

**Lisa Matthews:**

Ok so again today we are pleased to present EPA's research on wildfire smoke emissions impact on public health. Dr. Cascio is the Director of EPA's Environmental Public Health Division in the National Health and Environmental Effects Research Laboratory at EPA's Office of Research and Development.

At this point I would like to turn it over to Dr. Cascio who will lead us through today's presentation.

**Dr. Cascio:**

Thank you Lisa for the kind introduction. It's a pleasure to again have the opportunity to share some thoughts about a public health topic that is growing in importance and impact and having relevance to many public health officials across the country, as well as federal, state and local decision-makers. Today's topic will be a brief discussion of wildfire smoke and its health effects and some general comments on what tools are available to provide public health guidance and education during wildfire events. I will also briefly discuss the 2008 Wildfire Smoke Guide for Public Health Officials and a plan to update the guide over the next month lead by Susan Stone in EPA's Office of Air Quality Planning and Standards in partnership with EPA's Office of Research and Development, the US Forest Service, and the CDC. Our goal is to provide the draft version of this document for use by the States during the 2016 wildfire season. Our plan is to then go get feedback from States that will be incorporated into the writing of the final document with an expected release date of the final version by the start of the 2017 fire season.

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In this next slide, you can see wildfire and its smoke emission are a global burden and contribute to the burden of disease. This global map illustrates in dramatic way just how widespread wildfires are. The location of these fires as detected by NASA satellites of a 10 day period in February of this year (2016) are identified by a colored dot. The wide areas of red and yellow indicate the extensive distribution of wildfire around the globe. Today are also a public health concern in the U.S.

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Today we witness [that] wildfires and their emissions affect populations at the regional level. Some notable wildfires in recent years based on their size or severity are noted here.

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Today Wildfires are also a public health concern in the U.S. but are not new. In preparing for the webinar I learned some history of wildfire and that one of the first comprehensive historical accounts of a wildfire in North America was by Lewis and Clark. As shown in this slide there were a number of major fires during this example the 19th century. The Miramichi Fire for example in Maine and New Brunswick burned 3 million acres, it's hard to image something occurring on the east coast this big today. The Great Fire in Oregon in 1845 burned 1.5 million acres.

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The graph on this slide shows the annual acreage burned in the United States. While we know that the number of wildfires has not appeared to be increasing over recent time, as this graphic illustrates on the right we see that the total acreage burned each year has on average had increased substantially in recent years and these fires are having a greater impact on the population. As the statistics on the left point out, today nearly 10% of all land with housing is situated in the wildland-urban interface, and nearly 40% of housing units are at risk from wildfire effects.

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The EPA has an interest in wildfire emissions because of our mission to protect public health and the environment. The trends of increasing fire size and severity result in a greater risk to health and a greater contribution of wildfire emissions to air quality. We also have interest related to the impact of emissions for understanding global climate change.

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Wildfire emissions are complex physically and chemically. On the right side of the slide you see a scanning electron micrograph of particulate matter generated in a wildfire. Note the physical complexity of the particulate structure. Yet, emissions also include gases such as carbon monoxide and air toxics, heavy metal, and volatile organic carbon. Not appreciated by many, when emissions interact with Nitrogen dioxide in urban centers the result can be the formation of ozone having effects remote from the source of the fire.

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Wildfire emissions are now known to have substantial health effects. Two recent papers are highlighted here. A systematic review of the literature by Liu and colleagues that appeared in the journal Environmental Research last year that summarizes what is known about the association between wildfire smoke and health. And a very informative research paper by that describes the association between air pollution attributed to forest fires and emergency department visits. The link for these publications is provided on the slide, and I encourage people if they can get access to these papers – one is an open access paper so everyone should have no trouble getting it – so take a look at it.

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Some of the key findings are on the next slide, based on the body of evidence to date we can say that wildfire emissions contribute to all-cause mortality, worsening of asthma and chronic obstructive lung disease, bronchitis and pneumonia, childhood respiratory disease, clinical cardiovascular events and adverse birth outcomes, anxiety and symptoms such as: eye irritation, sore throat, wheeze, cough, & chest pain.

