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Smoking relapse risk is increased among individuals in recovery

Amanda J. Quisenberry[a,*], Jami Pittman[b], Renee D. Goodwin[c,d], Warren K. Bickel[e], Giordano D'Urso[f], Christine E. Sheffer[a]

[a] Department of Health Behavior, Roswell Park Comprehensive Cancer Center, Elm and Carlton Streets, Buffalo, NY, 14203, United States
[b] College of Liberal Arts & Sciences, Wayne State University, 4841 Cass Avenue, Detroit, MI, 48201, United States
[c] Department of Epidemiology and Biostatistics, Graduate School of Public Health and Health Policy, United States
[d] Institute of Implementation in Population Health, The City University of New York, 55 West 125th Street, New York, New York, 10027, United States
[e] Addiction Recovery Research Center, Virginia Tech Carilion Research Institute, 2 Riverside Circle, Roanoke, VA, 24016, United States
[f] Department of Neurosciences, Reproductive and Odontostomatological Sciences, University of Naples Federico II, Naples, Italy

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ABSTRACT

Background: The prevalence of cigarette smoking among individuals with a history of substance use disorders (SUDs) remains up to four times higher than those without a history of SUDs. More than half of individuals who attain sustained remission from SUDs will die of tobacco-related diseases. The aim of this secondary data analysis was to compare the risk for smoking relapse among smokers with no history of SUDs and smokers in recovery from SUDs after multi-component, cognitive-behavioral treatment for tobacco dependence.

Methods: Participants were randomized to receive 6 sessions of multicomponent cognitive-behavioral therapy (adapted for lower socioeconomic groups or standard), 8 weeks of nicotine patches, and were followed for 6 months in the parent randomized clinical trial. Participants passed a urine drug test prior to enrollment. Recovery was assessed at baseline by self-report to the question, "Do consider yourself in recovery from drugs or alcohol?" Relapse was defined as any smoking for 7 consecutive days.

Results: Participants were primarily lower SES and identified as racial and/or ethnic minorities. Cox proportional hazards models revealed that the risk of smoking relapse following tobacco dependence treatment was greater among smokers in long-term (HR: 1.44; 95% CI: 1.01, 2.05) and short-term (HR: 1.98; 95% CI: 1.30, 3.03) recovery than for smokers with no history of SUDs.

Conclusions: Our findings indicate that smokers in recovery from SUDs have 1.5–2 times the risk of relapse than smokers with no history of SUDs. More effective relapse prevention interventions are needed for this vulnerable, high-risk group of smokers.

1. Introduction

More than half of individuals who attain sustained remission from non-tobacco Substance Use Disorders (SUDs) will die of tobacco-related diseases (Hurt et al., 1996). Recovery from alcohol and drug problems is considered a process of change through which individuals achieve abstinence from substances and improve health, wellness and quality of life (Administration, 2012). Yet, the prevalence of cigarette smoking among individuals in recovery is up to four times greater than the prevalence in the general population (Campbell et al., 2019; Guydish et al., 2016; Guydish et al., 2011; Kalman et al., 2005; Weinberger et al., 2015), and cigarette smoking may increase the risk of relapse to substance use (Weinberger et al., 2017). Although public health tobacco control efforts have greatly reduced the prevalence of cigarette smoking overall, these efforts have been remarkably ineffective among individuals in remission or recovery from other SUDs (Department of Health and Human Services, 2014; Forouzanfar et al., 2015; Guydish et al., 2011; Weinberger et al., 2019).

Cessation of cigarette use at any age provides significant health benefits, but achieved before age 40 reduces the risk of death from smoking-related diseases by 90% (Gellert et al., 2012; Jha et al., 2013). Evidence-based treatments for tobacco dependence significantly increase the odds of attaining long-term abstinence, but the degree to which individuals in recovery benefit from these treatments remains unclear (Department of Health and Human Services, 2014; Fiore et al., 2008; Hughes and Kalman, 2006; Prochaska et al., 2004; Thurgood

* Corresponding author at: HRI Scientist Department of Health Behavior Roswell Park Comprehensive Cancer Center, Carlton A-408, Buffalo, NY, 14203 (716) 845-4918, United States.
E-mail address: amanda.quisenberry@roswellpark.org (A.J. Quisenberry).

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et al., 2016). Relevant research shows mixed findings with positive results indicating some smoking cessation success among individuals in substance abuse treatment, though the likelihood of long-term cessation is limited (Prochaska et al., 2004; Thurgood et al., 2016).

Tobacco dependence is highly correlated with other SUDs, and the relationship among these disorders is complex. Smokers are five times more likely to use alcohol or illicit drugs than non-smokers (Administration, 2013; Breslau, 1995; Goodwin et al., 2018; Moeller et al., 2018; Weinberger et al., 2016; Weinberger et al., 2019). A history of alcohol or drug dependence is strongly associated with the maintenance of tobacco dependence (Goodwin et al., 2014). Individuals with SUDs start smoking earlier, smoke for longer, and become more tobacco dependent than those without SUDs (De Dios et al., 2009; Goldstein et al., 2012; Goodwin et al., 2011; Hughes, 2002; Myers and Kelly, 2006; Richter et al., 2002). Cigarette smoking and drug and alcohol use share similar environmental, social, and behavioral factors, in addition to similar biochemical endogenous reinforcement suggesting common underlying mechanisms (Biederman et al., 2006). For instance, nicotine and other substances produce similar reinforcing dopaminergic effects in the ventral tegmental area of the mid-brain and the nucleus accumbens (Nestler, 2005) and chronic exposure to nicotine and other substances can impair dopaminergic responses to reward and cause long-term sensitization of the dopaminergic system after discontinuation of use (Koob, 2009; Koob and Le Moal, 2008a,b). Thus, the neuroplasticity that supports the development and maintenance of SUDs might influence the ability to discontinue tobacco use and vice versa. Specifically, several recent studies suggest that cigarette use is associated with increased risk of SUD relapse (Weinberger et al., 2017), and alcohol and cannabis use are associated with increased risk of persistence of cigarette use and relapse among former smokers (Weinberger et al., 2018).

Research on the treatment of tobacco dependence among individuals in recovery is primarily focused on individuals in treatment for or recently discharged from treatment for non-tobacco SUDs (Prochaska et al., 2004; Thurgood et al., 2016). The prevalence of smoking generally decreases as the length of recovery increases (Monti et al., 1995), but many factors are likely to contribute to this trend such as increases in socioeconomic status or increased coping strategies. Some evidence suggests improved tobacco dependence treatment outcomes among smokers who have been abstinent for a longer period of time, but given the enormous variability in the studies, conclusions about the role of duration of recovery in tobacco dependence treatment are tentative at best (Prochaska et al., 2004). Understanding the relationship between recovery from and length of recovery from SUDs and tobacco dependence treatment outcomes has implications for tailoring and optimizing treatment delivery for individuals with remitted substance use problems.

