



Wildfires and heat-wave in the Russian Federation – Public health advice

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Introduction

High temperatures and sparse rainfall dominated the weather in the Russian Federation during June and July, with temperatures hovering 4–8 °C above average across a large swath of the country. Moscow recorded its highest temperature ever (39 °C). Before 2010, the hottest temperature in Moscow was 38.8 °C, recorded 90 years ago.

Since the end of July, this record heat-wave has been accompanied by extensive wildfire outbreaks (1,2): over 26 000 wildfires in 22 regions of the Russian Federation. They covered a total area of 816 515 hectares, including 1104 sites of peat fires covering an area of 1760 hectares. These wildfires have produced a dense plume of smoke spreading over hundreds of kilometres (3).

Since late July, the Russian Federation authorities have reported high concentrations of carbon monoxide and particulate matter, exceeding manyfold the maximum permissible concentration. The pollution varied strongly over time and across the territory of the city of Moscow and Moscow district. Direct comparison of the monitoring results with WHO air quality guideline levels is difficult owing to differences in monitoring methods and, especially, to the scarcity of data on the respirable fraction of particulate matter (with a diameter under 10 µm (PM₁₀) or 2.5 µm (PM_{2.5})) which has the best documented health effects. Even approximate information nevertheless indicates that the concentration of particulate matter exceeded manyfold the WHO guideline levels (4,5).

Further concern was raised when, on 9 and 10 August, the fires came close to the forests affected by the Chernobyl nuclear reactor accident in 1986. The Bryansk region was one of the regions of the Russian Federation most affected by the accident, although the amount of radioactivity in the soil has decreased by over 90% since the levels deposited in 1986. According to the Russian authorities, no wildfires were reported in the Bryansk region where the affected forests are located, nor close to radiochemical plants.

Exposure and health effects

Exposure to forest and peat fire smoke

When biomass fuel burns, combustion is not complete and pollutants released include particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide and organic compounds. Once emitted, the pollutants may undergo physical and chemical changes. Thus, vegetation fires are major contributors of toxic gaseous and particle air pollutants into the atmosphere. These fires are also sources of “greenhouse” and reactive gases.

All these pollutants are also emitted into the air when biomass fuels are used. Epidemiological studies have found consistent associations between exposure to air pollutants (including particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide and organic compounds) due to wildfires and acute health effects (6–8). The effects of

smoke range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbated asthma and premature death.

Exposure to particulate matter is the main public health threat from short-term exposures to wildfire smoke. In particular, fine airborne particles (PM_{2.5}) penetrate deep into the respiratory tract and may cause a whole range of health problems. Studies have found that fine particles are linked (alone or with other pollutants) with increased mortality and aggravation of pre-existing respiratory and cardiovascular disease. In addition, particles are respiratory irritants, and exposure to particulate matter can cause persistent cough, phlegm, wheezing and difficulty in breathing. Particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function and pulmonary inflammation.

Carbon monoxide is produced during peat and forest burning. It enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. Carbon monoxide concentrations typical of population exposures to wildfire smoke do not pose a significant hazard, except to some sensitive individuals and to fire-fighters very close to the fire line. Exposure to higher levels of carbon monoxide (such as those that occur in major structural fires) can cause headache, weakness, dizziness, confusion, nausea, disorientation, visual impairment, coma and death, even in otherwise healthy individuals. Relatively short-term exposures to these levels, on the other hand, should not have detectable health impacts.

Wildfire smoke also contains significant quantities of respiratory irritants, which can act in concert to produce eye and respiratory irritation and potentially exacerbate asthma. Formaldehyde and acrolein are two of the principal contributors to the cumulative irritant properties of smoke (9).

Little is known about long-term health effects as a result of forest fires. The smoke contains several carcinogenic agents and long-term exposure to fine particles is associated with an increase in cardiovascular disease. Nevertheless, a short-term increase in exposure, such as that occurring as a result of a forest fire, is unlikely to have a marked impact on life-time cancer or cardiovascular risk (10).