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The next slide shows the overall health effects attributable to air pollution exposures in the form of a pyramid with excess deaths at the apex. As one moves downward in the pyramid the severity of the health effect diminishes, yet the number of people affected increases. The point I want to make here is that the deaths represent only the smallest number of people impacted. Hospitalizations, utilization of the health care system and discomfort impacting work or enjoyment of life contribute substantially to the overall societal burden of wildfire smoke. In a study by EPA's Ana Rappold, the economic impact of the 2008 Pocosin fire in Eastern North Carolina was estimated to be as much as \$48 million dollars. This was a fire that involved 45,000 acres and lasted about 200 days. That some is twice the cost of what the state had to pay to suppress that fire.

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Now I don't want to overwhelm you with clinical data, yet I do wish to share some results from a recent paper related to wildfire emissions and out-of-hospital cardiac arrest and hospitalizations for ischemic heart disease. As shown in the left-hand panel you can see the percent increase in OHCA as it relates to wildfire smoke in a study that was conducted in Australia. Wildfire emissions increase the risk for out-of-hospital cardiac arrest overall by just under 8% and this effect was greater in people over the age of 65 and men. On the right, we see similar findings occurred for ischemic heart disease except instead of men women appeared to be more sensitive.

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So given that people with respiratory and cardiovascular diseases and the aged are at higher risk, one might ask just what percentage of the population does this represent, if this is a significant percentage? As medical interest we would like to know this In a study by Wells and colleagues published in the medical journal PlosOne the National Health and Nutrition Examination Survey was used to make such a determination.

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What they found was that 27% falls into a least one susceptible group groups, individuals who are over 65 or have cardiac or respiratory disease!

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An important question for public health officials is "Is the public interested in information on air quality and wildfire smoke?" This slide was provided by Ana Rappold an epidemiologist in ORD, the Office of Research and Development at EPA who has evaluated the interest in air quality associated with wildfires in Washington State by looking at the frequency of hits that individuals looked at EPA's AirNow website. On the left panel you see Washington state with colored circles that represent both the size and location of large wildfires during 2015. On the right you see the session hits on AirNow from July to November last year. What is very apparent is that the level of interest was directly related to the size of the fire. For example, the Wolverine fire which occurred in late June/early July produced a small hit on the

graph, whereas the North Star fire which was in excess of 200,000 acres produced over 45,000 hits each day. So the answer appears to be clear. The public is seeking this information.

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Given that the public is seeking type of this information. One can ask what do they do with it. Again, referring to a paper by Wells and colleagues at the National Health and Nutrition Examination Survey (NHANES) was used to look at whether people changed their activity in response to poor air quality. Again they stratified based on the at risk populations as shown in this table.

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What they concluded was that 12.% of the study population changed activities due to bad air quality, and 25% of those with a respiratory condition changed activities. One would hope that the response rate would be greater. This raises the question from a public health perspective, are we providing the right kind of information in a way people can use it. Yet, from a public health perspective are we providing the right kind of information in a way people can use it? More research is needed in health literacy risk communication to better understand how to communicate this critically important information. Even less is known about how much relevant information is provided by health care workers, the health care systems for which they work or health care insurances companies to educate their at-risk patients

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Because of two very similar types of fires in eastern NC occurring only three years apart we had the opportunity to examine the reproducibility of the health effects associated with exposure to wildfire emissions. This work has been led by Ana Rappold who found the 2008 Pocosin Lakes National Wildlife Refuge fire to be associated with a number of respiratory conditions and interestingly heart failure. This is the fire I mentioned before which lasted a considerable amount of time which involved more than 40,000 acres. In 2011 another Pocosin fire very close to the first one occurred and again health outcomes were evaluated. The results of this study were published in the journal environmental health, which you see there. Interestingly, during the second fire the heart failure signal was not observed. While there are many potential explanations for this discrepancy it's also possible that increase awareness of the health effects of wildfire among a population sensitized by the 2008 event led to fewer events because of individual actions taken to avoid exposure. This is a hypothesis which is well worth pursuing, but it may suggest if true, that interventions that involves communication and messaging during and in advance of wildfires could have a public health benefit.

