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Safe from Wildfire Smoke

Healthy Environments
for Healthy Children

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Safe from Wildfire Smoke

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Foreword

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Director, UNICEF Programme Group

In an era where climate change and environmental degradation loom large, the fundamental right of every child to survive, thrive and reach their full potential is under unprecedented threat. Globally, landscape fires – including the ominous spectre of wildfires – are surging in both size and frequency. This alarming trend is, in no small measure, a consequence of the escalating climate crisis, ushering in hotter and drier conditions that provide an ideal breeding ground for these destructive infernos.

Amid this environmental upheaval, wildfires unleash bursts of fine particulate matter ($PM_{2.5}$) exposure, the repercussions of which extend beyond the immediate crisis. Unlike prolonged exposure to ambient air pollution, the $PM_{2.5}$ emanating from landscape fires is intermittent yet significantly more intense, posing a distinctive peril.

The impact of wildfire smoke on children is profound and unsettling. Studies reveal that wildfire-specific $PM_{2.5}$ is approximately 10 times more harmful to children's respiratory health compared to $PM_{2.5}$ from other sources, particularly affecting the vulnerable age group of 0 to 5 years. Wildfire smoke has been extensively linked to increased respiratory morbidity and mental health issues, ranging from asthma and cardiovascular diseases to lung ailments. Prenatal exposure to wildfire smoke is associated with low birthweight, premature birth and increased risk of child deaths. Moreover, the enduring impact of wildfires extends beyond immediate health concerns and casts a long shadow on children due to injuries, disabilities, trauma, loss of learning and recreational opportunities, and displacement.

The repercussions of landscape fires are staggering. Every year, 44 million people globally are exposed to air quality classified as unhealthy, and an additional 4 million are exposed to levels deemed 'hazardous' to health. Regions in Central and West Africa, as well as South and Southeast Asia, bear the brunt of landscape fire smoke, with an estimated 677,745 premature deaths annually – an alarming toll rivalling that of global fatalities from HIV or malaria – nearly 40 per cent of which occur in children under 5 years of age. Furthermore, the majority occur in low- and middle-income countries (LMICs).

This technical note endeavours to distil a wealth of research, guidance and tools, and synthesize a comprehensive understanding of the impact of wildfire smoke on children. It is intended for policymakers and implementers, and seeks to empower meaningful action that shields children from the harmful effects of wildfire smoke, supplementing existing guidance on air pollution. We also hope that this technical note along with country experiences will inform and help shape formal global guidance on this critical issue.

In a world where the very survival of our children hangs in the balance, this technical note serves as a clarion call for collective, decisive action – because safeguarding our children's future demands nothing less than our unwavering commitment and immediate intervention.

The Children's Environmental Health Collaborative
https://ceh.unicef.org/

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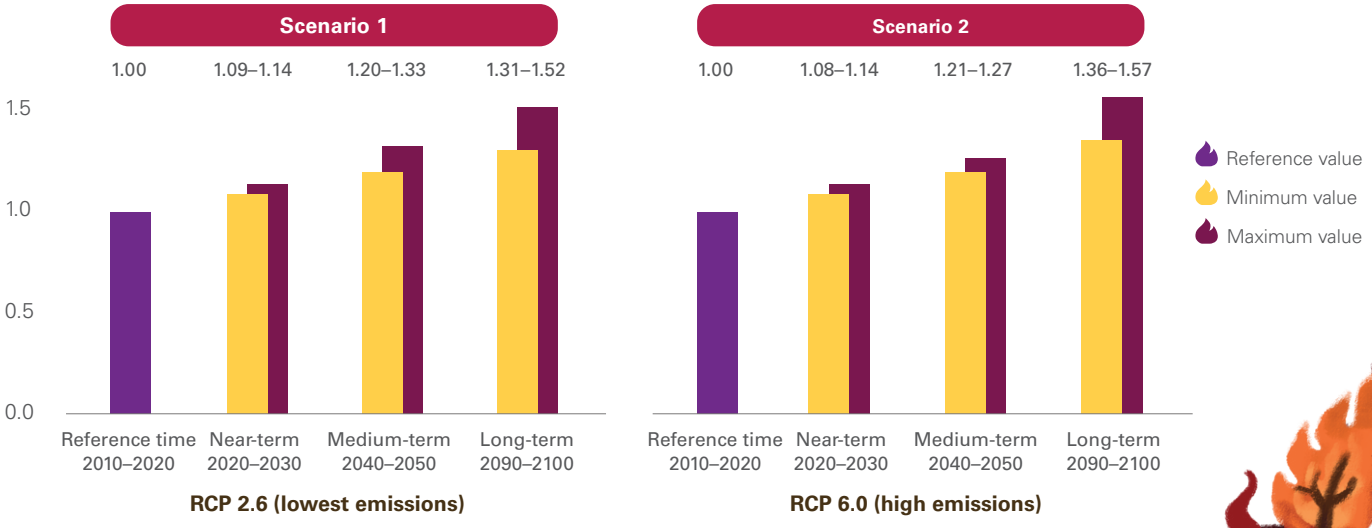
1. Climate change is increasing the risk of wildfires

Wildfires are projected to become more frequent and intense, with a global increase of extreme fires from current levels to 14 per cent more by the end of 2030, 30 per cent more by the end of 2050 and 50 per cent more by the end of the century.[1]

Figure 1: Projections for global change of wildfires



By the end of the century, even under the model for lowest emissions possible, we will likely see a significant increase of wildfire events, by at least a factor of 30 per cent.

Source: Douglas I. Kelley, UK Centre for Ecology and Hydrology, via UNEP, *Spreading Like Wildfire*, 2022.

A 'landscape fire' is any managed or unmanaged fire burning in natural or settled lands. This catch-all term includes unplanned and uncontrolled fires, such as wildfires. In most cases landscape fires are started in agricultural and pasture lands and then spread to forests and other natural plant communities (e.g., bushlands, grasslands and savannahs), and from there to residential areas and even cities.[2] 'Wildfire' is described as free-burning vegetation fire that can start via natural processes – such as lightning – or via anthropogenic activities, either intentional or not.[3]

Less than 10 per cent of wildfires account for more than 90 per cent of the total area burned annually, and are often the result of poor or absent policy, planning and governance decisions related to land use and demographic shifts.[4] Additionally, climate change is

Where the fires are

The NASA Earth Observatory has a dynamic fire map, which, since 2000, has tracked actively burning fires – of various types – around the world. It shows seasonal trends and highlights the increasing frequency and size of fires over time.

Global Forest Watch is another platform. An initiative of the World Resources Institute, it is an open-source web application to monitor global forests in near-real time.

associated with creating conditions such as increased drought, longer and more intense heatwaves, low relative humidity, dry lightning and strong winds, all contributing to hotter, drier and longer fire seasons.[5] Emissions from wildfires such as carbon dioxide, a major greenhouse gas, also contribute to climate change, which then creates a positive feedback loop.[6]

In 2019, Global Forest Watch counted over 4.5 million fires worldwide that were larger than one square kilometre. **Wildfires currently account for 6 to 8 billion tons of carbon emissions, which translates to approximately 20 per cent of total global greenhouse gas emissions and is equivalent to the entire transport sector's footprint. By 2100, their share can increase to become 30 per cent of global emissions**.[7]

Wildfires are of great concern, and climate change is only exacerbating their destructive effects on environments and society. Wildfires, unlike managed fires used as a positive practice in forestry, are often hazardous for animals, soil and forests, and are also damaging to human health and well-being in ways that go beyond the immediate fire. **Between 2010 and 2019, approximately 2 billion people were exposed to at least one day of substantial air pollution generated by landscape fires, an almost 7 per cent increase compared to the decade prior**; concentrations of pollution from landscape fires were four times higher in low-income countries compared to high-income countries, which speaks to variability in exposure via socio-economic disparities.[8] Because of the smoke's ability to travel for hundreds of miles from the source, smoke from wildfires contained within political borders has a potential of becoming a multinational threat to public health, especially to those living in low- and middle-income country (LMIC) settings.

Most research assessing exposure, however, is primarily concentrated in high-income countries. These findings can nevertheless help illustrate a global trend and provide lessons that can be transferred to lower-income settings. For example, as of 2023, the United States of America saw an estimated annual average **increase of approximately 1 billion person-days[i] of exposure to heavy smoke and medium smoke, and more than 2.5 billion person-days for light smoke**.[9] A 2017 study predicts that the current rate of population **exposure to wildfire smoke will increase across Europe to between 12 and 20 per 1,000 persons annually by 2100, and cause a 138 per cent increase in deaths due to all related causes**.[10]

Wildfires are therefore already contributing to significant health issues for the most vulnerable populations, including pregnant women and children. As they proliferate, wildfire smoke will become a growing cause for concern across nations.

The most affected are often least responsible for climate change

According to Xu et al., the five countries with the highest population-weighted concentrations of fire-sourced $PM_{2.5}$ were Angola, the Central African Republic, the Congo, the Democratic Republic of the Congo and Zambia. The countries with the highest annual average number of exposure days to substantial fire-sourced air pollution were similar, with Angola, the Congo, the Democratic Republic of the Congo, Gabon and Zambia, each seeing more than 115 days per year between 2010 and 2019.

In a study assessing data between 2000 and 2014, the five countries with the largest number of child deaths associated with fire-sourced $PM_{2.5}$ were the **Democratic Republic of the Congo, India, Indonesia, Nigeria** and **Uganda**.

Therefore, the countries most affected are also most vulnerable to experiencing large disparities, and are less likely to access the resources they need to protect the health of their children against this hazard.

i A 'person-day' measure is an accounting approach to estimating the overall reach of an event – e.g., if 100 people are each exposed for five days, that would yield 500 person-days.

2. Wildfire smoke presents a significant risk to children

Fire-sourced PM exposure is associated with an increased risk of child mortality. Each 1 µg/m^3 increment of $PM_{2.5}$ emanating from fires was associated with a 2.3 per cent increase in the risk of child mortality; exposure was found to be 'super-linear', meaning that the per-unit exposure to larger fires led to increased toxicity.

2.1. Wildfire smoke is more toxic to children

While ambient air pollution – i.e., pollution found daily in the air – poses a persistent, year-round health risk in many urban and industrialized areas, wildfire smoke tends to have more immediate and localized impacts. In addition, exposure to wildfire smoke can be more hazardous than ambient air pollution alone. This is because wildfires release more particulate matter (PM) that is smaller in size than is found in ambient air; in fact, forest fire smoke is chiefly made up of particulate matter 2.5 micrometres in diameter or smaller, often annotated as $PM_{2.5}$.[11]

$PM_{2.5}$ deposits more deeply in the airways than larger particles, with more potential for adverse effects on the lungs and subsequently the circulation system as a result.[21] **Compared to $PM_{2.5}$ from other sources, $PM_{2.5}$ released from wildfires has been found to be approximately 10 times more harmful to respiratory health, particularly in children**.[22] This is in part because fire-sourced air pollution contains more PM_1 than ambient air pollution, with wildfires emitting more than two times that of prescribed fires.[23]

What is in wildfire smoke?

