

Wildfire Smoke

LOCAL PUBLIC HEALTH
& SAFETY OFFICERS

Guidance on
cancelling events
or activities, and
closing schools

JULY 2019



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NOWCAST & FORECASTING TOOLS

NowCast particulate matter (PM_{2.5}) concentrations use averages of between 3 and 12 hours that can be compared to 24-hour standards and health indexes. The U.S. Environmental Protection Agency's (EPA) NowCast algorithm is designed to respond when air quality conditions are rapidly changing, which is common during wildfire smoke events. NowCast concentrations use longer averaging times when air quality is stable, and shorter averaging times when conditions are changing quickly. NowCast concentrations, unlike hourly data, are suitable for comparison with federal standards and the Air Quality Index (AQI) and the Washington Air Quality Advisory (WAQA) breakpoints.

Introduction

The Washington State Departments of Health and Ecology have been asked about when to cancel outdoor events and activities or close schools due to wildfire smoke impacts on public health. Decisions about closures, relocations, or evacuations are made at the local level in Washington. This document provides guidance for local health officers about air concentrations of smoke considered a health threat.

Recommended particulate matter action levels for closures and cancellations

When outdoor forecasted 24-hour or NowCast PM_{2.5} concentrations:

- Equal or exceed 35.5 µg/m³ (WAQA value 151/AQI value 101) recommend cancelling children's outdoor recess, physical education, athletic practices and games, or moving them indoors or to an area with good air quality.
 - With the WAQA, this concentration is the lower level of the "unhealthy" category.
 - With the AQI, this concentration is the lower level of the "unhealthy for sensitive groups" category.
- Equal or exceed 80.5 µg/m³ (WAQA value 201/AQI value 164) consider recommending cancelling outdoor public events and activities.
 - With the WAQA, this concentration is the lower level of the "very unhealthy" category.
 - With the AQI, this concentration is within the "unhealthy" category.
- Equal or exceed 150.5 µg/m³ (WAQA value 301/AQI value 201) recommend cancelling outdoor public events and activities.
 - With the WAQA, this concentration is the lower level of the "hazardous" category.
 - With the AQI, this concentration is the lower level of the "very unhealthy" category.

When school is in session and indoor PM_{2.5} concentrations:

- Equal or exceed 150.5 µg/m³ (WAQA value 301/AQI value 201) discuss school closure with administrators.
 - With the WAQA, this concentration is the lower level of the "hazardous" category.
 - With the AQI, this concentration is the lower level of the "very unhealthy" category.

Factors to consider for outdoor event and activity cancellations and school closures

In addition to the action levels, other factors and issues specific to your area should be considered when making decisions about closures and cancellations to protect health and welfare.

Outdoor Events and Activities

- What is the forecast for how long wildfire smoke levels will remain high?
- Are smoke conditions getting worse, getting better, or staying about the same?
- Is there an option to relocate to an area with cleaner air?
- If children or others requiring care are involved, will adults be available as caretakers?
- Will there be impacts on economic or job security by cancelling the activity or event?
- Are there other weather factors to consider, like excessive heat or humidity, that would further increase risk of outdoor exposure?
- Is the visibility safe for driving?

Schools

- What is the forecast for how long wildfire smoke levels will remain high?
- Have all options to improve indoor air quality been attempted?
- Are students and staff who are sensitive to smoke allowed to stay home if it is safer?
- Is it safe to walk or bike to school?
- Is the visibility safe for driving?
- Are there other weather factors to consider, like excessive heat or humidity, that would further increase health risks?
- Where will children be relocated if schools are closed? Is the air quality better there?
- If children or others requiring care are involved, will adults be available as caretakers?
- Will there be impacts to economic or job security for parents missing work to attend to children?
- While moving to another location, will people be more exposed outdoors than if they had just stayed indoors?
- Are there other safety concerns about relocating people?