The level and duration of exposure, age, individual susceptibility, including the presence or absence of pre-existing pulmonary or cardiovascular disease, and other risk factors play significant roles in determining whether someone will experience smoke-related health problems.

Exposure to heat

Hot weather can cause illness and kill. The normal body temperature range (36.1–37.8 °C) is maintained by the hypothalamus, which constantly regulates the production and loss of heat. When the outdoor temperature is higher than the skin temperature, the only heat loss mechanism available is evaporation (sweating). Therefore, any factors that hamper evaporation, such as high ambient humidity, reduced cardiac output, reduced air currents (no breeze, tight-fitting clothes) or drugs with anticholinergic mechanisms, can result in a

rise of body temperature that may culminate in life-threatening heatstroke. A wide range of factors – such as chronic diseases, social isolation, being confined to bed, certain medical treatments and some types of occupation – increase the individual risk of heat stress (11).

For each population there is an optimum temperature at which the (daily or weekly) death rate is the lowest. Studies published between 1993 and 2003 from several European cities attribute a change of between 0.7% and 3.6% in all-cause mortality to a 1 °C increase of temperature above a certain threshold. A more recent assessment in 15 European cities in the period 1990–2001 estimated an increase in mortality for every 1 °C increase in apparent temperature¹ above thresholds of 2% (95% confidence interval (CI): 0.06–3.64) in northern cities and 3% (95% CI: 0.60–5.72) in southern cities.

The heat-wave of 2003 in western Europe caused more than 70 000 excess deaths in 12 European countries. The EuroHEAT project estimated a 7.6% to 33.6% increase in mortality during heat-wave episodes in nine European cities. The results showed a high heterogeneity of the effect between cities and populations. The impact of heat-waves of longer duration (over four days) was 1.5–5 times higher than for short heat-waves.

Heat-waves put at risk the elderly, children and people with chronic diseases. The role of housing and socioeconomic conditions varies greatly. The elderly suffer the greatest effects of heat-waves, with women bearing a higher burden of mortality than men.

The ultimate health effects will depend on the level of exposure² (the timing, frequency, intensity and duration of the heat-wave), the size and demographic profile of the exposed population, population sensitivity (such as through chronic diseases or drug treatment) and the prevention measures in place.

Combined exposure to heat and air pollution

The synergistic effect on mortality of high temperatures and air pollution is increasingly evident (12). Several studies (from Europe, the United States and Canada) have found that the effects of ozone and particulate matter are higher during the summer. Further evidence is growing that the effects of heat-wave days on mortality are greater on days with high levels of fine particulate matter. In the EuroHEAT study, mortality increased by 16.2% on heat-wave days with high ozone levels and by 14.3% on days with high PM₁₀ levels.

¹ Apparent temperature is a measure of relative discomfort due to combined heat and high humidity, developed on the basis of physiological studies on evaporative skin cooling and can be calculated as a combination of air temperature and dew point in °C. (Stedman RG. The assessment of sultriness. Part II. Effects of wind, extra radiation and barometric pressure on apparent temperature. *Journal of Applied Meteorology*, 1979, 18:874–885).

² There is no standard definition of a heat-wave. EuroHEAT, a project coordinated by the WHO Regional Office for Europe and co-funded by the European Commission Directorate-General for Health and Consumers, defines a heat-wave as a period in which the maximum and minimum apparent temperatures are over the ninetieth percentile of the monthly distribution for at least two days.

Re-suspended radionuclides

Published reports indicate that the worst-case wildfire scenario would result in re-suspension of up to 4% of radioactivity in the soil. The elements will be radioactive caesium and strontium plus a small proportion of transuranium elements, such as plutonium (up to 1.6%). The health risks associated with this re-suspension are likely to be close to negligible, owing to the low concentrations of these particles in the air at long distances from the fires and their low relative contributions to overall radioactivity in the air.

In the worst-case scenario, the radiation dose resulting from inhalation of re-suspended radioactive particles would contribute to a small extent to the occupational exposure of fire-fighters and would not exceed occupational exposure limits. The use of standard respirators to protect against smoke and dust will be sufficient to reduce the dose significantly.

