In the Wake of California Wildfires: Promoting Psychological Resilience for Individuals and Communities

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ABSTRACT

Climate change is increasing the frequency, intensity, and duration of wildfires in the United States (US), with Western states like California heavily impacted. Wildfires pose direct risks to individuals (e.g., property destruction, loss of life) and indirect risks through exposure to harmful fine particulate matter ($PM_{2.5}$) from wildfire smoke. However, the psychological impacts of wildfire exposure are largely understudied. To address this gap, this paper will 1) review existing literature on mental health impacts of wildfires, 2) present new empirical findings on mental health impacts of exposure to wildfires and wildfire-induced fine particulate matter ($PM_{2.5}$) among Californian residents, and 3) discuss key takeaways for mental health practitioners. We conducted a secondary data analysis of California households that took part in NielsenIQ's Annual Ailments, Health, and Wellness Survey (AAHWS) from 2011-2017. Participants (*N*=22,509) reported whether any household member had experienced depression and/or anxiety in the past six months. We linked these data, at the zip code level, with past year environmental data on wildfire and wildfire smoke ($PM_{2.5}$) exposure. Adjusting for key sociodemographic variables, fixed effect models show exposure to both wildfires and $PM_{2.5}$ was associated with significantly greater probability of household depression and/or anxiety in the following year. Clinicians should be aware of mental health needs associated with wildfire exposure, including wildfire smoke exposure. The need for enhanced monitoring of mental health symptoms during times of acute and chronic exposure is discussed, as well as opportunities to rapidly deploy mental health resources to promote psychological resilience in affected communities.

Keywords: wildfire, wildfire smoke, trauma, mental health, psychological resilience

Professional mental health practitioners in the United States (US) have a long history of delivering evidence-based services in response to traumatic events that create needs at the individual and community level (e.g., natural disasters, school violence). However, many practitioners are ill-equipped to understand and respond to needs created by wildfires—an understudied but rapidly increasing source of psychological trauma. Human-caused climate change is resulting in more frequent and severe environmental disasters in the US and across the globe, including heatwaves, droughts, and flooding (Clarke et al., 2022; Laufkötter, Zscheischler, & Frölicher, 2020). These climate changes are understood to directly affect wildfire activity, with global climate data showing that fire weather seasons have significantly lengthened since the 1970s over more than one-quarter of the Earth's surface and that global 'burnable' area has more than doubled (Jolly et al., 2015). Correspondingly, the incidence of forest fires across the world has more than doubled since 1984 (Mansoor et al., 2022).

These changes have been keenly felt in the western US, where increased spring and summer temperatures and earlier spring snowmelt (i.e., driven by warming temperatures caused by greenhouse gas emissions) increase the risk for large wildfire activity (Westerling et al., 2006). Since the 1970s, the western US has experienced a 4-fold increase in the number of large wildfires that consume at least 400 acres (Jolly et al., 2015). This changing fire landscape is illustrated by multiple recent wildfire disasters in California, including the 2018 Camp Fire (i.e., centered in Paradise, California) and the 2025 Los Angeles wildfires—examples of the extreme threat that large wildfires pose to both rural and urban communities.

The Camp Fire ignited on November 8, 2018 in Butte County, California, and ultimately destroyed the town of Paradise, becoming—to that point—the most destructive and deadliest wildfire in the state's history, with 85 fatalities, >153,000 acres burned, and >18,800 structures destroyed (State of California Watershed Emergency Response Team, 2018). Environmental conditions, including dry weather, strong winds, and heavy fuel loading (i.e., vegetation overgrowth), created optimal conditions for a wildfire outbreak, which was ultimately ignited by a high-voltage transmission tower later determined to have been improperly maintained by Pacific Gas & Electric (PG&E) (Maranghides et al., 2021; Kohn, 2021). Beyond loss of life and property, survey data collected at multiple time points in the aftermath of the Camp Fire showed that individuals who had been directly exposed to the wildfire had a significantly higher number of mental health symptoms in the months following the disaster, including symptoms of post-traumatic stress disorder (PTSD), depression, and anxiety (Silveria et al., 2022). Importantly, previous traumatic experiences, especially childhood trauma or adverse childhood events (ACEs), were found to significantly increase risk of poor mental health functioning in the wake of wildfire exposure, and personal resilience was inversely associated with mental health symptom severity (Silveria et al., 2022).