Wildfire particulate matter is comprised of matter formed through the chemical reactions of carbon monoxide, particulate matter, nitrogen oxides, volatile organic compounds and polycyclic aromatic hydrocarbons.[12,13] Notably, fire-sourced particulate matter is likely to have more potential to create oxidative stress,[ii] due to the high level of polycyclic aromatic hydrocarbons and charged organic compounds released in high-temperature combustion.[14] Fire-sourced PM is also made of more toxic components, in part because fires generate more free radicals that can contribute to oxidative stress in the body, and also because it could contain toxic pollutants from burning infrastructure; it is therefore considered more toxic to the body than ambient air pollution.[15,16,17,18] It includes black carbon, which is released by the burning of biomass fuels such as trees, which can also irritate the lungs and eyes.[19] Finally, wildfires increase the risk of exposure to ozone[20] because they generate both the nitrogen oxide and volatile organic compounds necessary for ozone production, although the ratio of each is variable and based on the type of fire and fuel associated.

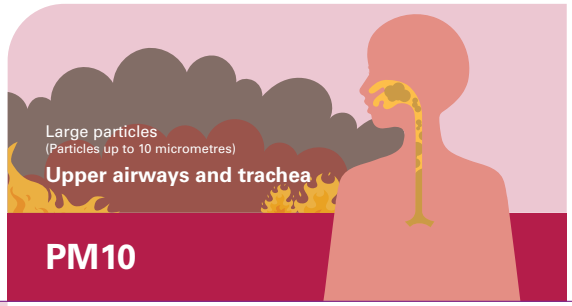
Black carbon is 'unparalleled'

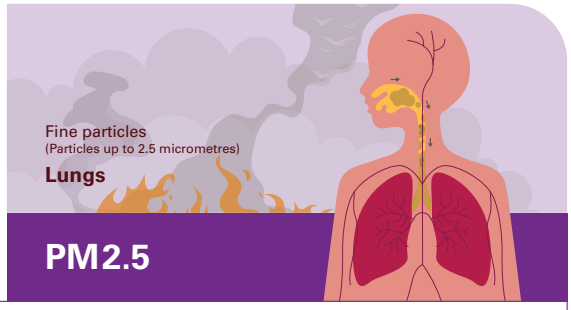
According to a new report by Project Drawdown, black carbon – often known as 'soot' – **has a short-term warming potential up to 1,500 times worse than carbon dioxide**, and is responsible for a large portion of premature deaths globally. The biggest source of black carbon is indoor cooking on cookstoves using biomass fuel like wood. Wildfires are also a significant and growing source.

Black carbon wildfire emissions in sub-Saharan Africa accounted for, on average, 62.4 per cent of the global total between 1981 and 2010.[24]

ii Oxidative stress is a phenomenon in the body caused by an imbalance between the production and accumulation of reactive oxygen species, or free radicals, in cells; the reactive species can cause damage if not readily made inactive.

Figure 2: Health effects of different particulate matter size





	PM10	PM2.5
Health effects	Irritates eyes, nose and throat, and can contribute to existing issues like asthma and cardiovascular inflammation.	Ranges from skin and eye problems, disturbed or reduced lung function leading to respiratory illnesses and worsened asthma, to illnesses like cancer, heart disease, brain and nervous system disorders. Both $PM_{2.5}$ and PM_{1} have been found to decrease lung function in children, with PM_{1} creating larger effects.
Health effects on fetal development	Both PM_{10} and $PM_{2.5}$ have been associated with an increased risk of preterm birth and low birth weight when pregnant women are exposed to elevated levels of particulate matter.	

Source: UNEP, *Spreading Like Wildfire*, 2022.

2.2. Impact of wildfire smoke exposure

Short-term and long-term exposure to fire-related $PM_{2.5}$ is associated with an increased risk of morbidity and mortality[iii] compared with ambient $PM_{2.5}$ found in day-to-day air pollution. However, more studies are yet to be conducted globally to provide stronger conclusions.

A 2023 study found that from 2010 to 2019, **approximately 2 billion people were exposed to at least one day of substantial landscape fire-sourced air pollution annually**. It also found that each person in the world would on average have approximately 10 days of exposure annually, higher than the decade prior. **Just as importantly, the same study found that landscape fire-sourced $PM_{2.5}$ and ozone were approximately four times higher in low-income countries compared to high-income ones.**[25] McDuffie et al. found that 55 per cent of $PM_{2.5}$ in sub-Saharan Africa in 2019 was a result of wildland-related fires, while East Asia reported the highest number of attributable deaths due to this PM source out of all of the regions.[26]

A 2020 study found that persons exposed to wildfire smoke contributing to an air quality index measurement of 150 for several days experienced the equivalent effect of smoking **seven cigarettes a day if they were outside the entire time.**[27]

Wildfires are more toxic everywhere

A 2021 analysis of cases collected from 43 countries found that short-term wildfire $PM_{2.5}$ exposure was responsible for 0.62 per cent of all-cause mortality, 0.55 per cent of cardiovascular mortality, and 0.64 per cent of respiratory deaths between 2000 and 2016.

In comparison, during the same time frame, exposure to $PM_{2.5}$ from ambient pollution in cities increased all-cause mortality by 0.44 per cent, cardiovascular mortality by 0.36 per cent, and respiratory mortality by 0.47 per cent.

Short-term exposure to wildfire $PM_{2.5}$ air pollution is therefore seen as more toxic.

iii Morbidity refers to the condition of suffering from a disease or medical condition, while mortality refers to deaths.

The global mortality burden attributable to smoke from landscape fires, which includes many forms of burning, was estimated to be 677,745 deaths annually, with almost 270,000 of these deaths – **approximately 40 per cent of the total** – occurring in children younger than 5 years of age.[28] **Another study found that 99 per cent of fire-associated deaths of children under 18 years occur in LMICs**.[29]

General population

Fire-sourced PM and ambient PM have overlapping health effects, but the former can lead to more severe consequences because of the PM's ability to penetrate deeper into the lungs and the circulation system which then carries it to the other organs. For instance, one study found that PM from wildfire smoke led to 10 per cent more respiratory-related, all-age hospitalizations than there would be without the smoke. In comparison, pollution from other sources increased all-age hospitalizations by around 1 per cent.[30]

When it comes to respiratory function, fire-sourced PM can lead to decreased pulmonary function; increased risk of respiratory infections including bronchitis and pneumonia; acute exacerbations of asthma; chronic obstructive pulmonary disease; and lung cancer. It has been associated with increased hospital admissions and respiratory mortality, as well as higher infection rates within those with pre-existing conditions like diabetes.[31] Spread of PM through the circulatory system has been linked to cardiovascular issues such as heart disease, coronary artery disease, stroke, arrhythmia and heart failure.[32] Also documented is an increased risk of developing gastric and other gastrointestinal cancers,[33] increased insulin sensitivity and risk of developing metabolic diseases like diabetes,[34] and possibly increased risk to the cerebrovascular system, which facilitates blood flow to and in the brain.[35]

Neurological consequences can be equally severe, with exposure to fire-sourced PM contributing to various forms of impaired cognitive development, dementia, suicidality and mental stress – such as anxiety – potentially due to an increase in oxidative stress, impaired signalling or inflammation of the brain.[36] Poor air quality can also affect sleep quality, which then in turn further contributes to the listed mental health challenges.[37]

Wildfires can also pave the way for other opportunistic diseases. A 2021 study found that wildfires were followed by an increased number of COVID-19 cases and deaths up to four weeks after exposure, with a substantial increase in some of the geographic areas studied.[38] Another review postulated that the long-term exposure to smoke led to impaired respiratory and immune responses to viruses and infections, which then can explain how people are more vulnerable to the COVID-19 virus.[39] Bacteria and fungi can be transported by the smoke emissions and cause potentially serious infections miles away from the fire source.[40]

More country-level associations between exposure and fetal development

A 2019 study conducted in **Indonesia** found a relationship between height at 17 years of age and exposure to particulate matter in the womb.

A 2021 study showed that across **Bangladesh, India and Pakistan**, there was a 5 per cent increase in the risk of pregnancy loss for every 1-μg/m^3 increment of fire-sourced $PM_{2.5}$ detected.

A 2022 study found that in **Brazil**, wildfire smoke exposure during pregnancy was likely associated with preterm births, with odds increasing up to 40 per cent in the Southeast Region when pregnant women were exposed during their first trimester.

Maternal health

An increasing body of research is indicating that wildfire smoke is likely causing the most harm to pregnant women, because it affects both the woman and the fetus. Wildfire smoke exposure, which can lead to pollutants crossing the placental barrier, increased risk of preterm birth, low birth weight and stillbirth. Pregnant women face unique respiratory risks to exposure,[41] in addition to the various contractable respiratory illnesses and infections. They are also at a higher risk of developing gestational hypertension[42] and gestational diabetes[43] if exposed. While the evidence base is growing, there are still areas to be explored further, such as maternal mental health and its effects on child health.

A meta-analysis found that female populations were more likely than males to end up in the emergency department when exposed to landscape fire smoke.[44] Pregnant women are more susceptible to respiratory issues because of the many changes that occur in the respiratory system during pregnancy. Hormones and physical changes due to the growing fetus can affect the respiratory tracts. This can lead to an increase in the amount of air breathed while simultaneously reducing the lung capacity, resulting in a feeling of shortness of breath and the need to breathe more frequently.[45] These changes in respiration can be exacerbated with exposure to wildfire smoke.

There was a significant positive association between exposure and gestational hypertension, with exposure to wildfire smoke $PM_{2.5}$ during the first trimester being significantly associated with gestational hypertension.[46] Additionally, a study based in Colorado – a state in the United States prone to wildfires – found a significant positive association between exposure to wildfire smoke and gestational diabetes during the first trimester, as well as across the entire pregnancy; for the former, there was a 14 per cent increase in risk of developing gestational diabetes.[47] It is thought that wildfire smoke could cause inflammation, which may lead to an imbalance in proteins and increase oxidative stress, which in turn can lead to common complications such as pre-eclampsia, spontaneous abortion and preterm birth.[48]

In addition, if the mother is exposed to air pollution during pregnancy, the pollutants could affect placental functions and trigger oxidative stress and inflammation, which in turn can lead to chronic health outcomes in the newborn and infant.[49] A combination of genetic and environmental factors can result in some children being born with higher susceptibility to specific health effects, such as asthma, after a mother's exposure to air pollution during pregnancy or due to smoke exposure during postnatal periods.[50]

More research is required to understand the mental health impacts of smoke on pregnant women and mothers.