Conceptual and empirical models of health disparities and smoking cessation indicate that differences in tobacco treatment outcomes emerge through complex reciprocal relations among demographic, psychosocial, and tobacco treatment-related factors (Adler and Stewart, 2010; Businelle et al., 2011; Ferguson et al., 2005; Fernander et al., 2007; Honjo et al., 2006; Manfredi et al., 2007; Sheffer et al., 2012a, b; Stronks et al., 1997; Varghese et al., 2014; Witkiewitz and Marlatt, 2004). Participants in this study were enrolled in a parent randomized controlled trial (RCT) for smoking cessation. The aims of this analysis were to: 1) characterize the sample to identify demographic and psychosocial features that vary by recovery status and may contribute to differences in tobacco treatment outcomes; 2) examine the relative risk of smoking relapse, defined as 7 consecutive days of any smoking following quit day, between smokers in recovery and smokers with no additional SUDs (NR); and 3) to delineate the risk of smoking relapse between smokers in short-term (STR) and long-term (LTR) recovery compared with NR. We expected STR and LTR smokers to demonstrate common characteristics associated with poor tobacco dependence treatment outcomes such as greater nicotine dependence levels (Hughes, 1993; Marks et al., 1997; Reich et al., 2008), less motivation and self-efficacy (Gwaltney et al., 2009), and greater negative affect (Baker et al., 2004; Degenhardt and Hall, 2001; Krentzman et al., 2015). We expected few differences in risk of smoking relapse between smokers in STR and LTR, but significant differences between STR/LTR smokers and NR in this treatment-seeking sample (Okoli and Khara, 2014).

2. Method

2.1. Participants

Participants were recruited by word of mouth, fliers placed in the community, and newspaper advertisements seeking smokers who were ready to quit smoking. Inclusion criteria included age 18 or older, smoking cigarettes daily, motivated to quit smoking, no regular use of other tobacco products, able to engage in treatment, attend at least one session of treatment, no contra-indication for use of the nicotine patch, no current use of medications for smoking cessation, drinking ≤ 20 alcoholic drinks per week, and providing a negative urine screen for drugs of abuse (i.e., 12 panel drug screen).

2.2. Procedure

Detailed methods of the RCT are published elsewhere (Sheffer et al., 2017). In brief, participants completed a baseline assessment that included a recovery status measure and were randomized to six weekly group sessions of standard or adapted cognitive-behavior treatment (CBT) for tobacco dependence (Evans et al., 2015), The quit day was on the day of the third session. Outcome assessments were completed three and six months after the quit day. Fig. 1 depicts the study design. Adapted CBT consisted of a systematic revision of the standard treatment manual that included: 1) a focus on eight modifiable factors identified in the literature specific to socioeconomic smoking disparities, 2) the addition of behavioral rehearsal components that were introduced early and encouraged frequently, and 3) cultural specificities such as referring to strategies as “tools,” and tailoring with relevant examples and scenarios, such as financial stress. Daily smoking was assessed weekly after the quit day during treatment, monthly by telephone during follow-up, and reviewed in person during the outcome assessment visits using the timeline follow back (Sobell and Sobell, 1992). Participants were provided $5 for travel and $25 compensation for each visit.

2.3. Measures

Standard demographic information was collected during the baseline assessment. Table 1 shows the descriptive statistics for each of the measures described below for the overall sample and by recovery status.

A broad definition of recovery was used because few individuals with SUDs receive formal diagnoses or treatment for SUDs (Substance Abuse and Mental Health Services Administration, 2014). Recovery status was self-identified. That is, recovery status was assessed by asking at baseline: “Do you consider yourself in recovery from drugs or alcohol?” If the response was yes, length of recovery was assessed with the question: “How many months have you been in recovery now?” STR was defined as ≤ 12 months of most recent recovery; LTR was defined > 12 months of most recent recovery.

2.3.1. Psychosocial measures

Standard tobacco use and psychosocial information was collected during the baseline assessment. Motivation, self-efficacy and concern about weight gain were measured on a scale of 0–10 with 0 = ”not at all” and 10 = ”the most ever” and the questions: “How much do you want to quit smoking?”, “How confident are you that you can quit using

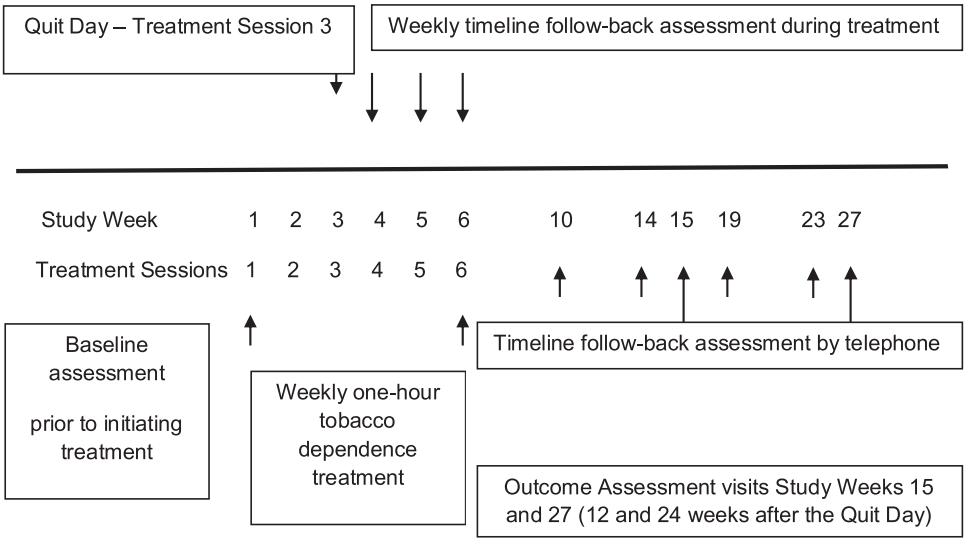

Fig. 1. Parent study timeline and procedures.

tobacco and stay quit for good?", and "How concerned are you about gaining weight after you quit?" (McCarthy et al., 2010; McKee et al., 2005; Moolchan et al., 2003; Perkins et al., 2001)

The MacArthur Scale of Subjective Social Status (SSS) was used to assess participants' perception of social status. Participants reported where they stood on a 10-rung ladder relative to others. Higher rungs represented higher social status (more money and education, better jobs) and lower rungs represented lower social status. SSS has been found to predict abstinence from smoking independently of socioeconomic status (SES) (Adler et al., 2000; Reitzel et al., 2011). Deprivation of basic needs was measured with the question, "In the last six months, to what degree did you feel that your basic needs such as healthy food and safe housing are being met?" Responses were measured on a scale of 0–10 with 0 = "not at all" and 10 = "the most possible."

