

**Surveillance of Asthma, Mental Health, Chronic Obstructive
Pulmonary Disease, and Acute Myocardial Infarction Presenting in NJ
Hospitals During the June 2023 Air Quality Impacts from the Canadian
Wildfire Event**

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Background

In June of 2023, air quality in New Jersey was impacted from extensive wildfires in Eastern Canada. During June 6-8, 2023, this wildfire smoke event caused the Air Quality Index (AQI) to reach “unhealthy” and “very unhealthy” levels across the state. The AQI is a measure that reflects the concentration of five major air pollutants that are regulated by the Clean Air Act. The AQI is based on the health-based national ambient air quality standards (NAAQS) for each of the five pollutants, including particulate matter with an aerodynamic diameter less than or equal to 2.5 micrograms (μm), also known as PM 2.5. Particulate matter 2.5 is the pollutant of concern for wildfire air impacts and was the driving factor of high AQI, or poor air quality, for all regions impacted by smoke from the Canadian wildfires during the June 2023 wildfire smoke event.

An AQI value of 100 corresponds to the NAAQS for a specific pollutant, that is, an AQI below 100 indicates that the concentration of the specific pollutant is below the NAAQS (USEPA 2024). AQI values from 101 to 150 are unhealthy for sensitive groups and AQI values over 150 are unhealthy for the public (AirNow.gov 2024). NJDEP operates air monitoring stations throughout the state and in June of 2023, 18 of these stations monitored for PM 2.5 (NJDEP 2023). An AQI for PM 2.5 greater than 150 was observed at several monitoring stations in NJ during the June 6-8, 2023 time period (NJDEP 2024).

Exposure to PM 2.5 from wildfire smoke, has been associated with adverse health effects. Specifically, wildfire smoke exposure is known to increase the risk of airway dysfunction and exacerbates pre-existing asthma. Inhalation of PM 2.5 from wildfire smoke causes lung injury through oxidative stress, airway epithelium compromise, and local and systemic inflammation, cell toxicity, and may be associated with new-onset asthma (Wilgus 2024; Adentona 2016). Wildfire smoke may also have acute adverse effects on people living with chronic obstructive pulmonary disease (COPD) (Reid 2019).

There is evidence of increased risk of cardiovascular events from PM 2.5 exposure. Chronic exposure to PM 2.5 can contribute to the development of cardiovascular disease (CVD) as these particles are small enough to be inhaled deeply into the lungs, and they can enter the bloodstream, and cause systematic inflammation, vasoconstriction, cardiac electrical changes, and formation of blood clots (Brook 2010; Wei 2024). Short-term exposure to PM 2.5 (over a few hours to weeks) can trigger CVD-related mortality and nonfatal events, such as acute myocardial infarction (AMI). Besides triggering or precipitating CVD events, short-term and chronic exposure to PM 2.5 may also result in increased risk to cardiovascular events after exposure (Brook 2010). Therefore, the risk of cardiovascular events may occur several days, or even months, after exposure to wildfire (Chen 2023).

Poor air quality impacts from extreme weather events, such as wildfire smoke, can also result in emotional distress, the development of new mental health conditions and a worsening situation for people already living with these conditions (WHO 2022; Crimando 2024).

During the June 2023 wildfire event, New Jersey Department of Health (NJDOH) staff monitored visits to NJ emergency departments presenting with symptoms of asthma. The

syndromic surveillance of near real-time data informed messaging by providing an estimate of the number of individuals who sought hospital care with symptoms of asthma during the air quality impacts from the Canadian Wildfires. The number of daily visits was compared to the daily average number of individuals over the two-week time-period prior to June 6th. There was an observed increase in the number of emergency department visits presenting with chief complaints of asthma or symptoms of asthma compared to the average number of daily visits for the two weeks before.

The purpose of this analysis is to evaluate the public health impacts among NJ residents during the wildfire smoke event using diagnoses from emergency department and inpatient hospital admissions data, which were finalized in August of 2024. The hospital data, received as uniform billing data, includes all diagnoses based on codes from the International Classification of Disease (ICD-10) (WHO 2019). This analysis provides the number of individuals who had a diagnosis of asthma (providing an update of the syndromic surveillance data monitored during the event) and includes diagnoses from other health impacts that could be associated with wildfire smoke exposure.