The 2025 Los Angeles wildfires show how rapid climate change is also increasing risk for residents of urban, densely populated areas. In early 2024, extreme precipitation in southern California led to rapid vegetation growth, which was followed by very hot temperatures in summer and fall. This resulted in highly combustible, dry vegetation across large swaths of the region. The onset of warm and exceptionally powerful Santa Ana

winds (i.e., up to 100 miles per hour) created an ideal environment for rapidly spreading urban wildfires (Tarik, Errett, & Casey, 2025). Indeed, two large wildfires (i.e., Palisades and Eaton) erupted in Los Angeles on January 7, 2025, causing the deaths of at least 28 people, destruction of >16,000 structures, and an economic loss estimated to be between $76 billion and $131 billion (Barnes et al., 2025; Li & Yu, 2025). Of note, the Santa Ana winds are expected to continue to cause major increases in large wildfire occurrence and overall burned areas in California by the year of 2085, primarily due to effects of projected temperature increases (Westerling et al., 2011). While the mental health impacts of the recent Los Angeles fires are not yet known, electronic health record (EHR) data from Kaiser Permanente, the state's largest healthcare provider, show the Los Angeles fires increased acute healthcare utilization, with outpatient neuropsychiatric visits significantly higher than expected during the wildfire exposure period (Casey et al., 2025).

Overall, however, the psychological impacts of wildfires remain largely understudied. Studies from other hazards-related disasters show that direct exposure increases risk for a variety of mental health-related challenges. For instance, a large body of research has shown that Hurricane Katrina had negative psychological impacts on residents of Gulf Coast, including increases in mental health symptoms and suicidality (Kessler et al., 2006; Raker et al., 2019; An et al., 2019). A systematic mapping review of global literature on flood exposure found consistent mental health impacts for victims of flooding, including symptoms of PTSD, depression, and anxiety (Fernandez et al., 2015). Individuals directly exposed to the 2010 Canterbury earthquakes (i.e., centered in Christchurch, New Zealand) and the 2004 Indian Ocean tsunami showed elevated

symptoms of PTSD, anxiety, and depression after the events, with some mental health impacts persisting for months and/or years following exposure (Beaglehole et al., 2019; van Griensven et al., 2006).

A recent scoping review on the psychological impacts of wildfires shows scant existing rigorous studies in this area, with only 11 studies based in the US, most using cross-sectional survey data, and an almost exclusive focus on PTSD symptoms (To, Eboreime, & Agyapong, 2021). These findings consistently show an increased rate of trauma-related mental health symptoms in both adults and children following direct wildfire exposure (To et al., 2021). More recently, concerns have emerged that not only direct exposure to wildfires but also indirect exposure to harmful fine particulate matter ($PM_{2.5}$) from wildfire smoke may negatively impact mental health. A 2022 scoping review on the mental health effects of wildfire smoke exposure identified 15 studies, only nine of which used quantitative methods and all of which focused on a single wildfire smoke exposure event (Eisenman & Galway, 2022). Wildfire smoke contains large concentrations of fine particulate matter ($PM_{2.5}$), as well as other hazardous air pollutants, which, due to climate change, are increasing (Liu et al., 2016). Poor air quality, including exposure to $PM_{2.5}$, can have serious impacts on individuals' psychological wellbeing. A 2021 meta-analysis of data from >1.4 million participants across 30 studies identified strong associations between poor air quality (i.e., ambient particulate matter pollution) and increased risk for suicidality and depression (Liu et al., 2021). These findings contrasted with an older meta-analysis that included 22 studies published between 2009 and 2019 that did not find associations between fine particulate matter and depression, though that

meta-analysis noted concerns with credibility (i.e., high heterogeneity and inconsistent results across studies) (Fan et al., 2020).

Rigorous studies are urgently needed to better understand the relationship between wildfire and wildfire smoke exposure in order to plan for and deliver mental health services to individuals and communities. Therefore, we conducted a longitudinal quantitative analysis, using integrated environmental and survey-response data from a large sample of Californian households, to better understand the mental health impacts of exposure to wildfires and wildfire-induced fine particulate matter ($PM_{2.5}$). Findings have important implications for mental health professionals in California and beyond.

