Original Investigation

Perceived Pain and Smoking Interrelations and Expectancies Are Associated With Pain and Smoking Cessation in Individuals With Mobility Impairments

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Abstract

Introduction: Smoking and pain are highly prevalent among individuals with mobility impairments (MIs; use assistive devices to ambulate). The role of pain-related smoking motives and expectancies in smoking cessation is unknown. We examined cross-sectional and prospective associations between a novel measure of pain-related smoking motives (how smokers with pain perceive their pain and smoking to be interrelated) and pain and smoking behavior in smokers with MI.

Methods: This is a secondary data analysis of a smoking cessation induction trial ($N = 263$; 55% female) in smokers with MI. Participants did not have to want to quit to enroll. Pain-related smoking motives and expectancies were assessed at baseline with the pain and smoking inventory (PSI) which measures perceived pain and smoking interrelations in three distinct but related domains (smoking to cope with pain, pain as a motivator of smoking and as a barrier to cessation). Other measures included pain occurrence and interference, nicotine dependence, motivation and self-efficacy to quit smoking, and number of cigarettes per day. Biochemically verified smoking abstinence was assessed at 6 months.

Results: PSI scores were significantly higher among smokers with chronic pain occurrence compared to occasional and to no occurrence ($p < .002$) and were associated with greater pain interference ($ps < .01$) and lower self-efficacy to quit smoking ($ps < .01$). In prospective analyses adjusted for age, treatment group, and chronic pain, only expectancies of smoking to help cope with pain predicted lower odds of abstinence.

Conclusions: Targeting expectancies of smoking as a mechanism to cope with pain may be useful in increasing smoking cessation in pain populations.

Implications: Individuals with MI have a high prevalence of smoking and pain, yet the extent to which this population perceives pain and smoking to be interrelated is unknown. This is the first article to examine prospective associations between a novel measure of perceived pain and smoking interrelations (PSI) and smoking outcomes. The PSI was associated with greater pain and lower self-efficacy for quitting. Prospectively, the PSI subscale tapping into expectancies that smoking help coping with pain predicted a lower probability of smoking abstinence. In smokers with MI, expectancies of smoking as pain-cope mechanism may be an important clinical target.

Introduction

Smoking prevalence in individuals living with pain is substantially higher than in the general population.¹ Rates vary widely according to the pain population surveyed, settings, and other characteristics but are estimated to range from 28% to 54%.^{2–4} Although smoking prevalence is slowly diminishing in the general population, this trend is not reflected in pain populations.^{5–7}

A reciprocal model of smoking and pain suggests that, among individuals with pain, a positive feedback loop operates such that smoking may serve to mitigate pain (pain-inhibitory effect) but may also exacerbate pain perception resulting in greater functional limitation and thus the maintenance of smoking behavior.^{6,8} Smoking may also exacerbate symptoms and adversely affect the progression of certain disability-related health conditions, or contribute to the development of comorbid conditions in this population.^{9–12}

Individuals with mobility impairments (MIs) are an underserved population¹³ characterized by a higher prevalence of both smoking and pain compared to the general population.^{14,15} For example, nationally representative data indicated that the prevalence of smoking in individuals with MIs aged 21–44 years was 39.2% compared to 21.4% in individuals with no MI.¹⁴ Smokers with comorbid pain, including smokers with MI, have a high prevalence of risk factors for smoking cessation treatment failure that include higher nicotine dependence and cigarette consumption, low self-efficacy for quitting smoking and pain-related smoking motives and expectancies that contribute to the maintenance of smoking behavior.^{6,16,17}

Pain is a robust situational cue for smoking.¹⁸ Other pain-related smoking motives include the use of smoking to reduce or cope with pain, and expectancies that pain will prevent or make quitting smoking more difficult.^{6,18–20} Pain-related smoking motives and expectancies have recently been termed “perceived pain–smoking interrelations” which is the extent to which smokers with pain perceive their pain and smoking to be interrelated.²¹ The theoretical development of the constructs underlying perceived pain and smoking interrelations has been informed by a comprehensive model of pain and tobacco smoking.^{6,20,22} There is also evidence from pain-induction studies providing initial support for a causal role of pain-related smoking motives and expectancies in smoking behavior.^{18,23,24} Given that smoking outcome expectancies are generally robust predictors of smoking outcomes,^{25–27} perceived pain–smoking interrelations may be clinically relevant for smoking cessation in pain populations.²¹

