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RESEARCH REPORT

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Socio-economic status moderates within-person associations of risk factors and smoking lapse in daily life

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Abstract

Background and Aims: Individuals of lower socio-economic status (SES) display a higher prevalence of smoking and have more diffxiculty quitting than higher SES groups. The current study investigates whether the within-person associations of key risk (e.g. stress) and protective (self-efficacy) factors with smoking lapse varies by facets of SES.

Design and setting: Observational study using ecological momentary assessment to collect data for a 28-day period following a smoking quit attempt. Multi-level mixed models (i.e. generalized linear mixed models) examined cross-level interactions between lapse risk and protective factors and indicators of SES on smoking lapse.

Participants: A diverse sample of 330 adult US smokers who completed a larger study examining the effects of race/ethnicity and social/environmental influences on smoking cessation.

Measurements: Risk factors included momentary urge, negative affect, stress; protective factors included positive affect, motivation, abstinence self-efficacy; SES measures: baseline measures of income and financial strain; the primary outcome was self-reported lapse.

Findings: Participants provided 43 297 post-quit observations. Mixed models suggested that income and financial strain moderated the effect of some risk factors on smoking lapse. The within-person association of negative [odds ratio (OR) = 0.967, 95% CI= 0.945, 0.990, $P < 0.01$] and positive affect (OR = 1.023, 95% CI = 1.003, 1.044, $P < 0.05$) and abstinence self-efficacy (OR = 1.020, 95% CI = 1.003, 1.038, $P < 0.05$) on lapse varied with financial strain. The within-person association of negative affect (OR = 1.005, 95% CI = 1.002, 1.008, $P < 0.01$), motivation (OR = 0.995, 95% CI = 0.991, 0.999, $P < 0.05$) and abstinence self-efficacy (OR = 0.996, 95% CI = 0.993, 0.999, $P < 0.01$) on lapse varied by income. The positive association of negative affect with lapse was stronger among individuals with higher income and lower financial strain. The negative association between positive affect and abstinence self-efficacy with lapse was stronger among individuals with lower financial strain, and the negative association between motivation and abstinence self-efficacy with lapse was stronger among those with higher income. The data were insensitive to detect statistically significant moderating effects of income and financial strain on the association of urge or stress with lapse.

Conclusion: Some risk factors (e.g. momentary negative affect) exert a weaker influence on smoking lapse among lower compared to higher socio-economic status groups.

KEYWORDS
Ecological momentary assessment, financial strain, income, mHealth, socio-economic status, tobacco cessation

INTRODUCTION

Tobacco use is the leading cause of preventable death and disease in the United States [1–3]. Overall rates of tobacco smoking have declined [4] and there is an increasing proportion of smokers who have successfully quit [5]. Unfortunately, striking inequities have emerged such that low socio-economic status (SES) populations showed a slower rate of decline, leaving smoking increasingly concentrated in this population [6]. Despite having higher rates of tobacco use overall, lower SES groups are just as likely to make a smoking quit attempt as higher SES groups [7], but they are less likely to achieve smoking cessation success [8–10].

Social cognitive models of addiction posit that internal cues such as negative affect can influence urge and motivation to smoke, which influence lapse likelihood. Cognitive factors such as self-efficacy and expectancies may also influence lapse likelihood [11–14]. A central principle of these models is that key factors associated with behavior change (e.g. affect and self-efficacy) can fluctuate, depending on time and context [11, 15]. Unlike studies that rely upon retrospective reports, ecological momentary assessment (EMA) records participants' subjective experiences in real-time and real-world settings, thus capturing data that are more ecologically valid, less influenced by recall bias and can elucidate within-person associations [16]. EMA studies have established that stress, positive affect and negative affect, urge, motivation and abstinence self-efficacy are key risk factors for smoking lapse [17–26].