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Neonatal health

Global-level studies on the effects of wildfire-related air pollution on pregnancy outcomes are still sparse but evidence demonstrates that, while wildfire-sourced air pollution has overlapping health outcomes with those caused by ambient air pollution, the former has more serious consequences. The Colorado study cited above found that over the second trimester of pregnancy, **each 1 µg/m³ increase in wildfire smoke $PM_{2.5}$ across the trimester was associated with a 13.2 per cent increase in the odds of preterm birth**.[51] In 2022, a study conducted in Brazil, which is fire prone and has a high rate of preterm births, also found that wildfire smoke exposure may increase the risk of preterm birth.[52] Another study looking at births in California between 2007 and 2010 found that first-trimester exposure to wildfires led to a 28 per cent increased risk of fetal gastroschisis, a defect that can restrict fetal growth and increase the risk of stillbirth.[53] A 2020 study of young children in Australia found that children exposed to bushfire smoke in utero were more likely to report respiratory infections a few years later.[54]

These studies suggest that the effects are possible because the fine particles can either cross the placenta to act directly on the fetus – which has cells more sensitive to exposure compared to mature cells – or elicit inflammatory responses in the woman which then influence fetal development indirectly.[55,56]

Infant health

Infants are rapidly developing; in particular, their immune systems and lungs are undergoing considerable development.[57] Infants also breathe more rapidly than adults and take in more air relative to their body weight.[58] They also have less nasal deposition of particles, meaning that a higher proportion of particles can penetrate deeply into the lungs.

In terms of morbidity, a 2023 study of over 36,000 children under the age of 5 in 48 LMICs found that $PM_{2.5}$ from fires was more strongly associated with acute respiratory infection than $PM_{2.5}$ from non-fire sources.[59]

In addition, while long-term exposure to PM_1 and $PM_{2.5}$ by children was associated with poorer lung function, the association is consistently stronger with regards to exposure to PM_1, which penetrates deeper into children's respiratory systems.[60] Prenatal exposure to significant ozone has been linked with a higher risk of developing paediatric diabetes in children under 6 years of age.[61]

Child and adolescent health and well-being

Fire-sourced PM exposure is associated with an increased risk of child mortality. Each 1 µg/m³ increment of $PM_{2.5}$ emanating from fires was associated with a 2.3 per cent increase in the risk of child mortality;[62] exposure was found to be 'super-linear', meaning that the per-unit exposure to larger fires led to increased toxicity.

Children and adolescents have also been found to develop health issues after early life exposure to wildfire smoke, although many of the associations are still in their nascent stages. Children are an especially vulnerable population because they have increased exposure (i.e., children often spend more time outdoors), they breathe more air relative to their body weight and they are still growing and developing.[63] Children exposed to wildfire smoke in utero are therefore likely to be more vulnerable to infections and disease, as well as at higher risk of any health consequences resulting from being born with congenital defects, particularly in the respiratory and nervous systems.[64] A growing body of literature has connected exposure to PM with lower lung function in children, stunted physical growth[65] and neurological and metabolic dysfunction.

Early life wildfire smoke exposure is associated with immune dysregulation and lung function decrements in adolescence. In addition, children and adolescents who are obese experience more severe asthma events.[66] A 2021 study that looked at admissions to a children's hospital found that wildfire-sourced $PM_{2.5}$ was estimated to increase respiratory hospitalizations by 30 per cent.[67] Another 2023 study found that wildfire smoke events led to an increase of 13 per cent in asthma cases recorded by emergency departments, compared to generalized air pollution.[68] A study of wildfire exposure in rhesus macaque monkeys also found associations between exposure to wildfire smoke during infancy and immune system dysfunction in adolescence, which could potentially lead to developing diabetes.[69]

Studies have found that exposure to particulate matter

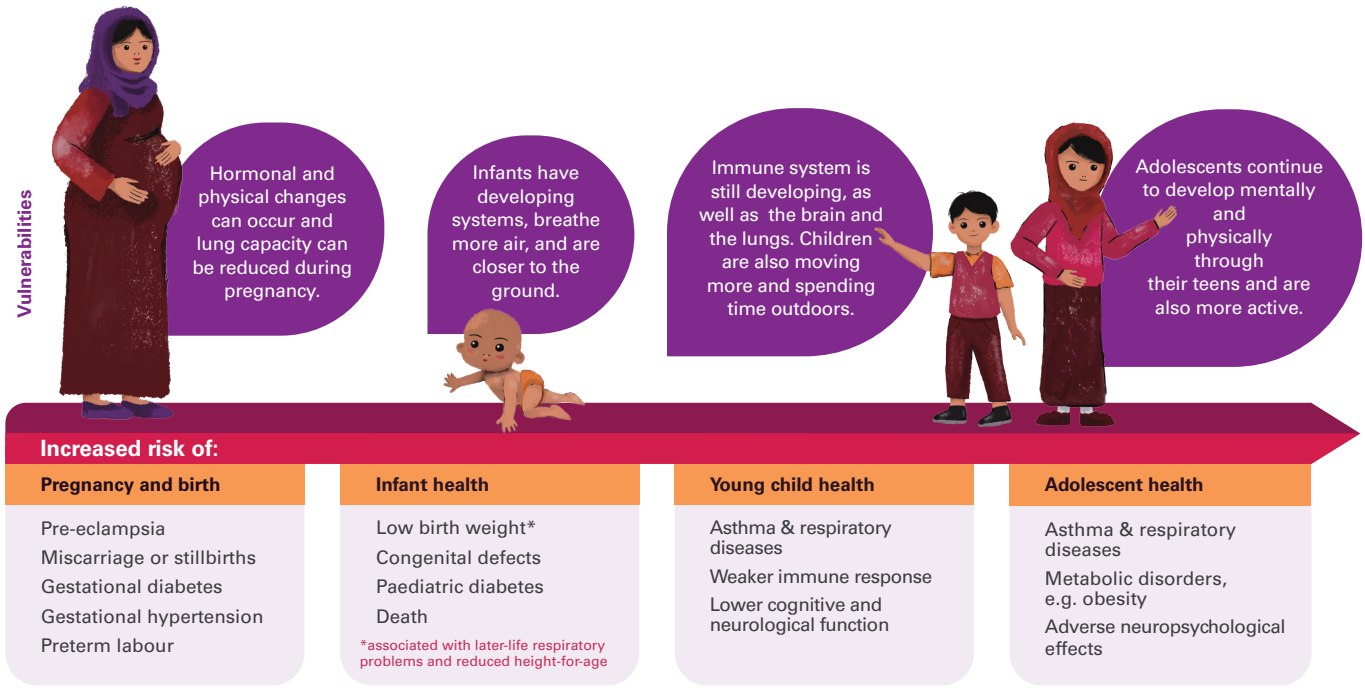
may have neurophysiological effects in children, contributing to higher risk of developing attention deficit hyperactivity disorder, autism and poor memory.[70]

These neurophysiological effects, as well as infrastructural challenges caused by wildfires, have resulted in adverse learning outcomes within affected populations. For instance, an assessment of almost 11,700 schools in the United States has found that smoke-attributable $PM_{2.5}$ exposure during the school year reduced test scores by 0.15 per cent of a standard deviation,[71] and another in Brazil found decreased performance in most subjects after exposure to wildfires, with the effects worsened over time, especially for regions with lower incomes.[72] These effects are likely to become more frequent and severe as wildfire incidence spikes, especially in regions where large populations are abutting forests and other vulnerable landscapes; for instance, of the 186,080 schools assessed in Brazil, 25 per cent had recorded more than 7 wildfires within a buffer of 10 kilometres around the school.[73] Additionally, wildfire smoke has been observed to affect outdoor recreational activities, which subsequently leads to adverse well-being outcomes.[74,75]

In Canada, the rate of post-traumatic stress disorder (PTSD) in children and adolescents 18 months after the incidence of a wildfire was found to be between 27 to 37 per cent. Students who had experienced a greater impact from the wildfire (e.g. having personally seen it or having one's home destroyed) exhibited significantly higher scores on measures of PTSD, depression, anxiety and alcohol/substance use. They also had lower self-esteem and quality-of-life scores. Students with lower resilience scores exhibited a similar pattern. One third of students in Grades 7 to 12 were found to meet criteria for depression compared to approximately half of that in the control group.[76] One study that evaluated substance use in college students 18 months after the Fort McMurray wildfire in Canada found a rate of 15.5 per cent for high-risk drinking, 13 per cent for problematic drug use, and 4.4 per cent for moderate-high nicotine dependence, with some gender differences in each category.[77]

Studies assessing the effects of wildfires on the mental health of children and adolescents have primarily taken place in Western settings. There is a need for more research to be conducted in LMIC settings to understand the global impacts of wildfires and wildfire smoke on the mental health of children.

Figure 3: Effects of wildfire smoke on child health and well-being across life stages



Source: Adapted from Lein et al., 'Forged in Fire: Environmental health impacts of wildfires', UC Davis Environmental Health Sciences Center, 2023.

3. Signs and symptoms of exposure in children

Children – young children in particular – who breathe in wildfire smoke may experience a wide range of symptoms.[78,79] It is important for caregivers to become familiar with the health symptoms of inhaling wildfire smoke so that they can act immediately to mitigate further harm.

Physical symptoms in children may include:

- **Chest pain and tightness**
- **Trouble breathing**
- **Wheezing**
- **Coughing**
- **Burning or irritation in the nose, throat and eyes**
- **Dizziness**
- **Other symptoms, including longer-term health impacts**

If the child is experiencing breathing problems, is unable to sleep, or is experiencing noticeable health problems, they should be taken to a health facility immediately

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4. Protecting children from wildfire smoke

A holistic approach needs to be instituted to effectively mitigate the potential harm caused by wildfires to the health and well-being of children. This requires placing a strong primary health care response at the centre of the preparedness, mitigation, response and recovery efforts.

This document primarily focuses on protecting children from wildfire smoke. Therefore, this chapter covers the essentials that every household, school and health facility should have to address wildfire smoke, as well as the interventions that can be implemented in these spaces that will have the most influence on a child's health and well-being.

Access to the referenced technologies and interventions required for managing exposure to wildfire smoke may be more challenging in low-resource settings. This guidance can be further adapted to suit local contexts and used to advocate with governments based on evidenced recommendations.

If a fire is approaching or authorities are calling for evacuation...support evacuation first!

This guidance is primarily focused on the management of air pollution caused by wildfire smoke. To manage evacuation and shelter efforts, authorities can use the following resources as guides:

- Ready for Wildfire has preparedness and evacuation tips for individuals.
- The US Fire Administration provides recommendations for how local governments can help prepare their communities for future fire events.

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4.1. Household preparedness and response

Local governments, front-line workers and civil societies can help prepare households living in high-risk zones – as well as those nearby likely to experience smoke exposure – to protect themselves. Front-line workers and local organizations can help implement risk communication campaigns ahead of each wildfire season.

The following simple framework for households and communities can be used by front-line workers to improve awareness and preparedness in schools, households, health facilities and other communal spaces.[80,81]

Table 1: What to do to protect children from wildfire smoke

Always:

1. Pay attention to local weather and air quality news and public health advisories, including those related to wildfire smoke.
2. Know the symptoms in children and the health facility to visit.

