Wildfire smoke and symptoms affecting mental health among adults in the U.S. state of Oregon

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Abstract

The physical and mental health impacts of wildfires are wide-ranging. We assessed associations between exposure to wildfire smoke and self-reported symptoms affecting mental health among adults living in Oregon. We linked by interview date and county of residence survey responses from 5807 adults who responded to the 2018 Behavioral Risk Factor Surveillance System's depression and anxiety module with smoke plume density, a proxy for wildfires and wildfire smoke exposure. Associations between weeks in the past year with medium and heavy smoke plume densities and symptoms affecting mental health during the two weeks before the interview date were estimated using predicted marginal probabilities from logistic regression models. In the year before completing the interview, 100% of respondents experienced ≥2 weeks of medium or heavy smoke, with an average exposure duration of 32 days. Nearly 10% reported being unable to stop or control their worrying more than half the time over the past two weeks. Medium or heavy smoke for 6 or more weeks in the past year, compared to ≤4 weeks in the past year, was associated with a 30% higher prevalence of being unable to stop or control worrying more than half the time during the past two weeks (prevalence ratio: 1.30, 95% confidence interval: 1.03, 1.65). Among adults in Oregon, selected symptoms affecting mental health were associated with

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extended durations of medium and heavy smoke. These findings highlight the burden of such symptoms among adults living in communities affected by wildfires and wildfire smoke.

Keywords

Environmental; Epidemiology; Mental health; Surveillance; Wildfire

1. Introduction

In 2018, 2109 wildland fires burned nearly 900,000 acres in the U.S. state of Oregon (National Interagency Fire Center, 2018). Major fires included the Klondike Fire, which began with a lightning strike on July 15, 2018, burned over 175,000 acres, and resulted in an estimated cost of US$ 104.5 million and the Substation Fire, which started on private land on July 17, 2018, destroyed a historic home, and resulted in one death directly attributed to the fire (Gabbert, 2018; National Interagency Coordination Center, 2018). Both the size and the frequency of wildfires such as these challenge public health and safety officials to mobilize firefighting resources, alert the public of the dangers of wildfires and smoke, and put in place evidence-based strategies to keep community members safe from fire, smoke, ash, and debris.

The impacts of experiencing, responding to, and recovering from wildfires are wide-ranging. Wildfires can cause burns and smoke-related injuries that can range from mild to fatal (Shusterman et al., 1993; Sonoma County Department of Health Services, 2018). Wildfires generate enormous quantities of smoke that can linger over areas within and near the fire perimeter or drift far from the original burn sites. Respiratory health effects of wildfire smoke inhalation are well-described and include exacerbations of asthma, chronic obstructive pulmonary disease, and other respiratory health conditions (Shusterman et al., 1993; Cascio, 2018; Rice et al., 2021; Reid et al., 2016; Liu et al., 2015; Chen et al., 2021). Exposure to wildfire smoke has also been negatively associated with attention (Cleland et al., 2022) and positively associated with adverse pregnancy and birth outcomes (Abdo et al., 2019; Heft-Neal et al., 2022; Evans et al., 2022) and sleep-related symptoms (Rodney et al., 2021).

Epidemiologic studies suggest that the impact on mental health of having survived a wildfire is substantial (Shusterman et al., 1993; Rodney et al., 2021; Eisenman et al., 2021; Zhang et al., 2022; Moosavi et al., 2019; Mao et al., 2022; To et al., 2021). In 2018, investigators assessed the health and well-being of residents one year after a major wildfire in Sonoma County, California and found that 37% of residents with a history of depression or other emotional health problem reported that the conditions worsened in the year since the wildfires (Sonoma County Department of Health Services, 2018). Similarly, Rodney et al. (2021) conducted a cross-sectional survey in the Canberra region of Australia following the 2019–2020 bushfires and found that respondents reported anxiety, depression, and disrupted or poor sleep attributed to bushfire smoke (Rodney et al., 2021). In light of findings such as these, we conducted this study to assess associations between the duration of wildfire smoke

exposure and the prevalence of self-reported symptoms affecting mental health among adults living in Oregon, a U.S. state regularly affected by wildfires, in 2018.

2. Methods

2.1. Study population

We analyzed data from the 2018 Behavioral Risk Factor Surveillance System (BRFSS) (Centers for Disease Control and Prevention, 2018). BRFSS is a cross-sectional telephone survey conducted annually to collect information about health-related risk behaviors, chronic health conditions, and use of preventive services from noninstitutionalized adult residents of the United States, including individuals in all 50 states, the District of Columbia, and three U.S. territories (Centers for Disease Control and Prevention, 2014).