Conceptual models such as the reserve capacity model may be useful for understanding tobacco cessation inequities in lower SES groups [27–29]. This model posits that lower SES groups experience greater exposure to negative experiences, contextual and interpersonal demands, and have a reduced pool of tangible, interpersonal and intrapersonal resources that may facilitate coping. These exposures may contribute to higher levels of negative emotion and stress and lower levels of positive emotion, which could interfere with behavior change [27–29]. Research on economic scarcity (a characteristic of low SES) and associated stressors also suggests that scarcity results in decisional biases shifted towards immediate concerns at the expense of long-term goals and may deplete cognitive resources important for self-regulating health behaviors [30–32]. Indeed, experimental and 'real-world' studies demonstrate that thinking about financial challenges has a more detrimental impact on the ability to perform actions in accordance with goals among lower versus higher SES individuals [30]. This suggests that SES may alter the immediate impact of stress on the ability to resist impulses—such as a cigarette in moments of stress. In other words, SES may act as a moderator of the momentary relationship between stress and smoking. By employing EMA, it may be possible to investigate whether momentary risk factors have a differential influence on individuals with different levels of SES. Although prior research has provided a critical foundation for understanding whether lower SES groups may be more at risk for poor health outcomes (e.g. due to contextual factors) [33] and the potential buffering effects of cognitive factors (e.g. mindfulness) [34] on the association between risk factors and smoking outcomes, few studies have used EMA to investigate whether momentary associations between mechanisms of behavior change (e.g. stress and self-efficacy) vary by a between-person factor such as SES.

The purpose of the current study was to investigate whether the dynamic, within-person associations between evidence-based risk factors derived from social cognitive models and lapse differ, depending on two facets of SES. Although SES, or one's 'position in the societal structure', [35] is sometimes conceptualized as a composite of several constructs, researchers have yet to establish a single, widely accepted definition of SES as it encompasses economic, social and contextual facets [36, 37]. Importantly, subjective (e.g. financial strain) and objective (e.g. income) indicators of financial facets of SES may operate differentially in their effect on smoking outcomes. Numerous studies have shown strong links between financial SES indicators and smoking status, lapse and morbidity/mortality. For example, there is a striking disparity in the prevalence of smoking among adults who live in higher- versus lower-income households (10 and 25%, respectively) [6]. Similarly, higher perceived financial strain has been linked to greater smoking intensity (e.g. smoking more cigarettes per day [38]), higher dependence [39] and reduced likelihood of smoking cessation at 26 weeks post-quit attempt [10] and over time (at 3 and 26 weeks post-quit attempt) [40]. However, few studies have investigated whether subjective (financial strain) and objective (income) indicators of SES moderate the acute association between risk factors and lapse in the moment. We hypothesized that the positive within-person association between momentary risk factors (i.e. urge, stress and negative affect) and lapse and the negative within-person association between momentary protective factors (i.e. positive affect, motivation to quit and abstinence self-efficacy) and lapse would be stronger among those with lower income and higher financial strain.

METHODS

Participants and procedures

Participants were US smokers recruited from the Houston, TX area for a NIH-funded study conducted from May 2005 to June 2007 to examine the effects of race/ethnicity and social/environmental influences on smoking cessation. Eligible participants were at aged least 21 years; had smoked five or more cigarettes per day for the last year; motivated to quit within the next month; had a home address and telephone number; and could read, write and speak English at a sixth-grade or higher literacy level. Participants were excluded if they

regularly used other tobacco products, had a contraindication for the nicotine patch or used cessation products other than the patch, had a household member enrolled in the study or were enrolled in another smoking cessation study during the past 90 days. Of those eligible, 424 enrolled. All participants were scheduled to attend six in-person visits and received smoking cessation counseling, self-help materials and nicotine patch therapy [41]. Participants answered EMAs using a palmtop personal computer (PPC) that they carried from 1 week prior to the quit date until their visit at week 4 (i.e. 28 days). The PCC was a pen-based, touch-screen system that was user-friendly and approximately the size of a pack of cigarettes. Participants typically did not report difficulty carrying it with them at all times. In line with the methodology used in more recent EMA studies, four random EMAs were scheduled to be sent each day during waking hours. Participants also self-initiated EMAs when they were about to smoke, had an urge to smoke or had already smoked (i.e. smoking, urge and slip EMAs).

Participants received up to $180 in gift cards for study visits and additional compensation for completing EMAs, which was pro-rated based on the percentage of random EMAs completed (up to $250 in additional gift cards); 391 of enrolled participants completed any type of EMA in the pre- and post-quit period, with an overall compliance rate of 75.8% for random EMAs. The current study included participants who completed at least one random EMA during the post-quit period and had data on study moderators (n = 330). Procedures were approved by the University of Texas MD Anderson Cancer Center Institutional Review Board. Informed consent was obtained from all participants. Additional details regarding the study have been published elsewhere [42].

