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Original Investigation

Non-daily Cigarette Smoking: Stability and Transition to Abstinence in Young Adults

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Abstract

Introduction: There is increasing recognition that non-daily cigarette smoking is common in early adulthood but less is known about its stability over time, or what influences transitions to heavier or nonsmoking. We examined the stability of non-daily smoking in a sample of young adults, and tested whether social and cognitive factors predicted transitions to other smoking patterns over time.

Aims and Methods: Participants were 579 young adults (18–24 years old at enrollment, 52% male) who were non-daily and never-daily cigarette smokers and California residents. Participants completed 13 waves of assessment over 3 years. We used descriptive statistics to evaluate the frequency of consistent abstinence, defined as no cigarette use at two consecutive waves and no cigarette use at any subsequent waves. Cox and logistic regression were used to test predictors of consistent abstinence.

Results: We found that 55% of participants smoked intermittently throughout the study, while 43% were consistently abstinent by the end of the study; few transitioned to daily smoking. Stopping smoking was associated with having fewer smoking friends, smoking less in social situations, having lower positive reinforcement expectancies for smoking, and having stronger intent to quit. Post hoc analyses indicated those who stopped smoking tended to report reductions in positive reinforcement expectancies and increased intent to quit in the 6 months before stopping.

Conclusions: Findings suggest a substantial minority of young adult non-daily smokers may stop on their own, but that the majority continue smoking and may require intervention. Interventions for this population should address social motives and reinforcement expectancies.

Implications: The majority of young adults who are non-daily cigarette smokers appear to maintain this habit over an extended period and may require intervention. Interventions that focus on reducing expectancies for positive effects of and social motives for cigarette use and on increasing intent to quit smoking may be most effective.

Introduction

Historically, cigarette smoking research has focused on regular, daily smokers, while non-daily cigarette use was typically conceptualized as a transient state.[1] However, recent years have seen increasing attention on intermittent or non-daily cigarette smokers, particularly in youth and emerging adult (eg, 18–24 years old) populations. This reflects the increasing awareness that non-daily smoking is more prevalent than previously thought, and may be a stable pattern for some smokers.[2] It also reflects the fact that intermittent users of cigarettes may not describe themselves as smokers,[3] and thus may not be identified as candidates for intervention. This is a particularly important missed opportunity during adolescence and emerging adulthood, as most dependent daily smokers begin their use during this period.[4,5] Even those who maintain intermittent smoking accrue health risks. Evidence suggests that increased risk of mortality compared with non-smoking begins at 6–10 cigarettes per month and increases with heavier use.[6]

Despite increasing attention, our knowledge about the temporal stability of non-daily smoking is less complete. In a study of high school seniors, White et al. found that about one in five reported non-daily smoking at each of five assessments over 2 years.[7] Of those who reported non-daily smoking at any timepoint, 56%–72% reported the same status 6 months later. Subsequent studies suggest non-daily patterns can be stable over multiple years during specific developmental periods (eg during college).[8] However, other studies suggest change is more common,[9] and longer-term studies have shown decreased stability over longer periods.[3] These discrepancies may reflect methodological variations, including differences in how smoking is operationalized and in frequency and length of follow-up. Moreover, nicotine consumption during these developmental stages tends toward instability.[10] As a result, longitudinal studies with brief follow-up duration, or with long periods between waves, may fail to fully capture patterns of use over time. One goal of the present study was to address this gap by following a

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cohort of emerging adults over 3 years with four waves of measurement per year.

In addition to questions about stability, the mechanisms that maintain non-daily smoking are not clear. Daily smokers are thought to smoke to avoid aversive withdrawal symptoms.[11] Previous studies suggest non-daily smokers can exhibit symptoms of dependence, though such findings may be at least partly driven by greater dependence among former daily, now non-daily smokers.[12] However, dependence is unlikely to fully explain intermittent use, particularly for never-daily smokers. Identifying factors that maintain cigarette use and also those that predict transitions to nonsmoking are key to the design of successful interventions for non-daily smokers. The development of such interventions should be a public health priority because non-daily smoking confers a risk of morbidity and mortality, and because the lower level of physical dependence in this population should make abstinence less challenging to achieve. While research is limited, initial observational evidence indicates non-daily smokers are more likely to make quit attempts and modestly more likely to quit compared with daily smokers.[13] To the extent that such interventions lead to cessation among non-daily smokers who would have progressed to heavier use, they may also be particularly impactful in terms of mitigating the effects of smoking on morbidity and mortality.

One overarching framework for understanding mechanisms that motivate either maintenance or change in smoking behavior is social cognitive theory (SCT).[14] Broadly, SCT posits a model based on reciprocal interactions among individual factors (eg, cognitions), the social environment, and behavior.[15] For non-daily smokers in emerging adulthood, social and cognitive factors may be particularly powerful drivers of smoking behavior. Social factors that may maintain non-daily smoking among emerging adults include more frequently associating with smokers, smoking more often in social situations, and greater exposure to pro-smoking messages.[16–19] Cognitive factors that may reinforce continued smoking include cigarette expectancies (ie beliefs about the effects of cigarette use), including stronger beliefs that smoking will have reinforcing effects or will aid weight loss, and weaker beliefs that smoking will yield negative long-term consequences. Other cognitive factors include lower intent to stop cigarette use, and lower self-efficacy for achieving abstinence (ie, weaker belief in one's own ability to stop cigarette use).[20–22] Although these constructs have been correlated with smoking status or behavior, a nuanced understanding of the nature of these relationships is lacking. More specifically, it is unclear to what extent interindividual variation, or intraindividual variation over time, may predict changes in smoking patterns.