In 2018, the core BRFSS questionnaire was supplemented with an optional survey module to query respondents about their symptoms of depression and anxiety. The depression and anxiety module was used in three jurisdictions, including the U.S. state of Oregon. In 2018, 5946 adults in Oregon, aged 18 years and older, participated in the survey; response rates were 48.9% among individuals contacted and interviewed via landline telephone and 36.9% among individuals contacted and interviewed via cellphone (Centers for Disease Control and Prevention, 2019). The response rate for BRFSS is calculated as the number of respondents who completed the survey as a proportion of all eligible and likely-eligible people (i.e., response rate formula #4), per standards set by the American Association for Public Opinion Research (American Association for Public Opinion Research, 2016). For detailed information about the 2018 BRFSS questionnaire development, survey sampling and interviewing methods, iterative proportional fitting (i.e., raking), and response rates, see the 2018 BRFSS Summary Data Quality Report (Centers for Disease Control and Prevention, 2019).

We excluded from our analysis 139 respondents with missing responses to demographic survey questions included in our final model, for a final population of 5807 adult BRFSS respondents from Oregon who responded to the survey module. The 2018 BRFSS interviews for these 5807 respondents were conducted between January 9, 2018 and February 28, 2019.

Oregon Health Authority is not required to obtain Institutional Review Board (IRB) approval to conduct BRFSS surveys because the primary intent in conducting BRFSS is non-research. The analytic plan for the present study was reviewed and determined to be exempt from full IRB review at the Centers for Disease Control and Prevention.

2.2. Measures of wildfire smoke exposure

As a proxy for exposure to wildfire smoke, we used daily, county-level estimates of smoke plume density from 2017 to 2019 from the U. S. National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System, developed by NOAA's National Environmental Satellite, Data, and Information Service Satellite Analysis Branch (National Oceanic and Atmospheric Administration, 2021). Hazard Mapping System estimates of smoke plume density are based on visual classification by expert image analysts of smoke plumes recorded by near real-time polar and geostationary satellite observations (National

Oceanic and Atmospheric Administration, 2021). Smoke plume densities are qualitatively categorized as light, medium, and heavy based on the apparent opacity of the smoke plumes in the satellite imagery. These classifications correspond to approximate density values in the ranges of 0–10, 10–21, and 21+ micrograms per cubic meter, respectively (National Oceanic and Atmospheric Administration, 2021). Technical details about the satellite equipment in use in 2017–2019, the Hazard Mapping System, and classification of smoke density are available elsewhere (National Oceanic and Atmospheric Administration, 2021).

For our analysis, we used Hazard Mapping System estimates for each day between January 9, 2018 and February 28, 2019, inclusive, to identify the maximum density smoke plume detected in each of Oregon's 36 counties. We then calculated the days of medium and heavy plume density in each county for the preceding 365 days and linked these county-level totals with each BRFSS respondent's data by interview date and county of residence (Supplemental Material Fig. S1). When we assessed the distributions of days with each smoke category, we found that the entire population experienced at least six days of medium and six days of heavy smoke (Fig. 1) and that the low ends of each distribution were not a single subgroup of respondents with low exposure in both categories — that is, we were unable to identify a single group to consider as a referent group for all analyses. To address this issue, we described the exposures using two metrics: (1) the number of weeks with heavy-density smoke plume and (2) the number of weeks with medium- or heavy-density smoke plume. We categorized these distributions into two-week categories and combined categories in which there were few observations (Supplemental Material Table S1). The two resulting smoke plume exposure metrics were: (1) weeks with heavy-density smoke plume (0 to <2, 2 to <4, and 4 weeks) and (2) weeks with medium- or heavy-density smoke plume (2 to <4, 4 to <6, and 6 weeks).

2.3. Self-reported depressive disorder and symptoms affecting mental health

To report ever having a depressive disorder, BRFSS participants responded to the following question: "*[Have you ever been told] you have a depressive disorder (including depression, major depression, dysthymia, or minor depression)?*" Four specific symptoms were assessed using survey questions that began with "*Over the last 2 weeks, how often have you been bothered by…*" The four specific symptoms were *"having little interest or pleasure in doing things;" "feeling down, depressed, or hopeless;" "feeling nervous, anxious, or on edge;"* and *"not being able to stop or control worrying."* For each symptom, response options were never, several days, more than half the days, and nearly every day; we dichotomized these responses as never or several days versus more than half the days or nearly every day. Responses of more than half the days and nearly every day are hereafter referred to together as more than half the days. These four symptoms, individually and considered together, indicate symptoms, behaviors, or conditions and are referred to as *symptoms affecting mental health.*

2.4. Covariates

For each respondent, BRFSS data include age, in years; educational attainment; employment status; race/ethnicity; and sex. BRFSS data also categorize each respondent's county of residence as metropolitan or non-metropolitan.