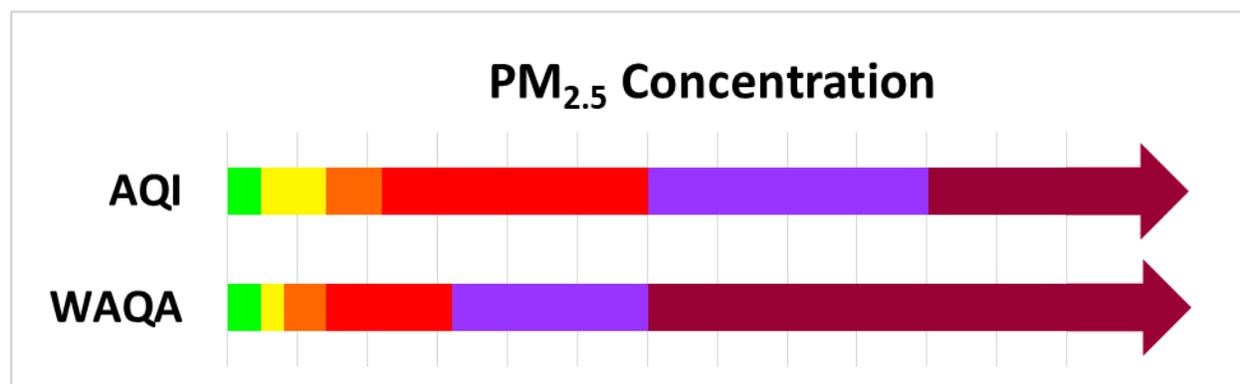
Steps to reduce smoke exposures

- Reduce outdoor time and activities.
- Stay indoors and keep indoor air as clean as possible.
- Keep windows closed and only allow entry of outside air through filtration.
- Restrict use of outside doors; double door entries can help keep smoke out.
- Wildfires often occur on hot days, and many schools and other indoor facilities do not have air conditioning. Pay attention to the heat and take steps to cool buildings.
- For more information:
 - [Improving Ventilation and Indoor Air Quality during Wildfire Smoke Events \(PDF\)](#)
 - [DOH Smoke From Fires](#)

Measuring wildfire smoke levels

The concentration of PM_{2.5} – particles less than 2.5 micrometers in diameter – is the most useful measurement of smoke levels to protect health. The Department of Ecology (Ecology) and local clean air agencies routinely monitor these levels outdoors. PM_{2.5} concentrations are grouped in health hazard levels. We recommend making health decisions based on the Washington Air Quality Advisory (WAQA). WAQA categories are set at lower PM_{2.5} concentrations than Air Quality Index (AQI) categories of the U.S. Environmental Protection Agency (EPA) (Figure 1). Health precautions in each category are based on current conditions weighted to “24 hour-like” average concentrations. Estimates are from hourly monitored concentrations using EPA’s NowCast algorithm.

Figure 1: AQI and WAQA categories



Outdoor measurements

Knowing if forecasted smoke levels are expected to remain high over several days can help decision-making about closing facilities or relocating people. In addition to forecasts, monitor outdoor PM_{2.5} concentrations frequently during wildfire smoke events. Smoke levels can change dramatically in a short time period. There are several key issues to consider in using current air monitoring data for health decisions.

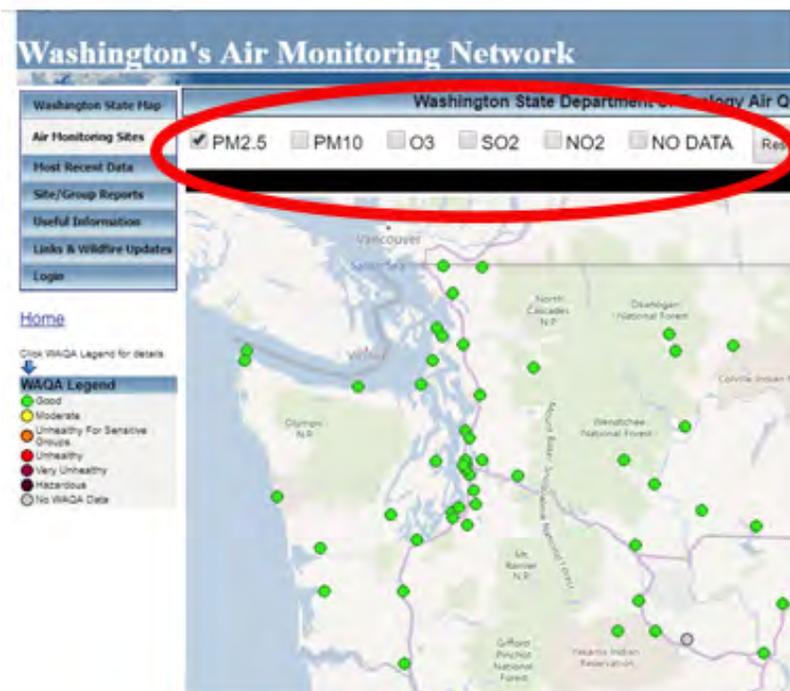
- Hourly updates are widely available of past PM_{2.5} concentrations based on different averaging times. Health guidance is based on 24 hours of PM_{2.5} exposure from epidemiologic studies.
- Forecasts of expected PM_{2.5} concentrations over several days are ideal for making health decisions, but these are not always immediately available for the area of concern.
- It is not recommended to apply the average of the PM_{2.5} concentration over the last 24 hours to anticipate smoke levels in the next 24 hours when making health decisions.
- A one-hour average would be too short to indicate the expected smoke levels over the next 24 hours.