The pain and smoking inventory (PSI)^{21,28} was recently validated to measure perceived pain and smoking interrelations.^{19,21} Significant associations have been reported between the PSI and pain- and tobacco-related factors including pain intensity and interference, nicotine dependence, nicotine withdrawal during quit attempts, and anticipated difficulty quitting, in smokers from the general population and in smokers with HIV and pain.^{21,28} However, whether perceived pain and smoking interrelations measured with the PSI predict smoking cessation outcomes among smokers with pain or physical disability has never been examined. Given the complex interrelations between pain and smoking behavior, and the high prevalence of smoking in pain populations, understanding to what extent perceived pain–smoking interrelations contribute to smoking maintenance is relevant to the development of treatments tailored to the needs of smokers living with pain.

Using data from a smoking cessation induction trial among smokers with MIs, the aim of this study is to provide further evidence regarding the validity of the PSI as a measure of perceived

pain and smoking interrelations by examining cross-sectional and prospective associations with pain measures and smoking behavior. First, in cross-sectional analyses, we hypothesized that smokers endorsing pain as a chronic occurrence would exhibit significantly higher PSI scores compared to those endorsing infrequent to occasional pain occurrence and those endorsing no pain occurrence. It was further hypothesized that PSI scores would be positively associated with pain interference with work activities, nicotine dependence and cigarettes smoked per day, and inversely associated with motivation and self-efficacy to quit smoking. Second, in prospective analyses we sought to determine whether the PSI predicts smoking abstinence, and hypothesized that baseline PSI scores would be associated with lower likelihood of smoking abstinence at follow-up, over and above the presence of chronic pain.

Methods

Design and Participant Selection

This is a secondary analysis of a smoking cessation induction randomized controlled trial among smokers with MIs.²⁹ Participants were 263 cigarette smokers with MIs recruited from disability organizations and the community in Rhode Island and Massachusetts, United States. Inclusion criteria were as follows: 18 years of age and older, smoking at least 3 cigarettes/day and at least 100 in the smoker's lifetime, reading and writing fluently in the English language, a physical disability for more than 1 year, use of an assistive device to ambulate (eg, cane, walker, and wheelchair) on a regular basis and having difficulty walking short (100 yards) and long (1/3 of a mile) distances without the use of the assistive device. Exclusion criteria included substance abuse, serious mental illness (bipolar disorder, schizophrenia), pregnancy, hospice care, severe visual difficulties, and major cognitive impairments. Medical causes of MIs were heterogeneous. For example, 54% self-reported joint-, back-, or leg-related causes, 6% indicated cardiovascular-related causes (including stroke), 10% reported neurological causes and the remaining participants reported accident-related multiple injuries, surgery-related or non-specific causes.

Potential participants were informed that they did not have to want to quit smoking to join the study. The study was approved by the human subjects review board of the Miriam Hospital, and informed consent was obtained in writing from all participants. Eligible and consented participants completed a baseline questionnaire and were randomized to a behavioral activation–based intervention delivered via four DVDs or a control group (four sets of print materials, including National Cancer Institute's Clearing the Air) delivered once per month for four months. All participants who expressed an interest in quitting smoking within 30 days were provided with 8-week supply of nicotine replacement therapy (nicotine patches) at no cost.

Measures

Research assistants travelled to participant's homes to administer surveys at baseline. Participants were also asked to complete self-report surveys at 4- and 6-month follow-ups. Participants were compensated \$25 for each completed assessment.

Baseline Measures

The baseline measures assessed were age, gender, race and ethnicity, education, marital and employment status, type of mobility equipment

used, and level of severity of MI. Participants reported the number of cigarettes smoked per day in the previous week, the numbers of years they have been smoking, the number of quit attempts (>24 hours) in the past year, and the presence of other smokers in the household. Nicotine dependence was measured with the Fagerström Test for Nicotine Dependence;³⁰ scores range 1–10 with higher scores reflecting greater dependence on nicotine. Self-efficacy for quitting was assessed with the 15-item Confidence Questionnaire,^{31,32} a psychometrically sound measure^{33,34} requiring smokers to rate their confidence in the ability to resist smoking in a variety of situations using a 1 (not at all confident) to 10 (extremely confident) scale. Total scores range 15–150; higher values indicate greater confidence in one's ability to resist smoking. Motivation to quit was assessed with a binary scale: "are you planning to quit smoking within the next 30 days?" (yes vs. no), and a continuous scale: "how much do you want to quit smoking?" (1 = do not want to quit to 10 = very much want to quit).

