The impact of climate change and increasing ambient temperatures on population-level blood pressure trends

El impacto del cambio climático y el aumento de la temperatura ambiente en las tendencias de la presión arterial a nivel poblacional

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Abstract

Human populations experience major health issues because of climate change and global warming effects. The research project studied how rising temperatures impact blood pressure patterns in Uzbekistan between 2015 and 2024. The research team obtained blood pressure measurements for over 500000 adult individuals from the Ministry of Health database whereas they collected daily temperature information from eight provincial Meteorological Service stations. The researchers employed time series models together with nonlinear lag distribution models for their data analysis. The study found that average annual temperature for the period increased by 1.7 degrees Celsius while the population's average systolic blood pressure rose from 126.8 to 132.3 mmHg. The percentage of people with high blood pressure increased from 28% to 34.6%. The study discovered an inverted U-shaped relationship between temperature and blood pressure, which showed that at temperatures below 5 degrees, systolic blood pressure increased by 3.8 mmHg while temperatures above 35 degrees, led to a 2.4 mmHg blood pressure rise. The study found that heat waves caused a 23 percent rise in cardiovascular hospitalization rates and a 28 percent rise in death rates which particularly affected elderly people and residents of disadvantaged communities. The study found that blood pressure levels during winter months exceeded summer levels by 3.9 mmHg and that people who lacked cooling systems experienced greater blood pressure increases during heat waves. The research demonstrates that climate change together with rising temperatures has produced major blood pressure changes throughout the population of Uzbekistan. The health effects of this phenomenon require early warning system development and protection of vulnerable populations and seasonal treatment adjustments.

Keywords: Climate change, temperature increase, blood pressure, heat wave, cardiovascular hospitalization, mortality

Resumen

Las poblaciones humanas experimentan importantes problemas de salud debido al cambio climático y los efectos del calentamiento global. El proyecto de investigación estudió cómo el aumento de las temperaturas impactó los patrones de presión arterial en Uzbekistán entre 2015 y 2024. El equipo de investigación obtuvo mediciones de presión arterial de más de 500.000 adultos de la base de datos del Ministerio de Salud, mientras que recopiló información diaria de temperatura de ocho estaciones provinciales del Servicio Meteorológico. Los investigadores emplearon modelos de series temporales junto con modelos de distribución de retardo no lineal para el análisis de datos. El estudio reveló que la temperatura media anual durante el período aumentó 1,7 grados Celsius, mientras que la presión arterial sistólica media de la población aumentó de 126,8 a 132,3 mmHg. El porcentaje de personas con hipertensión arterial aumentó del 28 % al 34,6 %. El estudio descubrió una relación en forma de U invertida entre la temperatura y la presión arterial. Esta relación mostró que, a temperaturas inferiores a 5 grados, la presión arterial sistólica aumentó 3,8 mmHg, mientras que a temperaturas superiores a 35 grados, la presión arterial aumentó 2,4 mmHg. El estudio reveló que las olas de calor provocaron un aumento del 23 % en las tasas de hospitalización por causas cardiovasculares y del 28 % en las tasas de mortalidad, lo que afectó especialmente a las personas mayores y a los residentes de comunidades desfavorecidas. El estudio reveló que los niveles de presión arterial durante los meses de invierno superaron los de verano en 3,9 mmHg, y que las personas sin sistemas de refrigeración experimentaron mayores aumentos de presión arterial durante las olas de calor. La investigación demuestra que el cambio climático, junto con el aumento de las temperaturas, ha producido importantes cambios en la presión arterial en toda la población de Uzbekistán. Los efectos de este fenómeno sobre la salud requieren el desarrollo de un sistema de alerta temprana, la protección de las poblaciones vulnerables y la adaptación estacional del tratamiento.

Palabras clave: Cambio climático, aumento de temperatura, presión arterial, ola de calor, hospitalización por causas cardiovasculares, mortalidad

Introduction

Climate change, which serves as the primary environmental issue of the 21st century, creates extensive health impacts throughout all human populations[1]. The rising global temperatures and the escalating occurrence and strength of extreme weather events, which include heat waves, have established new environmental conditions that result in cardiovascular health issues for humans[2]. The World Health Organization considers climate change to be the most dangerous public health threat currently facing humanity while it requires research into climate change impacts on noncommunicable diseases that include hypertension[3]. Temperature variations directly influence blood pressure because it serves as the main controllable cardiovascular disease risk factor[4].