As a more predictive alternative in using current monitoring data, EPA and Ecology adopted a NowCast formula for the averaging time of PM_{2.5} concentrations that ranges between 3 and 12 hours based on existing conditions. Indexes and PM_{2.5} concentrations that apply the NowCast averaging formula are a good alternative to forecast data to make health decisions in advance of smoke events. These are the main ways to check the current PM_{2.5} concentrations using NowCast. More information about [NowCast is available online.](#)

On the Internet

1. Check the WAQA hazard categories by color on **Ecology's [Air Monitoring Network](#)**, which are updated hourly (Figure 2).
 - Select *only* PM_{2.5} for wildfire smoke among the pollutant check boxes at the top of the network map. Each dot on the map represents an air monitoring network site; pick the one closest to the area of concern.
 - The color of the dot corresponds to the WAQA categories.
 - When the monitor dot is red for “unhealthy” or worse, the PM_{2.5} concentration is equal to or above 35.5 µg/m³.
 - When the monitor dot is purple for “very unhealthy” or worse, the PM_{2.5} concentration is equal to or above 80.5 µg/m³.
 - When the monitor dot is maroon for “hazardous” or worse, the PM_{2.5} concentration is equal to or above 150.5 µg/m³.
 - Although there are PM_{2.5} concentrations available on the Ecology’s website, these are not for the correct averaging time for these decisions. The WAQA value (rather than PM_{2.5} concentration) based on the NowCast formula is also reported.

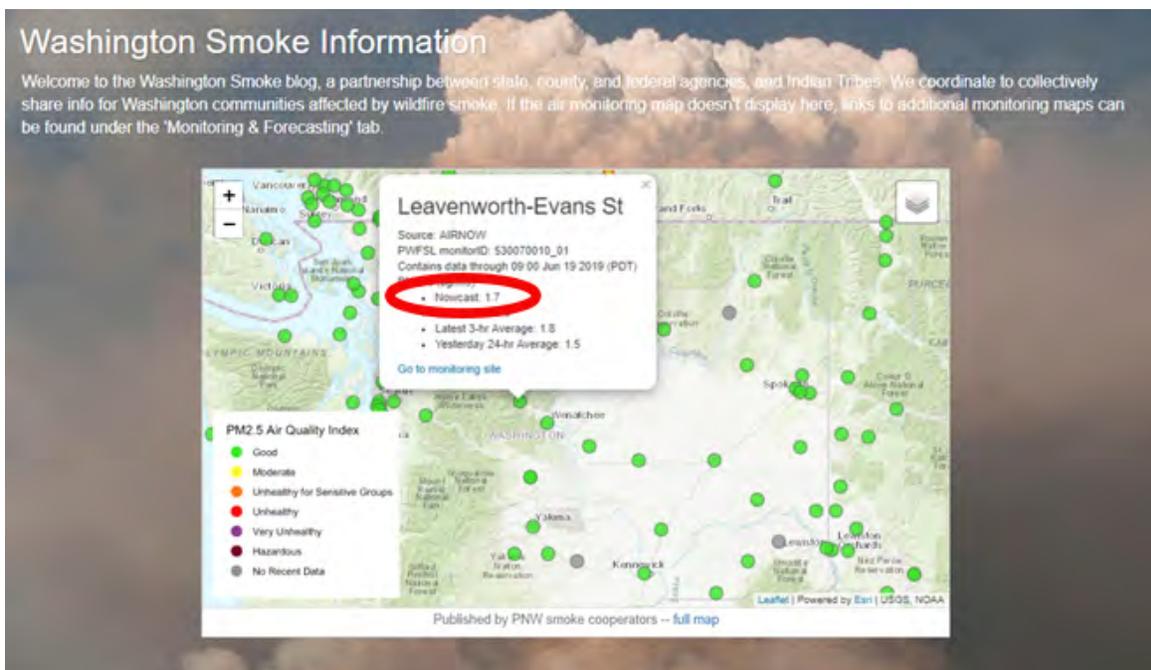
Figure 2: [Department of Ecology Air Monitoring Network](#)



Select PM_{2.5} for wildfire smoke from the available pollutant measurements (circled here). Observe the color of the monitor of interest for the current WAQA NowCast value.

2. Check the NowCast PM_{2.5} concentrations on the air monitoring network map at the top of the website [Washington Smoke Information](#), updated hourly (Figure 3). **Do not** consider the colors on this map when applying the action levels in this guidance. The color of the dots on the Smoke Blog do not always correspond with Ecology’s network map because the Smoke Blog applies AQI while Ecology applies WAQA.
 - If viewing via smartphone: to get to the air monitoring network map, select the “Monitoring and Forecasting” tab.
 - Select the link for mobile users under “Current Air Quality Conditions.”
 - Select the air monitoring network site closest to the area of concern.
 - A pop-up will appear that indicates the monitor site name and various PM_{2.5} concentrations. Check the NowCast PM_{2.5} concentration.
 - Select the monitor of interest to view a pop-up with more detailed information.
 - Find the current NowCast PM_{2.5} concentration within the list of PM_{2.5} (µg/m³) options (shown in red circle).