Conceptually, the purpose of this study was to evaluate whether non-daily smoking persists over time and thus may require intervention, as well as to identify potential intervention targets. Our primary goal was to test the hypothesis that within-subjects changes in social and cognitive constructs would predict a greater likelihood of stopping smoking in a sample of emerging adults who were non-daily cigarette smokers at baseline and were followed quarterly for 3 years. Specifically, we used Cox regression models to test the hypothesis that increases in intent to quit smoking, expectancies for negative consequences from smoking, and abstinence self-efficacy, and reductions in expectancies for reinforcement from smoking, social exposure to other smokers, and exposure to pro-smoking messages would prospectively predict a greater likelihood of stopping smoking. For variables that were associated with a greater likelihood of stopping smoking, planned post hoc tests were then used to test whether those who stopped smoking experienced larger changes in the prior 6 months compared with those who continued to smoke. Finally, exploratory analyses compared participants who stopped smoking to those who did not in terms of the frequency with which they smoked in specific social and nonsocial contexts.

Methods

Participants

Young adults (n = 579; 52.5% male) aged 18–24 (at enrollment, M = 19.8, SD = 1.8) were recruited for a longitudinal study of intermittent cigarette smoking. In terms of race/ethnicity, 44.0% identified as white, 21.4% as Latinx, 17.8% as Asian or Pacific Islander, and 10.4% as members of multiple racial/ethnic groups. Eligibility criteria included having smoked cigarettes at least monthly for the past 6 months; never having smoked daily for 1 month or more, and being a California resident at enrollment. Assessments were conducted via a web-based survey implemented via SurveyMonkey (San Mateo, CA), and regular internet access was required.

Procedures

Candidates were recruited using paid online advertisements, primarily via boosted Facebook posts. Advertisements were set to appear to users whose profiles indicated they were 18–24 years old and residing in California. Advertisements indicated recent cigarette use was required, and included a link to the study website. Candidates who followed the link provided informed consent and completed an eligibility screen. Those who were eligible and interested completed the baseline assessment at that point. Additional assessments were completed quarterly for the next 3 years, yielding a total of 13 assessment points. At annual assessments (baseline, Y1, Y2, and Y3) participants completed one-time surveys of recent smoking and related constructs. Three quarterly assessments occurred between each pair of annual assessments. At quarterly assessments, participants reported cigarette smoking and related constructs in the past 24 h on each of 9 consecutive days. All quarterly assessments began on a Saturday and thus included 5 weekdays and 4 weekend days. All procedures were approved by the Institutional Review Board at the University of California, San Diego. Recruitment was conducted on a rolling basis, with the first participants completing baseline assessments in March 2015, and the final participants completing Y3 assessments in September 2020. Participants were compensated $25 for annual assessments and up to $40 for quarterly assessments.

Measures

Demographic characteristics were measured by self-report at baseline, including age, sex, race, ethnicity, and student status. At baseline participants also reported age at the time they had their first puff of a cigarette. Because of the small cell sizes, race, and ethnicity were combined and collapsed into a categorical variable that included white, Asian or Pacific Islander, Latinx, and multiple or other racial/ethnic backgrounds. Similarly, student status was reduced to a binary variable indicating whether participants were full-time students.

Social cognitive predictors were measured at each assessment. Cigarette expectancies were assessed using the short form of the Smoking Consequences Questionnaire,[23] a 21-item measure that yields scores for expectancies for positive reinforcement (5 items, scoring range 5–35), negative reinforcement (7 items, 7–49), negative consequences (4 items, 4–28), and weight concern (5 items, 5–35). Subscale internal consistency over time ranged from α = 0.89 to 0.94 for positive reinforcement, 0.88 to 0.95 for negative reinforcement, 0.87 to 0.93 for negative consequences, and 0.88 to 0.94 for weight concern. Behavioral intent was evaluated by two items on which participants rated intent to quit cigarettes in the next month and in the next year, both on a scale from 0 (no intent) to 4 (strong intent). Exposure to models of cigarette smoking was measured using two items on which participants estimated the proportion of their friends who currently smoke cigarettes, and the frequency of exposure to cigarette advertisements. Finally, self-efficacy for abstaining from smoking was measured via the Smoking Self-Efficacy Questionnaire (SEQ-12),[24] on which participants reported their perceived ability to abstain in high-risk situations. For the SEQ-12, internal consistency over time ranged from α = 0.83 to 0.89 (12 items, scoring range 0–48).