Surveillance of emergency department (ED) visits and inpatient hospitalizations in NJ for asthma, COPD, AMI, and mental health disorders was conducted to determine whether increases in visits and hospitalizations were observed during the poor air quality days as compared to the time-period preceding the air quality impacts. For AMI, surveillance was conducted during and two weeks after the air quality impacts.

Methods

The number of visits among patients who were discharged from the emergency department or were hospitalized were obtained and compared between the two-week time period prior to wildfire smoke air quality impacts in NJ and the days that NJ's air quality was impacted. Because the risk of AMI may be observed for several weeks after air quality impacts, the surveillance time-period included two weeks after the air quality impacts. The comparison time-period was chosen to be two weeks prior to air quality impacts since other seasonal factors, such as pollen or holidays, can influence or exacerbate the occurrence of health outcomes such as asthma or mental health events.

Counts for asthma visits or hospitalizations were identified with an ICD-10 code of J45 as the primary diagnosis or any of the first 13 diagnoses from ED and inpatient hospitalization uniform billing data. While the uniform billing data includes all diagnoses, these analyses focused on either primary diagnoses or any diagnoses up to the first 13. Patients with an inpatient hospitalization or emergency department visit with COPD as any of the first 13 diagnoses were obtained using ICD-10 codes J40 to J44. The number of emergency department and inpatient hospitalization visits for AMI with an ICD-10 of I21 or I22 as the primary diagnosis were obtained. These ICD-10 codes are used for NJ's environmental health indicators obtained on an annual basis under our Environmental Public Health Tracking cooperative agreement with the Centers for Disease Control and Prevention's National Center for Environmental Health.

Emergency department visits with primary and secondary diagnosis codes of mental health disorders were also obtained. These mental health disorders diagnoses include the following: adult personality and behavior disorders, miscellaneous, childhood-onset behavioral disorders, schizophrenia, schizotypal, and delusional disorders; anxiety, stress-related, and somatoform disorders; substance use disorders, self-harm, and mood disorders. The corresponding ICD-10 codes for these conditions were obtained from an analysis evaluating mental health-related emergency department visits during

extreme heat including primary and secondary discharge diagnoses (Nori-Sarma 2022). A detailed description of each of the ICD-10 codes within each of the mental health disorder categories is provided in their report (Nori-Sarma 2022).

The percent change of number of visits was calculated to show the average number of daily visits in the two-week time frame prior to the wildfire impacts as compared with the number of daily visits during the air quality impacts. For AMI diagnoses, the number of visits were compared between the time frame of the two weeks prior to the wildfire event and the two weeks following the wildfire event.

Statistical Analyses

Counts by day were compared in the timeframe prior to the wildfire smoke impacts with cases occurring during the three-day period when the AQI was elevated in NJ due to impacts from wildfire smoke. As mentioned above for AMI, the time periods compared were the two-week period preceding AQI impacts due to the wildfires and two weeks after the last day of the AQI impacts. The Wilcoxon signed-rank test was used to determine whether the distribution of the number of visits after the onset of poor air quality from wildfire smoke to NJ was statistically significantly higher than the number of visits prior to the air quality impacts (Hollander 2013). This statistical test is used when the data are not normally distributed (in this case because the sample size is small) and therefore the two-sample, t-test to compare mean number of visits is not statistically appropriate. The data analysis for this report was generated using SAS software, Version 9.4 of the SAS System for Windows (SAS 2023).

For health outcomes that had a statistically significant increase in the number of visits after the onset of poor air quality from wildfire smoke the Chi-squared test was conducted to determine whether there were statistically significant differences in characteristics among patients with visits or hospitalizations prior to the air quality impacts and during the poor air quality impacts. Specifically, the Chi-squared test was used to determine whether there were differences between sex, age, race and geographic location of the patients who were treated between the two time periods.

Results

The mean number of visits prior to the AQI impacts was obtained for each health outcome and the percent change from the mean (two weeks preceding the air impacts) were obtained for each day of the air quality impacts (and for the two-week period after for AMI). These descriptive statistics are shown in the Tables 1 through Table 7 below.

