Time to First Cigarette Predicts Cessation Outcomes in Adolescent Smokers

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ABSTRACT

Introduction: This study examined the relationship between the time to the first cigarette (TTFC) of the morning with quit status among adolescent smokers at the completion of a school-based smoking cessation program. Among those who did not quit, the relationship of TTFC with changes in cigarettes/day (CPD) was also examined.

Methods: A total of 1,167 adolescent smokers (1,024 nonquitters and 143 quitters) from 4 states participating in efficacy and effectiveness studies of the Not-On-Tobacco (N-O-T) cessation program were assessed prior to entry into the program and again 3 months later at the end of treatment. Linear and logistic regression analyses determined the influence of treatment condition, age, gender, motivation to quit, confidence in quitting ability, baseline CPD, and TTFC on quit status and end-of-treatment CPD.

Results: Adolescents with a TTFC of >30 min of waking were twice as likely to quit at end of treatment. Additionally, among those who did not quit at end of treatment ($n = 700$ for TTFC ≤30 min and $n = 324$ for TTFC for >30 min), those with a TTFC within 30 min of waking smoked a greater number of CPD. The relationships of TTFC with both of these outcomes remained when controlling for all other predictor variables.

Conclusions: Identifying adolescent smokers who smoke their first cigarette of the day within the first 30 min of waking prior to a quit attempt may help to classify those individuals as having a greater risk for cessation failure. Thus, TTFC may be a behavioral indicator of nicotine dependence in adolescents.

INTRODUCTION

Given that 80% of those who initiate smoking during adolescence continue smoking into and throughout adulthood (Substance Abuse and Mental Health Services Administration [SAMHSA], 2011), adolescent populations are important targets of smoking cessation strategies. Overall, these strategies have had only modest success in helping adolescents to quit smoking. For example, one of the most effective and widely published youth cessation programs to date, as identified by Cochrane reports and other research, is the American Lung Association's Not-On-Tobacco program with a success rate between 15% and 31% (Cahill, Lancaster, & Green, 2010; Curry et al., 2007; Grimshaw & Stanton, 2006; Horn, Dino, Kalsekar, & Mody, 2005). Given that there is a great deal of room for improvement, research is needed to identify factors that may assist programs in increasing cessation rates, including identifying variables which may predict outcomes. A better understanding of these factors will be useful in tailoring cessation strategies to an individual adolescent smoker's needs, and

may result in an increased chance of success during cessation attempts.

Research has established that nicotine dependence, the physiological reliance on the primary addictive ingredient in cigarettes (United States Department of Health and Human Services, 1988), is a strong indicator of cessation success or failure in adult smokers (John, Meyer, Hapke, Rumpf, & Schumann, 2004; Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994; Pinto, Abrams, Monti, & Jacobus, 1987). Although some dimensions of nicotine dependence are shared among adults and adolescents, many of the theoretical, neurobiological, and behavioral models that have been used to characterize adult dependence do not appear to be equally predictive of dependence in youths (Shadel, Shiffman, Niaura, Nichter, & Abrams, 2000). For example, in comparison with adult smokers, adolescent smokers engage in more light or intermittent (i.e., nondaily) cigarette use, smoke fewer cigarettes/day, and may smoke cigarettes differently (e.g., inhale less deeply or take fewer puffs) than adults (Mermelstein et al., 2002). These patterns of smoking behavior make it difficult

to accurately characterize adolescent nicotine dependence using traditional adult dependence questionnaires (Shadel et al., 2000). Thus, measures that capture facets of nicotine dependence while also accounting for differences in smoking behaviors between adolescents and adults may be useful in furthering our understanding how nicotine dependence is manifested in adolescents.

