Air Quality, Energy and Health
Science and Policy Summaries

Understanding the health impacts of sand and dust storms

Technical brief

Key messages

Sand and dust storms (SDS) result from turbulent winds that raise large quantities of particles from the ground into the air in emission areas. Emission areas are typically semi-arid and arid with limited vegetation cover, as bare ground is most susceptible to sediment entrainment by the wind. During SDS, large amounts of particles of a broad range of sizes and chemical composition are uplifted from the soil. SDS have significant impacts on the environment, climate, weather, ecosystems and human health. They are a significant concern that warrants multisectoral action with public health authorities. SDS are recognized as a climatic impact-driver, meaning that they can be considered as a climate hazard in risk assessments.

SDS activity varies widely depending on geographical location, climate conditions and local environmental factors. Major sources include large deserts in North Africa, the Middle East and Asia. Local sources are disturbed landscapes caused by climate factors (such as drought or ice cover reduction), agricultural practices, overgrazing and deforestation.

Larger sand particles remain relatively close to the ground in the emission area, while finer dust particles can be lifted kilometres high into the atmosphere and potentially travel thousands of kilometres to receptor areas. Receptor areas can be located close to or far away from SDS emission areas. The air in receptor areas contains a mix of dust particles and non-dust particles, which are emitted from both natural and anthropogenic sources, from both receptor and emission areas and during transport of dust air mases. SDS can last over various time periods with particulate matter (PM) concentrations exceeding 10 000 μg/m^3 during SDS events close to the sources and exceeding 1000 μg/m^3 in receptor areas.

Studies on the health effects of SDS have associated short-term exposure with increased mortality, as well as a higher incidence of respiratory and cardiovascular diseases, among other health conditions.

World Health Organization

However, there is a significant gap in understanding the long-term effects, as no studies have focused on chronic exposure. Detailed measurements on the PM concentrations, chemical composition and size distribution are needed for advancing on the assessment of the health impacts of SDS. Standardized research protocols are needed to enhance the consistency and robustness of future studies, particularly in the source regions of the Saharan belt and the Middle East.

Overview

What are sand and dust storms?

In this document, SDS refer to weather and environment related phenomena associated with strong winds that lift large amounts of sand and dust particles from bare, dry soils into the atmosphere. SDS vary in duration and extent based on meteorological and environmental factors. They can last from a few hours to several days, with localized storms covering small areas (*haboobs*) and large-scale events spanning thousands of kilometres (e.g. the Harmattan in the Sahel).

Dust sources are primarily located in arid and semi-arid regions where loose, fine sediments are exposed to strong winds. Major sources include the Sahara Desert (largest global dust contributor), the Middle East, Central Asia (e.g. the Aral Sea basin) and the Gobi Desert in East Asia *(1)*. These regions often feature dry lake beds, alluvial plains and deserts with minimal vegetation. Overall, global dust emissions from major sources (i.e. deserts) are approximately 22–29 billion kg per year, with North African source regions contributing roughly 50% *(2)*. Human activities such as overgrazing, deforestation and unsustainable land use practices exacerbate dust emissions by disturbing the soil surface and increasing the susceptibility of these areas to wind erosion *(3)*. Agricultural areas in Eastern Europe and drying landscapes within the southern United States are also sources of SDS *(4)*.

See SPS[1]: ***Agriculture – sectoral solutions for air pollution and health***

During SDS, large amounts of particles of a broad range of sizes and chemical composition are uplifted from the soil. Sand and dust are categorized by the size of the particles involved in SDS:

- Sand refers to coarse particles (with diameters of ≥ 60 µm).
- Dust refers to finer particles (with diameters of < 60 µm), including silt and clay.

Sand and dust particles are a conglomerate of different components, including large proportions of minerals such as quartz, clay, carbonate, feldspar and iron oxide, and variable proportions of salts such as gypsum. The proportion of different minerals depends on the origin of the dust (i.e. soil source).

