



Are posttraumatic stress and depressive symptoms pathways to smoking relapse after a natural disaster?



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ARTICLE INFO

Keywords:
Disasters
Hurricanes
Tobacco
Smoking
Relapse
Depression
PTSD

ABSTRACT

Background: Smoking relapse is rarely examined in disaster research. Thus, this study investigated smoking relapse nine and eighteen months after Hurricane Katrina and identified pathways and conditions for this outcome.

Methods: The data came from a prospective study of adult ever smokers who were living in New Orleans at the time Hurricane Katrina struck ($n = 1003$), and a comparison sample of Memphis residents ($n = 1001$) who were not directly impacted by the hurricane. Participants from both cities were recruited using random digit dialing and were surveyed nine and eighteen months after Hurricane Katrina. We assessed whether smoking relapse rates differed by city and evaluated potential mediators and moderators of this association using conditional process analysis.

Results: Though the probabilities of smoking relapse, posttraumatic stress, and depressive symptoms were higher among New Orleans than Memphis participants, hurricane exposure did not indirectly affect smoking relapse through increases in posttraumatic stress and depressive symptoms. Instead, as the number of hurricane-related events increased so to did the probability of smoking relapse through increases in depressive ($\beta = 0.08$, $SE = 0.03$, $p = .02$) and posttraumatic stress symptoms ($\beta = 0.08$, $SE = 0.04$, $p = .04$). Social support lowered the probability of smoking relapse by protecting against increases in depressive and posttraumatic stress symptoms.

Conclusions: Posttraumatic stress and depressive symptoms mediated the effects of disaster exposure on smoking relapse, and this effect was most pronounced among survivors who reported disaster-related stressors. Former smokers heavily exposed to disasters may benefit from postdisaster interventions that reduce depressive and posttraumatic stress symptoms, which may prevent smoking relapse.

1. Introduction

Disasters, which are also referred to as “big events,” “community-wide events,” or “collective trauma” (Fullerton et al., 2003), profoundly influence smoking behavior (Dimaggio et al., 2009), yet disaster research rarely focuses on postdisaster smoking relapse, which is partly responsible for the significant increase in smoking prevalence after disaster exposure (Erskine et al., 2013). Forman-Hoffman et al., (2005) first analyzed smoking relapse in the aftermath of the 9/11 World Trade Center terrorist attacks. In this study, which was a secondary analysis of a randomized controlled smoking cessation trial, they found that 16% of their sample relapsed seven days after the terrorist attack. Though this percentage seemed large, a week before the terrorist attack, 11.5% of their sample relapsed, which suggested the small increase in the incidence of smoking relapse was attributable to disaster exposure

given the expected decreasing trend over time in relapse (Forman-Hoffman et al., 2005). However, the Forman-Hoffman et al. (2005) study lacked a comparison group, which prevented them from drawing definitive conclusions about postdisaster relapse, and they may have underestimated the effect of disasters on smoking relapse because the sample included only participants who were highly motivated to quit smoking.

Two other studies examined smoking relapse since the Forman-Hoffman study (2005). The first was a small pilot study by Lanctot et al. (2008) who found that more than half of the former smokers in their sample retrospectively reported relapsing after Hurricane Katrina, and the most commonly cited reasons for relapse were stress, cravings, sadness, and depression. Similar conclusions were drawn by Erskine et al. (2013) who examined smoking prevalence after the Canterbury earthquakes using a large sample of adults from New Zealand

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($N = 1001$) who were interviewed 15 months after the earthquakes. They found that before the disaster, 41% of their sample were never smokers, 32% were former smokers, and 27% were current smokers. After the earthquakes, 24% of former smokers resumed smoking, and earthquake-related stress was reported as the primary reason they returned to smoking. Though these two studies indicated that smoking relapse was a significant problem after disaster exposure, design limitations, such as the use of a nonrandom sample, and the lack of a comparison group, prevented these studies from drawing definitive conclusions about postdisaster smoking relapse.

1.1. Identifying mechanisms and conditions for postdisaster smoking relapse

Disasters generally increase posttraumatic stress and depression (Fergusson et al., 2014; Reijneveld et al., 2005, 2003), and these sources of psychological distress may also serve as mechanisms for or pathways to smoking relapse. Smokers with posttraumatic stress and depression often experience negative affect, such as anger, contempt, disgust, guilt, fear, and nervousness, and other cognitive-affective processes, such as attentional control and rumination. Depressed smokers also experience low positive affect—reduced feelings of joy, interest, and alertness. Research suggests that individuals with posttraumatic stress and depression self-administer nicotine to regulate these symptoms (Beckham et al., 2013; Cook et al., 2007; Langdon and Leventhal, 2014; Mathew et al., 2016). When individuals quit smoking, either long or shortly before a traumatic event, such as a disaster, the reemergence of these symptoms during the onset of postdisaster psychological distress may increase the risk for smoking relapse (Cook et al., 2007).