Figure 3: [Washington Smoke Information](#) air PM_{2.5} monitoring map

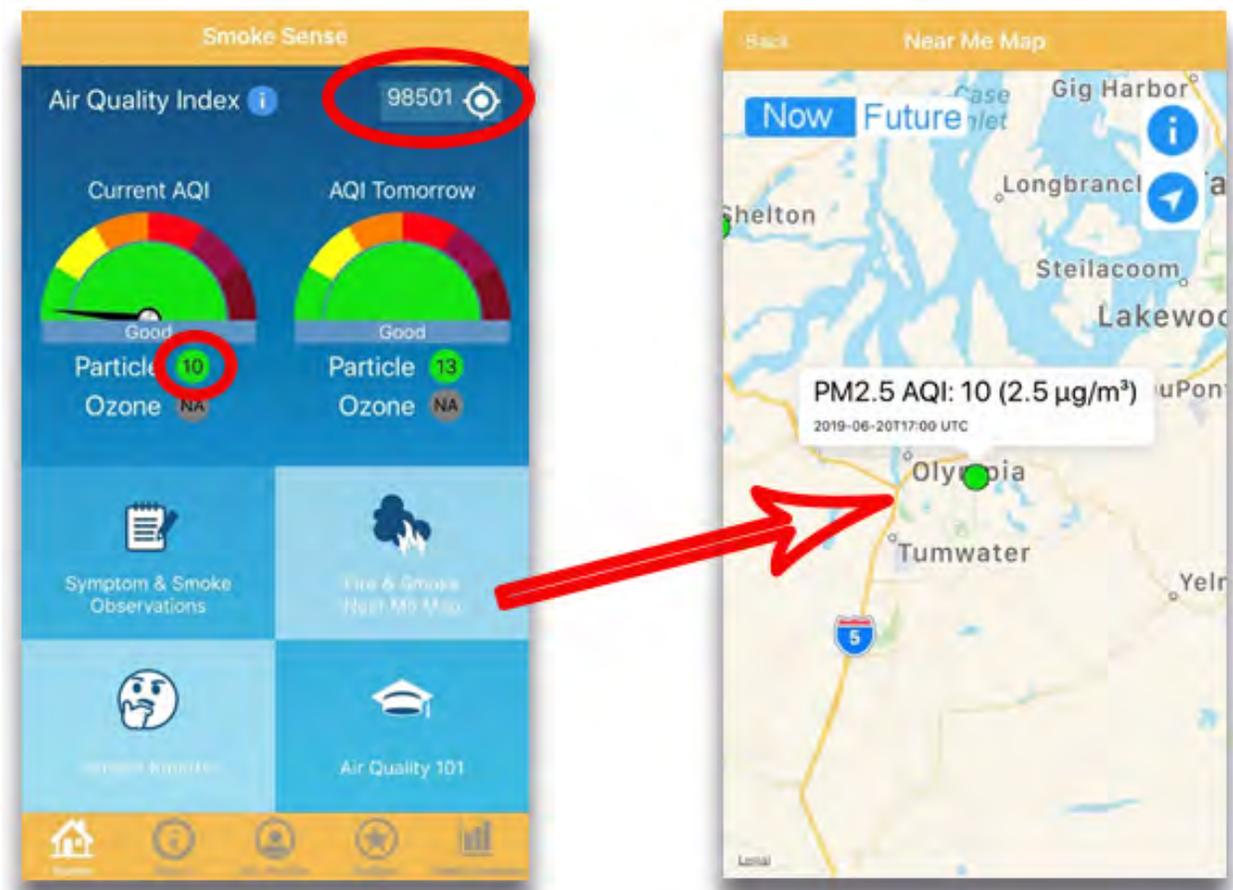


Smart phone apps

Check the AQI value for PM_{2.5} on either the **SmokeSense** or **EnviroFlash** (AIRNow) phone apps (Figure 4). **Do not** consider the colors on these when applying action levels. The color corresponds to the current AQI (EPA), which does not always match Ecology's network map, which uses the WAQA. [Information about SmokeSense is on the web.](#)

- On the opening screen of SmokeSense, make sure the zip code entered matches the area of concern for smoke. The app will identify data from the nearest monitor. Check the number for the **Current AQI Particle** and compare it to the AQI value that corresponds to the NowCast PM_{2.5} concentration action level.
- To ensure which monitor is being applied, tap the *Fire & Smoke Near Me Map*. Select the closest monitor of interest to view a pop-up with more detailed information of the AQI value and PM_{2.5} concentration.
- Select the zip code for the area of concern.
- Check the **Current AQI** value for *Particle*.
- To check the current data for a specific monitor, tap the *Fire & Smoke Near Me Map* box to move to the area map.

Figure 4: Smoke Sense phone app



Air quality forecasts

The SmokeSense and EnviroFlash apps contain air quality forecasts for selected communities in Washington. Though forecasts are updated daily, these do not cover wide areas. The Washington Smoke Information blog contains text and graphical discussions of statewide, regional or local air quality forecasts when wildfire smoke events are in progress. Smoke blog posts are not made when there is little smoke expected, or if smoke impacts are expected to be highly localized. Several air quality models provide hourly simulations of air quality across Washington, but these have various strengths and weaknesses. The [Monitoring and Forecasting](#) tab on the Smoke blog contains more information on these resources.