2.5. Statistical analysis

Characteristics of the BRFSS respondents and the weighted population estimate were analyzed taking into account the complex survey sample design of the BRFSS (Centers for Disease Control and Prevention, 2018). BRFSS data are weighted using iterative proportional fitting (i.e., "raking") that incorporates age, race/ethnicity, sex, education, homeowner versus renter status, marital status, region within state, and landline versus cellphone survey. Applying the resulting weights generates weighted population estimates that are representative of the source population of adults in Oregon aged 18 years and older. For this analysis, we generated weighted population estimates and percentages of the weighted population estimates, with 95% confidence intervals (CIs), within categories of age, educational attainment, employment status, metropolitan status, race/ethnicity, and sex. We conducted similar analyses to describe the distribution of responses to BRFSS questionnaire items about ever having a depressive disorder and about the four specific symptoms affecting mental health. To assess the occurrence of smoke plume days, we estimated the weighted mean, with 95% CI, number of days in the past year that respondents experienced each level of smoke in their county of residence. These univariate and bivariate descriptive analyses were conducted in SAS version 9.4 (SAS Institute, Inc. Cary, North Carolina).

We assessed the relationship between the number of weeks with each of the two smoke metrics and each outcome using predicted marginal probabilities from logistic regression models in SAS-callable SUDAAN (RTI International, Research Triangle Park, North Carolina). Specifically, we estimated the changes in the percentages reporting the outcomes more than half the days with increasing numbers of weeks with heavy-density smoke or medium- or heavy-density smoke in the past year. The logistic regression models were adjusted for age, employment status, metropolitan status, and sex. After these analyses, we conducted three sensitivity analyses to assess the impact on our results of changes in two metrics included in our main analyses. First, we conducted a sensitivity analysis in which we restricted our exposure metrics to those days that occurred May–October, inclusive, a period that corresponds to peak wildfire season in Oregon. Second, we conducted a similar sensitivity analysis in which we restricted our exposure metrics to those days that occurred in the past six months so that each BRFSS respondent was assigned exposure metrics corresponding only to the six months before their BRFSS interview date. Third, we conducted a separate sensitivity analysis in which we replaced the dichotomization of responses about symptoms affecting mental health in the past two weeks (more than half the days/nearly every day versus never/several days) with a dichotomization of several days/ more than half the days/nearly every day versus never – that is, ever versus never in the past two weeks. All results are presented as prevalence ratios (PRs) with 95% CIs.

3. Results

Characteristics of the 5807 BRFSS respondents and the weighted population estimate are shown in Table 1. Respondents came from each of Oregon's 36 counties. Overall, over a quarter of adults in Oregon reported ever having been told that they have a depressive disorder (26.1%; 95% CI: 24.7, 27.5). This percentage was notably lower in adults 65+ years (18.9%; 95% CI: 16.7, 21.1), those who graduated from college or technical school (21.4%; 95% CI: 19.4, 23.5), adults employed for wages or self-employed (22.0%; 95% CI: 20.4, 23.6), and men (18.9%; 95% CI: 17.2, 20.7). The highest percentage of adults with depressive disorders occurred among adults who reported being out of work or unable to work (52.7%; 95% CI: 47.9, 57.5).

Percentages of adults in Oregon who self-reported experiencing specific symptoms more than half the days of the past two weeks ranged from 7.7% (95% CI: 6.8, 8.6) reporting feeling down, depressed, or hopeless to 10.4% (95% CI: 9.4, 11.4) reporting feeling nervous, anxious, or on edge (Table 2). Percentages who reported depressive disorders were considerably higher among adults who reported the four symptoms more than half the days of the past two weeks, than among adults who reported them never or several days of the past two weeks.

Overall, adults in Oregon in 2018 experienced an average of 17.7 days (range: 6–60 days) on which the smoke plume was categorized as heavy and 31.8 days (range: 15–74 days) on which it was categorized as medium or heavy (Table 3). The mean numbers of days with each category of smoke were notably higher in nonmetropolitan counties and notably lower among adults who graduated from college or technical school, non-Hispanic black adults, and adults in metropolitan areas.

Table 4 shows adjusted associations of the two metrics of exposure with ever having a depressive disorder and having any of the four symptoms more than half the days during the past two weeks. For each exposure metric, highest prevalences and PRs were generated in the longest duration smoke categories, though 95% CIs for all associations include unity. For example, compared with <2 weeks of exposure to heavy smoke in the past year, exposure to ≥4 weeks of heavy smoke was associated with a 4% increase in the prevalence of ever having a depressive disorder (PR: 1.04, 95% CI: 0.90, 1.20).