METHOD

Datasets

We conducted a secondary data analysis that integrated household survey data and environmental data on wildfire and wildfire smoke (i.e., fine particulate matter [$PM_{2.5}$]). To accomplish this, we initially obtained data from California households completing the NielsenIQ's Annual Ailments, Health, and Wellness Survey (AAHWS) for the years 2011-2017. NielsenIQ maintains a nationally representative panel of households, geographically identified at the 5-digit zip code level, who annually report on a variety of economic and health-related behaviors for academic research purposes (Alviola et al., 2010; Zare & Zheng, 2021; Kim & Mark, 2023). For our study, we were interested in available mental health data, in which panelists were asked to indicate whether any household members had experienced "depression and/or anxiety" during the past 6 months." This variable was

available for the 2011-2017 survey datasets. Extracting the California subsample from the national sample resulted in 22,509 Californian households in our estimation sample. **Table 1** displays the sociodemographic characteristics of our AAHWS sample, as well as comparisons with the Census Bureau's American Community Survey (ACS) sample of Californian households (i.e., spanning 2012-2016). This post hoc comparison was completed because although the NielsenIQ panel is designed to be nationally representative, it is not necessarily representative at the state level. While our California AAHWS estimation sample and the ACS sample were largely similar, households in the AAHWS sample were more likely to live in detached, single-family houses and to have moderate (versus low or high) income, are more likely to be married, are more educated, are older, and are less likely to have children in the household.

We next obtained publicly available wildfire smoke data from the Environmental Change and Human Outcomes Lab of Stanford University (Childs et al., 2022). This dataset includes integrated ground, satellite, and reanalysis data for the US from 2006-2020; a machine learning model generates daily, gridded 10 km-square estimates of wildfire smoke-driven $PM_{2.5}$ (i.e., particulate matter with a diameter of 2.5 microns or less) concentrations. A wildfire $PM_{2.5}$ measure greater than zero implies the existence of some wildfire smoke, while a grid cell is assigned a value of zero when there is no smoke present. Exceeding 35 $\mu g/m^3$ over a 24-hour period is considered unhealthy, especially for sensitive groups, while prolonged exposure to 50 $\mu g/m^3$ can lead to serious health issues. Wildfire-driven PM is lower on average than ambient PM, as it is zero in the absence of wildfires. However, wildfire PM is known to be particularly toxic, with chemical constituents that lead

to increased pulmonary inflammation and oxidative stress, as well as a higher incidence of respiratory infections, compared to ambient urban PM (Aguilera et al., 2021). This dataset has been widely used to study the effects of wildfire smoke on non-mental health-related outcomes (Gould et al., 2023; Heft-Neal et al., 2023; Han et al., 2024). We spatially averaged this data to the zip code level and merged it with survey data from our AAHWS sample.

As the AAHWS data is annual and the month a household was surveyed is not documented, we utilized prior calendar year wildfire exposure measures to ensure exposure occurred prior to the reporting of household health conditions. We also matched to a household's prior year zip codes to ensure that any wildfire exposure was experienced in the year prior to the AAHWS survey (i.e., in case the household moved in the subsequent year). We constructed three measures of wildfire smoke exposure for our analysis: the number of days in the prior calendar year that a household's zip code experienced wildfire $PM_{2.5}$ exceeding 20, 35, or 50 $\mu g/m^3$. While thresholds of 35 and 50 $\mu g/m^3$ are commonly used thresholds, we also wanted to assess the lower threshold of 20 $\mu g/m^3$ given the higher toxicity of wildfire PM.

We obtained wildfire exposure data from the US Interagency Fire Occurrence Reporting Modules Fire Occurrence Data Records. The records contain information on fire events, including start and end dates, location, acreage burnt, and whether it was a prescribed fire or a wildfire. We limited our analysis to wildfire events that burned at least one acre of land, as smaller fires are unlikely to have detectable impacts on households, and people may react differently to prescribed fires than wildfires. We matched these fires

based on their coordinates to household zip codes. As with the wildfire smoke data, we considered the effect of wildfires that occurred during the calendar year prior to the completion of the AAHWS survey. Wildfire exposure measures include the number of days in the prior calendar year when a wildfire of at least 1 or 10 acres was burning either within a household's zip code or within 50 miles of the zip code's centroid. **Table 2** shows the wildfire and wildfire smoke exposure variables used in the analysis.

Statistical analysis

We linked the two wildfire data sets (i.e., wildfire smoke and wildfire exposures) to the 2011-2017 AAHWS data by zip code to obtain an annual panel of households, their sociodemographic and household characteristics, an indicator for whether a household member had experienced depression and/or anxiety in the prior 6 months, zip code and county of residence, and the measures of wildfire and wildfire smoke exposure from 2010-2016. About 15.8% of panelists in our sample reported a household member experiencing depression and/or anxiety. Notably, anxiety and depression are highly comorbid with each other, both are internalizing disorders, and global data have found that ~45% of individuals with a lifetime history of major depressive disorder also had at least one diagnosed anxiety disorder (Kalin, 2020; Kessler et al., 2015).