Cigarette and other substance use was measured at each assessment using the Timeline Follow Back (TLFB).[25] The TLFB has good psychometric characteristics, and has been validated for online use and with non-daily smokers.[26] At annual assessments, participants were asked whether they had used each of cigarettes, e-cigarettes, other nicotine/tobacco products, alcohol, and marijuana in the past 14 days. Positive responses triggered additional items evaluating quantity used (cigarettes, alcohol) or whether any use occurred (e-cigarettes, other nicotine/tobacco products, marijuana) on each of the past 14 days. At quarterly assessments, participants reported the number of cigarettes smoked, the number of alcoholic drinks consumed, and whether or not they had used e-cigarettes, other nicotine/tobacco products, and marijuana in the past 24 h on each of 9 consecutive days. Data were collapsed to create time-varying variables reflecting the frequency of use (in days) of each product at each timepoint (eg, *cigarette days*). To account for variability between timepoints in the number of days assessed, we created *assessment days*, a time-varying variable reflecting the number of days on which use was assessed at each timepoint. At quarterly timepoints participants were asked how many cigarettes they smoked in each of several contexts that were not mutually exclusive: in the morning, in the afternoon, at night, at home, at work, in the car, while drinking, in social situations, and while with others who were smoking. These variables were aggregated within timepoints.

Our primary outcome was *consistent abstinence*. The Diagnostic and Statistical Manual (*DSM-5*) of the American Psychiatric Association defines early remission from tobacco use disorder as not having met diagnostic criteria for at least 3 months.[27] Consistent with this definition, we coded participants as having achieved consistent abstinence if they reported no cigarettes at two consecutive timepoints (approximately 3 months apart), and continued to report abstinence for all subsequent timepoints. That is, the two consecutive timepoints could occur at any point during the study, including at the last two study assessments. Participants were coded as having achieved consistent abstinence at the time of the second consecutive nonsmoking timepoint. Because this was not a cessation study participants did not have a strong incentive to report abstinence, and we have previously found that self-reported data were consistent with nicotine levels in a subsample.[28] Thus, we made no assumptions about smoking at timepoints when participants were missing data.

Analytic Plan

Bivariate tests were used to evaluate whether age, age at the first cigarette, and student status predicted consistent abstinence and should be taken into account in hypothesis tests. Sex, racial/ethnic background, and frequency of alcohol, marijuana, and e-cigarette use were included as covariates in hypothesis tests. To account for the possibility that heavier smokers were less likely to achieve consistent abstinence, total cigarettes in the past 14 days at the baseline assessment were also included.

To test the hypothesis that social cognitive factors predicted the likelihood of consistent abstinence, we utilized a Cox regression approach that allowed the incorporation of time-varying predictors.[29] The outcome variable was whether consistent abstinence was achieved, and if so at what timepoint. Once a participant was censored (ie, reached consistent abstinence), subsequent observations were not included in the model. We utilized the time-varying covariates (*tvc*) module in Stata to test the model's proportional hazards assumption with respect to hypothesized predictors.[30] Our initial model specified all SCT predictors (positive reinforcement expectancies, negative reinforcement expectancies, negative consequences expectancies, weight concern expectancies, intent to quit in the next month, intent to quit in the next year, proportion of friends who smoke, exposure to cigarette advertisements, and abstinence self-efficacy) as time-varying predictors. SCT predictors with p values > .10 were omitted and the model was refit.

Following hypothesis testing, post hoc analyses evaluated whether more proximal changes in the variables retained in the final Cox models predicted consistent abstinence. In contrast to the Cox models utilizing time-varying predictors from baseline to the point at which censoring occurred, post hoc analyses examined change in the 6 months preceding censoring. For each substance use or SCT variable retained in the Cox model, we calculated change over the final three assessment periods included in the model. For participants who reached consistent abstinence, this represented the period from the last time that cigarette smoking was reported until consistent abstinence was achieved. For those who continued smoking, this represented their last three study timepoints. We conducted logistic regression analyses to evaluate whether these change scores predicted the likelihood of consistent abstinence. All analyses were conducted in Stata IC 15.2, with alpha = 0.05.

Results

Preliminary Analyses

Clinical and demographic characteristics of the sample are summarized in Table 1. All SCT predictors were found to satisfy the proportional hazards assumption. Student status and age at first cigarette were not associated with the likelihood of consistent abstinence, and were not included in hypothesis tests. A total of 246 participants (42.5%) transitioned to consistent abstinence. Typically this occurred during the latter half of the study: 32 participants reached consistent

Table 1. Smoking and Other Substance Use at Baseline

Characteristic	*M* (SD) or %	Median	Interquartile range
Age at baseline	19.82 (1.80)	20.53	19.17–22.06
Gender (% male)	53.15%	—	—
Racial/ethnic background (% white)	49.25%	—	—
Student status (% full-time student)	60.21%	—	—
Proportion of friends smoking	44.21%	—	—
Age at first cigarette	17.04 (2.00)	17	16–18
Smoking days in past 2 weeks	5.28 (3.87)	4	2–8
Total cigarettes in past 2 weeks	12.37 (17.67)	7	3–15
Alcohol days in past 2 weeks	4.94 (3.48)	4	2–7
Marijuana days in past 2 weeks	3.79 (4.88)	1	0–7
E-cigarette days in past 2 weeks	1.61 (3.44)	0	0–1
Hookah tobacco days in past 2 weeks	0.90 (2.23)	0	0–1