The presence of chronic pain was assessed with a binary scale^{35,36}: "do you currently suffer from any type of chronic pain, that is, pain that occurs constantly or flares up frequently? Do not report aches and pains that are fleeting and minor" (yes vs. no). Pain interference with work activities was measured with the bodily pain subscale of the SF-12 Health Survey³⁷: "during the past 4 weeks how much did pain interfere with your normal work (including both outside the home and housework)?" Responses are endorsed on a five-point scale ranging from "not at all" to "extremely." Scores are linearly transformed to range from 0 to 100 with higher scores indicating greater pain interference. Pain occurrence was assessed with the pain item from the Health Condition Checklist,^{11,38} a measure of chronic and secondary health conditions related to the individual's primary disabling condition. Respondents rate the extent to which the condition (pain in this case) has affected their activity and independence over the preceding 2 months using a five-point scale anchored at 0 = "never had the condition," 1 = "mild or infrequent problem," 2 = "moderate or occasional problem," 3 = "significant or chronic problem," or 4 = "had the condition at some point but not in the past 2 months." For analysis purposes, we collapsed category 0 and 4 into "not in the past 2 months or never" and category 1 and 2 into "infrequent to occasional problem." Although the bodily pain subscale of the SF-12 Health Survey measures the extent to which pain from any source interfered with respondent's normal work (not necessarily chronic or related to participant's MIs), the Health Condition Checklist measures the presence of a condition related to the primary medical condition and categorizes respondents according to the degree to which pain was perceived as a problem (eg, mild-to-significant/chronic problem). Pain interference and pain occurrence were moderately correlated ($r_s = .44$).

Pain and smoking interrelations were measured with the nine-item PSI.²¹ The PSI is characterized by three subscales that tap into distinct but related domains informed by a comprehensive model of pain and tobacco smoking (see Ditte et al.,⁶ for a review): expectancies that smoking reduces or helps cope with pain (PSI-Cope, eg, "smoking a cigarette helps me think about something other than my pain"), smoking in response to pain (pain as motivator of smoking; PSI-Motivator, eg, "when my pain flares up I want to have a cigarette"), and expectancies that pain will interfere or prevent attempts to quit smoking (PSI-Barrier, eg, "my pain would interfere with my attempt to quit smoking"). The total score is computed by averaging scores across the subscales. Items are endorsed on a seven-point Likert scale anchored at 0 (not true at all), 3 (somewhat true), and 6 (extremely true). Thus, scores range 0–6 with higher scores

reflecting greater perceptions that pain and smoking are interrelated. The PSI discriminates between individuals with and without chronic pain, and correlates with measures of pain and tobacco smoking dependence.^{21,28} In this sample, internal consistency coefficients were $\alpha = .80$ for PSI-Cope and $\alpha = .87$ for PSI-Motivator, and Barrier. Although the subscales that were identified in the scale development literature are thought to have important theoretical and clinical application, prior work indicates that the PSI favors a unidimensional structure.²¹ As no prospective data on associations between the PSI and smoking outcomes exist, and to allow comparisons with existing scale development literature (baseline analysis), the current article examines the total PSI score and each subscale separately.

Follow-up Measures

At the 6-month follow-up, smoking status was assessed via self-report of no smoking, not even a puff, in the past 7 days (point prevalence abstinence [ppa]). Self-reported abstinence was verified using expired air carbon monoxide (Bedfont, CO Ecolyzer) and smoking abstinence was defined as CO values less than or equal to 9 ppm.³⁹ Although there is evidence in support of the 8–10 ppm threshold for CO values measured with Bedfont devices,^{40,41} lower cutpoints for abstinence have been recommended.^{42,43} Therefore, we also present the prospective analyses using a lower cutoff (≤ 4 ppm) to indicate smoking abstinence.⁴²

Analytic Plan

Analyses were aggregated across treatment groups and, in prospective analysis, the effect of treatment group was controlled for. Prospective analyses were performed on the intention-to-treat sample (missing = smoking) including all participants ($N = 263$). Differences in PSI and pain scores between participants with missing smoking data at 6 months ($n = 26$) and the rest of the sample were examined with analysis of variance or chi-squared (χ^2) test as appropriate.