In our empirical model, the dependent variable is a binary indicator for a household reporting that a household member experienced depression and/or anxiety in the prior 6 months. The independent variables include wildfire exposure (i.e., seven total variables as represented in **Table 2**) and sociodemographic covariables, including age, education, income, and race/ethnicity of the respondent. We estimate this relationship using the

quasi-Poisson maximum likelihood method described in Cameron and Trivedi (2007), which relaxes the Poisson distribution assumption (i.e., allowing for overdispersion in the data) and is appropriate for binary outcomes. Specifically, we utilized the "ppmlhdfe" package in STATA. We chose this method for two primary reasons. First, the package allows for estimation of high dimensional fixed effects, not computationally feasible using standard binary outcome models such as a logit or probit model. This allowed us to control for either Designated Market Area (DMA) region (i.e., a larger geographic region frequently used by NielsenIQ for marketing studies) or county level fixed effects – in other words, to account for baseline differences in depression/anxiety across geographies, as well as calendar year fixed effects to control for state-wide temporal trends. Second, the pseudo-Poisson model lends itself to easier interpretation as coefficients can be interpreted as quasi- or semi-elasticities.

We estimated the model for each wildfire exposure variable separately using both DMA region and county fixed effects in addition to calendar year fixed effects. Our preferred model used DMA region-level fixed effects. There are 7 DMA regions in California, such that using DMA region fixed effects reduces the number of parameters to estimate relative to county fixed effects, improving model parsimony and statistical power. Nevertheless, DMA regions should provide a good proxy for regional variation in geographic trends. DMA regions align with how individuals receive information and make decisions—particularly in contexts involving public awareness, political messaging, or consumer behavior (Shafer et al., 2020; Sides, Vavreck & Warshaw, 2022). DMA region fixed effects can capture unobserved heterogeneity tied to shared media content, regional campaigns, or advertising

strategies that are not necessarily aligned with county boundaries. As a sensitivity analysis, we replicated the analysis with county-fixed effects, with the limitation that there are 58 counties in California and some counties have few AAHWS observations; county-level fixed effects may reduce statistical power, absorb meaningful cross-county variation and potentially overfit the model.

RESULTS

Table 3 and Table 4 display the empirical estimation results for wildfire exposure and wildfire smoke exposure, respectively. In the tables, each column represents a separate estimation of the model using DMA region-level or county-level fixed effects. Results showed that households with higher educational attainment, as well as those living in a single-family house, were generally less likely to report depression and/or anxiety. Larger households, lower-income households, those who identified as white and non-Hispanic, and households currently or previously receiving public benefits from the Women, Infants, and Children (WIC) program were generally more likely to report depression and/or anxiety.

Findings show that prior year wildfires and wildfire smoke ($PM_{2.5}$) exposure are associated with a greater probability of a household reporting depression/anxiety. Each additional day with a $\geq$1 acre wildfire burning within one's zip code is associated with a 7.5% increase in the probability of a household reporting depression/anxiety the following year or about a 1.2 percentage-point increase in absolute terms (i.e., 0.075 * 0.158 = 0.01185). There was no statistically significant impact of a $\geq$10 acre wildfire, likely due to limited power to estimate this effect, as few households in the sample experienced such a

large fire during the years for which data were gathered. However, we found similar impacts for a ≥1 and ≥10 acre wildfire within 50 miles of a household's zip code. An additional day of such exposure was associated with a 2.6-2.8% increase in the probability of a household reporting depression/anxiety in the following year.

The effects of wildfire smoke exposure on mental health were larger than those estimated for wildfire exposure, with higher levels of fine particulate matter pollution from wildfire smoke corresponding to larger impacts. Table 4 shows an additional day in the prior year with wildfire $PM_{2.5}$ exceeding 20μg/m^3, 35μg/m^3, or 50μg/m^3 is associated with a 2.6-3.0%, 4.4-5.0%, and 5.0-6.5% increase in the probability of a household reporting depression and/or anxiety in the following year, respectively. In absolute terms, these represent increases of up to 0.5, 0.8, and 1 percentage point, respectively. Given that wildfire smoke lasts about 2-3 days on average (see **Table 2**), this suggests that wildfire smoke could be associated with a 2-3% absolute increase in depression and/or anxiety per year in impacted areas of California.

