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Insomnia symptoms as a risk factor for cessation failure following smoking treatment

Nicole A. Short¹, Brittany M. Mathes¹, Brittany Gibby¹, Mary E. Oglesby¹, Michael J. Zvolensky^{2,3}, and Norman B. Schmidt¹

¹Department of Psychology, Florida State University

²University of Houston

³University of Texas MD Anderson Cancer Center

Abstract

Insomnia symptoms are associated with smoking, and may interfere with smoking cessation. Specifically, studies have shown that smoking-related sleep problems are associated with long-term smoking relapse, and longer sleep duration is associated with successful smoking cessation. However, it is currently unclear whether pre- or post-quit insomnia symptoms are associated with smoking cessation outcomes. As such, the current study aimed to extend previous findings by using a measure of insomnia symptoms as a predictor of smoking cessation failure by month 3 following smoking cessation treatment. Additionally, we examined whether post-quit insomnia symptoms predicted cessation outcomes. Results indicated that pre-, but not post-quit insomnia, predicted smoking cessation failure by 3 months post-cessation, after covarying for depressive symptoms, anxiety sensitivity, alcohol use disorder severity, treatment condition, and number of cigarettes per day. These findings add to the literature on insomnia symptoms as a risk factor for difficulties with smoking cessation, and suggest it may be a worthy clinical target for smoking populations who are interested in quitting smoking.

Keywords

insomnia; sleep disturbances; smoking; smoking cessation

According to reports by the Centers for Disease Control and Prevention (2014), approximately 42.1 million adults in the United States are current cigarette users, despite the well-documented health implications associated with smoking, including lung cancer, heart disease, stroke, and chronic obstructive pulmonary disease. Annually, tobacco use leads to upwards of 480,000 preventable deaths in the US, and costs the country \$289 billion annually in direct healthcare expenditures and productivity losses. Although many current

Send correspondence to Norman B. Schmidt, Department of Psychology, Florida State University, 1107 W. Call St., Tallahassee, FL 32306-4301 USA, Tel: (850) 645-1766, Fax: (850) 644-7739, schmidt@psy.fsu.edu.

Declaration of Interest.

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users express a desire to quit smoking, those who attempt to quit often fail. Specifically, data suggests that smokers often report one or more failed quit attempts in a given year (e.g., 40%; Deiches et al., 2013), and that current pharmacological and psychological treatment interventions are associated with high rates of relapse (>70%; Fiore et al., 2008; Piasecki, 2006). In general, smokers have a high likelihood of relapsing after a quit attempt, however, data suggests that specific risk factors increase this likelihood in certain smokers.

Previous research has provided evidence to support the existence of several “fixed” risk factors for smoking relapse. These fixed factors cannot be changed or modified during treatment, but are still associated with treatment outcomes (i.e., higher rates of relapse) including genetics, socioeconomic status, and higher levels of cigarette smoking (Barbeau et al., 2004; Chen et al., 2012; Japuntich et al., 2011; McCarthy et al., 2015; McKee et al., 2015). In addition to these fixed risk factors, other malleable factors have been identified that are associated with smoking cessation failure. These risk factors can theoretically be intervened upon to improve smoking cessation outcomes, and include high anxiety sensitivity, low distress tolerance, anhedonia, and difficulties with emotion regulation (Assayag et al., 2012; Brown et al., 2009; Farris et al., 2015; Leventhal et al., 2015). However, although these risk factors are theoretically malleable, some (e.g., anhedonia, distress tolerance, emotion regulation difficulties) cannot be addressed utilizing brief interventions, making their utility in helping to improve smoking cessation rates less clear. Thus, it is important for research to continue to be directed toward identifying malleable risk factors for smoking cessation failure, as they represent potential targets before or during treatment for smoking cessation, and may subsequently serve to improve treatment outcomes.