Groups at highest risk (9)

Certain groups of people are at higher risk than others: people with asthma, other respiratory diseases and cardiovascular disease, elderly people, children, pregnant women, smokers and fire-fighters.

Individuals with asthma and other respiratory diseases

Levels of pollutants that may not affect healthy people may cause breathing difficulties in people with asthma, chronic obstructive pulmonary disease, or other chronic pulmonary diseases.

Individuals with cardiovascular disease

Diseases of the circulatory system include high blood pressure, cardiovascular diseases, such as coronary artery disease and congestive heart failure, and cerebrovascular conditions, such as hardening of the arteries (atherosclerosis), that bring blood to the brain. These chronic conditions can render individuals susceptible to attacks of angina pectoris (transient chest pain), heart attacks, sudden death due to cardiac arrhythmia, acute congestive heart failure or stroke. People with multiple chronic diseases are also at high risk from heat exposure.

People with other chronic pre-existing diseases

Virtually all chronic diseases present a risk of death/illness due to heat. Evidence is strongest for people with psychiatric disorders, depression, diabetes and pulmonary, cardiovascular and cerebrovascular conditions. Any disease or condition that confines someone to bed and reduces their ability to care for themselves or to leave home daily also increases the risk. This is because of a general reduction in the ability to behave in an appropriate manner in response to heat. Diarrhoea or febrile illness, particularly in children, and pre-existing renal or metabolic diseases may increase the risk of heat-related illness and death, because these may be associated with excessive fluid loss and dehydration.

Elderly people

Elderly people may also be more affected than younger people because important respiratory defence mechanisms decline with age; in addition they are at risk from heat because of their impaired thermoregulation system.

Children

Even children without any pre-existing illness or chronic conditions are considered a sensitive population because their lungs are still developing, making them more susceptible to air pollution than healthy adults. Several factors lead to increased exposure in children compared with adults: they tend to spend more time outside; they engage in more vigorous activity; and they inhale more air (and therefore more smoke constituents) per pound of body weight. Children are also more sensitive to prolonged heat exposure.

Pregnant women

While there have not been studies of the effects of exposure to wildfire smoke on pregnancy outcomes, there is substantial evidence of adverse effects of repeated exposures to cigarette smoke, including both active and passive smoking. Wildfire smoke contains many of the same compounds as cigarette smoke. Therefore it would be prudent to consider pregnant women as a potentially susceptible population as well.

Smokers

People who smoke, especially those who have smoked for many years, have compromised lung function. Due to the adaptation of their lungs to ongoing irritation, however, smokers are generally less likely to report symptoms from exposure to irritant chemicals than are nonsmokers. Nevertheless, they may still be injured by wildfire smoke.

Summary of health effects

Smoke

In the acute phase of the smoke episode, the increase in ill health may lead to emergency department visits, hospitalization and mortality from:

- internal burns due to the inhalation of hot gaseous products of combustion, which can cause serious respiratory complications;
- burns to the body;
- worsened pulmonary function and respiratory distress;
- acute exacerbation of asthmatic and respiratory disease;
- acute respiratory illness in children; and
- acute cardiovascular events leading to death.

Chronic effects include:

- increased incidence of asthmatic and respiratory disease;
- development of new cases of chronic respiratory disease; and
- decreased life expectancy.

Other possible risks include:

- traffic, marine and aircraft crashes due to reduced visibility from thick smoke; and
- fatalities during emergency evacuations with increased risk among emergency service staff, including fire-fighters.

Heat

The health effects of heat exposure range from heat rash, heat oedema, heat syncope, heat cramps and heat exhaustion to heatstroke. Heatstroke is fatal in 10–50% of all cases and may lead to neurological morbidity in 20–30% of patients. It is still underreported, as causes of death may be attributed instead to cardiovascular and respiratory diseases.