DISCUSSION

To our knowledge, these are among the first empirical findings to show that wildfire smoke exposure has a dose-response relationship with poor mental health among a large sample of US residents, such that additional days of exposure to harmful wildfire $PM_{2.5}$ resulted in an increased likelihood of household anxiety and depression within the following year, when adjusting for key covariables. This is important given that—to this point—scientific findings on the association between wildfire smoke exposure and mental health have been inconsistent and limited, with a dearth of quantitative studies using

longitudinal data sources (Eisenman & Galway, 2022). Findings that wildfire smoke are temporally associated with poor mental health are also significant given that households who experience wildfire smoke may be located hundreds or even thousands of miles from the original wildfire source. For instance, smoke from the 2023 Canadian wildfires was transported across North America to the Gulf of Mexico and across the Atlantic to Europe, illustrating the far-reaching atmospheric impacts of largescale wildfires. Thus, there may be lack of awareness or attention to the harmful impacts of smoke exposure, particularly when originating from distant fires.

In addition, results point to the serious potential mental health impacts on communities that have repeat exposure to wildfire smoke. A small body of literature—much of which is of low methodological rigor—has explored acute and chronic health risks of long-term exposure to wildfire smoke, with the most salient findings being increased risk of multiple types of cancer, including lung cancer (Grant & Runkle, 2022). On single days of high $PM_{2.5}$,cardiovascular and respiratory events, as well as overall mortality, are known to increase (Crabbe, 2012; Doubleday et al., 2020). Current findings call attention to the need to better understand psychological symptoms that result from both acute and chronic smoke exposure. Finally, the integration of environmental data for wildfire and $PM_{2.5}$ exposure with largescale household survey data is another important contribution to the literature, as this methodology holds promise in elucidating mechanisms through which real-time exposure to wildfires and wildfire smoke may negatively impact psychological health.

Acute exposure to wildfires has, unsurprisingly, been associated with trauma-related symptoms, with previous reviews showing high rates of PTSD and other trauma-related symptoms among residents exposed to severe wildfires, with some trauma-related symptomology persisting for up to 10 years following a wildfire disaster (Bryant et al., 2022; To et al., 2021). Impacts on symptoms of depression and anxiety symptoms have been much less studied. However, multiple survey-based studies within communities impacted by severe wildfires have shown elevated rates of depression and anxiety in the months following the event (Agyapong et al., 2018; Bryan et al., 2020; Marshall et al., 2007).

The mechanisms through which wildfire smoke affects individual mental health, including symptoms of anxiety and depression, likely operate on multiple levels and demand future study. For instance, general air pollution is known to affect physiological changes within the body, including causing inflammation, altering neurological structures and functions, and causing development of multiple chronic health conditions (e.g., chronic and acute respiratory illnesses) (Bhui et al., 2023). Cognitively, wildfire smoke exposure may evoke feelings of helplessness, dread, and worry about both immediate and long-term impacts on oneself and loved ones. Fine particulate matter has also been shown to lead to cognitive decline, especially among older individuals (Duchesne et al., 2022; Weuve et al., 2012). On a behavioral level, wildfire smoke may prompt negative coping behaviors (e.g., physical inactivity, increased alcohol and drug use). Indeed, short-run exposure to particulates has been associated with increased criminal behaviors, traffic violations, and traffic accidents (Bondy et al., 2020; Braun & Villas-Boas, 2023; Burkhardt et al., 2019; Burnett & Sheldon, 2025; Chambers, 2022; Lu et al., 2018; Sager, 2019).

In terms of community impacts, wildfire smoke, especially when prolonged, may result in periods of social isolation and disruption of key activities that promote social wellbeing (e.g., school closures, disruptions for community and/or faith-based events). On a systems level, wildfire smoke—particularly in an era of increased largescale wildfire activity—may yield broader economic changes, prompt community displacement, or create resource scarcity (e.g., food and water shortages) for individuals—all of which may have huge impacts on psychological wellbeing.

Implications for Mental Health Practitioners

Evidence from the current study adds to a growing body of literature that shows the need for prevention and treatment of mental health symptoms that result from increasingly severe wildfires in the western US and beyond. Professional mental health practitioners have a key role to play in preparing for and responding to trauma and mood-related symptoms that are likely to impact many residents during and after wildfire and wildfire smoke exposure. To this point, the role of mental health practitioners has primarily been considered in terms of disaster response in the immediate aftermath of devastating fires. However, the increasing frequency and severity of wildfires, as well as the rapid increase in exposure to harmful wildfire smoke for communities both near and far from wildfire sources, demands that mental health providers take a leading role in also developing strong prevention, screening, and linkage to care systems for individuals who are at-risk for negative wildfire-related psychological impacts.