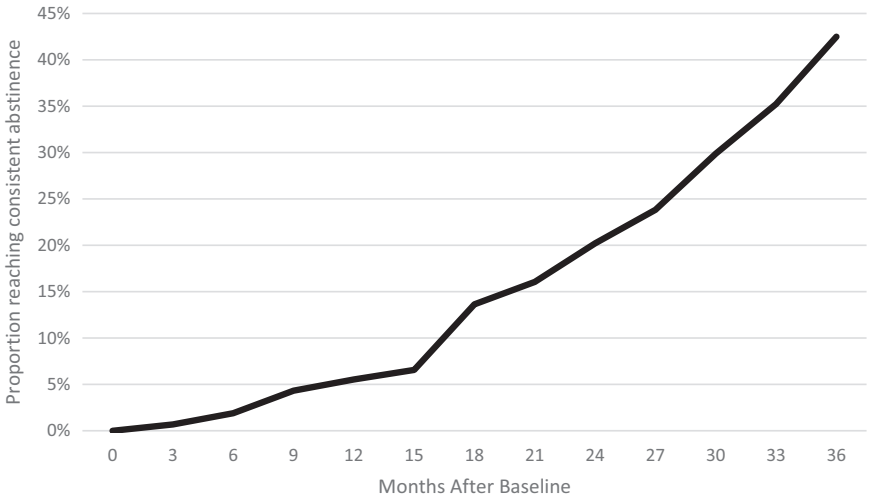

Figure 1. Cumulative proportion of the sample achieving consistent abstinence over time.

abstinence during the first year of the study compared with 85 during the second year and 129 during the third year. The cumulative proportion of participants who had reached consistent abstinence over time is shown in Figure 1. Of the participants who continued to smoke, most did so intermittently. Across waves, the proportion of participants who reported daily smoking ranged from 4% to 15%. However, only 14 (2.4%) participants reported daily smoking in the final two waves in which they participated. Thus, the remaining 319 participants (55.1% of the sample) continued to smoke intermittently throughout the study. Missing data increased over time. All participants provided data at baseline, compared with 91%–97% at the next four waves (ie, through Y1), 87%–92% at the middle four waves (through Y2), and 83%–86% at the final four waves (though Y3). Consistent with recommendations in the literature,[31,32] hypothesis tests utilized all available data, without imputing missing values.

Primary Analyses

In the Cox models (Table 2), we found changes in certain SCT predictors over time were associated with shifting from intermittent cigarette smoking to consistent abstinence. Participants with stronger positive reinforcement expectancies were less likely to report consistent abstinence, with each additional 1-point increase in expectancies predicting 2.4% lower likelihood of consistent abstinence; put differently, a one standard deviation increase in positive reinforcement expectancies predicted 19% lower likelihood of consistent abstinence. Similarly, those who reported a higher proportion of friends who smoke were less likely to achieve consistent abstinence, with each 10% increase in the proportion of smoking friends predicting a 7% decline in the odds of consistent abstinence. Finally, intent to quit cigarettes in the next month was positively associated with consistent abstinence, with each 1-point increase in intent predicting a 24% greater likelihood of consistent abstinence.

The association between abstinence self-efficacy and consistent abstinence was not statistically significant. There were few differences between racial/ethnic groups, though those in the multiple or other racial/ethnic group (10.4% of the sample) were 38% less likely to reach consistent abstinence compared with white participants. There were no differences in abstinence rates between men and women. Those who reported smoking more cigarettes during the past 2 weeks at baseline were less likely to reach consistent

Table 2. Cox Regression Model of the Likelihood of Achieving Consistent Abstinence

Predictor	HR	95% CI	*p* value
Female	0.98	0.76 to 1.27	.900
Racial/ethnic identification			
White	(Reference)		
Asian or Pacific Islander	0.89	0.64 to 1.26	.532
Latinx	0.81	0.59 to 1.12	.195
Multiple or other	0.62	0.39 to 0.99	.045
Time-varying predictors			
Baseline total cigarettes	0.99	0.98 to 1.00	.024
Assessment days	0.94	0.88 to 1.01	.118
E-cigarette days	0.96	0.92 to 1.01	.148
Marijuana days	0.96	0.92 to 0.99	.026
Alcohol days	0.92	0.87 to 0.97	.001
Proportion of friends who smoke	0.99	0.99 to 1.00	.011
Positive reinforcement expectancies	0.98	0.96 to 0.99	.006
Intent to quit in the next month	1.24	1.14 to 1.35	<.001
Abstinence self-efficacy	1.01	1.00 to 1.02	.075

HR, hazard ratio; CI, confidence interval.

abstinence. More frequent use of alcohol and marijuana each predicted a lower likelihood of attaining abstinence, but e-cigarette frequency did not. The remaining time-varying SCT predictors were not associated with consistent abstinence and were omitted from the final model: expectancies for negative reinforcement, negative consequences, and weight control; intent to quit in the next year; and exposure to cigarette advertisements.

Post Hoc Analyses

In Table 3 provides descriptive statistics for baseline values and change over the last three timepoints for each predictor by abstinence group. Of the SCT predictors, intent to quit in the next month and abstinence self-efficacy changed the most, while the proportion of friends who smoke was most stable. We used logistic regression to evaluate whether change scores were associated with likelihood of consistent abstinence. Model covariates included race/ethnicity, sex, baseline age, total cigarettes in the past 2 weeks at baseline, assessment days at the two timepoints used to calculate change scores, and baseline values of the substance use and SCT predictors. Results indicated that reductions in positive reinforcement expectancies (odds ratio [OR] = 0.94 [95% confidence interval = 0.92% to 0.96%], $p = .013$) and increases in intent to quit (OR = 1.30 [1.11 to 1.52], $p = .001$) were associated with consistent abstinence. Likelihood of consistent abstinence was not related to acute changes in abstinence self-efficacy or proportion of friends who smoke, or in alcohol, e-cigarette, or marijuana use.