Study visit measures (time non-varying)

At baseline, participants provided demographic information [e.g. age, gender, partner status, years of education and race/ethnicity (white, African American or Latino)] and information regarding other time non-varying measures. Household income was assessed using an 11-point categorical scale from less than $10 000 to $100 000 or more per year (< $10 000/year; $10 000–19 999/year; $20 000–29 999/year; $30 000–39 999/year; $40 000–49 999/year; $50 000–$59 999/year; $60 000–69 999/year; $70 000–70 999/year; $80 000–89 999/year; $90 000–99 999/year; ≥ $100 000/year). The mid-point of each range was taken and was then entered into the model as a continuous variable. Financial strain was assessed using the sum of eight items regarding the ability to pay for major necessities (e.g. 'At the moment, do you have problems paying your bills?') with response options 1 (no difficulty) to 3 (very great difficulty) [43]. Higher scores (range = 8–24) indicated greater levels of financial strain (Supporting information, Appendix A). Smoking dependence was assessed with two items: 'How many cigarettes per day do you smoke on average?' and 'How soon after waking do you smoke your first cigarette?', with response options (1) more than 60 minutes; (2) 31–60 minutes; (3) 6–30 minutes; or (4) 5 minutes or less.

EMA measures (time-varying)

Primary outcome

Smoking lapse. In random and urge EMAs, participants answered an item asking if they had smoked any cigarettes that they had not already recorded in the computer and how many cigarettes they smoked. Participants also self-initiated an assessment when they slipped (slip assessment) and recorded how many cigarettes they smoked during the slip, as well as when they were about to smoke (smoking assessment). A single 'lapse' variable was created using random, urge and slip assessments to indicate whether a participant reported smoking one or more times in the interval between two random EMAs (1 = lapse, 0 = no lapse). Because smoking assessments were initiated when a participant was about to smoke (but may have actually not done so after initiating the assessment), they were not included in the curation of the lapse variable in the main analyses. However, sensitivity analyses tested the robustness of results to the inclusion of smoking assessments in the lapse variable. In particular, all analyses were repeated using a lapse variable created from random, urge, slip and smoking assessments.

Risk factors for smoking lapse

Urge. The mean of the items 'I have an urge to smoke', 'I really want to smoke' and 'I need a cigarette' [answered on a scale of 1 (strongly disagree) to 5 (strongly agree)] was used as the total urge score (g-theory internal consistency reliability = 0.87) [44].

Stress. The item 'I feel stressed' [answered on a scale of 1 (strongly disagree) to 5 (strongly agree)] was used to assess stress.

Affect. The mean of the items 'I feel bored', 'I feel sad', 'I feel angry', 'I feel anxious' and 'I feel restless', and the mean of the items 'I feel enthusiastic', 'I feel happy' and 'I feel relaxed' (answered on a scale of 1 [strongly disagree] to 5 [strongly agree]) were used as a negative and positive affect score, respectively (internal consistency reliability = 0.67 for both).

Motivation to quit. The mean of the items 'My desire to be a non-smoker is very strong' and 'I am extremely motivated to be smoke free' [answered on a scale of 1 (strongly disagree) to 5 (strongly agree)] was used as the total motivation score (internal consistency reliability = 0.67).

Abstinence self-efficacy. The item 'I am confident in my ability not to smoke' [answered on a scale of 1 (strongly disagree) to 5 (strongly agree)] was used to assess abstinence self-efficacy.

Analytical plan

Mixed models were estimated with SAS version 9.4 PROC GLIMMIX with residual pseudo-likelihood estimation and an unstructured covariance matrix. Mixed models are recommended for data that have a nested structure (e.g. EMA observations nested within individuals)

because of their capability of separating sources of variance at different levels. Mixed models also allow for person-level predictors (e.g. income) and momentary level predictors (e.g. stress reported via EMA) simultaneously. Three models were estimated for each predictor (i.e. risk factors for smoking lapse): model A tested the within-person association of the risk factor (e.g. stress) at time *t* and lapse likelihood in the interval between the current (time *t*) and next (time *t* + 1) random EMA; model B tested the cross-level interaction between the 1 risk factor and moderator of income on lapse likelihood; and model C tested the cross-level interaction between the risk factor and moderator of financial strain on lapse likelihood. Models included the following covariates: the between-person effect of the predictors, time to first cigarette, cigarettes per day, age, education, partner status, gender, race/ethnicity, lapse at time *t*, time elapsed since quitting and time between prompts. Main effect models also controlled for income and financial strain. Models testing the interaction between income and risk factors controlled for financial strain; models testing the interaction between financial strain and risk factors controlled for income. Models included random intercepts and random slopes. To probe significant interactions, we estimated whether the within-person association between the risk factor (e.g. urge) and lapse was significantly different than zero at different levels of the moderator (i.e. among those with higher or lower than average income), and whether the strength and/or direction of the within-person association between the risk factor and lapse differed depending on the level of the moderator—these results are plotted in Figures 1–6. Due to technology glitches, some participants received more than four random EMAs per day and we retained all usable data. Predictor variables (i.e. risk factors such as stress) were person-mean centered so that zero refers to an individual's average value of the risk factor in a moment, and moderators were grand-mean centered so that zero refers to the average income or financial strain in the sample. The primary research question and analysis plan were not pre-registered, and thus results should be considered exploratory.

