



Attempts to quit smoking and relapse: Factors associated with success or failure from the ATTEMPT cohort study

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ABSTRACT

Objective: To identify predictors of attempts to stop smoking and predictors of relapse.

Methods: This study included 2431 smokers from pre-existing Internet panels in the United States, United Kingdom, Canada, France, and Spain. These panel members are Internet users who have registered voluntarily and agreed to participate in various online research studies. Respondents were aged 35–65 years, smoked \geq five cigarettes per day and intended to stop smoking in the next 3 months. They were followed every 3 months for up to 18 months via Internet contact on measures relating to quit attempts, smoking status, motivation to quit, nicotine cue, weight and weight concern, health-related factors, withdrawal symptoms, and smoking cessation aids.

Results: In this study, recent quit attempts strongly predicted future attempts, but also predicted subsequent relapse. Motivation to quit was predictive of future attempts but not of relapse/abstinence following the attempts. Relapse to smoking was associated with nicotine dependence, exposure to smoking cues, craving, withdrawal symptoms, and lack of smoking cessation aids.

Conclusions: The findings lend support to a model of cessation in which level of motivation to stop generates quit attempts but plays little role in relapse. Dependence, social smoking cues, and a recently failed quit attempt are important factors in relapse.

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1. Introduction

Smoking cessation is a dynamic process that often involves a sequence of unsuccessful attempts to quit before long-term abstinence is achieved. Although a significant number of smokers express a desire to quit smoking, only about one-third of them actually attempt to quit each year and few are successful (Rigotti, 2002; U.S. Department of Health and Human Services [USDHHS], 1990). Approximately 75% to 80% of smokers who attempt to quit relapse before achieving 6 months of abstinence. Of the remainder, relapses may occur years after a smoker initially quits (USDHHS, 1990). Making a quit attempt and maintaining abstinence after it are the two main components of the process of quitting (Hyland et al., 2006; West, McEwen, Bolling, & Owen, 2001).

Many studies have addressed factors associated with smoking cessation. However, most of the studies are either cross-sectional or limited to specific populations (e.g., patients with specific disease, or

receiving specific treatments). To our knowledge there are only two longitudinal studies that have looked at the effect of a wide range of variables both on predicting quit attempts and the success of those attempts in general populations (Hyland et al., 2006; West et al., 2001). In both cases, respondents were followed 1 year after the initial measurements and asked to report on any quitting in the intervening year. Attempts to stop smoking in the year between the two assessments were consistently predicted by past quitting behavior, intention to quit, concerns about the harmful effects of smoking, and lower enjoyment of smoking. Partner pressure to stop in the one study that examined it was predictive of quit attempts (West et al., 2001). Based on these studies, it appears that factors that predict the success of quit attempts are different from those that predict making an attempt.

These studies were limited by the long recall period; subjects may have forgotten attempts made during the year (Gilpin & Pierce, 1994). A second limitation is that several possible predictors were not canvassed (e.g., weight gain, physical and mental health, use of cessation aids). Another limitation of the Hyland and West studies was that they could not assess the influence of dynamic factors that change over time.

The ATTEMPT cohort study (West et al., 2006) followed smokers every quarter (3 months), allowing (1) more accurate estimates of the

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quit attempt and relapse rates and (2) exploration of predictors of a quit attempt in the near future and the subsequent relapse or abstinence. Measures were taken of a wide range of variables, including motivation, prior quit history, weight and weight concerns, use of cessation aids, and physical/mental conditions. Because of frequent measurements, the study also provided a unique opportunity to examine the role of time-varying factors in promoting quit attempts or relapse. The original ATTEMPT publication describes the overall methods for recruitment and data collection in more detail (West et al., 2006). In this original publication, the authors report results from the initial 12 months of the study, which demonstrate the feasibility of conducting a longitudinal survey among smokers via the Internet (West et al., 2006). A second publication using the ATTEMPT data (West & Zhou, 2007) reported that nicotine replacement therapy without formal behavioral support was associated with improved long-term abstinence rates (West & Zhou, 2007).

In this paper, we focus on the respondents who were enrolled after the first year of the study and completed at least one follow-up assessment during the 18-month follow-up period. We first estimated the cumulative attempt rates and relapse rates at 3 months, 6 months, and up to 18 months. Then, we used a discrete time survival analysis (D TSA) model to examine the association between potential predictor variables and the two smoking cessation outcomes: (1) attempts to stop smoking and (2) relapse among those who made quit attempts.

2. Methods

2.1. Data source

Briefly, the ATTEMPT study was a longitudinal, prospective, Web-based cohort study of smokers aged 35–65 years who smoked at least five cigarettes daily. To obtain a reasonable number of quit attempts during the follow-up period, we restricted the sample to those who expressed a willingness to quit smoking in the next 3 months. Participants were recruited from existing large Internet panels maintained by Harris Interactive, Inc., in the United States (US), Canada, the United Kingdom (UK), France, and Spain. These Internet panel members are Internet users who have registered voluntarily and agreed to participate in various online research studies. A random sample of panel members who met the age, country, and participation criteria were invited via e-mail to participate. In the US, invitations were sent to smokers previously identified from the overall panel. Because smokers had not been pre-identified in other countries, invitations were sent to a random sample of the panel's general population in those countries. The invitation directed panelists to the online screener questionnaire to determine study eligibility. Details of the ATTEMPT study design and conduct are provided in West et al. (2006). The feasibility and credibility of using the Internet for recruitment and follow-up, and the general similarity of the Internet cohort to national probability samples have been demonstrated in the ATTEMPT study (West et al., 2006).