The Fagerström Test for Nicotine Dependence (FTND) is a 6-item measure assessing dependence level. Scores range from 0 to 10 with greater values indicating greater dependence and a lesser likelihood of attaining abstinence (Fagerstrom et al., 1996; Heatherton et al., 1991).

The *Smoking Consequences Questionnaire-Adult (SCQ-A)* is a 55-item measure comprised of 10 subscales assessing the positive and negative outcome expectancies of smoking. Responses are rated on a scale of 0–9 where 0 = "completely unlikely" and 9 = "completely likely." Higher scores indicate a greater expectation that the consequence will occur because of smoking (Copeland et al., 1995).

Smoking policies at work and at home were assessed with the following options: a) no smoking anywhere inside or outside, b) no smoking inside, but smoking is allowed outside, c) smoking is allowed in certain areas inside, or d) smoking is allowed anywhere inside. Policies were considered smoke-free when a) or b) were endorsed. Smoke-free policies in the home are associated with increased odds of long-term abstinence (Messer et al., 2008).

The *Epworth Sleepiness Scale (ESS)* is an 8-item measure assessing the likelihood of falling asleep during daily activities on a 4-point scale where 0= "never" and 3 = "high chance of dozing." Higher scores indicate poor quality sleep (Johns, 1991). Poor sleep is associated with higher levels of stress, poverty, and ethnic minority status (Grandner et al., 2010; Patel et al., 2010).

Physical Activity was assessed with items from Behavioral Risk Factor Surveillance System assessing physical activity in the past month. Greater physical activity is associated with better sleep, mood, and judgment skills (Centers for Disease Control and Prevention, 2015; Penedo and Dahn, 2005).

The *Multidimensional Scale of Perceived Social Support (MSPSS)* is 12-item measure assessing levels of social support from family, friends, and significant other on a 7-point scale where 1 = "very strongly disagree" and 7 = "very strongly agree"(Dahlem et al., 1991; Zimet et al., 1988). Greater values indicate greater levels of support. More support is associated with improved abstinence outcomes (Fiore et al., 2008).

The *Positive and Negative Affect Schedule (PANAS)* is a 20-item measure composed of two scales assessing positive and negative affect on a 5-point scale where 1= "very slightly or not at all" and 5 = "extremely" (Watson et al., 1988). Higher scores indicate higher levels of positive or negative affect. Higher negative affect scores are associated with poorer abstinence outcomes (Kenford et al., 2002).

The *Center for Epidemiologic Studies Depression scale (CES-D)* is 20-item measure assessing past week distress and depressive symptomatology on a 4-point scale where 0 = "rarely" and 3 = "most of the time." Higher scores indicate higher levels of distress and depressive symptoms (Radloff, 1977).

The *Perceived Stress Scale - 4 (PSS-4)* is a 4-item measure of stress assessed on a 4 point scale ranging from "never" to "very often." Higher scores indicate greater stress levels and a lesser likelihood of abstinence (Cohen and Lichtenstein, 1990).

Rotter's Locus of Control (RLOCS) is a 29-item measure assessing perceived control over events. Scores range from 0 to 29 with greater values indicating a more externally-focused locus of control (Rotter, 1966). An externally-focused locus of control is associated with more impulsiveness and a lesser likelihood of achieving abstinence in treatment (Sheffer et al., 2012a).

The *Life Event Checklist (LEC)* is 17-item measure of lifetime exposure to traumatic events. Response options include: "happened to me" "witnessed it" "learned about it" "not sure" and "doesn't apply." A score of 1 is assigned if the event was directly experienced or witnessed and 0 for any other option (Gray et al., 2004). Higher scores indicate more exposure to trauma.

The *Life Event Stress Scale (LESS)* is a 43-item checklist of past year life events from the Social Readjustment Rating Scale (Holmes and Rahe, 1967; Masuda and Holmes, 1978). Events have scores corresponding to severity (e.g., death of a spouse = 100, Christmas season = 12). Higher scores indicate higher susceptibility to stress-related illness (Masuda and Holmes, 1978).

The *William's Everyday Discrimination Scale (WEDS)* is a 9-item measure assessing the frequency of experiencing interpersonal mistreatment on a 4-point scale where 0 = "never" and 3 = "often." Higher scores are associated with poorer physical health (Williams et al., 1997).

The *Perceived Discrimination Scale* (PDS) is a 3-item measure

Table 1
Demographic, environmental and clinical, psychosocial and treatment utilization differences among participants in recovery from substance use disorders and with no history of substance use disorders.