In adjusted analyses of the associations between the exposure metrics and each of the four symptoms, highest prevalences and PRs were again generated in the longest duration exposure categories (Table 5). Heavy smoke for ≥4 weeks in the past year, compared to <2 weeks in the past year, was associated with a 34% increase in the prevalence of feeling nervous, anxious, or on edge more than half the time during the past 2 weeks (PR: 1.34, 95% CI: 1.04, 1.72). Similarly, the highest categories of exposure to heavy smoke (≥4 weeks in the past year) and medium or heavy smoke (≥6 weeks in the past year) were associated with 29% and 30% increases, respectively, in the prevalence of being unable to stop or control worrying more than half the time during the past 2 weeks (heavy: PR: 1.29, 95% CI: 0.98, 1.70; medium or heavy: PR: 1.30, 95% CI: 1.03, 1.65).

Estimates generated by our first sensitivity analyses in which we restricted the exposure metrics to include only those smoke days that occurred May–October were identical or nearly identical in magnitude and precision to those generated by our main analyses (Supplemental Material Table S2). For our second sensitivity analysis in which we restricted the exposure metrics to include only those smoke days that occurred in the six months preceding the BRFSS interview date, the categories of the distributions of smoke duration were < 2, 2 to <4, and   4 weeks for both metrics. Like those of our main analysis, 95% CIs for the estimates generated by this sensitivity analysis largely included unity (Supplemental Material Table S3). Estimates generated by our third sensitivity analysis in which we dichotomized responses about symptoms affecting mental health were also similar to those generated by our main analysis (Supplemental Material Table S4). For several outcomes, associations with longer durations of exposure were attenuated and more precise. For example, the highest categories of exposure to heavy smoke and medium or heavy smoke were associated with 14% and 18% increases, respectively, in the prevalence of ever being unable to stop or control worrying during the past 2 weeks (heavy: PR: 1.14, 95% CI: 0.97, 1.33; medium or heavy: PR: 1.18, 95% CI: 1.03, 1.35).

4.   Discussion

In the U.S. state of Oregon, 4068 wildfires burned over 1.6 million acres in 2017–2018 (National Interagency Fire Center, 2018; National Interagency Fire Center, 2017). We conducted this analysis to assess the associations between exposure to wildfire smoke and symptoms affecting mental health among adults in Oregon in 2018 and found that 100% of respondents, representing 100% of the weighted population estimate of adults in Oregon, lived in a location in which medium or heavy smoke plumes were detected for at least 2 weeks in the past year. We also found that the highest duration categories of exposure to medium or heavy smoke were associated with selected symptoms during the past two weeks. These findings provide valuable insights into the burden of symptoms affecting mental health among adults living in wildfire-affected areas.

People impacted by wildfires include those living in neighborhoods directly impacted by wildfires, some of whom had their homes, work-places, or other places in their communities burned by wildfires or were advised to evacuate because of encroaching wildfires. Even people not directly threatened by wildfires can be impacted by wildfire smoke, as residents might be advised to cancel outdoor events, reduce the time they spend outdoors, and prepare themselves and their families for the possibility of evacuation. Community infrastructure can also be impacted, such as when public buildings are used as cleaner air shelters or when vehicle or airport traffic is hindered by wildfire smoke.

In 2018, a rapid needs assessment was conducted in Sonoma County, California to assess the health of residents one year after the 2017 Sonoma Complex Fires (Sonoma County Department of Health Services, 2018). Compared to the year before the fires, investigators observed increased post-fire prevalences of numerous symptoms affecting mental health, including anxiety or fear and feeling depressed, hopeless, or a loss of interest in normal activities. Especially traumatic experiences reported included seeing a direct threat to the life of oneself or a family member, being separated from a family member or unaware of

their location or well-being during the wildfire, being trapped or delayed in evacuation, having a home destroyed, and experiencing or witnessing a serious injury (Sonoma County Department of Health Services, 2018). Our findings support and extend what was learned about symptoms affecting mental health following the 2017 Sonoma Complex Fires and other major wildfires by describing changes in the prevalence of self-reported symptoms with increasing durations of exposure to wildfire smoke. Together, these findings can be used by public health officials and emergency responders as they consider the range of resources that might be needed in communities affected by not only wildfires, but also by plumes of wildfire smoke.

