

Relations of Alcohol Consumption With Smoking Cessation Milestones and Tobacco Dependence

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Objective: Alcohol consumption is associated with smoking cessation failure in both community and clinical research. However, little is known about the relation between alcohol consumption and smoking cessation milestones (i.e., achieving initial abstinence, avoiding lapses and relapse). Our objective in this research was to examine the relations between pretreatment alcohol consumption patterns (non/infrequent drinker, moderate drinker, binge drinker) and smoking cessation milestones and tobacco dependence. **Method:** Data were collected from 1,504 smokers (58.2% women; 83.9% White; mean age = 44.67 years, $SD = 11.08$) making an aided smoking cessation attempt as part of a clinical trial. Alcohol consumption pattern was determined with the Composite International Diagnostic Interview. Tobacco dependence was assessed with the Wisconsin Inventory of Smoking Dependence Motives (WISDM). **Results:** Alcohol consumption pattern was significantly associated with initial cessation and lapse, and these findings remained after controlling for the effects of treatment, race, gender, and cigarettes per day. Relative to moderate drinkers, both non/infrequent drinkers and binge drinkers were less likely to achieve initial cessation ($p < .05$), and binge drinkers were more likely to lapse ($p < .01$). When drinking categories were compared on tobacco dependence indices, results showed that relative to moderate drinkers, non/infrequent drinkers scored higher on several WISDM Primary Dependence Motives subscales (Tolerance, Loss of Control, and Automaticity) and binge drinkers scored higher on WISDM Secondary Dependence Motives subscales (Cue Exposure and Social–Environmental Goals). **Conclusions:** Non/infrequent drinkers' smoking cessation difficulties may be particularly related to core features of tobacco dependence, whereas binge drinkers' difficulties may be related to environmental and social influences.

Keywords: smoking cessation, alcohol consumption, nicotine dependence

The co-occurrence of cigarette smoking and alcohol consumption has been well documented (e.g., Dawson, 2000; Falk, Yi, & Hiller-Sturmhofel, 2006; Friedman, Tekawa, Klatsky, Sidney, & Armstrong, 1991). Smokers drink alcohol more often and drink more heavily than nonsmokers do (Dawson, 2000; Falk et al., 2006). Moreover, they tend to use both substances concurrently (e.g., Mintz, Boyd, Rose, Charuvastra, & Jarvik, 1985; Piasecki et al., 2011; Piasecki, McCarthy, Fiore, & Baker, 2008). There is also substantial comorbidity between tobacco dependence and alcohol use disorders (Falk et al., 2006; Jackson, Sher, Wood, & Bucholz, 2003). At least 60% of

those who are alcohol dependent smoke cigarettes (Falk et al., 2006), and 80% of these individuals smoke heavily (Dierker & Donny, 2008). Thus, smokers who also drink alcohol represent a significant subgroup of refractory smokers. The co-use of tobacco and alcohol has public health importance because of the synergistic carcinogenic effects of these substances (Pelucchi, Gallus, Garavello, Bosetti, & La Vecchia, 2006) and because ongoing alcohol consumption is a significant barrier to quitting smoking (e.g., Humfleet, Munoz, Sees, Reus, & Hall, 1999; Kahler et al., 2009; McKee, Krishnan-Sarin, Shi, Mase, & O'Malley, 2006).

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Alcohol consumption is typically—although not uniformly (Nothwehr, Lando, & Bobo, 1995)—found to be associated with smoking cessation failure in prospective community studies (Augustson et al., 2008; Hymowitz et al., 1997; Kahler et al., 2009; Osler, Prescott, Godtfredsen, Hein, & Schnohr, 1999; Sorlie & Kannel, 1990; Zimmerman, Warheit, Ulbrich, & Auth, 1990). Different measures of alcohol consumption—including frequency (Hymowitz et al., 1997), average quantity (Osler et al., 1999), and combined frequency and quantity (Augustson et al., 2008; Kahler et al., 2009)—have supported an association between higher alcohol consumption and smoking persistence. Somewhat surprisingly, smokers with lower alcohol consumption may also be less likely to quit smoking relative to more moderate drinkers. Kahler et al. (2009) found a significant positive quadratic effect for the association between alcohol involvement and smoking persistence such that those with the least and highest alcohol use showed the greatest rates of continued smoking relative to moderate drinkers. However, interpretation of these data and other epidemiologic research is limited because such research does not involve planned quit attempts. As such, it is unclear whether smokers with different alcohol consumption patterns persist in their smoking because they cannot quit or because they make fewer quit attempts.

Clinical trials permit more precise inferences about the relationship between alcohol consumption patterns and the ability to stop smoking because trials involve planned quit attempts with assessments concentrated around those attempts. Treatment research shows that alcohol consumption before (Hays et al., 1999; Humfleet et al., 1999; Leeman et al., 2008; Sherman, Wang, & Nguyen, 1996; Smith, Kraemer, Miller, DeBusk, & Taylor, 1999) and after smoking cessation treatment (Humfleet et al., 1999) is associated with reduced long-term smoking abstinence rates. In clinical trials involving real-time data assessment, smoking lapses were found to commonly occur in contexts involving alcohol (Baer & Lichtenstein, 1988; Borland, 1990; Shiffman, 1982; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). Although it has been fairly well established that postquit drinking acutely prompts smoking lapses, the relation between more stable prequit drinking patterns and cessation outcomes is less clear. This lack of clarity may arise because the few clinical trials that have been conducted with the goal of characterizing the relation between prequit drinking patterns and cessation outcomes have relied on gross, long-term measures of smoking abstinence (Hays et al., 1999; Humfleet et al., 1999; Leeman et al., 2008; Sherman et al., 1996; Smith et al., 1999). These long-term cessation outcomes are amalgams of diverse cessation processes (e.g., initial abstinence, lapse, and relapse), each of which may differentially relate to alcohol consumption patterns. Thus, using more discrete smoking cessation outcomes may reveal clearer and more powerful relations between drinking patterns and smoking outcomes.