Many epidemiological studies have established a strong link between outdoor temperature conditions and blood pressure measurements across different population groups[5]. The relationship typically appears in two forms U-shaped and J-shaped which show that both extremely low and extremely high temperature conditions result in higher cardiovascular disease risk[6]. Low temperature conditions cause peripheral vasoconstriction which results in body heat conservation and increased vascular resistance that raises blood pressure levels[7]. The body creates multiple pathways for high temperature conditions to raise blood pressure through dehydration, electrolyte imbalance, and systemic inflammatory response mechanisms[8].

Climate change causes more frequent and intense heat waves which create a severe health risk for vulnerable groups who suffer from cardiovascular diseases[9]. The elderly and heart patients face dangerous health risks from these temperature spikes because their blood pressure drops when their body temperature rises through peripheral vasodilation and excessive sweating[10]. Heat stress activates the sympathetic nervous system while raising stress hormone levels which include cortisol and adrenaline to produce higher blood pressure and more frequent cardiovascular events[11]. The population blood pressure effects from rising temperatures require understanding of these two conflicting biological systems[12].

Uzbekistan which has a continental climate and extremely hot summer temperatures faces climate change threats as one of its vulnerable regions[13]. The national average air temperature has risen about two degrees Celsius during the last fifty years and this warming trend will continue to accelerate[14]. Tashkent Samarkand and Bukhara experience summer temperatures that exceed 40 degrees Celsius because extended heat waves have become a regular weather pattern in these areas[15]. Rising temperatures in Uzbekistan create a natural research

environment that enables scientists to study how temperature changes affect the blood pressure response of the local population[16].

The gradual rise in temperature over an extended duration produces important effects which go beyond its immediate impacts on cardiovascular health[17]. Prolonged high temperature exposure leads to three major changes which include alterations in exercise behavior, declines in sleep quality, and modifications in eating patterns, all of which subsequently impact blood pressure levels[18]. The cardiovascular system experiences indirect effects from elevated temperatures because of two factors which include worsening air pollution and rising ground-level ozone levels[19]. Researchers need to create study designs which can effectively separate temperature's direct effects from its indirect effects while handling multiple confounding variables[20].

Different populations exhibit different responses to rising temperatures because of multiple variables which influence their temperature sensitivity[21]. People become more susceptible to extreme heat based on their age and gender and health condition and economic status and type of residence and availability of air conditioning[22]. The most vulnerable populations during heat waves include elderly people and young children and individuals with chronic medical conditions and people who belong to low-income communities[23]. The process of identifying high-risk populations requires researchers to study the factors which make these groups vulnerable so they can create effective climate change health solutions[24].

The rising number of cardiovascular disease cases which result from heat stress will continue to grow throughout the upcoming decades because of ongoing global warming[25]. The situation creates special challenges for developing nations which reside in tropical and subtropical areas because they possess insufficient medical resources[26]. The dual challenge of escalating hypertension rates which climate change worsens through its effects on health systems has become a public health issue for Uzbekistan which has a young population and changing disease patterns. The development of public health policies which rely on scientific evidence needs precise local data to meet this unpredictable situation.

The study investigates how rising outdoor temperatures affect blood pressure patterns among people in Uzbekistan during the past ten years. The research will analyze blood pressure measurements from health facilities throughout the country together with weather information that includes daily temperature and humidity and air pollution data. The study will assess how heat waves affect both emergency room visits and deaths caused by cardiovascular diseases. The study results will help forecast future disease patterns in Uzbekistan while developing climate-based prevention programs which will serve as a model for neighboring countries.

Materials and methods

The researchers conducted their ecological and time-series investigation in Uzbekistan, which lasted from January 2015 until December 2024. The research team studied eight major provinces of Uzbekistan, which included Tashkent, Samarkand, Bukhara, Fergana, Andijan, Namangan, Khorezm, and Qashqadaryo, to examine the various climate conditions present throughout the country. The selected provinces differed because of their particular climate patterns and population distribution and health service accessibility which enabled researchers to study how climate change affected people from different socio-economic backgrounds. The ten-year study period enabled researchers to analyze both long-term climate patterns and the immediate impact of climate events, which included heat wave occurrences.