	Variable	Category, or Range	Percent (n) or Mean (SD)	No SUDs (NR)	In Recovery from SUDs	
					Short-term	Long-term
					(≤12 mos.)	(> 12 mos.)
			n = 180	n = 80	n = 38	n = 62
Demographic	Age, y	21-73	48.4 (9.1)	48.0 (9.1)	47.1 (11.7)	49.7 (7.0)
	Sex	Male	71.1 (128)	71.2 (57)	68.4 (26)	72.6 (45)
	Partnered Status	Partnered	21.7 (39)	27.5 (22)	21.1 (8)	14.5 (9)
	Race and Ethnicity	White or Caucasian	18.3 (33)	17.5 (14)	7.9 (3)	25.8 (16)
		African American or Black	66.1 (119)	66.2 (53)	73.7 (28)	61.3 (38)
		Asian/Pacific Islander, American Indian, or multi-ethnic	5.6 (10)	5.0 (4)	10.5 (4)	3.2 (2)
		Other	10.0 (18)	11.2 (9)	7.9 (3)	9.7 (6)
		Non-Hispanic	80.0 (144)	85.0 (68)	84.2 (32)	71.0 (44)
	Work status[**]	Full time	10.0 (18)	16.2 (13)	2.6 (1)	6.5 (4)
		Part time	13.3 (24)	21.2 (17)	7.9 (3)	6.5 (4)
		Retired	3.9 (7)	3.8 (3)	2.6 (1)	4.8 (3)
		Disabled	13.9 (25)	10.0 (8)	10.5 (4)	21.0 (13)
		Unemployed	57.8 (104)	48.8 (39)	76.3 (29)	58.1 (36)
		Homemaker	1.1 (2)	0.0 (0)	0.0 (0)	3.2 (2)
	Household income	≤ $10,000	57.2 (103)	45.0 (36)	73.7 (28)	62.9 (39)
		$10,000 - $14,999	16.7 (30)	20.0 (16)	7.9 (3)	17.7 (11)
		$15,000 - $24,999	8.3 (15)	10.0 (8)	5.3 (2)	8.1 (5)
		$25,000 - $34,999	6.1 (11)	8.8 (7)	7.9 (3)	1.6 (1)
		$35,000 - $49,999	6.7 (12)	8.8 (7)	2.6 (1)	6.5 (4)
		≥ $50,000	5.0 (9)	7.5 (6)	2.6 (1)	3.2 (2)
	Education, y	7-20	12.3 (2.2)	12.7 (2.3)	11.8 (1.6)	12.1 (2.3)
	Education, categories	< 12 years	30.6 (55)	23.8 (19)	26.3 (10)	41.9 (26)
		12 years	36.1 (65)	36.2 (29)	50.0 (19)	27.4 (17)
		13-14 years	16.7 (30)	17.5 (14)	18.4 (7)	14.5 (9)
		> 15 years	16.7 (30)	22.5 (18)	5.3 (2)	16.1 (10)
	Health insurance status[**]	Medicaid and/or Medicare	90.6 (163)	82.5 (66)	100.0 (38)	95.2 (59)
		None	3.9 (7)	7.5 (6)	0.0 (0)	1.6 (1)
		Private	5.6 (10)	10.0 (8)	0.0 (0)	3.2 (2)
	Subjective Social Status	0-10	4.8 (1.9)	4.7 (1.8)	4.7 (2.2)	5.0 (2.0)
	Deprivation of basic needs	0-10	7.0 (2.9)	7.2 (2.8)	6.1 (3.3)	7.4 (2.6)
Psychosocial	Number of cigarettes per day	2-40	13.7 (7.3)	13.7 (7.2)	13.2 (7.4)	14.0 (7.3)
	Cigarettes per day, categories	≤10	41.7 (75)	40.0 (32)	47.4 (18)	40.3 (25)
		11-20	44.4 (80)	48.8 (39)	36.8 (14)	43.5 (27)
		21-30	10.6 (19)	8.8 (7)	13.2 (5)	11.3 (7)
		≥31	3.3 (6)	2.5 (2)	2.6 (1)	4.8 (3)
	Partner smoking[1]	Partner smokes	47.7 (53)	39.6 (21)	52.0 (13)	57.6 (19)
	Timing of last quit attempt	Never	11.1 (20)	10.0 (8)	13.2 (5)	11.3 (7)
		< 6 months ago	31.7 (57)	30.0 (24)	39.5 (15)	29.0 (18)
		6-12 months ago	10.6 (19)	11.2 (9)	10.5 (4)	9.7 (6)
		> 12 months ago	46.7 (84)	48.8 (39)	36.8 (14)	50.0 (31)
	Duration of last quit in weeks	0-1032	61.4 (125)	63.6 (147)	69.5 (124)	53.6 (94.1)
	Smokes menthol	Yes	88.9 (160)	87.5 (70)	94.7 (36)	87.1 (54)
	Age started smoking	7-53	16.7 (5.6)	17.2 (4.2)	16.8 (7.7)	15.9 (5.7)
	Years smoking	2-50	26.6 (11.0)	26.7 (10.7)	25.7 (12.8)	27.1 (10.3)
	Motivation	0-10	8.8 (1.9)	9.0 (1.5)	8.8 (2.0)	8.4 (2.3)
	Self-efficacy	1-10	7.6 (2.3)	7.7 (2.2)	7.9 (2.5)	7.4 (2.4)
	Concern about weight gain	0-10	5.2 (3.8)	5.1 (3.9)	5.1 (3.8)	5.5 (3.8)
	FTND	0-9	4.5 (2.2)	4.3 (2.5)	4.6 (2.1)	4.6 (2.1)
	SCQ	Negative affect reduction (0-9)	5.9 (2.1)	5.8 (2.0)	5.9 (2.2)	6.0 (2.1)
		Stimulation/state enhancement (0-8.7)	3.5 (2.2)	3.7 (2.1)	3.5 (2.2)	3.4 (2.2)
		Health risk (0-9)	7.8 (1.7)	7.8 (1.8)	7.7 (1.8)	7.8 (1.6)
		Taste/sensorimotor manipulation (0-8.9)	4.6 (2.1)	4.8 (2.0)	4.3 (2.1)	4.6 (2.1)
		Social facilitation (0-9)	3.9 (2.3)	4.1 (2.3)	3.6 (1.8)	3.9 (2.4)
		Weight control (0-9)	4.1 (2.4)	4.2 (2.5)	3.7 (2.3)	4.4 (2.5)
		Addiction (0-9)	6.2 (1.8)	6.0 (1.9)	6.2 (1.9)	6.6 (1.7)
		Negative physical feelings (0-9)	3.9 (2.4)	3.6 (2.4)	4.2 (2.5)	4.3 (2.4)
		Boredom reduction (0-9)	5.5 (2.2)	5.3 (2.2)	5.3 (2.5)	5.8 (2.0)
		Negative social impression (0-9)	4.5 (2.4)	4.1 (2.5)	4.6 (2.4)	4.8 (2.4)
	Smoking policy at work[2]	Smoke-free indoors	82.8 (77)	80.9 (38)	84.2 (16)	85.2 (23)
	Smoking policy at home[**]	Smoke-free indoors	56.7 (102)	48.8 (39)	81.6 (31)	51.6 (32)
	Epworth's Sleepiness Scale	0-23	6.7 (3.9)	6.2 (3.6)	6.5 (3.6)	7.6 (4.2)
	Physical activity in past month[3]	Yes	73.3 (132)	81.2 (65)	65.8 (25)	67.7 (42)
		Number of events (0-31)	10.9 (11.5)	12.3 (11.3)	9.2 (11.5)	10.3 (11.6)
		Number of minutes per event[3](0-120)	38.8 (35.4)	38.8 (32.9)	43.0 (39.5)	36.1 (36.3)
	MSPSS Total	Significant other (4-28)	21.2 (6.1)	20.9 (6.2)	22.6 (5.2)	20.7 (6.4)
		Friends (4-28)	19.9 (6.1)	19.8 (5.5)	19.6 (7.1)	20.3 (6.3)
		Family (4-28)	20.5 (6.9)	19.8 (6.7)	21.0 (7.8)	21.0 (6.7)
		Total (18-84)	61.6 (16.5)	60.5 (16.2)	63.2 (17.2)	62.1 (16.5)