These mechanisms may also be influenced by predisaster mental health and perceived social support. Pre-existing mental illness and distress exacerbate and increase the risk for mental disorders after disaster exposure (Norris et al., 2002; Sullivan et al., 2013). Sullivan et al. (2013) prospectively assessed a cohort of 503 veterans from New Orleans, Louisiana and found that veterans with a preexisting mental illness, compared to veterans without a preexisting mental illness, were almost 7 times (OR = 6.81 [95% CI = 2.90, 15.99]) more likely to have a new mental illness after Hurricane Katrina. Conversely, social support buffers against postdisaster psychological distress (Cohen and Wills, 1985). A cross-sectional study by Arnberg et al. (2012) investigated the protective effects of social support among 4600 adult Swedish tourists exposed to a tsunami in the Indian Ocean. Participants were surveyed 14 months after the disaster, and the researchers found the effect of social support was dependent upon the severity of exposure to the disaster—defined as the number of stressful experiences exposed to during the tsunami. The buffering effect of social support against posttraumatic stress was stronger for persons highly exposed to the disaster compared to those who were moderately or mildly exposed to the disaster (Arnberg et al., 2012).

1.2. Present study

This present study builds on the previous research of Forman-Hoffman et al. (2005) and others (Erskine et al., 2013; Lancot et al., 2008) by examining smoking relapse up to eighteen months after a sample of individuals were exposed to a natural disaster, and includes a comparison group that was relatively unaffected by the event. We also examine potential mechanisms, such as posttraumatic stress and depressive symptoms, and conditions, such as social support and pre-existing mental health, which act as pathways to postdisaster relapse. We hypothesized that individuals exposed to a disaster would have a higher risk of smoking relapse than individuals who were unexposed. Also, among individuals who were exposed to the disaster, those who reported more disaster-related stressors would have a higher risk of smoking relapse. We also hypothesized that disaster exposure and disaster-related stressors would indirectly affect smoking relapse through

increases in posttraumatic stress and depressive symptoms, and these pathways would be moderated by predisaster perceived social support and poor mental health, respectively.

2. Methods

2.1. Target population

Participants were recruited from two cities, New Orleans, Louisiana and Memphis, Tennessee. In New Orleans, the target population was residents covered by phone area code (504). Potential participants were 18–74 years of age, English-speaking, smoked at least 100 cigarettes in their lifetime, and were in New Orleans immediately before Hurricane Katrina, and returned to New Orleans by the time of survey administration. Memphis residents (area code 901) were recruited as a comparison group to isolate the effect of disaster exposure on smoking behavior. Memphis shared many sociodemographic characteristics with New Orleans according to census information collected in 2000 including per capita income (\$17,258 in New Orleans and \$17,838 in Memphis), population size (469,032 persons in New Orleans and 645,978 persons in Memphis), and telephone access (3.6% without telephones in New Orleans and 2.3% in Memphis). The same selection criteria were applied to Memphis residents, and residents from Memphis were excluded if they lived in Memphis for \leq six months or were Hurricane Katrina evacuees. We contacted 1531 eligible participants in New Orleans, of whom 1003 (65.5%) participated and completed the interview. In Memphis, 1141 eligible participants were contacted, and 1001 (87.8%) participated.

2.2. Procedures

A random digit dialing sample of residential landline phone numbers was obtained for area codes 504 and 901. A commercial service provided the 504 phone numbers and a university compiled the 901 numbers. Interviewers were required to make a minimum of 15 phone calls to each working telephone number before listing it as a non-contact. Upon successful contact, the interviewer confirmed whether the person was an adult and that the number was a residential number. The interviewer also confirmed whether the contacted person or another adult member of their household was a smoker. The adult with the most recent birthday was selected if more than one adult in the household met the smoking criterion.

The interviewers explained the study purpose and procedures and obtained verbal consent before administering the survey. Upon completing the survey, the interviewer informed the participant that he or she would be re-contacted in nine months to complete the follow-up survey. Participants were given a \$10 gift card for completing the baseline and follow-up interviews. Baseline surveys were administered between October 2006 and January 2007, and follow-up surveys between November 2007 and March 2008.

2.3. Measures

2.3.1. Independent variables

Hurricane exposure was measured by city location before Hurricane Katrina made landfall (Memphis or New Orleans). The extent of exposure to Hurricane Katrina was measured using a 12-item checklist that assessed disaster-related stressors (Brodie et al., 2006; see Supplemental Table 1). The checklist did not weight items regarding perceived severity. Also, the distribution of responses was highly skewed to the right; most participants reported no or one stressful exposure. Therefore, the checklist was categorized into four levels: no events, one event, two events, and three or more events.

2.3.2. Dependent variable

Smoking relapse was measured by asking participants to identify

whether they smoked cigarettes “daily,” “occasionally,” or “never” in the past month, and was asked for three distinct time frames. The first one retrospectively assessed smoking status a month before Hurricane Katrina. The second assessed past month smoking status at Time 1 and the last one assessed past month smoking status at Time 2. Smoking relapse occurred if the participant was a former smoker before Hurricane Katrina and smoked daily or occasionally in the past 30 days at Time 1. Also, smoking relapse occurred if they were not smoking in the past 30 days at Time 1, but were smoking daily or occasionally in the past 30 days at Time 2. The prevalence of smoking relapse was small at both time points ($N = 76$ [4%] and $N = 25$ [3%], respectively), therefore, to increase statistical power, both time points were combined.