For this analysis, we used BRFSS survey data and county-level smoke plume observations to estimate county-level wildfire smoke exposures for each BRFSS respondent. We generated county-level exposure estimates using NOAA's publicly-available data, which include categorizations of smoke plume density based on automated fire detection, digitization of smoke plume images, and expert image analyst review (National Oceanic and Atmospheric Administration, 2021). Wildfire smoke plumes typically include a mixture of particulates, gases, and other components that vary depending on the fuel burned in the fire. Because of this variation in the composition of smoke plumes, there is no single ground-level measurement that can best validate the estimates of wildfire smoke exposure used in this analysis. Supplemental Material Fig. S2 shows daily averages of 24-h average concentrations of particulate matter 2.5 μm in diameter ($PM_{2.5}$) (U.S. Environmental Protection Agency, 2022) and Hazard Mapping System smoke density category in four regions of Oregon (Oregon Health Authority, 2022). In each of the four regions, peaks in $PM_{2.5}$, a major component of wildfire smoke, appear to coincide with increases in smoke density. Nonetheless, county-level wildfire smoke exposures do not reflect personal exposure to wildfire smoke or to the stressors associated with wildfires. In fact, wildfires can occur at the same time as droughts, heat waves, and other environmental events and while Hazard Mapping System data provide valuable information about wildfire smoke plumes, if other environmental events coincided with periods of peak wildfire smoke, then our analyses could have generated associations that could be due in part or entirely to other hazards or to combinations of hazards. Furthermore, these data do not include information about factors that may have affected personal exposure and that could be used to assess the validity of the wildfire smoke exposure metrics we assigned or the psychological stressors they might reflect. For example, our data did not include information about the amount of time respondents spent in their county of residence or the extent to which the wildfires or wildfire smoke affected the respondents' activities. Overall, however, we do not envision that our results were affected by a systematic error attributable to the exposure assignment approach we used.

Similarly, our analyses do not account for other factors potentially associated with mental health status, including individuals' educational attainment or county-level measurements of ambient air pollutants, temperature, precipitation, or other weather-related factors. The relationships between individuals' mental health status and characteristics of the communities in which they live are complex and our data sources do not include information that might be used to assess them or their roles in the associations of wildfires and wildfire smoke with symptoms affecting mental health. Most notably, our analyses do not account

for evacuations due to wildfires and we have no data with which to assess the extent that the associations observed here might be affected by the experience of evacuating because of a wildfire. Finally, our analyses assessed the relationship between the number of smoke days in the past year and the frequency of symptoms in the past two weeks and do not account for potential differences in responses to smoke events that occurred in the days or weeks before the interviews were conducted compared to those that occurred closer to one year before the interviews. Nonetheless, our findings provide evidence of the lasting toll of wildfire smoke exposure on mental health and raise the possibility that survey questions soliciting information about longer time periods or about the onset of symptoms might provide additional information about the occurrence of such symptoms following periods of wildfire smoke.

In summary, we applied satellite-derived estimates of exposure to wildfire smoke to BRFSS survey data to estimate associations between wildfire smoke and symptoms affecting mental health. We used the number of days with wildfire smoke in each county as a proxy for duration of stress attributable to living in a community affected by wildfires. We found that among adults in Oregon, selected symptoms were associated with extended durations of smoke. These findings highlight the burden of symptoms affecting mental health among adults living in communities affected by wildfire smoke and can be used to plan recovery efforts in and near communities affected by wildfires.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Data availability

The authors do not have permission to share data.

Abbreviations:

BRFSS	Behavioral risk factor surveillance system
CI	Confidence interval
IRB	Institutional review board
NOAA	National Oceanic and Atmospheric Administration
PR	Prevalence ratio