(*continued on next page*)

Table 1 (*continued*)

	Variable	Category, or Range	Percent (n) or Mean (SD)	No SUDs (NR)	In Recovery from SUDs	
					Short-term	Long-term
	PANAS	**Positive* (15-50)**	**35.8 (7.8)**	**34.0 (8.0)[a]**	**38.3 (6.6)[a]**	**36.5 (7.8)**
		Negative (10-43)	16.7 (6.5)	16.4 (6.2)	16.0 (5.4)	17.5 (7.3)
	CES-D	0-43	13.2 (8.8)	13.1 (9.9)	14.1 (8.6)	12.8 (7.3)
	PSS-4	0-12	5.6 (2.8)	5.9 (2.7)	5.2 (3.2)	5.4 (2.6)
	LOCS	1-17	9.2 (3.2)	9.2 (3.6)	8.9 (2.9)	9.5 (2.9)
	Life Event Checklist	0-15	3.7 (3.6)	3.5 (3.7)	4.0 (3.5)	3.8 (3.6)
	Life Event Stress Scale	12-880	182.6 (145)	166.9 (154)	196.4 (102)	194.5 (155)
	William's Everyday Discrimination Scale	0-22	6.6 (5.0)	6.3 (4.9)	6.9 (5.9)	6.7 (4.5)
	Perceived Discrimination*	**3-15**	**6.9 (2.7)**	**6.5 (2.7)[a]**	**8.0 (2.7)[a]**	**6.8 (2.6)**
	Coping Self-Efficacy Scale	Problem-focused coping (10-60)	43.4 (11.8)	42.1 (11.9)	44.6 (11.5)	44.3 (11.9)
		Stop unpleasant emotions/thoughts (0-40)	27.5 (9.3)	26.5 (9.9)	27.5 (8.6)	28.8 (8.8)
		Get support from friends/family* (0-30)	**20.9 (7.3)**	**19.5 (7.8)[a]**	**21.4 (7.3)**	**22.4 (6.2)[a]**
		Total (67-260)	186.2 (49.3)	178.3 (52.7)	189.5 (43.3)	194.3 (47.3)
	BRCI	**Positive* (0-21)**	**14.5 (6.0)**	**13.6 (6.0)[a]**	**16.6 (5.4)[a]**	**14.4 (6.2)**
		Negative (0-20)	2.6 (3.7)	2.3 (3.5)	3.3 (4.2)	2.7 (3.6)
	Delay discounting	$100 (-13.7-4.7)	−3.8 (2.9)	−3.7 (3.1)	−4.2 (3.0)	−3.6 (2.6)
		$1000 (-13.7-4.7)	−4.9 (3.4)	−5.2 (3.4)	−4.9 (3.2)	−4.5 (3.6)
	Barratt Impulsiveness Scale-11	Attentional impulsiveness (8-25)	14.5 (3.6)	14.3 (3.8)	14.5 (4.2)	14.6 (2.8)
		Motor impulsiveness (13-36)	21.6 (4.0)	21.2 (3.7)	22.9 (4.9)	21.5 (3.7)
		Non-planning impulsiveness (11-38)	25.5 (4.7)	24.7 (4.9)	26.2 (5.4)	26.3 (3.9)
		Total (36-99)	61.6 (9.9)	60.1 (9.8)	63.6 (12.5)	62.3 (8.1)
	TPQ	Future-Oriented	67.2 (121)	65.0 (52)	78.9 (30)	62.9 (39)
	Self-Control Scale	Good self-control (34-90)	71.4 (12.1)	70.8 (12.7)	73.2 (9.2)	71.2 (12.9)
		Future time perspective (12-35)	26.7 (5.6)	26.0 (5.7)	28.3 (4.5)	26.5 (5.9)
		Problem solving (16-40)	32.4 (6.0)	32.5 (6.3)	32.4 (5.1)	32.4 (6.2)
		Self-reinforcement (4-15)	12.3 (2.5)	12.3 (2.7)	12.5 (2.4)	12.3 (2.5)
		Poor self-control (21-85)	44.4 (13.1)	42.9 (11.1)	44.2 (13.6)	46.6 (14.9)
		Distractibility (6-30)	11.1 (4.5)	10.5 (4.4)	11.1 (4.0)	10.5 (4.4)
		Delay of gratification (8-40)	18.8 (6.4)	18.3 (5.7)	18.8 (6.7)	19.3 (7.2)
		Present time perspective (7-35)	14.6 (5.3)	14.1 (4.3)	14.3 (5.9)	15.4 (6.1)
Treatment utilization	Patch use	Yes	95.4 (167)	95.0 (76)	91.7 (33)	98.3 (58)
	Patch, number[4]	1-146	40.8 (23.3)	42.3 (25.0)	38.5 (24.4)	40.1 (20.4)
	Number of treatment sessions attended	1-6	5.7 (0.9)	5.8 (0.6)	5.5 (1.2)	5.7 (1.0)

Means with the same letter superscript indicate the location of a significant difference; ^married or living with significant other.

* $p < .05$.

** $p < .01$.

[1] Of partnered respondents.

[2] Of employed respondents.

[3] In the past month other than regular job.

[4] Of those who used patches; SUDs = Substance use disorders; FTND = Fagerstrom Test for Nicotine Dependence; MSPSS = Multidimensional Scale of Perceived Social Support; PANAS = Positive and Negative Affect scale; CES-D = Center for Epidemiologic Studies Depression Scale; SCQ = Smoking Consequences Questionnaire; PSS-4 = Perceived Stress Scale – 4 items; LOCS = Rotters Locus of Control Scale; BRCI = Brief Religious Coping Inventory.

assessing the experience of discrimination on a 5-point scale (1 = "strongly disagree," 5 = "strongly agree"). Greater values indicate greater perceived discrimination (Fuller-Rowell et al., 2012a, b).

The *Coping Self-Efficacy Scale (CSE)* is a 26-item measure assessing confidence in performing coping behaviors on an 11-point scale (0 = "cannot do at all" to 10 = "certain can do"). Coping behaviors are grouped into three groups: problem-focused coping, stopping unpleasant emotions and thoughts, and getting support from friends/family. Higher scores indicate higher confidence in ability to cope (Chesney et al., 2006).

The *Brief Religious Coping Inventory (BRCI)* is a 14-item measure of positive and negative religious coping on a 4-point scale (0 = "not at all" to 3 = "a great deal"). Higher negative religious coping scores are associated with spiritual struggles (Pargament et al., 2011).