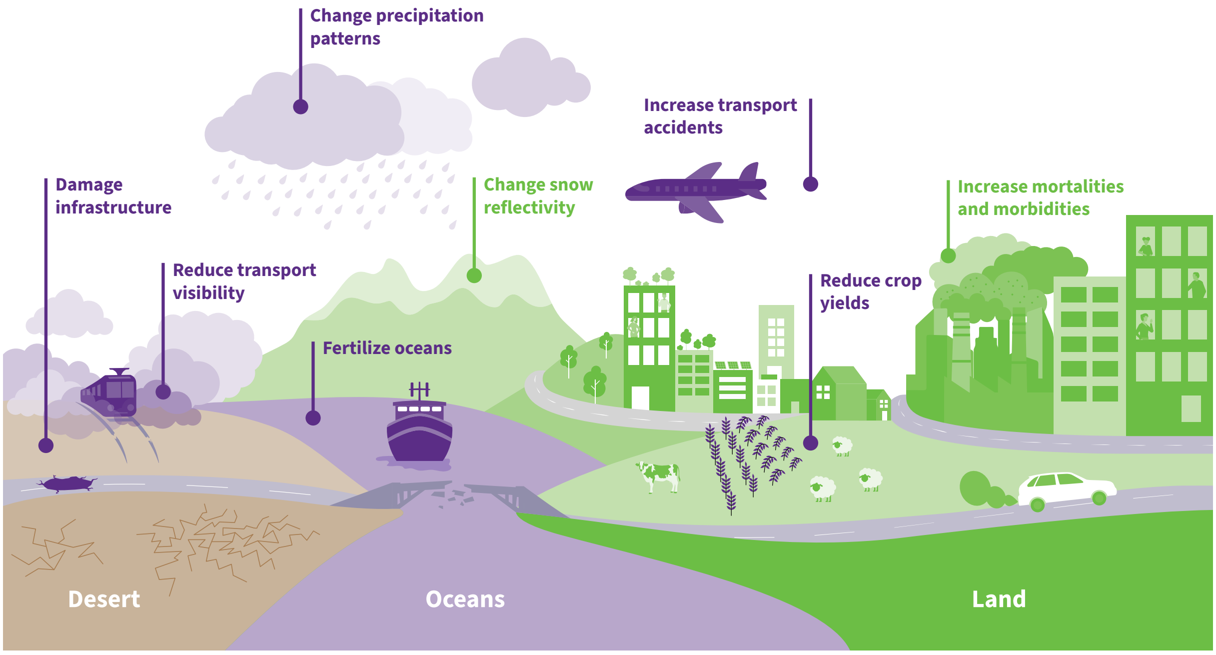
[1] Science and Policy Summary

SDS can be considered a type of dust event. This is because sand, the larger coarse particle, is mainly found near sources in the emission areas and has a very limited lifetime in the atmosphere. On the other hand, dust, the smaller particle, can remain suspended in the air for extended periods in the emission area and travel long distances to receptor areas. Therefore, SDS contribute to the presence of aerosols (or PM) of different sizes in the air (particularly for particles between 2.5 µm and 10 µm).
Dust transport occurs when strong winds lift fine particles into the atmosphere, allowing them to travel thousands of kilometres across continents and oceans. Once airborne, dust interacts with atmospheric processes (see Fig. 1), influencing weather and climate.

Dust particles in the atmosphere interact with sunlight by scattering and absorbing radiation, influencing the Earth's energy balance. Scattering occurs when dust reflects sunlight back into space, which can cool the Earth's surface and reduce temperatures locally. Conversely, dust absorption traps heat in the atmosphere, contributing to warming at higher altitudes *(5)*. The extent of scattering or absorption depends on the size and composition of the dust particles. For example, lighter coloured particles, mainly due to their composition, scatter more light; while darker particles, rich in iron or carbon, absorb more radiation. Moreover, dust affects cloud formation by serving as cloud condensation nuclei or ice nuclei, thereby influencing precipitation patterns and atmospheric dynamics *(6)*. In atmospheric chemistry, dust particles act as surfaces for chemical reactions, altering the composition of trace gases and aerosols in the atmosphere.