2.3.3. Mediators

Posttraumatic stress and depressive symptomatology, the hypothesized mediators, were measured using Breslau’s Short Screening Scale for PTSD (Breslau, Peterson, Kessler, & Schultz, 1999) and the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), respectively. Breslau’s Short Screening Scale for PTSD is comprised of seven dichotomous items based on the PTSD section in the Diagnostic and Statistical Manual of Mental Disorders and the World Mental Health Composite International Diagnostic Interview. This instrument is psychometrically sound and is correlated with PTSD diagnosis based on the structured clinical interview for PTSD (Breslau et al., 1999; Kimerling et al., 2006). Inter-item reliability was high in this sample ($\alpha = .80$). The CES-D consists of twenty questions that measure cognitive, affective, behavioral, and somatic symptoms of depression (Radloff, 1977). CES-D scores range from zero to 60, and a score of 16 or higher has excellent sensitivity and specificity to identify individuals at risk for clinical depression (Lewinsohn et al., 1997). Inter-item reliability was also very high in this sample ($\alpha = .91$).

2.3.4. Effect modifiers and confounders

Effect modifiers (also referred to as moderators or statistical interactions) included perceived social support and mental health status before Hurricane Katrina. Perceived social support before Hurricane Katrina was measured using four items from the Medical Outcomes Study Social Support scale (Sherbourne and Stewart, 1991). The inter-item reliability of this modified scale was high ($\alpha = .80$), and the total score was averaged, with higher scores indicating more perceived social support (min = 0 and max = 3). Last, mental health status before Hurricane Katrina was measured using a question from the Short-Form Health Survey (SF-36), which asked: “during the last 30 days before Katrina, for how many days was your mental health not good”. Participants reported their number of days spent with poor mental health (min = 0 and max = 30). Last, age, gender, race, household income, and education were self-reported, and all were considered potential confounders.

2.4. Statistical analyses

Samples from Memphis and New Orleans contained more Whites, females, and were slightly older than the area population distribution according to the 2000 U.S. census. Thus, the sample was weighted for race, sex, and age in each analysis to the known population (Kaltun and Flores-Cervantes, 2003).

Bivariate analyses, including correlations (see Supplemental Tables 2 and 3), compared Memphis and New Orleans participants on numerous sociodemographic and psychosocial characteristics. Categorical variable(s) were analyzed using the Rao–Scott chi-square, which adjusts for sample design, and weighted t-tests for continuous variables. These analyses, which were used to determine which confounders were to be included in the primary analysis, were completed in SAS 9.4 (SAS Institute, 2005). Primary analyses were completed using conditional process analysis (Hayes, 2013, 2012) in Mplus 7.4 software (Muthén

and Muthén, 2010), and unstandardized parameter estimates were derived using weighted least squares means and variance adjustment (WLSMV) to account for the mixture of continuous and categorical endogenous variables and adjust for missing data and minor violations of normality. Parameter estimates for indirect effects and standard errors were estimated and tested using the “Model Indirect” command in MPlus (Muthén and Muthén, 2010), and multiplicative interactions, which were mean centered, were manually removed ($p \geq .05$) in a stepwise fashion, and significant interactions were decomposed using simple slopes or spotlight analyses (Bauer & Curran, 2005; Rogosa, 1980).

The final model, which excluded non-significant interactions, was evaluated for model fit according to the (1) model chi-square (χ^2_M ; Hooper et al., 2008), (2) Steiger-Lind root mean square error of approximation (RMSEA; δ ; Steiger, 1990), (3) Bentler comparative fit index (CFI; χ^2_B ; Bentler, 1990), and (4) weighted root mean square residual (WRMR; Muthén and Muthén, 2010; Yu and Muthén, 2002). The published rules for interpreting fit indices were strictly adhered to (Bentler, 1990; Hooper et al., 2008; Schermelleh-Engel et al., 2003; Steiger, 1990).

3. Results

3.1. Sample characteristics

Participants from Memphis and New Orleans were very similar in age, sex, and smoking status before Hurricane Katrina (see Table 1 for details). Most of the sample had either a high school degree (31%) or some post-high school education (32%), but participants from New Orleans were slightly less educated than participants from Memphis ($p < .01$). Also, most of the sample reported a household income between \$20,000–\$80,000 dollars (58%), and there were some differences in household income between participants from New Orleans and Memphis ($p < .01$). Participants from New Orleans reported more social support (2.47 vs. 2.37, $p < .01$, respectively) and fewer days spent with poor mental health (3 vs. 5, $p < .01$, respectively) than Memphis participants. Importantly, the number of days spent with poor mental health before Hurricane Katrina in our sample was very similar to estimates reported from national samples (Centers for Disease Control and Prevention (CDC), 2004; Moriarty et al., 2009). Regarding confounding, education and household income were chosen as covariates for primary analyses because participants from New Orleans and Memphis differed significantly on these factors.

3.2. Are hurricane exposure and disaster-related stressors associated with smoking relapse?

The model, including covariates and the interaction, explained a small portion of the variance of smoking relapse (15%). Hurricane exposure was associated with smoking relapse; according to Fig. 1, participants from New Orleans, compared to Memphis, had a higher probability of smoking relapse after Hurricane Katrina ($\beta = 0.36$, $SE = 0.14$, $p = .01$). Poor mental health also moderated this association (see Table 2). Unexpectedly, the probability of smoking relapse was higher among New Orleans than Memphis participants after Hurricane Katrina when days spent with poor mental health was one standard deviation below the average value ($\beta = 0.69$, $SE = 0.20$, $p < .01$), and there was no association between hurricane exposure and smoking relapse after Hurricane Katrina when days spent with poor mental health before Hurricane Katrina was one standard deviation above the average value ($p = .89$).