As shown in Fig. 1, 3645 respondents met inclusion criteria and were recruited from Canada, France, Spain, the UK, and the US in spring 2004. All of these respondents were eligible to participate in the follow-up surveys. They were followed quarterly (every 3 months) for up to 18 months.

2.2. Outcome definitions

Smoking cessation outcomes (quit attempt and relapse) were assessed for each subject every 3 months. Participants could be classified as not making a quit attempt at one assessment (e.g., during the first 3 months), but making a quit attempt in the next assessment (e.g., during months 4–6). This is different from many smoking cessation studies, which classify participants based on response at only one time point.

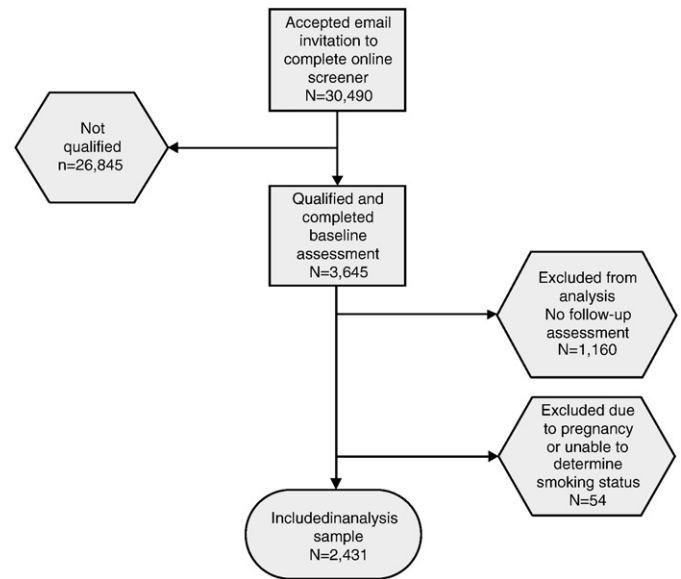


Fig. 1. Data collection flow chart, 2004 Cohort.

Quit attempt was defined by affirmative response to the question “During the past 3 months (90 days), have you made a serious attempt to stop smoking for good that lasted for at least a day (24 h)?” Although this definition excludes quit attempts that lasted less than a day, it helped to ensure that only serious quit attempts were counted.

Relapse was defined using two questions. For those who reported making a quit attempt in the past 3 months, an affirmative response to “Are you currently a cigarette smoker?” classified them as relapsed. For subsequent assessments, an affirmative response to “In the last 3 months have you smoked any cigarettes (even a puff)?” was evidence of relapse.

2.3. Other variable definitions

Potential predictor variables were selected to cover domains related to the smoking cessation process based on previous research or specific interest of investigators. Motivation to quit was measured by a 10-point Likert scale: “In the following 10-point scale, please select the number that best describes your current motivation to quit smoking cigarettes” (1 = not at all motivated, 10 = highly motivated). The following three questions were used to assess past quitting history: (1) “since you first began smoking cigarettes, how many serious attempts to stop smoking cigarettes for good have you made that lasted for at least a day (24 h)?” (2) “how long has it been since you last made a serious attempt to stop smoking cigarettes for good that lasted at least a day (24 h)?” and (3) “during the past 3 months (90 days), how many days in total did you not smoke any cigarettes (not even a puff)?” Smoking dependence was measured by the Fagerstrom Test for Nicotine Dependence (FTND) scale (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) ($\alpha=0.66$), which was found highly correlated to the number of cigarettes per day at enrollment (Pearson correlation coefficient=0.6). Therefore, we did not include baseline number of cigarettes per day in models. Nicotine cue was measured by the question “other than yourself does anyone regularly smoke cigarettes in your presence, such as at your home, work, car, or other places?” Weight concern and confidence to prevent weight gain were measured using Borrelli Scales ($\alpha=0.88$ and $\alpha=0.90$, respectively) (Borrelli & Mermelstein, 1998). Chronic physical health conditions included heart and circulation conditions, chronic respiratory conditions, endocrine or hormones, metabolic dysfunction, digestive conditions, and cancer, which were measured using a checklist containing individual conditions such as angina and

asthma. Respondents were asked “Have you ever been told by a doctor or other health care professional that you had any of the following conditions?”

For participants who made a quit attempt during the study follow-up, the following additional variables were included in the relapse model. Change in smoking consumption was calculated using the