Other sources of PM_{2.5} air pollution in Washington

Major sources of PM_{2.5} in Washington are wildfire, dust from tilling and harvesting, agricultural and silvicultural burning, and residential wood burning. Industrial and mobile sources also emit PM_{2.5}, though in smaller amounts than these other sources. While there is concern about PM_{2.5} from each of these sources of pollution, the chemical compositions can differ and this can affect toxicity. There are also different seasonal patterns. For example, residential wood burning generally occurs over several months and contributes to routinely high PM_{2.5} concentrations, particularly during cold and stagnant weather. In contrast, wildfire smoke tends to last for a few weeks and the PM_{2.5} concentrations can have very high daily peaks. Some of the highest acute exposures to air pollution in Washington are from wildfire smoke.

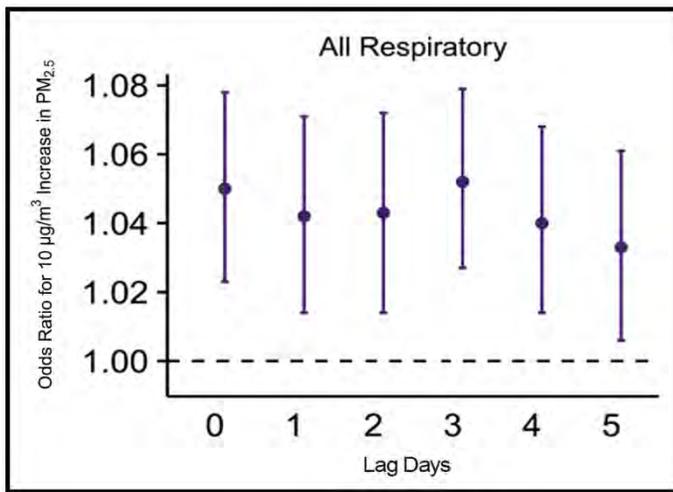
Health Concern of Smoke Exposures

Exposure to wildfire smoke, like all smoke, can cause health problems. Minor symptoms include burning eyes, runny nose and coughing. More life-threatening effects include asthma attacks, COPD flare-ups, abnormal heart rhythms, heart attacks, and strokes.

A 2012 study of Washington wildfire smoke impacts found that for a 10 µg/m³ increase in PM_{2.5} from wildfire smoke there is a 5% increased risk in same-day respiratory hospitalizations (odds ratio 1.052, 95% confidence interval 1.025-1.080) (Figure 5) [1]. The study found that, when focusing on specific respiratory impacts, there is an 8% increased risk for same-day asthma-related admissions for a 10 µg/m³ increase in PM_{2.5} from wildfire smoke (odds ratio 1.076, 95% confidence interval 1.019-1.136) [1].

The Department of Health (Health) collaborated with several local health jurisdictions in central Washington to examine emergency department and outpatient clinic visits during 2012 wildfires. Health found that average daily patient visits were 28% higher for cardiovascular disease and 18% higher for respiratory disease during wildfires, compared to the two-week period before wildfires [2]. The increased daily patient visits were most pronounced for respiratory disease in children [2].

Figure 5: Hospital or urgent care admissions – wildfire smoke



Emergency department or urgent care admissions associated with wildfire smoke exposures for 10 µg/m³ increase in PM_{2.5} from wildfire smoke in Washington in 2012. Includes lag analysis (0-5 days).

Figure adapted from Gan et al. 2017; results limited to GWR estimation of smoke [1]

Sensitive populations are especially at-risk for experiencing adverse health effects when smoke levels are elevated. Sensitive populations include people with heart and lung diseases, people with respiratory infections, people with diabetes, stroke survivors, infants, children, pregnant women, and people over 65 years of age. For wildfire smoke and other air pollution exposures, a smaller portion of the population will suffer from the most severe health impacts, such as death and hospitalizations, and a larger portion of the population will suffer subclinical effects. The most severe impacts first occur in sensitive populations. However, as wildfire smoke exposures increase, more of the public will start to experience these severe impacts (Figure 6).

Figure 6: Range of health effects from wildfire smoke exposure

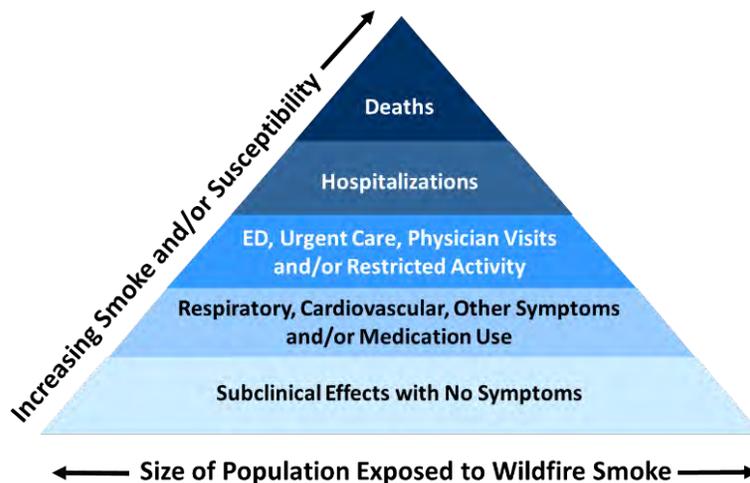


Figure adapted from Cascio 2018 [3]