Before	During	After
1. **Prepare an emergency kit (see Figure 4 below) including N95/KN95 masks**.[iv] Do not go outdoors during a wildfire to purchase these items unless crucial.	4. **Evacuate immediately if the house is at risk of catching fire!**	7. **If the child is experiencing any of the symptoms listed (see p. 9), take them to the health facility immediately! And pay attention to any physical or psychosocial symptoms in the months following.**
2. **Have an emergency evacuation plan ready, including medical information and what your children should do if separated**. Identify safe shelters nearby or in neighbouring towns, and prepare your children by ensuring that they have your contact information and know what to do if separated.	5. **Identify the best options for protecting children from exposure to smoke.** Keep children indoors with the doors and windows closed, if possible. If you have an air conditioner, run it with the fresh air intake closed if possible, to keep outdoor smoke from getting indoors. Use a portable air cleaner if available.	8. **Understand the continued risks to children at home and in school.** Children should not be doing any clean-up work, and ash and debris should be removed before returning home.
3. **If in a fire-vulnerable area, create a fire-resistant zone around the house** that is free of leaves, debris or flammable materials for at least 10 metres, if possible.	6. **Follow the DON'Ts (see p. 13) to limit exposure from other sources of air pollution during wildfire events.** Use common sense to guide the children's activity.	9. **Adhere to the DON'Ts (see p. 13) below after wildfire events.** 10. **Review how to be better prepared as a family next time.**

iv If the child has breathing problems, masks may not be helpful.

Figure 4: Preparing an emergency kit

The following items are suggested for inclusion in an emergency kit for households in high-wildfire-risk zones. Some of these items may overlap with items required to deal with emergencies caused by other climate-related shocks such as extreme heat or floods.

Source: Adapted from Americares, 'Wildfire Action Plan', 2023.

The following are **DON'Ts** during and in the immediate aftermath of a wildfire incident, recommended by the United States Western States Pediatric Environmental Health Specialty Unit (PEHSU), as these actions will increase the number of fine particulates in the air:[82]

- Smoking
- Using gas, propane or wood-burning stoves or fireplaces, or candles
- Using ozone-generating air cleaners
- Using natural-gas- or gasoline-powered generators indoors
- Using spray cans
- Frying or broiling meat
- Using the vacuum
- Burning waste

PEHSU also states that during wildfire smoke incidents, children should stay inside and air filtration should be used when possible. If a child must be outdoors, parents/caregivers can consider using a N95 mask for protection for children over the age of 7.

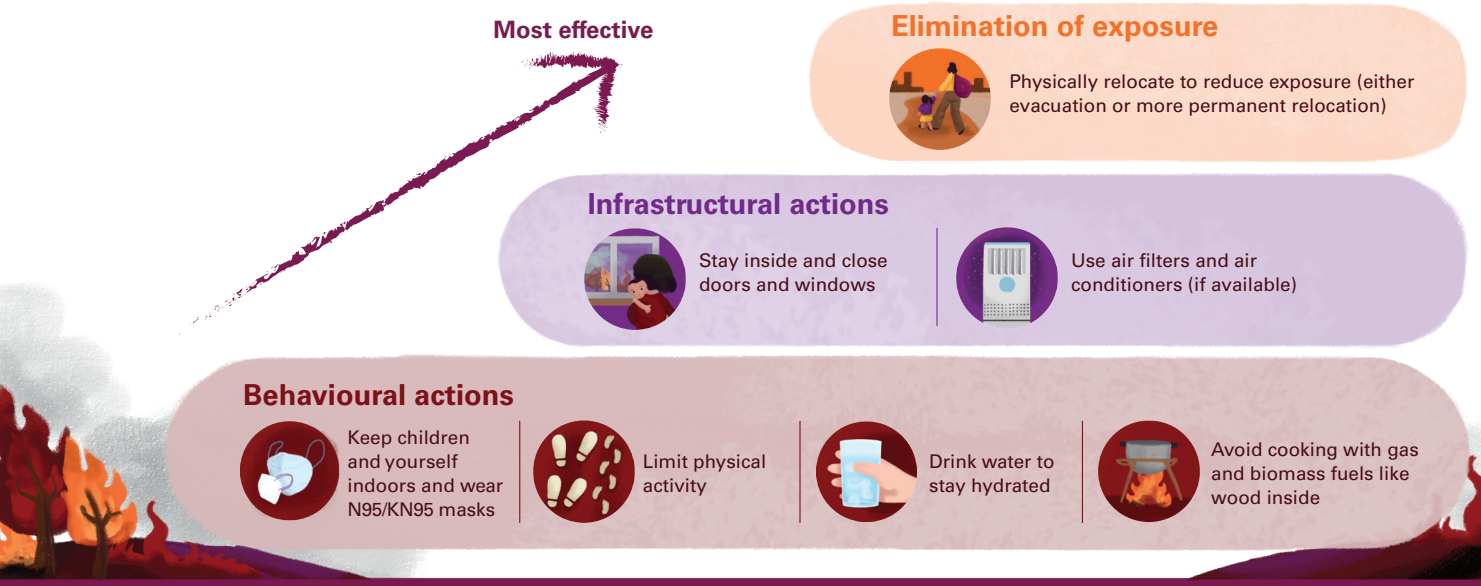
Children should never wear a mask if the mask or any of its parts present a choking hazard.

Children should not wear a mask if it causes breathing difficulty or if they are not able to remove the mask on their own.

Even in the absence of wildfires, air pollution can exist and affect a child's health drastically. Therefore, it is important to consider retrofitting the home to improve the living environment and modify day-to-day behaviours as much as possible to reduce exposure to household air pollution. These efforts can help a child grow, stay healthy and, therefore, be much more resilient to the effects of climate shocks such as wildfires. The following decision hierarchy can help illustrate how each type of individual or household action can vary in effectiveness, as well as limitations posed.

Each decision comes with its own limitations and challenges that need to be considered. For example, physically relocating will require resources and possible employment in the new locale. The effectiveness of keeping windows and doors closed will rely on how well the housing has been manufactured and whether indoor ventilation and filtration is adequate. Wearing a mask will not protect a child from pollutants such as gases, and it needs to be well fitted to be highly effective.

Figure 5: Caregiver actions to safeguard children from wildfire smoke



Source: Adapted from Lein et al., 'Forged in Fire', 2023.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After a wildfire incident – even after a wildfire has been controlled and extinguished – its impact can continue to harm adults' and children's health through air pollutants and by affecting access to critical health services. In the aftermath of wildfires, families can take steps to improve indoor air quality to help lower the overall risk of respiratory infections and other smoke-related diseases.

Children may not express their symptoms in the same way as adults and therefore need to be handled with more patience and support after experiencing a traumatic event. A meta-review of the mental health impacts of wildfires found that PTSD was the most evaluated psychological reaction in children,[83] and children may in general exhibit changes in their behaviours. Their recovery will be therefore influenced by how their caregivers are themselves able to cope after exposure to a wildfire.[84]

Understanding children's psychological needs after a traumatic experience

The National Child Traumatic Stress Network has developed resources that can be used by caregivers to provide psychological and emotional support to their children after a traumatic experience such as wildfire exposure. They can be adapted by policymakers and implementers for risk communication purposes, as well.

4.2. Health care facility preparedness and response

For facilities to treat symptoms of wildfire smoke, they likely will have to prepare to treat for all symptoms and health outcomes associated with wildfires. Therefore, a comprehensive preparedness and response protocol should be developed, including for evacuation if necessary.

Preparedness

All new facilities should be designed using building codes and guidelines for fire prevention, and existing facilities should be retrofitted based on plans for fire prevention and suppression. In addition, facilities should have emergency operational plans that provide for:

- Alert systems to be established and ready to use during wildfires as well as planned fire events.
- Reorganizing human resources, supplies and facilities to be ready for an influx of wildfire smoke-related illnesses.
- An evacuation plan that allows for the 'greatest good for the greatest number' of patients,[85] including transportation to the next nearest functional facility, while prioritizing the most vulnerable patients.

Climate and health-related education and drills can be incorporated into the routine capacity-building efforts conducted for medical and support staff in facilities. Resources for reference can be found in section 5 below.

Making health care facilities fireproof

In 2014, the Pan American Health Organization (PAHO) published guidance for improving the resilience of health facilities against possible fires. This includes recommendations for more fire-resistant materials for use during construction or retrofitting exercises, and a communications plan for expeditiously sharing information and planning for an evacuation.

During and after a wildfire or wildfire smoke event

During and after a wildfire, it is imperative that health care facilities are prepared to manage the increased admissions due to respiratory infections in the short and long term. Central to the response to the health impacts of wildfire, the health sector should play a role at all stages of disaster risk management, from prevention of adverse health outcomes to improving preparedness and response efforts in the aftermath of a wildfire.

E-toolkit for preventing health complications in children

PEHSU has developed an online toolkit for health providers to use as a reference when guiding patients – primarily children – on how to best protect themselves from environmental toxins and hazards, including particulates released by wildfires.

Triage and treatment

When a patient first arrives at a health facility during or after a wildfire, it is important to triage using the 'ABCDE' assessment:[86]

- **Airway** – Assess for patency, burn, swelling or bleeding that will compromise the patient quickly.
- **Breathing** – Most patients will be coughing. Assess for respiratory distress, wheezing, crouping and evidence of significant inhalation of products of combustion.
- **Circulation** – Assess for perfusion by level of consciousness, capillary refill, diaphoretic skin, pulse and blood pressure.
- **Disability** – Determine responsiveness, looking for compromise of brain or spinal cord.
- **Exposure of other major problems** – Assess for significant pain, inhalation of dangerous substances, wounds and burns (including those threatening limbs).

After the assessment, patients should be treated first for issues affecting breathing and the airway, followed by other injuries.

Facilities should have dedicated areas to perform triage and to closely assess any respiratory issues in infants and children. Clinical flowcharts (which can be found on the internet) provide models for the assessment of respiratory issues in minors. The most well-known flowchart is modelled on START, a triaging model that was developed in the United States in 1995.[v]

Example of triage flowchart for paediatric populations

The United States Department of Health and Human Services developed the JumpSTART flow chart for managing paediatric cases after a mass casualty event, such as a wildfire.

The Western Regional Alliance for Pediatric Emergency Management developed a 'Just-in-Time' basic clinical guidance with flow charts for assessing and managing paediatric respiratory illness, including diagnosing the severity of various respiratory illnesses.

Psychological aid for children

At the same time as triaging for physical symptoms, health workers should also attempt to triage for mental health issues. In the immediate aftermath, health workers can use a psychological first aid (PFA) approach to help children respond to, and process, their reactions after experiencing a wildfire.[87]

- For young children, sit or crouch at the child's eye level.
- Help school-age children verbalize their feelings, concerns and questions, and provide simple labels for common emotions (e.g., sad, mad, scared, worried).
- DO NOT use extreme words such as 'terrified' or 'horrified'.
- Talk to adolescents 'adult-to-adult' to communicate that you respect their feelings, concerns and questions.
- If communication seems impaired, speak simply and slowly.
- When you are unsure of how to help, ask 'What can I do to help?' and trust what the person tells you.