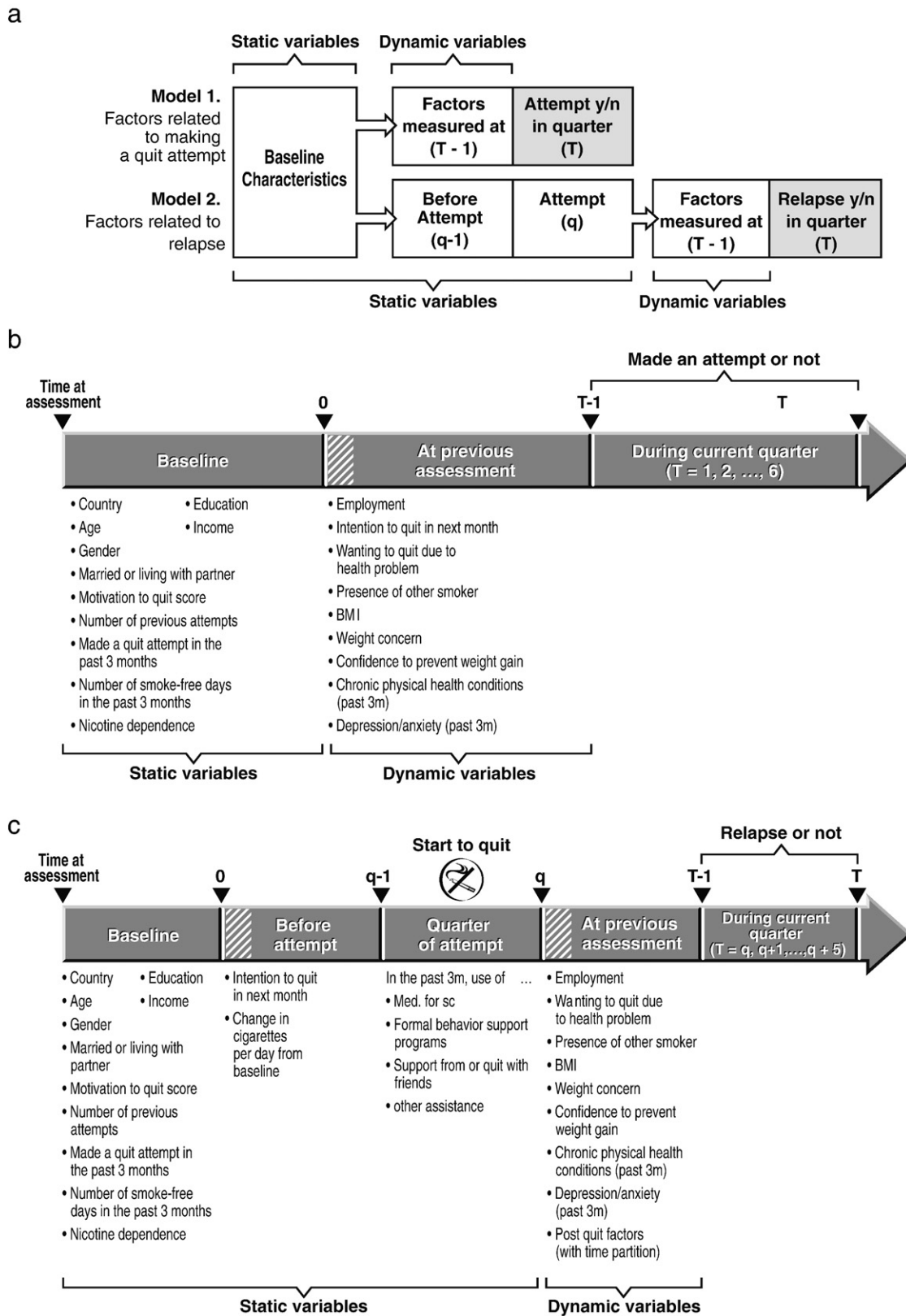


Fig. 2. Timing of variable measurements. (a) Overall. (b) Model 1: Quit Attempt. (c) Model 2: Relapse (among those who made a quit attempt). Note: q = Quarter in which quit attempt occurred, T = Timing of assessment ($T = 1, 2, \dots$). For Model 1, the outcome was whether a quit attempt was made in each quarter T . This model included factors measured at baseline and dynamic factors measured in the previous quarter ($T - 1$). For Model 2, the outcome was whether a relapse occurred in quarter T . This model included factors measured at baseline and dynamic factors at the previous quarter ($T - 1$). For Model 2, factors measured around the time of attempt are considered static.

numbers of cigarettes per day reported in the quarter before the quit attempt and baseline. Smoking cessation aids included use of medications for smoking cessation (nicotine replacement therapy [NRT] and bupropion), formal behavior support programs, support from or quit with friends or family, and other assistance such as herbal remedies, hypnosis, books, and the Internet. Because these actions themselves are efforts (i.e., attempts) to quit smoking, they were included only in the relapse model, but not the attempt model. The symptoms included in the Minnesota Nicotine Withdrawal Scale (Hughes & Hatsukami, 1986) were asked in each quarterly survey. However, to reduce participant burden, they were only asked whether symptoms occurred instead of using the five-point scale. We further grouped symptoms as mood disturbance (including irritability, restlessness, depressed mood, difficulty concentrating, and anxiety/nervousness; $\alpha=0.73$), sleep disturbance, desire or craving to smoke, and increased appetite. Note that increased appetite was administered along with hunger or weight gain as a single response option in the scale. In addition, the amount of post-quit weight change was defined as the actual weight change since the assessment before quit based on quarterly self-reported weight (in kilograms).

2.4. Statistical analysis

For longitudinal studies like ATTEMPT, where participants can drop out at any time, it is important to account for missing data appropriately. In addition, participants could make quit attempts at different times during the follow-up, and the study ended after 18 months for all the participants. Therefore, different participants may have different lengths of follow-up to observe relapse. Survival analyses allow for differential follow-up and efficiently accommodate missing data due to censoring (technically, this is right-censoring, such as drop-out and study termination). We conducted discrete time survival analysis because data were collected at discrete time intervals (quarterly). We chose these methods over approaches that require assumptions about missing data. The commonly used assumptions that all dropouts were relapsed or that subjects with complete data are representative of the entire sample can lead to biased estimates.