Dust from deserts, such as the Sahara, also travels across oceans *(7)*. Deposited dust fertilizes nutrient-poor regions like the Amazon rainforest and marine ecosystems. However, excessive dust deposition can disrupt local nutrient balances, harming sensitive environments. Dust can also damage vegetation by sandblasting leaves and altering soil chemistry *(8)*.

Fig. 1. The impacts of sand and dust storms



Source: inDust website (https://cost-indust.eu/index.php/media-room/resources).

Changes in climatic variables have resulted in more extreme temperatures, prolonged droughts, increased heat waves and evaporation, and intensified aridity in semi-dry and dry regions (i.e. increased desertification). Additionally, anthropogenic changes such as agricultural and forestry practices, desiccation of lakes, land use and water management systems can influence wind erosion, all of which create favourable conditions for dust emissions and increase the likelihood and severity of SDS *(9)*. Moreover, climate change is intensifying high-latitude dust activity as warming temperatures accelerate glacial retreat, exposing fine sediments to wind erosion. These newly uncovered dust sources, such as those in Iceland, Greenland, Alaska or Antarctica, contribute to global dust emissions. Climate change is projected to increase desertification, and the synergistic effect of both will reduce the productivity of dryland services (e.g. crops and livestock) and lower ecosystem health, including losses in biodiversity *(10)*.

The most recent Intergovernmental Panel on Climate Change reports conclude that SDS are still ranked as a climate factor with low confidence, and there is no agreement about the direction of future changes in dust emissions *(11)*. However, changes in land surface properties, like land cover, soil texture and composition, can be influenced by either humans (i.e. land and water management policies) or by climate change. The last few years have recorded exceptional SDS in terms of intensity and extent *(12)*. In the Middle East, in the past two decades, the drying up of lakes within the Sistan Plain have increased the frequency of SDS by roughly 40% in the Islamic Republic of Iran *(13)*. Overall, dust poses multiple challenges for environmental management, public health and climate adaptation efforts.

What role do SDS play in polluting the air?

One of the most significant environmental effects of SDS is the deterioration of air quality and the associated impacts on human health *(14)*. During SDS, levels of PM with aerodynamic diameters of < 2.5 µm ($PM_{2.5}$) and 10 µm (PM_{10}) can rise significantly, although PM_{10} concentrations are particularly increased due to the suspension of larger particles. These concentrations can be orders of magnitude higher than the World Health Organization (WHO) air quality guidelines for PM_{10} (an average of 45 µg/m^3 over a 24-hour period). Close to the emission sources, PM_{10} peaks usually exceed 1000 µg/m^3 *(14–17)* but also, receptor areas can register high PM_{10} concentrations as a consequence of an SDS. An intense dust event in 2023 affected more than 4 million km^2 across Mongolia and China, and even reached the Republic of Korea and Japan with PM_{10} concentrations exceeding 9000 µg/m^3 in China *(12)*. High PM_{10} peaks have also been observed in Europe and the Caribbean during African dust intrusions *(18, 19)*.

PM composition associated with an SDS varies by source and region, influenced by the type of soil (as mentioned above) and the transport of the air mass. SDS not only directly emit particles into the atmosphere but can carry biological (e.g. microorganisms, pollen spores) and chemical (e.g. polycyclic aromatic hydrocarbons, metals) pollutants *(20–23)*.

See SPS: ***Health effects of air pollution – evidence and implications***

Dust particles also provide surfaces for chemical reactions in the atmosphere, altering the composition of trace gases and aerosols. For instance, they can absorb pollutants like sulfur dioxide and nitrogen oxides, which increases the reactivity/toxicity of PM *(24)*. Additionally, particularly close to the emission area, for example in the Middle East and North Africa, deposited dust on the ground may be resuspended by strong winds or road traffic, leading to SDS that also effect air quality levels *(25)*.

Overall, the SDS contribution to total PM differs depending on the emission (i.e. soil components) and receptor areas (i.e. mixture with other aerosols and atmospheric chemistry processes during dust transport). These factors are directly connected with the physical-chemical characteristics of the PM (i.e. size and chemical composition) and consequently affect the potential PM toxicity. Detailed measurements of the PM concentrations, chemical composition and size distribution are needed to advance the assessment of SDS health effects.