RESULTS

The final sample (n = 330) was 53.64% female, 33.03% white non-Hispanic, 34.55% black/African American, 30.61% Hispanic/Latino and 1.82% other race/ethnicity. Participants reported a mean age of 42.02 years, mean annual income of $34 364 [standard deviation (SD) = 26 510], a mean financial strain score of 15.51 (SD = 4.73), an average of 13.02 years of education and smoked an average of 21.06 cigarettes per day (Table 1). Although it is impossible to test whether data were missing at random, missing data showed a very low correlation with risk factors and baseline covariates in the model. Participants provided a total of 43 297 post-quit observations from random (68.05%), urge (26.11%), slip (4.24%) and smoking (1.60%) assessments, and completed an average of 87.36 (range = 1–290) prompts. Table 2 presents results for the main effects of each predictor (model A), as well as results for the cross-level interactions (models B and C). Significant interactions are presented in Figures 1–6 and explained below.

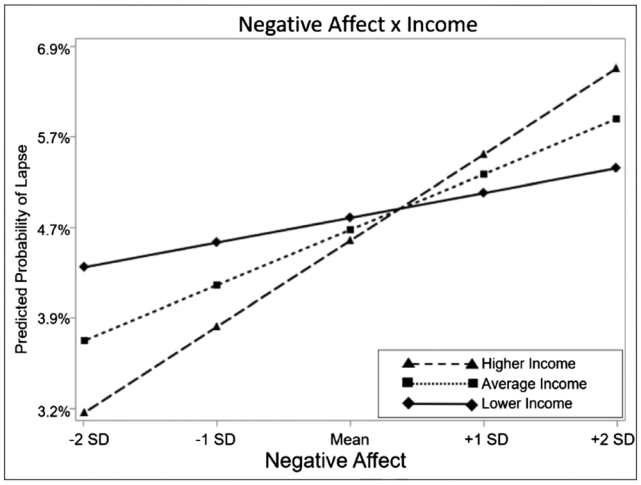

FIGURE 1 Cross-level interaction between negative affect and income

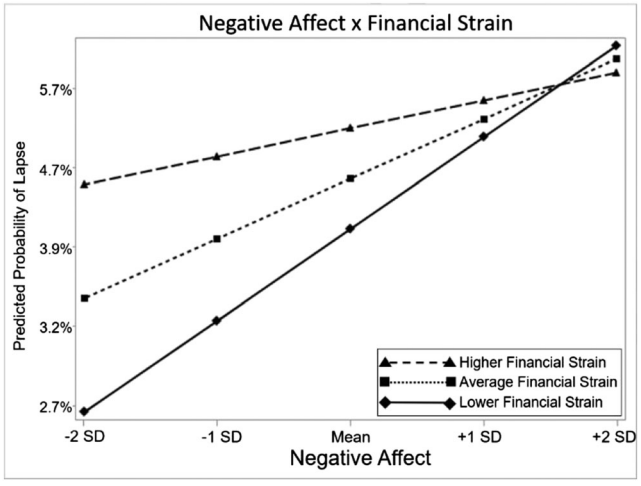

FIGURE 2 Cross-level interaction between negative affect and financial strain

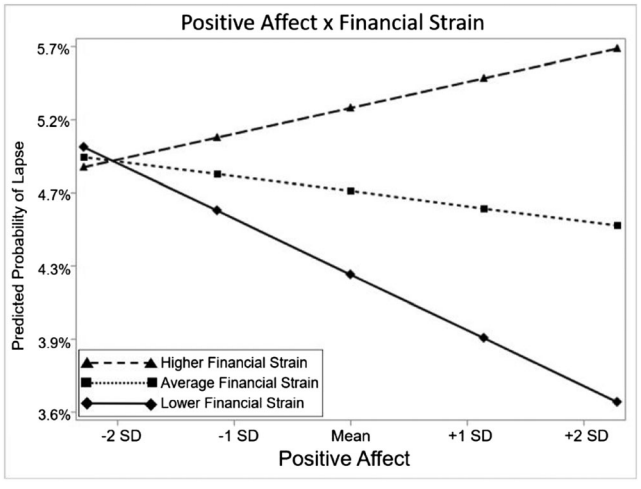

FIGURE 3 Cross-level interaction between positive affect and financial strain

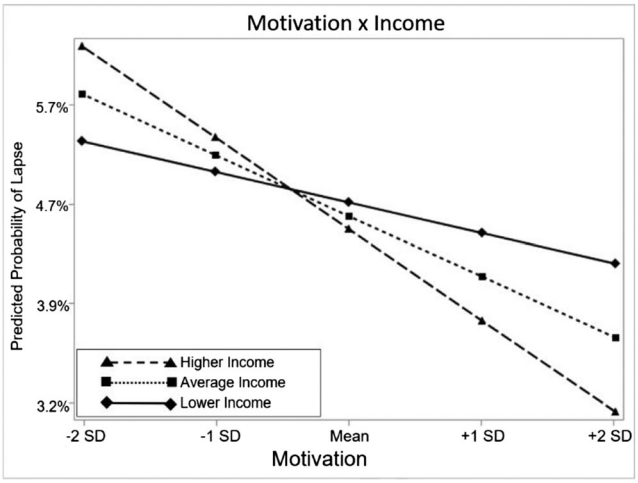

FIGURE 4 Cross-level interaction between motivation and income

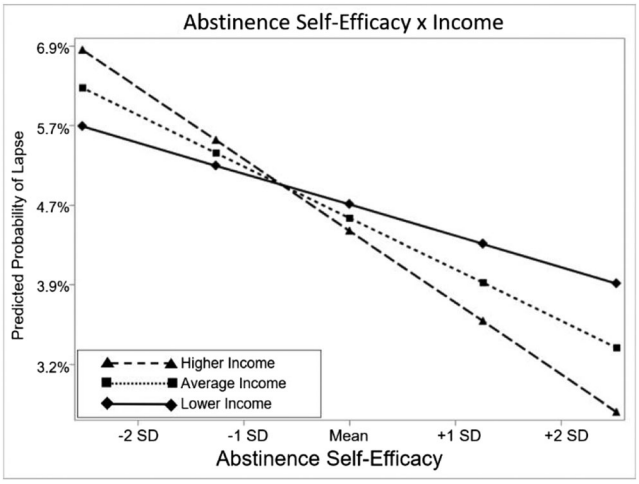

FIGURE 5 Cross-level interaction between abstinence self-efficacy and income

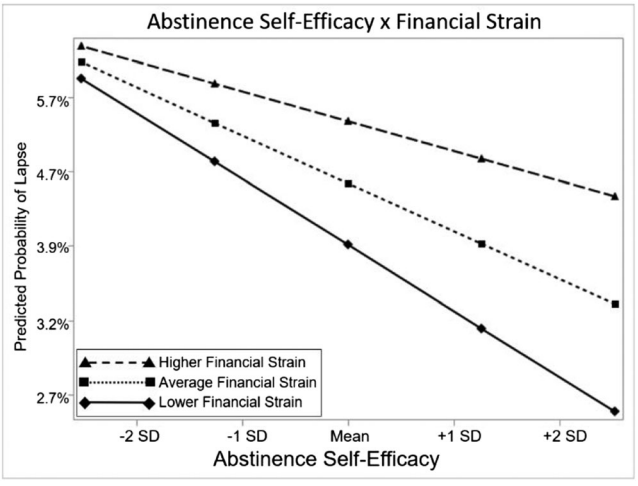

FIGURE 6 Cross-level interaction between abstinence self-efficacy and financial strain

TABLE 1 Demographic characteristics.

Variable	% or mean (SD)
Age (years)	42.02 (10.86)
Sex	
Female	53.64%
Male	46.36%
Race	
Non-Hispanic/Latino white	33.03%
Non-Hispanic Latino black	34.54%
Hispanic/Latino	30.61%
Other	1.82%
Income less than $30 000	53.03%
Years of education	13.02 (1.99)

SD = standard deviation.