Although survival analysis is common in the statistical literature, the DTSA (Allison, 1995; Hosmer & Lemeshow, 1989) is relatively unknown to smoking cessation researchers. The key concept in DTSA is “hazard” or “hazard probability” (h). It is a conditional probability

Table 1
Baseline characteristics

	Overall (n=2431)	Canada (n=71)	France (n=843)	Spain (n=289)	UK (n=737)	US (n=491)
<i>Sociodemographic characteristics</i>						
Mean (SD) age in years	46.0 (7.4)	48.7 (7.5)	45.1 (6.8)	44.6 (6.4)	45.4 (7.2)	49.1 (8.1)
Male	55%	32%	61%	63%	55%	46%
White	96%	97%	96%	96%	97%	93%
Higher education ^a	59%	70%	52%	74%	46%	80%
Median annual household income level	–	35 k to <50 k CAD	20 k to <30 k euro	20 k to <30 k euro	20 k to <25 k lb	35 k to <50 k USD
Married or living with partner	65%	61%	65%	72%	66%	57%
Employed (full or part time, or self)	73%	69%	76%	86%	68%	66%
<i>Motivational characteristics</i>						
Mean (SD) motivation to quit score (range 1 to 10 = highly motivated)	6.9 (1.9)	6.9 (1.7)	6.9 (1.8)	6.8 (2.1)	6.6 (1.9)	7.2 (1.7)
Intended to quit in the next 1 month	61%	45%	70%	69%	58%	49%
Wanting to quit due to current health problem or hospitalization	20%	17%	11%	13%	25%	33%
<i>Past quitting history</i>						
Mean (SD) number of previous quit attempts ^b	4.1 (4.0)	5.9 (5.3)	3.5 (3.4)	2.9 (3.2)	4.6 (4.5)	4.7 (4.3)
Ever made a quit attempt	93%	97%	91%	88%	95%	95%
Had a (failed) attempt in the 3 months prior to baseline	26%	37%	30%	29%	23%	22%
Mean (SD) number of smoke-free days in the 3 months prior to baseline	4.3 (12.7)	2.1 (4.4)	5.3 (13.5)	4.4 (12.7)	4.7 (14.3)	2.4 (8.5)
<i>Nicotine dependence</i>						
Mean (SD) FTND score (range 0 to 10 = highly dependent)	4.7 (2.4)	4.7 (2.1)	4.4 (2.5)	5.1 (2.4)	4.6 (2.4)	5.0 (2.3)
<i>Nicotine cue</i>						
Presence of other smokers	80%	76%	80%	88%	81%	73%
<i>Weight-related characteristics</i>						
Mean (SD) BMI (kg/m ²)	26.8 (5.4)	29.1 (6.5)	25.3 (4.5)	26.7 (4.9)	27.2 (5.2)	28.4 (6.3)
Obesity (BMI ≥ 30 kg/m ²)	24%	38%	14%	25%	27%	33%
Mean (SD) weight concern score (range 1 to 10 = most concerned)	5.5 (2.4)	5.2 (2.3)	6.4 (2.3)	4.8 (2.3)	5.0 (2.2)	5.4 (2.3)
Mean (SD) confidence to prevent weight gain score (range 1 to 10 = most confident)	5.4 (2.2)	5.4 (2.2)	5.1 (2.1)	6.3 (2.2)	5.3 (2.3)	5.6 (2.4)
<i>Health-related characteristics</i>						
Mean (SD) number of chronic physical health conditions in 3 months prior to baseline	0.7 (1.0)	0.9 (1.0)	0.7 (1.0)	0.6 (0.9)	0.6 (1.0)	0.8 (1.2)
No such conditions	58%	45%	58%	58%	61%	56%
Had symptoms or was bothered by depression or anxiety in 3 months prior to baseline	29%	31%	34%	25%	25%	27%

BMI = body mass index. FTND = Fagerstrom Test for Nicotine Dependence. SD = standard deviation.

^a Higher education was reported as more than high school graduate in Canada and the US, and 14 or more years of formal education in France, Spain, and the UK.

^b Truncated to 20 if greater.

that an event occurs at a certain time t , given that the event has not occurred before t . For example, the hazard of relapse between 3 months and 6 months is the conditional probability that one relapsed between 3 months and 6 months given that he or she had not relapsed during the first 3 months. The hazard is used to estimate the “survival probability” (S), i.e., the probability that the subject has not relapsed in 6 months. Willett and Singer (1993) described a “method of cumulation” to estimate S , which is an application of the Kaplan–Meier method (also known as the product limit method; Allison, 1995) when time is discrete. In this paper, the cumulative event occurrence rate was estimated using 1 minus the estimated survival probability. See Willett and Singer (1993) and Xie, McHugo, Drake, and Sengupta (2003) for an introduction to this method.

The DTSA models (also known as logit models for discrete time; Allison, 1995; Hosmer & Lemeshow, 1989; Willett & Singer, 1993) are used to assess group effects. In the DTSA models, the hazard probability is used instead of the unconditional probability in regular logit models (such as logistic regression models, generalized estimating equations, and generalized linear mixed models). Correspondingly, the group effect is measured using odds ratio, the ratio of the odds of hazards in two groups:

$$OR = \frac{h_1}{1-h_1} / \frac{h_2}{1-h_2}$$

Note that the difference between the odds ratio estimated in the DTSA models and the odds ratio estimated in regular logit models is due to the use of conditional probability given that the event has not occurred. We chose the DTSA model in our analysis because our interest is among those subjects who maintain abstinence. The DTSA model allows us to answer questions such as “What is the effect of nicotine dependence on relapse within 3 months?” and “Given that patients have maintained abstinence for 3 months, what is the effect of nicotine dependence on their relapse in the next 3 months?” By testing interactions between time and covariates, the DTSA model also allows us to assess whether some effects vary over time. In this paper, two DTSA models were used to examine the association between potential predictor variables and the two smoking cessation outcomes. Note that subjects could make their first attempt any time during the follow-up period and that relapse could occur the next day or could be delayed for many months. The longitudinal models take advantage of the ATTEMPT study design by using reported information from responders across all time points.