One promising construct in this regard may be sleep problems, which have been associated with smoking behaviors (Wetter et al., 1994). Various types of sleep problems (e.g., shortened sleep duration, waking up during the night to smoke, etc.) have been examined among individuals who smoke. One specific type of sleep problems, insomnia symptoms (i.e., difficulties initiating and maintaining sleep), are common among individuals who smoke and may be relevant to the cessation process. Regarding insomnia, within some individuals, insomnia symptoms may be persistent and result in clinically significant distress and impairment, and thereby warrant a diagnosis of insomnia disorder (American Psychiatric Association, 2013). Both insomnia symptoms and insomnia disorder can be associated with a wide variety of daytime consequences, such as fatigue, irritability, difficulty concentrating, and problems with mood regulation (Ohayon, 2002). Additionally, insomnia symptoms are fairly prevalent, with approximately a third of individuals in the general population suffering from such concerns at least occasionally (Breslau et al., 1996). Better understanding the link between insomnia symptoms and smoking would be beneficial because insomnia is a treatable condition through brief interventions such as cognitive behavioral therapy for insomnia (CBT-I; Edinger et al., 2001). If insomnia is associated with increased smoking behaviors or difficulties with cessation, it is plausible that brief interventions targeting sleep would result in benefits with smoking outcomes as well.

A large body of research has indicated that smoking is associated with insomnia symptoms. For example, several studies have found that sleep problems (e.g., difficulties initiating and

maintaining sleep) are elevated in smokers compared to non-smokers (Phillips et al., 1995; Wetter et al., 1994). This pattern has been replicated in a recent large, epidemiological study and demonstrates a dose-dependent pattern, with increased numbers of cigarettes smoked per day associated with increased levels of sleep difficulties (McNamara et al., 2014). This pattern has also been replicated with objectively measured sleep parameters utilizing polysomnography (Zhang et al., 2006). These results have primarily been interpreted in the context of the effect of cigarette smoking on sleep: nicotine stimulates neurotransmitters that affect the sleep-wake cycle (Krause et al., 2002; Zhang et al., 2008), potentially disrupting sleep patterns. As such, at the biological level, cigarette smoking may have an effect of impairing sleep.

Although it is clear that smoking is associated with insomnia symptoms, it is less clear whether these insomnia symptoms might in turn contribute to difficulties in smoking cessation. Theoretically, it is plausible that insomnia symptoms may negatively affect smoking cessation outcomes through several pathways. For example, cigarette smoking during abstinence attempts could be motivated by a desire to decrease fatigue or relieve problems with concentration, which are commonly associated with poor sleep (Ohayon, 2002). Additionally, sleep is important for mood and behavior regulation (Goldstein et al., 2014; Paterson et al., 2011), thus cigarette smoking may be used as a maladaptive coping strategy for individuals with dysregulated emotions and difficulties with inhibiting impulsive behaviors. Consistent with this conceptualization, Hamidovic and de Wit (2009) found that experimentally sleep deprived smokers increased smoking behaviors and displayed impaired behavioral inhibition and attention in comparison to those who slept.

Few studies have empirically examined the effect of sleep-related problems on cessation attempts. For example, Boutou and colleagues demonstrated that awakening during the night to smoke is negatively associated with 6-month abstinence from smoking assessed via phone interview (2008). Similar, Peters et al. showed that individuals who reported smoking at night and poor sleep quality demonstrated poorer smoking outcomes following smoking cessation, assessed via validated smoking measures (2011). Both studies measured smoking at night through a one-item dichotomous index, and it is unclear whether smoking at night results from insomnia symptoms or higher levels of nicotine addiction. Peters et al. assessed sleep quality through the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), a validated measure of sleep quality that was used to separate participants into groups of good and poor sleepers. Okun and colleagues (2011) did not replicate these findings: one-item measures of disturbed sleep and sleep quality (pre- and post-quit) drawn from depression and smoking-related measures were not significantly associated with smoking outcomes (measured via interview and through carbon monoxide readings) at one- or three-months following cessation. Next, Rapp and colleagues (2007) found that longer baseline sleep duration assessed via one item (i.e., "How many hours do you sleep on average at night") was associated with successful cessation after one year among nurses, assessed via a one-item measure ("Do you smoke at present?"). However, sleep duration is conceptually different from insomnia symptoms as individuals differ in the amount of sleep necessary for them to feel rested (Ferrara et al., 2001).

These studies suggest that sleep difficulties may contribute to problems with cessation. However, results of the prior studies have been inconsistent, and it remains unclear as to what type of sleep disturbances are associated with smoking cessation difficulties (poor sleep quality, insomnia, hypersomnia, sleep disturbances during withdrawal, and sleep duration have all been examined). Furthermore, the majority of studies have used one-item measures of sleep disturbances, which may be relatively less reliable than measures with multiple items, and the study that did use a validated measure utilized the more broad construct of sleep quality rather than insomnia symptoms specifically. Finally, knowledge of the timing of sleep disturbances (i.e., pre- vs. post-cessation) associated with smoking cessation failure is critical, as this would address whether intervening on sleep prior to smoking cessation attempts might be beneficial.

