



CLIMATE-SENSITIVE PREVENTIVE MEDICINE: NEW CHALLENGES FOR CENTRAL ASIAN COUNTRIES

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ABSTRACT: Climate change is increasingly recognized as one of the most serious public health challenges of the twenty-first century, significantly influencing morbidity, mortality, and population vulnerability worldwide. This review examines climate-sensitive preventive medicine as an emerging scientific and practical paradigm aimed at identifying, assessing, and mitigating health risks associated with climatic and environmental changes. Rising ambient temperatures, increasing frequency of heatwaves, air pollution, water scarcity, desertification, and extreme weather events have profound effects on human health, particularly in regions with arid climates and limited adaptive capacity. Central Asian countries are among the most climate-vulnerable regions due to rapid warming rates, ecological degradation, urbanization, and socioeconomic transitions. The article analyzes key mechanisms linking climate factors to cardiovascular, respiratory, metabolic, and infectious diseases and highlights the role of climate-sensitive approaches in strengthening preventive medicine and public health systems. It is concluded that climate-sensitive preventive medicine is essential for improving population resilience, reducing climate-related disease burden, and supporting sustainable healthcare development in Central Asia.

Keywords: climate-sensitive preventive medicine, climate change, public health, environmental health, Central Asia, heat stress, adaptation strategies.

КЛИМАТОЧУВСТВИТЕЛЬНАЯ ПРОФИЛАКТИЧЕСКАЯ МЕДИЦИНА: НОВЫЕ ВЫЗОВЫ ДЛЯ СТРАН ЦЕНТРАЛЬНОЙ АЗИИ

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АННОТАЦИЯ: Изменение климата все чаще признается одной из самых серьезных проблем общественного здравоохранения XXI века, оказывающей значительное влияние на заболеваемость, смертность и уязвимость населения во всем мире. В данном обзоре рассматривается климаточувствительная профилактическая медицина как новая научная и практическая парадигма, направленная на выявление, оценку и смягчение рисков для здоровья, связанных с климатическими и экологическими изменениями. Повышение температуры окружающей среды, увеличение частоты волн жары, загрязнение воздуха, нехватка воды, опустынивание и экстремальные погодные явления оказывают глубокое воздействие на здоровье человека, особенно в регионах с засушливым климатом и ограниченными адаптационными возможностями. Страны Центральной Азии входят в число наиболее уязвимых к изменению климата регионов из-за быстрых темпов потепления, деградации окружающей среды, урбанизации и социально-экономических преобразований. В статье анализируются ключевые механизмы, связывающие



климатические факторы с сердечно-сосудистыми, респираторными, метаболическими и инфекционными заболеваниями, и подчеркивается роль климаточувствительных подходов в укреплении профилактической медицины и систем общественного здравоохранения. Сделан вывод о том, что климаточувствительная профилактическая медицина имеет важное значение для повышения устойчивости населения, снижения бремени болезней, связанных с изменением климата, и поддержки устойчивого развития здравоохранения в Центральной Азии.

Ключевые слова: климаточувствительная профилактическая медицина, изменение климата, общественное здравоохранение, охрана окружающей среды, Центральная Азия, тепловой стресс, стратегии адаптации.

RELEVANCE: In the twenty-first century, climate change has transformed from a primarily environmental concern into a major determinant of population health. According to the World Health Organization, climate change is expected to cause approximately 250,000 additional deaths annually between 2030 and 2050 due to heat stress, malnutrition, malaria, and diarrheal diseases [1]. Furthermore, climate-related factors already contribute significantly to the global burden of disease, particularly in low- and middle-income countries with limited adaptive resources.

Central Asian countries, including Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan, are experiencing climate changes at a rate exceeding the global average. Over the past 50 years, average temperatures in the region have increased by 1.5–2.0°C, while the frequency and intensity of heatwaves have risen markedly [2]. Water scarcity, shrinking glaciers, desertification, and increased dust storms further exacerbate environmental stressors. These changes pose serious threats to public health, contributing to heat-related mortality, cardiovascular and respiratory diseases, renal disorders, malnutrition, and infectious disease outbreaks.