Asthma

The number of emergency department visits with a primary diagnosis of asthma diagnosed discharges was statistically significant higher in the three-day period during the wildfire air quality impacts compared to the two weeks before ($p < 0.01$). On June 7th, there was a 112% increase in the number of visits compared to the average daily visits of the two-week period prior. While inpatient hospitalizations for asthma as primary diagnosis or any diagnosis, and ED visits for asthma as any diagnosis were slightly higher on the first two days of the poor

air quality, there were no statistically significant differences than the time preceding the event (Table 1).

Table 1: Emergency department and inpatient hospitalizations for asthma before and during June 2023 wildfires

Date	Asthma as primary diagnosis				Asthma as primary or any diagnosis*			
	Emergency Department visits (p<0.01)†		Inpatient Hospitalizations (p=0.46)†		Emergency Department visits (p=0.06)†		Inpatient Hospitalizations (p=0.38)†	
23-May	105		19		553		195	
24-May	96		10		542		189	
25-May	79		14		520		203	
26-May	94		19		524		183	
27-May	95		12		462		131	
28-May	81		15		457		120	
29-May	116		14		555		142	
30-May	103		8		559		210	
31-May	94		24		572		224	
1-June	90		16		523		206	
2-June	69		14		457		196	
3-June	93		9		470		141	
4-June	90		14		497		145	
5-June	108		19		582		228	
Daily average (May 23 to June 5)	94		15		520		180	
Following wildfire smoke impact		% change from daily average		% change from daily average		% change from daily average		% change from daily average
6-June	108	15%	16	7%	535	3%	215	19%
7-June	199	112%	16	7%	616	18%	191	6%
8-June	161	71%	11	-27%	568	9%	180	0%

*Asthma is one of the first 13 diagnosis codes, including primary

† One sided p-value for Wilcoxon signed rank test

To explore whether the characteristics among patients with visits or hospitalizations for asthma differed prior to the air quality impacts and during the poor air quality impacts days, the proportion of visits by sex, age group, race, and geographic location of each patient’s residence were compared between the two time periods.

The proportion of females who had a primary diagnosis of asthma at the emergency department during the wildfire impacts was statistically significantly higher during the poor air quality days compared to the two weeks prior. As shown in Table 2, 60% of the patients were female during the event as compared to 52% in the two weeks prior (p< 0.01).

Table 2: Demographic characteristics of ED visits for primary asthma diagnosis between two time periods before and during air quality impacts from Canadian Wildfires

Characteristic		Two Weeks Prior to WFE*	During WFE	p-value†	
Sex	Males	626 (48%)	185 (40%)	<0.01	
	Females	687 (52%)	283 (60%)		
Age group	Both sexes	less than 5	149 (11%)	36 (8%)	<0.01
		5 to 17	292 (22%)	100 (21%)	
		18 to 40	432 (32%)	191 (41%)	
		41 to 65	347 (26%)	125 (27%)	
		65 and older	93 (7%)	16 (3%)	
Males		less than 5	103 (16%)	24 (13%)	0.08
		5 to 17	172 (27%)	52 (28%)	
		18 to 40	182 (29%)	70 (38%)	
		41 to 65	140 (22%)	36 (19%)	
		65 and older	29 (5%)	3 (2%)	
Females		less than 5	46 (7%)	12 (4%)	0.04
		5 to 17	120 (17%)	48 (17%)	
		18 to 40	250 (36%)	121 (43%)	
		41 to 65	207 (30%)	89 (31%)	
		65 and older	64 (9%)	13 (5%)	
Geography	Northern	792 (60%)	288 (62%)	0.64	
	Southern	521 (40%)	180 (38%)		
Race	White	391 (30%)	144 (31%)	0.35	
	Black	548 (42%)	210 (45%)		
	Asian	21 (2%)	5 (1%)		
	Other/Declined	353 (27%)	109 (23%)		

*WFE=wildfire event, 6/6-6/9/23

† Chi-square test of equal proportions

There was a statistically significant difference in the age groups of ED visits with a primary diagnosis of asthma. Specifically, the proportion of visits occurring among individuals between 18 and 40 years of age interval during the event was higher (41%) as compared to the proportion of visits in that age group for two weeks prior (33%). The proportion of visits among patients aged 65 and older was lower during the days of the wildfire impact (3%) as compared to the two weeks prior (7%).

