

Seasonal Summary of Summer 2023

Wildfire Smoke:

Measuring Potential Health Outcomes Associated with Particulate Matter 2.5 from Wildfire Smoke in Michigan

Michigan Department of Health and Human Services

Bureau of Environmental Health

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Executive Summary

Smoke pollution originating from Canadian wildfires increased airborne particulate matter 2.5 (PM_{2.5}) concentrations in Michigan during June through August 2023. Short-term exposure to elevated PM_{2.5} can result in acute respiratory and cardiovascular health outcomes up to five days after exposure. We sought to determine if there was an excess of these health outcomes in Michigan during periods of poor air quality due to wildfire smoke. Specifically, we compared the daily frequency of emergency department (ED) visits for air quality-related health outcomes during times of elevated PM_{2.5} to the daily frequency of such ED visits during times when PM_{2.5} was not elevated. PM_{2.5} concentrations were measured via 23 air monitors around the state. ED visits were measured using data from the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE). Standardized incidence ratios (SIRs) were used to compare the daily frequency of emergency department visits with cardiovascular, air quality-related respiratory and asthma chief complaints during monitoring days (days in which the 24-hour average PM_{2.5} was greater than 35.4 µg/m³ at any air quality monitor in the state and the following five days) and non-monitoring days (all other days) during June 1 through August 31, 2023. ED visit frequency for cardiovascular (SIR=0.98, 95% CI [0.93, 1.04]), respiratory (SIR=1.07, 95% CI [1.00, 1.15]) and asthma (SIR=1.20, 95% CI [0.92, 1.55]) conditions during wildfire monitoring days were not statistically different from visit frequency during non-monitoring days. While these statewide associations were not statistically significant, further investigation of effects among specific populations and areas of the state is warranted.

Background

Smoke originating from wildfires in Canada from June through August 2023 caused poor air quality in Michigan, including high concentrations of particulate matter 2.5 (PM_{2.5}). During this period, the state had its first-ever statewide Air Quality Action Day alert.¹

Studies have shown that both short-term (up to 24-hours) and long-term exposure to elevated PM_{2.5} levels may cause adverse cardiovascular outcomes (e.g., outcomes related to ischemic heart disease and heart failure) and air quality-related respiratory conditions (e.g., exacerbation of asthma) requiring emergency department (ED) visits and/or hospitalizations.^{2,3,4} Acute negative health outcomes typically present zero to five days after exposure.³

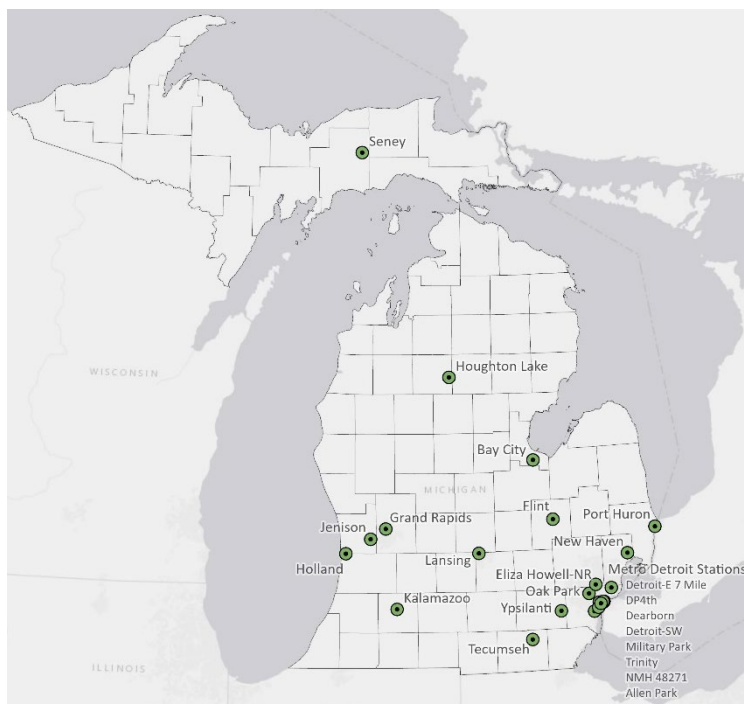
The aim of this analysis was to examine whether poor air quality due to wildfire smoke was associated with an increase in adverse health outcomes. We compared the frequency of ED visits in Michigan for air quality-related health outcomes on monitoring days during and following days with elevated PM_{2.5} levels to the frequency of such ED visits on non-monitoring days of non-elevated air quality during June through August 2023.