Traditional preventive medicine approaches, which primarily focus on individual behavioral risk factors, are insufficient to address these complex and systemic threats. Climate-related health risks operate at population, environmental, and ecosystem levels and require integrated, anticipatory strategies. Climate-sensitive preventive medicine offers a framework that incorporates climatic, environmental, social, and biological determinants into health risk assessment and prevention planning. For Central Asian countries, where environmental vulnerability intersects with demographic and socioeconomic challenges, this approach is particularly relevant and timely [3].

MATERIALS AND METHODS: This review is based on a comprehensive analysis of contemporary international and regional scientific literature addressing climate change, climate-sensitive health outcomes, and preventive medicine. Relevant publications were identified through systematic searches of PubMed, Scopus, Web of Science, and Google Scholar, as well as reports and guidelines from the World Health Organization, the Intergovernmental Panel on Climate Change (IPCC), the World Bank, and the United Nations Development Programme.

The search strategy included keywords such as climate change, climate-sensitive health, preventive medicine, environmental health, heat-related mortality, and Central Asia. Priority was given to peer-reviewed articles, large-scale epidemiological studies, systematic reviews, and international reports published within the last 10–15 years. Earlier foundational works were also



included to provide conceptual context. A qualitative content analysis approach was used to synthesize evidence on mechanisms of climate-related health impacts, vulnerable population groups, and preventive strategies relevant to Central Asian settings. Climate Change as a Determinant of Population Health

RESULTS AND DISCUSSION: Climate change affects human health through multiple direct and indirect pathways. Direct effects include heat-related illnesses, dehydration, heat stroke, and increased mortality during extreme temperature events. Indirect effects involve deterioration of air and water quality, food insecurity, altered distribution of infectious diseases, and psychosocial stress.

Heat exposure is one of the most significant climate-related health threats. Epidemiological studies demonstrate that heatwaves are associated with a 10–20% increase in all-cause mortality, particularly among elderly individuals and patients with cardiovascular and respiratory diseases [6]. In Central Asia, summer temperatures frequently exceed 40°C, creating prolonged periods of thermal stress. Repeated exposure to high temperatures disrupts thermoregulation, increases cardiovascular strain, and exacerbates chronic diseases.

Air pollution represents another critical pathway linking climate change and health. Rising temperatures contribute to increased ground-level ozone formation and intensify the health impacts of particulate matter. According to global estimates, air pollution is responsible for approximately 6.7 million premature deaths annually [7]. In urban areas of Central Asia, combined exposure to heat and air pollution significantly elevates the risk of cardiovascular and respiratory morbidity.

Climate-Sensitive Non-Communicable Diseases

Non-communicable diseases (NCDs) account for more than 70% of total mortality globally and represent a growing burden in Central Asian countries [8]. Climate change exacerbates many risk factors associated with NCDs, making climate-sensitive prevention essential.

Cardiovascular diseases are particularly sensitive to temperature extremes. Studies indicate that each 1°C increase in ambient temperature may be associated with a 2–5% rise in cardiovascular mortality [9]. Heat stress increases blood viscosity, heart rate, and dehydration, contributing to thrombosis and acute cardiovascular events. Individuals with hypertension, ischemic heart disease, and diabetes are especially vulnerable.

Respiratory diseases are also strongly influenced by climate conditions. Heat, air pollution, and dust storms contribute to asthma exacerbations, chronic obstructive pulmonary disease, and respiratory infections. Desertification and increased frequency of dust storms in Central Asia further amplify respiratory health risks.

Metabolic disorders, including obesity and type 2 diabetes mellitus, are indirectly affected by climate change. Extreme heat reduces physical activity, disrupts sleep patterns, and alters dietary behavior, contributing to metabolic imbalance. Evidence suggests that climate-related stressors may accelerate the progression of metabolic syndrome, particularly in urban populations [10].

Climate Change and Infectious Diseases



Climate variability plays a critical role in the emergence and transmission of infectious diseases. Changes in temperature, precipitation, and humidity influence pathogen survival, vector distribution, and human exposure patterns. According to the World Health Organization, climate change increases the risk of vector-borne, water-borne, and food-borne infections [11].

In Central Asia, rising temperatures and altered precipitation patterns create favorable conditions for gastrointestinal infections due to water scarcity and compromised sanitation. Heat-related deterioration of water quality increases the incidence of diarrheal diseases, which remain a significant public health concern in vulnerable populations.