Considering these gaps in the current literature, we tested whether pre- and post-quit insomnia symptoms predict smoking cessation failure 3 months following smoking cessation treatment. Participants in the current study underwent either standard smoking cessation treatment or an anxiety-based smoking intervention prior to their cessation attempt. In addition to testing whether insomnia symptoms predict cessation failure, we covaried for depressive symptoms, anxiety sensitivity, and alcohol use disorder severity in analyses to determine if these effects are specific to insomnia symptoms rather than psychological symptoms commonly comorbid with them (e.g., depression, anxiety, and alcohol use disorder; Harvey, 2008; Zhabenko et al., 2012). Furthermore, to be consistent with prior literature and to separate potential effects of treatment or level of pre-quit smoking, we covaried for treatment condition (Peters et al., 2011; Rapp et al., 2007), as well as number of cigarettes per day. Considering the current literature, we hypothesized that both pre- and post-quit insomnia symptoms would predict cessation failure three months after smoking cessation treatment, above and beyond the effects of our covariates.

Method

Participants

A sample of 579 individuals (48.1% female) were recruited from the community for a larger study investigating the effectiveness of an anxiety-based smoking cessation treatment program (for more procedural details, see Johnson et al., 2013). Eligibility criteria included being at least 18 years old, smoking daily for at least one year, currently smoking at least eight cigarettes per day, and being motivated to quit smoking. Exclusion criteria included the presence of a psychotic disorder, use of a smoking cessation aid (e.g., pharmacotherapy), and presence of a significant medical condition that could interfere with participation. For the current study, participants were excluded if had missing data at follow-up, resulting in a sample size of 250 individuals (52.8% female); however, the pattern of results remained consistent whether participants who did not complete their follow-up were excluded or coded as relapsed. The average age of the sample was 38.97 years old ($SD = 13.85$). Please see Table 1 for further demographic information.

Procedure

Participants were recruited from the community for a larger study examining the effectiveness of a smoking cessation treatment program that targeted anxiety symptoms associated with cigarette use. Full details are reported in Schmidt et al. (2016); however, the current analyses have not been reported elsewhere. Individuals were screened for eligibility via phone, and, if deemed eligible, scheduled for a baseline appointment, during which participants provided informed consent, and completed a semi-structured clinical interview and a battery of self-report questionnaires. After completion of the baseline assessments, participants were randomized to one of two conditions: active (i.e., anxiety-related smoking cessation program) or control (i.e., standard smoking cessation program). Following completion of the treatment program, participants periodically completed follow-up assessments, which consisted of completing self-report questionnaires and interviews with study staff. All procedures were approved by the university's Institutional Review Boards.

Measures

Clinician-Administered

Structured Clinical Interview for DSM-IV (SCID; First et al., 2001): The SCID is a semi-structured clinical interview that assesses the presence of psychiatric disorders. All interviews were conducted by doctoral-level graduate students, who were trained in the administration of the SCID. Training consisted of watching recordings of previous interviews and discussing case conceptualizations, as well as practicing the administration of the interview with trained interviewers. All diagnoses were discussed and confirmed with a licensed clinical psychologist. Additionally, all interviews were audio-recorded and 12.5% were randomly selected by MJZ to assess for reliability (no discrepancies in diagnostic status were noted).

Timeline Followback (TLFB; Sobell et al., 1992): The TLFB is a semi-structured interview that assesses tobacco use. A calendar and memory aids are used to assist participants in reporting the extent of daily use (i.e., number of cigarettes). TLFBs were administered by trained study staff. Data for the TLFB was collected the week following participants' quit attempts. TLFB data was collected at Month 3 following cessation. Here, scores were summed across the entire month to represent Month 3 smoking status, and then recoded to 0 = *no cigarettes*, 1 = *at least one cigarette* in the month. The TLFB has demonstrated excellent psychometric properties in previous studies (Sobell et al., 1992).