Our final set of post hoc analyses compared participants who used cigarettes throughout the study to those who stopped smoking in terms of the contexts in which they used cigarettes. For participants who stopped smoking during the study, only timepoints prior to consistent abstinence were included. We conducted a series of longitudinal mixed-effects regression analyses, evaluating whether the number of cigarettes smoked in each context varied by time, whether the participant ultimately stopped smoking, and the interaction between the two. Each model had a single context as the outcome, and included age, sex, racial/ethnic background, and total cigarettes at each timepoint as covariates. There were no interactions between time and stopping smoking, indicating group differences were consistent over time; interaction terms were not retained. For most contexts, the groups did not differ, but there were differences in contexts related to social activity. First, compared to continuing smokers, participants who later stopped smoking tended to report smoking more cigarettes while driving ($z = 3.83$, $p < .001$), in the morning ($z = 4.09$, $p < .001$), and in the afternoon ($z = 4.17$, $p < .001$). In contrast, participants who continued smoking reported consuming more cigarettes than their counterparts at night ($z = -3.73$, $p < .001$), in social situations ($z = -3.08$, $p = .002$), while with others who were smoking ($z = -2.10$, $p = .035$), and while drinking alcohol ($z = -3.32$, $p = .001$).

Discussion

The first aim of this study was to assess the stability of non-daily smoking over 3 years in a sample of young adults. Consistent with earlier studies,[7] slightly more than half of the participants remained non-daily smokers at the end of the study. Most of the remainder (43% of the sample) transitioned to nonsmoking, defined as reporting no cigarette consumption for the last two or more waves of participation (~6 months or more). Only a small minority (2.4%) shifted to daily smoking by the time the study ended.

Additional aims included testing the hypothesis that changes in SCT-based predictors would be associated with the change in smoking patterns. Cognitively, participants with stronger expectancies for positive reinforcement from cigarettes were more likely to continue smoking. Behaviorally, those who reported a higher level of intent to stop smoking in the next month were more likely to ultimately stop. Socially, having a higher proportion of friends who smoke cigarettes was associated with a lower likelihood of stopping. Additionally, post hoc analyses suggested that participants who stopped smoking tended to smoke less in social situations prior to stopping compared with those who continued smoking throughout the study. Post hoc analyses also indicated that participants who stopped reported larger reductions in expectancies for positive reinforcement from smoking and larger increases in intent to quit in the 6 months before they stopped. These models of the period prior to transition suggest that, as SCT would predict, both cognitive and social factors contributed to the likelihood of stopping smoking.

Smoking research has long demonstrated an association between expectancies for both positive and negative reinforcement and ongoing cigarette consumption among heavier users.[33–35] Few previous studies have evaluated to what extent this association holds for light or intermittent smokers. We found that a shift to nonsmoking was preceded by decrements in positive reinforcement expectancies but not negative reinforcement expectancies. This is consistent with the hypothesis that intermittent, non-daily smokers tend to smoke in pursuit of anticipated positive reinforcement, and with an earlier finding of increased positive but not negative reinforcement expectancies following smoking initiation.[36] Recent evidence suggests that among non-daily smokers attempting to quit, the temptation to smoke and lapses are each associated

Table 3. Mean Change in Raw Scores Over the Final Three Assessments for Those Who Did and Did Not Achieve Consistent Abstinence, and Odds Ratios and Confidence Intervals from Logistic Regression Model Testing Whether Change in **Raw** Predictor Values Over the Final Three Assessments Was Associated With Consistent Abstinence

Variable	Baseline *M* (SD)		Change scores		Logistic model		*p* value
	Abstinent	Non-abstinent	Abstinent	Non-abstinent	OR	95% CI	
Alcohol days	4.67 (3.24)	5.14 (3.63)	0.39	1.82	**0.97**	**0.91 to 1.04**	0.382
Vaping days	1.73 (3.90)	1.53 (3.07)	0.19	1.35	**0.94**	**0.88 to 1.00**	0.064
Marijuana days	3.47 (4.91)	4.03 (4.85)	0.29	1.60	**0.96**	**0.91 to 1.02**	0.206
Intent to quit	1.35 (1.31)	1.26 (1.18)	0.37	0.08	**1.30**	**1.11 to 1.52**	0.001
Positive reinforcement expectancies	17.32 (8.18)	17.14 (7.92)	-0.49	0.95	**0.94**	**0.92 to 0.96**	0.010
Friends who smoke	42.08 (24.53)	45.80 (26.47)	1.23	2.65	**0.99**	**0.99 to 1.00**	0.235
Self-efficacy	29.21 (10.11)	28.83 (9.74)	1.82	2.14	**1.00**	**0.98 to 1.02**	0.974

The difference between the predictor score at the final pre-abstinence assessment and the predictor score two timepoints earlier was calculated. Positive change scores reflect an increase over the final three timepoints, and negative change scores a decrease. Each logistic model adjusted for racial/ethnic background, sex, age at baseline, total cigarettes in the past 2 weeks at baseline, assessment days at the two timepoints used to calculate change scores, and the value of the substance use, or SCT variable at baseline.
OR, odds ratio; CI, confidence interval; SCT, social cognitive theory.

with both low positive affect and high negative affect.[37] This indicates that, while non-daily smokers may conceptualize their smoking primarily as a way to increase positive mood, the onset of acute distress may trigger smoking.