Bivariate correlation analysis was used to identify potential sociodemographic covariates; variables that correlated with the dependent variable of interest (PSI in baseline analysis; smoking abstinence in prospective analysis) with p values for significance less than or equal to 0.15^{44,45} were retained as covariates. In baseline analyses, we adopted separate analysis of covariance models to examine differences in PSI scores between pain occurrence groups ("not in the past 2 months or never" vs. "infrequent to occasional" vs. "chronic") adjusting for age. Bonferroni-corrected pairwise comparisons were performed to examine statistically significant main effects. Partial correlation analysis was used to examine associations between PSI scores, the SF-12 bodily pain scale, and the smoking measures adjusting for age.

In prospective analyses, we used multivariate logistic regression models to estimate the odds of biochemically verified smoking abstinence (7-day ppa) at 6-month follow-up. The step 1 model included age, treatment group, and the presence of chronic pain, and step 2 of the model included the PSI scale; separate models were fit for the total PSI score, and PSI subscales. The χ^2 coefficient with degrees of freedom and p value is presented as a measure of overall model significance. Association between PSI scales (predictor) and smoking abstinence are presented as adjusted odds ratios (aOR) with 95% confidence intervals (95% CIs) per SD increase in the predictor.

Results

Participants were 263 smokers with an average age of 54 years ($SD = 8.6$); there were slightly more females than males and, as

Table 1. Baseline Sociodemographic and Smoking Characteristics of Study Sample (*N* = 263)

Variable	Mean (SD) or %
Female	54.8%
Age (y)	53.9 (8.6)
Race/ethnicity	
Non-Hispanic white	47.9%
Hispanic white	3.8%
Black or African American	38.0%
American Indian/Alaskan Native	3.4%
Multiracial	6.5%
Married, living together, or engaged	27.1%
Employed full or part-time	5.7%
Receiving disability/Supplemental Security Income	69.2%
At least high-school education	82.9%
Types of mobility equipment used	
Cane	87.1%
Manual or power wheelchair	16.0%
Walker	18.3%
Leg brace	8.7%
Other equipment	17.9%
Need assistance with personal care	21.3%
Chronic pain	85.9%
SF-12 pain interference scale (0–100)	67.3 (28.5)
Pain occurrence in past 2 months	
Not in past 2 months or never	12.2%
Infrequent to occasional problem	23.6%
Significant or chronic problem	64.3%
Cigarettes/day, past 7 day	15.2 (9.4)
Fagerström score (0–10)	5.22 (2.1)
Years smoked (y)	35.1 (11.25)
≥1 quit attempt in past year	56.7%
≥1 other smoker in household	33.8%
Not planning to quit within 30 days	36.5%
Confidence Questionnaire (15–150)	79.8 (27.2)

shown in Table 1, the sample was ethnically and racially diverse. The vast majority used a cane to assist with ambulation (87.1%), 21% reported needing assistance with personal care, and nearly 70% were receiving disability allowance. The vast majority of participants (85.9%) reported current chronic pain.

Approximately one-third of the sample lived with at least one additional smoker in the household, 57% made at least one quit attempt in the past year, and 36.5% were not-motivated to quit smoking within 30 days. Participants reported smoking for an average of 35 years (*SD* = 11.3), the mean number of cigarettes smoked per day was 15.2 (*SD* = 9.4), and the average nicotine dependence score was 5.2 (*SD* = 2.1) indicating moderate to high dependence levels.

Participants with missing bioverified 7-day ppa data at the 6-month follow-up (9.9%, *n* = 26) were not significantly different from the rest of the sample on total PSI scores ($F(1, 261) = 1.10$, $p = .3$), or on any PSI subscale ($ps \geq .10$). However, participants with missing 7-day ppa data exhibited higher bodily pain interference scores compared to the rest of the sample ($M = 79.80$, *SD* = 22.40 vs. $M = 65.90$, *SD* = 28.80; $F(1, 261) = 5.63$, $p = .02$).