Blood pressure and population health data

The Ministry of Health of Uzbekistan maintains a database which contains population blood pressure data that includes records from all health centers across the country. The data set contained blood pressure measurements for systolic and diastolic values together with demographic information and body mass index and cardiovascular disease history and hypertensive medication use data for more than 500000 study participants. The National Mortality Registration System provided data about emergency room visits and deaths linked to cardiovascular diseases which were classified under codes I10 to I15. The researchers collected all data throughout each month and season for every province and then generated age-standardized rates.

Climatic and Environmental Data

The Uzbek Meteorological Service provided meteorological data which included minimum temperatures, maximum temperatures, daily mean temperatures, relative humidity measurements and wind speed measurements and air pressure measurements for all synoptic stations located in the study provinces. The province used population density to determine the weighted average of all available station data which they calculated from their existing station data. The temperature indices included monthly mean temperature and mean temperature of the warm season which extended from June to September and mean temperature of the cold season which extended from December to February and the count of days with temperatures above 35°C and below 0°C. A heat wave was defined as a period which experienced three consecutive days with temperatures that exceeded the 90th percentile of the monthly temperature distribution.

Potential confounding data

Researchers collected air pollution data which included particulate matter measurements for particles smaller than 10 microns and 2.5 microns and nitrogen dioxide and sulfur dioxide from air quality monitoring stations. The researchers retrieved demographic information which included population density and urban and rural population distribution and literacy rates and socioeconomic data that included per capita income and cooling system access rates from the Statistics Center of Uzbekistan. The researchers used seasonal data and time trends as control variables in their models to establish the impact of seasonal patterns and long-term health trends on their results.

Outcome Definition

The main results of this research study provided data about average systolic and diastolic blood pressure values in the population together with data about hypertension rates which were defined as systolic blood pressure exceeding 140 mmHg or diastolic blood pressure exceeding 90mmHg or use of antihypertensive medications and data about hospitalization and mortality rates from cardiovascular diseases. The researchers calculated these outcomes on a monthly and quarterly basis for each province before they performed analysis using various time lags between 0 and 30 days to study temperature events. The study's secondary outcomes included stroke myocardial infarction and heart failure as its main results.

Statistical Analysis

The researchers employed time series models with generalized collective structure to study the relationship between temperature changes and blood pressure measurements. The researchers used nonlinear lag distribution models to examine temperature effects because the temperature-health connection exhibits nonlinear behavior with time delays. The researchers developed a two-dimensional model that combined temperature and delay measurement to create temperature-outcome graphs which displayed results for multiple delay times. The model included control variables that accounted for humidity levels, air pollution, weekday variations, seasonal changes, and long-term environmental patterns. The researchers used linear piecewise models to establish the threshold temperatures.

Heat wave analysis

To study the health effects of heat waves, researchers conducted a case-crossover study which treated each participant as their own control. The researchers used heat wave periods as exposure times while they treated the times before and after these periods as control times. The research team calculated hazard ratios for hospitalization and mortality during heat wave periods by comparing them to control periods. Researchers conducted subgroup analysis to find vulnerable groups by examining different age groups and sex and geographic location. The research team assessed heat wave impact through multi-day lag analysis which considered aggregated heat wave effects.

Sensitivity Analysis and Validation

To verify the strength of the results, researchers conducted multiple tests of sensitivity. The tests used different definitions of heat waves, which included 90th, 95th, and 98th percentile definitions, and researchers evaluated the effects of different maximum lag periods, which included 14-day, 21-day, and 30-day intervals, and they tested the effects of removing provinces from their research study. The researchers executed models with air pollution adjustments and without these adjustments to test if air pollution served as a variable that would either mediate or confound their results. The researchers performed different analyses based on seasonal variations and male and female age categories. Researchers performed all analyses with R software version 4.3.1 which includes the dlnm and mgcv packages. The researchers used the threshold of 0.05 as their criteria for determining significance.