Previous studies of young adult smokers have indicated that baseline intent to quit is a prospective predictor of becoming a nonsmoker.[38] Our results extend this finding by indicating that acute increases in intent to quit may precede transitions to nonsmoking. Some studies have suggested that anti-tobacco messages from a variety of sources, conflict with friends and family about smoking, and home restrictions on use are associated with greater intent to quit.[39–41] Among young adults, greater intent to quit has been associated with negative perceptions of the tobacco industry[42] and with more frequent exercise.[38] However, the extent to which most of these characteristics can modify the intent to quit is uncertain. One exception is anti-tobacco messaging; studies suggest that anti-tobacco advertisements can increase motivation to stop smoking.[43] Additional research is needed to identify anti-tobacco content and messages that most effectively increase intent to quit, as well as to identify other interventions that may be effective.

We also found that multiple variables related to exposure to smokers predicted a greater likelihood of transition to nonsmoking, including having fewer friends who smoke and smoking less frequently in social situations. This is consistent with previous work indicating that young adults who smoke tend to have more friends who also smoke.[44] Additionally, exposure to smoking by friends and family has been associated with lower likelihood of cessation in young adult samples.[45] This finding suggests the potential benefit of anti-smoking campaigns. Such campaigns have been shown to reduce the social acceptability of smoking among peers,[46] and so could lead to fewer friends who smoke, increasing the likelihood of becoming a nonsmoker. Additionally, recent work suggests that young adult non-daily smokers who identify as social smokers may tend to maintain smoking to a greater extent than those who identify as "occasional smokers."[47] Taken together, these findings suggest that young adults who have social motives for smoking may be particularly vulnerable to chronic cigarette use, even if at lower use frequency, and thus are a key target for intervention.

Notably, the likelihood of stopping smoking was inversely associated with frequency of alcohol and marijuana use, consistent with well-documented overlap in the use of these substances[48] and with evidence that co-use inhibits smoking cessation.[49] This suggests that prevention and intervention programs that focus solely on tobacco may be less effective, and that such programs should address the risks associated with use of other substances. Accordingly, incorporating tobacco use in interventions addressing alcohol and marijuana use may also prove effective. In contrast, e-cigarette use frequency was unrelated to whether participants stopped smoking cigarettes. This could mean that e-cigarette use inhibits cigarette cessation. However, it may more likely reflect the fact that young adults are more likely to vape for appetitive purposes than in an effort to quit cigarettes.[50] Studies suggest that vaping may aid cigarette cessation when cessation is the goal, but does not predict stopping cigarettes otherwise.[51]

Finally, we found that participants who identified as being from multiple or other racial/ethnic backgrounds were 38% less likely than white participants to reach consistent abstinence. The majority of this group (78%) identified as being from multiple backgrounds. There is little investigation of smoking patterns among such individuals in the literature; however, the proportion of such individuals in the US population is growing rapidly,[52] making evaluation of smoking patterns important. One large study using national survey data from 1994 to 2008 suggested that the likelihood of lifetime cigarette use among young adults from multiple backgrounds was comparable to their white peers, and the likelihood of regular smoking was somewhat less.[53] However, further investigation is needed, particularly in light of changes in the tobacco landscape in the past decade. If individuals from multiple backgrounds are less likely to stop smoking in young adulthood, as our data suggest, there is a need for additional research to address this disparity.

Certain aspects of this study may limit generalizability to the population of young adults, including that all participants were California residents at the time of enrollment and were recruited via social media. We relied on self-report of cigarette consumption which may be subject to underreporting, though we have previously found good agreement between

self-report and biological measures of use in a subsample of 90 of these participants.[28] Additionally, while smoking behavior was assessed in a total of 13 waves across 3 years, each individual wave consisted of a 9- or 14-day period. As a result, it is possible that some participants who met the criteria for consistent abstinence engaged in cigarette use that occurred between waves and was not captured. However, this study was designed to have less time between waves than previous cohort studies to reduce this possibility.

We sought to evaluate the stability of non-daily cigarette smoking among young adults and to explore predictors of transitions away from non-daily smoking. A small majority of participants remained non-daily smokers. Most of the remainder stopped smoking altogether. Consistent with the predictions of SCT, we found that smoking behavior was associated with both social and cognitive factors. Findings suggest that many young adults who smoke intermittently will stop on their own, but also that many will not. For the latter group, there is a need for interventions to assist with cessation. Our results suggest such interventions should include components designed to reduce social motives, positive reinforcement expectancies, and concurrent use of other substances and to increase intent to quit in the near future. Additional research is needed to evaluate whether such interventions might be best designed as anti-smoking campaigns broadly delivered to young adults or as interventions directly delivered to individuals who seek cessation assistance.

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Declaration of Interests

The authors declare no conflicts of interest.

Data Availability

Data are available from the first author upon request.