The different combinations of dust and non-dust PM mixtures within emission versus receptor areas calls for the separate evaluation of the health effects of dust storms in emission and receptor areas, with the effects of dust PM and non-dust PM being assessed independently during dust episodes in receptor sites *(26–28)*.

What are the health effects of SDS?

Over the past two decades, research on the health effects of SDS has grown considerably. A scoping review of 204 epidemiological studies summarized the evidence, identified research gaps, and classified exposure assessment methods and associated health effects *(14)*. Most studies focused on Asian dust, followed by Saharan and Middle Eastern dust, with only a few studies on American and Australian deserts. These studies have linked SDS to a range of health effects, including both mortality and morbidity outcomes. Respiratory and cardiovascular diseases are most associated with SDS exposure, along with other health conditions such as allergic, eye and infectious diseases. The review also identified significant variability in SDS exposure measurement methods and methodological differences in study designs. The existing body of evidence primarily focuses on short-term health effects, with most studies using time-series and case-crossover designs to assess outcomes during or immediately after a dust storm. No studies are currently available on the long-term health effects of desert dust, such as those occurring months or years after exposure *(14)*.

A comprehensive systematic review with meta-analysis of 71 time-series studies found a significant 1.21% increase in the risk of all-cause mortality on dust days compared with non-dust days *(29)*. The risk associated with PM_{10} was slightly higher on dust days, while for $PM_{2.5}$ the risk was higher during non-dust days. The review also reported a 2.52% increase in the risk of cardiovascular mortality, with no significant change in respiratory mortality. Additionally, cardiovascular hospital admissions increased by 0.94%, while respiratory admissions exhibited a more pronounced rise of 6.93% during dust days *(29)*. Other literature reviews have also reported associations between short-term exposure to SDS and a variety of cardiovascular and respiratory outcomes, also lacking evidence of chronic exposure to SDS *(30–32)*.

Moreover, toxicological research provides support for biological plausibility of epidemiological associations between this particulate air pollutant and SDS events including exacerbation of asthma, hospitalization for respiratory infections and seasonal allergic rhinitis *(33)*. Other impacts of dust storms are an increase in road accidents, lack of access to health centres as well as the closure of communication routes.

While there is strong evidence of exposure to SDS and a variety of morbidity and mortality outcomes, the variability in the epidemiological approaches makes it difficult to fully assess the level of potential harm. However, developing a standardized research protocol is necessary to harmonize study designs, SDS exposure assessments and health outcome measurements, to ensure more robust and comparable findings *(28)*. In addition, the vast majority of the epidemiological studies focused on acute effects by evaluating whether daily peaks in desert dust were associated with concurrent peaks in mortality and morbidity. The current research underscores a significant gap in understanding the long-term health effects of SDS *(34)*. Finally, there is a specific need for more research on the effects of SDS in the source regions of the Saharan belt and the Middle East. Improved SDS exposure measurement technologies and increased public awareness efforts could help mitigate the adverse health effects.

From an economic standpoint, the World Bank estimated global welfare losses from dust-related $PM_{2.5}$ at approximately US$ 3.6 trillion in 2013. At the regional level, East Asia and the Pacific suffered the greatest welfare losses of US$ 1380 billion, with Europe and Central Asia having the second highest estimated losses of US$ 1170 billion *(35, 36)*. In the Middle East and North Africa, SDS cost about US$ 140 billion annually which represents over 2.5% of gross domestic product *(35, 36)*.

See SPS: *The economic costs of the health effects of air pollution*

Box 1. United Nations Coalition to Combat Sand and Dust Storms

The Coalition consists of 19 Members both United Nations (UN) and non-UN agencies, with the Food and Agriculture Organization, UN Convention to Combat Desertification, UN Economic and Social Commission for Asia and the Pacific, UN Economic and Social Commission for Western Asia, UN Development Programme, UN Environment Programme, WHO and the World Meteorological Organization leading specific working groups related to adaptation and mitigation, forecasting and early warning, health and safety, policy and governance as well as mediation and regional collaboration.

The mandate of the Coalition is to ensure coordination and collaboration of the UN-system response to SDS on activities, knowledge exchange, advocacy and funding initiatives as well as capacity-building and preparedness enhancement.