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Now one of the questions is there biological evidence that avoidance of exposure could have a clinical benefit or a biological benefit. In a study by Allen et Al. HEPA Filtration was used to lower exposure burden in a wood smoke impacted community in British Columbia. They made two significant observations. HEPA filtration improved biomarkers in inflammation in men and in people having BMI's greater than 25, and improves blood vessel function in people older than 43 years, and those with BMIs

>25, and those spending more than 75% of their time indoors, which makes sense because they would have benefitted from the HEPA filter more. Now what you see in the slide is reactive hyperemia index, which is a measure of vascular function. So HEPA filtration during the fire event benefitted the physiologic and biochemical characteristic of the individual, now that does not immediately translate in this study to a clinical benefit, but let me talk briefly about what we believe to be the mechanisms of how such clinical events occurs.

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You might be saying to yourself at this point. I can easily see how inhaling wildfire smoke can cause respiratory conditions, but how can it affect inflammation in the body, blood vessel function or even cause a heart attack or sudden death. This slide shows the current thinking on the potential mechanisms linking particulate exposure to cardiovascular events. In brief, particles interact with the lung and produce inflammatory proteins that travel throughout the body having effects beyond the lungs. You see that in the first arrow number 1. It's also known that particles activate the protein receptors in the lung that are linked to the central nervous system leading to changes in signals to the body including the heart and blood vessels. That is shown in number 2, leading to changes in the balance of the autonomic nervous system and sympathetic, which is the fight or flight response, or the para-sympathetic system that slows the heart rate down. There is also the possibility that the smallest particles move into the blood and brain where they act. Research is ongoing to understand these mechanisms and to learn how they might be interrupted.

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Many federal departments and agencies work collaboratively to protect the public from wildfire and its emissions. I won't go into a description of the slide in detail – it's fairly large - but it should be apparent there is substantial involvement at the federal level with a lot of coordination at the state level. As Lisa said, these slides will be available later so anyone interested can take a look at that.

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The Office of Research and Development is actively engaged in wildfire research applying its expertise to better understand the links between wildfire emission and health effects. Work supported by the national research programs includes characterizing emission, atmospheric chemistry, ambient monitoring methods and human exposures. Our environmental health scientists are using epidemiological methods and models to understand the effects of emissions on public health and also the potential benefits of public health messaging of smoke forecasts. Such studies are complemented by cellular and animal toxicology studies to better define the biological mechanisms accounting for such effects. Of particular interest is measuring the relative toxicity of different types of fuels and how those toxicities change depending on the local conditions. Scientists in our National Exposure Research Laboratory are working to incorporate wildfire emission data into their models of air pollution. We are also trying to better understand the potential impact of climate change on wildfire risk, its implications for health and how emissions might impact climate change.

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The next two slides provide just two examples of the work that is being done using sophisticated sampling technologies to collect and measure the emissions from fires and to look at the toxicology of different fuels. You can see the long list of particulates, gases and chemicals that can be monitored by drones, weather balloons and land based-sampling methods.

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Some of the cutting edge work is being supported by the Joint Fire Science Program. The Joint Fire Science Program is an interagency research program established by Congress in 1998 to foster research on wildfire. The Department of the Interior and the Department of Agriculture govern the program. The research goals of the work being supported the Joint Fire Science Program and our division is to compare the relative cardiopulmonary toxicity and mutagenicity of PM emissions from different fuel types these include pine, oak, peat, chaparral and burning conditions whether it's flaming or smoldering. One of the goals is to provide a potency ranking matrix for the various types of fuel, for example pine, oak, peat, or grasses. To date, we've also looked at the toxicology of the particles collected and found an interesting result, which is that the larger particles had greater pulmonary toxicity whereas the smaller particles emitted during that fire had greater cardiovascular toxicity.

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One of the best sources of up-to-date information about wildfire and its impacts on air quality is the AirNow website that is supported by the EPA and the states. Within the EPA it is the Office of Air and Radiation that supports the AirNow website which is the internet portal for valuable information about local air quality and educational material for the public and health care providers. Now included on the AirNow website in the upper right hand corner, which is circled, is a link to Current Wildfire Conditions.

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When you click this link you are provided with a map of North America with the location of all active wildfires as shown on this screenshot taken from today. On the right-hand side of the screen is a small tab next to the arrow that when activated will open a new screen allowing the viewer to explore additional data layers on the map. And if you're like me and you've never looked at this map before, you will be extraordinarily surprised by the number of active fires that are occurring in the United States. You will also see, in the gray, smoke plumes which are emanating from some of the larger fires and the areas they are projected to affect. Now those plumes may be at ground level or may be at higher elevations. The map does not allow you to distinguish between the two. But if one hits the tab there marked with the red arrow, we will see the data layers.