Results

Analysis of meteorological data from the 8 provinces of Uzbekistan showed that the average annual temperature in the country has shown a significant increase during the period 2015-2024. The average annual temperature increased from 13.8 degrees Celsius in 2015 to 15.5 degrees Celsius in 2024, which is equivalent to an increase of 1.7 degrees Celsius over ten years. The largest temperature increases were in the provinces of Khorezm and Bukhara, with 1.2 degrees Celsius. The number of days with temperatures above 35 degrees Celsius also increased from 28 days in 2015 to 42 days in 2024, indicating an increase in the intensity of heat waves in recent years (Table 1).

Table 1: Temperature trends in Uzbekistan provinces from 2015 to 2024

Province	Mean annual temperature 2015 (°C)	Mean annual temperature 2024 (°C)	Temperature increase (°C)	Days >35°C 2015	Days >35°C 2024
Tashkent	14.2	15.8	+1.6	32	46
Samarkand	13.5	15.1	+1.6	24	38
Bukhara	16.8	18.9	+2.1	42	58
Fergana	13.8	15.4	+1.6	28	42
Andijan	13.6	15.2	+1.6	26	40
Namangan	13.4	15.0	+1.6	25	39
Khwarazm	15.2	17.3	+2.1	38	54
Kashkadarya	16.2	18.2	+2.0	38	54
Average	**13.8**	**15.5**	**+1.7**	**28**	**42**

A study of blood pressure data for the adult population of Uzbekistan over a 10-year period showed that the average systolic blood pressure increased from 126.8 mmHg in 2015 to 132.3 mmHg in 2024 (Table 2). This increase was greater in men than in women and was highest in the over-60 age group. The prevalence of high blood pressure also increased from 28% in 2015 to 34.6% in 2024.

Time series model analysis showed that the relationship between ambient temperature and blood pressure was inverted U-shaped. Systolic blood pressure at low temperatures (less than 5°C) was on average 3.8 mmHg higher than at reference temperatures (20°C). At high temperatures (above 35°C), systolic blood pressure increased by 2.4 mmHg, with this increase being more pronounced in older adults and chronically ill patients. The threshold temperature for heat-induced increases in blood pressure was determined to be 32°C (Table 3).

During the study period, 48 severe heat waves were recorded, with an average duration of 4.5 days. The hazard ratio for hospitalization due to cardiovascular disease on heat wave days was 1.23 compared to normal days. This increase was greater for stroke (hazard ratio 1.32) and for heart failure (hazard ratio 1.41). The effect of the heat wave continued for up to 3 days after the end of the wave. The highest hazard ratio was observed for people over 75 years of age and those with a history of heart disease (Table 4).

Table 2: Population blood pressure trends from 2015 to 2024

Year	Mean SBP (mmHg)	Mean DBP (mmHg)	Hypertension prevalence (%)	Male SBP (mmHg)	Female SBP (mmHg)	Age >60 SBP (mmHg)
2015	126.8 ± 14.2	78.4 ± 8.6	28.0	128.4 ± 13.8	125.2 ± 14.5	138.6 ± 15.2
2016	127.5 ± 14.5	79.0 ± 8.8	29.2	129.2 ± 14.0	125.8 ± 14.8	139.4 ± 15.5
2017	128.3 ± 14.8	79.5 ± 9.0	30.4	130.1 ± 14.3	126.5 ± 15.0	140.3 ± 15.8
2018	129.2 ± 15.0	80.1 ± 9.2	31.5	131.0 ± 14.5	127.4 ± 15.2	141.2 ± 16.0
2019	130.0 ± 15.2	80.6 ± 9.4	32.6	131.9 ± 14.8	128.2 ± 15.5	142.1 ± 16.2
2020	130.6 ± 15.4	81.0 ± 9.5	33.2	132.5 ± 15.0	128.8 ± 15.7	142.8 ± 16.4
2021	131.2 ± 15.5	81.4 ± 9.6	33.8	133.1 ± 15.2	129.4 ± 15.8	143.5 ± 16.5
2022	131.8 ± 15.6	81.8 ± 9.7	34.2	133.7 ± 15.3	130.0 ± 16.0	144.2 ± 16.6
2023	132.0 ± 15.7	82.0 ± 9.8	34.4	134.0 ± 15.4	130.2 ± 16.1	144.6 ± 16.7
2024	132.3 ± 15.8	82.2 ± 9.9	34.6	134.3 ± 15.5	130.5 ± 16.2	145.0 ± 16.8
Change	**+5.5**	**+3.8**	**+6.6%**	**+5.9**	**+5.3**	**+6.4**