Shiffman et al. (2006) first noted that achieving long-term abstinence depends on achieving several milestones: short-term abstinence, avoidance of a lapse, and avoidance of relapse. Analyses that include these cessation subunits as outcome variables may provide more fine-grained information about the specific nature of drinking-related risk than a single long-term smoking outcome. Focusing on smokers' baseline alcohol consumption pattern (before they try to quit) may have particular clinical utility because baseline consumption is an easily measured pretreatment characteristic that could be used for treatment tailoring. Thus, one

of the goals of this research is to examine the relations between prequit drinking patterns (non/infrequent drinkers, moderate drinkers, and binge drinkers) and smoking cessation milestones. We chose to examine alcohol consumption categorically because evidence suggests that its relation with smoking persistence is non-monotonic (Kahler et al., 2008, 2009).

If there is an association between alcohol consumption pattern and specific smoking cessation milestones, then it is important to explore potential mechanisms for these relations. Information on mechanisms might be used to develop more efficacious treatments, or it might clarify the nature of the risk posed by different types of alcohol use (e.g., are patterns of low and high alcohol consumption both associated with the same risk factors for cessation failure?). In the current research, we take a modest first step toward understanding the association between alcohol consumption patterns and smoking outcomes by exploring one route via which baseline drinking patterns could influence cessation failure. Specifically, we examined the association between persistent drinking patterns and dimensions and severity of tobacco dependence. We focused on tobacco dependence because it is a multidimensional construct that may provide preliminary, descriptive information about the relation between alcohol consumption patterns and smoking motivation. In addition, tobacco dependence is implicated in cessation success, and examining its relation with different drinking patterns could facilitate the development of treatments that mitigate the impact of alcohol consumption on quitting smoking.

There is some evidence of a positive association between tobacco dependence severity and alcohol consumption. Smokers who consume greater amounts of alcohol smoke more cigarettes (Dawson, 2000; Friedman et al., 1991) and score higher than other smokers on standardized measures of tobacco dependence severity (Dierker & Donny, 2008; Hays et al., 1999). However, such research reveals little about the motives influencing tobacco use. To address this limitation, we used the Wisconsin Inventory of Smoking Dependence Motives (WISDM-68; Piper et al., 2004)—a multidimensional assessment of nicotine dependence—to examine whether smokers with different drinking patterns have different tobacco dependence motivations. The WISDM-68 targets 13 different smoking dependence motives reflecting influences that may cause people to smoke in a dependent manner. Prior research (Piper, Bolt, et al., 2008) suggests that these 13 WISDM motives form two broad dimensions or composites with distinct correlates. The primary dependence motives (PDMs) index the degree to which smoking is heavy, automatic, out of control, and related to significant craving, factors that may represent the core features of dependence (Piasecki, Piper, & Baker, 2010b; Piper, Bolt, et al., 2008). The secondary dependence motives (SDMs) assess auxiliary motives, such as smoking because of environmental or social influences or smoking for instrumental reasons such as to control mood or hunger (Piasecki et al., 2010b; Piper, Bolt, et al., 2008; Piper, McCarthy, et al., 2008). In this study, we investigated relations between smokers' drinking patterns and WISDM-68 components to shed light on the motivational processes that could contribute to drinking-related differences in smokers' cessation outcomes.

Although many motivational paths could link smokers' drinking patterns with their smoking cessation outcomes, two possibilities seem particularly worthy of exploration. One pos-

sibility is that certain drinking patterns denote lifestyle factors that both accompany drinking and undermine tobacco cessation. A second possibility is that certain drinking patterns index stable person factors (e.g., personality traits, cognitive styles, genetics) that increase the risk for core elements of nicotine dependence, which, in turn, could lead to failure to quit smoking. It is plausible that binge drinkers may be most influenced by the first path, where lifestyle factors and sensory cues associated with heavy drinking (e.g., dense exposure to smoking cues, many smokers in the person's social network) motivate smoking and undermine cessation. This hypothesis is consistent with literature showing that smoking cues become more evocative while drinking (e.g., Burton & Tiffany, 1997; King & Epstein, 2005; Piasecki et al., 2008; Sayette, Martin, Wertz, Perrott, & Peters, 2005). In addition, alcohol augments the subjective rewarding effects of smoking (Piasecki et al., 2008; Rose et al., 2004), which may foster the instrumental use of smoking, consistent with the SDMs. As such, we expect that binge drinking does not index the core elements of tobacco dependence but rather increases the tendency to smoke (and relapse) because smoking is valued for instrumental reasons (e.g., to socialize, to increase pleasure). Thus, we expected that binge drinkers would be higher than moderate drinkers in SDMs; we did not make an explicit prediction about their PDM scores.

Smoking motivation among non/infrequent drinkers in a clinical sample, however, may be most influenced by the second path. Because non/infrequent drinkers would not experience the dense exposure to contextual or situational smoking cues that would accompany a heavy drinking lifestyle, they may instead show heightened cessation failure because of more severe core nicotine dependence (potentially because dependence prompts more severe withdrawal symptoms). If non/infrequent drinkers are not motivated by situational or instrumental reasons for smoking (e.g., smoking because of cues or to socialize), they are likely to be motivated by core dependence motives (e.g., smoking has become automatic). In other words, heightened intrinsic motives are needed to sustain smoking in the face of unfavorable environmental support. Thus, we expected that non/infrequent drinkers, relative to moderate drinkers, would be higher in PDMs; we did not make an explicit prediction about their SDM scores.

This study used data from a large clinical trial to examine the relations between pretreatment alcohol consumption patterns (non/infrequent drinker, moderate drinker, binge drinker) and (a) smoking cessation milestones and (b) patterns, dimensions, and severity of tobacco dependence. The primary hypothesis was that compared with moderate drinkers both binge drinkers and non/infrequent drinkers would be less likely to achieve smoking cessation milestones (i.e., achieve initial abstinence, avoid lapse and relapse). Because we hypothesized that binge drinkers would be higher in SDMs than moderate drinkers, we speculated that binge drinkers may be particularly vulnerable to lapsing (consistent with evidence that lapses occur in response to smoking cues; Shiffman et al., 1996). Moreover, because we expected that non/infrequent drinkers would be higher than moderate drinkers in PDMs, we speculated that non/infrequent drinkers might be particularly likely to fail to achieve initial abstinence due to their more severe dependence-associated withdrawal symptoms.