Delay discounting is the degree to which rewards are modulated by the delay to their receipt (Logue et al., 1986). Participants completed the adjusting amount computerized delay discounting tasks assessing two magnitudes ($100 and $1000) of hypothetical rewards. Tasks require participants to make a series of choices among smaller sooner versus larger later amounts for seven time delays (1 day, 1 week, 6 months, 1 year, 5 years and 25 years). The final value at the end of the series is the indifference point for that magnitude. The indifference point is the value of subjective equality between the smaller, sooner and larger, later amount. Indifference points are then fit to Mazur's (1987) hyperbolic discounting model to determine k and expressed as the natural logarithm of k ($\ln k$). Higher k values indicate a greater preference for the smaller sooner reward and lower values indicate a preference for the larger, later reward (Mazur, 1987). A preference for larger later rewards is linked with improved tobacco dependence treatment outcomes (Sheffer et al., 2014, 2012a).

The *Barratt Impulsiveness Scale-11 (BIS)* is a 30-item measure assessing general impulsiveness and includes three subscales: motor impulsiveness (acting without thinking), cognitive or attentional impulsiveness (making quick cognitive decisions), and non-planning impulsiveness (lack of concern about the future) (Reise et al., 2013). Items are scored on a 4-point scale (0 = "rarely/never," 3 = "almost always/always"). Greater values indicate more impulsiveness and poorer tobacco dependence treatment outcomes (Sheffer et al., 2012a).

The *Time Perspective Questionnaire (TPQ)* is a single-item measure of future orientation assessed on a 5-point scale (strongly disagree to strongly agree) by the question: "How much do you agree with the following statement: You spend a lot of time thinking about how what you do today will affect your life in the future." Strongly agree or agree responses are considered "future-oriented" (Fong and Hall, 2003; Hall,

Table 2
Characteristics of participants who did and did not self-report recovery status.

	Variable	Respondents n = 180 M (SD)/%	Non-respondents n = 47 M (SD)/%
Demographic and Psychosocial Characteristics	**Education, y****	12.3 (2.2)	11.3 (1.7)
	Deprivation of basic needs**	7.0 (2.9)	5.7 (3.4)
	CES-D*	13.2 (8.8)	16.5 (8.8)
	Barratt Impulsiveness Scale-11 Attentional Impulsiveness*	14.5 (3.6)	15.7 (3.3)
	Self-Control Scale/Good self-control*	71.4 (12.1)	67.2 (14.8)
	Self-Control Scale/Self reinforcement**	12.3 (2.5)	11.3 (3.0)
	Self-Control Scale/Distractibility*	12.8 (5.6)	11.1 (4.5)
	MSPSS family support*	19.9 (6.1)	17.7 (6.8)
	MSPSS total**	20.5 (6.9)	17.3 (7.9)
	Coping Self-Efficacy Scale*	43.4 (11.8)	39.1 (14.2)
Treatment- related characteristics	**Number of Sessions Attended*****	5.7 (0.9)	5.3 (1.4)
	Nicotine Patch Use**	96	83.3
	Attended 6 month outcome assessment***	95.6	59.6
	Number of days to relapse	60.1 (69.2)	62.5 (67.8)
	Total number of days abstinent	75.0 (66.3)	74.5 (64.2)

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

2012; Sansone et al., 2013).

The *Self-Control Scale (SCS)* is a 39-item measure composed of two scales assessing good and poor self-control on a 5-point scales ("not at all true" to "very true" or "never" to "usually"). Good self-control includes three subscales: future time perspective (seven items), problem solving (eight items), and self-reinforcement (three items). Poor self-control includes three subscales: present time perspective (seven items), delay of gratification (eight items), and distractibility (six items). Higher scores reflect higher levels of good or poor self-control (Pearson et al., 2013).

Treatment utilization was assessed with three measures: Nicotine patch use (yes/no); number of nicotine patches used; and number of treatment sessions attended. Daily nicotine patch use was assessed using the timeline follow-back (TLFB) procedure (Sobell and Sobell, 1992), a validated self-report measure.

2.3.2. Smoking relapse

Days to first smoking relapse, the outcome variable, was defined as any smoking for seven consecutive days following the quit day (Hughes et al., 2003), thus including participants who had no days of abstinence (n = 5). This was assessed with the TLFB procedure (Sobell and Sobell, 1992), an accurate and reliable procedure for recalling the daily number of cigarettes smoked over the last 30 days (Toll et al., 2005).

2.4. Statistical analysis

Descriptive analyses (i.e., frequencies, means and standard deviations) were conducted followed by comparisons using one-way analysis of variance (ANOVA) and χ^2 analyses as appropriate. Bonferroni post-hoc tests were used for multiple comparisons. Adjusted p-values are presented in Table 1. Differences among participants who responded to the recovery question and those who did not (responded versus non-respondents) were evaluated to examine the potential for selection bias.

A cox proportional hazards survival analysis (CPH) model, including hazard ratios (HR) and associated confidence intervals (CI), was used to evaluate the relative risk of smoking relapse (in days) between participants in recovery from SUDs and those who were not. Survival data were right censored (i.e., censored if the occurrence of an event/relapse was unknown). Variables that differed significantly by recovery status (i.e., significant variables in Table 1: work status, health insurance status, smoking policy at home, perceived discrimination, level of support from friends and family, positive PANAS, and positive religious coping) were included as covariates in the model. Treatment condition was included in the model to control for the effects of treatment condition. No gross violations of the proportional hazards assumption were apparent when evaluating Schoenfeld residuals.

We examined differences in the relative risk of relapse among those not in recovery from SUDs, those in short-term ($\leq$ 12 months) recovery from SUDs, and those in long-term ($>$ 12 months) recovery from SUDs, with another right censored CPH model. This model included all significant variables from the previous CPH model (i.e., treatment condition, insurance status, positive religious coping).

3. Results

3.1. Participants

Of the 227 participants who attended at least one session of treatment in the clinical trial, 79.3% (n = 180) responded to the recovery status question and were included in this analysis. Table 1 describes these participants overall and by SUD recovery status. Participants were primarily male, middle aged, identified as racial or ethnic minorities, and were of lower income and education level. About three-quarters (73.9%) reported household incomes of less than $15,000. Mean years of education was 12.3 (SD 2.2). Over half of participants (57.8%) were unemployed and 90.6% were enrolled in Medicaid and/or Medicare. Over half reported that they were in recovery from SUDs (55.6%; n = 100), 38.0% (n = 38) of whom reported STR and 62.0% (n = 62) reported LTR.