Universal prevention interventions designed to reduce the risk for depression and anxiety have been shown to be effective, both in preventing onset of mood and anxiety-

related disorders as well as reducing symptoms (Stockings et al., 2016). Practitioners in communities impacted by wildfires should become familiar with available local prevention interventions (e.g., through schools, community centers, and social services) and advocate for increased access to prevention services, particularly for children and families. Beyond mental health prevention, general prevention strategies, such as increasing awareness about the mental health risks associated with wildfire and wildfire smoke exposure, as well as how to limit smoke exposure, are needed both among both the general population and, especially, among policymakers and community leaders. Provision of free or subsidized air purifiers as well as "clean air shelters," or community centers and other public spaces outfitted with HEPA air filters, could substantially mitigate smoke exposure (Wright et al., 2024).

During times of acute exposure to wildfires and wildfire smoke, selective interventions (i.e., for those at higher risk for mental health disorders and/or for those already demonstrating symptoms) are likely to be useful when implemented within impacted communities. Existing tools such as the Screening, Brief Intervention, and Referral to Treatment (SBIRT) approach may be beneficial when adapted to mental health symptoms. SBIRT is a comprehensive approach that enables practitioners in primary care and/or community-based settings to quickly identify individuals in need of early intervention and treatment services and 'triage' them to an appropriate level of care (e.g., brief intervention, referrals to specialty treatment). Efforts to scale up mental health screening and develop strong referral systems in areas impacted by wildfires may be an important part of building capacity and meeting community needs. Furthermore, because

substance misuse and dependence are understood to increase during times of stress and adversity, using SBIRT with individuals with known wildfire and/or smoke exposure may help to improve identification and treatment. Professional mental health practitioners who are treating clients in wildfire-impacted communities should be alert to symptoms of depression and anxiety and should seek to understand how wildfire smoke exposure may impact their clients' functioning across a variety of areas (e.g., psychological, behavioral, social) in order to develop appropriate treatment plans. Increasing the relevant mental health workforce available to provide care to wildfire-impacted areas through temporary licensing waivers and telehealth flexibilities may be policies that states can enact in the short term (Scott et al., 2022).

In addition to direct services, mental health practitioners are also well-suited to consider how to promote broader resilience among impacted individuals and communities. A conceptual framework for promoting psychological resilience promotion proposed by Li and colleagues (2015) provides a useful structure for considering how resilience factors at the individual, interpersonal, and community levels may help mitigate the negative effects of a widespread adverse event for a community. The framework highlights the importance not only of the development of individual-level coping skills (e.g., problem solving, growth-oriented mindset, self-efficacy), but also the important role that family, school, and community systems play in reducing individual psychological risk and increasing the likelihood of positive adaptation despite ongoing adversity (Li et al., 2015).

Limitations

This study has several important limitations that should be considered. Notably, while objective environmental data were used to achieve granular measures of wildfire and $PM_{2.5}$ exposure, our measure of depression and anxiety was limited to self-report data at the household level. Future studies that incorporate clinical data and/or utilize more robust measures of depression and anxiety are needed to build upon these preliminary findings. In addition, there were some small differences between our large sample of Californian households and the general statewide population. Thus, these findings should not be considered as indicative of statewide prevalence data, and the identified associations between wildfire and wildfire smoke exposure and mental health may be different for other populations. Finally, the timing of our variables does not allow for detailed understanding of when mental health symptoms emerge and how they may vary over time based on wildfire and wildfire smoke exposure. Future studies that incorporate more innovative methods, such as ecological momentary assessment, may be helpful in elucidating important aspects of the timing of symptom onset and progression.

Conclusion

This paper highlights new evidence for links between wildfire smoke exposure and negative mental health and contributes to the small but growing body of literature suggesting that wildfires pose serious threats to individuals' psychological wellbeing. Findings call attention to the important role that professional mental health practitioners should play not only in responding to psychological needs that result from acute wildfire events, but in planning for the ways that more frequent and more severe wildfires are likely to threaten individual and community resilience. Strengthening mental health prevention,

screening, and treatment systems within affected communities will be critical to improving psychological outcomes in the wake of wildfires and harmful wildfire smoke exposure.