Way forward

Urgent, coordinated actions based on three main pillars are needed at multiple levels to reduce SDS impacts on health, the environment and the economy.

Collect, share and analyse exposure and health data

- Invest in and maintain reliable ground-level monitoring networks (with local and regional representation) for ambient PM (including chemical composition and size distribution, i.e. PM_1, $PM_{2.5}$, PM_{10}) to ensure accurate data collection and assessment.
- Invest in measurement and models for source apportionment to identify dust and non-dust components.
- Enhance health data collection, data sharing and analysis to identify and close existing knowledge gaps and evaluate the effectiveness of control measures to identify those that are most cost effective.
- Conduct further toxicological studies to further our understanding of the effects of SDS on health.
- Ensure standardization of protocols of SDS-related epidemiological studies.
- Design new epidemiological studies on the long-term health effects of SDS.
- Advance the development of impact-based assessment (i.e. long-term effects) and forecasting (i.e. short-term effects) products to feed into early warning systems.

Institutional strengthening

- Ensure multisectoral coordination with ministries of health, meteorology, environment and other sectors that will leverage early warning systems for a timely public health response, facilitate adaptive action within communities and reduce anthropogenic sources of air pollution during SDS events.
- Develop regional policies to support actions to reduce harm to public health when air pollution alerts are issued at a national level.
- Enhance the skills and knowledge of government agencies to design and implement programmes that reduce or retard desertification and strengthen resilience and response capabilities.
- Ensure a robust civil registration and vital statistics system as well as health surveillance linked with environmental health risks including air pollution and climate change.

- Launch awareness campaigns tailored to specific sectors to educate officials and the public on the risks of SDS and effective strategies to reduce exposure and mitigate SDS occurrences.
- Develop and/or strengthen training programmes for health care workers to respond to SDS events, air pollution episodes and climate change impacts.

Implement science-based interventions

- Promote sustainable agricultural, water and landscape management practices.
- Reduce local anthropogenic emissions of pollutants during SDS episodes.
- Develop and enforce building codes and urban planning guidelines that consider the impacts of SDS, ensuring that infrastructure can withstand dust storms without significant damage.
- Integrate SDS mitigation strategies with broader climate change adaptation plans, recognizing the interconnectedness of these environmental challenges.
- Develop regional cooperations for long-term SDS mitigation, recognizing their transboundary nature.

Dust storm over Brisbane, Australia in September 2019.

Methodology

WHO defined the scope of the document and collaborated with its Advisory Groups (Scientific Advisory Group on Air Pollution and Health, SAG; and the Global Air Pollution and Health – Technical Advisory Group, GAPH-TAG) members, which cover a wide range of expertise, to prepare the initial draft based on an overview of the health impacts of SDS, supplemented by expert advice. Evidence for this rapid review was gathered and presented at monthly discussions with global experts and colleagues from WHO Collaborating Centers and the World Meteorological Organization (WMO). The sections were selected through group consensus and the content written was developed though collective wisdom of the group. The WHO Air Quality Guidelines, published in 2021, provided good practice statements for sand and dust storms, which highlighted research needs that have developed in this document. A lot of the experts involved in the WHO Air Quality Guidelines development are part of the group, and represent all regions. The draft underwent peer review by specialists from various research institutes and universities. Additionally, an early version of the document was presented for peer-review at the Technical Advisory Group and Scientific Advisory Group on Air Pollution and Health meeting. And feedback was addressed by the main contributors. Finally, WHO staff and consultants from the WHO Air Quality, Energy and Health Unit reviewed the report to ensure alignment with the WHO requirements for the collections of Air Quality, Energy and Health Science and Policy Summaries. This series synthesizes current knowledge and evidence on air quality, energy access, climate change links and health, primarily to inform intergovernmental discussions.

Acknowledgements

The WHO gratefully acknowledges the many individuals and organizations, including those from its Advisory Groups (SAG and GAPH-TAG), who contributed to the development of this document.