There was also some evidence that disaster-related stressors were associated with smoking relapse after Hurricane Katrina; reporting two events, compared to no events, was associated with an increased probability of smoking relapse after Hurricane Katrina ($\beta = 0.58$, $SE = 0.25$, $p = .02$). However, there was no evidence of a dose-

Table 1
Characteristics of participants from Memphis and New Orleans ($N=2004$; weighted estimates)^a.

	N (%) or mean (SD)			p^b
	Total ($N=2004$)	Memphis ($n=1001$)	New Orleans ($n=1003$)	
Race^c				
Non-Hispanic Whites	1029 (52%)	489 (25%)	539 (27%)	.31
Non-Hispanic	805 (40%)	422 (21%)	383 (19%)	
Blacks	162 (8%)	88 (4%)	74 (4%)	
Other minorities				
Sex				
Males	792 (48%)	421 (24%)	371 (24%)	.67
Females	1212 (52%)	580 (26%)	632 (27%)	
Age	42 (SD = 15)	41 (SD = 15)	42 (SD = 15)	.25
Education				
No high school degree	342 (17%)	127 (6%)	215 (11%)	< .01
High school	607 (31%)	332 (17%)	276 (14%)	
graduate or	632 (32%)	333 (17%)	299 (15%)	
equivalent	410 (21%)	202 (10%)	208 (10%)	
Some post-high				
school education				
College graduate				
Household income				
> \$20,000	353 (18%)	165 (8%)	188 (9%)	< .01
\$20,000–\$40,000	500 (25%)	267 (13%)	234 (12%)	
\$40,000–\$80,000	454 (23%)	188 (9%)	266 (13%)	
> \$80,000	383 (19%)	205 (10%)	177 (9%)	
Refused to answer	314 (16%)	176 (9%)	138 (7%)	
Disaster-related stressors^d				
None	388 (39%)	–	388 (39%)	–
One event	229 (23%)	–	229 (23%)	
Two events	194 (19%)	–	194 (19%)	
Three or more	192 (19%)	–	192 (19%)	
events				
Perceived social support	2.42	2.37	2.47	< .01
before Hurricane	(SD = 0.78)	(SD = 0.82)	(SD = 0.75)	
Katrina ^e				
Days spent with poor	4 (SD = 9)	5 (SD = 10)	3 (SD = 8)	< .01
mental health before				
Hurricane Katrina ^f				
Depressive symptoms^g	13.79	11.88	15.70	< .01
(SD = 12.31)	(SD = 11.13)	(SD = 13.11)		
Posttraumatic stress	1.59	1.43	1.76	< .01
symptoms ^h	(SD = 2.24)	(SD = 2.19)	(SD = 2.28)	
Smoking status before Hurricane Katrina				
Former	675 (34%)	322 (16%)	353 (18%)	.49
Occasional	268 (13%)	143 (7%)	125 (6%)	
Daily	1053 (53%)	530 (27%)	523 (26%)	
Smoking relapse after Hurricane Katrinaⁱ				
No	1903 (95%)	965 (58%)	938 (47%)	.04
Yes	101 (5%)	36 (2%)	65 (3%)	

^a Memphis and New Orleans samples were weighted to match the demographics from the 2000 U.S. Census. Weighted frequencies were rounded to the nearest whole number. Percentages were rounded to the nearest whole number and means and standard deviations to the nearest hundredth. Missing data was less than 5% for all characteristics and accounted for some group totals and percentages not matching the expected value.

^b p -values were derived from Rao-Scott Chi-Squared tests for frequencies and independent-t-tests for means and standard deviations. All p -values were rounded to the nearest hundredth.

^c Hispanics or Latinos, Asians, and participants of other racial backgrounds were designated as “Other minorities.”

^d The hurricane exposure checklist was only given to participants who lived in New Orleans.

^e Higher scores indicated more perceived social support; minimum and maximum scores are 0 and 3, respectively.

^f Higher scores indicated more days spent with poor mental health; minimum and maximum scores are 0 and 30, respectively.

^g Higher scores indicated more depressive symptoms; minimum and maximum scores are 0 and 60, respectively.

^h Higher scores indicated more posttraumatic stress symptoms; minimum and maximum scores are 0 and 7, respectively.

ⁱ Smoking relapse was defined as former smokers before or nine months after

Hurricane Katrina who were now smoking daily or occasionally nine or eighteen months after Hurricane Katrina, respectively.

response relationship because there were no differences in smoking relapse between participants who reported one event compared to no events ($p = .11$), and three or more events compared to no events ($p = .15$). There was also no evidence of a dose-response when disaster-related stressors were analyzed continuously ($\beta = 0.08$, $SE = 0.07$, $p = .21$).

3.3. Are hurricane exposure and disaster-related stressors indirectly associated with smoking relapse through increases in depression and posttraumatic stress symptoms?