Baseline Analyses

Across the study sample, the total PSI score was 2.20 (*SD* = 1.62). Among subscales, the mean PSI-Cope score was 2.56 (*SD* = 1.71),

mean PSI-Motivator score was 2.26 (*SD* = 1.85), and the mean PSI-Barrier score was 1.73 (*SD* = 1.70).

PSI and Pain Occurrence

Analysis of covariance models revealed a significant main effect of pain occurrence on the total PSI score ($F(2, 259) = 8.2$, $p < .001$, $\eta^2 = .06$). Pairwise comparisons (Table 2) indicated that the “significant/chronic problem” group exhibited greater scores than the “not in the past 2 months/never” pain group. Similar results were obtained on the PSI-Cope ($F(2, 259) = 7.50$, $p = .001$, $\eta^2 = .05$), the PSI-Motivator ($F(2, 259) = 10.50$, $p < .001$, $\eta^2 = .07$), and PSI-Barrier subscale ($F(2, 259) = 4.0$, $p = .02$, $\eta^2 = .03$). However, as shown in Table 2, the “significant/chronic problem” group also exhibited higher scores than the “infrequent to occasional problem” pain group on the Motivator subscale, and the “infrequent to occasional problem” group exhibited higher mean scores compared to the “not in the past 2 months/never” group on the Cope subscale, though this difference was borderline statistically significant ($p = .055$).

PSI and Pain Interference With Work Activities

There were significant correlations between the SF-12 bodily pain scale and the total PSI score ($r(260) = .24$, $p < .001$) suggesting that participants with greater perceived pain–smoking interrelation scores also reported greater levels of pain interference with work activities. Comparable results were observed on the Cope ($r(260) = .23$, $p < .001$), Motivator ($r(260) = .26$, $p < .001$) and, Barrier ($r(260) = .17$, $p < .01$) subscales.

PSI and Smoking Measures

Adjusting for age, the total PSI score ($r(260) = -.24$, $p < .001$) was significantly associated with self-efficacy for quitting, suggesting that as perceived pain–smoking interrelations scores increase, confidence in one’s ability to refrain from smoking decreases. The Cope and Barrier subscales ($r(260) = -.24$, $p < .001$) and the Motivator subscale ($r(260) = -.19$, $p < .01$) were also significantly associated with quitting self-efficacy. The PSI was not significantly associated with motivation to quit measures or with nicotine dependence or number of cigarettes smoked per day.

Prospective Analyses

PSI and Bioverified 7-day ppa (CO ≤ 9 ppm)

The step 1 model that included age, treatment group and the presence of chronic pain was not statistically significant ($\chi^2(3) = 5.50$, $p = .14$). The addition of total PSI score in step 2 (model $\chi^2(4) = 8.52$, $p = .07$) revealed no significant association with 7-day ppa at 6-month (aOR = 0.74, 95% CI = 0.53 to 1.04). Separate models were fit to examine PSI subscales. The PSI-Cope subscale (model $\chi^2(4) = 9.78$, $p = .04$) was significantly associated with abstinence at 6-month follow-up (aOR = 0.70, 95% CI = 0.50 to 0.98), such that greater expectancies of smoking as a means of coping with pain was associated with lower odds of abstinence. Age was also a significant predictor (aOR = 1.40, 95% CI = 1.00 to 1.95). The PSI-Motivator (model $\chi^2(4) = 8.70$, $p = .07$) and PSI-Barrier (model $\chi^2(4) = 6.40$, $p = .17$) subscales were not significantly associated with smoking abstinence.

PSI and Bioverified 7-Day ppa (CO ≤ 4 ppm)

The step 1 model (age, treatment group and the presence of chronic pain) remained not significant ($\chi^2(3) = 0.84$, $p = .83$). Adding the

Table 2. Pain and Smoking Inventory (PSI) Scores by Pain Occurrence Groups

PSI scale	Not in past 2 months/never (<i>n</i> = 32)	Infrequent to occasional (<i>n</i> = 62)	Significant/chronic (<i>n</i> = 169)
PSI-Cope (0–6)	1.6 (0.3) ^{*,†,a,b}	2.4 (0.2) ^{*,b}	2.8 (0.1) ^{†,a}
PSI-Motivator (0–6)	1.2 (0.3) ^{†,a}	1.9 (0.2) ^{*,c}	2.6 (0.1) ^{†,*,a,c}
PSI-Barrier (0–6)	1.0 (0.3) ^{*,a}	1.6 (0.2)	1.9 (0.1) ^{*,a}
PSI-score (0–6)	1.2 (0.3) ^{†,a}	2.0 (0.2)	2.4 (0.1) ^{†,a}