Public health advice

WHO has developed this guidance to meet the urgent need for up-to-date information and evidence-based recommendations for those exposed to heat-waves and high concentrations of air pollutants. It will be updated as new information becomes available. The guidance summarizes and highlights the principal elements in the publication *Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide (13)* and the advice in the WHO/European Commission heat–health action plans (14), which are applicable to the events surrounding the wildfires and heat-wave in the Russian Federation, and builds on earlier publications on wildfires (9).

- Remain indoors. During such high-pollution episodes all people, particularly those at risk, children and elderly people, should stay indoors as much as possible and away from roads with heavy traffic. Direct ventilation from streets with heavy traffic should be avoided.
- Keep your home cool. Close windows and shutters (if available). Move to the coolest room in the home, especially at night. In the long term, ensure energy-efficient cooling and heating.
- Stay in air-conditioned spaces. Homes with central air conditioners generally have fewer outdoor particles indoors compared to homes that use open windows for ventilation. Most air conditioners are designed to enable recirculation of indoor air. Those systems that have both “outdoor air” and “recirculate” settings need to be set on “recirculate” during fire/smoke events. In addition, central air conditioners (and some room air conditioners) contain filters that can remove some airborne particles with different degrees of efficiency. If possible, replace the air-conditioner filter with a pleated medium- or high-efficiency particle filter. Schools, childcare centres,

retirement homes, nursing homes, hospitals and hospices should provide air-conditioned rooms for susceptible individuals. Air-conditioned emergency shelters with adequate particle filtration should be located inside large commercial buildings, educational facilities or shopping centres. It is beneficial to stay in less polluted buildings and in cooler environments. For newer air conditioners with a “fresh air ventilation system” that brings in outdoor air continuously or semi-continuously, the “fresh air” component of the system should be turned off during smoke events. Mechanical ventilation systems used in public and commercial buildings differ, and require special attention

- Reduce other sources of indoor air pollution, such as smoking cigarettes, using propane gas or wood-burning stoves, spraying aerosol products, and frying or grilling food. Reducing indoor pollutant emissions during smoke events can decrease indoor particle levels, which may partly compensate for increased particle loading from the outdoor air.
- Avoid increased physical activities and strenuous exercise.
- Particulate respirators³ (9) are indicated for particularly susceptible populations (such as those with pre-existing respiratory and cardiovascular problems). Some individuals may wish to wear masks when they move outside, particularly if they are exposed to higher concentrations of particulate matter. If you or your relatives use a mask, check if the mask is able to filter very small particles (PM_{2.5}) and if it fits well, providing a tight seal around the wearer’s mouth and nose (15).
- Keep the body cool and hydrated. Take cool showers or baths. Alternatives include cold packs and wraps, towels, sponging and foot baths. Wear light, loose-fitting clothes of natural materials. If you go outside, wear a wide-brimmed hat or cap and sunglasses.
- Drink regularly and avoid drinks with sugar or alcohol.
- Help others. If anyone you know is at risk, help them to get advice and support. Elderly or sick people living alone should be visited at least daily. If the person is taking medication, check with the treating doctor how they can influence their thermoregulation and fluid balance and if they present any cardiorespiratory symptoms.
- If you have a health condition, keep medicines below 25 °C or in the fridge (read the storage instructions on the packaging). Seek medical advice if your conditions aggravate, and request special attention if you are suffering from a chronic medical condition or taking multiple medications.
- If a family member or someone you are assisting presents with hot dry skin and delirium, convulsions and/or unconsciousness and/or shows a serious aggravation of cardiorespiratory symptoms, call the doctor/ambulance immediately. If you or a family member present respiratory problems, consult your doctor as soon as possible.

³ In the European Union, a CE-certified filtering face-piece class 2 (FFP2) (95%).

- Motor vehicle drivers should use the headlights during day time to improve conspicuousness and visibility. Reduce unnecessary travel.

For further heat protection measures, see Annex 1 and the WHO information sheets on the public health response to heat-waves (16).

For first aid measures for burns, see Annex 2.

Local health information

Throughout the heat-wave and the period of fires, the public should monitor and follow the recommendations of the local health authorities.