Most epidemiologic research of wildfire smoke focuses on acute health effects that occur within a week of elevated 24-hour PM_{2.5} exposures. There is minimal research about long-term health effects

of wildfire smoke exposure [4]. There is some evidence that most people recover from exposures to wildfire smoke within weeks. Studies of wildland firefighters found that forced expiratory capacity in one-second (FEV1) declines over a firefighting season, and returns to baseline within months [4]. In general, particle clearance from lungs of healthy people is nearly complete after several weeks. Clearance takes longer in people with progressive lung diseases [5, 6]. The amount of time it takes for particles to clear the body is relatively long compared to most wildfire smoke episodes in the Pacific Northwest. Most people will likely recover a few weeks after inhalation of wildfire smoke. However, there may be some residual physical damage.

Several epidemiologic studies focusing on health impacts of wildfire smoke have been published recently. There is a much larger body of published research about PM_{2.5} exposures from other sources of air pollution. Meta-analyses combining the results of several studies demonstrate that short-term increases in PM_{2.5} from a wide range of sources are associated with higher rates of deaths and hospitalizations [7, 8]. Many of these deaths and hospitalizations are due to cardiovascular and respiratory effects. Increased cardiovascular hospitalizations include congestive heart failure and ischemic heart disease [9]. Underlying respiratory diseases that are worsened include asthma, chronic obstructive pulmonary disease (COPD) and pneumonia [9]. In adults and children, research indicates that elevated exposures to PM_{2.5} leads to poor lung function [10, 11]. Exposure to PM_{2.5} in children may not only worsen asthma, but may lead to development of asthma [12]. While worsening heart and lung effects from PM exposure have been studied the most, there is increasing evidence that PM_{2.5} may also lead to several other effects, such as strokes [13], development of type 2 diabetes [14, 15], neurological and cognitive impairment [16, 17], and poor birth outcomes like pre-term delivery or babies born with low birth weight [18, 19]. In research specific to wildfire smoke PM_{2.5} exposures, the pattern of impacts appears similar to that of PM_{2.5} from other sources. However, there is little information for some of these impacts specific to wildfire smoke.

Summary Tables of Air Quality and Public Health Guidance

Figure 7: Washington Air Quality Advisory guidance – public health

Washington Air Quality Advisory (WAQA) Guidance for Public Health Actions



Health Advisory Category Forecasted 24-Hour Average or NowCast PM _{2.5} Concentration (µg/m ³)	Recommended Public Health Actions For use with Washington Air Quality Advisory PM _{2.5} NowCast values and forecasted 24 hour PM _{2.5} concentrations.
Good PM _{2.5} 0 - 12.0	<ul style="list-style-type: none"> If smoke incident is forecasted in your area, review the Washington Wildfire Response document for Severe Smoke Episodes and the Wildfire Smoke Guide for Public Health Officials. More health tips on the Department of Health Smoke From Fires website. More information about wildfire and air quality at WA Smoke.
Moderate PM _{2.5} 12.1 – 20.4	<ul style="list-style-type: none"> Distribute information to public health partners and the public. Focus on identifying and getting information to vulnerable populations. Refer people to the WA Smoke Blog for more information about status of wildfires. Provide information about steps to take with health advisory categories: DOH Washington Air Quality Advisory Graphic (English).
Unhealthy for Sensitive Groups PM _{2.5} 20.5 – 35.4	<p>Above recommendations, plus:</p> <ul style="list-style-type: none"> Issue press release, identify sensitive groups and encourage them to reduce exposure. For extended duration of smoke recommend spending time in a cleaner air setting in the community (air-conditioned library) or leaving the area until air quality improves. For extended duration of smoke, open a cleaner air shelter for sensitive groups. If school is in session, refer to the DOH Air Pollution and School Activities Guide.
Unhealthy PM _{2.5} 35.5 – 80.4	<p>Above recommendations, plus:</p> <ul style="list-style-type: none"> Recommend cancelling children's outdoor athletic events and practices, or moving them indoors or to an outdoor space with good air quality. Recommend the public limit strenuous outdoor activities. Recommend that sensitive groups shelter-in-place, spend time in a cleaner air setting in the community (air-conditioned library) or leave the area until air quality improves. For extended duration of smoke, open and publicize cleaner air shelters for sensitive groups.
Very Unhealthy PM _{2.5} 80.5 – 150.4	<p>Above recommendations, plus:</p> <ul style="list-style-type: none"> Consider cancelling outdoor public events and activities. Recommend shelter-in-place for the general population. Share information about periods of improved air quality to guide essential outdoor activity and ventilation of dwellings.
Hazardous PM _{2.5} : >150.4	<p>Above recommendations, plus:</p> <ul style="list-style-type: none"> Cancel outdoor public events and activities. If school is in session, discuss school closure with administrators if indoor air cannot be kept cleaner. Recommend voluntary evacuation for sensitive groups.