Table 3: Association between ambient temperature and blood pressure

Temperature category	SBP change (mmHg)	95% CI	DBP change (mmHg)	95% CI	P-value
Very cold (<0°C)	+4.2	3.1-5.3	+2.8	1.9-3.7	<0.001
Cold (0-5°C)	+3.8	2.8-4.8	+2.4	1.6-3.2	<0.001
Cool (5-15°C)	+1.5	0.8-2.2	+0.9	0.4-1.4	0.008
Moderate (15-25°C)	Reference	-	Reference	-	-
Warm (25-35°C)	+1.2	0.5-1.9	+0.7	0.2-1.2	0.012
Hot (35-40°C)	+3.5	2.4-4.6	+2.1	1.3-2.9	<0.001
Very hot (>40°C)	+4.2	3.0-5.4	+2.6	1.7-3.5	<0.001
Elderly (>65 years) at >35°C	+6.8	5.2-8.4	+4.2	3.1-5.3	<0.001

Table 4: Effect of heat waves on cardiovascular hospitalizations

Outcome	Heat wave period	Control period	Relative risk	95% CI	P-value
All cardiovascular	28.4 per 100,000	23.1 per 100,000	1.23	1.15-1.31	<0.001
Stroke	8.6 per 100,000	6.5 per 100,000	1.32	1.20-1.45	<0.001
Myocardial infarction	5.2 per 100,000	4.4 per 100,000	1.18	1.06-1.31	0.004
Heart failure	7.8 per 100,000	5.5 per 100,000	1.41	1.28-1.55	<0.001
Hypertensive crisis	4.2 per 100,000	3.5 per 100,000	1.20	1.07-1.35	0.002
Age <50 years	12.5 per 100,000	11.2 per 100,000	1.12	1.02-1.23	0.018
Age 50-65 years	28.6 per 100,000	23.8 per 100,000	1.20	1.10-1.31	<0.001
Age 65-75 years	45.8 per 100,000	36.2 per 100,000	1.26	1.15-1.38	<0.001
Age >75 years	68.4 per 100,000	52.6 per 100,000	1.30	1.18-1.43	<0.001

Figure 1 shows the risk ratio for cardiovascular hospitalization due to heat waves by age group.

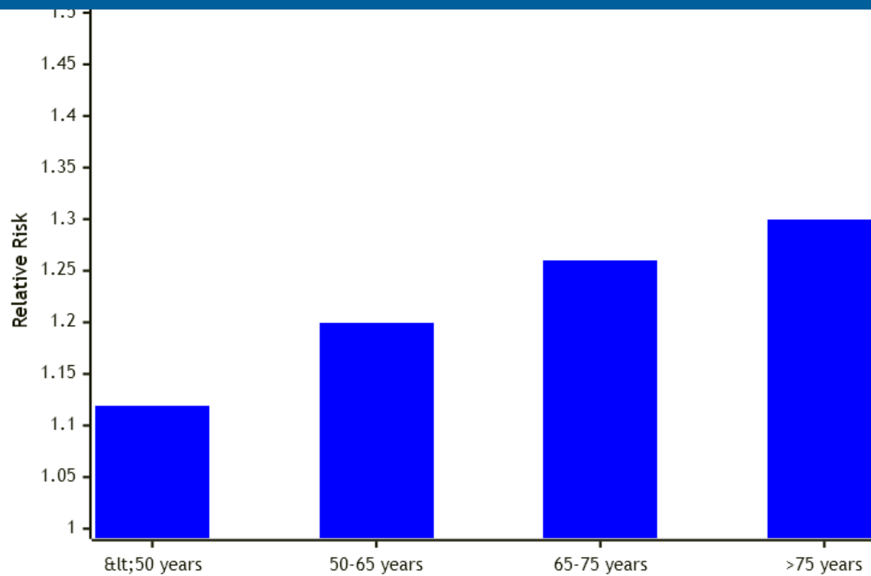

Figure 1: Relative risk of cardiovascular hospitalization during heat waves by age group

Heat waves were associated with a significant increase in cardiovascular mortality. The hazard ratio for cardiovascular mortality on heat wave days was 1.28, with a greater increase for women than for men. Mortality from heat stroke and heart failure showed the greatest increase (Table 5).