Climate change also affects zoonotic and vector-borne diseases by expanding the geographic range of vectors and reservoirs. Although traditionally considered low-risk regions for certain vector-borne infections, Central Asian countries may face emerging threats due to ecological shifts and increased human mobility.

Climate-sensitive preventive medicine represents an integrated public health approach that explicitly incorporates climatic and environmental factors into disease prevention strategies. Unlike traditional preventive models, which often focus on individual-level risk modification, climate-sensitive prevention operates at population and systems levels. This approach is particularly relevant in regions such as Central Asia, where climate-related exposures affect large segments of the population simultaneously and interact with socioeconomic vulnerabilities.

Public health systems must adapt to climate-related challenges by shifting from reactive responses to anticipatory and preventive strategies. Climate-sensitive surveillance systems enable early identification of health risks associated with extreme temperatures, air pollution episodes, and water scarcity. For example, heat-health action plans implemented in several countries have been shown to reduce heat-related mortality by 20–30% through early warning systems, public education, and targeted protection of vulnerable groups [12]. The integration of similar mechanisms into Central Asian public health systems could significantly reduce climate-attributable morbidity and mortality.

Sanitary-epidemiological services play a central role in climate-sensitive preventive medicine, particularly in monitoring environmental determinants of health. In Central Asian countries, these services traditionally focus on controlling infectious diseases, food safety, and environmental hygiene. However, climate change necessitates an expansion of their mandate to include systematic assessment of climate-related health risks.

Environmental monitoring of air quality, water resources, and soil conditions provides critical data for evaluating population exposure to climate-sensitive hazards. Rising ambient temperatures and prolonged droughts contribute to increased concentrations of airborne particulate matter and chemical contaminants, which are associated with higher rates of respiratory and cardiovascular diseases [13]. By integrating meteorological data with health surveillance systems, sanitary-epidemiological services can identify high-risk periods and regions, enabling timely preventive interventions.

Furthermore, climate-sensitive epidemiological analysis allows for the identification of emerging health threats linked to environmental change. For instance, increased temperatures and water shortages may facilitate outbreaks of water-borne infections, particularly in rural and peri-urban areas with limited infrastructure. Strengthening laboratory capacity, data integration, and intersectoral coordination is essential for enhancing the effectiveness of sanitary-epidemiological services in a changing climate.



Primary healthcare systems are uniquely positioned to implement climate-sensitive preventive measures due to their close interaction with the population. In Central Asian countries, primary care facilities account for approximately 85–90% of healthcare encounters, making them critical points for early risk identification and prevention [14].

Climate-sensitive primary care involves incorporating environmental and climatic risk assessment into routine medical practice. This includes identifying patients at increased risk during heatwaves, such as elderly individuals, patients with cardiovascular or renal diseases, and pregnant women. Evidence suggests that targeted counseling and preventive measures during extreme heat events can reduce hospital admissions by up to 15–20% [15].

Primary healthcare providers also play a vital role in health education and community outreach. Public awareness campaigns on hydration, heat avoidance, air pollution protection, and safe water use are essential components of climate-sensitive prevention. In addition, digital health tools and mobile applications can support real-time monitoring of environmental conditions and provide personalized preventive recommendations.

Climate change disproportionately affects vulnerable population groups, including children, older adults, individuals with chronic diseases, low-income populations, and outdoor workers. The vulnerability of these groups is determined by a combination of physiological sensitivity, exposure intensity, and limited adaptive capacity.

Children are particularly susceptible to climate-related health risks due to their developing thermoregulation systems and higher exposure to environmental pollutants. Studies indicate that heat exposure during early life may increase the risk of chronic respiratory and cardiovascular diseases later in life [16]. Elderly individuals experience reduced physiological adaptability to temperature extremes, leading to higher rates of heat-related morbidity and mortality.

Socioeconomic factors further amplify vulnerability. Populations with limited access to cooling, clean water, and healthcare services face significantly higher climate-related health risks. In Central Asia, rural communities and informal urban settlements are especially exposed to extreme heat and water insecurity. Addressing these inequalities requires targeted preventive strategies that integrate social protection and public health interventions.