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Figure 8: Washington Air Quality Advisory guidance – general public

WAQA WASHINGTON AIR QUALITY ADVISORY

Check air quality conditions at ecology.wa.gov/WAQA

	<p>GOOD</p> <p>Air pollution is so low so there is little health risk. It's a great day for everyone to enjoy the outdoors!</p>	<p>SENSITIVE GROUPS INCLUDE:</p> <ul style="list-style-type: none"> • People with health conditions such as: <ul style="list-style-type: none"> - Asthma, COPD, diabetes, & other heart/lung diseases - Respiratory illnesses & colds - Stroke survivors • Children under 18 & adults over 65 • Pregnant women • People who smoke
	<p>MODERATE</p> <p>People with health conditions should limit spending any time outdoors & avoid strenuous outdoor activities. They may begin to have worsened symptoms.</p>	
	<p>UNHEALTHY FOR SENSITIVE GROUPS</p> <p><i>All of the above &:</i> All sensitive groups should limit spending any time outdoors. People with health conditions may have worsened symptoms. Healthy people may start to have symptoms.</p>	
	<p>UNHEALTHY FOR EVERYONE</p> <p>Everyone, especially sensitive groups, should limit time spent outdoors, avoid strenuous activities outdoors, & choose light indoor activities.</p>	
	<p>VERY UNHEALTHY FOR EVERYONE</p> <p>Everyone should stay indoors, avoid all strenuous activity, close windows & doors if it's not too hot, set your AC to recirculate, & use a HEPA air filter if possible.</p>	
	<p>HAZARDOUS FOR EVERYONE</p> <p><i>All of the above &:</i> People with heart or lung disease, or those who have had a stroke, should consult their healthcare provider about leaving the area & wearing a properly-fitted respiratory mask* if they must go outdoors. Follow burn bans and evacuation orders.</p>	

KNOW THE SYMPTOMS:

- Watery or dry eyes
- Coughing/wheezing
- Throat & sinus irritation
- Phlegm
- Shortness of breath
- Headaches
- Irregular heartbeat
- Chest pain

If you are experiencing serious symptoms, seek immediate medical attention.

Air pollution from dust, vehicles, woodstoves, wildfires, & industries can seriously impact your health.

*For more health information & how to choose the proper respiratory mask, visit doh.wa.gov/smokefromfires.



January 2018

Figure 9: [Washington Air Quality Advisory Guidance for Children’s School Activities](#)

Air Pollution and School Activities

Public Health Recommendations for Schools on Fine Particle Air Pollution



Air Quality Conditions*					
First, check local air conditions at https://fortress.wa.gov/ecy/enwiwa/ and then use this chart.					
	Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy/ Hazardous
Recess (15 minutes)	No restrictions.	Allow students with asthma, respiratory infection, lung or heart disease to stay indoors.	Keep students with asthma, respiratory infection, and lung or heart disease indoors.	Keep all students indoors and keep activity levels light.	Keep all students indoors and keep activity levels light.
P.E. (1 hour)	No restrictions.	Monitor students with asthma, respiratory infection, lung or heart disease. Increase rest periods or substitutions for these students as needed.	Keep students with asthma, respiratory infection, lung or heart disease, and diabetes indoors. Limit these students to moderate activities. For others, limit to light outdoor activities. Allow any student to stay indoors if they don't want to go outside.	Conduct P.E. indoors. Limit students to light indoor activities.	Keep all students indoors and keep activity levels light.
Athletic Events and Practices (Vigorous activity 2-3 hours)	No restrictions.	Monitor students with asthma, respiratory infection, lung or heart disease. Increase rest periods and substitutions for these students as needed.	Students with asthma, respiratory infection, lung and heart disease, or conditions like diabetes shouldn't play outdoors. Consider moving events indoors. If events are not cancelled, increase rest periods and substitutions to allow for lower breathing rates.	Cancel events. Or move events to an area with "Good" air quality — if this can be done without too much time spent in transit through areas with poor air quality.	Cancel events. Or move events to an area with "Good" air quality — if this can be done without too much time spent in transit through areas with poor air quality.

**Students with asthma should be following their Asthma Action Plan in all Air Quality Conditions.*

Light Activities: Playing board games, throwing and catching while standing, and cup stacking.

Moderate Activities: Yoga, shooting basketballs, dance instruction, and ping pong.

Vigorous Activities: Running, jogging, basketball, football, soccer, swimming, cheerleading, and jumping rope.

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Air Pollution and School Activities, page 2

School Closures

School closures are the decision of the individual school district, usually in consultation with the local health department. Consult your local health department (www.doh.wa.gov/localhealth) if you have questions about air pollution and health.

WAQA Index

Activity recommendations are based on the Washington Air Quality Advisory (WAQA) index. The WAQA uses the same color-coded categories as the EPA's Air Quality Index (AQI), but the WAQA fine particulate matter (PM_{2.5}) categories are set at lower levels of air pollution to be more protective of health. The WAQA shows air quality as poor earlier, with less pollution in the air.