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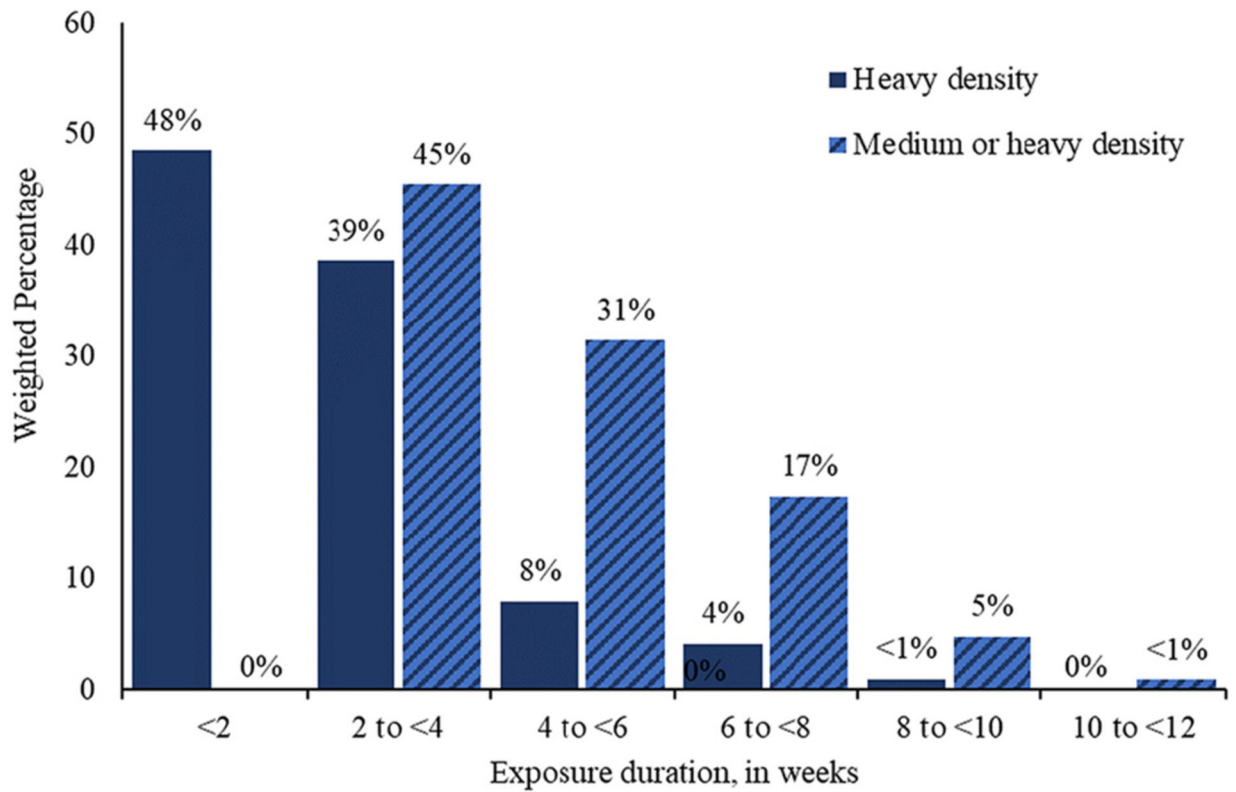
Fig. 1.
All respondents lived in a location in which a smoke plume was detected in the past year. Weeks with heavy-density smoke ranged from <1 to 8.6 (6–60 days); weeks with medium-density smoke ranged from <1 to 4.7 (6–33 days). Taken together, respondents experienced 2.1 to 10.6 weeks (15–74 days) with medium- or heavy-density smoke.

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Table 1

Characteristics of adults in Oregon – 2018 Behavioral Risk Factor Surveillance System.

Characteristics	Survey sample No.	Weighted population estimate No.[b,c]	Weighted population estimate Percentage (95% CI)[d]	Depressive disorder[a] Percentage (95% CI)[e]
Total	5807	3254	100.	26.1 (24.7, 27.5)
Age, in years				
18–24	414	367	11.3 (10.1, 12.5)	30.0 (24.6, 35.4)
25–34	766	563	17.3 (16.1, 18.5)	31.0 (27.3, 34.6)
35–44	823	541	16.6 (15.5, 17.8)	26.5 (23.3, 29.7)
45–54	982	505	15.5 (14.4, 16.6)	25.8 (22.4, 29.1)
55–64	1064	538	16.5 (15.4, 17.7)	28.1 (24.7, 31.5)
65+	1758	741	22.8 (21.5, 24.0)	18.9 (16.7, 21.1)
Educational attainment				
Less than high school	359	326	10.0 (8.8, 11.2)	29.8 (24.2, 35.5)
Graduated high school	1372	789	24.2 (22.9, 25.6)	26.5 (23.6, 29.4)
Some college or technical school	1838	1181	36.3 (34.7, 37.9)	28.6 (26.2, 30.9)
Graduated college or technical school	2238	958	29.4 (28.1, 30.8)	21.4 (19.4, 23.5)
Employment status				
Employed for wages or self-employed	3140	1833	56.3 (54.8, 57.9)	22.0 (20.4, 23.6)
Out of work/unable to work	646	380	11.7 (10.6, 12.7)	52.7 (47.9, 57.5)
Homemaker, student, or retired	2021	1041	32.0 (30.5, 33.5)	23.7 (21.1, 26.2)
Metropolitan status				
Metropolitan county	4700	2687	82.6 (81.3, 83.8)	26.4 (24.8, 27.9)
Nonmetropolitan county	1107	568	17.4 (16.2, 18.7)	24.8 (21.5, 28.2)
Race/ethnicity				
Black, non-Hispanic	66	56	1.7 (1.2, 2.2)	26.2 (24.7, 27.6)
Hispanic	495	334	10.3 (9.3, 11.3)	29.4 (16.9, 41.9)
Other, non-Hispanic	424	280	8.6 (7.6, 9.6)	22.5 (17.7, 27.3)
White, non-Hispanic	4822	2585	79.4 (78.1, 80.8)	29.0 (22.9, 35.1)
Sex				
Female	3122	1660	51.0 (49.4, 52.6)	33.0 (30.9, 35.1)
Male	2685	1594	49.0 (47.4, 50.6)	18.9 (17.2, 20.7)

[a] Based on responses to the survey question, "*[have you ever been told] you have a depressive disorder (including depression, major depression dysthymia, or minor depression)?*"

[b] In thousands.