In addition to physical health outcomes, climate change has substantial impacts on mental health and psychosocial well-being. Extreme weather events, prolonged heat exposure, and environmental degradation contribute to increased levels of stress, anxiety, and depression. According to global estimates, climate-related stressors may increase the prevalence of mental health disorders by 10–15% in vulnerable populations [17].

In Central Asian contexts, climate-induced economic instability, such as reduced agricultural productivity and water scarcity, exacerbates psychosocial stress, particularly among rural populations. Preventive medicine must therefore address mental health as an integral component of climate-sensitive health strategies. Community-based mental health services, social support programs, and resilience-building interventions are essential for mitigating the psychological impacts of climate change.

Effective climate-sensitive preventive medicine requires strong intersectoral collaboration. Health outcomes are influenced by policies in environmental protection, urban planning, water management, energy, transportation, and labor. Fragmented approaches are insufficient to address the systemic nature of climate-related health risks.

The “Health in All Policies” framework provides a foundation for integrating health considerations into climate adaptation and mitigation strategies. For example, urban planning policies that increase green spaces and improve ventilation can reduce urban heat island effects



and improve air quality, leading to measurable health benefits [18]. Similarly, water management strategies that ensure safe and sustainable water supply directly contribute to the prevention of water-borne diseases.

In Central Asia, strengthening coordination between health authorities, environmental agencies, and local governments is essential for implementing climate-sensitive preventive programs. Joint data platforms, shared indicators, and coordinated action plans can enhance the effectiveness of public health interventions and optimize resource utilization.

Investing in climate-sensitive prevention yields substantial economic benefits. Global health economic analyses indicate that every dollar invested in climate-resilient health systems can generate returns of up to four dollars through reduced healthcare costs and productivity gains [19]. Preventive measures targeting heat-related illnesses, air pollution exposure, and water safety are particularly cost-effective.

For Central Asian countries, where healthcare expenditures related to chronic disease management are increasing, climate-sensitive preventive medicine offers a pathway to sustainable health system financing. By reducing the incidence and severity of climate-related diseases, preventive interventions can alleviate pressure on healthcare infrastructure and improve long-term economic stability.

Despite the growing recognition of climate-sensitive preventive medicine as a priority for public health systems, its practical implementation faces a number of significant challenges. One of the main limitations is the methodological complexity of assessing climate-related health risks. Climate impacts are multifactorial, long-term, and often indirect, making it difficult to establish clear causal relationships between specific climatic exposures and health outcomes. This complexity requires advanced analytical models, long-term datasets, and interdisciplinary expertise, which are not always readily available in Central Asian healthcare systems [20].

Technical and infrastructural limitations also pose major barriers. Effective climate-sensitive prevention depends on reliable environmental monitoring systems, digital health infrastructure, and integrated health information systems. In many regions of Central Asia, environmental monitoring networks are fragmented, and access to real-time climatic and health data remains limited. Insufficient laboratory capacity and lack of standardized indicators further constrain the ability to assess population exposure and vulnerability comprehensively.

Ethical and legal considerations must also be addressed. The integration of climate, environmental, and health data raises concerns related to data privacy, informed consent, and data governance. Clear regulatory frameworks are required to ensure ethical use of personal and population-level data while enabling effective public health action. In addition, climate-sensitive interventions must be designed in a way that avoids exacerbating social inequalities, particularly among already vulnerable populations [21].

Resource constraints represent another critical challenge. The implementation of climate-sensitive preventive programs requires financial investment, trained personnel, and institutional support. Many Central Asian countries face competing healthcare priorities, which may limit the allocation of resources to climate-related prevention. Moreover, international models of climate-sensitive health systems cannot be directly transferred without adaptation to local socioeconomic, cultural, and environmental contexts.

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To overcome these challenges, a phased and context-specific approach to climate-sensitive preventive medicine is recommended. One of the key strategic directions is the development of national frameworks for climate and health. Such frameworks should integrate climate risk assessment into public health planning and define clear roles for health authorities, environmental agencies, and local governments.