Self-Report

Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007): The IDAS is a 64-item self-report measure that assesses the presence and severity of depressive and anxiety symptoms. Participants are asked to rate the extent to which they have experienced various symptoms over the past two weeks (1 = *not at all*, 5 = *extremely*), including lassitude, suicidality, traumatic intrusions, and insomnia. In this study, only the insomnia subscale was used (e.g., "I had trouble falling asleep"), and was administered at baseline as well as the week following individuals' quit attempts. Consistent with previous research (Watson et al., 2007), the IDAS as a whole at baseline ($\alpha = .93$) and post-quit ($\alpha = .93$)

demonstrated excellent internal consistency, and the insomnia subscale at baseline ($\alpha = .88$) and post-quit ($\alpha = .89$) demonstrated good internal consistency in this study.

Beck Depression Inventory-II (BDI-II; Beck et al., 1988): The BDI-II is a 21-item self-report measure that assesses depressive symptom severity. Participants are asked to rate the extent to which they have experienced various depressive symptoms (0 = no symptoms, 3 = severe symptoms), including feelings of sadness, changes in appetite, and anhedonia. For this study, we did not include the item assessing changes in sleep in order to avoid conceptual overlap with the IDAS insomnia subscale. Without this item, our modified BDI-II demonstrated excellent internal consistency in the current study ($\alpha = .94$).

Anxiety Sensitivity Index-3 (ASI-3; Reiss et al., 1986; Taylor et al., 2007): The ASI-3 is an 18-item self-report measure that assesses severity of anxiety sensitivity. Participants are asked to rate the extent to which they fear anxiety-related symptoms (0 = very little, 4 = very much). The ASI-3 consists of three subscales: cognitive (e.g., “When my thoughts speed up I worry I might be going crazy”), physical (e.g., “It scares me when my heart beats rapidly”), and social (e.g., “I worry that other people will notice my anxiety”). The ASI-3 demonstrated excellent internal consistency in this study ($\alpha = .93$).

Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993): The AUDIT is a 10-item self-report measure that assesses the presence of problematic drinking behaviors. Participants are asked to rate how often they have used alcohol and/or experienced associated problems (e.g., inability to stop drinking once started, missing work or school, blacking out) in the past month (0 = never, 4 = almost daily), which are summed to create a total score. The AUDIT demonstrated good internal consistency in this study ($\alpha = .82$).

The Fagerstrom Test for Nicotine Dependence (FTND; Heatherton et al., 1991): The FTND is a six-item self-report measure that assesses severity of nicotine dependence. Participants are asked to answer questions regarding their cigarette use and smoking behavior. In this study, only item four was used to assess cigarette use as a covariate (i.e., “How many cigarettes per day do you smoke?”).¹ This item is coded on a 0 to 3 scale, with 0 being 0–10 cigarettes per day, and 3 being greater than 31 cigarettes per day. The FTND has shown good internal consistency in previous studies (Heatherton et al., 1991), and approached adequate internal consistency in the current study ($\alpha = .67$).

Results

Preliminary Analyses

First, means, standard deviations, and zero-order correlations were examined for each variable of interest (see Table 2). Mean number of cigarettes per day was slightly lower than in prior smoking cessation trials (Nakamura et al., 2014), while FTND total scores ($M = 5.04$) were similar to prior investigations (Peters et al., 2011), and were consistent with the clinical cut-off for nicotine dependence (Huang et al., 2008). BDI scores (excluding the sleep item) were slightly higher than a previous sample of women presenting for smoking

cessation treatment (Okun et al., 2011), and were in the mild range (Beck et al., 1988). Mean AUDIT scores were not in the clinical range (Toll et al., 2007).

Mean levels of IDAS – insomnia scores were somewhat lower than psychiatric patients (Watson et al., 2007), which is expected considering our sample was not necessarily diagnosed with a psychiatric disorder. Mean insomnia scores were quite similar from pre- to post-quit, and did not significantly differ ($p = .874$). Correlations were generally in the expected directions. Regarding covariates, insomnia symptoms (pre- and post-quit) were significantly associated with both depressive symptoms and anxiety sensitivity. Pre-quit insomnia symptoms were weakly negative correlated with number of cigarettes per day. Additionally, pre-quit insomnia was significantly associated with post-quit insomnia symptoms, as well as Month 3 smoking status.