Data Sources and Methods

PM_{2.5} Exposure

Daily 24-hour average PM_{2.5} concentrations were obtained from 23 air monitors across the state that reported PM_{2.5} data to the Electronic Surveillance System for the Early notification of Community-Based Epidemics (ESSENCE)⁵ (Figure 1) from June 1 to August 31, 2023. When PM_{2.5} concentrations reached a level determined to be unsafe for sensitive groups (24-hour average > 35.4 µg/m³)⁶ at any monitor in the state, surveillance on select health conditions began and continued for five days following the final day of elevated PM_{2.5} measurements. These days (hereafter referred to as 'monitoring days') comprised the exposure period in our assessment of health outcomes. All other days from June 1 to August 31 (hereafter referred to as 'non-monitoring days') comprised the non-exposure period.

Figure 1. Air quality monitor locations reporting PM_{2.5} data to EPA AirNow and ESSENCE in Michigan during Summer 2023 (June 1 - August 31). Dots indicate monitor locations.



Data adapted from Department of Environment, Great Lakes, and Energy (EGLE). Air Monitoring Sites. Data retrieved August 6, 2024.⁵

Health Outcomes

ED visits for which patients had chief complaints associated with asthma, air quality-related respiratory outcomes and cardiovascular health outcomes (Appendix A. ESSENCE Queries for ED Visits of Concern) were identified in the ESSENCE,⁷ which gathers data in real time from participating hospital EDs across the state. During the analysis time period, 98% of Michigan EDs reported data into ESSENCE.

Statistical Analysis

Standardized incidence ratios (SIRs) were calculated for each outcome to determine if there was a statistically significant difference between the observed average number of daily ED visits across Michigan during monitoring days and the expected average number of daily ED visits from non-monitoring days. When the SIR is greater than 1.00, it means that the state has more ED visits observed during monitoring days than would be expected based on ED visits on non-monitoring days.

Byar’s 95% confidence intervals (95% CIs) were used to test whether the SIR shows evidence of a statistical difference in ED visits. If the 95% CI does not include the value 1.0 in its range, then the SIR is statistically different.

Results

Between June 1 and August 31, 2023, 24-hour average PM_{2.5} measurements among the 23 monitors ranged from 9 to 178 µg/m³. There were 51 monitoring days: 22 days with elevated PM_{2.5} levels (as defined in *PM_{2.5} Exposure*, above), and 29 days within a 5-day post-exposure lag period following a day with elevated PM_{2.5} levels (Appendix B).

Statewide, the number of ED visits for cardiovascular outcomes (SIR=0.98, 95% CI [0.93, 1.04]), air quality-related respiratory outcomes (SIR=1.07, 95% CI [1.00, 1.15]) and asthma (SIR=1.18, 95% CI [0.87, 1.56]) during monitoring days were not statistically different from the number of ED visits for these conditions on non-monitoring days (Table 1).

Table 1. Standardized Incidence Ratios (SIRs) for air quality-related respiratory, asthma and cardiovascular emergency department visits comparing PM_{2.5} monitoring days (observed) to non-monitoring days (expected), Michigan, June 1- August 31, 2023.

| Chief Complaint | Daily Average Observed Cases | Daily Average Expected Cases | SIR (95% CI) |
|---------------------------------|-------------------------------------|-------------------------------------|---------------------|
| Air quality-related respiratory | 813 | 759 | 1.07 (1.00, 1.15) |
| Asthma only | 49 | 42 | 1.18 (0.87, 1.56) |
| Cardiovascular | 1,155 | 1,174 | 0.98 (0.93, 1.04) |

Data adapted from National Syndromic Surveillance Program. *Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE)*. Data retrieved June 6, 2024.⁸

Discussion

Michigan experienced 22 days of elevated PM_{2.5} concentrations related to wildfire smoke between June 1 and August 31, 2023. While ED visits for asthma and air quality-related respiratory conditions increased 18% and 7%, respectively, during monitoring days, these results were not statistically significant. EGLE publicly issued Air Quality Alert Days at various points throughout the 2023 summer,⁹ and MDHHS issued a press release on June 30, 2023.¹⁰ These notices informed the public about the poor air quality (measured or forecasted), provided information about the health effects of PM_{2.5} and encouraged the public to be aware of their outside activity, especially if they were part of a sensitive group. These outreach efforts may

have helped prevent some people from experiencing health conditions associated with wildfire smoke and thus dampened the increase in corresponding ED visits.