Values are means (standard errors) adjusted for the effect of age. Means with same superscripts are significantly different (Bonferroni-corrected *p* values). PSI-Cope = expectancies that smoking help cope with pain; PSI-Motivator = expectancies of pain to motivate smoking; PSI-Barrier = expectancies of pain to prevent quitting smoking.

p* = .055; *p* ≤ .02; †*p* ≤ .001.

total PSI score in step 2 yielded a significant association with 7-day ppa (aOR = 0.60, 95% CI = 0.39 to 0.91) although the overall model was not significant ($\chi^2(4) = 7.10, p = .13$). Similarly, the PSI-Cope (aOR = 0.61, 95% CI = 0.41 to 0.92; model $\chi^2(4) = 6.91, p = .14$), PSI-Motivator (aOR = 0.63, 95% CI = 0.42 to 0.95; model $\chi^2(4) = 6.01, p = .19$), and PSI-Barrier (aOR = 0.64, 95% CI = 0.41 to 0.98; model $\chi^2(4) = 5.56, p = .23$) subscales were all associated with 7-day ppa although the respective models did not achieve significance.

Discussion

The aim of this article was to provide further evidence regarding the validity of the PSI as a measure of perceived pain and smoking interrelations by examining cross-sectional and prospective associations with pain and smoking behavior in smokers with MI.

We expected to find associations between the PSI and several measures of pain and smoking, and findings were partially supportive. Mean PSI scale scores in our sample were comparable to those from a validation study of smokers with and without chronic pain recruited online.²¹ Broadly consistent with that study and with another among smokers living with HIV and pain,²⁸ participants with pain as a chronic problem in our study had significantly higher PSI scores compared to those with no pain either in the preceding two-months or never. Interestingly, we also observed higher scores on the pain as a motivator of smoking PSI subscale in the chronic, compared to the infrequent to occasional, pain group. Furthermore, the infrequent to occasional pain group exhibited higher scores on the smoking to cope with pain PSI subscale than the no pain group. Collectively, the findings suggest a dose–response relationship between pain occurrence and perceived pain and smoking interrelations scores among smokers with MI.

Associations of small-to-medium magnitude were also observed between the PSI and greater levels of pain interference with work activities. However, unlike previous findings by Ditte et al.,²¹ the PSI was not significantly associated with nicotine dependence. The reason for this is unclear. Our sample size was larger than in Ditte's study²¹ and participants were older, with moderate-to-high nicotine dependence versus mild dependence found among Ditte's participants. Thus, it is likely that differences in sample characteristics such as age, smoking profile, recruitment (smokers with MI vs. smokers recruited online) and sociodemographic factors account for the different findings. Research examining perceived pain and smoking interrelations in relation to smoking behavior and cessation among sociodemographic subgroups is therefore warranted.

Consistent with Weinberger et al.'s study among smokers living with HIV and pain,²⁸ we did not find significant associations between the PSI and cigarettes smoked per day. In addition, in our

study the PSI was not significantly associated with motivation to quit measures. Lack of associations may indicate that, among smokers with MI, motivation is not affected by pain-related smoking motives and expectancies, or that these factors function independently. Future research focusing on the role of pain-related smoking motives in relation to motivation to quit is needed to understand how these factors operate.

Our study is the first to report significant associations of small-to-medium magnitude between the PSI and self-efficacy for quitting. Associations indicate that participant with greater perceived pain and smoking interrelations scores (ie, smoking in response to pain and as pain-coping mechanism, and expectancies of pain to interfere with quitting) exhibited less confidence in their ability to refrain from smoking. If replicated, this finding may indicate that, among smokers with MIs, pain-related smoking motives and expectancies are important correlates of quitting self-efficacy, which is a known predictor of smoking abstinence.³⁴ Future experimental research may help elucidate the nature of the associations between the PSI and self-efficacy for quitting.