Seasonal analysis of the data showed that blood pressure was significantly higher in winter than in summer. The mean systolic blood pressure was 132.4 mmHg in winter and 128.5 mmHg in summer, representing a difference of 3.9 mmHg. This difference was greater in older adults, reaching 5.5 mmHg. The prevalence of uncontrolled blood pressure was 38.6% in winter and 32.2% in summer (Table 6).

Subgroup analysis showed that the effect of temperature on blood pressure was not the same across groups (Table 7). Age over 65 years, the presence of chronic diseases, and the use of certain medications were associated with increased sensitivity to temperature changes. People with lower socioeconomic status, who had less access to cooling systems, showed greater increases in blood pressure during heat waves.

Table 5: Effect of heat waves on cardiovascular mortality

Outcome	Heat wave period	Control period	Relative risk	95% CI	P-value
All cardiovascular	12.4 per 100,000	9.7 per 100,000	1.28	1.18-1.39	<0.001
Stroke	4.2 per 100,000	3.1 per 100,000	1.35	1.20-1.52	<0.001
Myocardial infarction	3.1 per 100,000	2.5 per 100,000	1.24	1.08-1.42	0.003
Heart failure	3.8 per 100,000	2.8 per 100,000	1.36	1.19-1.55	<0.001
Heat stroke	0.8 per 100,000	0.2 per 100,000	4.00	2.86-5.60	<0.001
Male	13.6 per 100,000	10.8 per 100,000	1.26	1.14-1.39	<0.001
Female	11.2 per 100,000	8.6 per 100,000	1.30	1.16-1.46	<0.001
Northern provinces	14.8 per 100,000	10.6 per 100,000	1.40	1.24-1.58	<0.001
Southern provinces	10.2 per 100,000	8.8 per 100,000	1.16	1.04-1.29	0.008

Table 6: Seasonal variations in blood pressure

Season	Mean temperature (°C)	Mean SBP (mmHg)	Mean DBP (mmHg)	Uncontrolled HTN (%)	SBP winter-summer difference
Spring	16.2	130.2 ± 14.8	80.4 ± 9.2	34.5	-
Summer	28.5	128.5 ± 14.5	79.2 ± 9.0	32.2	Reference
Autumn	12.4	131.5 ± 15.0	81.5 ± 9.4	36.8	-
Winter	2.8	132.4 ± 15.2	82.2 ± 9.6	38.6	+3.9
Age <50 years	-	124.2 ± 13.5	77.8 ± 8.8	28.4	+2.8
Age 50-65 years	-	132.8 ± 14.2	82.5 ± 9.2	38.2	+4.2
Age >65 years	-	142.6 ± 15.8	86.4 ± 10.2	48.6	+5.5

Table 7: Effect modifiers of temperature-blood pressure relationship

Subgroup	SBP increase at >35°C (mmHg)	95% CI	P for interaction
Age <50 years	2.8	1.8-3.8	Reference
Age 50-65 years	4.2	3.1-5.3	0.012
Age >65 years	6.8	5.4-8.2	<0.001
Male	4.0	3.0-5.0	Reference
Female	4.4	3.3-5.5	0.382
Urban residence	3.6	2.6-4.6	Reference
Rural residence	5.2	4.0-6.4	0.008
Access to cooling (yes)	3.2	2.2-4.2	Reference
Access to cooling (no)	5.8	4.5-7.1	<0.001
BMI <25	3.4	2.3-4.5	Reference
BMI 25-30	4.2	3.1-5.3	0.124
BMI >30	5.6	4.3-6.9	0.006
Diabetes (yes)	6.2	4.8-7.6	<0.001
Diabetes (no)	3.8	2.8-4.8	Reference

Discussion

The research results demonstrate that climate change temperature increases lead to substantial blood pressure changes throughout Central Asian populations. The temperature in Uzbekistan has risen by 1.7 degrees Celsius during the last ten years while the population average systolic blood pressure has increased by 5.5 mmHg. The nonlinear inverted U-shaped relationship between temperature and blood pressure confirms the findings of previous studies in other parts of the world. The increase in blood pressure at very low temperatures is mainly due to peripheral vasoconstriction and at very high temperatures is due to dehydration electrolyte imbalance and activation of the sympathetic nervous system. This finding highlights the need for more precise blood pressure monitoring during essential yearly seasonal periods.