The two models of quit attempt and relapse include both static variables measured at baseline (e.g., sociodemographics, past quitting history) and dynamic variables that might change over the course of the study (noted as $T-1$ in Fig. 2; e.g., weight and weight concerns). The relapse model also contains variables measured before quit ($q-1$ in Fig. 2) or during the quarter of quit attempt (q in Fig. 2).

We were particularly interested in considering the association between symptoms like mood disturbance or sleep disturbance and relapse. We wanted to distinguish symptoms that presented post-quit separately from those that were already present before quitting. The hypothesis was that subjects who presented with these symptoms after quit (i.e., post-quit symptoms) may be more likely to relapse. However, if these symptoms were present before a quit attempt, they may not affect the relapse. By partitioning the time intervals, we can specifically assess the association between post-quit symptoms and relapse. In the relapse model, we partitioned the time into two parts: the quarter of quit attempt and the quarters after quit attempt, so that the model allows different odds ratios for pre-quit and post-quit effects.

The strategy for model specification was to include all variables of interest into a main effects model with careful consideration to timing of assessments relative to outcomes. Including all variables of interest in the models reduces the risk of biased parameter estimates in logit models when true predictors are not included. Collinear variables were either deleted or grouped, so that the variables included in the final model were not collinear. In addition, we examined all two-way interactions of covariates with time; we report only meaningful significant interaction effects in the Results section.

3. Results

3.1. Cohort description and retention

The multinational cohort for this analysis includes 2431 subjects from Canada (3%), France (35%), Spain (12%), the UK (30%), and the US (20%) who were followed for 3–18 months, i.e., completed at least the month 3 assessment, excluding those who were pregnant during the study period or provided inconsistent responses to their smoking status questions. Table 1 summarizes the characteristics of these subjects at baseline. Of these, 75% ($n=1835$) completed the second follow-up assessment (month 6), and 60% ($n=1461$) completed the first three follow-up assessments. Overall, 831 (34%) completed all six follow-up assessments.

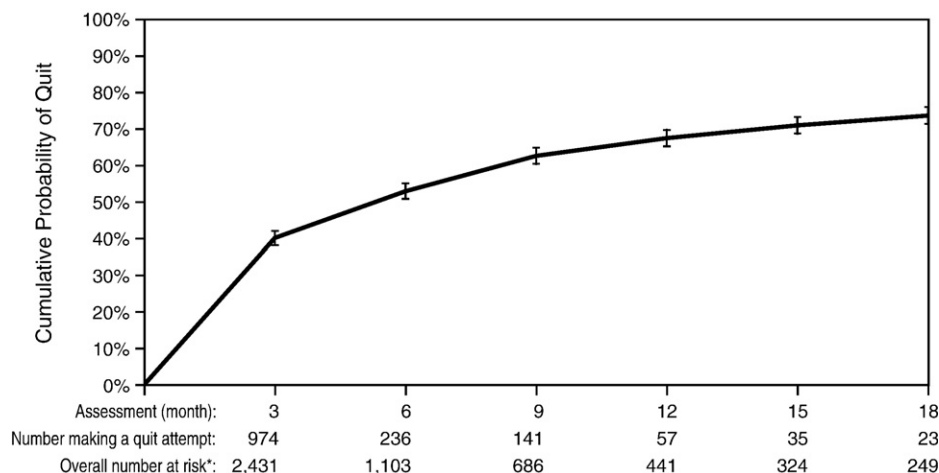


Fig. 3. Cumulative probability of a quit attempt (Kaplan–Meier estimates with 95% confidence intervals). *Subjects “at risk” are those who completed the current assessment and had not yet made a quit attempt as of the previous assessment.

3.2. Quit attempts

The Kaplan–Meier estimate of the cumulative attempt rate over 18 months is 74%—that is, it is estimated that 74% of eligible subjects intending to quit smoking in the next 3 months will actually make a quit attempt during the next 18 months (Fig. 3).

3.3. Factors related to quit attempt (Model 1)

Table 2 presents the association of each factor with making a quit attempt in any quarterly period. Subjects in all countries had a similar

likelihood of making a quit attempt. Male participants were 20% less likely than females to make a quit attempt (odds ratio [OR]=0.80; 95% confidence interval [CI]: 0.67, 0.94), but other sociodemographic variables were not associated with making an attempt. Each two-point increase in score for motivation to quit raised the likelihood (odds) of an attempt by more than 10% (OR=1.12; 95% CI: 1.02, 1.22). Subjects who reported an intention to quit in the next month were more than twice as likely to make an attempt in the subsequent quarter compared with others (OR=2.49; 95% CI: 2.11, 2.94).