Method

Participants

A total of 1,504 smokers from southeastern Wisconsin participated in a smoking cessation clinical trial (see Piper et al., 2009). To be included, participants had to smoke at least 10 cigarettes per day for the past 6 months and be motivated to quit smoking. Study candidates were excluded if they had a medical condition that was a contraindication for study medication; reported a history of psychosis, bipolar disorder, or an eating disorder; or consumed six or more alcoholic beverages at least 6 days a week (this is a contraindication for bupropion use, one of the cessation medications). This study was approved by the University of Wisconsin Health Sciences Institutional Review Board.

Procedure

Study candidates were recruited through TV, radio, and newspaper advertisements; community flyers; and earned media, including radio and TV interviews and press releases. Study candidates who passed an initial phone screen were invited to an information session where they provided written informed consent. Participants then attended three baseline assessments during which they underwent multiple screenings, including a medical history screening, vital signs measurements, and a carbon monoxide breath test. Participants also completed demographic, smoking history, and tobacco dependence questionnaires.

Treatment

Eligible participants were randomized, blocked on gender and ethnicity, to one of six treatment conditions: (a) bupropion SR (150 mg once daily for 3 days and then twice daily for a total of 9 weeks, starting 1 week prior to the quit day and continuing 8 weeks following the quit day; $n = 264$); (b) nicotine lozenge (2 or 4 mg based on time to first cigarette as per package instructions for 12 weeks starting on the quit day; $n = 260$); (c) nicotine patch (21, 14, and 7 mg; titrated down over the 8 weeks starting on the quit day; $n = 262$); (d) nicotine patch plus nicotine lozenge ($n = 267$); (e) bupropion SR plus nicotine lozenge ($n = 262$); or (f) placebo ($n = 189$). When combinations of medications were used, their dosing regimens were the same as when the medications were used as monotherapies. There were five distinct placebo subconditions, matched to each of the active treatment conditions (i.e., placebo bupropion, placebo lozenge, placebo patch, placebo patch plus lozenge, and placebo bupropion plus lozenge), with an approximately equal number of individuals assigned to each subcondition. Participants received study medication at each visit and returned any unused medication at the following visit. Randomization was double blind and used a blocked randomization scheme with sex and self-reported race (White or non-White) as the blocking variables. Staff did not know to which type(s) of medication (i.e., patch, pill, and/or lozenge) a participant would be assigned until the moment of randomization, and study staff were unaware of whether the medication was active or placebo. In addition to pharmacotherapy, all participants received six counseling sessions, each lasting between 10 and 20 min, at study visits, which oc-

curred 8–15 days before their quit day, on their quit day, and at 1, 2, 4, and 8 weeks after their quit day.

Measures

Smoking status. Daily smoking data were collected with a smoking calendar using timeline follow-back. The maximum amount of time for recall was 4 weeks. Seven-day point prevalence abstinence was assessed during the visit at 8 weeks after the quit day and biochemically confirmed (carbon monoxide < 10 parts per million).

Milestone variables. Three smoking cessation milestone variables were created using the smoking calendar data. The initial cessation variable indicates whether participants smoked zero cigarettes on at least 1 day in the first 14 days of the study. The lapse milestone variable—computed for those who achieved initial abstinence—indicates the number of days between the first day participants smoked zero cigarettes and the first day they returned to smoking. The relapse variable—computed for participants who lapsed—indicates the number of days from the lapse day until the relapse day (the first of 7 consecutive days of smoking). Individuals were censored at the time of their last contact if they did not report an event (i.e., lapse or relapse; Japuntich, Piper, Leventhal, Bolt, & Baker, 2011). We chose to examine smoking cessation milestones out to 8 weeks postquit because the most valid smoking assessments occurred within this timeframe.

Alcohol consumption. Smokers' alcohol consumption patterns were assessed via the Composite International Diagnostic Interview, a structured clinical interview that was administered by certified study personnel using Computer Assisted Personal Interviews, Version 20 (Kessler & Ustun, 2004). The analyses presented in this article are based on average alcohol consumption in the past 12 months rather than history of an alcohol use disorder. However, we also examined whether the relation between pretreatment drinking pattern and smoking outcomes was influenced by history of alcohol use disorder (also assessed via the Composite International Diagnostic Interview). All participants were asked, "In the past 12 months, how often did you usually have at least one drink?" *Non/frequent drinkers* were classified as those who indicated no drinking in the past 12 months or drinking less than once per month in the past 12 months. Participants who responded that they drank at least once each month were then asked, "On the days you drank in the past 12 months, about how many drinks did you usually have per day?" *Moderate drinkers* were classified as consuming three or fewer drinks per an occasion for women and four or fewer drinks per an occasion for men. *Binge drinkers* were classified as consuming four or more drinks per an occasion for women and five or more drinks per an occasion for men. This classification is based on the National Institute on Alcohol Abuse and Alcoholism (2004) standardized conceptual definition of a binge drinking pattern (although the current study's interview did not assess whether these drinks were consumed over the course of 2 hr or less, as recommended by the National Institute on Alcohol Abuse and Alcoholism Task Force).

Demographic information. A demographics questionnaire assessed characteristics including gender, race, age, education level, marital status, and income.

Dependence. The Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991), a six-item scale with fair internal consistency ($\alpha = .61$), measured tobacco dependence. The WISDM-68 (Piper et al., 2004) was also used to assess tobacco dependence by exploring 13 different theoretically derived motivational domains, with subscales possessing good internal consistency (.87 or greater; Piper et al., 2004). These 13 subscales form two broad dimensions with distinct correlates, PDMs and SDMs (Piper, Bolt, et al., 2008).