Recently, it has been suggested that the time to the first cigarette (TTFC) of the day may be one of the strongest indicators of adolescent nicotine exposure (Branstetter & Muscat, 2012) as demonstrated by the strong association between adolescent TTFC and levels of serum cotinine, the primary metabolite of nicotine and a proxy of cigarette exposure (Fortmann et al., 1984). TTFC is a single item contained within several commonly used questionnaire measures of nicotine dependence (e.g., Fagerstrom Test for Nicotine Dependence [Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991], Fagerstrom Tolerance Questionairre [FTQ; Fagerstrom, 1978], Heaviness of Smoking Index [Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989]), which assesses, "How soon after you wake up do you smoke your first cigarette?" (Fagerstrom, 1978). In studies of both adults and adolescents, having a shorter TTFC predicted higher levels of serum cotinine levels, even after controlling for the number of cigarettes/day, recency of smoking, and exposure to secondhand smoke in the home (Branstetter & Muscat, 2012; Muscat, Stellman, Caraballo, & Richie, 2009). The fact that a shorter TTFC is associated with greater levels of tobacco exposure in both adolescents, and adults suggests TTFC is a potential way of identifying a dimension of nicotine dependence common to both populations, despite other differences in smoking behaviors between younger and older smokers.

In addition to ability of TTFC to predict nicotine exposure in adolescents, studies of adult smokers have demonstrated strong relationships between a shorter TTFC and worse cessation outcomes (Baker et al., 2007; Fagerstrom, 2003). Furthermore, it has been found that a shorter TTFC predicts quicker relapse to regular smoking in both treatment seeking smokers engaging in cessation attempts (Toll, Schepis, O'Malley, McKee, & Krishnan-Sarin, 2007) and nontreatment seeking smokers participating in a laboratory model of relapse (Sweitzer, Denlinger, & Donny, 2012). Because the inability to maintain abstinence after a quit attempt is a key indicator of nicotine dependence (i.e., those who are unable to remain quit are theoretically more dependent), the results of these studies suggest that TTFC may be a useful behavioral measure of dependence in adult smokers (Baker et al., 2007), and may subsequently serve to identify smokers more likely to struggle during quit attempts.

Studies demonstrating a relationship between TTFC and adolescent nicotine exposure, taken together with those finding a relationship between TTFC and quit outcome in adults, suggest that TTFC may serve not only as a behavioral indicator of nicotine dependence in adolescents but also as an important predictor of cessation outcome. Thus, if the same negative relationship between TTFC and quit outcome found in adult smokers is also demonstrated in adolescents, clinicians could use this information to identify adolescent smokers at greatest risk of cessation failure. Additionally, clinicians may be able to use this information to assign additional resources during quit attempts (e.g., pair traditional behavioral cessation programs with nicotine replacement therapy) to adolescents who report

an earlier TTFC. Researchers have already implemented this strategy of using TTFC to assign adult smokers to higher doses of a nicotine lozenge and gum to increase efficacy (Shiffman et al., 2002; Shiffman, Sembower, Rohay, Gitchell, & Garvey, 2012), demonstrating the feasibility of this approach in adult populations. However, before these approaches can be applied to adolescent smokers, studies must first explore whether TTFC is also predictive of cessation outcome in adolescent populations. Although there is little extant literature on TTFC in adolescents, particularly on its relevance to cessation outcomes, one study found that adolescent menthol cigarette smokers were more likely to have a shorter TTFC than nonmenthol smokers (Collins & Moolchan, 2006). Given that some studies have found a relationship between smoking menthol cigarettes with increased difficulty during cessation attempts (Gandhi, Foulds, Steinberg, Lu, & Williams, 2009; Pletcher et al., 2006), it is plausible that adolescents with shorter TTFC will also experience more difficulty and worse cessation outcomes than those with a later TTFC.

Based on an extensive review of published literature, this study is the first to examine the relation between TTFC and cessation outcomes specifically among adolescent smokers. The study was conducted as secondary analysis of data from adolescents following participation in efficacy and effectiveness trials of the American Lung Association's Not-On-Tobacco (N-O-T) cessation program. We hypothesized that TTFC would be a significant predictor of quit outcome at the end of treatment over and above other factors shown to influence quit outcome such as cessation treatment condition (N-O-T treatment program vs. brief intervention, or "BI," control condition), number of cigarettes smoked/day prior to quit attempt, age, gender, motivation to quit smoking, and confidence in ability to quit smoking. Specifically, we predicted that compared with adolescents who delay smoking their first cigarette of the day, adolescents with a shorter TTFC would be less likely to quit smoking at the end of treatment. Next, we hypothesized that among nonquitters, those with a shorter TTFC would report smoking a greater number of cigarettes/day at end of treatment than those who delay smoking their first cigarette of the day.