Subjects who had more attempts in the past were more likely to make a new attempt than those who had fewer attempts in the past

Table 2
Odds ratios (95% confidence intervals) for factors related to making a quit attempt or relapse

Factor	Model 1: Attempt (n=2431)	Model 2: Relapse (n=1466)
<i>Sociodemographic</i>		
Country		
Canada vs. US	1.27 (0.75, 2.13)	1.94 (0.63, 5.98)
France vs. US	0.82 (0.66, 1.04)	0.63 (0.41, 0.95)*
Spain vs. US	1.05 (0.79, 1.40)	0.60 (0.36, 0.99)*
UK vs. US	0.92 (0.74, 1.15)	0.62 (0.41, 0.92)*
Age (per 10-year increase)	1.00 (0.89, 1.11)	0.76 (0.63, 0.92)*
Male vs. female (female was the reference category)	0.80 (0.67, 0.94)*	1.04 (0.78, 1.39)
Higher vs. lower education level	0.94 (0.80, 1.11)	0.94 (0.71, 1.24)
Household income level (per increment of 1 quartile)	1.04 (0.96, 1.12)	1.00 (0.88, 1.14)
Married or living with partner vs. single	0.96 (0.81, 1.14)	0.96 (0.71, 1.28)
Employed vs. other ^a	1.10 (0.91, 1.32)	0.82 (0.59, 1.14)
<i>Motivational</i>		
Baseline motivation to quit score (per 2-unit increase, range 1 to 10 = highly motivated)	1.12 (1.02, 1.22)*	1.01 (0.86, 1.17)
Intent to quit in 1 month vs. other ^b	2.49 (2.11, 2.94)*	1.04 (0.79, 1.37)
Wanting to quit due to current health problem or hospitalization vs. other ^a	1.10 (0.88, 1.36)	1.06 (0.74, 1.51)
<i>Past quitting history prior to baseline</i>		
Number of quit attempts ever (per 4-attempt increase)	1.16 (1.07, 1.25)*	1.06 (0.94, 1.21)
Made a (failed) quit attempt in the past 3 months vs. other	2.46 (2.03, 2.98)*	1.61 (1.17, 2.23)*
Number of smoke-free days in the past 3 months (per 10-day increase)	1.07 (1.00, 1.14)*	1.01 (0.91, 1.12)
<i>Nicotine dependence</i>		
Baseline FTND score (per 2-unit increase, range 0 to 10 = highly dependent)	0.86 (0.80, 0.92)*	1.16 (1.03, 1.30)*
<i>Nicotine cue</i>		
Presence of other smokers vs. no presence ^a	0.87 (0.72, 1.05)	1.38 (1.03, 1.85)*
<i>Weight related</i>		
BMI (per 5-kg/m increase) ^a	1.06 (0.98, 1.14)	0.94 (0.82, 1.08)
Weight concern score (per 2-unit increase, range 1 to 10 = most concerned) ^a	1.02 (0.95, 1.11)	1.12 (0.98, 1.28)
Confidence to prevent weight gain score (per 2-unit increase, range 1 to 10 = most confident) ^a	1.06 (0.98, 1.15)	1.01 (0.89, 1.15)
<i>Health related</i>		
“Bothered by” chronic physical health conditions in the past 3 months vs. not ^a	1.07 (0.90, 1.27)	0.98 (0.73, 1.31)
Had symptoms or was bothered by depression or anxiety in the past 3 months (yes vs. no) ^a	1.10 (0.92, 1.31)	1.42 (1.02, 1.99)*
<i>Change in smoking consumption</i>		
Change in cigarettes per day from baseline to before quit	NA	0.99 (0.96, 1.01)
<i>Smoking cessation aids during the Quarter quarter of quit attempt</i>		
Use of medications for smoking cessation vs. no use	NA	0.63 (0.47, 0.83)*
Use of formal behavior support programs vs. no use	NA	0.62 (0.34, 1.13)
Support from or quit with friends or family vs. no	NA	0.91 (0.63, 1.32)
Use of other assistance for smoking cessation vs. no use	NA	0.81 (0.58, 1.12)
<i>Other post-quit factors^c</i>		
Desire or craving to smoke (yes vs. no)	NA	1.38 (0.81, 2.35)
Mood disturbance (yes vs. no)	NA	1.51 (0.84, 2.71)
Sleep disturbance (yes vs. no)	NA	1.92 (1.07, 3.44)*
Increased appetite, hunger, or weight gain (yes vs. no)	NA	0.28 (0.16, 0.51)*
Weight change from the assessment before the quit attempt (per 5-kg gain)	NA	1.11 (0.78, 1.56)

BMI = body mass index. FTND = Fagerstrom Test for Nicotine Dependence. NA = not applicable.

* $p \leq 0.05$.

^a Dynamic variables, measured at the previous assessment.

^b For attempt model, dynamic variables, measured at the previous assessment; for relapse model, static, measure before quit.

^c Dynamic variables, measured at the previous assessment; displayed the odds ratio only for factors that presented after quit.

(OR=1.16; 95% CI: 1.07, 1.25), and subjects who had made a failed attempt in the 3 months prior to entering the study were more than twice as likely to make a new attempt compared with subjects who had not recently attempted to quit (OR=2.46; 95% CI: 2.03, 2.98). However, the effect of the recent failed quit attempt, pronounced in the first three quarters, diminished as time passed (significant time interaction effect with recent failed quit attempt: OR=1.77 to 2.91 in the first few quarters, and 0.84 to 1.38 in the later quarters). Subjects who had more smoke-free days in the 3 months prior to baseline were also slightly more likely to make an attempt (OR=1.07; 95% CI: 1.00, 1.14).

Higher levels of nicotine dependence as measured by the baseline FTND score were associated with lower likelihood of a quit attempt (OR=0.86; 95% CI: 0.80, 0.92). Neither the presence of other smokers in the household or at work nor weight or health-related concern was associated with the likelihood of a quit attempt.

3.4. Relapse rate

As shown in Fig. 4, the relapse rate was very high within the quarter of a quit attempt (close to 80%). Of those who did not relapse within the first quarter of making an attempt, almost 60% relapsed in the next quarter. However, after two quarters of abstinence, the relapse rate dropped below 20% and the cumulative relapse rate reached a plateau. In other words, the longer participants maintained abstinence, the less likely they were to relapse in the next quarter.