Withdrawal. Participants completed ecological momentary assessment reports four times a day (just after waking, two random prompts, and prior to going to bed at night) for 1 week prequit and 1 week postquit. Ecological momentary assessment reports assessed participants' withdrawal symptoms on 10-point Likert-type scales, including their negative affect and craving. Withdrawal scores were aggregated across each day.

Social network information. Participants listed up to nine people who provided them with emotional support or instrumental support and who were important. One additional name was allowed if participants had a romantic partner. Network sizes varied from zero to 10. The interview assessed how many people in a participant's social network smoked.

Analytic Plan

Analyses were conducted using PASW Statistics 17.0. Cox proportional hazards survival analysis was used to assess the relation between smokers' alcohol consumption pattern and their likelihood of lapsing and relapsing. Individuals were censored at the time of their last contact if they did not report an event (e.g., lapse, relapse). Having a lapse or relapse was coded 0. Logistic regression was used for initial cessation and 8-week point prevalence analyses (smoking = 1). For the logistic regression analyses, we used the intent-to-treat principle; participants who did not provide outcome information were assumed to be smoking. For both the point prevalence and survival models, we used a classical model-building procedure to determine which variables would be included in each model (Hosmer & Lemeshow, 2000). Interactions between alcohol consumption pattern and all possible covariates (treatment, age, gender, race, education, marital status, history of alcohol use disorder, and number of cigarettes smoked per day) were examined. No significant interactions were detected and were therefore not included in the final models. Alcohol consumption pattern was added into each model last to examine its influence on smoking outcomes with other covariates in the model. For all analyses, alcohol consumption pattern was dummy coded with moderate drinkers as the comparison group. Finally, analysis of variance was used to examine whether smokers with different alcohol consumption patterns differ in terms of their smoking characteristics (tobacco dependence, withdrawal severity, and number of smokers in their social network). The Benjamini–Hochberg procedure, which protects against Type I errors, was used to correct for multiple comparisons involving smoker characteristics and tobacco dependence motives among the different alcohol consumption patterns (Benjamini & Hochberg, 1995; Keselman, Cribbie, & Holland, 2002).

Results

Group Characteristics

A total of 1,504 participants (58.2% women) were randomized into the study. The majority of participants were White (83.9%), 13.6% were African American, and 2.5% reported another race. Participants' mean age was 44.7 years ($SD = 11.1$), they smoked 21.4 ($SD = 8.9$) cigarettes per day at baseline, and they had made 5.7 ($SD = 9.7$) previous quit attempts. Five hundred fifteen (37.5%) reported no drinking or infrequent drinking, 648 (47.1%) reported moderate drinking, and 212 (15.4%) reported binge drinking in the past 12 months. Nondrinkers ($n = 133$; 9.4%) and infrequent drinkers ($n = 382$; 27.1%) were combined into one group because they did not differ on smoking outcomes (i.e., reaching smoking cessation milestones and achieving point prevalence abstinence). Smokers with different drinking patterns (non/infrequent, moderate, and binge drinkers) were compared on demographic variables using analyses of variance for continuously scaled variables and chi-square tests for dichotomous variables. Group differences were examined to guide selection of covariates for the primary outcomes models. As shown in Table 1, smokers with different drinking patterns differed in terms of their age, gender, race (White vs. non-White), education (a high school education or less vs. postsecondary education), cigarettes smoked per day, and history of alcohol use disorder (either alcohol abuse or alcohol dependence).

Achievement of Milestones

Of the 1,504 smokers in the study, alcohol consumption was assessed for 1,375 participants. Of these 1,375 participants, 1,308 (95.1%) had complete calendar data for the first 14 days following the target quit day. Of those 1,308, a total of 1,152 achieved initial tobacco abstinence (88.1%). Of the 1,152 who achieved initial tobacco abstinence, 706 relapsed (61.3%). Of the 706 who relapsed,

224 relapsed (31.7%). Finally, 613 participants (44.6%) reported point prevalence abstinence at 8 weeks postquit. Forty-three percent of the non/infrequent drinkers, 48% of the moderate drinkers, and 39% of the binge drinkers reported abstinence at 8 weeks postquit. Progression through the milestones by drinking pattern is shown in Figure 1.

Univariate Alcohol Consumption Pattern Models

Alcohol consumption patterns were tested in univariate models predicting smoking cessation milestones and 8-week point prevalence abstinence. Results showed that alcohol consumption pattern was significantly associated with failure to reach initial cessation and with days to lapse but not with days to relapse. Specifically, both non/infrequent drinkers and binge drinkers, relative to moderate drinkers, were more likely to fail to achieve initial cessation (odds ratio [OR] = 2.07, $p < .01$, 95% CI [1.42, 3.02], and $OR = 1.81$, $p = .02$, 95% CI [1.11, 2.96], respectively). There was no association between non/infrequent drinking and lapse ($p = .83$) and relapse ($p = .98$). Binge drinkers, however, were more likely than moderate drinkers to lapse during the 8-week treatment period (hazard ratio [HR] = 1.43, $p < .01$, 95% CI [1.17, 1.76]). However, there was no association between binge drinking and relapse ($p = .23$). Finally, alcohol consumption pattern was significantly associated with 8-week point prevalence abstinence. Binge drinkers were more likely than moderate drinkers to be smoking 8 weeks following the target quit date ($OR = 1.43$, $p = .03$, 95% CI [1.04, 1.95]). Although there was a moderate-sized effect for the relation between non/infrequent drinking and 8-week point prevalence abstinence, this effect was not significant ($OR = 1.23$, $p = .08$, 95% CI [0.97, 1.55]).

Multivariate Models

Any demographic and smoker characteristic variables (age, gender, race, education, marital status, history of alcohol use disorder, and number of cigarettes smoked per day) that were significantly associated with smoking outcomes were included in each model, along with treatment and alcohol consumption pattern. Pattern of alcohol consumption was entered last into each model to measure whether it accounted for variance after controlling for the other predictor variables. Nonsignificant terms were removed from the model via backward deletion, and the model was refit to determine the best fitting model.