Following PFA, skills for psychological recovery (SPR) can be developed. SPR is an evidence-informed modular approach to help children, adolescents, adults and families in the weeks and months following disaster and trauma.[88]

Common psychological and behavioural stresses can manifest in children (in different age groups) as coping strategies after experiencing a disaster. Medical professionals can become familiar with these signs (found in Annex 2) as proxy indications of psychological stress, and can bring in mental health specialists, case workers or other trained professionals to provide additional support to the child and caregiver.

Providing psychosocial support to children and families in the aftermath of disasters

The American Academy of Pediatrics has developed a guide for health professionals and social workers seeking to provide psychological support to children who have experienced a traumatic event. This can be used to adapt facility-specific recommendations to incorporate into wildfire preparedness and response trainings and drills.

v Formal scientific review of the efficacy of JumpSTART has been limited. However, it is probably the most commonly used paediatric mass casualty triage algorithm in the United States.

Discharge

At the time of discharge from the health facility, health workers can take the opportunity to raise awareness amongst patients and caregivers about the dangers of air pollution in general, and encourage them to practice individual protective action as well as contribute to community efforts where possible.

Health workers can:[89]

- Ensure that patients are aware of their underlying vulnerabilities, especially if they are children or pregnant women, and incorporate education on air pollution and landscape fires during discharge and repeat visits.
- Encourage patients to use air quality notification systems and to avoid behaviours that increase their exposure when possible, such as being outside or cooking without ventilation.
- Create a 'patient action plan' along with the patient or caregiver that has a few simple actions that the patient or caregiver can commit to, such as always carrying masks, always carrying inhalers if the patient has asthma, etc.

Health facilities can also maintain a stock of well-fitting and certified respirators or face masks, such as N95 masks, which can help to reduce exposure to particulate matter when properly worn.

Evacuation

When developing an evacuation plan for a health facility in the event of disasters such as wildfires, the principles outlined by PAHO in *Hospitals Don't Burn! Hospital Fire Prevention and Evacuation Guide* should be considered.[90] Some examples include ensuring the plan is simple so that the instructions are easy to follow in the case of an emergency, and identifying temporary holding sites where patients can be evacuated to before they are taken to a final destination. Ultimately the principles aim to provide the 'greatest good for the greatest number' of patients. The full list can be found in Annex 1.

Co-burden of extreme heat and wildfires

Heat stress and fires are often considered highly correlated hazards, as extreme temperatures play a key role in both occurrences. Health care providers can reference UNICEF's technical note *Protecting Children from Heat Stress* to understand how to prepare facilities for health outcomes related to heat during the same season as wildfires.

4.3. School and early childhood development centre preparedness and response

Preparedness

To prepare schools and early child development centres for the event of a wildfire (and other emergencies), education sectors and school administrators need to make concerted efforts to develop emergency plans.

School administrators should aim to:

- Assess whether their schools are in low-risk or high-risk areas.
- Create a liveable space.
- Improve the fire resistance of school buildings.
- Improve preparedness by reviewing existing policies that affect schools.
- Develop a school-specific air quality chart that aligns levels of air quality with the specific actions to be taken by administrators (an example can be found in section 5 below).
- Make emergency operations and evacuation plans, which include identifying at least two exits for every room in the building.
- Invest in staff training in first aid response.
- Run 'drills' to practice evacuating the premises quickly and safely, which also provides insight into what accommodations may be required for students with disabilities or other needs.
- Have approved masks available for various age groups.

Education departments can also help children understand how climate change is affecting their personal experiences with events like wildfires, floods and other shocks. This can be done by incorporating climate change education into the annual curricula across all classes or grades, as well as conducting drills to help students practice safe and timely evacuation and shelter behaviours.

Fire education in schools

The Global Fire Monitoring Center, established in 1998, has developed a range of child-friendly materials and complementary teacher guides focused on understanding what causes landscape fires like wildfires, how to recognize hazards like wildfire smoke, and what children can do to protect themselves and others. These resources can be found here.

The American Public Health Association's Children's Environmental Health Committee developed a useful lesson plan for introducing conversations on climate and health to Classes 9–12.

UNICEF has been supporting school safety trainings and programmes in countries like Chad, Armenia and India in order to prepare students to take quick and safe actions in the face of any disaster or harmful action.

During and after a wildfire or wildfire smoke event

In the event of wildfire or wildfire smoke above safe levels, schools should have guidance in place for announcing school closings and issuing masks to faculty and students. They should also have contact information for the nearest health facilities in case students are exhibiting symptoms of respiratory or other health issues. Actions can include:

- Ensuring that everyone is crawling **low under any smoke to exit the building**, to avoid inhaling it.
- Effective communication between schools, caregivers and government focal points.
- Access to and distribution of necessary supplies such as face masks, clean water and any medicine for students with chronic health issues.
- Information for how to transport children experiencing severe symptoms to the nearest readily available health care facility for treatment.
- Cleaning up debris within and around school buildings after an event to allow students to safely return to school.
- Providing PFA for students to support them in the immediate aftermath.

Schools can also develop useful interpretations of daily air quality index (AQI) readings and develop risk-informed actions to take for each corresponding level (for an example, see section 5 below).

Setting up school preparedness and response processes

The Readiness and Emergency Management for Schools Technical Assistance Center has developed a procedure document to help school administrators prepare for and respond to wildfires efficiently.

It has also developed guidance for implementing 'brief and focused' PFA that can help students recover from trauma associated with shocks such as wildfires.

The US EPA has also developed school-specific guidance for mitigating and managing air pollution due to wildfires.

4.4. National preparedness and response

Governments have an important role to play in co-ordinating mitigation, preparedness, response and recovery efforts for all communities in the event of a wildfire, and so consequently are addressing wildfires wholly, not just the smoke events. The involvement of both public and private sectors in emergency planning will improve the effectiveness and sustainability of the solutions. Policymakers should invest in:

- **Mitigating and preventing wildfires through an integrated management approach:** This includes fuel management, such as cleaning brush, using controlled burns strategically, instituting firebreaks and improving intersectoral land management policies.
- **Preparedness efforts that can enable quick action in the case of wildfires:** This includes investing in early warning systems, emergency plans across sectors, risk communication campaigns that promote positive behaviours and practices, and building communities to be fire adaptive.
- **Building climate-resilient communities using nature-based solutions:** This includes instituting better forestry guidance and protection, and supporting communities to find livelihood opportunities that encourage the maintenance of green spaces.
- **Develop national and international policies aligned with global frameworks for wildfire management, and promote knowledge exchange for improving coordinated action.**

The following specific actions can be considered by policymakers to mitigate the probability of a wildfire as well as effectively prepare to respond to the community health effects caused by wildfires.

Mitigating and preventing wildfire-related health issues

Protecting the health of the most vulnerable requires a concerted effort to prevent wildfires from happening in the first place, with particular focus on:

- Investing in both fire suppression and prevention, which requires investing in long-term sustainable practices to protect forests and peatlands.
- Adapting land-use policies to provide incentives for better land-use planning and management practices, which can include everything from practicing better boundary and forest management, to regulations around fire use.
- Developing regional, national and sectoral emergency protocols that build capacities for suppressing and responding to wildfires, including within the health sector.
- Implementing existing fire management mechanisms that include establishing or using surveillance and monitoring systems, conducting vulnerability assessments and developing policies that improve national and international multisectoral collaboration (examples of global and national collaborations can be found in section 4 below).
- Increasing funding for direct and indirect wildfire management practices.
- Improving air quality through multisectoral plans for reducing air pollution and emissions.

Preparing communities for wildfires

Governments can support communities residing in high-risk areas to prepare for the eventuality of a wildfire by instituting interventions such as 'wildfire community preparedness days' in which all public and private actors get involved in raising awareness and committing to preventative actions.

Challenges in predicting smoke concentrations

While wildfires can be physically isolated to the area of burning, the smoke can blanket surrounding areas for hundreds of miles, cross geopolitical borders, and be influenced by multiple factors. Governments must regularly check for updates available on public forecast and surveillance systems, such as the Copernicus Atmosphere Monitoring Service, and communities should become accustomed to checking for air quality updates daily through the news or mobile applications.

Guidelines for improved land management and fire response

Earth.org shared five sustainable forest management strategies that can be used to prevent and limit the spread of wildfires in forests, and the International Association of Wildland Fire shared tips on how to prevent fires happening in the dense carbon-storing peatlands of Southeast Asia, where climate change and poor land-use practices are contributing to more frequent fires.

Investing in preparedness and responsive public health measures

The following steps can be taken by governments to augment and reinforce preparedness efforts, particularly in regions where wildfires are frequent or risk remains high:

- Invest in disaster risk reduction through preparedness efforts, building capacities of community health workers and other providers, implementing risk communication campaigns aligned with early warning systems, and conducting risk assessments to understand and address vulnerabilities.
- Plan mandatory evacuations by developing and disseminating information on possible evacuation routes ahead of any known wildfire season.
- Establish an emergency response taskforce or committee which is responsible for mobilizing communities in the event of a wildfire, and for building school-based capacities of teachers and students to administer first aid to those affected by wildfires or wildfire smoke.
- Develop emergency protocols for the health, education and other social sectors where children can potentially be affected by wildfire smoke.
- Ensure that mandatory evacuation plans and emergency shelters with essential resources such as filters, masks and water are in place in the case of an emergency event.
- Enable expedient distribution of and easy access to necessary supplies, such as relevant medicines, to service providers such as health facilities and pharmacies
- Establish alert and notification systems that regularly disseminate information on air quality and provide risk communication messaging.
- Encourage government officials and health workers to sign up for apps (such as SmokeSense) that provide push/text notifications of risk communication messaging.
- Establish protocols for schools and other community facilities when air quality is above a certain threshold.
- Prioritize actions and services that protect populations from violence, sexual exploitation and abuse during and after disasters such as wildfires.
- Support access to community health services during and after wildfires, including for psychosocial support services.

Protecting disaster victims from exploitation and abuse

In an emergency setting, there is a higher risk of sexual exploitation and abuse of children because of the instability introduced into their environments. It is critical for governments to implement safety nets and services that help raise awareness about the risk factors, who is vulnerable, and what can be done to protect them. The National Sexual Violence Resource Center can provide a framework for developing guidelines to help address this.

UNICEF Brazil strengthens health response during Brazil wildfires in Amazon state

Because of record below-average precipitation levels in the Amazon state of Brazil in 2023, a late start to the rainy season, and abnormally warm ocean water due to the El Niño effect, 60 of the 62 municipalities of the Amazon state experienced fire emergencies and two experienced intense droughts (as of October 2023). According to the Brazilian National Institute for Space Research, 2023 also had the highest number of hot spot alerts since 1998.