Table 2 shows the percentage of age group visits by sex. The impact of age on visits was evaluated for males and females separately. While the proportion of visits are higher within the 18 to 40 age group for both males and females, the differences in proportions are statistically significant only among females.

There were no differences in proportion of asthma as primary diagnosis emergency department discharges between the race of the patient or the geographic region of the state (Table 2).

COPD

As shown in Table 3, there was not a statistically significant difference in the distribution of number of ED visits or inpatient hospitalizations for patients with a COPD diagnosis (any of up to 13 diagnoses). It should be noted there was a 25% increase in inpatient hospitalizations on the first day of the air quality impacts and a milder increase was observed during all three days.

Table 3: Emergency department and inpatient hospitalizations for COPD before and during June 2023 wildfires

Date	COPD as primary or any diagnosis*			
	Emergency Department visits (p=0.29)†		Inpatient Hospitalizations (p=0.06)†	
23-May	159		218	
24-May	167		210	
25-May	151		216	
26-May	149		201	
27-May	136		174	
28-May	133		155	
29-May	144		187	
30-May	155		245	
31-May	155		245	
1-June	160		218	
2-June	189		222	
3-June	133		182	
4-June	128		158	
5-June	167		246	
Daily average (May 23 to June 5)	152		206	
Following wildfire smoke impact		% change from daily average		% change from daily average
6-June	160	5%	257	25%
7-June	147	-3%	236	15%
8-June	160	5%	218	6%

*COPD is one of 13 diagnosis codes, including primary

† One sided p-value for Wilcoxon signed rank test

Mental Health Disorders

Table 4 shows the number of visits to the ED for mental health disorder diagnoses, including primary and secondary diagnoses. There was a statistically significant increase in the number of visits for

anxiety, stress-related, and somatoform disorders during the wildfire impacts compared to the two weeks prior ($p=0.03$). As shown in Table 4, the first day of the poor air quality impacts had a 19% increase in the number of visits and the second day a 15% increase as compared to the two weeks prior. There were no differences in the distribution of number of visits for the other mental health disorders diagnosed between these two time periods. It should be noted there was an increase in the number of visits for childhood-onset behavioral disorders on the first day of the air quality impacts but the distribution of visits was not statistically significantly different.

Table 4: Emergency department (ED) visits for Mental Health and Specific Causes (Primary and Secondary Diagnoses) in NJ before and during June 2023 wildfires

Date	Anxiety, stress-related, somatoform disorders ($p=0.03$)†		Mood disorders ($p=0.42$)†		Childhood-onset behavioral disorders ($p=0.47$)†		Schizophrenia, schizotypal, and delusional disorders ($p=0.19$)†		Miscellaneous mental health ($p=0.41$)†		Adult personality and behavioral disorders ($p=0.26$)†		Substance use disorders ($p=0.34$)†		Self-harm ($p=0.39$)†	
23-May	212		80		78		54		5		2		378		55	
24-May	219		94		64		64		3		1		397		74	
25-May	248		83		74		65		10		3		364		48	
26-May	241		77		61		53		6		2		399		45	
27-May	181		73		58		53		6		5		419		20	
28-May	186		84		66		51		6		6		365		35	
29-May	166		67		62		57		5		3		430		41	
30-May	224		107		66		65		5		2		449		64	
31-May	240		101		84		58		7		3		368		53	
1-June	215		92		74		62		10		4		405		43	
2-June	237		94		69		64		10		1		410		59	
3-June	213		83		58		39		12		3		381		32	
4-June	183		64		51		60		6		3		375		41	
5-June	237		101		81		71		13		5		457		71	
Daily average (May 23 - June 5)	214		86		68		58		7		3		400		49	
Following impact		% ††		% ††		% ††		% ††		% ††		% ††		% ††		% ††
6-June	254	19%	76	-12%	92	35%	51	-12%	6	-14%	3	0%	386	-4%	53	8%
7-June	246	15%	85	-1%	58	-15%	72	24%	7	0%	2	-33%	410	3%	46	-6%
8-June	225	5%	91	6%	65	-4%	69	19%	7	0%	2	-33%	410	3%	50	2%