[c] Due to rounding, the sum of category-specific weighted population estimates may not equal the total weighted population estimate.

[d] Column percentage.

[e] Row percentage.

Table 2

Self-reported symptoms affecting mental health over the past two weeks among adults in Oregon – 2018 Behavioral Risk Factor Surveillance System.

Symptom	Survey sample No.	Weighted population estimate No.[b,c]	Weighted population estimate Percentage (95% CI)[d]	Depressive disorder[a] Percentage (95% CI)[e]
Little interest or pleasure in doing things				
Never/several days	5333	2972	91.3 (90.4, 92.3)	22.0 (20.7, 23.3)
More than half the days	474	282	8.7 (7.7, 9.6)	69.3 (64.4, 74.3)
Feeling down, depressed, or hopeless				
Never/several days	5396	3005	92.3 (91.4, 93.2)	22.3 (20.9, 23.6)
More than half the days	411	249	7.7 (6.8, 8.6)	72.3 (66.8, 77.8)
Nervous, anxious, or on edge				
Never/several days	5241	2916	89.6 (88.6, 90.6)	21.7 (20.3, 23.1)
More than half the days	566	338	10.4 (9.4, 11.4)	63.9 (59.0, 68.9)
Cannot stop or control worrying				
Never/several days	5284	2934	90.2 (89.2, 91.2)	22.2 (20.8, 23.5)
More than half the days	523	320	9.8 (8.8, 10.8)	62.1 (56.7, 67.4)

[a] Based on responses to the survey question, "*[have you ever been told] you have a depressive disorder (including depression, major depression dysthymia, or minor depression)?*"

[b] In thousands.

[c] Due to rounding, the sum of category-specific weighted population estimates may not equal the total weighted population estimate.

[d] Column percentage.

[e] Row percentage.

Table 3

Mean number of days with smoke in two smoke plume categories in the 365 days before respondents' 2018 Behavioral Risk Factor Surveillance System interviews by population characteristics.

	Smoke plume density	
	Heavy	**Medium or heavy**
Characteristics	**Mean (95% CI) days**	**Mean (95% CI) days**
Total	17.7 (17.4, 18.0)	31.8 (31.4, 32.1)
Age, in years		
18–24	17.8 (16.9, 18.8)	32.0 (30.9, 33.2)
25–34	17.2 (16.4, 17.9)	30.9 (30.0, 31.8)
35–44	17.0 (16.4, 17.7)	30.6 (29.8, 31.4)
45–54	17.4 (16.7, 18.1)	31.2 (30.3, 32.1)
55–64	18.0 (17.3, 18.7)	32.0 (31.1, 32.9)
65+	18.6 (17.9, 19.2)	33.3 (32.5, 34.1)
Educational attainment		
Less than high school	17.8 (16.6, 19.0)	32.3 (30.9, 33.8)
Graduated high school	18.4 (17.9, 19.0)	32.8 (32.0, 33.5)
Some college or technical school	18.2 (17.7, 18.7)	32.3 (31.7, 33.0)
Graduated college or technical school	16.5 (16.1, 16.9)	30.0 (29.5, 30.5)
Employment status		
Employed for wages or self-employed	17.5 (17.1, 17.9)	31.3 (30.8, 31.8)
Out of work/unable to work	18.6 (17.6, 19.5)	32.8 (31.7, 34.0)
Homemaker, student, or retired	17.8 (17.3, 18.3)	32.2 (31.5, 32.9)
Metropolitan status		
Metropolitan county	17.1 (16.8, 17.4)	30.7 (30.3, 31.1)
Nonmetropolitan county	20.5 (19.6, 21.3)	36.8 (35.8, 37.8)
Race/ethnicity		
Black, non-Hispanic	13.1 (12.1, 14.2)	25.7 (24.0, 27.3)
Hispanic	16.4 (15.7, 17.2)	30.1 (29.0, 31.1)
Other, non-Hispanic	16.6 (15.6, 17.5)	30.0 (28.7, 31.3)
White, non-Hispanic	18.1 (17.8, 18.4)	32.3 (31.9, 32.7)
Sex		
Female	17.3 (17.0, 17.7)	31.3 (30.8, 31.8)
Male	18.1 (17.6, 18.5)	32.2 (31.6, 32.7)

Table 4

Adjusted associations between the number of weeks in two smoke plume categories and the prevalence of ever having a depressive disorder or reporting any of the four symptoms more than half the time during the past two weeks.