The Government of Brazil has taken measures in recent years to prevent and better respond to massive wildfires, such as reducing deforestation and improving forest management practices. The Brazilian Ministry of Health has established guidelines to inform actions on protecting populations from the effects of wildfires. For instance, it published wildfire-related public health risk warnings and recommendations, and information on the role of environmental health surveillance in mitigating health risks. During the current wildfires, the Ministry also identified and distributed critical medical supplies to address the symptoms related to wildfires, malnutrition, and other health outcomes associated with the simultaneous drought and fire events, through collaborations with organizations on the ground and community health centers.

UNICEF Brazil concurrently collaborated with the Government of Brazil, through the Ministry of Health, as well as the Amazon State Health Surveillance Foundation, the National Foundation for Indigenous Peoples, and PAHO to monitor the epidemiological events and coordinate a strong response to protect the health and well-being of vulnerable populations affected by the drought and fire. UNICEF is also part of the indigenous emergency group activated by the Ministry of Indigenous Peoples, which includes the National Foundation for Indigenous Peoples, the Indigenous Peoples State Federation, and indigenous organizations. Some key areas of support included:

- Conducting a rapid assessment of maternal and child health and the nutritional needs of children and pregnant women most vulnerable to the wildfire and drought events, as well as the impacts of drought on water, sanitation and hygiene services and the incidence of acute diarrhoea in children.
- Equipping community health agents with nutritional classification discs and mid-upper arm circumference measuring tapes to enable nutritional surveillance in the most affected areas.
- Purchasing ReSoMal, F75 and F100 to treat children with severe malnutrition, and designing nutrition protocols, including case management for undernourished children.
- Providing ad hoc solutions for restoring water access and water treatment with hypochlorite.
- Mobilizing indigenous youth communicators to collect information and raise awareness through effective risk communication.
- Improving school preparedness and response by providing informative materials on the impact of climate shocks and on violence prevention, in order to prevent school evasion and raise caregiver awareness of the issue.
- Developing social media communication materials for caregivers on how to protect children from wildfire smoke, including instructions on how to use hypochlorite, how to use masks properly, and how to prepare for emergencies in the future.

Example of social media communication on protecting children from wildfire smoke in Brazil

Building climate-resilient communities

In order to foster communities equipped to manage the challenges of wildfire and other climate shocks, governments can:

- Incorporate goals for strengthening child-centric primary health care into existing and future climate commitments.
- Set policy and budgets for annual capacity building for first aid and response in the government bodies responsible for responding to disasters.
- Finance adaptations in primary health care response, including capacity building, education and risk communication, and early warning and notification systems.
- Foster collaboration between climate and health ministries to engender greater prioritization of health in national climate agendas.
- Realize a low-carbon society, which seeks greater integration of renewable energy and sustainable practices within health facilities.
- Support adaptation of all operational processes required to be adequately prepared, and allocate relevant and timely supplies.
- Set global and region-specific benchmarks that reflect child health priorities.

Community health workers play a critical role

At the community level, community health workers play a crucial role in raising awareness about the dangers of wildfire smoke and the actions individuals can take to protect themselves and the most vulnerable in their households.

- Create more platforms within which health professionals can advocate for greater climate action and contribute to global advocacy efforts.

Developing and participating in national and international cooperation frameworks

Wildlands often do not adhere to political borders and therefore countries and regional groups need to work together to protect them from experiencing wildfires due to lack of management. The next section provides examples of existing cooperation mechanisms that are working to improve engagement and action on mitigating and responding to wildfires across borders.

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5. Preventing wildfires: Examples of cooperation

Preventing wildfires and mitigating their impacts is the most important action for governments to invest in. With climate change intensifying, the frequency and severity of wildfires are on the rise, making proactive prevention measures crucial. As wildfires do not adhere to national borders, and their impacts are felt globally, governments should aim to establish or join collaborative and international efforts that share resources, best practices and surveillance systems that can together enhance the effectiveness of prevention and mitigation strategies.

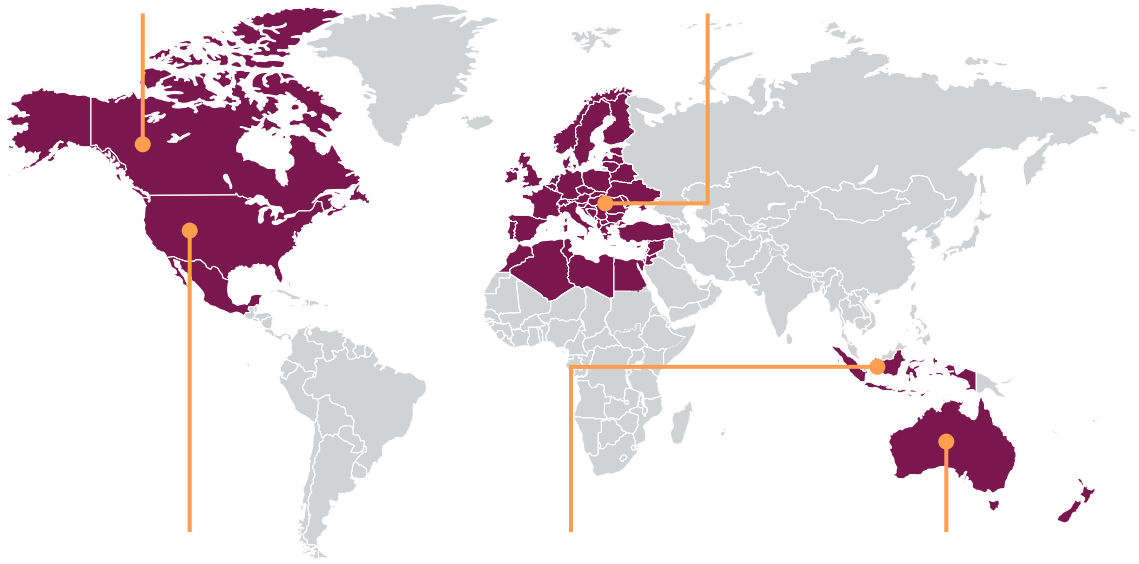
The Sendai Framework for Disaster Risk Reduction 2015–2030, adopted in 2015 by the United Nations Member States, committed to establishing an international wildfire preparedness mechanism (IWPM) to address the need for a more co-ordinated and international response. This Framework built upon the spearheading work of regional communities such as the Southern African Development Community, which passed a multistate cooperation protocol in 2002 to improve management practices of transboundary forests.[91] The following is a curated list of global and national-level programmes aimed at protecting global communities from the impacts of wildfires.

Global

- **Global Disaster Alert and Coordination System (GDACS):** This is a cooperation framework between the United Nations and the European Commission which provides real-time access to web-based disaster information systems to approximately 25,000 subscribers immediately after the onset of a disaster, including forest fires. It also functions as an online knowledge exchange platform for almost 19,000 users associated with governments and disaster response organizations.
- **Global Fire Management Hub:** The Food and Agriculture Organization of the United Nations and the United Nations Environment Programme launched the Global Fire Management Hub in 2023 to strengthen countries' capacity to implement integrated fire management frameworks and practices. In November 2023, the African Forestry and Wildlife Commission was invited to join and contribute to its mandate.
- **International Association of Wildland Fire (IAWF)**: This is a professional membership association focused on bringing together implementers across countries to promote exchange of expertise in managing and preventing wildfires.
- **The United Nations International Strategy for Disaster Reduction (UNISDR) Global Wildland Fire Network (GWFN):** Created in 2004 under UNISDR, the GWFN is an umbrella network made of 14 independent regional wildland fire networks with their own respective mandates. Together with the Wildland Fire Advisory Group, it was convened by the Global Fire Monitoring Center to support reducing the negative impacts of landscape fires, advance best practices, and align the work with the commitments made under the Sendai Framework.
- **World Meteorological Organization Vegetation Fire and Smoke Pollution Warning Advisory and Assessment System (VFSP-WAS):** This is an international network of research and operational centres aiming to enhance the ability of countries to deliver timely and high-quality vegetation fire and smoke pollution forecasts, observations and knowledge. The first development phase for this system was launched in 2018, and it now has regional centres in Southeast Asia and North America.

Regional and national

- **Canadian Wildland Fire Information System**: This initiative by the Ministry of Energy and Natural Resources of Canada creates daily fire weather and fire behaviour maps year round with the support of satellite data and local fire management agencies. The data is ranked based on the Canadian Forest Fire Danger Rating System, which then triggers the relevant fire management activities.
- **European Forest Fire Information System** (EFFIS): Established in 1998, EFFIS has supported European, Middle Eastern and North African countries in accessing the latest reliable information on wildland fires affecting the region. There are currently 40 countries involved in the network, and EFFIS provides specific support to the Emergency Response Coordination Centre in Brussels during the fire season.



- **United States Forest Service**: Part of the United States Department of Agriculture, the US Forest Service has been responsible for managing wildland fires for more than 100 years, with the support of other federal agencies as well as tribal, state and local partners. It is currently implementing a domestic National Cohesive Wildland Fire Management Strategy and also working with other countries to promote knowledge exchange across borders.
- **Fire-Free Alliance** (FFA): This is a voluntary multi-stakeholder group made up primarily of forestry and agriculture companies with non-government organizations and others committed to resolving Indonesia's persistent fires and haze arising from land burning. The FFA focuses on community engagement as a successful approach for reducing incidence and mitigating spread.
- **Fire Management Working Group and the Australasian Forest Fire Management Group** (FMWG-FFMG): The United States, Canada, Mexico, Australia and New Zealand established these groups in the 1950s and adapted them in the late 1990s to exchange resources for fire suppression support.

Comparing policies and approaches

While contributing to regional and international efforts, each country has its own contextualized approach to wildfire management based on its respective geographic, demographic and climatic needs. A 2023 comparative analysis provides some insights on country-to-country variability.

An important component of managing landscape fires is working with the local community and understanding how cultural practices can be beneficial during the response. An example of how local cultures helped manage wildfires while also improving biodiversity can be found in this case study on the Namibia-Finland Forestry Programme that ran from 1996 to 2001.