References

1. Shiffman S, Tindle H, Li X, *et al*. Characteristics and smoking patters of intermittent smokers. *Exp Clin Psychopharmacol*. 2012;20(4):264–277.
2. Schane R, Glantz S, Ling P. Nondaily smoking: an increasingly prevalent pattern. *Arch Int Med*. 2009;162(19):1742–1744.
3. Robertson L, Iosua E, McGee R, Hancox R. Nondaily, low-rate daily, and high-rate daily smoking in young adults: a 17-year follow-up. *Nicotine Tob Res*. 2016;18(5):943–949.
4. Perry C, Perez A, Bluestein M, *et al*. Youth or young adults: which group is at highest risk for tobacco use onset? *J Adolesc Health*. 2018;63(4):413–420.
5. US Department of Health and Human Services. *Preventing Tobacco Use Among Young and Young Adults: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.
6. Inoue-Choi M, Christensen C, Rostron B, *et al*. Dose-response association of low-intensity and nondaily smoking with mortality in the United States. *JAMA Netw Open*. 2020;3(6):e206436.
7. White H, Bray B, Fleming C, Catalano R. Transitions into and out of light and intermittent smoking during emerging adulthood. *Nicotine Tob Res*. 2009;11(2):211–219.
8. Klein E, Bernat D, Lenk K, Forster J. Nondaily smoking patterns in young adulthood. *Addict Behav*. 2013;38(7):2267–2272.
9. Cabriales J, Maldonado B, Cooper T. Smoking transitions in a sample of Hispanic daily light and intermittent smokers. *Addict Behav*. 2016;62:42–46. doi:10.1016/j.addbeh.2016.06.009
10. Schweizer C, Roesch S, Khoddam R, Doran N, Myers M. Examining the stability of young-adult alcohol and tobacco co-use: a latent transition analysis. *Addict Res Theory*. 2014;22(4):325–335.
11. Benowitz N. Nicotine addiction. *N Engl J Med*. 2010;362(24):2295–2303.
12. Shiffman S, Scholl S, Mao J. Very-low-nicotine-content cigarettes and dependence among non-daily smokers. *Drug Alcohol Depend*. 2019;197:1–7. doi:10.1016/j.drugalcdep.2018.12.021
13. Tindle H, Shiffman S. Smoking cessation behavior among intermittent smokers versus daily smokers. *Am J Publ Health*. 2011;101(7):e1–e3.
14. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Decis Process*. 1991;50(2):248–287.
15. Schunk D, DiBenedetto M. Motivation and social cognitive theory. *Contemp Educ Psychol*. 2020;60:101832. doi:10.1016/j.cedpsych.2019.101832
16. Villanti A, Johnson A, Rath J, *et al*. Identifying "social smoking" US young adults using an empirically-driven approach. *Addict Behav*. 2017;70:83–89. doi:10.1016/j.addbeh.2017.02.004
17. Lisha N, Thrul J, Ling P. Latent class analysis to examine patterns of smoking and other tobacco products in young adult bar patrons. *J Adolesc Health*. 2019;64(1):93–98.
18. East K, McNeill A, Thrasher J, Hitchman S. Social norms as a predictor of smoking uptake among youth: a systematic review, meta-analysis and meta-regression of prospective cohort studies. *Addiction*. 2021;116(1):2953–2967. doi:10.1111/add.15427.
19. Park M. How smoking advocates are connected online: n examination of online social relationships supportive smoking behaviors. *J Health Commun*. 2020;25(1-2):82–90.
20. Heinz A, Kassel J, Berbaum M, Mermelstein R. Adolescents' expectancies for smoking to regulate affect predict smoking behavior and nicotine dependence over time. *Drug Alcohol Depend*. 2010;111(Suppl 2):128–135.
21. Feng G, Jiang Y, Li Q, *et al*. Individual-level factors associated with intentions to quit smoking among adult smokers in six cities of China: findigns from the ITC China Survey. *Tob Control*. 2010;19(8):i6–i11.
22. Hoeppner B, Hoeppner S, Schick M, *et al*. Using the text-messaging program SmokefreeTXT to support smoking cessation for nondaily smokers. *Subst Use Misuse*. 2019;54(2):1260–1271.
23. Myers M, McCarthy D, MacPherson L, Brown S. Constructing a short form of the smoking consequences questionnaire with adolescents and young adults. *Psychol Assess*. 2003;15(6):163–172.
24. Etter J, Bergman M, Humair J, Perneger T. Development and validation of a scale measuring self-efficacy of current and former smokers. *Addiction*. 2000;95(6):1–13.
25. Sobell LC, Sobell MB. *Timeline Followback: A Calendar Method for Assessing Alcohol and Drug Use*. Toronto: Addiction Research Foundation; 1996.
26. Ramo DE, Hall S, Prochaska JJ. Reliability and validity of self-reported smoking in an anonymous online survey with young adults. *Health Psychol*. 2011;30(6):693–701.
27. American Psychiatric Association. *Diagostic and Statistical Manual of Mental Disorders. 5th ed*. Arlington, VA: American Psychiatric Association; 2013.
28. Doran N, Correa J, Myers M, Tully L. Associations between self-reported and biological measures of nicotine consumption among young adult nondaily cigarette smokers. *Am J Addict*. 2020;29(6):471–475.
29. Dunning A, Collins S, Fitzgerald D, Rua S. Correctly modelling CD4 cell count in Cox regression analysis of HIV positive patients.