Initial cessation. After controlling for the effects of treatment, race, and number of cigarettes smoked per day, alcohol consumption pattern significantly predicted achievement of initial cessation. Specifically, both non/infrequent drinkers ($OR = 1.73$, $p < .01$, 95% CI [1.17, 2.55]) and binge drinkers ($OR = 1.78$, $p = .03$, 95% CI [1.07, 2.94]) were more likely than moderate drinkers to fail to achieve initial cessation. Additional analyses showed no significant difference in achievement of initial cessation between nondrinkers and infrequent drinkers.

Latency to lapse. After controlling for the effects of treatment, race, gender, and cigarettes smoked per day, pattern of alcohol consumption significantly predicted time to first lapse. Specifically, binge drinkers ($HR = 1.42$, $p < .01$, 95% CI [1.15, 1.74]) were more likely to lapse than were moderate drinkers (see Figure 2).

Table 1

Characteristics of Non/Infrequent Drinkers, Moderate Drinkers, and Binge Drinkers

Demographic variable	Non/infrequent drinker	Moderate drinker	Binge drinker
<i>n</i>	515	648	212
Age (in years)			
<i>M</i>	46.97 ^a	44.52 ^a	38.64 ^b
<i>SD</i>	10.96	10.54	10.83
% female	62.9% ^a	51.9% ^b	57.1% ^{a,b}
% White	80% ^a	88% ^b	89.6% ^b
% with more than a high school education	65.7% ^a	77.4% ^b	68.2% ^a
% married	44.1% ^a	48.9% ^a	33% ^b
% with a history of alcohol use disorder	53% ^a	47.7% ^a	65.1% ^b
Number of cigarettes smoked per day			
<i>M</i>	22.28 ^a	21.10 ^b	20.82 ^{a,b}
<i>SD</i>	9.58	8.64	8.36

Note. Within each row, numbers with different superscript letters differ significantly with $p < .05$.

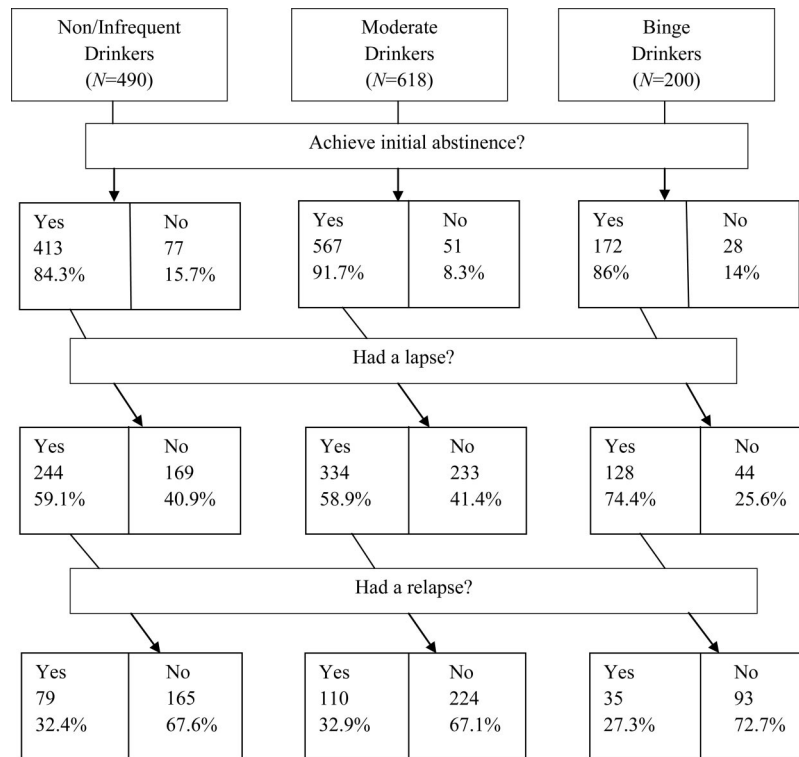


Figure 1. Progression through smoking cessation milestones for non/infrequent, moderate, and binge drinkers. The *N* in the first row reflects available data at the initial abstinence milestone. The lapse variable was computed only for those who achieved initial abstinence. The relapse variable was computed only for participants who lapsed.

Point prevalence abstinence. After controlling for the effects of treatment, race, and cigarettes smoked per day, alcohol consumption pattern significantly predicted 8-week postquit point prevalence abstinence. Results showed that binge drinkers ($OR = 1.44, p = .03, 95\% CI [1.04, 1.99]$) were less likely than moderate drinkers to be abstinent at the end of treatment.

Differences in Dependence, Smokers in the Social Network, and Withdrawal

Analysis of variance was used to examine whether smokers with different alcohol consumption patterns differed in terms of their tobacco dependence, the number of smokers in their social network, and withdrawal severity. The Benjamini–Hochberg procedure was applied for all comparisons; the pattern of statistical significance remained the same with and without such correction. As shown in Table 2, non/infrequent drinkers scored higher than moderate drinkers on the FTND and the PDM subscales of the WISDM–68. Non/infrequent drinkers were significantly higher on three of the four PDM subscales: Automaticity, Loss of Control, and Tolerance. Finally, non/infrequent drinkers scored lower than moderate drinkers on one SDM subscale: Taste and Sensory Properties. Binge drinkers were higher than moderate drinkers on the following SDM subscales of the WISDM–68: Cue Exposure and Social–Environmental Goals (see Table 2). Binge drinkers did not differ from moderate drinkers on any of the PDM subscales. The same patterns of differences in dependence motives remained even after controlling for age, gender, race, and education.

Next, we examined the association between smokers' prequit drinking pattern and the number of smokers in their social network. Binge drinkers reported significantly more smokers in their network, relative to moderate drinkers; non/infrequent drinkers reported fewer smokers in their network than moderate drinkers did (see Table 2). There was no association between alcohol consumption pattern and living with a smoker. Finally, smokers with different alcohol consumption patterns did not differ in terms of their mean postquit craving and negative affect.