6. The essential toolbox: Key resources

Households, schools, early child development centres and health facilities in wildfire risk zones or in areas with generally high air pollution can aim to access the following essential supplies and resources. This will allow them to be at least minimally prepared to mitigate the harmful impacts of wildfire smoke, particularly if children and pregnant women are affected. These essentials are: **the air quality index (AQI), respirators or face masks, and air cleaners with appropriate filters.**

Air Quality Index

Air quality is determined by the mix of pollutants found in ambient air. These pollutants include emissions such as carbon monoxide, as well as particulate matter made up of solid and liquid particles discharged into the air as a result of human activity. In 2021, the World Health Organization (WHO) released updated standards for levels considered healthy in a given time and space.[92]

Figure 6: WHO guidelines for air pollution by pollutant and year

Pollutant	Averaging time	2005 AQGs	2021 AQGs
$PM_{2.5}$, μg/m³	Annual 24-hour[a]	10 25	5 15
PM_{10}, μg/m³	Annual 24-hour[a]	20 50	15 45
O_3, μg/m³	Peak season[b] 8-hour[a]	- 100	60 100
NO_2, μg/m³	Annual 24-hour[a]	40 -	10 25
SO_2, μg/m³	24-hour[a]	20	40
CO, mg/m³	24-hour[a]	-	4

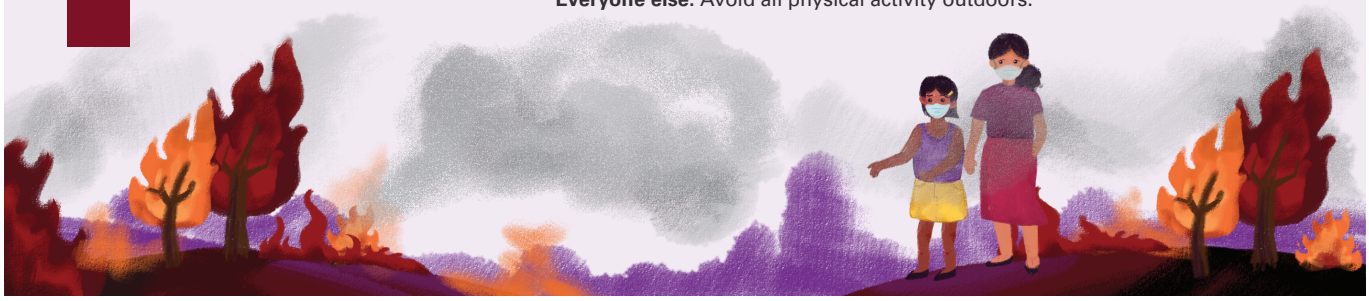
μg = microgram
[a]99th percentile (i.e. 3–4 exceedance days per year).
[b] Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running- average O_3 concentration.
Note: Annual and peak season is long-term exposure, while 24 hour and 8 hour is short-term exposure.

Source: WHO Air Quality Guidelines, 2021.

What most people are familiar with, however, is the air quality index (AQI), which is a country-specific indexing of a mix of these pollutants as determined by the country's own health and meteorological services. The AQI focuses on health effects that a person may experience within a few hours or days after breathing unhealthy air. One of the more known AQIs is that of the United States Environmental Protection Agency (US EPA). **It is important to note that each country's categorization of AQI may vary and may account for different combinations of pollutants.** The US EPA's AQI reports on the most common pollutants: ozone, $PM_{2.5}$ and PM_{10}, carbon monoxide, nitrogen dioxide and sulfur dioxide.

Figure 7: Example of health guidance based on country-specific AQI

Air quality index	Who needs to be concerned?	What should I do?
Good 0–50		It's a great day to be active outside.
Moderate 51–100	Some people who may be unusually sensitive to particle pollution	**Unusually sensitive people:** Consider making outdoor activities shorter and less intense. Watch for symptoms such as coughing or shortness of breath. These are signs to take it easier. **Everyone else:** It's a good day to be active outside.
Unhealthy for sensitive group 101–150	Sensitive groups include **people with heart or lung disease, older adults, children and teenagers, pregnant people, and outdoor workers**	**Sensitive groups:** Make outdoor activities shorter and less intense. It's OK to be active outdoors, but take more breaks. Watch for symptoms such as coughing or shortness of breath. **People with asthma:** Follow your asthma action plan and keep quick relief medicine handy. **People with heart disease:** Symptoms such as palpitations, shortness of breath, or unusual fatigue may indicate a serious problem. If you have any of these, contact your health care provider.
Unhealthy 151–200	**Everyone**	**Sensitive groups:** Avoid long or intense outdoor activities. Consider rescheduling or moving activities indoors. **Everyone else:** Reduce long or intense activities. Take more breaks during outdoor activities.
Very unhealthy 201–300	**Everyone**	**Sensitive groups:** Avoid all physical activity outdoors. Reschedule to a time when air quality is better or move activities indoors. **Everyone else:** Avoid long or intense activities. Consider rescheduling or moving activities indoors.
Hazardous 301–500	**Everyone**	**Sensitive groups:** Remain indoors and keep activity levels low. Follow tips for keeping particle levels low indoors. **Everyone else:** Avoid all physical activity outdoors.



Source: Adapted from US EPA, 2023.

A school-based example can look like the following, from California, United States, which pairs AQI levels with recommendations for restrictions at each level. Again, these should be adapted to reflect the local AQI charts. These can be incorporated into larger emergency preparedness, evacuation and shelter plans.

Figure 8: Example of school-based activity recommendations by air quality

Activity	Level 1 AQI 0–50 $PM_{2.5}$ 0–12 µg/m³	Level 2 AQI 50–100 $PM_{2.5}$ 13–35 µg/m³	Level 3 AQI 101–150 $PM_{2.5}$ 36–55 µg/m³	Level 4 AQI 151–200 $PM_{2.5}$ 56–150 µg/m³	Level 5 AQI 201 or higher $PM_{2.5}$ 151–500 µg/m³
Recess (15 mins)	No restrictions	Ensure that sensitive individuals are medically managing their condition.*	Sensitive individuals should exercise indoors or avoid vigorous outdoor activities.*	Exercise indoors or avoid vigorous outdoor activities. Sensitive individuals should remain indoors.*	No outdoor activity. All activities should be moved indoors.
Physical education (1 hr)	No restrictions	Ensure that sensitive individuals are medically managing their condition.*	Sensitive individuals should exercise indoors or avoid vigorous outdoor activities.*	Exercise indoors or avoid vigorous outdoor activities. Sensitive individuals should remain indoors.*	No outdoor activity. All activities should be moved indoors.
Athletic Practice and Training (2-4 hrs)	No restrictions	Ensure that sensitive individuals are medically managing their condition.*	Reduce vigorous exercise to 30 minutes per hour of practice time with increased rest breaks and substitutions. Ensure that sensitive individuals are medically managing their condition.*	Exercise indoors or reduce vigorous exercise to 30 minutes of practice time with increased rest breaks and substitutions. Sensitive individuals should remain indoors.*	No outdoor activity. All activities should be moved indoors.
Scheduled Sporting Events	No restrictions	Ensure that sensitive individuals are medically managing their condition.*	Increase rest breaks and substitutions per CIF guidelines for extreme heat.** Ensure that sensitive individuals are medically managing their condition.*	Increase rest breaks and substitutions per CIF guidelines for extreme heat.** Ensure that sensitive individuals are medically managing their condition.*	Event should be rescheduled or relocated.

School districts may consider closures based on site-by-site concerns

* Sensitive individuals include all those with asthma or other heart/lung conditions.
**California Interscholastic Federation

Source: Berkeley Public Schools, 'Air Quality Response Plan', 2023.

It is recommended that individuals check weather forecasts on television, radio or on their phone routinely to not only prepare one's self for the day or week, but to also understand seasonal trends for long-term resilience. Mobile applications that can be downloaded and used to regularly check the AQI can be found online, such as in lists like these. The most popular AQI mobile applications include (available on both iPhone and Android systems):

- IQAir AirVisual: Has real-time data and shared health recommendations.
- AirCare: Shares both air quality information and health recommendations, as well as UV index and allergens data with the respective recommendations.

It is recommended to seek national authority guidance on air quality.

Respirators or face masks for children

There is a wide range of options available on the market today for protecting individuals from air pollution caused by various sources. They do not, however, all provide the same level of protection.

The benefits of wearing an N95 face mask to protect against wildfire smoke has not been systematically evaluated. PEHSU, however – supported by the American Academy of Pediatrics – states that properly fitted **N95 masks can protect children from wildfire smoke.** Outside of the United States, KN95s are seen to have a similar protective effectiveness, as both mask types are rated to capture 95 per cent of particles as small as 0.3 microns.[93]

For children aged 7 or older, an adult small N95 mask will most likely fit. It is unlikely that children younger than 7 years of age will find properly fitting N95 masks; for these children, medical/surgical masks may fit their faces, but these masks will not provide the protection provided by the N95 mask. Other reports have cautioned against the use of N95 masks for children as they are not made to fit children and will not protect them from wildfire smoke.[94] In addition, there are concerns that masks may give users a false sense of security, prompting more outdoor activity and wildfire smoke exposure. **PEHSU cautioned against using masks for children with cardiovascular or respiratory disease, but it is also important to consider the costs and benefits of each unique situation when making these decisions on behalf of children.**

To improve the efficacy of using a mask, it is important that they be fitted correctly over the child's face (see Figure 9).

What are N95 and KN95 masks?

An N95 respirator is an air-purifying respirator certified by the United States National Institute for Occupational Safety and Health. They are filter masks that fit snugly over the nose and mouse and, when properly worn, can filter out 95 per cent of smoke particles.

A KN95 is an equivalent that meets certain international standards and is commonly used outside of the United States. It provides the same protection against smoke particles as the N95. N95s are considered to have met stricter requirements, however, including the ability to filter out bacteria and viruses.

Figure 9: Guidance on proper face mask usage

Source: UNICEF, 'Child Mask Use: Everything you need to know', 2020.