The model, including covariates, explained a small portion of the variance of postdisaster posttraumatic stress (11%) and depressive symptoms (26%). As shown in Table 2, participants from New Orleans compared to Memphis had more posttraumatic stress ($\beta = 0.41$, $SE = 0.13$, $p < .01$) and depressive symptoms ($\beta = 4.68$, $SE = 0.71$, $p < .01$) after Hurricane Katrina. Posttraumatic stress symptoms were associated with an increase in the probability of smoking relapse after Hurricane Katrina ($\beta = 0.06$, $SE = 0.03$, $p = .02$). However, hurricane exposure did not indirectly affect smoking relapse through increases in posttraumatic stress symptoms ($p = .07$). Depressive symptoms were not associated with smoking relapse after Hurricane Katrina ($p = .22$).

Among participants living in New Orleans during Hurricane Katrina, reporting one event ($\beta = 3.21$, $SE = 1.22$, $p = .01$), or three or more hurricane-related events ($\beta = 6.77$, $SE = 1.36$, $p < .01$), compared to no events, was associated with increased depressive symptoms after Hurricane Katrina. Similarly, reporting two events ($\beta = 0.54$, $SE = 0.25$, $p = .03$), or three or more events ($\beta = 1.16$, $SE = 0.25$, $p < .01$), compared to no events, was associated with increased posttraumatic stress symptoms after Hurricane Katrina. Analyzing disaster-related stressors continuously showed better evidence of a dose-response relationship; each disaster-related event was associated with an increase in depressive ($\beta = 1.54$, $SE = 0.33$, $p \leq .01$) and posttraumatic stress symptoms ($\beta = 0.23$, $SE = 0.06$, $p \leq .01$). Depressive ($\beta = 0.01$, $SE = 0.01$, $p = .02$) and posttraumatic stress symptoms ($\beta = 0.07$, $SE = 0.03$, $p = .03$) were also associated with an increased probability of smoking relapse after Hurricane Katrina. Importantly, as the number of hurricane-related events increased so to did the probability of smoking relapse through increases in depressive ($\beta = 0.08$, $SE = 0.03$, $p = .02$) and posttraumatic stress symptoms ($\beta = 0.08$, $SE = 0.04$, $p = .04$; see Table 3).

3.4. Do predisaster social support and poor mental health moderate the depressive symptoms and posttraumatic stress pathways?

There was no evidence that predisaster poor mental health moderated the depressive symptoms and posttraumatic stress pathways. These pathways, however, were to some degree moderated by predisaster perceived social support. For instance, among participants who reported one hurricane-related event, compared to no events, and when perceived social support before Hurricane Katrina was one standard deviation below the average value, the pathway from disaster-related stressors to smoking relapse through depressive symptoms was significant ($\beta = 0.06$, $SE = 0.03$, $p = .04$), but the pathway weakened as perceived social support increased. The same pattern was observed for posttraumatic stress symptoms though the associations were non-significant (see Table 3).

4. Discussion

This study supports and extends the results of Forman-Hoffman et al. (2005) and others (Erskine et al., 2013; Lanctot et al., 2008) regarding the effect of disaster exposure on smoking relapse. Initially, we knew, based on the results by Forman-Hoffman et al., that the risk of

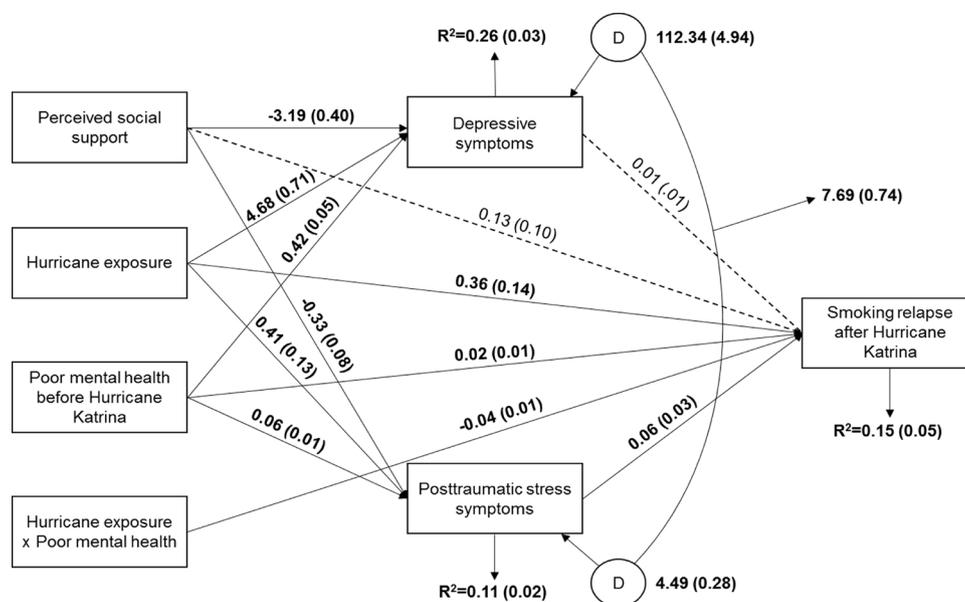


Fig. 1. A path model illustrating the adjusted effects of disaster exposure on posttraumatic stress and depressive symptoms (unstandardized estimates). Bolded text or a solid path arrow denotes a significant path ($p \leq .05$), and a dotted line denotes a nonsignificant path (see Table 2 for complete details).