Table 1

Sociodemographic characteristics of estimation sample (N=22,509) completing the NielsenIQ Annual Ailments, Health, and Wellness Survey (AAHWS) from 2011-2017, compared to the California subsample of the American Community Survey (ACS) from 2011-2016

		Estimation Sample	CA ACS (5-yr 2016)
Total Household Income	<$25,000	14%	13%
	$25,000–$49,999	25%	14%
	≥$50,000	61%	74%
Number of Household Members	1 person	31%	27%
	2 people	41%	37%
	3 people	13%	15%
	4 people	10%	12%
	5+ people	6%	9%
Type of Residence	Single-family detached	71%	58%
	Single-family attached	3%	7%
	Apartment (2+ units)	21%	32%
	Mobile home or other	4%	4%
Marital Status (Adults 15+)	Single	18%	37%
	Married	57%	47%
	Divorced/separated	16%	11%
	Widowed	9%	5%
Age and Number of Children	No children under 18	83%	65%
	1+ child/children under a8	17%	35%
Age of Household Head	Under 25 Years	0.3%	3%
	25-34 Years	6%	16%
	35-44 Years	13%	19%
	45-54 Years	22%	20%
	55-64 Years	29%	19%
	65+ Years	30%	23%
Employment Status (Adults 16+)	Employed	66%	59%
	Unemployed or Not in Labor Force	34%	41%
Household Head Education	Less than high school	1%	18%
	High school graduate	10%	20%

	Some college/associate degree	30%	29%
	Bachelor's degree or higher	59%	33%
Race/Ethnicity	White or Hispanic	71%	60%
	Black/African American	9%	6%
	Asian	12%	14%
	Other/multiple races	8%	20%
Hispanic Origin	Not Hispanic/Latino	88%	61%
	Hispanic/Latino	12%	39%

Table 2

Wildfire exposure variables and exposure summary statistics for estimation sample (N=22,509), 2010-2016

Number of Days in Prior Year with:	Mean	Mean Conditional on Non-Zero	Max
>=1 acre Wildfire within Zip Code	0.041	1.44	6
>=10 acre Wildfire within Zip Code	0.019	1.24	4
>=1 acre Wildfire within 50 miles of Zip Code	0.512	1.89	11
>=10 acre Wildfire within 50 miles of Zip Code	0.339	1.64	8
Wildfire $PM_{2.5}$ > 20μg/m^3 within Zip Code	0.168	2.97	27
Wildfire $PM_{2.5}$ > 35μg/m^3 within Zip Code	0.050	2.64	20
Wildfire $PM_{2.5}$ > 50μg/m^3 within Zip Code	0.023	2.37	16

Table 3

Estimation results showing increased risk of depression and/or anxiety in the following six months after various exposures to wildfires

Effect: Number of Days in Prior Year with...	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 acre Wildfire within Zip	0.0746**	0.041						
	(0.034)	(0.052)						
10 acre Wildfire within Zip			0.054	0.006				
			(0.064)	(0.044)				
1 acre Wildfire within 50 mi of Zip					0.0283***	0.018		
					(0.005)	(0.012)		
10 acre Wildfire within 50 mi of Zip							0.0258***	0.016
							(0.009)	(0.015)
Household Size	0.147***	0.147***	0.147***	0.147***	0.147***	0.147***	0.147***	0.147***
	(0.018)	(0.028)	(0.018)	(0.028)	(0.018)	(0.028)	(0.018)	(0.028)
Single Family House	-0.280***	-0.279***	-0.279***	-0.279***	-0.282***	-0.279***	-0.281***	-0.279***
	(0.055)	(0.053)	(0.054)	(0.053)	(0.055)	(0.053)	(0.055)	(0.053)
Household Income Under $50k	0.263***	0.255***	0.264***	0.256***	0.262***	0.255***	0.263***	0.256***
	(0.033)	(0.046)	(0.033)	(0.045)	(0.033)	(0.046)	(0.033)	(0.046)
Household Income Over $100k	-0.029	-0.017	-0.030	-0.017	-0.029	-0.017	-0.030	-0.017
	(0.046)	(0.055)	(0.046)	(0.055)	(0.045)	(0.055)	(0.046)	(0.055)
Married	-0.059	-0.071	-0.057	-0.070	-0.059	-0.070	-0.058	-0.070
	(0.073)	(0.065)	(0.073)	(0.064)	(0.073)	(0.065)	(0.073)	(0.064)
Children	-0.118*	-0.122	-0.118*	-0.122	-0.119*	-0.122	-0.118*	-0.122
	(0.069)	(0.083)	(0.069)	(0.083)	(0.068)	(0.083)	(0.069)	(0.083)
Employed	-0.048	-0.042	-0.048	-0.042	-0.047	-0.042	-0.047	-0.042
	(0.055)	(0.046)	(0.055)	(0.046)	(0.055)	(0.046)	(0.055)	(0.046)
College Degree or More	-0.113***	-0.105**	-0.114***	-0.105**	-0.112***	-0.105**	-0.113***	-0.105**
	(0.026)	(0.042)	(0.026)	(0.042)	(0.026)	(0.042)	(0.026)	(0.042)
White, Non-Hispanic	0.295***	0.273***	0.296***	0.273***	0.295***	0.273***	0.296***	0.273***
	(0.055)	(0.054)	(0.055)	(0.055)	(0.056)	(0.055)	(0.055)	(0.055)
Currently or Previously on WIC	0.376***	0.348***	0.377***	0.349***	0.376***	0.349***	0.377***	0.349***
	(0.077)	(0.084)	(0.077)	(0.084)	(0.077)	(0.084)	(0.077)	(0.084)
Year Fixed Effects	X	X	X	X	X	X	X	X
DMA Region Fixed Effects	X		X		X		X	