ESSENCE has widespread coverage of EDs in Michigan, with approximately 98% of EDs in the state reporting into the system. This coverage provided sufficient data for this analysis and captured most ED visits in the state. Rapid collection of visits via this system allows monitoring in near-real-time to aid in public health response to urgent events.

This analysis had several limitations. Individuals who sought care at places other than EDs, or who did not seek care at all, were not included in this analysis. In addition, while the textual information in chief complaint data can provide important contextual information about ED visits and is available rapidly, not all visits will have the same amount of contextual information, and queries need to be carefully constructed to include abbreviations, acronyms and potential misspellings of criteria. Further investigation utilizing other datasets (e.g., hospital discharges, Medicaid claims) is warranted to better understand the public health impacts of acute PM_{2.5} exposure from wildfire smoke in Michigan.

While studies have found that PM_{2.5} exposure is associated with adverse health outcomes,^{2,3,4} it is possible that the level of PM_{2.5} pollution, the geographic scope of PM_{2.5} pollution, or the duration of PM_{2.5} exposure in Michigan was not substantial enough to result in a statistically significant increase in ED visits for the health outcomes of concern. Note that the lack of finding a significant increase in certain health conditions does not suggest that no residents sought care at an ED as a direct result of wildfire smoke-associated poor air quality.

This investigation focused on acute health effects on days with elevated PM_{2.5} levels and a following five-day lag period. This lag period was based on established literature³ and was used in our real-time reporting. However, while people may seek treatment for acute effects of PM_{2.5} up to five days after exposure, there may have been insufficient numbers of such individuals to generate a substantial increase beyond what would be expected and using a long monitoring period may have diluted the measurable impacts of PM_{2.5} exposure.

Finally, our assignment of a “monitoring” day required just one monitor in the state to have a 24-hour PM_{2.5} average > 35.4 µg/m³. Thus, all residents in the state were considered to have been exposed to wildfire smoke on those days when, in fact, the elevated exposure could have been limited regionally. This broad assignment of statewide exposure to wildfire smoke may hinder our ability to accurately measure the potential health impact of wildfire smoke. Furthermore, while much of the state's population resides in areas near air quality monitors that report their data to the Environmental Protection Agency's AirNow Program and ESSENCE, some areas are more sparsely covered, including much of the northern Lower Peninsula and Upper Peninsula.⁵ This lack of local data reduces the ability to analyze air quality and associated health outcomes at a more granular level, specifically in more rural areas of the state. Additionally, assessing health outcomes across the entire summer may have similarly diluted impacts that occurred only during and after certain periods of poor air quality, and not others (e.g., if there were monitoring days in certain areas that had high PM_{2.5} levels far beyond the 35.4 µg/m³ threshold, which may have resulted in more health effects than monitoring days with lower PM_{2.5} close to that threshold).

Conclusion

This examination of statewide emergency department visits in Michigan between June 1 and August 31, 2023, using ESSENCE did not find a statistically significant excess of air quality-related respiratory, asthma or cardiovascular ED visits associated with poor air quality due to wildfire smoke. MDHHS will continue to use ESSENCE for timely monitoring of trends in these health outcomes during the wildfire smoke season (June-August) with analyses that address some of the limitations discussed above.

Next Steps

Future efforts to investigate the potential health impacts of wildfire smoke in Michigan will investigate trends at regional and time-specific levels, assessing the health effects of wildfire smoke in areas and at times where PM_{2.5} levels were highest, and where populations were large enough to have sufficient statistical power.

In addition, we will explore:

- The use of additional data sources that capture healthcare encounters outside of emergency departments, such as urgent care centers and other healthcare settings.
- The inclusion of sensitivity analyses using post-exposure lag periods of varying lengths (e.g., a five-day lag period and shorter lag periods), similar to what has been done in a Massachusetts investigation of the health effects of 2023 summer wildfire smoke,¹¹ as well as certain other studies of wildfire smoke health effects.^{12,13,14}

Educational opportunities will be explored to provide local public health departments and the general public with the results of this report and future wildfire smoke investigations in Michigan.

Appendix A. ESSENCE Queries for ED Visits of Concern

The ESSENCE keywords (found in chief complaints) used in queries are listed below, containing both inclusion and exclusion criteria for each health concern. These include keywords to identify patients who fit the query parameters. Only one keyword must be present to fit query parameters. Parameters include abbreviations, misspellings and variations.