smoking relapse was higher two weeks after disaster exposure; our study demonstrates that the risk of smoking relapse persists for at least eighteen months post-disaster. Also, because Forman-Hoffman et al. examined relapse over a short period, they were unable to examine whether the severity of exposure increased the probability of smoking relapse. By examining smoking relapse over an extended period, our study detected this effect; we observed that the magnitude of exposure to disaster-related stressors is associated with smoking relapse. More importantly, a particularly novel finding was that the probability of smoking relapse was moderated by the number of days spent with poor mental health before Hurricane Katrina. Among those who spent very few days with poor mental health, the probability of smoking relapse was higher for participants from New Orleans than from Memphis, and there was no difference in smoking relapse between participants from New Orleans and Memphis among those with many days spent with poor mental health. Participants with poor mental health before Hurricane Katrina may have a history of traumatic and stressful events, whereas Hurricane Katrina could have served as the first traumatic event for participants with good mental health, and this event, as has been shown in past research (Boyko et al., 2015; Forbes et al., 2015), increased their risk of smoking relapse.

The extent of exposure to Hurricane Katrina, as measured by disaster-related stressors, seems to be the primary factor that determines whether depressive and posttraumatic stress symptoms are pathways to smoking relapse. Many hurricane-related events, such as losing property or friends and relatives, involve a significant loss of financial and social resources, and resource loss increases the risk of PTSD and depression after disaster exposure (Hobfoll et al., 2006). Experiencing multiple disaster-related events compounds resource loss, which would further increase the severity of PTSD and depression. As posttraumatic stress and depressive symptoms increase, former smokers may experience more negative affect, less positive affect, and cognitive impairment, which would increase the risk of smoking relapse (Cook et al., 2007; Mathew et al., 2016). Previous disaster research also shows that posttraumatic stress and depression increase the risk for cigarette use (Biggs et al., 2010; Boscarino et al., 2011; Breslau et al., 2003; Fullerton et al., 2013; Nandi et al., 2005; Rohrbach et al., 2009), but this is the first study to show empirically that disaster-related events indirectly affect smoking relapse through increases in posttraumatic stress and depressive symptoms.

Social support protects against smoking relapse after Hurricane

Katrina by decreasing the effect of disaster-related stressors on depressive and posttraumatic stress symptoms. This observation aligns with the social support buffering hypothesis (Cohen and Wills, 1985), and also extends the application of social support to smoking behavior, primarily when the smoking behavior is associated with depression or posttraumatic stress. However, social support is not directly associated with smoking relapse. Social support has mixed findings for postdisaster smoking behavior; one study demonstrated that it was a protective factor (Flory et al., 2009), another a risk factor (Vlahov et al., 2004), and another, similar to this study, showed no association at all (Nandi et al., 2005). Past research shows that the benefits of perceived social support peaks 84 days after abstinence, and minimization of negative support—interactions with members in one's social network that involved resentment, sadness, or shame (Lincoln, 2000)—during more prolonged periods of abstinence is essential for cessation maintenance (Lawhon et al., 2009; Mermelstein et al., 1986). Therefore, in our sample, the benefits of perceived social support for may have weakened over time.

This study has some significant limitations. First, most variables included in this study were assessed retrospectively, which limits our ability to draw stronger conclusions about our findings. Though retrospective assessments of smoking status are consistent over time and match well with contemporaneous reports of smoking behavior (Bernaards et al., 2001; Kenkel et al., 2003), retrospective reports of perceived social support and poor mental health have been shown to be over- and under-stated, respectively, compared to contemporaneous reports (Smith et al., 1999; Takayanagi et al., 2014). Relatedly, poor mental health, though a correlate of depression and anxiety-related disorders (Centers for Disease Control and Prevention, 1998), is a weaker indicator of psychological functioning than clinical records or other valid measures of depression and posttraumatic stress. These results will need to be replicated in future studies that include stronger indicators of predisaster psychological and social functioning, ideally collected contemporaneously.

Second, smoking has been shown to increase the risk for depression and posttraumatic stress (Mathew et al., 2016; Van der Velden et al., 2008, 2007) and vice-versa; we were unable to control for this bi-directional effect because we combined Time 1 and Time 2 smoking relapse. Larger prospective studies are needed to increase cases of relapse, and multiple waves of data are needed to improve the estimation of indirect effects by minimizing the bi-directional effect of smoking and

Table 2
Weighted least squares means and variance adjusted estimates for a recursive model of hurricane exposure and smoking relapse (N = 1960^a).