Strengthening climate-health surveillance systems is essential. This includes integrating meteorological data with epidemiological surveillance to identify climate-sensitive disease patterns and predict health risks during extreme weather events. Establishing early warning systems for heatwaves, air pollution episodes, and water-related hazards can significantly reduce morbidity and mortality. Evidence from international experience shows that well-coordinated heat-health warning systems can reduce heat-related deaths by up to 30–40% [21].

Capacity building and workforce development are also critical. Medical education and public health training programs should incorporate climate and environmental health competencies. Healthcare professionals must be equipped with knowledge and skills to recognize climate-related health risks, provide appropriate preventive counseling, and participate in community-level adaptation initiatives. Interdisciplinary collaboration between clinicians, epidemiologists, environmental scientists, and data specialists should be actively promoted.

Another strategic priority is the integration of climate-sensitive prevention into primary healthcare. Routine health assessments should include evaluation of climate-related risk factors, particularly for high-risk groups such as elderly individuals, patients with chronic diseases, outdoor workers, and pregnant women. Community-based interventions, including public education campaigns and local adaptation programs, can enhance population resilience and reduce exposure to climate-related hazards [18,20].

Intersectoral collaboration must be strengthened to address the upstream determinants of climate-related health risks. Policies in urban planning, housing, water management, energy, and



transportation have profound health implications. For example, improving urban green spaces, ensuring access to safe drinking water, and promoting energy-efficient housing can significantly reduce heat exposure and improve overall health outcomes. Coordinated action across sectors is essential for effective climate-sensitive prevention.

Climate-sensitive preventive medicine is closely aligned with the principles of sustainable development and the Sustainable Development Goals (SDGs), particularly those related to health, climate action, and social equity. By addressing environmental determinants of health and reducing vulnerability to climate-related risks, preventive medicine contributes to long-term population health and social stability.

In Central Asia, climate change threatens not only health but also food security, water resources, and economic development. Preventive strategies that reduce climate-related disease burden can support broader development goals by enhancing workforce productivity, reducing healthcare costs, and strengthening social resilience. According to global estimates, climate-adaptive health systems can yield economic returns of three to five times the initial investment through reduced disease burden and increased productivity [21].

From a sustainability perspective, climate-sensitive prevention shifts the focus from short-term crisis response to long-term resilience building. This approach emphasizes prevention, adaptation, and preparedness, reducing dependence on costly emergency interventions and healthcare services. As climate risks continue to intensify, the integration of climate-sensitive preventive medicine into national health strategies becomes not only desirable but essential.

CONCLUSIONS: Climate-sensitive preventive medicine represents a necessary and timely evolution of public health practice in the context of accelerating climate change. This review demonstrates that climatic and environmental factors have a profound and multifaceted impact on population health, influencing the incidence and severity of cardiovascular, respiratory, metabolic, infectious, and mental health disorders. Central Asian countries, characterized by arid climates, rising temperatures, water scarcity, and environmental degradation, are particularly vulnerable to these climate-related health threats.

Traditional preventive medicine approaches, focused primarily on individual behavioral risk factors, are insufficient to address the systemic and population-wide nature of climate-related health risks. Climate-sensitive preventive medicine provides a comprehensive framework that integrates climatic, environmental, social, and health data to identify vulnerable populations, anticipate health risks, and implement targeted preventive interventions. Evidence presented in this review indicates that climate-sensitive strategies, including early warning systems, strengthened environmental surveillance, and primary healthcare adaptation, can substantially reduce climate-attributable morbidity and mortality.

The successful implementation of climate-sensitive preventive medicine in Central Asia requires overcoming methodological, technical, and resource-related challenges. Strengthening surveillance systems, investing in workforce capacity, ensuring ethical data governance, and fostering intersectoral collaboration are essential steps toward effective climate-health adaptation. Importantly, preventive measures must be tailored to regional contexts and prioritize equity to protect the most vulnerable population groups.

In conclusion, climate-sensitive preventive medicine should be recognized not merely as an emerging academic concept but as a strategic public health tool for safeguarding population health in the face of climate change. Its integration into national healthcare systems can enhance resilience, reduce health inequalities, and support sustainable development. For Central Asian countries, adopting climate-sensitive preventive approaches represents a critical opportunity to



modernize preventive medicine and protect public health in an increasingly unstable climate environment.

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