DESERT DUST EXPOSURE AND RESPIRATORY HEALTH IN SOUTHERN UZBEKISTAN: MECHANISMS, VULNERABLE GROUPS AND IMPLICATIONS FOR PRIMARY CARE

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Abstract. Background: Southern Uzbekistan, comprising the Surkhandarya and Kashkadarya regions, is among the hottest and driest parts of Central Asia and is regularly affected by dust events, including the hot, dust-laden south-westerly wind known locally as the “Afghan” wind. Although the health effects of desert dust have been documented in other arid regions, evidence for this part of Uzbekistan remains scarce. **Methods:** A narrative review was conducted of international guidelines, global assessments and peer-reviewed studies on desert dust and respiratory health, and the findings were interpreted in relation to the climatic and social conditions of Southern Uzbekistan. **Results:** Dust events sharply increase concentrations of coarse (PM10) and fine (PM2.5) particulate matter, which may exceed World Health Organization guideline levels many times over. The main respiratory effects reported in the literature are exacerbations of asthma and chronic obstructive pulmonary disease, increased respiratory infections and upper airway irritation, driven by oxidative stress, airway inflammation and the biological and chemical components carried on dust particles. Children, older adults, people with chronic respiratory or cardiovascular disease and outdoor workers are the most vulnerable groups, and the coincidence of dust events with extreme heat in the region is likely to amplify risk. **Conclusion:** Primary care is well placed to reduce the respiratory burden of dust events. A three-phase framework – preparation before the dust season, protection during dust events and follow-up afterwards – is proposed, together with priorities for local monitoring and research.

Keywords: desert dust; dust storms; particulate matter; PM2.5; PM10; asthma; COPD; respiratory health; primary care; Central Asia; Uzbekistan.

INTRODUCTION

Air quality is one of the most important environmental determinants of health. The World Health Organization (WHO) revised its global air quality guidelines in 2021, substantially lowering the recommended limits for particulate matter in response to growing evidence that health effects occur even at low concentrations [1]. While much attention has been paid to particulate pollution from traffic and industry, natural sources, and desert dust in particular, contribute a large share of airborne particles in arid regions of the world.

Sand and dust storms are a recurring hazard across the global dust belt, which stretches from North Africa through the Middle East to Central and East Asia. A joint global assessment by the United Nations Environment Programme, the World Meteorological Organization and the United Nations Convention to Combat Desertification concluded that these events affect health, agriculture, transport and livelihoods across large areas, and that their health impact is still insufficiently quantified [2]. Central Asia is one of the most active dust-source regions within this belt; the Karakum and Kyzylkum deserts and the exposed bed of the former Aral Sea are recognised as major source areas [3].

Southern Uzbekistan – the Surkhandarya and Kashkadarya regions – lies at the southern edge of this system. The area has a sharply continental arid climate, with long, hot summers in which air temperatures frequently exceed 40 °C and with low annual precipitation that falls mainly in winter and spring. In Surkhandarya, the hot, dry and dust-laden south-westerly wind known locally as the “Afghan” wind can blow for several days and markedly reduces air quality and visibility. A large proportion of the population lives in rural areas and works outdoors in agriculture and livestock farming, which increases the likelihood of direct exposure.

Despite these conditions, most published research on dust and health in Uzbekistan has focused on the Aral Sea region in the north-west, and the respiratory effects of dust exposure in the southern regions have received little attention. The aim of this article is to summarise current evidence on the mechanisms through which desert dust affects the respiratory system, to identify the population groups at greatest risk in Southern Uzbekistan and to propose practical measures that can be implemented at the level of primary care.

MATERIALS AND METHODS

This study was designed as a narrative review, an approach chosen because the topic spans atmospheric science, environmental epidemiology and clinical medicine. Sources were identified through searches of PubMed, Scopus and Google Scholar and through the websites of WHO and United Nations agencies. The search terms included “desert dust”, “dust storm”, “sand and dust storms”, “particulate matter”, “PM10”, “PM2.5”, “respiratory health”, “asthma”, “COPD” and “Central Asia”, used individually and in combination.