† One sided p-value for Wilcoxon signed rank test

†† Percent change from daily average

To explore whether the characteristics among patients with visits or hospitalizations for anxiety, stress-related, and somatoform disorders differed prior to the air quality impacts and during the poor air quality impacts, the proportion of visits by sex, age group, race, and geographic location of each patient’s residence were compared between the two time periods. There were no statistically significant differences between these demographic categories (Table 5).

Table 5: Demographic characteristics of ED visits for anxiety disorders between two time periods before and during air quality impact from Canadian Wildfires

Characteristic		Two Weeks Prior to WFE*	During WFE	p-value†
Sex	Males	1130 (38%)	262 (36%)	0.4
	Females	1837 (62%)	458 (64%)	
Age group				
Both sexes	less than 5	55 (5%)	9 (1%)	0.39
	5 to 17	478 (16%)	113 (16%)	
	18 to 40	1228 (41%)	322 (44%)	
	41 to 65	929 (31%)	214 (30%)	
	65 and older	312 (10%)	67 (9%)	
Males				
	less than 5	11 (1%)	2 (1%)	0.99
	5 to 17	165 (15%)	39 (15%)	
	18 to 40	529 (47%)	122 (47%)	
	41 to 65	336 (30%)	78 (30%)	
	65 and older	89 (8%)	21 (8%)	
Females				
	less than 5	9 (0.5%)	2 (0.4%)	0.26
	5 to 17	313 (17%)	74 (16%)	
	18 to 40	699 (38%)	200 (44%)	
	41 to 65	593 (32%)	136 (30%)	
	65 and older	223 (12%)	46 (10%)	
Geography				
	Northern	1611 (54%)	389 (54%)	0.99
	Southern	1391 (46%)	336 (46%)	
Race				
	White	1746 (58%)	439 (60%)	0.21
	Black	546 (18%)	113 (16%)	
	Asian	53 (2%)	8 (1%)	
	Other/Declined	657 (22%)	165 (23%)	

*WFE=wildfire event, 6/6-6/9/23

† Chi-square test of equal proportions

Acute myocardial infarction

There were no statistical differences between the distribution of inpatient hospitalizations due to AMI before and the two weeks after the air quality impacts from the wildfires (Table 6.).

Table 6: Inpatient Acute Myocardial Infarction (AMI) before and 14 days after June 2023 wildfire impacts

Date	Inpatient Hospitalizations (p=0.16)† For AMI as primary or any diagnosis*	
23-May	102	
24-May	89	
25-May	89	
26-May	97	
27-May	84	
28-May	77	
29-May	95	
30-May	117	
31-May	118	
1-June	111	
2-June	107	
3-June	109	
4-June	81	
5-June	102	
Daily average (May 23 -June 5)	98	
Dates following wildfire smoke event		% change from Daily average
6-June	119	21%
7-June	88	-10%
8-June	100	2%
9-June	94	-4%
10-June	81	-17%
11-June	84	-14%
12-June	88	-10%
13-June	85	-13%
14-June	102	4%
15-June	84	-14%
16-June	93	-5%
17-June	82	-16%
18-June	79	-19%
19-June	120	22%

*AMI is one of 13 diagnosis codes, including primary

† One sided p-value for Wilcoxon signed rank test

Conclusions

During this wildfire smoke event with elevated concentrations of PM 2.5 across the state, the number of ED visits among NJ residents with a primary diagnosis of asthma was statistically significantly higher compared to the two-week time-period before the event. Overall, females had a higher proportion of ED visits with a primary diagnosis of asthma than males during the air quality impacts as compared to the two weeks before. Previous studies have observed increased asthma visits among women (Wilgus 2024; Reid 2016; Haikerwal 2016; Kondo 2019). It remains unclear whether women have greater biological susceptibility to wildfire smoke, are more likely of having uncontrolled asthma, or are more likely to seek medical care for asthma-related symptoms during a wildfire smoke episode (Reid 2016).