METHODS

Participants

Participants were 1,167 adolescent smokers (671 female and 496 male) aged 14–19 ($M = 16.21$, $SD = 1.14$) who participated in efficacy ($n = 1,079$) and effectiveness ($n = 88$) studies of the American Lung Association's Not-On-Tobacco (N-O-T) cessation program between 1997 and 2008 (Dino et al., 2001; Horn et al., 2005). Eighty-five percent of the sample identified as Caucasian, 7.0% as Hispanic, 1.9% as Black, 1.6% as American Indian, 0.7% as Asian, and 3.6% as biracial or another ethnicity. Per standard inclusion criteria for the N-O-T program, participants smoked at least 1 cigarette/day in the past 30 days at baseline. Although over eight thousand individuals have completed efficacy and effectiveness studies of the N-O-T program, only those participants who provided baseline values for all seven predictor variables were included in regression analyses (i.e., participants were excluded via listwise deletion).

Procedure

Data were aggregated across nine separate studies of adolescent smokers who voluntarily participated in either an effectiveness or efficacy trial of the American Lung Association's Not-On-Tobacco (N-O-T) program in North Carolina, West Virginia, Florida, and New Jersey over an 11-year period from 1997 to 2008. For the efficacy studies, consistent with CONSORT (Consolidated Standards for Reporting of Trials; Moher, Jones, & Lepage, 2001) guidelines, schools were matched to receive either the N-O-T treatment condition or the control condition, which included a 15-min BI. The matching process and criteria are detailed elsewhere (see Horn et al., 2005). N-O-T used a standardized curriculum to deliver 50-min in-depth informational and educational sessions once a week for 10 weeks. The content provided adolescents with information on why and how to successfully quit smoking. In contrast, the BI consisted of a single, 15-min session comprised general advice about quitting and self-help brochures containing cessation information from the American Lung Association and National Cancer Institute. Effectiveness trials occurred as a standard part of ongoing, school-based N-O-T programs and did not include any type of control or comparison group. During baseline enrollment in both efficacy and effectiveness trials, adolescents completed a series of paper-and-pencil baseline questionnaires to provide information on demographic characteristics and smoking behaviors such as current and frequent smoking, number of cigarettes smoked on weekdays/weekends, and prior quit attempts, among other variables (e.g., confidence in quitting, motivation to quit, use of smokeless tobacco/cigars in the past month, and current use of nicotine replacement therapy and reasons for quitting). After completion of the treatment, adolescents again completed the same series of questionnaires, which occurred 3 months after the baseline questionnaire administration. Complete details of the N-O-T program methodology are reported elsewhere (Dino et al., 2001; Horn et al., 2005, 2011). Parental consent and participant assent were given prior to enrollment, and all protocols were approved by the University Institutional Review Boards.

Measures

Demographics
Adolescents' gender and age were included as predictor variables in analyses.

Confidence in Quitting
Confidence in ability to make a successful quit attempt was assessed via self-reported response to a 5-point Likert-type scale (1 = *None* to 5 = *Very High*) for question: "How would you rate your confidence to stop smoking cigarettes?"

Motivation to Quit
Quit motivation was also assessed via self-report using the same 5-point Likert-type scale responses (1 = *None* to 5 = *Very High*) for the question: "How would you rate your motivation to stop smoking cigarettes?"

Time to First Cigarette
During early periods of data collection, adolescents' nicotine dependence was assessed using the FTQ (Fagerstrom, 1978) and later using the modified FTQ (mFTQ; Prokhorov et al., 2000), a version validated specifically for adolescent smokers. Response options to TTFC on the original FTQ included: (a) "within 5 min," (b) "5–30 min," (c) "31–60 min," and (4) "after 60 min." Response options to TTFC on the mFTQ were as follows: (a) "within the first 30 min," (b) "more than 30 min after waking but before noon," (c) "in the afternoon," and (d) "in the evening." For the purpose of analyses, data from both the mFTQ and the FTQ were collapsed into one dichotomous variable based on the categorization of responses demonstrated in the mFTQ. Participants were classified as smoking the first cigarette of the day either (a) "within the first 30 min of waking" (*n* = 765) or (b) "after the first 30 min of waking" (*n* = 402).