Parameters	Unstandardized	SE	p
<u>Direct effects</u>			
Hurricane exposure → Depressive symptoms			
Memphis	REF		
New Orleans	4.68	0.71	< .01
Number of days spent with poor mental health → Depressive symptoms	0.42	0.05	< .01
Perceived social support → Depressive symptoms	- 3.19	0.40	< .01
Education → Depressive symptoms			
No high school degree	REF		
High school graduate or equivalent	1.61	0.86	.06
Some post-high school education	1.66	0.96	.08
College graduate	3.90	1.11	< .01
Household income → Depressive symptoms			
> \$80,000	REF		
\$40,000–\$80,000	0.81	1.03	.43
\$20,000–\$40,000	3.91	1.02	< .01
> \$20,000	5.19	1.11	< .01
Refused to answer	0.66	1.16	.57
Hurricane exposure → Posttraumatic stress symptoms			
Memphis	REF		
New Orleans	0.41	0.13	< .01
Number of days spent with poor mental health → Posttraumatic stress symptoms	0.06	0.01	< .01
Perceived social support 30 days → Posttraumatic stress symptoms	- 0.33	0.08	< .01
Education → Posttraumatic stress symptoms			
No high school degree	REF		
High school graduate or equivalent	0.11	0.17	.51
Some post-high school education	- 0.30	0.18	.10
College graduate	- 0.06	0.23	.78
Household income → Posttraumatic stress symptoms			
> \$80,000	REF		
\$40,000–\$80,000	0.11	0.19	.55
\$20,000–\$40,000	0.21	0.19	.27
> \$20,000	0.42	0.21	.05
Refused to answer	- 0.41	0.23	.08
Hurricane exposure → Smoking relapse			
Memphis	REF		
New Orleans	0.36	0.14	.01
Depressive symptoms → Smoking relapse	0.01	0.01	.22
Posttraumatic stress symptoms → Smoking relapse	0.06	0.03	.02
Number of days spent with poor mental health → Smoking relapse	0.02	0.01	.01
Perceived social support Katrina → Smoking relapse	0.13	0.10	.19
Education → Smoking relapse			
No high school degree	REF		
High school graduate or equivalent	0.15	0.18	.39
Some post-high school education	- 0.09	0.20	.66
College graduate	- 0.57	0.26	.03
Household income → Smoking relapse			
> \$80,000	REF		
\$40,000–\$80,000	- 0.34	0.21	.10
\$20,000–\$40,000	0.05	0.19	.80
> \$20,000	- 0.24	0.27	.36
Refused to answer	- 0.06	0.25	.81
Hurricane exposure x Number of days spent with poor mental health → Smoking relapse	- 0.04	0.01	.01
<u>Moderated effects^b</u>			
Hurricane exposure x Number of days spent with poor mental health → Smoking relapse			
Memphis	REF		
New Orleans at 1SD below the average number of days spent with poor mental health	0.69	0.20	< .01

Table 2 (continued)

Parameters	Unstandardized	SE	p
New Orleans at 1SD above the average number of days spent with poor mental health	0.02	0.18	.89
<u>Indirect effects^b</u>			
Hurricane exposure → Depressive symptoms → Smoking relapse			
Memphis	REF		
New Orleans	0.03	0.02	.23
Hurricane exposure → Posttraumatic stress symptoms → Smoking relapse			
Memphis	REF		
New Orleans	0.02	0.01	.07
<u>Disturbance variances and covariances</u>			
Depressive symptoms	112.34	4.94	< .01
Posttraumatic stress symptoms	4.49	0.28	< .01
Depressive symptoms with Posttraumatic stress symptoms	7.69	0.74	< .01
<u>R²</u>			
Depressive symptoms	0.26	0.03	< .01
Posttraumatic stress symptoms	0.11	0.02	< .01
Smoking relapse	0.15	0.05	< .01

^a 44 cases were removed from the analyses (less than 2% missing from analyses).

^b Moderated effects were tested using simple slope analyses.

[†] The model had excellent fit according to chi-square test of model fit (DF = 2, $\chi^2_M = 0.36, p = .83$), RMSEA ($\epsilon = 0.00$ [90% CI = 0.00, 0.03]), CFI (1.00), and WRMR (0.08).

psychological distress. Third, almost 40% of participants who lived in New Orleans during Hurricane Katrina reported no hurricane-related stressful events, which suggests that many participants in New Orleans had limited exposure to Hurricane Katrina. The checklist we used to measure disaster-related stressors was not comprehensive and issues, such as victimization and property loss (other than home damage), were not addressed. Thus, a small number of people may have been misclassified, which would bias our estimates downward regarding smoking relapse and posttraumatic stress and depressive symptoms pathways. Last, the original study excluded persons who did not own a telephone or only used a mobile phone for communication; spoke languages other than English; or never returned to New Orleans after Hurricane Katrina; therefore, potentially vulnerable individuals were not included in the study.

In conclusion, posttraumatic stress and depressive symptoms mediate the effects of disaster exposure on smoking relapse, and this effect is most pronounced among survivors who experience more disaster-related stressors. Persons who have been severely exposed to a disaster may benefit from postdisaster interventions that target psychological distress, specifically depression and posttraumatic stress. By decreasing posttraumatic stress and depressive symptoms, these interventions may prevent many former smokers from returning to tobacco after disaster exposure.

Role of funding Source

The study was supported by a National Institute on Drug Abuse grant (1 R21 DA021782-01, K. Ward, PI).

Contributors

AA formulated the research questions, hypotheses, conducted analyses, and prepared the 1 st draft of the manuscript. All authors revised the 1 st draft and approved the final manuscript.

Conflict of interest

No conflict declared.

Table 3
Weighted least squares means and variance adjusted estimates for a recursive model of disaster-related stressors and smoking relapse ($N = 979$)[†].

