)

US Department of Health and Human Services. (1989). *Reducing the health consequences of smoking: 25 years of progress*. Washington, DC: Government Printing Office.

Vainio, H., Weiderpass, E., & Kleihues, P. (2001). Smoking cessation in cancer prevention. *Toxicology*, 166(1–2), 47–52.

Velicer, W. F., Redding, C. A., Sun, X., & Prochaska, J. O. (2007). Demographic variables, smoking variables, and outcome across five studies. *Health Psychology*, 26(3), 278–287.