The age group of the patients who visited an ED differed, with a higher proportion of visits noted among individuals between the ages of 18 and 40 during the air quality impacts, and a statistically significant increase was observed in this age group among females. There have been previous findings of increases in asthma ED visits during wildfire events observed among age groups above 20 and below 65 (Reid 2016).

Climate change has been associated with impacts in behavioral health and increases in mental health episodes (Crimando 2024; WHO 2022; Nori-Sarma 2022). The increase in NJ emergency department visits for anxiety-related primary and secondary diagnoses during the wildfire event is consistent with previous literature in the western United States (Zhu 2024).

While there was not a statistically significant difference in COPD visits, there was an observed increase in the number of hospitalizations in NJ during the wildfire air impacts. There have been inconsistent findings in the literature on associations between ED visits and hospitalizations for COPD during wildfire impacts (Reid 2019; Wilgus 2024). More research is warranted to explore whether there are impacts among certain populations with specific risk factors (Wilgus 2024).

While the biological mechanism of short-term exposures to wildfire smoke and cardiovascular events has been established, the literature is not consistent in demonstrating increase ED visits for CVD, or specifically AMI, during or after wildfire smoke exposures (Weinstein 2015). Although PM 2.5 exposure is an established trigger of CVD events that occur hours or days after exposure, impacts to the cardiovascular system may result in increased risk to cardiovascular events months or years after exposure. It is not possible to elucidate potential synergistic impacts of this three-day exposure on future cardiovascular events (Chen 2023).

Limitations

Characterizing illnesses that resulted in emergency department visits likely underestimates the number of individuals who sought medical attention through urgent care or their primary care physicians or treated symptoms at home. Therefore, the observed increase in asthma and anxiety disorders may be an underestimate of the impact from the wildfire smoke. Individuals with COPD or other mental health disorders may also have been impacted by the poor air quality but did not seek medical attention from a NJ hospital. It is unknown whether the increase in visits with a diagnosis of

asthma and anxiety disorders was an exacerbation of pre-existing asthma and anxiety disorders or new onset.

There are other limitations to this analysis including CVD only focused on AMI, and there could have been impacts on CVD other than AMI in the two weeks following the wildfire smoke event.

Public health implications and next steps

This analysis of ED visits and inpatient hospitalizations characterized the populations most at-risk for adverse health effects based on impacts from the June 2023 wildfire smoke event. The current analysis of diagnoses codes found the impacts on the air quality on asthma related emergency department visits and anxiety disorder to be greater during the event. These findings can help enhance messaging during future wildfire smoke events. Determining the effect of wildfire smoke on population-specific groups enables tailored public health recommendations to reduce the burden of disease and may inform what resources may be needed during a future wildfire impact.

During the 2023 wildfire air impacts, NJDOH developed a fact sheet which was disseminated through local health departments and posted on NJDOH and NJDEP websites: nj.gov/health/ceohs/documents/ceohs%20content/NJDOH%20Poor%20Air%20Quality%20Factsheet.pdf. While public health messaging and recommendations will continue to target the general population there are additional steps that may be considered to tailor to most at-risk groups. While NJDOH's factsheet already addressed vulnerable populations who should take extra precautions during these types of events, these findings indicate future messaging should target young adults (aged 18-40) to ensure they take actions to protect themselves from wildfire smoke effects.

Based on the observed increase in NJ emergency department visits due to anxiety disorders during this event, outreach should be developed focusing on prevention and awareness of adverse mental health outcomes. Messaging should be developed to inform clinicians and mental health care providers and the individuals with these pre-existing conditions about steps they can take to potentially mitigate and manage symptoms.