Several differences were found between those who responded to the recovery question (respondents, n = 180) and those who did not (non-respondents, n = 47; see Table 2). Non-respondents characteristics were generally indicative of more difficulty quitting, although respondents' deprivation of basic needs was greater. Non-respondents appeared to have a bit more difficulty with impulsiveness, self-control, social support, and coping. Non-respondents mean CES-D scores reached the 16 point cut-off for probable depression while respondent's scores were about 3 points lower. Non-respondents attended 5.3 sessions versus 5.7 sessions of treatment and used the nicotine patches for 2 fewer weeks than respondents, which suggests less engagement, more difficulty adhering to the protocol, or more perhaps more challenges quitting that might not be reflected in the number of days to relapse. Consequently, even though the respondents who comprised this sample have many characteristics that make cessation challenging in common with non-respondents, they are likely to be more adherent and engaged than the non-respondents.

3.2. Differences among participants in self-reported recovery and not in recovery from SUDs

Several demographic and psychosocial differences were found between the STR, LTR, and NR groups, shown in Table 1. Fewer participants in STR and LTR reported working part-time or full-time compared to NR (part-time: 7.9% and 6.5% vs. 21.2%; full-time: 2.6% and 6.5% vs. 16.2%; (χ^2 = 23.7, df = 10, p = .01). More participants in STR reported smoke-free policies in their homes (81.6% vs. 51.6% (LTR) vs. 48.8% (NR); χ^2 = 12.3, df = 2, p = .002).

Significant differences were found in the levels of positive affect on the PANAS (F(21, 77) = 4.46, p = .01); positive religious coping on the RCOPE (F(21, 77) = 3.17, p = .05); perceived discrimination on the PDS (F(21, 77) = 4.11, p = .02); and getting support from family and friends on the CSE (F(21, 77) = 3.00, p = .05). STR (M = 38.3 (SD 6.6) reported higher levels of positive affect than NR (M = 34.0 (SD 8.0), p = .02), but no differences were found between STR and LTR (M = 36.5 (SD 7.8), p = .76) nor between LTR and NR (p = .17). STR (M = 16.6 (SD 5.4) reported higher levels of positive religious coping than NR (M = 13.6 (SD 6.0), p = .04), but no differences were found between STR and LTR (M = 14.4 (SD 6.2), p = .23) nor between LTR and NR (p = 1.0). STR (M = 8.0 (SD 2.7)) reported higher levels of perceived discrimination than NR (M = 6.5 (SD 2.7), p = .02), but no differences were found between STR and LTR (M = 6.8 (SD 2.6), p = .09) nor between LTR and NR (p = 1.0). LTR (M = 22.4 (SD 6.2) reported higher levels of coping by getting support from family and friends than NR (M = 19.5 (SD 7.8), p = .05) but no differences were found between LTR and STR (M = 21.4 (SD 7.3), p = 1.0) nor between STR and NR (p = .55).

No differences were found between STR, LTR, and NR in treatment utilization including the number of treatment sessions attended (M = 5.5 (SD 1.2) vs. M = 5.7 (SD 1.0) vs. M = 5.8 (SD 0.6); F(21, 77) = 1.51, p = .22); nicotine patch use (91.7% vs. 98.3% vs. 95.0%, χ^2 = .2.3, df = 2, p = .31); or the mean number of patches used (M = 35.3 (SD 25.7) vs. M = 39.4 (SD 20.9) vs. M = 40.2 (SD 26.1), F (21, 72) = .51, p = .60). Importantly, no differences were found between STR, LTR, and NR in the proportion of participants lost to follow-up (7.9% vs. 4.8% vs. 2.5%; χ^2 = 1.8, df = 2, p = .41).

3.3. Cox proportional hazards models

The first CPH Model retained recovery status (Y/N), treatment condition (standard/adapted), work status (full time, part time, retired, disabled, unemployed, home maker), health insurance status (Medicaid/Medicare, none, private), home smoking policy (smoke free Y/N), perceived discrimination, support from family and friends, positive PANAS score, and positive religious coping score as covariates. Significant effects for three variables were found: treatment condition (HR: 1.68; 95% CI: 1.22, 2.33; p = .002); positive religious coping (HR: .97; 95% CI: .94, .99; p = .035); and recovery status (HR: 1.48, 95% CI: 1.05, 2.09; p = .024).

The second CPH model retained treatment condition, health insurance status, positive religious coping, and recovery status delineated into 3 groups (i.e., not in recovery from SUDs, in short-term (≤ 12 months) recovery from SUDs, and in long-term (> 12 months) recovery from SUDs) and found significant effects for treatment condition, positive religious coping, and recovery status. Table 3 shows that participants in the standard treatment condition (HR: 1.57; 95% CI: 1.15; 2.15; p = .005) had a greater risk of smoking relapse. For every one unit increase in positive religious coping, the risk of relapse decreased by 3% (HR: .97; 95% CI: .95, 1.00; p = .031). Participants in STR (HR: 1.98; 95% CI: 1.30, 3.03; p = .002) and LTR (HR: 1.44; 95% CI: 1.01, 2.05; p = .043) had a greater risk of relapse when compared to NR. No significant differences in time to smoking relapse were found between participants in short-term and long-term recovery. Fig. 2 depicts the survival function of the three recovery status groups.

Table 3
Cox Proportional Hazards Survival Analysis Results for Days to Smoking Relapse (n = 180).

Variable	HR	95% CI	p-value
*Recovery Status			
In Long Term Recovery (LTR)	1.44	(1.01, 2.05)	.043
In Short Term Recovery (STR)	1.98	(1.30, 3.03)	.002
Not in Recovery (NR)	Reference		
*Treatment Condition	1.57	(1.15, 2.15)	.005
Health Insurance Status			
Medicaid and/or Medicare	.48	(.22, 1.04)	.061
None	.43	(.15, 1.23)	.115
Private	Reference		
*Positive Religious Coping	.97	(.95, 1.00)	.031

* significant at p < .05.

4. Discussion

In this group of primarily lower SES smokers, a history of SUD was associated with increased risk of smoking relapse compared to smokers with no history of SUD. Our findings show that risk of smoking relapse for smokers in recovery was consistently higher than for smokers with no SUDs. Participants in STR had almost 2 times the risk and those in LTR had 1.5 times the risk of smoking relapse compared to NR participants. These findings suggest that smokers in recovery from SUDs have more difficulty preventing relapse after quitting tobacco than individuals with no history of SUDs, even with intensive, evidence-based treatment for tobacco use. The challenges preventing relapse appeared to be more pronounced for individuals in recovery from SUDs for one year or less.