Public health services should provide:

- early information on fire hazards;
- information for the public about their health impacts and indications on how to protect themselves;
- information on help lines, social services, ambulances, clean-air and cooling-down spaces, transport and emergency medical services;
- local hospital services for treatment of medical emergencies and acute illness;
- primary care services and outpatient services for management of cases in the community;
- facilities for oxygenation and respirators for particularly vulnerable populations;
- local medical assistance and attention, including doctors;
- preparation and implementation of outpatient assistance; and
- public spaces to serve as clean-air and cooling-down shelters.

Medical evacuation of whole populations to other geographical locations is not recommended.

Long-term advice

Preventing the health effects of heat-waves requires a portfolio of actions at different levels: from health system preparedness coordinated with meteorological early warning systems to timely public and medical advice and improvements to housing and urban planning. These actions can be integrated in a heat–health action plan.

To avoid fires during heat-waves it is essential that forests are maintained over time, fire hazard measures systematically implemented and people informed about the hazards.

For targeted public health advice, effective and accurate air quality monitoring should be available, particularly to measure those pollutants that are most dangerous to health such as fine particulate matter (PM₁₀ and PM_{2.5}).

In areas where fires are likely to occur, state and local public health agencies should consider making preparations to inform the population and to take action. Information should be simple (for example, “The season for wildfires is approaching; there are things you can do now to help protect your health and prepare your home in the event of a wildfire”) and should list a contact phone number or web site for further information. Information should further provide advice for the general public and for people with chronic diseases.

Sources of further information

- Wildfire smoke. A guide for public health officials. Revised July 2008 (http://www.californiabreathing.org/images/stories/publications/wildfire_smoke_guide_july08.pdf).
- Vegetation fires. Technical hazard sheet (http://www.who.int/hac/techguidance/ems/vegetation_fires/en/)
- How to deal with burn injuries (http://www.who.int/violence_injury_prevention/other_injury/burns/en/index.html)
- Health guidelines for vegetation fire events. Background papers (http://www.who.int/docstore/peh/Vegetation_fires/vegetationfirbackgrtoc.htm)
- Air quality and health (<http://www.who.int/mediacentre/factsheets/fs313/en/index.html>)
- Health relevance of particulate matter from various sources (http://www.euro.who.int/_data/assets/pdf_file/0007/78658/E90672.pdf)
- Outdoor air pollution: assessing the environmental burden of disease at national and local levels (http://www.who.int/quantifying_ehimpacts/publications/ebd5/en/index.html)
- Heat–health action plans (<http://www.euro.who.int/en/what-we-do/health-topics/environmental-health/Climate-change/activities/prevention,-preparedness-and-response/public-health-responses-to-weather-extremes,-particularly-heat-waves/heathealth-action-plans>)
- Ten information sheets on heat-waves (<http://www.euro.who.int/en/what-we-do/health-topics/environmental-health/Climate-change/activities/prevention,-preparedness-and-response/public-health-responses-to-weather-extremes,-particularly-heat-waves/heathealth-action-plans/ten-information-sheets-on-heat-waves>)
- Respiratory tract diseases (http://www.who.int/topics/respiratory_tract_diseases/en/)

- Effective media communication during public health emergencies. WHO handbook and field guide (http://www.who.int/csr/resources/publications/WHO_CDS_2005_31/en/)
- Safe hospitals in emergencies and disasters (<http://www.wpro.who.int/NR/rdonlyres/390133EC-089F-4C77-902DDFEE8532F558/0/SafeHospitalsinEmergenciesandDisasters160709.pdf>)
- Rospotrebnadzor, the Russian Agency for Consumer Rights and Human Well-being (<http://www.rospotrebnadzor.ru/>)
- Roshydromet, the Russian federal service for hydrometeorology and environmental monitoring (<http://www.meteorf.ru/default.aspx>)