This document was written by Ali Al-Hemoud (Kuwait Institute for Scientific Research, Kuwait); Sara Basart (World Meteorological Organization); Betrand Bessagnet (ICIMOD, Lalitpur, Nepal); Julia C Fussell (Imperial College London, United Kingdom of Great Britain and Northern Ireland); Masahiro Hashizume (University of Tokyo, Japan); Philip K Hopke (University of Rochester, United States); Kenza Khomsi (General Directorate of Meteorology, Morocco, until 2024); Xavier Querol (Spanish Research Council, IDAEA-CSIC, Spain); Najat A Saliba (American University of Beirut, Lebanon); Massimo Stafoggia (Lazio Region Health Service, Italy); Oriol Teixidó (Ricardo PLC, Abu Dhabi, United Arab Emirates); Aurelio Tobias (Spanish Council for Scientific Research, Spain); and Kerolyn Shairsingh (WHO Department of Environment, Climate Change and Health).

Peer-reviewers included Rami Alfarra (Qatar Environment and Energy Research Institute, Qatar); Mostafa Hadei (Kermanshah University of Medical Sciences, Islamic Republic of Iran); and Abbas Shahsavani (Shahid Beheshti University of Medical Sciences, Islamic Republic of Iran).

Additionally, an early version of this SPS was presented for peer-review at the Technical Advisory Group and Scientific Advisory Group on Air Pollution and Health meeting in Beijing, China, in October 2024.

The development of this document was led by Sophie Gumy and Kerolyn Shairsingh (WHO Department of Environment, Climate Change and Health) with inputs and review from Karla Cervantes, Pierpaolo Mudu, and Cristina Vert (WHO Department of Environment, Climate Change and Health).

The production of this report was supported by funds generously provided by the Clean Air Fund; Foreign, Commonwealth and Development Office of the Government of the United Kingdom; the Government of the Netherlands; the Ministry of Foreign Affairs, European Union and Cooperation of the Government of Spain; the Norwegian Agency for Development Cooperation; and the Spanish Agency for International Development Cooperation.

Declarations of interest

All external experts submitted a declaration of interest to WHO disclosing potential conflicts of interest that might affect, or might reasonably be perceived to affect, their objectivity and independence in relation to the subject matter of the report. WHO reviewed each of the declarations and concluded that none could give rise to a potential or reasonably perceived conflict of interest related to the subjects covered by the report.

References

1. Ginoux P, Prospero JM, Gill TE, Hsu NC, Zhao M. Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products. Rev Geophys. 2012;50:3 (https://doi.org/10.1029/2012RG000388).

2. Kok JF, Adebiyi AA, Albani S, Balkanski Y, Checa-Garcia R, Chin M et al. Contribution of the world's main dust source regions to the global cycle of desert dust. Atmos Chem Phys. 2021;21(10):8169-8193 (https://doi.org/10.5194/acp-21-8169-2021).

3. Global sand and dust storm source base map. Bonn: United Nations Convention to Combat Desertification; 2024 (https://www.unccd.int/resources/brief/global-sand-and-dust-storm-source-base-map).

4. Bessagnet B, Menut L, Colette A, Couvidat F, Dan M, Mailler S, Létinois L et al. An evaluation of the CHIMERE Chemistry Transport Model to simulate dust outbreaks across the Northern Hemisphere in March 2014. Atmos. 2017;8(12):251 (https://doi.org/10.3390/atmos8120251).

5. Li Y, Kang S, Zhang X, Li C, Chen J, Qin X et al. Dust dominates the summer melting of glacier ablation zones on the northeastern Tibetan Plateau. Sci Total Environ. 2023;856:159214 (https://doi.org/10.1016/j.scitotenv.2022.159214).

6. Shi Y, Liu X. Dust radiative effects on climate by glaciating mixed-phase clouds. Geophys Res Lett. 2019;46:6128-6137 (https://doi.org/10.1029/2019GL082504).

7. Prospero JM, Collard F-X, Molinié J, Jeannot A. Characterizing the annual cycle of African dust transport to the Caribbean Basin and South America and its impact on the environment and air quality. Global Biogeochem Cycles. 2014;29:757-773 (https://doi.org/10.1002/2013GB004802).