Cardiovascular ED Visits

Cardiac alert, chest pain, congestive heart failure, myocardial infarction, ischemia, acute coronary syndrome, cerebrovascular accident, stroke (AND NOT heat), ischemic stroke, transient ischemic attack, angina, atrial fibrillation, tachycardia, heart attack, irregular heartbeat, palpitation, heart racing, blood pressure, hypertension, heart disease, dysrhythmia, bradycardia.

Air Quality-related Respiratory ED Visits¹⁵

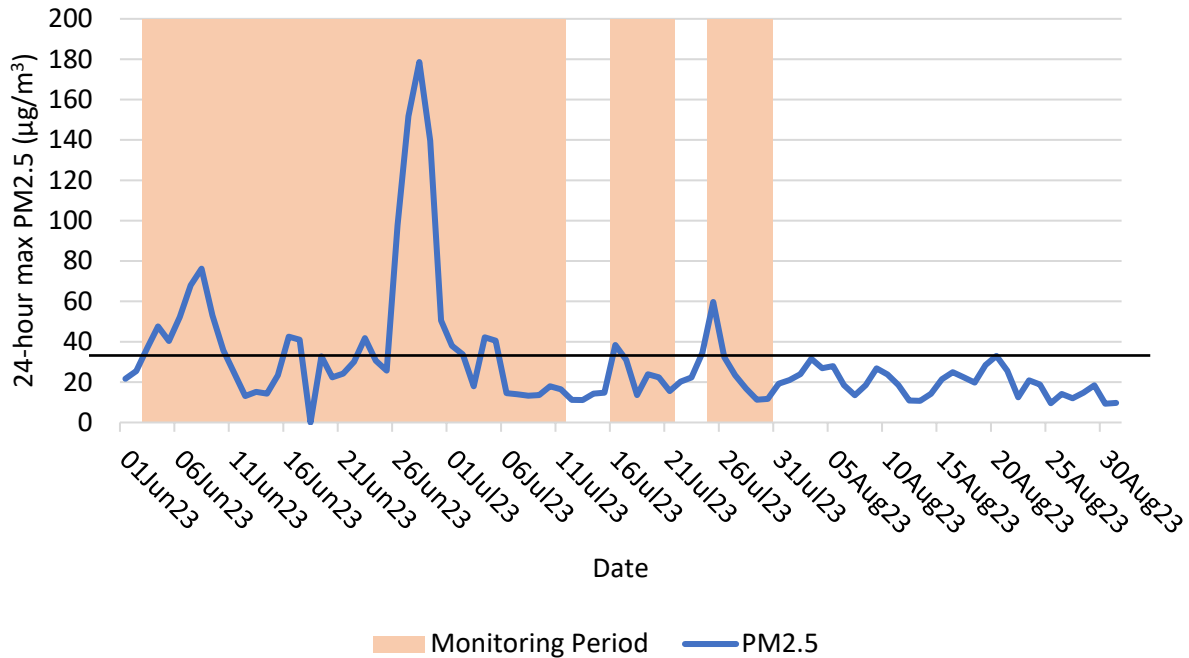
Acute bronchitis, emphysema, chronic obstructive airway disease, chronic obstructive lung disease, chronic obstructive pulmonary disease, asthma, bronchospasm, reactive airway disease (AND NOT 'not asthma'), bronchasthma, difficulty breathing, breathing problem, chest tightness, chronic cough, dyspnea, shortness of breath (AND NOT cough, cold, congestion, febrile, fever, or high temperature).

Asthma ED Visits (Subset of Air Quality-related Respiratory ED Visits)

Asthma, bronchospasm, reactive airway disease (AND NOT 'not asthma').

Appendix B. PM_{2.5} Daily Measurements, June-August 2023

Figure 2. 24-hour PM_{2.5} Measurements from Michigan Air Quality Monitors, June-August 2023.



Data for daily 24-hour average PM_{2.5} concentrations adapted from National Syndromic Surveillance Program. *Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE)*.⁸ Data retrieved June 6, 2024.

The black horizontal line indicates monitoring threshold of 35.4 µg/m³. Shaded areas indicate monitoring period, blue line indicates the maximum 24-hour average PM_{2.5} concentration across all 23 air quality monitors in the state measuring PM_{2.5} during the summer 2023 season.

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