Primary Analyses

Pre-Quit Insomnia Symptoms—First, to examine whether pre-quit insomnia symptoms predict Month 3 smoking status, we calculated a logistic regression equations (see Table 3). In Step 1, our covariates (depressive symptoms, anxiety sensitivity, alcohol use disorder severity, condition, and number of cigarettes per day) were entered. In Step 2, baseline insomnia symptoms derived from the IDAS were entered. Month 3 smoking status served as the dependent variable. Please note the same pattern of results was found for all analyses whether number of cigarettes per day (as measured by the FTND) or the FTND total score was entered as a covariate.

In terms of Month 3 smoking status, our full model was statistically significant ($\chi^2 [1, N = 147] = 20.82, p = .002$), accounted for between 13.2% (Cox and Snell R Square) and 18.0% (Nagelkerke R Square) of the variance in smoking status, and correctly classified 65.3% of all cases. Regarding covariates, number of cigarettes per day significantly predicted smoking status in Step 1, with higher numbers of cigarettes per day predicting a lower likelihood of cessation failure by Month 3. In Step 2, pre-quit insomnia symptoms significantly predicted smoking status, with increased insomnia severity associated with increased risk of being in the smoking group at Month 3.

Post-Quit Insomnia Symptoms—Next, to examine whether post-quit insomnia symptoms as a withdrawal symptom predict cessation failure by Month 3. In Step 1, our covariates (depressive symptoms, anxiety sensitivity, alcohol use disorder severity, condition, and number of cigarettes per day) were entered. In Step 2, IDAS – insomnia scores from the week after participants' quit attempts were entered. Month 3 cessation outcome served as a dependent variable in separate regressions. Our full model was significant ($\chi^2 [1, N = 129] = 21.91, p < .001$), accounted for 15.6% to 21.2% of the variance in smoking status, and correctly classified 78.5% of all cases. Post-quit insomnia symptoms were not significantly associated with smoking status at Month 3.

Discussion

The current study expanded upon the literature regarding the effects of sleep disturbances on smoking cessation failure by examining both pre- and post-quit insomnia symptoms as

predictors of cessation outcomes. Consistent with hypothesis, pre-quit insomnia symptoms were associated with higher risk of smoking cessation failure. This is also consistent with previous work suggesting that various indicators of poor sleep (i.e., awakening at night, smoking at night, poor sleep quality, and shorter sleep duration) are associated with poor smoking cessation outcomes (Boutou et al., 2008; Peters et al., 2011; Rapp et al., 2007), and extend this work by demonstrating that insomnia symptoms specifically appear to be tied to difficulties with smoking cessation. Importantly, our findings also extend this literature by covarying for psychological symptoms commonly associated with insomnia symptoms, such as depression, anxiety risk factors, and substance use. These results therefore provide further confidence that insomnia symptoms in particular may confer greater risk for poor smoking cessation outcomes above and beyond the effects of commonly comorbid symptoms.

Inconsistent with our hypothesis, post-quit insomnia symptoms did not significantly predict smoking cessation failure. This is somewhat surprising as disrupted sleep is common during the immediate cessation period (Colrain et al., 2004), and has been hypothesized to contribute to poor cessation outcomes as individuals may choose to smoke to cope with fatigue and associated attention problems due to poor sleep during the period of withdrawal after cessation (Hamidovic et al., 2009). Specifically, prior research has found that individuals tend to experience more awakenings during the night, measured through both behavioral observations and polysomnography during smoking cessation (Colrain et al., 2004). However, much of the research on the effect of smoking cessation on sleep has been conducted within the laboratory under controlled conditions. Thus, it is unclear whether individuals making a cessation attempt on their own, who may lapse or continue to use at some points, experience similar changes in sleep. It is also possible that for some, smoking cessation may actually improve sleep due to the negative effects of smoking on sleep quality (McNamara et al., 2014). Additionally, although research has shown that individuals do self-report sleep disturbances as a withdrawal symptom following smoking cessation (Welsch et al., 1999), to our knowledge, studies have not directly tested whether self-reported insomnia symptoms change following a smoking cessation attempt. Indeed, participants in our sample did not report significant changes to their insomnia symptoms at pre- vs. post-quit. It is possible that our measure of insomnia symptoms was not sensitive to changes experienced by participants over the brief period measured, thus limiting our ability to detect effects of post-quit insomnia on smoking cessation outcomes. However, other studies of treatment-seeking smokers using measures of insomnia or sleep quality (rather than withdrawal symptoms) also found no changes in sleep in the period immediately following a cessation attempt (Okun et al., 2011). As such, it is possible that insomnia severity itself does not change immediately post-cessation, and that only pre-quit insomnia symptoms are associated with smoking cessation failure. Further research is necessary to confirm this pattern of findings.