Priority was given to international guidelines, global assessments, systematic reviews and mechanistic reviews published in peer-reviewed journals. Studies were included if they addressed the sources and characteristics of desert dust, its effects on the respiratory system or the management of respiratory disease in relation to environmental exposure. Opinion pieces without supporting evidence, commercial material and non-scientific web pages were excluded. The selected sources were analysed qualitatively and the findings were grouped into four themes: dust sources and exposure, mechanisms of respiratory injury, clinical outcomes and vulnerable groups. These findings were then interpreted in relation to the climatic and social conditions of Southern Uzbekistan in order to develop recommendations for primary care.

RESULTS

Dust sources and exposure in Southern Uzbekistan. Dust events in Central Asia occur most frequently in spring and summer, when soil moisture is low and wind activity is high [3]. In Southern Uzbekistan, natural drivers – an arid climate, sparse vegetation and strong seasonal winds – act together with human factors such as overgrazing, the removal of desert shrubs, the salinisation and abandonment of irrigated land, and soil disturbance from construction. The global assessment identifies land degradation and drought as the principal factors that increase dust emissions over time and warns that climate change may intensify these processes in dryland regions [2].

Particle size and guideline values. The respiratory effects of dust depend first of all on particle size. Coarse particles with an aerodynamic diameter below 10 μm (PM10) are deposited mainly in the nose, pharynx and large airways, whereas fine particles below 2.5 μm (PM2.5) reach the small airways and alveoli. Table 1 presents the current WHO guideline values for both fractions.

Table 1. WHO 2021 air quality guideline levels for particulate matter [1]

Fraction	Main site of deposition in the respiratory tract	Annual mean	24-hour mean
PM10	Nasal cavity, pharynx, trachea and large bronchi	15 μg/m³	45 μg/m³
PM2.5	Small airways and alveoli; the finest fraction may enter the circulation	5 μg/m³	15 μg/m³

During dust events, PM10 concentrations can exceed these values many times over [4]. The hazard is not determined by particle size alone: desert dust carries minerals such as quartz, soluble salts, metals and, in agricultural areas, residues of agrochemicals, as well as bacteria, fungal spores, endotoxin and pollen [4, 5]. The composition of dust therefore varies with its source, and this variation helps to explain why similar particle concentrations can produce different health effects in different regions.

Mechanisms of respiratory injury. Experimental and mechanistic studies show that inhaled dust particles trigger oxidative stress in the airway epithelium, which leads to the release of pro-inflammatory cytokines, recruitment of inflammatory cells and impairment of the epithelial barrier [5]. Microbial components such as endotoxin amplify this inflammatory response, while allergens carried on particle surfaces can sensitise the airways and provoke allergic reactions. In people with pre-existing airway disease, these processes lower the threshold for bronchospasm and mucus hypersecretion, which explains why exacerbations of chronic disease are among the most consistent findings in epidemiological studies.

Clinical respiratory outcomes. A systematic review of studies from different dust-affected regions found that dust events are associated with increased hospital admissions and emergency visits for respiratory causes on the day of the event and during the following days [6]. A review of lung health in the context of climate change and dust storms likewise reported associations with asthma exacerbations, chronic obstructive pulmonary disease (COPD) exacerbations, respiratory infections and, in some settings, increased respiratory mortality [7]. Table 2 summarises the main respiratory outcomes described in the literature.

Table 2. Principal respiratory outcomes associated with desert dust exposure

Outcome	Proposed mechanism	Clinical relevance
Asthma exacerbation	Airway inflammation, allergen exposure, bronchial hyperreactivity	Increased reliever use, emergency visits and hospital admissions
COPD exacerbation	Oxidative stress, mucus hypersecretion, impaired mucociliary clearance	Worsening dyspnoea, hospital admissions, risk of respiratory failure
Respiratory infections	Epithelial barrier damage, transport of microorganisms on particles	Bronchitis and pneumonia, particularly in children and older adults
Upper airway irritation	Mechanical and chemical irritation of the mucosa	Rhinitis, sinusitis, sore throat and cough
Allergic sensitisation	Pollen, fungal spores and other allergens carried on dust	New or worsening allergic rhinitis and asthma symptoms

Vulnerable groups. The literature consistently identifies children, older adults, pregnant women, people with chronic respiratory or cardiovascular disease and outdoor workers as the groups at greatest risk [4, 7]. Children are particularly susceptible because their airways are still developing and they inhale more air per kilogram of body weight than adults. In Southern Uzbekistan, the size of the rural, outdoor-working population – farmers, herders, construction workers and drivers – makes occupational exposure an especially important consideration.