8. UNEP-WMO-UNCCD Global assessment of sand and dust storms. Nairobi: United Nations Environment Programme; 2016 (https://www.unccd.int/resources/publications/global-assessment-sand-and-dust-storms).

9. Sand and dust storms compendium: information and guidance on assessing and addressing the risks. Bonn: United Nations Convention to Combat Desertification; 2022 (https://www.unccd.int/resources/publications/sand-and-dust-storms-compendium-information-and-guidance-assessing-and).

10. Mirzabaev A, Wu J. Desertification. In: Shukla PR, Skea J, Calvo Buendia E, Masson-Delmotte V, Pörtner HO, Roberts DC et al., editors. Climate change and land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change; 2019 (https://www.ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf).

11. IPCC Sixth assessment report. Working Group 1: the physical science basis. Intergovernmental Panel on Climate Change; 2021 (https://www.ipcc.ch/report/ar6/wg1/).

12. WMO Airborne Dust Bulletin, 8. Geneva: World Meteorological Organization; 2024 (https://library.wmo.int/idurl/4/68953).

13. Rami A, Hamidi M, Navayi Neya B. Atmospheric analysis of dust storms in Sistan region. J Atmos Sol-Ter Phys. 2022;227:105800 (https://doi.org/10.1016/j.jastp.2021.105800).

14. Lwin KS, Tobias A, Chua PL, Yuan L, Thawonmas R, Ith S et al. Effects of desert dust and sandstorms on human health: a scoping review. Geohealth. 2023;7(3): e2022GH000728 (https://doi.org/10.1029/2022GH000728).

15. Middleton N. Desert dust hazards: a global review. Aeolian Res. 2017;24:53-63 (https://doi.org/10.1016/j.aeolia.2016.12.001).

16. Sarkar S, Chauhan A, Kumar R, Singh RP. Impact of deadly dust storms (May 2018) on air quality, meteorological, and atmospheric parameters over the northern parts of India. Geohealth. 2019;3(3):67-80 (https://doi.org/10.1029/2018GH000170).

17. Shahsavani A, Naddafi K, Jafarzade Haghighifard N, Mesdaghinia A, Yunesian M, Nabizadeh R et al. The evaluation of PM10, PM2.5, and PM1 concentrations during the Middle Eastern Dust (MED) events in Ahvaz, Iran, from April through September 2010. J Arid Environ. 2012;77:72-83 (https://doi.org/10.1016/j.jaridenv.2011.09.007).

18. Cuevas-Agulló E, Barriopedro D, García RD, Alonso-Pérez S, González-Alemán JJ, Werner E et al. Sharp increase in Saharan dust intrusions over the western Euro-Mediterranean in February–March 2020–2022 and associated atmospheric circulation, Atmos Chem Phys. 2024;24(7):4083-4104 (https://doi.org/10.5194/acp-24-4083-2024).

19. Yu H, Tan Q, Zhou L, Zhou Y, Bian H, Chin M et al. Observation and modeling of the historic “Godzilla” African dust intrusion into the Caribbean Basin and the southern US in June 2020. Atmos Chem Phys. 2021;21(16):12359-12383 (https://doi.org/10.5194/acp-21-12359-2021).

20. Griffin DW. Atmospheric movement of microorganisms in clouds of desert dust and implications for human health. Clin Microbiol Rev. 2007;20(3):459-477 (https://doi.org/10.1128/cmr.00039-06).

21. D’Amato G, Holgate ST, Pawanka R, Ledford DK, Cecchi L, Al-Ahmad M et al. Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization. World Allergy Organ J. 2015;8(1):25 (https://doi.org/10.1186/s40413-015-0073-0).

22. Rodríguez S, Alastuey A, Alonso-Pérez S, Querol X, Cuevas E, Abreu-Afonso J et al. Transport of desert dust mixed with North African industrial pollutants in the subtropical Saharan Air Layer. Atmos Chem Phys. 2011;11(13):6663-6685 (https://doi.org/10.5194/acp-11-6663-2011).