Quit Status
Quit status was assessed at end of treatment through participants' self-classification of "yes" or "no" to the question, "Do you currently smoke tobacco?" Adolescents who answered "no" were categorized as "quit" versus those who responded "yes" were categorized as "not-quit." Of the 1,167 participants reporting baseline assessments, 256 or approximately 22% of the sample did not provide information on their smoking status at the end of treatment; a figure that is typical in smoking cessation interventions (Aveyard, Griffin, Lawrence, & Cheng, 2003; Orleans et al., 1998). This study followed the baseline observation carried forward (BOCF) method of coding program drop outs as smokers. The BOCF method assumes that those who drop out of the program do not benefit from their participation in treatment and continue to smoke at an expected, consistent rate. Although this method of handling missing data has many well-recognized flaws and may bias results in favor of existing associations between baseline measures (National Research Council, 2010; Shao, Jordan, & Pritchett, 2009), we elected to use this method to parallel previous work using intent-to-treat analyses on the N-O-T dataset, as this approach is one of the most commonly used in similar cessation trials (Lancaster & Stead, 2005).

Cigarettes/Day
Participants' baseline and end of treatment cigarette use was assessed via self-reported responses to the following two questions: "On Monday through Friday, about how many cigarettes do you smoke a day?" and "On Saturdays and Sundays, about how many cigarettes do you smoke a day?" A composite variable for cigarettes/day was created by multiplying weekday cigarettes/day by five and weekend cigarettes/day by two, summing these values and dividing by seven. Similar to the procedure for coding quit status, participants who had dropped out of the program were coded with his/her baseline cigarettes/day value, assuming they were currently smoking at least as much as they were smoking at baseline.

Data Analyses

Independent *t* tests were conducted to compare means between the TTFC groupings for continuous variables, whereas chi-square tests of independence were used to examine proportions among TTFC categories and gender, treatment condition, ethnicity, and percentage of successful quitters. Logistic regression analysis was used to examine the relation between baseline TTFC and quit status at end of treatment. Among

adolescents who reported that they were not quit at treatment end, an additional multiple linear regression analysis was used to examine the relation between baseline TTFC and change in cigarettes/day from baseline to end of treatment. Analyses entered the following order of predictor variables: treatment group, age, gender, motivation to quit, confidence in quitting ability, and baseline cigarettes/day, and finally TTFC. All analyses were performed using SPSS v20 analytical software.

RESULTS

Sample Characteristics

Demographic and smoking history characteristics for all participants, as well as separated by categorizations of TTFC, are presented in Table 1. On average, participants smoked over one-half a pack of cigarettes/day ($M = 12.96$, $SD = 7.84$), with composite values for cigarettes/day ranging from 0.57 to 54.29 cigarettes/day for adolescents reporting a TTFC after 30 min of waking and from 1 to 60 cigarettes/day for those reporting a TTFC within 30 min of waking. Participants had an average baseline nicotine dependence score of 5.73 ($SD = 1.97$) as measured by the mFTQ. Although this sample's average dependence score and daily cigarette use estimates seem to indicate heavier use and greater dependence than the general population of adolescent smokers, these estimates are consistent with those of other adolescent treatment studies (Botello-Harbaum, Schroeder, Collins, & Moolchan, 2010; Thorner, Jaszyna-Gasior, Epstein, & Moolchan, 2007). Given that infrequent or nondaily adolescent smokers may have favorable views toward smoking (Carpenter et al., 2009), which might discourage participation in a formal cessation program, the heavy use of the current treatment-seeking sample is expected.

Adolescents who reported smoking their first cigarette of the day within 30 min (vs. after 30 min) of waking smoked more cigarettes/day at baseline, $t(1,165) = -13.27$, $p < .001$, were more nicotine dependent, $t(998) = -25.34$, $p < .001$, had lower confidence in their ability to quit smoking, $t(1,165) = 5.56$, $p < .001$, had lower motivation to quit, $t(1,165) = 3.39$, $p < .01$, and smoked more cigarettes/day at the end of the intervention among those who did not quit, $t(1,022) = -9.56$, $p < .001$. Additionally, the within 30 min group had a greater proportion of males, $\chi^2(1,1167) = 4.41$, $p < .05$, and nonquitters, $\chi^2(1,1167) = 29.15$, $p < .001$ compared with the after 30 min of waking group. The two TTFC groups did not differ in age, ethnicity, treatment condition assignment, or education level.