References

- USEPA 2024. Particulate Matter (PM) Pollution. [epa.gov/pm-pollution](https://www.epa.gov/pm-pollution) Accessed June 28, 2024.
- AirNow.gov 2024. Air Quality Index (AQI) Basics. airnow.gov/aqi/aqi-basics/ Accessed June 28, 2024.
- NJDEP May 2023. New Jersey Ambient Air Monitoring Network Plan 2023 nj.gov/dep/airmon/pdf/nj-network-plan-2023-draft.pdf Accessed June 28, 2024.
- NJDEP May 22, 2024. 2023 NEW JERSEY AIR QUALITY INDEX (AQI) EXCEEDANCE DAYS & SITES. nj.gov/dep/airmon/pdf/2023-nj-aqi-exceedance-days.pdf
- Wilgus M, Merchant M. Clearing the Air: Understanding the Impact of Wildfire Smoke on Asthma and COPD. *Healthcare* 2024, 12(3), 307.
- Adetona O, Reinhardt TE, Domitrovich J, et al. Review of the health effects of wildland fire smoke on wildland firefighters and the public. *Inhalation Toxicology*. 2016;28:95–139.
- Reid CE, Maestas MM. Wildfire smoke exposure under climate change: impact on respiratory health of affected communities. *Curr Opin Pulm Med*. 2019;25(2):179-187.
- Brook RD, Rajagopalan S, Pope CA3rd, et al, American Heart Association Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease, and Council on Nutrition, Physical Activity and Metabolism. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation*. 2010;121:2331-78.
- Chen AI, Ebisu K, Benmarhnia T, Basu R. Emergency department visits associated with wildfire smoke events in California, 2016-2019. *Environ Res*. 2023 Dec 1;238(Pt 1):117154.
- Wei Y, Feng Y, et al. Exposure-response associations between chronic exposure to fine particulate matter and risks of hospital admission for major cardiovascular diseases: population based cohort study. *BMJ* 2024;384.
- World Health Organization. Mental health and Climate Change: Policy Brief.3 June 2022. ISBN:9789240045125 [who.int/publications/i/item/9789240045125](https://www.who.int/publications/i/item/9789240045125)
- Crimando S. Climate-informed Disaster Behavioral Health Response: Preparing for the Challenges. *The Dialogue: A Quarterly Technical Assistance Journal on Disaster Behavioral Health Produced by the SAMHSA Disaster Technical Assistance* 2024;19(3): 5 -11. samhsa.gov/sites/default/files/dtac-dialogue-vol-19-issue-3.pdf
- World Health Organization. (2019). International statistical classification of diseases and related health problems (11th ed.). <https://icd.who.int/>
- Nori-Sarma A, Sun S, Sun Y, et al. Association Between Ambient Heat and Risk of Emergency Department Visits for Mental Health Among US Adults, 2010 to 2019. *JAMA Psychiatry*. 2022;79(4):341–349.

Hollander M., Wolfe D., Chicken E. Nonparametric Statistical Methods. 3rd Edition. John Wiley & Sons, 2013.

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Reid, C.E.; Jerrett, M.; Tager, I.B.; Petersen, M.L.; Mann, J.K.; Balmes, J.R. Differential respiratory health effects from the 2008 northern California wildfires: A spatiotemporal approach. *Environ. Res.* 2016, 150, 227–235.

Chen, H., Samet, J.M., Bromberg, P.A. et al. Cardiovascular health impacts of wildfire smoke exposure. *Part Fibre Toxicol.* 2021;18(2).

Haikerwal, A.; Akram, M.; Sim, M.R.; Meyer, M.; Abramson, M.J.; Dennekamp, M. Fine particulate matter (PM_{2.5}) exposure during a prolonged wildfire period and emergency department visits for asthma. *Respirology* 2016, 21, 88–94.

Zhu, Q., Zhang, D., Wang, W. et al. Wildfires are associated with increased emergency department visits for anxiety disorders in the western United States. *Nat. Mental Health* 2, 379–387 (2024).

Kondo, M.C.; De Roos, A.J.; White, L.S.; Heilman, W.E.; Mockrin, M.H.; Gross-Davis, C.A.; Burstyn, I. Meta-Analysis of Heterogeneity in the Effects of Wildfire Smoke Exposure on Respiratory Health in North America. *Int. J. Environ. Res. Public Health* 2019, 16, 960.

Wettstein ZS, Hoshiko S, Fahimi J, Harrison RJ, Cascio WE, Rappold AG. Cardiovascular and Cerebrovascular Emergency Department Visits Associated With Wildfire Smoke Exposure in California in 2015. *J Am Heart Assoc.* 2018 Apr 11;7(8).

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