Exploratory Analyses

Next, we attempted to determine whether the relation between smokers' drinking patterns and their tobacco dependence levels might account, in part, for the relation of their drinking patterns with their cessation outcomes. To explore this possibility, we determined whether entering a dependence measure into the model would reduce the relation between drinking pattern and (a) initial cessation or (b) end-of-treatment abstinence (the two outcomes most strongly related to drinking pattern). We selected only dependence measures that were significantly related with each type of drinking pattern for entry into these models. The subscale Social–Environmental Goals was significantly associated with initial cessation ($OR = 1.14, p = .01$) and reduced the relation of binge drinking with initial cessation to nonsignificance ($p = .07$); the binge drinking effect size (OR) dropped from 1.81 to 1.58 when the Social–Environmental Goals subscale was included in the model. No other subscales reduced the relation of binge drink-

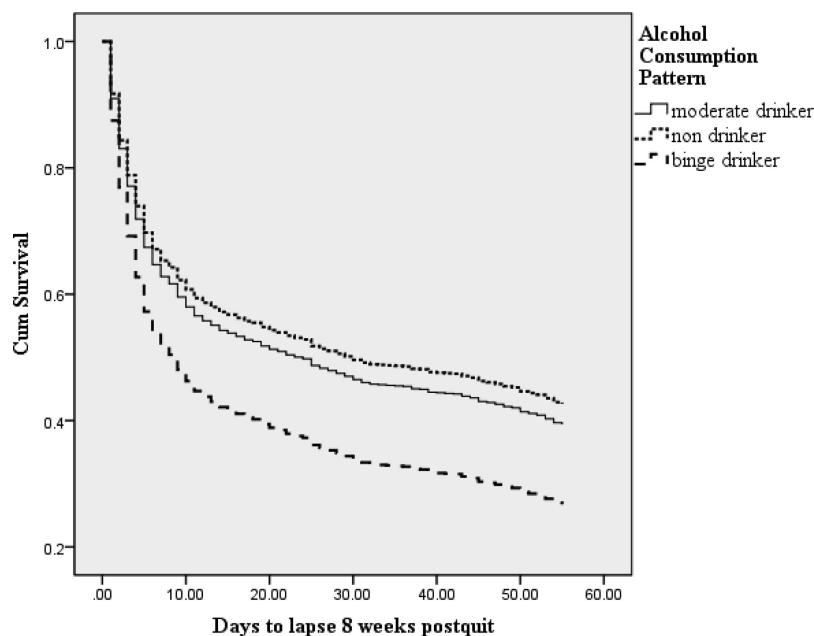


Figure 2. Survival curves for non/infrequent, moderate, and binge drinkers.

ing with initial abstinence to nonsignificance. In addition, no subscales meaningfully reduced the relation of non/infrequent drinking with initial cessation.

Next, we explored the effect of entering dependence measures in models predicting end-of-treatment abstinence. Similar to the initial abstinence model, when the Social–Environmental Goads subscale was included in the model, it was significantly associated

with 8-week point prevalence ($OR = 1.18, p < .01$), and binge drinking was no longer significantly associated with abstinence ($p = .14$). The binge drinking OR dropped from 1.43 to 1.27 when the Social–Environmental Goads subscale was included in the model. Although the univariate model examining the relation between non/infrequent drinking and end-of-treatment abstinence was not significant ($OR = 1.23, p = .08$; this test occurred in a

Table 2
Dependence Indices and Contextual Variables for Non/Infrequent Drinkers, Moderate Drinkers, and Binge Drinkers

Index or variable	Non/infrequent		Moderate		Binge	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
FTND total	5.80***	1.98	5.12	2.19	5.16	2.27
WISDM total	54.38	12.13	53.31	12.65	54.98	12.13
PDM total	5.09***	1.18	4.82	1.19	4.90	1.09
Automaticity	4.88***	1.67	4.46	1.67	4.60	1.61
Control	5.37***	1.41	5.08	1.44	5.12	1.38
Craving	5.01	1.39	4.92	1.29	5.01	1.14
Tolerance	5.13***	1.28	4.83	1.45	4.85	1.43
SDM total	3.78	1.16	3.77	1.03	3.93	1.01
Attachment	3.39	1.80	3.21	1.70	3.25	1.60
Behavior	3.52	1.46	3.47	1.35	3.48	1.28
Cognitive	3.54	1.72	3.64	1.66	3.41	1.63
Cue	4.60	1.29	4.70	1.16	5.08***	1.09
Negative	4.59	1.45	4.51	1.35	4.54	1.33
Positive	3.99	1.60	4.02	1.41	4.01	1.47
Senses	3.98*	1.55	4.19	1.39	4.27	1.44
Social Goads	3.30	1.86	3.21	1.70	4.35***	1.75
Weight Control	3.13	1.86	3.08	1.83	3.00	1.84
Number of smokers in social network	2.67**	1.80	3.01	1.94	3.75***	1.83

Note. FTND = Fagerström Test for Nicotine Dependence; WISDM = Wisconsin Inventory of Smoking Dependence Motives; PDM = primary dependence motives; SDM = secondary dependence motives. Thirteen tests compared non/infrequent drinkers and binge drinkers with moderate drinkers. The *p* values reflect Benjamini-Hochberg corrections for Type I error.

* $p < .05$. ** $p < .01$. *** $p < .001$.

subsample, which limited power), we explored whether any of the PDM subscales that were associated with non/infrequent drinking would reduce this relation. When the PDM Tolerance subscale was entered in the end-of-treatment prediction model, Tolerance was a significant predictor of end-of-treatment abstinence ($OR = 1.25$, $p < .01$), and the relation of non/infrequent drinking with end-of-treatment abstinence was meaningfully reduced ($OR = 1.15$; $p = .24$). The FTND, which correlates highly with the PDM (Baker et al., 2007), accounted for a similar reduction in the predictive relation, as did the PDM Tolerance subscale.