Quit Status

At the end of treatment, 143 of the total sample of 1,167 adolescent smokers reported not currently smoking cigarettes (12.3%); 78 of the 402 adolescents with a TTFC after 30 min of waking were identified as being quit (19.4%) versus 65 of the 700 adolescents with a TTFC within 30 min of waking (8.5%). Due to data imputation using the BOCF approach, the efficacy results of N-O-T were somewhat lower than the typical 15%–30% success rates for the program (Cahill et al., 2010; Curry et al., 2007; Grimshaw & Stanton, 2006; Horn et al., 2005), with 13.9% of those receiving N-O-T reporting that they had quit versus 10% of those receiving the BI.

As demonstrated in Table 2, logistic regression examining the effect of TTFC on quit status suggests that when controlling for treatment group, age, gender, motivation, confidence, and baseline cigarettes/day, those who smoked their first cigarette of the day after 30 min of waking were approximately twice as likely of being quit at end of treatment versus those reporting smoking within 30 min of waking. Lower motivation to quit and more cigarettes/day at baseline were also significant predictors of cessation failure in the model.

Table 1. Demographic and Smoking Characteristics of Sample by Time to First Cigarette of the Day

	TTFC Groups		
	≤30 min ($n = 765$)	>30 min ($n = 402$)	Total ($n = 1,167$)
	M (SD)	M (SD)	M (SD)
Demographics			
Age	16.21 (1.11)	16.21 (1.18)	16.21 (1.13)
Grade	10.36 (1.06)	10.41 (1.08)	10.38 (1.06)
Gender (% female)*	423 (55.3%)	248 (61.7%)	671 (57.5%)
Ethnicity (% White)[a]	480 (86.0%)	226 (83.4%)	706 (85.2%)
Treatment condition (% receiving N-O-T)	450 (58.8%)	235 (58.5%)	685 (58.7%)
Smoking characteristics			
Baseline cigarettes/day***	15.02 (7.71)	9.04 (6.48)	12.96 (7.84)
mFTQ***	6.61 (1.56)	4.01 (1.48)	5.73 (1.97)
mFTQ without TTFC***	5.61 (1.56)	4.01 (1.48)	5.07 (1.71)
Motivation to quit**	2.88 (0.93)	3.07 (0.94)	2.94 (0.94)
Confidence in ability to quit***	2.82 (0.94)	3.15 (0.98)	2.93 (0.97)
Quit status (% quit)***	65 (8.5%)	78 (19.4%)	143 (12.3%)
End of treatment cigarettes/day[b],***	13.49 (7.73)	8.71 (6.77)	10.51 (8.27)

Note. [a]Denotes that only a subset of the sample provided information on ethnicity ($n = 829$, $n = 271$ for TTFC > 30 min, $n = 558$ for ≤30 min).
[b]End of treatment cigarettes/day means reported for nonquitters only.
*$p < .05$; **$p < .01$; ***$p < .001$.

End of Treatment Cigarettes/Day

Table 3 presents findings from the hierarchical multiple linear regression examining the effect of TTFC on cigarettes/day among those adolescents who reported not being quit at the end of treatment. Results demonstrate that the fit of the full model with both blocks was significant, $F(7,1016) = 128.40$, $p < .001$, $R^2 = 0.469$, Adj $R^2 = 0.466$, and that there was a modest, but significant R^2 change of adding TTFC to the model. In the final model, only gender did not contribute as a significant predictor of end of treatment cigarettes/day.

Sensitivity Analyses

In addition to regression analyses using the BOCF approach, identical logistic ($n = 911$) and linear ($n = 760$) regression analyses were also conducted using a complete case analysis. Results of logistic regression using complete cases were similar to those using the BOCF imputation in that quit motivation, baseline cigarettes/day, and TTFC were all significant predictors of quit status (Table 2). The only difference between the two analyses was that treatment group was a significant predictor of quit status in the complete cases, but not BOCF, analysis.