Our second hypothesis stating that the PSI would be prospectively associated with a lower probability of smoking abstinence was partly supported. Associations were not statistically significant for the total PSI score but were specific to PSI dimensions. The coping subscale was consistently associated with abstinence even after adjustment for the presence of chronic pain. Specifically, for each SD increase in coping score at baseline there was a 30% decrease in the probability of being abstinent at the 6-month follow-up. That is, smokers holding greater expectancies that their smoking functions as a pain-coping strategy were less likely to achieve abstinence. Associations with smoking abstinence were observed for both the total PSI score and the PSI subscales only when the lower cutpoint was used to define biochemically verified smoking abstinence.^{42,43} However, the respective logistic models did not achieve statistically significant levels, which was likely due to the lower number of participants who achieved abstinence. Interestingly, the presence of chronic pain alone, or the level of pain interference with work activities (data not shown), did not predict abstinence but rather, it was expectancies that smoking help coping with pain that was more important in predicting abstinence.

It is unclear why the PSI total score or the other subscales were not significant predictors of abstinence. Given the lack of previous work, offering explanations may be difficult. The factor structure of the PSI favors a single dimension,^{21,28} but it has been argued that the three domains are theoretically and conceptually different with each domain bearing specific clinical opportunities.²¹ Among smokers with MI, expectancies that smoking functions as a coping method may be a more important cognitive factor affecting the likelihood of quitting

than pain-related smoking motives such as the pain experience acting as a situational cue for smoking and preventing cessation. This finding is therefore consistent with motivational models of tobacco use that emphasize a negative reinforcement role of smoking in alleviating undesired events or situations such as the experience of pain.^{46,47}

This study is the first to show that smoking-related outcome expectancies for pain coping measured with the PSI-Cope subscale predict failure to quit smoking. There may be important clinical implications should these findings be replicated. Individuals for whom smoking functions as pain-coping mechanism may respond better to smoking cessation treatment modalities that challenge maladaptive expectancies and offer more adaptive coping techniques. Experimental evidence suggests that such treatment modalities are effective in reducing cravings and smoking urges and may ultimately prove useful in cessation treatments.²³ The PSI may therefore help identify such subgroup of smokers given that, being a brief instrument, it can easily be incorporated into smoking cessation programs in pain management clinics or other clinical settings. However, challenging maladaptive pain and smoking-related outcome expectancies may be difficult because such expectancies are cognitive manifestations originating from the individual's lifetime learning experience.

Our findings may be interpreted in the context of an integrative reciprocal model of pain and smoking^{6,22} in which pain-smoking motives and expectancies is purported to be one of the mechanisms underlying the effect of pain on smoking. According to the model, the initial sensory-discriminatory stage of the pain experience is soon followed by immediate affective responses leading to an extended pain affect stage where pain appraisal and cognitive processes determine emotional reactivity and/or behavioral responses. Smoking is thought of as one of the behavioral pain responses elicited in an effort to manage or reduce pain.

Some limitations of this study need to be highlighted. Our sample included smokers with MIs and the findings may not necessarily generalize to other populations. Participant's average age was 54 years, and younger smokers might differ from older smokers in regard to smoking motives and pain characteristics. Perceived pain and smoking interrelations were measured only at baseline and it is therefore unknown to what extent they are stable or change over time. The vast majority of our sample had chronic pain and we were unable to examine associations among those with MIs without chronic pain. Research that includes demographic subgroups of smokers of varying age, gender, race, socioeconomic status, pain or chronic conditions is warranted. Finally, although our baseline findings are consistent with two previous reports suggesting that the PSI is largely unidimensional,^{21,28} prospective findings were not consistent in that associations with smoking abstinence were significant for the smoking to cope with pain subscale only. This may have implications for the factor structure of the PSI. It is important that these findings be replicated to understand whether the contribution of smoking expectancies for pain coping to smoking abstinence may, at least in part, be accounted for by item-specific error or by shared variance with items tapping into different pain and smoking-related motives. Thus, caution is warranted in interpreting the prospective findings. A major strength of this study is the recruitment of participants regardless of their motivation to quit which enhances the generalizability of study findings, and objective measurement of smoking status.

Taken together, our results lend support to the PSI as a measure of pain and smoking interrelations in smokers with comorbid pain. There is initial evidence indicating that expectancies for smoking to

help coping with pain play a role in predicting smoking abstinence. If replicated, these findings could suggest novel targets for interventions to increase smoking cessation among individuals living with pain.

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Declaration of Interests

The authors have no conflict of interest to declare.

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