Overall, these findings add to a growing body of research indicating that sleep disturbances may be a critical but understudied factor in relapse to substance use (Welsch et al., 1999). Indeed, in addition to cigarette smoking, sleep disturbances have been implicated in relapse to alcohol (Brower et al., 1998), as well as cannabis use (Babson et al., 2013). Whether insomnia is a causal factor involved in smoking cessation, and the mechanism for why sleep problems may lead to increased risk of relapse is currently unknown. However, it may be

that the link between sleep and emotion regulation, self-control, and impulsivity plays a role, as those with poor sleep may be less able to utilize effective emotion regulation strategies or resist urges to use substances (Goldstein et al., 2014; Paterson et al., 2011). Additionally, individuals may use substances as a coping strategy to either help them fall asleep or to cope with the negative effects of poor sleep, such as fatigue (Hamidovic et al., 2009). Future research incorporating assessments of these potential mechanisms is critical for better understanding the association between sleep disturbances and difficulties with the cessation of smoking, as well as other substances.

Our findings have several clinical implications. For example, considering that these findings indicate that pre-quit insomnia symptoms predict smoking cessation failure, it is possible that addressing insomnia symptoms prior to a cessation attempt could lead to better outcomes. Indeed, a pilot study of cognitive behavioral therapy for insomnia (CBT-I) integrated with smoking cessation treatment demonstrated that CBT-I effectively reduced insomnia symptoms among treatment-seeking smokers. Additionally, those in the CBT-I condition maintained abstinence for a longer period of time compared to those who received standard smoking treatment, though overall the treatment conditions did not differ in cessation rates (Fucito et al., 2014). However, the authors cautioned that due to the small sample size typical for a pilot study, some effects may not have been detected. In sum, more research is needed to determine whether sleep-related interventions may improve outcomes for individuals seeking smoking cessation treatment.

The results of the current study should be considered in light of its limitations. First, no diagnostic evaluation of insomnia or objective assessment of sleep problems (e.g., polysomnography; Chesson et al., 1997) was available. Thus, future research could benefit from the inclusion of such measures to determine objective sleep disturbances are also associated with smoking cessation failure. Additionally, considering our sample was not recruited for poor sleep specifically, future research should attempt to replicate these findings within a sample of individuals with insomnia disorder or clinically significant sleep complaints. This is particularly salient given the IDAS – insomnia subscale has no accepted clinical cut-off for insomnia disorder, so it is difficult to determine the generalizability of these results to individuals with clinically significant insomnia symptoms. Relatedly, although the IDAS is a well-validated measure of depression and anxiety symptoms, to our knowledge, the IDAS – insomnia subscale has not been compared to gold standard measures of insomnia, such as the Insomnia Severity Index (Morin et al., 2011). As such, further research utilizing such measures would be an important next step in the literature. However, we examined the relationship between the IDAS – insomnia and the ISI within another sample of treatment-seeking mixed anxiety and mood disorder participants and found that these measures were strongly correlated. We also calculated a preliminary cut score for the IDAS – insomnia subscale based on its comparison to the ISI, and this indicated that approximately 18% of the current sample would potentially meet criteria for clinically significant insomnia symptoms. This suggests that more research is needed to determine whether results would generalize to individuals with insomnia disorder. Finally, it is also important to note that our study demonstrated an association between insomnia symptoms and difficulties with smoking cessation, but it did not test whether insomnia symptoms *caused* difficulties with smoking cessation. Other alternative explanations that could explain

the association between insomnia symptoms and smoking cessation difficulties must be tested, and include factors such as nicotine dependence.

In addition, the present investigation did not have an objective and/or biochemical measures of smoking status at follow-up. Although meta-analytic research has supported the use of self-report data when determining smoking status (Patrick et al., 1994), future work would benefit from the use of multi-method assessments of smoking status. Next, our sample consisted of treatment-seeking smokers, who also may have responded to advertisements regarding both smoking cessation and decreasing anxiety. Considering this, the current findings may not generalize to all individuals who smoke. Additionally, our use of a one-item index of number of daily cigarettes as covariate was one item of the FTND. A more reliable index to be used for future research could be the TLFB. Finally, there was a large amount of drop-out in the current sample. However, our attrition rates are consistent with previous smoking cessation trials (Boutou et al., 2008; Peters et al., 2011), and our pattern of results remained the same whether drop-outs were considered relapsed or excluded from analyses.