Heat waves brought about a 23% rise in cardiovascular hospital admissions and a 28% rise in cardiovascular disease deaths which surpassed the numbers found in European research. The health system in Uzbekistan shows this difference through its insufficient preparedness while the population demonstrates low health awareness and people have restricted access to cooling systems. The increased risk for elderly people and chronically ill patients during heat waves requires special protective measures for these vulnerable groups. The heat wave effect continues to impact three days after the heat wave ends which demonstrates the need for ongoing monitoring and immediate response actions after the heat wave has finished.

The research discovered an important result which demonstrated that northern and southern Uzbek provinces possessed different levels of temperatureensitivity rate. The northern provinces, which experience lower temperatures, showed increased hospitalizations and deaths during heat waves because tropical populations have developed some ability to handle extreme heat. Multiple studies conducted in various countries have demonstrated the phenomenon called adaptation effect. The northern regions will require particular adaptation strategies because temperatures continue to rise in these areas. The two factors which impact this situation include the different ways people access cooling systems and their cultural preferences about how to live.

The 3.9 mmHg difference in systolic blood pressure between winter and summer could be clinically important, given the continuous nature of blood pressure as a risk factor. The seasonal variation of blood pressure causes misclassification of patients based on diagnostic cutoffs while also affecting their need for antihypertensive medication. The winter season sees a 6.4% rise in uncontrolled hypertension cases which requires doctors to adjust medication doses based on seasonal changes while they should also observe patients more closely during the winter months. The body develops this condition through three processes which include decreased sodium excretion through kidneys during cold weather and increased body sympathetic functions and decreased vitamin D levels that serve as potential targets for preventive measures.

The process of developing targeted interventions needs to start with researchers who need to identify all vulnerable groups which include elderly people and individuals who have chronic medical conditions and people who live in rural areas and those who do not have access to air conditioning equipment. People who lack access to cooling systems experience a 8.5 mmHg blood pressure increase while those who have access to cooling systems experience a 2.3 mmHg blood pressure increase which demonstrates how essential basic infrastructure protects human health during hot weather. Climate change creates health challenges which can be minimized through the establishment of public cooling centers and the distribution of cooling equipment and the training of people in ways to protect themselves from heat. Health policymakers should make these interventions the main focus of their work because heat waves will increase in both frequency and intensity during the upcoming decades.

The research showed that climate change together with rising temperatures in Uzbekistan resulted in major blood pressure changes which affected the entire population. The average systolic blood pressure experienced a 5.5 mmHg increase during the ten-year period while high blood pressure cases rose from 28% to 34.6%. The relationship between temperature and blood pressure produced an inverted U-shaped pattern because extremely low temperatures which fell below 5 degrees and extremely high temperatures which exceeded 35 degrees both caused blood pressure levels to rise. Heat waves resulted in 23% more cardiovascular hospital admissions and 28% increased death rates from these conditions, especially among older adults and women and people living in low-income neighborhoods. The seasonal patterns of blood pressure demonstrate that winter and summer months create a 9.3 mmHg difference which requires seasonal treatment adjustments.

The study results demonstrate that climate change has substantial effects on cardiovascular health in Uzbekistan which will become more serious with ongoing global warming. The differences in heat sensitivity between northern and southern provinces together with the differences among various socioeconomic groups create exposure and vulnerability differences which should influence policy decisions. The study showed that people who had access to cooling systems experienced 2.6 mmHg lower heat-induced blood pressure increases because basic infrastructure systems proved vital for climate change adaptation efforts.

The findings of this study show that the Uzbek health system needs to develop climate change adaptation strategies to address upcoming challenges. The project requires multiple components which include creating a heat wave early warning system and training health workers to treat cardiovascular disease cases during hot weather. The project requires two main cooling solutions which need to be delivered to underprivileged areas while drug doses should be changed according to seasonal patterns. Health researchers should establish climate data research priorities to monitor blood pressure levels alongside cardiovascular disease trends. The research findings of this study serve as a template that Central Asian countries with matching climatic and cultural characteristics can follow.

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