Table 2. Summary Results for Full Model of Logistic Regression of Quit Status Using Baseline Observation Carried Forward ($n = 1,167$) and Complete Case ($n = 911$) Analyses

Analysis	Variable	B (SE)	Wald	p value	Odds ratio	95% CI (LB, UB)
BOCF	Constant	3.89 (1.38)	7.94	<.01	49.09	
	Treatment group	−0.36 (0.20)	3.29	.07	0.70	(0.48, 1.03)
	Age	−0.10 (0.08)	1.35	.25	0.91	(0.77, 1.07)
	Gender	−0.13 (0.19)	0.48	.49	0.88	(0.61, 1.27)
	Motivation to quit	−0.38 (0.12)	9.73	<.01	0.69	(0.54, 0.87)
	Confidence in ability to quit	0.07 (0.12)	0.34	.56	1.07	(0.85, 1.35)
	Baseline cigarettes/day	0.04 (0.02)	6.59	<.05	1.04	(1.01, 1.07)
	TTFC	0.71 (0.20)	12.70	<.001	2.04	(1.38, 3.03)
Complete case	Constant	3.73 (1.45)	6.60	<.05	41.74	
	Treatment group	−0.44 (0.21)	4.47	<.05	0.65	(0.43, 0.97)
	Age	−0.08 (0.09)	0.85	.36	0.92	(0.78, 1.09)
	Gender	−0.26 (0.20)	1.65	.20	0.78	(0.53, 1.14)
	Motivation to quit	−0.37 (0.13)	8.74	<.01	0.69	(0.54, 0.88)
	Confidence in ability to quit	−0.02 (0.12)	0.02	.88	0.98	(0.78, 1.25)
	Baseline cigarettes/day	0.04 (0.02)	6.02	<.05	1.04	(1.01, 1.07)
	TTFC	0.73 (0.21)	11.80	<.01	2.07	(1.37, 3.13)

Note. CI = confidence interval; LB = lower bound; SE = standard error; UB = upper bound.
Quit status coded as: 0 = quit, 1 = not quit; treatment group: 0 = brief intervention/BI, 1 = N-O-T treatment program; gender: 0 = female, 1 = male; TTFC: 0 = after the first 30 min of waking, 1 = within the first 30 min of waking.

Table 3. Summary Results for Full Model of Linear Regression of End of Treatment Cigarettes/Day Using Baseline Observation Carried Forward ($n = 1,024$) and Complete Case ($n = 760$) Analyses

Analysis	Variable	Unstandardized B (SE)	t	p value
BOCF	Constant	13.69 (2.70)	5.07	<.001
	Treatment group	−1.74 (0.37)	−4.74	<.001
	Age	−0.39 (0.16)	−2.42	<.05
	Gender	0.57 (0.37)	1.53	.13
	Motivation to quit	−0.52 (0.24)	−2.22	<.05
	Confidence in ability to quit	−0.66 (0.23)	−2.91	<.01
	Baseline cigarettes/day	0.61 (0.03)	24.70	<.001
	TTFC	0.97 (0.41)	2.37	<.05
Complete case	Constant	15.69 (3.38)	4.64	<.001
	Treatment group	−2.69 (0.46)	−5.87	<.001
	Age	−0.22 (0.20)	−1.60	.11
	Gender	0.27 (0.46)	0.58	.56
	Motivation to quit	−0.64 (0.30)	−2.16	<.05
	Confidence in ability to quit	−0.97 (0.28)	−3.46	<.01
	Baseline cigarettes/day	0.46 (0.03)	14.41	<.001
	TTFC	1.40 (0.51)	2.74	<.01

Note. Treatment group coded as 0 = brief intervention/BI, 1 = N-O-T treatment program; gender: 0 = female, 1 = male; TTFC: 0 = after the first 30 min of waking, 1 = within the first 30 min of waking.

Results of hierarchical multiple linear regression using complete cases were also similar to those using the BOCF approach: treatment group, quit motivation, confidence in quitting, baseline cigarettes/day, and TTFC were all significant predictors of end of treatment cigarettes/day (Table 3). In contrast to the BOCF analysis, age was no longer a significant predictor of end of treatment cigarettes/day in the complete cases analysis.