In: *2013 Stata Conference 16, Stata Users Group; New Orleans, LA; 18–19 July 2013*; 2013. https://ideas.repec.org/p/boc/norl13/16.html.
30. Ruhe C. Estimating survival functions after stcox with time-varying coefficients. *Stata J*. 2016;16(4):867–879.
31. Si Y, West B, Veliz P, *et al*. An empirical evaluation of alternative approaches to adjusting for attrition when analyzing longitudinal survey data on young adults' substance use trajectories [published online ahead of print May 18, 2022]. *Int J Psychiatr Res*. doi:10.002/mpr.1916.
32. Xi W, Pennell M, Andridge R, Paskett E. Comparison of intent-to-tat analysis strategies for pre-post studies with loss to follow-up. *Contemp Clin Trials Commun*. 2018;11:20–29. doi:10.1016/j.conctc.2018.05.008
33. Wetter D, Smith S, Kenford S, *et al*. Smoking outcome expectancies: factor structure, predictive validity, and discriminant validity. *J Abnorm Psychol*. 1994;103(4):801–811.
34. Copeland A, Brandon T, Quinn E. The smoking consequences questionnaire-adult: measurement of smoking outcome expectancies of experienced smokers. *Psychol Assess*. 1995;7(4):484–494.
35. Kaufmann A, Malloy E, Haaga D. Examining outcome expectancies for smoking vs. abstinence among adult daily smokers. *Addict Behav* 2020;102:106140. doi:10.1016/j.addbeh.2019.106140
36. Doran N, Schweizer C, Myers M. Do expectancies for reinforcement from smoking change after smoking initiation? *Psychol Addict Behav*. 2011;25(1):101–107.
37. Shiffman S, Scholl S, Mao J, *et al*. Ecological momentary assessment of temptations and lapses in non-daily smokers. *Psychopharmacology*. 2020;237(8):2353–2365.
38. Frith E, Loprinzi P. Exercise facilitates smoking cessation indirectly via intention to quit smoking: Prospective cohort study among a national sample of young smokers. *Am J Health Promot*. 2018;32(5):1234–1238.
39. Omole T, McNeel T, Choi K. Heterogeneity in past-year smoking, current tobacco use, and smoking cessation behaviors among light and/or non-daily smokers. *Tob Induc Dis*. 2020;18:74. doi:10.18332/tid/125724
40. Mozaffarian D, Afshin A, Benowitz N, *et al*. AHA scientific statement population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. *Circulation*. 2012;126(12):1514–1563.
41. Myung S-K, McDonnell D, Kazinets G, Seo H, Moskowitz J. Relationships between household smoking restrictions and intention to quit smoking among Korean American male smokers in California. *J Korean Med Sci*. 2010;25(2):245–250.
42. Nguyen N, Lisha N, Neilands T, Jordan J, Ling P. Differential associations between anti-tobacco industry attitudes and intention to quit smoking across young adult peer crowds. *Am J Health Promot*. 2019;33(6):876–885.
43. Ickes M, Butler K, Wiggins A, *et al*. Truth ads, receptivity, and motivation to use or quit tobacco among college students. *J Am Coll Health*. 2020;68(4):366–373.
44. Lenk K, Erickson D, Forster J. Trajectories of cigarette smoking from teens to young adulthood: 2000 to 2013. *Am J Health Promot*. 2018;32(5):1214–1220.
45. Joo H, Cho M, Cho Y, Joh H-K, Kim J. Predictors of long-term smoking cessation among smokers enrolled in a university smoking cessation program. *Medicine*. 2020;99(5):e18994.
46. Perry C, Creamer M, Chaffee B, *et al*. Research on youth and young adult tobacco use, 2013-2018, from the Food and Drug Administration - National Institues of Health Tobacco Centers of Regulatory Science. *Nicotine Tob Res*. 2020;22(7):1063–1076.
47. Johnson A, Villanti A, Williams V, *et al*. Smoking trajectory classes and impact of social smoking identity in two cohorts of US young adults. *Emerg Adulthood*. 2019;7:258–269. doi:10.1177/2167696818763949
48. Cohn A, Johnson A, Rose S, *et al*. Population-level patterns and mental health and substance use correlates of alcohol, marijuana, and tobacco use and co-use in US young adults and adults: results from the population assessment for tobacco and health. *Am J Addict*. 2018;27(6):491–500.
49. Kahler C, Spillane N, Metrik J. Alcohol use and initial smoking lapses among heavy drinkers in smoking cessation treatment. *Nicotine Tob Res*. 2010;12(7):781–785.
50. Saddleson M, Kozlowski L, Giovino G, *et al*. Enjoyment and other reasons for electronic cigarette use: Results from college students in New York. *Addict Behav* 2016;54:33–39. doi:10.1016/j.addbeh.2015.11.012
51. Mantey D, Cooper M, Loukas A, Perry C. E-cigarette use and cigarette smoking cessation among Texas college students. *Am J Health Behav*. 2017;41(6):750–759.
52. US Census Bureau. *The Two or More Races Population: 2010*; 2012. https://www.census.gov/newsroom/releases/archives/race/cb12-182.html#:~:text=According%20to%20the%202010%20Census,which%20grew%20by%209.2%20percent. Accessed May 24, 2022
53. Goings T, Hidalgo S, McGovern P. Racial/ethnic differences in cigarette use trends in the United States among multiracial and other youth, 1994–2008. *J Drug Issues*. 2018;48:90–105. doi:10.1177/0022042617731338