Smoke plume density, No. weeks	Survey sample	Weighted population estimate		Depressive disorder[a]		Any symptom[b]	
	No.	No.[c,d]	Percentage (95% CI)	Prev (95% CI)[e]	PR (95% CI)[f]	Prev (95% CI)[e]	PR (95% CI)[f]
Heavy							
<2	2644	1577	48.5 (46.9, 50.1)	25.7 (23.8, 27.7)	Referent	33.9 (31.7, 36.1)	Referent
2 to <4	2327	1256	38.6 (37.0, 40.2)	26.4 (24.3, 28.7)	1.03 (0.92, 1.15)	33.1 (30.8, 35.5)	0.98 (0.89, 1.07)
4	836	421	12.9 (12.0, 13.9)	26.6 (23.5, 30.1)	1.04 (0.90, 1.20)	36.5 (33.0, 40.3)	1.08 (0.96, 1.21)
Medium or heavy							
2 to < 4	2480	1479	45.5 (43.9, 47.0)	26.1 (24.1, 28.2)	Referent	34.2 (32.0, 36.5)	Referent
4 to < 6	1878	1022	31.4 (29.9, 32.9)	24.9 (22.6, 27.3)	0.95 (0.84, 1.08)	31.3 (28.7, 34.0)	0.91 (0.82, 1.02)
6	1449	753	23.1 (21.8, 24.4)	27.8 (25.2, 30.5)	1.07 (0.94, 1.21)	36.9 (34.1, 39.9)	1.08 (0.97, 1.19)

[a] Based on responses to the survey question, "*[have you ever been told] you have a depressive disorder (including depression, major depression dysthymia, or minor depression)?*"

[b] Any of the following four symptoms reported more than half the days: (1) little interest or pleasure in doing things; (2) feeling down, depressed, or hopeless; (3) nervous, anxious, or on edge; (4) cannot stop or control worrying.

[c] In thousands.

[d] Due to rounding, the sum of category-specific weighted population estimates may not equal the total weighted population estimate.

[e] Prevalence.

[f] Prevalence ratio, adjusted for age, employment status, metropolitan status, and sex.

Table 5

Adjusted associations between the number of weeks in two smoke plume density categories and four symptoms self-reported as occurring more than half the time during the past two weeks.

Smoke plume density, No. weeks	Little interest or pleasure in doing things		Feeling down, depressed, or hopeless		Nervous, anxious, or on edge		Cannot stop or control worrying	
	Prev (95% CI)[a]	PR (95% CI)[b]	Prev (95% CI)[a]	PR (95% CI)[b]	Prev (95% CI)[a]	PR (95% CI)[b]	Prev (95% CI)[a]	PR (95% CI)[b]
Heavy								
<2	8.4 (7.1, 9.9)	Referent	7.6 (6.3, 9.2)	Referent	9.8 (8.5, 11.4)	Referent	9.3 (7.9, 11.0)	Referent
2 to < 4	8.4 (7.1, 10.0)	1.01 (0.79, 1.28)	7.6 (6.4, 9.0)	1.00 (0.78, 1.29)	10.2 (8.8, 11.8)	1.04 (0.84, 1.28)	9.8 (8.4, 11.3)	1.05 (0.84, 1.32)
4	10.5 (8.4, 13.1)	1.26 (0.95, 1.66)	7.9 (6.1, 10.2)	1.04 (0.76, 1.42)	13.1 (10.7, 16.0)	1.34 (1.04, 1.72)	12.0 (9.7, 14.9)	1.29 (0.98, 1.70)
Medium or heavy								
2 to < 4	8.1 (6.7, 9.6)	Referent	7.7 (6.3, 9.3)	Referent	9.8 (8.4, 11.4)	Referent	9.4 (8.0, 11.2)	Referent
4 to < 6	8.3 (6.8, 10.0)	1.02 (0.78, 1.34)	7.2 (5.9, 8.8)	0.94 (0.72, 1.23)	10.2 (8.6, 12.0)	1.04 (0.83, 1.31)	8.6 (7.2, 10.3)	0.91 (0.71, 1.17)
6	10.4 (8.7, 12.3)	1.29 (1.00, 1.65)	8.2 (6.7, 10.0)	1.07 (0.81, 1.40)	11.9 (10.1, 14.0)	1.22 (0.97, 1.52)	12.3 (10.4, 14.4)	1.30 (1.03, 1.65)

[a] Prevalence.

[b] Prevalence ratio, adjusted for age, employment status, metropolitan status, and sex.