DISCUSSION

The evidence reviewed indicates that dust events in Southern Uzbekistan should be regarded not only as a meteorological phenomenon but also as a recurring public health hazard, with the respiratory system as the main target. A feature of particular concern in this region is that dust events often coincide with extreme heat. High temperatures cause dehydration and place additional strain on the cardiorespiratory system, while

dust adds an inflammatory burden to the airways. Periods in which the "Afghan" wind and heat waves occur together are therefore likely to be the most dangerous, especially for older adults and patients with chronic disease.

Primary care is well placed to reduce this burden, because family physicians and nurses already know which of their patients have asthma, COPD or heart disease. Current international asthma guidance recommends that every patient with asthma should have a written action plan and should be advised on reducing exposure to environmental triggers, including outdoor air pollution [8]. Building on this principle, we propose a three-phase framework for primary care in dust-affected areas (Table 3).

Table 3. Proposed primary care framework for reducing the respiratory impact of dust events

Phase	Key actions
Before the dust season	Update registers of patients with asthma, COPD and cardiovascular disease; review and optimise controller therapy; provide written action plans; check inhaler technique; advise on suitable respirators (FFP2/N95) and eye protection; vaccinate eligible patients against influenza and pneumococcal infection in line with national schedules.
During a dust event	Advise vulnerable patients to stay indoors with windows closed and to limit physical exertion outdoors; recommend a well-fitting respirator when going outside is unavoidable; remind patients to drink enough fluids, particularly during hot weather; ensure that reliever medication is available; prepare clinics for an increase in respiratory presentations.
After a dust event	Contact high-risk patients to check for worsening symptoms; review patients who needed emergency care; record dust-related presentations to support local surveillance; reinforce education on prevention before the next event.

Early warning is the element that links these phases together. If forecasts of dust events were communicated to the population and to health facilities one or two days in advance – through text messages, mobile applications or the media – patients and

clinicians would have time to act. At present, however, the number of stations that continuously measure PM10 and PM2.5 in Southern Uzbekistan appears to be limited, which makes both warnings and research more difficult. Methodological reviews emphasise that separating the effects of desert dust from those of other pollution sources requires reliable particle monitoring linked to health data [4, 6]. Expanding monitoring in Surkhandarya and Kashkadarya should therefore be a priority.

In the longer term, reducing dust emissions at their source is essential. Measures such as planting drought-tolerant native shrubs, establishing shelter belts and improving pasture management can slow land degradation, which the global assessment identifies as a major driver of dust emissions [2]. In the dry conditions of the south, such measures will be effective only if appropriate local plant species and water-saving irrigation methods are used.

This review has several limitations. It is a narrative rather than a systematic review, and no meta-analysis was performed. It does not include primary data from health facilities in Southern Uzbekistan, and most of the evidence comes from other dust-affected regions, where dust composition and population characteristics may differ. Local studies are therefore needed – for example, time-series analyses linking days with dust events to emergency calls and hospital admissions for respiratory causes in Surkhandarya – to confirm and quantify the associations described here.

CONCLUSION

Desert dust is a significant and recurring environmental hazard in Southern Uzbekistan. Dust events raise concentrations of PM10 and PM2.5 far above WHO guideline levels and are associated with exacerbations of asthma and COPD, respiratory infections and upper airway irritation, mediated by oxidative stress, airway inflammation and the biological and chemical components of dust. Children, older adults, people with chronic disease and outdoor workers are at greatest risk, and the frequent coincidence of dust with extreme heat in the region is likely to increase this risk further.

Primary care can play a central role in reducing the respiratory burden of dust events through a structured approach of preparation, protection and follow-up. Combined with expanded air quality monitoring, early warning and local epidemiological research, such an approach could provide an effective and affordable means of protecting the health of the population of Southern Uzbekistan.

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