Parameters	Unstandardized	SE	p
<u>Direct effects</u>			
Disaster-related stressors → Depressive symptoms			
No events	REF		
One events	3.21	1.22	.01
Two events	1.61	1.41	.25
Three or more events	6.77	1.36	< .01
Number of days spent with poor mental health → Depressive symptoms	0.43	0.06	< .01
Perceived social support → Depressive symptoms	-2.43	0.65	< .01
Education → Depressive symptoms			
No high school degree	REF		
High school graduate or equivalent	1.18	1.32	.37
Some post-high school education	0.36	1.46	.81
College graduate	2.04	1.62	.21
Household income → Depressive symptoms			
> \$80,000	REF		
\$40,000–\$80,000	0.47	1.49	.76
\$20,000–\$40,000	3.35	1.54	.03
> \$20,000	6.17	1.71	< .01
Refused to answer	0.16	1.83	.93
Disaster-related stressors x Perceived social support → Depressive symptoms	-2.93	1.39	.04
Disaster-related stressors → Posttraumatic stress symptoms			
No events	REF		
One events	0.34	0.23	.15
Two events	0.54	0.25	.03
Three or more events	1.16	0.25	< .01
Number of days spent with poor mental health → Posttraumatic stress symptoms	0.07	0.01	< .01
Perceived social support → Posttraumatic stress symptoms	< -0.01	0.12	.97
Education → Posttraumatic stress symptoms			
No high school degree	REF		
High school graduate or equivalent	0.18	0.23	.45
Some post-high school education	-0.63	0.25	.01
College graduate	-0.17	0.32	.59
Household income → Posttraumatic stress symptoms			
> \$80,000	REF		
\$40,000–\$80,000	-0.14	0.26	.58
\$20,000–\$40,000	0.07	0.27	.80
> \$20,000	0.24	0.30	.43
Refused to answer	-1.02	0.36	.01
Disaster-related stressors x Perceived social support → Posttraumatic stress symptoms	-1.01	.27	< .01
Disaster-related stressors → Smoking relapse			
No events	REF		
One events	0.37	0.23	.11
Two events	0.58	0.25	.02
Three or more events	0.37	0.26	.15
Depressive symptoms → Smoking relapse	0.01	0.01	.01
Posttraumatic stress symptoms → Smoking relapse	0.07	0.03	.03
Number of days spent with poor mental health → Smoking relapse	-0.02	0.01	.15
Perceived social support → Smoking relapse	0.09	0.01	.61
Education → Smoking relapse			
No high school degree	REF		
High school graduate or equivalent	0.11	0.24	.64
Some post-high school education	-0.01	0.24	.98
College graduate	-0.80	0.46	.08
Household income → Smoking relapse			
> \$80,000	REF		
\$40,000–\$80,000	-0.35	0.25	.16
\$20,000–\$40,000	0.01	0.27	.97
> \$20,000	-0.71	0.32	.03
Refused to answer	-0.18	0.38	.63

Moderated effects^b

Table 3 (continued)

Parameters	Unstandardized	SE	p
Disaster-related stressors x Perceived social support → Depressive symptoms			
No events	REF		
One event at 1SD below the average perceived social support	5.38	1.55	< .01
One event at 1SD above the average perceived social support	1.04	1.65	.53
Disaster-related stressors x Perceived social support → Posttraumatic stress symptoms			
No events	REF		
One event at 1SD below the average perceived social support	1.08	0.30	< .01
One event at 1SD above the average perceived social support	-0.41	0.31	.19
<u>Indirect Effects</u>			
Disaster-related stressors → Depressive symptoms → Smoking relapse			
No events	REF		
One events	0.04	0.02	.08
Two events	0.02	0.02	.29
Three or more events	0.08	0.03	.02
Disaster-related stressors → Posttraumatic stress symptoms → Smoking relapse			
No events	REF		
One events	0.02	0.02	.26
Two events	0.04	0.02	.13
Three or more events	0.08	0.04	.04
<u>Conditional Indirect Effects</u>			
Disaster-related stressors x Perceived social support → Depressive symptoms → Smoking relapse			
No events	REF		
One event at 1SD below the average perceived social support	0.06	0.03	.04
One event at 1SD above the average perceived social support	0.01	0.02	.55
Disaster-related stressors x Perceived social support → Posttraumatic stress symptoms → Smoking relapse			
No events	REF		
One event at 1SD below the average perceived social support	0.07	0.04	.07
One event at 1SD above the average perceived social support	-0.03	0.02	.22
<u>Disturbance variances and covariances</u>			
Depressive symptoms	131.04	8.93	< .01
Posttraumatic stress	4.38	0.37	< .01
Depression symptoms with Posttraumatic stress symptoms	7.52	1.03	< .01
<u>R²</u>			
Depressive symptoms	0.24	0.03	< .01
Posttraumatic stress symptoms	0.16	0.03	< .01
Smoking relapse	0.26	0.09	< .01

^a24 cases were removed from the analyses (2% missing from analyses).

^b Moderated effects were tested using simple slope analyses.

[†] The model had acceptable fit according to chi-square test of model fit (DF = 1, $X^2_M = 1.90$, $p = .17$), RMSEA ($\epsilon = 0.03$ [90% CI = 0.00, 0.10]), CFI (1.00), and WRMR (0.20).

Acknowledgements

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.drugalcdep.2018.09.025>.

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