3.5. Factors related to relapse following a quit attempt (Model 2)

In Table 2, the last column presents the association of each factor with the probability of relapse for subjects who made at least one quit attempt. Country differences were noted—subjects in the US and Canada were more likely to relapse in any 3-month period compared with subjects in France, Spain, or the UK (OR with US as reference=0.63, 0.60, 0.62, respectively). Also, subjects who were older were less likely to relapse during the follow-up period (OR=0.76; 95% CI: 0.63, 0.92). Other demographic factors were not associated with relapse, nor were motivation/intent and wanting to quit due to health issues.

Subjects with failed quit attempts just prior to baseline were 61% more likely to relapse than those who had not recently tried to quit (OR=1.61; 95% CI: 1.17, 2.23). However, number of previous quit attempts, or number of smoke-free days in the 3 months prior to baseline are not significantly associated with relapse. Higher baseline FTND scores were associated with higher likelihood of relapse

(OR=1.16; 95% CI: 1.03, 1.30), although the relationship of baseline FTND scores with relapse diminished over time (significant time interaction effect with baseline FTND: OR=1.23 for the first quarter after quitting and 1.03 for the second quarter). Subjects who tried to quit in the presence of other smokers were more likely to relapse than those who did not (OR=1.38; 95% CI: 1.03, 1.85).

While change in smoking consumption prior to quit is not associated with relapse, use of smoking cessation medication at the time of quitting was associated with less likelihood of relapse (OR=0.63; 95% CI: 0.47, 0.83). Other measures to support cessation, such as formal programs or help from family/friends, were not statistically significant, but the direction of these effects suggested a positive influence.

Subjects who experienced cessation-related sleep disturbance were far more likely to relapse than those who did not (OR=1.92; 95% CI: 1.07, 3.44). Subjects who experienced anxiety or depression were more likely to relapse than those who did not (OR=1.42; 95% CI: 1.02, 1.99). Mood disturbances (OR=1.51; 95% CI: 0.84, 2.71) and post-quit desire or craving to smoke (OR=1.38; 95% CI: 0.81, 2.35), although not statistically significant, suggested a greater likelihood toward relapse. It is also noticed that without mood disturbance in the model, the effects of post-quit craving and sleep disturbance were more pronounced.

Neither starting body weight (body mass index) nor concerns about weight gain were significantly associated with relapse. An affirmative response to increased appetite/hunger/weight gain (yes/no) after quitting was associated with lower relapse (OR=0.28; 95% CI: 0.16, 0.51). On the other hand, the amount of post-quit weight change was not prognostic for lower relapse rate in the next quarter (OR=1.11; 95% CI: 0.78, 1.56). However, when dichotomizing the amount of weight change by 5-kg increase or not, we found its association to relapse is similar to the single yes/no item of increased appetite/hunger/weight gain (OR=0.56; 95% CI: 0.23, 1.34).

4. Discussion

This study suggests that two different sets of factors predict different components of the cessation process: quit attempt and subsequent relapse. Higher motivation and intent to quit predicts making a quit attempt but is not associated with subsequent relapse. Smokers who have recently made a failed attempt to quit are more likely to try again but also more likely to relapse than those who have not tried recently. These findings are consistent with findings from a previous prospective study (West et al., 2001), and give credence to the concept of habitual quitters who repeatedly try and fail to stop

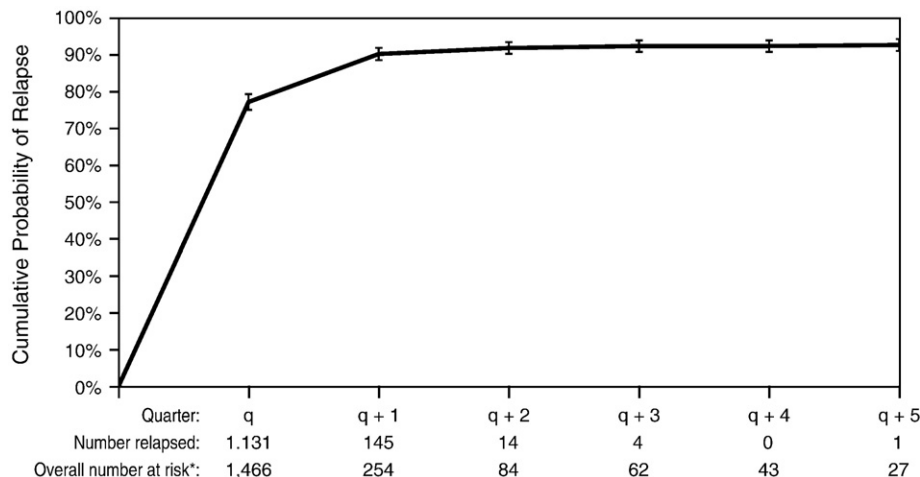


Fig. 4. Cumulative probability of relapse among subjects who made a quit attempt (Kaplan–Meier estimates with 95% confidence intervals). Note. q =quarter in which the quit attempt was made. *Subjects “at risk” were those who had made a quit attempt, completed the current assessment, and had not yet relapsed as of the previous assessment.

smoking. In addition, our analysis suggested that the effect of the recent failed quit attempt, pronounced in the first three quarters, diminished as time passed. That is, for those subjects who made a quit attempt in the 3 months prior to baseline but have not made another quit attempt in the following 9 months, their odds of making a quit attempt in the next 3 months are not different from those who did not make a quit attempt in the 3 months prior to baseline.