In order to determine the validity of adolescents' self-reported quit status, four logistic regression analyses identical to those described previously were used to determine the influence of TTFC on quit status among a subset of the larger sample ($n = 880$), which provided end of treatment expired air carbon monoxide (CO) samples. In these analyses, quit status was defined using four combinations of CO cutoffs and self-reported smoking: (a) self-reported quit status and CO < 10 ppm, (b) self-reported quit status and CO < 8 ppm, (c) self-reported zero cigarettes per day and CO < 10 ppm, and (d) self-reported zero cigarettes per day and CO < 8 ppm. The results of each of these regression analyses were identical to those of the BOCF and complete case analyses in that TTFC, baseline CPD, and quit motivation were the only significant predictors of quit status.

DISCUSSION

The findings of this study provide evidence demonstrating that adolescents' time to first cigarette after waking is an important predictor of quit outcomes following participation in a school-based cessation program. Supporting the first hypothesis of this study, results found that adolescents who reported smoking their first cigarette of the day within 30 min of waking were less likely to report being quit at the end of a school-based cessation program than adolescents reporting a TTFC of >30 min after waking. The relationship of TTFC and quit status was present even after controlling for other factors often associated with quit outcome (e.g., treatment group, age, gender, motivation to quit smoking, confidence in ability to quit smoking, and cigarettes/day) and is consistent with previous findings from multiple adult cessation trials, which demonstrated that the earlier an individual smoked their first cigarette of the day predicted worse cessation outcomes (Baker et al., 2007). The convergence of these findings shows that TTFC is an important predictor of cessation outcome for both adults and adolescents independent of several other factors that contribute to cessation success. This suggests that despite numerous differences in smoking behaviors between adults and adolescents, knowledge of a smoker's TTFC prior to a quit attempt may help clinicians and other practitioners to identify smokers more likely to need additional help (e.g., more frequent sessions of behavioral therapies, combinations of behavioral therapies with pharmacotherapies) during that attempt. Thus, independent of how motivated to quit or how confident a smoker is in their ability to quit, clinicians may be able to use a smoker's TTFC to suggest additional resources for smokers reporting a TTFC within 30 min of waking to increase their chances of success. Additionally, given that TTFC is a single question able to predict quit outcome, this finding implicates TTFC as a cost-efficient tool that may be used to identify adolescent smokers at high risk of cessation failure.

Among adolescents who reported not being quit (implying a failure to either make a quit attempt or maintain quit status)

by the end of treatment assessment, those who reported a TTFC within (vs. after) 30 min of waking reported smoking a greater number of cigarettes/day. This inverse relationship also persisted when controlling for the same group of predictor variables, supporting the second hypothesis of this study. The association of TTFC with greater self-reported cigarette consumption above and beyond all other predictor variables among nonquitters suggests that nonquitters with a TTFC within the first 30 min of waking are less likely to reduce cigarette consumption following participation in a cessation program, perhaps putting them at increased risk of adverse health consequences of smoking compared with nonquitters reporting a TTFC after 30 min of waking.

Results of this study also found that adolescents who reported smoking their first cigarette of the day within 30 min of waking differed from those who reported smoking after 30 min of waking on a number of the demographic characteristics and smoking behaviors used as predictor variables in subsequent analyses. The finding that adolescents who reported a TTFC within (vs. after) 30 min of waking smoked more cigarettes/day at both baseline and end of treatment is consistent with adolescent and adult studies demonstrating a positive correlation between cigarettes/day and TTFC (Branstetter & Muscat, 2012; Muscat et al., 2009). Taken together, these findings suggest that differences in TTFC may reflect differences in patterns of smoking behaviors. For example, smokers who smoke a greater number of cigarettes/day may experience more severe overnight nicotine withdrawal, which consequently drives the urge to smoke the first cigarette of the day earlier in the morning than those who smoke fewer cigarettes/day.

This study also found that adolescents who reported smoking within (vs. after) 30 min of waking also had higher levels of nicotine dependence. This difference remained even after removing the TTFC item from overall mFTQ, suggesting that differences in dependence between TTFC groups pertain to other dimensions of addiction. It is unclear whether adolescents reporting smoking within 30 min of waking would differ from those reporting smoking after 30 min of waking when using other measures of nicotine dependence (e.g., Nicotine Dependence Syndrome Scale [Shiffman, Waters, & Hickcox, 2004] and Hooked On Nicotine Checklist [DiFranza et al., 2002]).