Urge

There was a significant positive association between urge and lapse [odds ratio (OR) = 1.216, 95% confidence interval (CI) = 1.101, 1.344, P = 0.0001]. The data were insensitive to detect a moderating effect of income and financial strain on the association between urge and lapse (Table 2).

Stress

There was a significant positive association between stress and lapse (OR = 1.166, 95% CI = 1.086, 1.253, P < 0.0001). The data were insensitive to detect a moderating effect of income and financial strain on the association between stress and lapse (Table 2).

Negative affect

There was a significant positive association between negative affect and lapse (OR = 1.325, 95% CI = 1.178, 1.491, P < 0.0001). Income moderated the association between negative affect and lapse (OR = 1.005, 95% CI = 1.002, 1.008, P = 0.0004) (Table 2). There was a stronger positive association between negative affect and lapse among those whose income is 1 SD above the mean (OR = 1.516, 95% CI = 1.337, 1.720, P < 0.0001), compared to those whose income is 1 SD below the mean (OR = 1.314, 95% CI = 1.159, 1.489, P < 0.0001) (Figure 1).

Financial strain moderated the association between negative affect (NA) and lapse (OR = 0.967, 95% CI = 0.945, 0.990, P = 0.0053) (Table 2). There was a significant positive association between negative affect and lapse among those whose financial strain was 1 SD below the mean (OR = 1.434, 95% CI = 1.256, 1.637, P < 0.0001), compared to those whose financial strain was 1 SD above the mean (OR = 1.389, 95% CI = 1.227, 1.573) (Figure 2).

TABLE 2 Multi-level logistic regression estimates for predictors and lapse with cross-level interactions during a quit attempt

Predictors	Urge OR (95% CI)	Stress OR (95% CI)	NA OR (95% CI)	PA OR (95% CI)	Motivation OR (95% CI)	ASE OR (95% CI)
Model A: main effect						
Predictor	1.216(1.101, 1.344)**	1.166(1.086, 1.253)***	1.325(1.178, 1.491)***	0.976(0.882, 1.080)	0.796(0708, 0.895)**	0.780(0.719, 0.847)***
Model B: predictor × income						
Predictor	1.411(1.291, 1.543)	1.167(1.086, 1.253)	1.279(1.184, 1.380)	0.971(0.879, 1.074)	0.783(0.698, 0.878)	0.773(0.713, 0.836)
Income	0.997(0.989, 1.005)	1.000(0.992, 1.009)	0.999(0.991, 1.008)	0.999(0.991, 1.008)	0.999(0.991, 1.007)	0.999(0.991, 1.007)
Predictor × income	1.003(0.999, 1.006)	1.000(0.997, 1.003)	1.005(1.002, 1.008)**	0.998(0.994, 1.001)	0.995(0.991, 0.9999)*	0.996(0.993, 0.999)**
Model C: predictor × FS						
Predictor	1.411(1.290, 1.545)	1.174(1.093, 1.260)	1.353(1.206, 1.517)	0.960(0.869, 1.060)	0.787(0.701, 0.885)	0.773(0.714, 0.837)
FS	1.022(0.980, 1.065)	1.026(0.984, 1.070)	1.027(0.985, 1.071)	1.024(0.981, 1.069)	1.024(0.983, 1.067)	1.035(0.994, 1.079)
Predictor × FS	0.997(0.978, 1.016)	0.989(0.975, 1.004)	0.967(0.945, 0.990)**	1.023(1.003, 1.044)*	1.016(0.992, 1.041)	1.020(1.003, 1.038)*

All models controlled for the between-person (i.e. level 2) effect of the predictors, time to first cigarette, cigarettes per day, age, education, partner status, gender, race/ethnicity, lapse at time *t* and time elapsed since quitting. Main effect models also controlled for income and financial strain. Models testing the interaction between income and predictors controlled for financial strain; models testing the interaction between financial strain and predictors controlled for income. FS = financial strain; NA = negative affect; PA = positive affect; ASE = abstinence self-efficacy; OR = odds ratio; CI = confidence interval.

***< 0.0001;

**< 0.01;

*< 0.05.