Despite these limitations, the current study extends the literature on the relationship between insomnia symptoms and difficulties with smoking cessation by demonstrating that pre-quit insomnia symptoms are prospectively associated with smoking cessation failure at 3-month follow-up. Given the negative physical health implications associated with smoking and the cessation difficulties that are common among smokers, our findings add to the literature by highlighting an important factor that may contribute to difficulties with smoking cessation. Furthermore, our results add to the breadth of research indicating that sleep disturbances can have a variety of negative physical and mental health outcomes. In sum, our findings provide support for insomnia symptoms being involved in difficulties with smoking cessation and highlight the potential importance of targeting sleep difficulties among individuals making a smoking cessation attempt.

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Table 1**Participant Demographics**

Variable	Percent of Sample
Gender (Female)	52.8%
Racial/Ethnic Identity	
White/Caucasian	86.0%
Black/Non-Hispanic	3.2%
Hispanic	3.2%
Black/Hispanic	0.4%
Asian	0.4%
Other (e.g., more than 1 race)	2.0%
Education	
Some college	33.2%
Graduated from 4-year college	18.4%
Completed some graduate or professional school	17.6%
Graduated from high school or equivalent	16.8%
Graduated from 2-year college	10.4%
Did not graduate from high school	3.6%
Currently employed	94.0%
Marital Status	
Never married	38.4%
Married/cohabitating	37.2%
Divorced	17.6%
Separated	4.0%
Widowed	2.8%
Psychiatric Diagnoses	
1	40.0%
Anxiety Disorder	22.0%
Alcohol and Substance Use Disorder	7.2%
Mood disorder	7.2%
Other (e.g., anorexia nervosa)	2.0%

Note: $n = 250$.

Table 2

Means, standard deviations, and zero-order correlations for all variables.

	1	2	3	4	5	6	7	8
1 Depression	-	-	-	-	-	-	-	-
2 AS	.50***	-	-	-	-	-	-	-
3 AUDIT	.05	.15*	-	-	-	-	-	-
4 Condition	-.04	-.06	-.16*	-	-	-	-	-
5 Cigarettes/Day	.05	-.02	-.07	.05	-	-	-	-
6 Pre-Quit Insomnia	.50***	.36***	.10	-.02	-.16*	-	-	-
7 Post-Quit Insomnia	.33***	.27***	-.05	-.02	-.04	.43***	-	-
8 Month 3 Smoking Status	.11	.16	.15	.06	-.23***	.26***	.14	-
<i>Mean (SD)</i>	9.24 (9.26)	14.00 (11.73)	5.49 (5.24)	1.46 (.50)	.82 (.73)	11.86 (5.25)	11.82 (5.16)	.62 (.49)

Note: n=250;*
= $p < .05$;**
= $p < .01$;***
= $p < .001$.

Number of cigarettes per day was coded as 0 (0–10 cigarettes per day), 1 (11–20), 2 (21–30) and 3 (31+); AS = Anxiety Sensitivity; AUDIT = Alcohol Use Disorder Identification Test.

Table 3

Hierarchical Logistic Regression Analyses of Predictors of Smoking Outcomes

Step	Predictor Variables	Month 3 Smoking Status		
		B	Wald	OR (95% CI)
1	Depression	.01	.27	1.01 (.97, 1.06)
	AS	.02	1.42	1.02 (.99, 1.06)
	AUDIT	.06	2.98	1.07 (.99, 1.15)
	Condition	.50	1.81	1.65 (.80, 3.43)
	Cigarettes/Day	-.69	6.60	.50* (.30, .85)
2	Pre-Quit Insomnia	.11	4.55	1.11* (1.01, 1.22)
	Post-Quit Insomnia	-.02	.12	.98 (.90, 1.08)

Note.

* = $p < .05$;

** = $p < .01$; OR =

Odds Ratio; CI = Confidence Interval; AS = Anxiety Sensitivity; AUDIT = Alcohol Use Disorder Identification Test. Please note post-quit insomnia was analyzed in a separate regression but results were included in the same table for ease of comparison.