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4. *Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide.* Copenhagen, WHO Regional Office for Europe, 2006 (http://www.euro.who.int/_data/assets/pdf_file/0005/78638/E90038.pdf, accessed 23 August 2010).
5. *Air quality and health.* Geneva, World Health Organization, 2008 (<http://www.who.int/mediacentre/factsheets/fs313/en/index.html>, accessed 23 August 2010; Fact sheet No. 313).
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12. *Health risks of ozone from long-range transboundary air pollution*. Copenhagen, WHO Regional Office for Europe, 2008 (http://www.euro.who.int/_data/assets/pdf_file/0005/78647/E91843.pdf, accessed 23 August 2010).
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Annex 1. Heat protection

The WHO programme on climate change and green health services and sustainable development monitors the forecasting of heat-waves in Europe with a heat-wave probability forecasting tool developed and operated by the German Weather Service (<http://www.euroheat-project.org/dwd/>). This system is not yet activated for the Russian-speaking countries. Heat-wave information needs to be gathered from Roshydromet, the Russian federal service for hydrometeorology and environmental monitoring (<http://www.meteorf.ru/default.aspx>).

The WHO Regional Office for Europe sends alert messages to focal points at the national level, together with links to information and support material for preparedness and response to heat. This information may then be adapted, used and disseminated as appropriate in the respective national context.

The Regional Office recommends that each country – or region – develop heat–health action plans¹ which can be updated with specific fire and drought protection advice, as well as air pollution information.

These heat–health action plans contain a list of core elements:

1. agreement on a lead body (to coordinate a multipurpose collaborative mechanism between bodies and institutions and to direct the response if an emergency occurs);
2. accurate and timely alert systems (heat–health warning systems that trigger warnings, determine the threshold for action and communicate the risks);
3. a heat-related health information plan (about what is communicated, to whom and when);
4. a reduction in indoor heat exposure (medium- and short-term strategies and advice on how to keep indoor temperatures low during heat episodes);
5. particular care for vulnerable population groups;
6. preparedness of the health and social care system (staff training and planning, appropriate health care and the physical environment);
7. long-term urban planning (to address building design, and energy and transport policies that will ultimately reduce heat exposure); and
8. real-time surveillance and evaluation.

¹ Heat–health action plans [web site]. Copenhagen, WHO Regional Office for Europe, 2010 (<http://www.euro.who.int/en/what-we-do/health-topics/environmental-health/Climate-change/activities/prevention,-preparedness-and-response/public-health-responses-to-weather-extremes,-particularly-heat-waves/heathealth-action-plans>, accessed 23 August 2010).

Information targeted at specific audiences is available in the form of information sheets² including:

- recommendations for the public during heat-waves;
- vulnerable population groups;
- recommendations for general practitioners;
- recommendations for retirement and care home managers;
- adverse effects of drugs during hot weather;
- considerations for medical professionals about drinking recommendations during hot weather and heat-waves;
- key principles of heat risk communication;
- mild and moderate heat illnesses and their management,
- management of life-threatening heatstroke; and
- reducing indoor temperatures during hot weather.

² Climate change. Ten information sheets on heat-waves [web site]. Copenhagen, WHO Regional Office for Europe, 2010 (<http://www.euro.who.int/en/what-we-do/health-topics/environmental-health/Climate-change/activities/prevention,-preparedness-and-response/public-health-responses-to-weather-extremes,-particularly-heat-waves/heathealth-action-plans/ten-information-sheets-on-heat-waves>, accessed 23 August 2010).

Annex 2. First aid advice for burns¹

- Stop the burning process by removing clothing.
- Apply cold water and keep the burnt area in contact with cold water for some time.
- Extinguish flames by allowing person to roll on the ground or apply a blanket, or by using water or other flame-extinguishing liquids.
- Obtain medical care.
- Do not commence first aid before ensuring own safety.
- Do not apply ice, pastes or oils to the burnt area.

¹ *Facts about injuries. Burns.* Geneva, World Health Organization, 2008 (http://www.who.int/violence_injury_prevention/publications/other_injury/en/burns_factsheet.pdf, accessed 23 August 2010).

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