Positive affect

The data were insensitive to detect a main effect of positive affect on lapse likelihood, as well as a moderating effect of income on the association between positive affect and lapse. Financial strain moderated the association between positive affect and lapse (OR = 1.023, 95% CI = 1.003, 1.044, *P* = 0.027) (Table 2). The negative association between positive affect and lapse was significant among those whose financial strain was 1 SD below the mean (OR = 0.859, 95% CI = 0.739, 0.998, *P* = 0.048), but this association was not significantly different from zero among those whose financial strain is 1 SD above the mean (Figure 3).

Motivation

There was a significant negative association between motivation and lapse (OR = 0.796, 95% CI = 0.708, 0.895, *P* = 0.0001). Income moderated the association between motivation and lapse (OR = 0.995, 95% CI = 0.991, 0.999, *P* = 0.040) (Table 2). There was a significant negative association between motivation and lapse among those whose income is 1 SD above the mean (OR = 0.693, 95% CI = 0.587, 0.819, *P* < 0.0001), but this association was not significantly different than zero among those whose income is 1 SD below the mean (Fig. 4). The data were insensitive to detect a moderating effect of financial strain on the association between motivation and lapse (Table 2).

Abstinence self-efficacy

There was a significant negative association between abstinence self-efficacy and lapse (OR = 0.780, 95% CI = 0.719, 0.847, *P* < 0.0001). Income moderated the association between abstinence self-efficacy and lapse (OR = 0.996, 95% CI = 0.993, 0.999, *P* = 0.010) (Table 2). There was a stronger negative association between abstinence self-efficacy and lapse among those whose income is 1 SD above the mean (OR = 0.697, 95% CI = 0.624, 0.779, *P* < 0.0001), compared to those whose income is 1 SD below the mean (OR = 0.855, 95% CI = 0.766, 0.955, *P* = 0.006) (Figure 5).

Financial strain moderated the association between abstinence self-efficacy and lapse (OR = 1.020, 95% CI = 1.003, 1.038, *P* = 0.019) (Table 2). There was a stronger negative association between abstinence self-efficacy and lapse among those whose financial strain is 1 SD below the mean (OR = 0.701, 95% CI = 0.621, 0.791, *P* < 0.0001), compared to those whose financial stain is 1 SD above the mean (OR = 0.852, 95% CI = 0.766, 0.949, *P* = 0.004) (Figure 6).

Sensitivity analyses

The results for sensitivity analyses mirrored those in Table 2, except that the data were insensitive to detect a moderating effect of financial strain on the associations of positive affect ($P = 0.052$) and abstinence self-efficacy ($P = 0.074$) with lapse, as well a moderating effect of income on the association of negative affect ($P = 0.088$) and motivation ($P = 0.063$) with lapse. However, the strength of the association between the predictors and lapse at different levels of income and financial strain mirrored those of the main analyses in Table 2.

DISCUSSION

Indicators of SES were found to moderate the within-person association of key smoking risk factors with lapse likelihood. Contrary to hypotheses, the positive within-person association between negative affect and lapse was weaker among individuals with lower income and higher financial strain compared to those with higher income and lower financial strain. Similarly, the negative within-person association of positive affect, motivation and abstinence self-efficacy with lapse was weaker among individuals with lower levels of income and higher levels of financial strain.

The higher probability of lapse among those with higher financial strain is in line with research suggesting that lower SES groups have greater difficulty quitting [6, 45], as well as the reserve capacity model [28, 29] and the strength model of self-control [46]. The latter suggests that exerting self-control on one task may diminish the ability to exert self-control on different, subsequent tasks, and may be related to negative health behaviors [46]. Thus, it was hypothesized that the within-person associations of stress and negative affect with lapse would be stronger in lower SES groups. However, the association of negative affect with lapse was stronger among those with higher SES. Therefore, these data did not support the hypothesis that lower SES groups are more sensitive to risk factors such as negative affect. Despite the weaker within-person association of negative affect with lapse among those with higher financial strain and among those with lower income, those individuals still displayed a higher probability of lapse relative to smokers with lower financial strain and higher income, consistent with our prior work showing that stress mediates the association of SES with lapse [34]. One interpretation could be that frequent exposure to negative affect in lower SES groups makes individuals less sensitive to those exposures. This could be consistent with shift-and-persist or conservation of resources models, which suggest that there may be benefits to reappraising or regulating negative emotions among those who face frequent adversity or stressors [47–49].