These findings are consistent with and extend previous research on smoking cessation among individuals with remitted substance use problems that suggests individuals in recovery from SUDs are at increased risk of smoking relapse (Kelly et al., 2018). Among individuals with alcohol use disorder, duration of recovery appears to be positively associated with abstinence from tobacco after group treatment for tobacco dependence (Kalman et al., 2006). Among individuals with SUDs, risk of smoking relapse appears to decrease as length of time in recovery increases (Kelly et al., 2018). This study is consistent with these findings and indicates that individuals with a history of SUDs do have more difficulty preventing relapse than individuals without a history of SUDs.

These findings provide additional insights into the potential factors associated with differences in relapse to smoking among a sample that included a high proportion of individuals categorized as lower SES, a group that demonstrates disparate tobacco dependence treatment outcomes (Sheffer et al., 2014). No significant differences between STR, LTR, and NR in household income and educational level were found in the preliminary analyses. Nonetheless, we conducted an exploratory analysis by adding SES to the CPH models. The results showed that the days to relapse HR's were minimally altered and SES was not a significant factor. Health insurance status, a proxy for SES, was significant when evaluating recovery status as a dichotomous variable, but not when dividing those in recovery by duration of recovery. Positive religious coping slightly decreased the risk of smoking relapse in this sample, which may be related to a spiritual external locus of control, a feature of 12-step recovery programs (Li et al., 2000). Indeed, individuals with higher religiosity are less likely to use substances (Oleckno and Blacconiere, 1991) and among those in recovery, higher levels of religiosity are associated with greater optimism, stress resiliency, and perceived support (Pardini et al., 2000), characteristics often associated with successful smoking cessation outcomes.

Understanding the challenges that smokers with remitted substance use problems experience while preventing relapse from smoking is important to the development of more effective and perhaps tailored treatments for this group. The increased relapse rates among

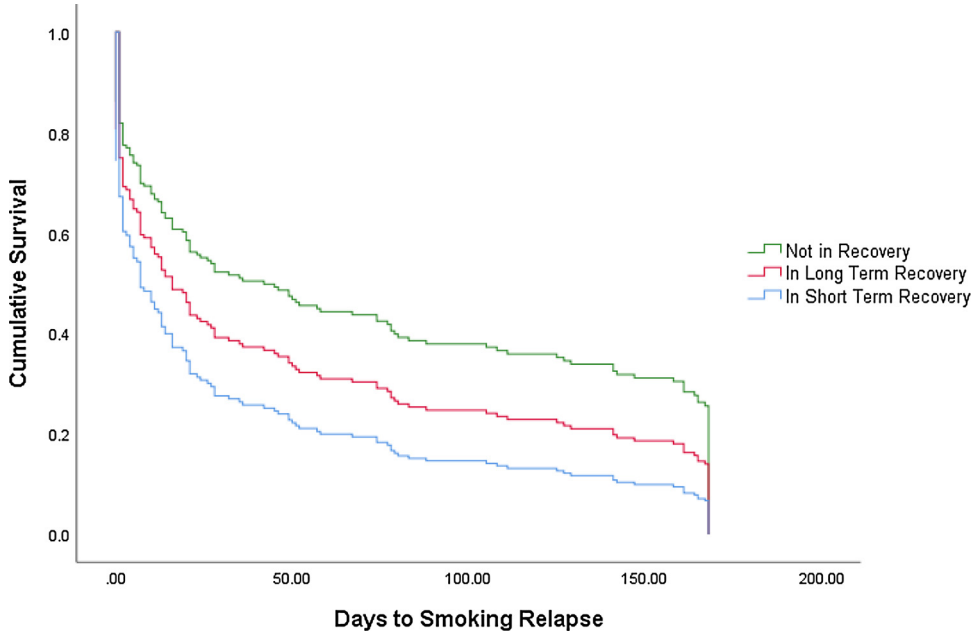

Fig. 2. Survival Curves by Recovery Status.

participants in recovery might be attributed to relapse with other substances (Kalman et al., 2010; Kohn et al., 2003; Sullivan and Covey, 2002) or with the management of unrecognized, undiagnosed, and/or untreated co-occurring mental health disorders (Kalman et al., 2010). Another possibility is that smoking functions as a substitute for other drug use rendering the maintenance of cessation more difficult when in recovery, an effect that may reduce over time. Further, neuroadapatations that co-occur with recovery from drug abuse (Humphreys and Bickel, 2018) might take some time to develop and be more robust and beneficial for those in LTR than in STR. Formative research is needed to ascertain the range of factors associated with relapse prevention after treatment for tobacco dependence for smokers in recovery.

The strengths of this study include a no SUDs comparison group; the assessment of duration of recovery; a detailed demographic and psychosocial assessment; and the provision of treatment of high enough intensity and efficacy to enable patterns in relapse prevention to emerge. The limitations include a definition of recovery based on self-report as opposed to diagnosis; although we sought to balance exactitude with the reality that most individuals who experience problems with SUDs never receive a formal diagnosis or treatment for SUDs (Substance Abuse and Mental Health Services Administration, 2014). In fact, many studies involving substance use recovery as a variable of interest utilize these types of self-report measures and rarely report on behavior prior to recovery (Sobell et al., 2000). Nonetheless, the selected sample may not reflect the actual population of people in recovery from SUD's limiting generalizability. Best practices for determining recovery status are needed to help standardize and simplify future research efforts while providing consistency for comparability across studies. Limitations also include no identification of co-morbid psychiatric diagnoses, which may affect smoking relapse, and no identification of past substances used. Risk of smoking relapse might vary by substance/s used. The primary focus of the clinical trial was not the use of other substances, so while participants using other substances were excluded at baseline, we are unable to ascertain if relapse to smoking was associated with use of other substances after baseline. Finally, this study was not powered to find differences in relapse outcomes among three groups, so actual differences might be more pronounced than reflected in the findings.

5. Conclusion

These findings indicate that individuals with a history of remitted SUDs are likely to have more difficulty preventing relapse to smoking after tobacco dependence treatment, compared with individuals without a history of SUDs. Among a primarily lower SES group of smokers undergoing treatment for tobacco dependence, risk of smoking relapse was 1.5–2 times greater for smokers in recovery than for smokers with no SUDs. The risk of relapse was greater for individuals in recovery for one year or less. More research is needed to understand the factors associated with tobacco dependence treatment outcomes among individuals with SUDs and to develop more effective treatment approaches for this vulnerable, high-risk group of smokers.

Author disclosures

The authors have no disclosures.

Contributors

CES and WKB conceptualized the design and implementation of the study. AJQ, CES, and JP developed the secondary hypotheses and drafted the manuscript. AJQ conducted the statistical analysis. GD, WKB, and RDG contributed significantly to editing and development of the final manuscript. All authors read and approved the final manuscript.

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