Discussion

Extant prospective studies have generally found that greater prequit alcohol consumption increases the likelihood of cessation failure (Augustson et al., 2008; Hays et al., 1999; Hymowitz et al., 1997; Kahler et al., 2009; Leeman et al., 2008; Osler et al., 1999; Sorlie & Kannel, 1990; Zimmerman et al., 1990). Our findings extend this research by shedding light on the stages of cessation at which specific alcohol consumption patterns (non/infrequent, moderate, binge) pose a risk. Results showed that binge drinkers, relative to moderate drinkers, were less likely to achieve initial cessation from smoking and were more likely to lapse during the 8 weeks following the target quit day. Like binge drinkers, non/infrequent drinkers were less likely than were moderate drinkers to achieve initial cessation. But non/infrequent drinkers who made it past the first milestone of initial cessation lapsed and relapsed at about the same rate as moderate drinkers. Finally, we compared the tobacco dependence motives of smokers with different alcohol consumption patterns. Results showed that relative to moderate drinkers, non/infrequent drinkers were higher on several PDM subscales (Tolerance, Loss of Control, and Automaticity) and binge drinkers were higher on several SDM subscales (Cue Exposure and Social-Environmental Goals). Relative to moderate drinkers, binge drinkers also had significantly more smokers in their social network and non/infrequent drinkers had fewer smokers in their social network.

Alcohol consumption patterns were also associated with different demographic and smoker characteristics. Non/infrequent drinkers, relative to moderate drinkers, were more likely to be female, were less educated, and smoked more cigarettes per day. Non/infrequent drinkers were more likely than both moderate and binge drinkers to endorse being a racial or ethnic minority, and they were older than the binge drinkers. Binge drinkers were less educated than moderate drinkers and more likely than both moderate and non/infrequent drinkers to endorse having a history of an alcohol use disorder. Although some of these demographic and smoker characteristics increase risk for cessation failure (i.e., lower educational attainment, cigarettes smoked per day), the relations between drinking pattern and smoking cessation outcomes persisted even after accounting for such variables.

Overall, this research suggests that both non/infrequent and binge drinkers have a particularly difficult time achieving initial cessation. Those who reported a non/infrequent or binge drinking pattern were approximately 2 times more likely than moderate drinkers to fail to achieve initial cessation (ORs of 2.08 and 1.81, respectively). These are substantial effects; the effect sizes are larger than those of several other clinically relevant binary variables that have been shown to be associated with initial cessation

(education $OR = 1.69$; gender $OR = 1.13$; marital status $OR = 1.45$; smoking at work $OR = 1.24$; Japuntich et al., 2011). Only race ($OR = 2.94$) and smokers living in the home ($OR = 2.40$; Japuntich et al., 2011) have larger effect sizes with regard to predicting initial cessation. Likewise, the effect of binge drinking on smoking lapse was relatively large. The effect of binge drinking on initial lapse ($OR = 1.42$) exceeds that of other binary demographic characteristics that have been associated with lapse (education $OR = 1.20$; gender $OR = 1.21$; race $OR = 1.33$; marital status $OR = 1.31$; smoking in the home $OR = 1.18$; Japuntich et al., 2011). These variables have been shown to be clinically meaningful predictors of smoking abstinence. That prequit drinking pattern surpasses a majority of these effects suggests that it meaningfully identifies smokers who may be especially vulnerable to early cessation failure and lapsing.

Non/infrequent drinkers' cessation attempts were only thwarted during initial cessation. It is unclear why those with less alcohol involvement were particularly vulnerable to failure during initial cessation and not during subsequent milestones. We considered the possibility that removing those who failed to achieve initial abstinence from lapse analyses limited power to detect an effect on later smoking outcomes (see Figure 1). However, examination of the lapse and relapse effect sizes (.98 and .99, respectively) suggested that there was little effect to detect. We also considered whether the quit attempt caused particularly severe early withdrawal symptoms among non/infrequent drinkers. However, non/infrequent and moderate drinkers reported a similar level of withdrawal symptoms during early cessation and out to 1 week postquit. Perhaps initial cessation winnowed out those non/infrequent drinkers who were most vulnerable to failure, leaving a group of people that were at least as able as moderate drinkers to maintain abstinence. In other words, the non/infrequent drinkers who cleared the initial cessation milestone may have been particularly hardy with regard to the challenges posed by subsequent milestones. Of, course, this does not explain the mechanism involved in this effect, nor does it account for why a similar selection effect did not occur with binge drinkers.

Binge drinkers' risk for cessation failure was expressed during both the initial cessation and the lapse milestones. Conversely, binge drinkers who lapsed faced a similar risk of relapse as moderate drinkers. It could be that a binge drinking lifestyle provides an unusually high number of opportunities to lapse, but once the binge drinker smokes, the fate of the lapse is the same as for smokers who lapse for other reasons. It appears that motivational forces independent of drinking become ascendant once a lapse occurs. A similar pattern of findings has been reported in research examining the impact of postquit acute drinking episodes on smoking outcomes. Postquit alcohol consumption has been shown to prompt smoking lapse but does not appear to reduce the likelihood of recovering from a lapse (Borland, 1990). Even though binge drinkers' transition from lapse to relapse is not remarkable, their heightened rates of failure in both establishing initial cessation and avoiding lapse set them on a path toward disproportionate cessation failure by the end of treatment.

Non/infrequent and binge drinkers show different patterns of risk for failure across the smoking cessation milestones, and they also have a different pattern of associations with tobacco dependence motives. Non/infrequent drinkers scored higher than moderate drinkers only on PDM subscales (Automaticity, Loss of

Control, and Tolerance), whereas binge drinkers scored higher only on SDM subscales (Cue Exposure and Social–Environmental Goals). The elevated PDM subscale scores reported by non/infrequent drinkers reflect a pattern of smoking that is heavy, automatic, and characterized by a sense of loss of control. These findings are consistent with other clinical research demonstrating elevated core tobacco dependence characteristics among nondrinkers (Leeman et al., 2008). Taken together, these findings suggest that smoking and perhaps cessation failure among non/infrequent drinkers is governed by core features of dependence (Piasecki, Piper, & Baker, 2010a; Piasecki et al., 2010b; Piper, Bolt, et al., 2008). This highly automatized pattern of smoking may help explain why those with lower alcohol involvement have difficulties quitting despite not experiencing the dense exposure to contextual smoking cues that binge drinkers often experience as part of their drinking lifestyle. A similar hypothesis was posited by Kahler et al. (2009), who found that relative to moderate drinkers, smokers with lower alcohol involvement show greater smoking persistence. Although the PDM scale and its subscales failed to account for the relation between non/infrequent drinking and initial abstinence, both the PDM Tolerance subscale and the FTND reduced the relation between non/infrequent drinking and end-of-treatment abstinence. These results suggest the possibility that core tobacco dependence processes may partially influence smoking motivation among non/infrequent drinkers.