Home air cleaners and appropriate filters

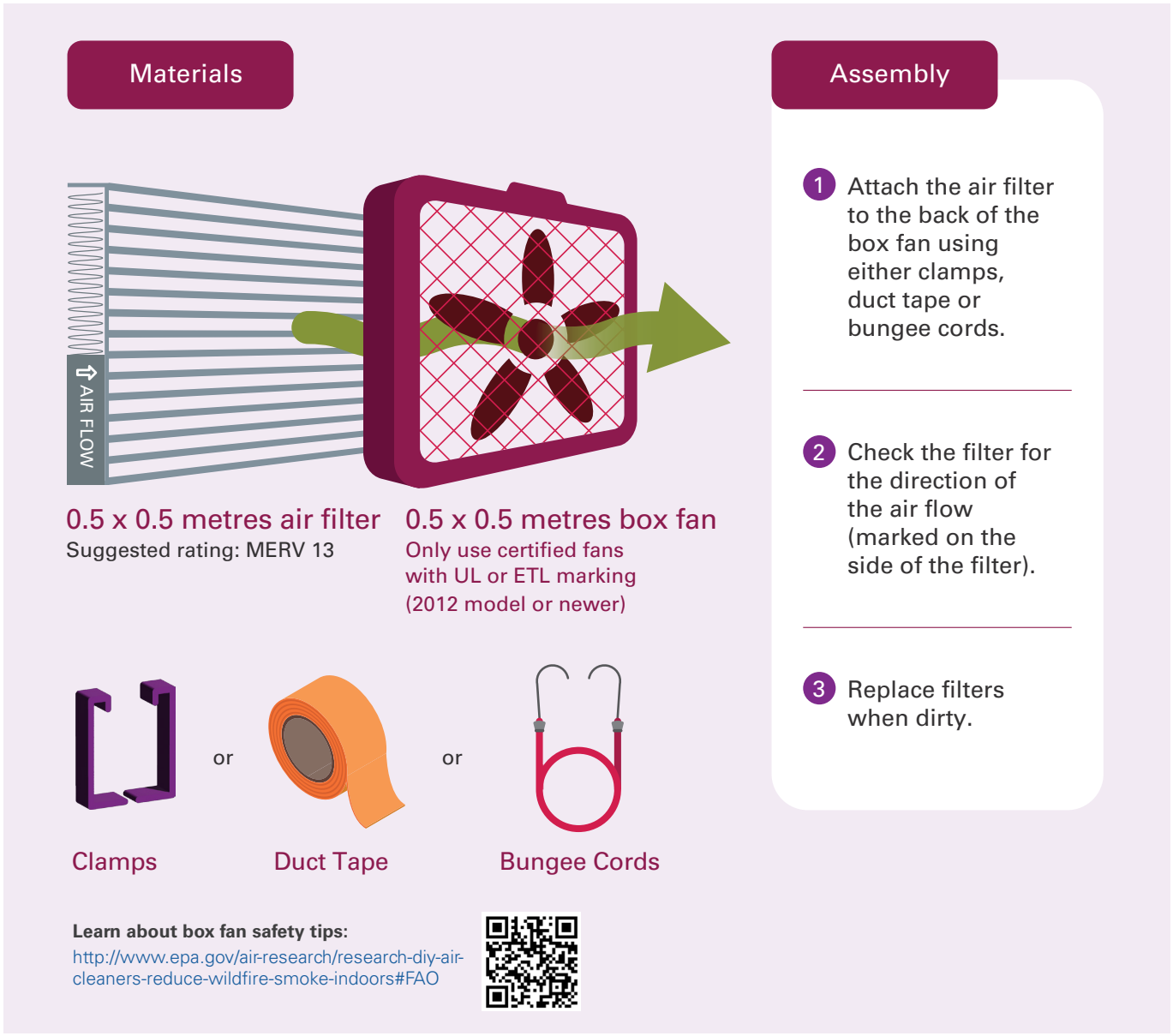
The indoor concentration of air pollutants is influenced by a combination of indoor sources – such as the use of polluting heating and lighting technologies – and pollutants in the ambient air. Children living in environments where ambient air is highly polluted, such as in densely populated cities in LMICs, may face increased exposure to air pollutants. Depending on the particular pollutant, building design, ventilation and filtration, indoor concentrations of air pollutants originating from the outdoors ranges from less than 10 per cent to close to 100 per cent of outdoor levels, according to WHO.[95]

The same report noted that **the use of portable air cleaners in households showed significant reductions in indoor $PM_{2.5}$ concentrations, ranging from 40 to 82 per cent, but health outcomes were inconsistent.** Cardiovascular and respiratory health indicators and biomarkers of inflammation were the primary outcomes measured; specific paediatric outcomes were not reported. Based on the evidence, WHO concluded that the use of portable air filters in homes was premature. More research is needed on the efficacy of air filtration in home settings to improve health outcomes for pregnant women and children. The US EPA website[96] provides information on the use of air filtration in homes and during wildfire incidents.[97,98]

There are two cost-effective options that can be pursued by households and by governments seeking to improve access to cleaner air quality.

The first option is a makeshift air cleaner recommended by the US EPA that can be used to reduce exposure to wildfire smoke in indoor settings, although a conclusive time frame for their use is not provided. These 'do-it-yourself' (DIY) air filters are considered to be a relatively low-cost and reasonably effective option for short-term use. **It is important to note that because their effectiveness varies drastically based on the materials used and the context in which they are used, DIY air filters may not be suitable for every situation.**

Figure 10: How to build a DIY air cleaner to reduce wildfire smoke indoors



Source: Adapted from US EPA, 'DIY Air Cleaner to Reduce Wildfire Smoke Indoors', 2021.

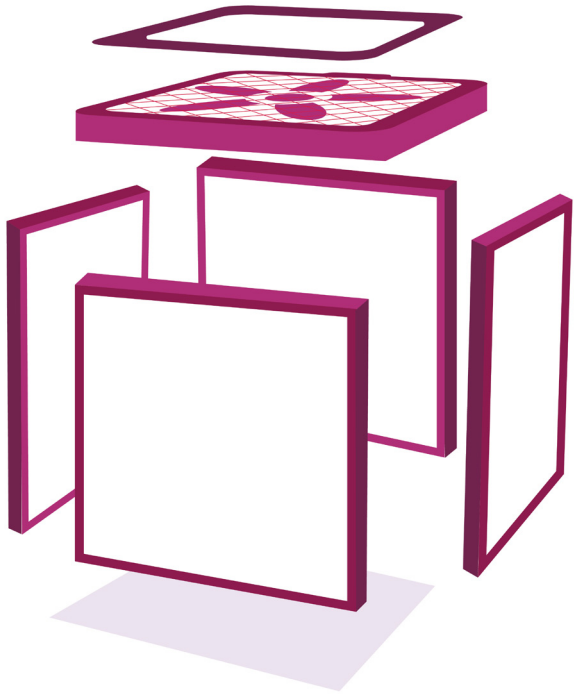
The second option is the Corsi-Rosenthal Box, another DIY box fan air filter proven to reduce indoor exposure to airborne particles such as wildfire smoke. During wildfires in the United States, they have functioned as affordable and temporary solutions for a variety of settings including offices and school rooms.[99]

Using the right air filters for the cleaners

It is important that ionization should never be used when cleaning the air. Ionic air filters and cleaners have been demonstrated to cause negative health effects and, in the presence of some common chemicals, can create byproducts that are carcinogenic, per Liu et al., 2021.

Figure 11: Corsi-Rosenthal Box

DIY box fan air filter



Source: UC Davis, 'Science in Action: How to Build a Corsi-Rosenthal Box', 2023

7. Additional resources

Resources for adapting existing training, education and risk communication content

- 10 Wildfire Safety Tips to Keep Children Safe – Save the Children
- Climate Change: Wildfires and children's health – American Public Health Association's Children's Environment Health Committee
- Create a Clean Room to Protect Indoor Air Quality During a Wildfire – US Environmental Protection Agency (in multiple languages)
- Defensible Space: Defend your home against wildfires by creating a safe perimeter – Cal Fire
- Get Smart about Wildfire Smoke: Clear guidelines for schools and wildfire smoke – California Department of Education
- Helping Children After a Wildfire: Tips for parents and teacher – National Association of School Psychologists
- Smoke-Ready Toolbox for Wildfires – US Environmental Protection Agency
- Vegetation Fire and Smoke Pollution Warning and Advisory System – World Meteorological Organization, Global Fire Monitoring Center, Global Atmosphere Watch, and Interdisciplinary Biomass Burning Initiative
- Wildfire Smoke and Children – Centers for Disease Control and Prevention
- Wildfires And Mask Use – Pediatric Environmental Health Speciality Units

Resources for health professionals on climate change and health education

- 2021 Children's Health and Wildfire Smoke Workshop: Workshop recommendations – US Environmental Protection Agency
- Climate Change and Human Health ECHO Program – ECHO Institute
- The Climate Resilience for Frontline Clinics Toolkit – Americares and Harvard T.H. Chan School of Public Health
- Climate Resources for Health Education – Columbia University Mailman School of Public Health
- Recordings from Climate and Health Responder Course for Health Professionals – Columbia University Mailman School of Public Health
- Wildfire Resources – National Child Traumatic Stress Network
- Wildfires: What parents need to know – American Academy of Pediatrics

Networks focused on children's environmental health

- Children's Environmental Health Collaborative
- Children's Environmental Health Network
- Pediatric Environmental Health Specialty Units (PEHSU)
- Sustainable Forestry Initiative

Resources for children on wildfires and wildfire smoke

- *A Story of Health* chapter: Sofia's Story (Health Effects of Wildfires) – Follow Sofia and her family as they learn how to protect themselves from the immediate and longer term health dangers of a wildfire, with a focus on children's health and prevention strategies.
- *Why Is Coco Orange?* – This picture book for children ages 4–8 helps children learn about air quality and how to stay healthy when the air quality is bad (also available in Spanish).
- *Why Is Coco Red?* – The sequel to *Why Is Coco Orange?* helps children learn about wildfire smoke and air quality (also available in Spanish).

Annex 1

Guiding principles for developing a health facility evacuation plan

The following guiding principles should be taken into consideration when developing an overarching emergency response protocol for health facilities, as recommended by PAHO:

- Every effort should be made to include evacuation considerations when designing or retrofitting hospital facilities.
- Full evacuation of a hospital should generally be considered as a last resort when mitigation or other emergency response efforts are not expected to maintain a safe care environment. Patient safety is always the primary concern.
- **Simplicity is key; the staff will need a simple plan to follow in an emergency.**
- Flexibility is vital because the procedures must be adaptable to a variety of situations.
- Self-sufficiency at the unit level is important because timely communication from hospital leaders may be difficult or even impossible; employees at every level must know immediately what to do in their area.
- It may be necessary to evacuate patients to holding sites before transportation resources and/or receiving destinations are available. If the medical facility cannot accommodate a horizontal safe site (a location on the same floor safe from danger), then assembly points located away from the main clinical areas should be identified and designated.
- Individual patient care units should stay together at the assembly points whenever possible (instead of the patients in these units being divided into separate groups according to their ambulatory status). This is because the unit teams familiar with their patients will be better able to manage them in a chaotic situation away from the care unit.
- Emergency medical system personnel and other external patient transporters should generally not be asked to come into the hospital to load patients because of the risks, time delays and inefficiency associated with this process when large numbers of patients are involved. Instead, evacuating patients should be taken to meet their transporting ambulances and other vehicles in rapid-throughput staging areas.
- **When difficult choices must be made, leaders and staff must focus on the 'greatest good for the greatest number.'**

Annex 2

Common signs of psychological distress in children after experiencing a wildfire

Age range (Years)	Common regressive reactions	Common physiological reactions	Common emotional and behavioural reactions
1–5	• Bedwetting in a child who before the disaster was toilet trained • Thumb-sucking • Greater fear (of darkness, animals, monsters, strangers)	• Loss of appetite • Overeating • Indigestion and other digestive problems	• Nervousness • Anxiety about being away from parents or other primary caregivers • Irritability and disobedience
5–11	• Clinginess with parents or other primary caregivers • Crying or whimpering • Requests to be fed or dressed	• Headaches • Complaints of visual or hearing problems • Sleep problems and nightmares • Overeating or loss of appetite	• School phobia • Social withdrawal • Irritability and disobedience
11–14	• Competing with younger siblings for attention from parents or other primary caregivers • Failure to perform chores and fulfil normal responsibilities	• Headaches • Complaints of vague aches and pains • Overeating or loss of appetite • Skin problems • Sleep problems	• Loss of interest in activities • Poorer school performance • Disruptive behaviour • Resistance to authority
14–18	• Resumption of earlier behaviours and attitudes • Decline in previous responsible behaviour	• Headaches • Sleep problems • Digestive problems • Vague physical complaints	• Increase or decrease in physical activity • Depression • Isolation • Antisocial behaviour

Source: Substance Abuse and Mental Health Services Administration, 2018.

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