County Fixed Effects		X		X		X		X
Observations	22,509	22,479	22,509	22,479	22,509	22,479	22,509	22,479

Notes. Each column represents a separate model estimation. Robust standard errors in parentheses are clustered at the Designated Market Area (DMA) region level in odd columns and at the county level in even columns. The dependent variable in all columns is an indicator for household depression and/or anxiety in the next six months. X denotes inclusion of corresponding fixed effects. WIC stands for the Women, Infants, and Children supplemental nutrition program. *** p<0.01, ** p<0.05, * p<0.1.

Table 4

Estimation results showing increased risk of depression and/or anxiety in the following six months after various exposures to harmful wildfire smoke ($PM_{2.5}$)

Effect: Number of Days in Prior Year with...	(1)	(2)	(3)	(4)	(5)	(6)
Wildfire $PM_{2.5}$ > 20ug/m3 within Zip	0.0304***	0.0263***				
	(0.008)	(0.008)				
Wildfire $PM_{2.5}$ > 35ug/m3 within Zip			0.0499***	0.0444***		
			(0.013)	(0.017)		
Wildfire $PM_{2.5}$ > 50ug/m3 within Zip					0.0654***	0.0500**
					(0.017)	(0.022)
Household Size	0.147***	0.147***	0.147***	0.147***	0.147***	0.147***
	(0.018)	(0.028)	(0.018)	(0.028)	(0.018)	(0.028)
Single Family House	-0.280***	-0.279***	-0.280***	-0.279***	-0.280***	-0.279***
	(0.054)	(0.053)	(0.054)	(0.052)	(0.054)	(0.052)
Household Income Under $50k	0.264***	0.256***	0.264***	0.256***	0.264***	0.256***
	(0.033)	(0.045)	(0.033)	(0.046)	(0.033)	(0.045)
Household Income Over $100k	-0.030	-0.018	-0.030	-0.018	-0.031	-0.018
	(0.046)	(0.056)	(0.046)	(0.055)	(0.045)	(0.055)
Married	-0.058	-0.070	-0.057	-0.069	-0.056	-0.069
	(0.073)	(0.064)	(0.072)	(0.064)	(0.072)	(0.064)
Children	-0.119*	-0.122	-0.118*	-0.121	-0.117*	-0.121
	(0.069)	(0.083)	(0.069)	(0.083)	(0.069)	(0.083)
Employed	-0.045	-0.041	-0.045	-0.041	-0.046	-0.041
	(0.056)	(0.047)	(0.055)	(0.046)	(0.055)	(0.046)
College Degree or More	-0.114***	-0.105**	-0.114***	-0.105**	-0.114***	-0.105**
	(0.025)	(0.042)	(0.025)	(0.042)	(0.025)	(0.042)
White, Non-Hispanic	0.294***	0.272***	0.295***	0.273***	0.296***	0.273***
	(0.056)	(0.055)	(0.056)	(0.055)	(0.056)	(0.055)
Currently or Previously on WIC	0.376***	0.349***	0.377***	0.350***	0.376***	0.349***
	(0.077)	(0.084)	(0.077)	(0.084)	(0.077)	(0.084)
Year Fixed Effects	X	X	X	X	X	X
DMA Region Fixed Effects	X		X		X	
County Fixed Effects		X		X		X
Observations	22,509	22,479	22,509	22,479	22,509	22,479

Notes. Each column represents a separate model estimation. Robust standard errors in parentheses are clustered at the Designated Market Area (DMA) region level in odd columns and at the county level in even columns. The dependent variable in all columns is an indicator for household depression and/or anxiety in the next six months. X denotes inclusion of corresponding fixed effects. WIC stands for the Women, Infants, and Children supplemental nutrition program. *** p<0.01, ** p<0.05, * p<0.1

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