Smokers with a higher baseline nicotine dependence are less likely to make a quit attempt and more likely to relapse. Our analysis suggested that the relationship of baseline FTND scores with relapse diminished over time. For those subjects who made it through their first 3 months of quitting, their baseline FTND did not predict future relapse. Presence of other smokers as a nicotine cue predicted higher likelihood of relapse, although it is not associated with whether an attempt is initiated.

Smoking cessation medication use (NRT or bupropion) at the time of the quit attempts was protective against relapse. Specific analysis focusing on NRT has been addressed in a separate paper (West & Zhou, 2007). Use of other methods or aids also has positive influence, although they were not statistically significant (OR=0.62; 95% CI: 0.34, 1.13). The lack of statistical significance might be due to the small number of subjects who used other smoking cessation methods (2% used formal behavior support programs, 8% used social support, and 11% used other smoking cessation aids). Reduction in smoking consumption was used by some smokers as an approach to quit smoking. Our analysis did not suggest an association between changes in cigarettes per day before quit and relapse following the quit attempt.

Subjects who experienced smoking withdrawal as sleep disturbance or depression/anxiety were far more likely to relapse than those who did not. Mood disturbance and craving to smoke were not significant factors, but the magnitude of effect suggested relapse. Although there is overlap across these measures, they were not exactly the same. More subjects reported mood disturbance than anxiety/depression which may have been considered illnesses diagnosed by a physician. Subjects with anxiety/depression before quit are approximately 30% more likely to relapse in the quarter making a quit attempt, while subjects with mood disturbance presented before quit, which is clearly not related to smoking withdrawal, had similar odds of relapse to those without.

Our analysis did not support a hypothesis that body weight or concerns about weight are related to making a quit attempt. Among those who did make a quit attempt, we found that weight concern did not predict relapse, which is consistent with other studies (Borrelli & Mermelstein, 1998; Pisinger & Jorgensen, 2007). However, weight concern may be important in young adults or a specific subpopulation, which is worth further investigation. Our analysis found that weight gain after quit was associated with less relapse. This appears at first to be counter-intuitive. However, there is a possibility that weight gain reflects a concentration of motivational energy on staying off cigarettes and not being too concerned about gaining weight. Because subjects were followed quarterly, we were only able to assess the effect of post-quit weight gain for those who remained abstinent by the end of the quarter when a quit attempt was made. We noticed that most weight was gained during the quarter that a quit attempt was made. The subjects who were most bothered by weight gain may have relapsed by the end of that quarter. We were not able to assess the relationship between post-quit weight gain and short-term relapse.

The study findings combine to suggest what experts have long known from clinical observation: the pattern of quit attempts changes over time. Smokers caught in the cycle of consecutive failed attempts are not likely to achieve abstinence. Attempts are more likely to occur when the buildup of motivation and intention have reached a sufficiently high level. Thwarting relapse (i.e., sustaining abstinence) is a distinctly separate effort and seems to require the willingness to use smoking cessation aids, tolerating the inevitable withdrawal symptoms, and avoidance of other smokers.

Of concern in a non-probability-based Internet sample is whether the results are generalizable. We were able to show that the baseline sample was similar to that found using national household surveys for most demographic characteristics (West et al., 2006); thus it provides wide coverage of the general population. The ATTEMPT cohort was somewhat more educated than the general populations, however, and smokers are more prevalent in lower socioeconomic strata. Yet, the study includes 41% of participants without post-high school education. Another concern about generalizability relates to the limitation of the sample to subjects who already intended to stop smoking. Therefore, the attempt rate from our cohort is likely higher than that among general smokers. However, it is important to note that the analyses of associations between variables and smoking outcomes within the ATTEMPT cohort are valid even if the cohort is not completely representative of the broader smoker population as a whole.

The attrition rate during the follow-up period was at a level expected (about 50% in one-year follow-up). We showed that respondents followed up were similar on key variables to those who dropped out (West et al., 2006). There is no evidence that dropouts are related to the smoking status. The survival analyses performed for this paper provide unbiased estimates accounting for differing lengths of follow-up due to attrition.

Although we had relatively frequent observations at 3-month intervals, it is still possible that recall of quit attempts and other information related to quit attempts suffered from recall bias (Shiffman et al., 1997). In addition, we are limited in what we can say about the timing of quit attempts and other time-varying covariates. For instance, weight gained during the quarter of a quit attempt may have consisted of weight gain that occurred before quitting and after quitting. More frequent follow-ups or other study designs are needed for further exploration.

Our measure of relapse does not allow for brief temporary lapses (a participant is classified as having relapsed if they smoked at all—"even a puff"—in the prior 3-month period). This strict definition of relapse may miss some smokers who had brief lapses of smoking but essentially maintained the quit attempt. However, it is not clear how many lapses to allow before considering a quit attempt failed (and the start of a new quit attempt) (Velicer & Prochaska, 2004).

All in all, by presenting prospective data on quit attempts and relapse from relatively frequent measurements in a large multi-national sample, this study extends our understanding of the process of smoking cessation. Any single study of population samples, however ambitious, has limitations, and this study is no exception. However, seen in the context of other studies that have been reported, this work provides heft to key concepts that can be used to guide public health policy. While the ATTEMPT study reiterates the importance of smoking history and motivation/intent in generating quit attempts, it highlights the fact that other variables come into play once the attempt has been made. Specifically, nicotine cue and withdrawal symptoms, plus craving, must be addressed to maximize success rates from cessation attempts.

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