Fine Particulate Matter, Indoor Air Quality, and Health

Wildfires, wood burning, and air stagnation increase the fine particulate matter in the air we breathe. Fine particulate matter travels easily indoors, especially if ventilation systems are drawing outside air into their system. It also comes in through doors, windows, and small openings. Over time, concentrations of fine particulate matter indoors can approach concentrations outdoors.

Exercising students breathe deeper and more often and take in more air, and more air pollution, into their lungs. Breathing polluted air can cause health problems, including aggravating asthma and other respiratory diseases. Anyone experiencing symptoms such as wheezing, shortness of breath, chest pain, headache, and dizziness should be seen by a medical provider.

Schools should reduce inside physical activities once air quality has reached or exceeds the "Unhealthy" category. Increased physical activity requires students to breathe faster, use more oxygen, and produce more CO₂.

School buildings with enhanced filtration will have improved indoor air quality. Supplemental use of properly sized HEPA-charcoal air filters, have been shown to improve indoor air quality by reducing particulate matter and chemicals in smoke.

Asthma Action Plan

<http://www.doh.wa.gov/YouandYourFamily/IllnessandDisease/Asthma/WhatShouldIExpectfrommyHealthCareProvider.aspx>

More Information

For more information on indoor or outdoor air quality issues, including wildfire smoke, see <http://www.doh.wa.gov/CommunityandEnvironment/AirQuality.aspx> or contact us toll free at 1-877-485-7316.

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Citations

1. Gan, R.W., et al., *Comparison of wildfire smoke estimation methods and associations with cardiopulmonary-related hospital admissions*. *Geohealth*, 2017. **1**(3): p. 122-136.
2. Washington Department of Health, et al., *Surveillance Investigation of the Cardiopulmonary Health Effects of the 2012 Wildfires in North Central Washington State*. 2015.
3. Cascio, W.E., *Wildland fire smoke and human health*. *Sci Total Environ*, 2018. **624**: p. 586-595.
4. Black, C., et al., *Wildfire smoke exposure and human health: Significant gaps in research for a growing public health issue*. *Environ Toxicol Pharmacol*, 2017. **55**: p. 186-195.
5. Lippmann, M., D.B. Yeates, and R.E. Albert, *Deposition, retention, and clearance of inhaled particles*. *Br J Ind Med*, 1980. **37**(4): p. 337-62.
6. Houtmeyers, E., et al., *Regulation of mucociliary clearance in health and disease*. *Eur Respir J*, 1999. **13**(5): p. 1177-88.
7. Requia, W.J., et al., *Global Association of Air Pollution and Cardiorespiratory Diseases: A Systematic Review, Meta-Analysis, and Investigation of Modifier Variables*. *Am J Public Health*, 2017: p. e1-e8.
8. Achilleos, S., et al., *Acute effects of fine particulate matter constituents on mortality: A systematic review and meta-regression analysis*. *Environ Int*, 2017. **109**: p. 89-100.
9. Anderson, J.O., J.G. Thundiyil, and A. Stolbach, *Clearing the air: a review of the effects of particulate matter air pollution on human health*. *J Med Toxicol*, 2012. **8**(2): p. 166-75.
10. Gauderman, W.J., et al., *The effect of air pollution on lung development from 10 to 18 years of age*. *N Engl J Med*, 2004. **351**(11): p. 1057-67.
11. Adam, M., et al., *Adult lung function and long-term air pollution exposure. ESCAPE: a multicentre cohort study and meta-analysis*. *Eur Respir J*, 2015. **45**(1): p. 38-50.
12. Islam, T., et al., *Relationship between air pollution, lung function and asthma in adolescents*. *Thorax*, 2007. **62**(11): p. 957-63.
13. Shah, A.S., et al., *Short term exposure to air pollution and stroke: systematic review and meta-analysis*. *BMJ*, 2015. **350**: p. h1295.
14. He, D., et al., *Association between particulate matter 2.5 and diabetes mellitus: A meta-analysis of cohort studies*. *J Diabetes Investig*, 2017. **8**(5): p. 687-696.
15. Wang, B., et al., *Effect of long-term exposure to air pollution on type 2 diabetes mellitus risk: a systemic review and meta-analysis of cohort studies*. *Eur J Endocrinol*, 2014. **171**(5): p. R173-82.
16. Xu, X., S.U. Ha, and R. Basnet, *A Review of Epidemiological Research on Adverse Neurological Effects of Exposure to Ambient Air Pollution*. *Front Public Health*, 2016. **4**: p. 157.
17. Heusinkveld, H.J., et al., *Neurodegenerative and neurological disorders by small inhaled particles*. *Neurotoxicology*, 2016. **56**: p. 94-106.
18. Li, X., et al., *Association between ambient fine particulate matter and preterm birth or term low birth weight: An updated systematic review and meta-analysis*. *Environ Pollut*, 2017. **227**: p. 596-605.
19. Lamichhane, D.K., et al., *A meta-analysis of exposure to particulate matter and adverse birth outcomes*. *Environ Health Toxicol*, 2015. **30**: p. e2015011.