The current results are among the first, to our knowledge, to indicate that momentary increases in protective factors (e.g. positive affect, motivation and abstinence self-efficacy) show a weaker or no association with lapse among individuals with lower SES compared to higher SES individuals (Figures 3–6). Theories of positive emotion (e.g. broaden and build; upward spiral theory) hypothesize that positive emotions build resources to regulate responses to threat and facilitate behavior change [50–52]. Similarly, abstinence self-efficacy is a central component of behavior change and a momentary predictor of smoking lapse [13, 18, 20]. Bandura proposed that there is a reciprocal relationship between the development of self-efficacy and engagement with challenging situations that enhance a sense of mastery and control [53, 54]. The literature broadly supports a positive linear association between self-efficacy and performance, yet several studies have demonstrated that because people are often faced with multiple competing goals, factors such as goal importance may result in the prioritization of certain goals and the shifting of limited resources to goals that are more personally important [55]. Indeed, studies have shown a positive within-person association between self-efficacy and performance when goal importance was high, but no association when goal importance was low [56]. Thus, one possible explanation for the current findings is that momentary increases in protective factors may have a weaker or no effect on lapse among lower SES groups to the extent that they have competing demands that require resources or are more personally important. This work also highlights the need to disaggregate the complex association between self-efficacy and health behavior change that may exist at the between- and within-person levels [57, 58]. Lower SES smokers may also be so taxed that it is difficult to exercise agency to engage in health behavior change, even when they experience increases in protective factors [53, 54, 59]. Future studies should assess the degree to which competing demands influence the effect of protective factors on smoking lapse in-the-moment.

The current results have implications for smoking cessation interventions that have been translated into daily life (e.g. just-in-time adaptive interventions, or JITAIs) [60] to deliver support when individuals experiences risk for lapse or when protective experiences can be leveraged. However, the current results suggest that, depending on SES, JITAIs targeting certain risk factors for lapse may have disparate outcomes. As shown in Figures 1–6, lapse likelihood shows very little association with negative affect or with protective factors (e.g. positive affect) among lower compared to higher SES individuals. Future research should carefully examine socio-economic differences in the efficacy of in-the-moment interventions as new approaches and treatment targets may be needed to intervene effectively with low SES individuals. Mindfulness or social support-based interventions have been posed as promising intervention targets to reduce SES-related smoking inequities [34, 61], but unique gradients of associations herein suggest that interventions may need to be targeted depending on the level of SES, even among very low SES groups.

There were limitations to this study. Electronic cigarettes (e-cig) were not available at the time of data collection; thus, caution should be used in generalizing results to e-cig users. However, more than 80% of adult tobacco users continue to use combustible products exclusively (e.g. cigarettes, cigars and pipes), and cigarettes are one of the most commonly used combustible products by lower SES groups [62, 63]. Although the data were collected in 2005–07, they

present a unique opportunity to examine research questions using a racially and ethnically diverse sample of smokers attempting to quit. With a sample consisting of nearly equal numbers of white, African American and Hispanic individuals, the current results are thus more generalizable. Moreover, the risk factors examined herein have been robust predictors of smoking lapse since the 1990s [25, 26] and in current studies [64, 65], and are unlikely to have undergone a meaningful change in the last decade or two. As such, these data remain extremely relevant in today's tobacco landscape. Income and financial strain are just two of many SES indicators; thus, the current results should be replicated to test robustness of findings across samples. The current study did not collect data on nicotine patch therapy compliance or counseling, limiting the ability to test whether patch therapy influenced outcomes. Results reported herein do not imply causation.

The current study provides important and novel information concerning the moderating effect of facets of SES on risk factors for smoking lapse. Although the present research was conducted within a very low SES population (i.e. 42% of participants reported having an annual income of less than $25 000), the results suggest that momentary precipitants of smoking lapse did not exert as strong an influence on lapse likelihood among very low SES groups. This research has implications for interventions seeking to reduce socio-economic-related inequities in racially and ethnically diverse individuals undergoing a smoking quit attempt.

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DECLARATION OF INTERESTS

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AUTHOR CONTRIBUTIONS

Lindsey N. Potter: Conceptualization; formal analysis; writing-original draft; writing-review and editing. **Chelsey Schlechter:** Conceptualization; formal analysis; writing-original draft; writing-review and editing. **Inbal Nahum-Shani:** Writing-review and editing. **Cho Y Lam:** Writing-review and editing. **Paul Cinciripini:** Writing-review and editing. **David W Wetter:** Conceptualization; funding acquisition; writing-original draft; writing-review and editing.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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