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The data layers include the fire locations from the Hazard Mapping System, latest PM2.5 AQI from Temporary Monitors near the sites of wildfires provided by the US Forest Service, and from AirNow Stationary Monitors around the country, and also the Illustration of Smoke Plumes I commented on

from the Hazard Mapping System, there's also a link to the wildfire Incident Information System (InciWeb).

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At the bottom of the page if you scroll down there are three buttons that provide links to "Current Advisories", information about "Fires and Health" and what to do "Before, During and After a Wildfire"

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If you press the Current Advisories button, this is what comes up. Here's a screen shot of the Smoke Advisories and Forecasts broken out by the states that participate. You can click on those to see if there are any active fires or smoke conditions that one needs to know about.

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If you were to press the Fires and Your Health button, we will see useful information about smoke and health. It also provides useful links to health resources and educational resources.

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Clicking the Before, During and After Wildfire button provides a link to the CDC's emergency Preparedness and Response website where you can find further information about wildfire. Taken in total there is quite a lot of useful information.

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I'm going to transition now to a short discussion on Wildfire Smoke: A Guide for Public Health Officials. Probably one of the most important guidance documents for public health officials providing information to protect the public from the adverse effects of wildfire smoke is the 2008 Wildfire Smoke: A Guide for Public Health Officials. This publication emerged in response to the 1999 fires on the Hoop reservation. Led by the University of Washington and the California Office of Environmental Health Hazard Assessment the original guide was based on limited health and air quality information. The Guide was updated in 2008 when more health information was known. A current version can be found on the California Environmental Health Hazard Assessment (CA OEHHA) website and the link is shown on the slide and also at the end of presentation.

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For those of you who do not know the document I've listed some of the key elements of the Guide. These include the Composition of smoke, Characteristics of wildfire smoke, Health effects of smoke, Sensitive populations, we spoke a little about that early, more is known about this today- the aged, those with heart and lung disease, children, Specific strategies to reduce smoke exposure, Estimating

particulate matter levels, Recommendations for public health actions including Preseason public service announcements and Public advisories and protective measures.

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For completeness I need to mention two documents produced by the British Columbia Center for Disease Control. The covers are shown here - One is entitled Guidance for BC Public Health Decision Markers During Wildfire Smoke Events, and the other is Evidence Review: Reducing time outdoors during wildfire smoke events: Advice to stay indoors, advice to reduce outdoor physical activity, and cancelling outdoor events. Some of the general recommendations are shown on this slide. For the individual. These are simple messages - Stay indoors. Reduce outdoor activity – the reason being your exposure is related to the time that you're exposed as well as your ventilation rate which is going to be related to the level of your activity. Consider an N-95 respirators in the short-term. Activate asthma/COPD action plans. Use a home clean air shelter. At the community level decisions can be made to cancel outdoor events, provide community clean air shelters, increase air filtration in institutions, or if necessary, evacuate.

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This spring a group of federal partners has started the process to up-date the Guide. So if it's so useful why should we up-date it. Because of the importance of this document as a common source of information and because of the continued emergence of new health data a revision will improve the quality and utility of the document we believe. The anticipated upgrades will better define health effects and include more information related to children.

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This slide provides a general outline of the anticipated timeline for producing and delivering a draft up-date Guide. A writing group is already working to complete a first draft by the end of March. In April we plan to send the document to the States for comments, we will then incorporate comments into a first revision sometime in May. Our hope or our expectation is to have this first revised draft ready to deliver to the States to use during this coming year's wildfire season. Late in the summer we will again ask for feedback on the document and how it can be improved. We plan to provide a final draft for approval during the winter of 2016-17 and have a final version available by the wildfire season starting in 2017. We realize the timeline is ambitious but the writing team is committed to getting this done, and there is a great deal of coordination amongst representatives of different agencies.

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For more information please visit the websites listed on this slide. The slides will be available through your link to the webinar. I hope you have found this presentation useful and have a better appreciation for the work the EPA and its contributing to protecting public health and making our communities more resilient to the impacts of wildfire emissions. I will be pleased to answer any of your questions. So thank you very much for your attention.