23. Tong D, Gill T, Sprigg W, Van Pelt R, Baklanov A, Barker B et al. Health and safety effects of airborne soil dust in the Americas and beyond. Rev Geophys. 2023;61(2): e2021RG000763 (https://doi.org/10.1029/2021RG000763).

24. Ho KF, Wu K-C, Niu X et al. Contributions of local pollution emissions to particle bioreactivity in downwind cities in China during Asian dust periods. Environ Pollut. 2019;245:675-683 (https://doi.org/10.1016/j.envpol.2018.11.035).

25. Querol X, Tobías A, Pérez N, Karanasiou A, Amato F, Stafoggia M et al. Monitoring the impact of desert dust outbreaks for air quality for health studies. Environ Int. 2019;130:104867 (https://doi.org/10.1016/j.envint.2019.05.061).

26. Miri A, Middleton N. Long-term impacts of dust storms on transport systems in south-eastern Iran. Nat Hazards. 2022;114(1):291-312.

27. Shahsavani A, Tobías A, Querol X, Stafoggia M, Abdolshahnejad M, Mayvaneh F et al. Short-term effects of particulate matter during desert and non-desert dust days on mortality in Iran. Environ Int. 2020;134:105299 (https://doi.org/10.1016/j.envint.2019.105299).

28. Tobías A, Stafoggia M. Modeling desert dust exposures in epidemiologic short-term health effects studies. Epidemiol. 2020;31(6):788-795 (https://doi.org/10.1097/EDE.0000000000001255).

29. Tobias A, Querol X, Roqué M, Suu Lwin K, Yuan L, Ith S et al. Short-term exposure to desert dust and sandstorms and all-cause and cause-specific mortality and morbidity: a systematic review and meta-analysis. Environ Int. 2025;196:109277 (https://doi.org/10.1016/j.envint.2025.109277).

30. Domínguez-Rodríguez A, Baez-Ferrer N, Abreu-Gonzalez P, Rodríguez S, Díaz R, Avanzas P et al. Impact of desert dust events on the cardiovascular disease: a systematic review and meta-analysis. J Clin Med. 2021;10(4):727 (https://doi.org/10.3390/jcm10040727).

31. Hashizume M, Kim Y, Ng CFS, Chung Y, Madaniyazi L, Bell ML et al. Health effects of Asian dust: a systematic review and meta-analysis. Environ Health Perspect. 2020;128:PMC7319773 (https://doi.org/10.1289/EHP5312).

32. Pouri N, Karimi B, Kolivand A, Mirhoseini SH. Ambient dust pollution with all-cause, cardiovascular and respiratory mortality: a systematic review and meta-analysis. Sci Total Environ. 2024;912:168945 (https://doi.org/10.1016/j.scitotenv.2023.168945).

33. Fussell JC, Kelly FJ. Mechanisms underlying the health effects of desert sand dust. Environ Int. 2021;157:106790 (https://doi.org/10.1016/j.envint.2021.106790).

34. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization; 2021 (https://iris.who.int/handle/10665/345329). Licence: CC BY-NC-SA 3.0 IGO.

35. World Bank and Institute for Health Metrics and Evaluation. The Cost of Air Pollution Strengthening the Economic Case for Action. Washington, DC: World Bank; 2016. (https://documents1.worldbank.org/curated/en/781521473177013155/pdf/108141-REVISED-Cost-of-PollutionWebCORRECTEDfile.pdf). License: CC BY 3.0 IGO.

36. Sand and dust storms in the Middle East and North Africa (MENA) Region: sources, costs, and solutions. Washington, DC: The World Bank; 2019 (https://documents1.worldbank.org/curated/en/483941576489819272/pdf/SAND-AND-DUST-STORMS-IN-THE-MIDDLE-EAST-AND-NORTH-AFRICA-MENA-REGION-SOURCES-COSTS-AND-SOLUTIONS.pdf).

References were last accessed 15 February 2025.

Suggested citation. Understanding the health impacts of sand and dust storms: technical brief. Geneva: World Health Organization; 2025 (Air Quality, Energy and Health Science and Policy Summaries). https://doi.org/10.2471/B09453

Scan to view more Air Quality, Energy and Health Science and Policy Summaries.