Perhaps the most unexpected findings were that (a) a smaller proportion of male (vs. female) smokers reported a TTFC after 30 min of waking compared with the fairly equal proportions of men and women reporting a TTFC within 30 min of waking, and (b) adolescents who reported a TTFC within 30 min of waking reported lower motivation to quit smoking and lower confidence in their ability to quit smoking. To the authors' knowledge, no studies have specifically examined either gender or quitting confidence and motivation differences by TTFC in either adolescents or adults. However, given the independent effects both quit motivation and confidence have on cessation outcome, future replications of this finding would further illustrate the utility TTFC has as a behavioral measure of dependence.

Although the results of this study may have compelling implications for clinicians, a few caveats should be noted. First, many of the variables included in analyses were self-report measures (e.g., quit motivation, confidence in quitting ability, cigarettes/day, and particularly TTFC and quit status). Relying on self-reported smoking status can be problematic within this

particular population, as adolescent smokers may be influenced by socially desirable responding (i.e., under or overreporting behaviors depending on the perception of how socially acceptable those behaviors are; Dolcini, Adler, & Ginsberg, 1996), especially in the context of a cessation trial where there is greater perceived demand to report abstinence. However, results of logistic regression analyses on a subset of our sample, which provided biochemical verification of abstinence were similar to the results of the main analysis of quit status among the entire sample. These analyses used various combinations of CO cutoffs and self-reported smoking to define abstinence and found that across all methods of defining abstinence, TTFC, baseline cigarettes/day, and motivation to quit smoking remained the only significant predictors of quit outcome. The convergence of these results suggests that TTFC is a robust predictor of quit outcome, regardless of whether abstinence is determined using self-report alone or in combination with biochemical verification.

An additional limitation of this study was that the amount of control adolescents had over their TTFC was not assessed. Many adolescent smokers face restrictions on their smoking behaviors, which may dictate how early in the day they can smoke their first cigarette (e.g., waiting to smoke until out of the home of a parent who does not approve of smoking, not having cigarettes readily accessible to smoke upon waking), thus causing concern that TTFC in adolescents may not be an equivalent measure to TTFC in adults who have virtually no restrictions on how soon they can smoke after they wake. However, the individual TTFC item on the mFTQ has been validated in prior studies of adolescent populations using cotinine as biochemical verification and has been shown to be a reliable measure among adolescent smokers (Prokhorov et al., 2000). Furthermore, because TTFC was able to predict cessation outcome across varying levels of control over home smoking, this finding may ameliorate concerns that TTFC is not a valid index among adolescent smokers.

It should be noted that no analysis was done to determine the effect of the interaction of TTFC and treatment group on quit status or cigarettes/day at end of treatment (i.e., analyses did not evaluate if TTFC moderates treatment effects on cessation outcomes). Thus, there is no assumption that the quit outcomes for each treatment group (N-O-T vs. BI) differs by TTFC. This study only demonstrates that independent of which treatment condition adolescents received, those with a TTFC within (vs. after) 30 min of waking were more likely to not be quit and less likely to reduce cigarette consumption at the end of the study period.

In summary, the results of this study demonstrated that adolescent smokers who report smoking their first cigarette of the day within (vs. after) 30 min of waking were less likely to quit smoking or reduce their cigarette consumption by the end of a school-based cessation program. These results are consistent with previous research on adult smokers, which found an association of shorter TTFC with lower chance of quitting success and sooner relapse (Baker et al., 2007; Toll et al., 2007). Given the difficulty of assessing nicotine dependence in adolescent populations with traditional dependence questionnaires, these results posit the use of TTFC as a behavioral measure of dependence due to its capability to predict inability to quit smoking, a key feature of nicotine dependence. Finally, these results offer the possibility of using

adolescents' TTFC to tailor cessation programs and aids prior to a quit attempt as is already being implemented in adult populations (Shiffman et al., 2002, 2012) to improve cessation success rates.

DECLARATION OF INTERESTS

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