For binge drinkers, smoking appears to be especially influenced by a motivational path reflecting lifestyle factors and environmental cues that accompany drinking. Specifically, binge drinkers scored higher than moderate drinkers on the WISDM–68 subscales Cue Exposure (“My life is full of reminders to smoke”; “If I always smoke in a certain place it is hard to be there and not smoke”) and Social–Environmental Goals (“I’m around smokers much of the time”; “Most of the people I spend time with are smokers”). That binge drinkers scored higher than moderate drinkers on the Cue Exposure and Social–Environmental Goals subscales reflects the relative density of smoking cues in their environment as well as the pull of such cues, that is, their influence on smoking motivation. Not only did binge drinkers report greater relative importance of social influences on their motivation to smoke but, compared with moderate drinkers, they also reported having more smokers in their social network. Thus, binge drinkers may be less able than moderate drinkers to quit smoking because alcohol is frequently accompanied by other smoking cues (e.g., smokers in the social network), because alcohol is a well-established smoking cue (Burton & Tiffany, 1997; King & Epstein, 2005; Sayette et al., 2005), and because such cues may be especially evocative for binge drinkers (especially while drinking).

The differences in smoking motives endorsed by non/infrequent, binge, and moderate drinkers could account, in part, for the different cessation outcomes achieved by these groups. The potential motivational importance of social influences on binge drinkers’ smoking motivation was underscored by exploratory analyses showing that the WISDM–68 Social–Environmental Goals subscale influenced the relation between binge drinking pattern and smoking abstinence. When the Social–Environmental Goals subscale was included in the initial cessation and 8-week postquit point prevalence abstinence regression models, Social–Environmental Goals was related to these smoking outcomes, and it also reduced the associations of binge drinking

with each outcome. The findings were less clear with regard to the risk posed by non/infrequent drinking for cessation. However, there was suggestive evidence that the risk posed was caused, in part, by heightened core tobacco dependence. Although, contrary to our prediction, non/infrequent drinkers did not experience more severe withdrawal symptoms than moderate drinkers did, dependence is not always associated with withdrawal (Robinson et al., 2011) and could exert an influence on cessation failure through multiple other paths.

Treatment Implications

Our findings have treatment implications. For instance, prequit alcohol consumption pattern is an easily measured pretreatment characteristic that could be used for treatment tailoring. Non/infrequent drinkers may especially benefit from interventions that target their tendency to have greater physical tobacco dependence, such as encouraging them to use combination nicotine replacement therapy during a quit attempt.¹ Binge drinkers, on the other hand, may particularly benefit from training to avoid smoking-related cues, including avoiding drinking alcohol and other smokers at least for the first month of the quit attempt. In addition, encouraging binge drinkers to practice nonsmoking coping responses in typical smoking settings could help them limit the influence of smoking cues on their behavior. Although this type of training is already included in most evidence-based smoking cessation counseling, it should be particularly emphasized among smokers with stable binge drinking patterns.

Limitations

This research has several limitations that should be considered. First, the method of examining milestones only for those participants who reached a previous milestone affects the relationship of the predictor variables to the later milestones. For example, if a drinking pattern has a strong association with failure to achieve initial cessation, that drinking pattern may be underrepresented in the subgroup available for lapse and relapse analyses. This underrepresentation likely affects the patterns of relationships with lapse and relapse predictors. Those who fail early on are removed from analysis, which may come at the expense of lower power to detect effects for subsequent milestones. A second limitation is that the heaviest drinkers (six or more drinks per day, at least 6 days per week) were excluded from the sample, which limits the generalizability of the findings to the heaviest drinkers. However, only 34 candidates were excluded from the study on the basis of this exclusion criterion (1.7% of exclusionary responses). A third limitation is that the dependence motives rely on self-reports. Thus, tobacco dependence motives only represent attributions or beliefs associated with drinking patterns. Finally, because participants

¹ The effect of combination therapy relative to monotherapy was slightly more effective for non/infrequent drinkers than for binge drinkers. Binge drinkers who were on monotherapy versus combination therapy had similar initial cessation rates (87% vs. 88.4%, respectively), whereas 6% more non/infrequent drinkers achieved initial cessation when taking combination therapy versus monotherapy (90% vs. 84.3%, respectively). These effects are not large, but they are consistent with the notion that more nicotine dependent individuals may benefit from combination therapy (Loh et al., 2012).

were not randomly assigned to a drinking pattern, we did not conduct formal mediation analyses. Therefore, differences in drinking patterns can only be viewed as suggestive of potential mechanisms influencing the relation between drinking pattern and cessation outcomes.

Conclusion

In summary, our results suggest that alcohol consumption pattern is a marker of risk for cessation failure. Both non/infrequent and binge drinkers were less likely than moderate drinkers to achieve initial cessation from smoking. Moreover, binge drinkers were more likely than were moderate drinkers to lapse during the 8-week treatment period following the target quit day. Relative to moderate drinkers, non/infrequent drinkers scored higher on several WISDM-68 PDM subscales and binge drinkers scored higher on several WISDM-68 SDM subscales. These results suggest that different motivational pathways influence smoking cessation failure among smokers at opposite ends of the alcohol consumption continuum. Binge drinkers' cessation difficulties may be particularly related to environmental and social influences, whereas non/infrequent drinkers' difficulties may be more influenced by core features of tobacco dependence. However, further research is clearly needed to clarify mechanisms underpinning smoking motivation in smokers with different alcohol consumption patterns.

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