Effect of High Temperatures on Daily Counts of Mortality from Diseases of Circulatory System in Astana, Kazakhstan

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Summary. *Background and Objective. Associations between hot temperatures and both overall and cardio- and cerebrovascular mortality have been observed in many European, North American, and Southeastern Asian cities. However, the effects varied among the settings with limited evidence from the countries with arid and semiarid climates. The aim of this study was to assess the effect of air temperature on deaths from the selected diseases of the circulatory system in the city of Astana, Kazakhstan.*

Material and Methods. The daily counts of deaths from hypertensive diseases (ICD-10 codes, I10–I15), cerebrovascular diseases (ICD-10 codes, I60–I69), and ischemic heart disease (ICD-10 codes, I20–I25) during the warm seasons (April–September) of 2000–2001 and 2006–2010 were obtained from the City Registry Office. The associations between the maximum apparent temperature (average of lags 0–3) and mortality were assessed by a first-order autoregressive Poisson regression with the adjustment for barometric pressure (average of lags 0–3), wind speed, and effects of month, year, holidays, and weekends.

Results. Altogether, there were 282, 1177, and 2994 deaths from hypertensive diseases, cerebrovascular diseases, and ischemic heart disease, respectively. The maximum effective temperature varied between −2.2°C and 44.5°C. An increase in temperature by 1°C was associated with a 1.9% (95% CI, 0.3–3.5) increase in the daily number of deaths from cerebrovascular diseases and with a 3.1% (95% CI, 0.2–6.1) decrease in the number of deaths from hypertensive diseases among women.

Conclusions. The results suggest a positive association between the maximum apparent temperature and the daily counts of deaths from cerebrovascular diseases and an inverse association between temperature and mortality from hypertensive diseases, but only among women.

Introduction

The deleterious effects of both heat and cold on human health are well recognized (1). Although associations between hot summer temperatures and both overall and cardiovascular mortality have been observed in high-, middle-, and low-income countries, the results varied among the settings (2–10). The greater effects of warmer temperatures were observed in more-northern cities, while the effect of colder temperatures was more pronounced in more-southern locations (5). People living in cities, particularly elderly, are among the most vulnerable groups bearing a high risk of death from ambient heat exposure (2, 7). In some populations, women are more sensitive to the effects of high temperatures than men (10). Moreover, it has been suggested that developing countries are more sensitive to climate change because of a more vulnerable population and generally a less advanced public health infrastructure (3).

In spite of the fact that the effects of high temperatures on cardiovascular mortality were assessed in high-, middle-, and low-income settings with the low or average levels of cardiovascular mortality, only few studies have been performed in the countries of the former Soviet Union (11), which might be particularly vulnerable to climate change given their exceptionally high mortality from cardiovascular diseases combined with rapid aging of the population and large social inequalities. Moreover, previous studies were performed in temperate, subtropical, and tropical climates (2–10), while evidence on the effect of temperature on cardiovascular diseases from continental, semiarid, and arid climates is still scarce.

Kazakhstan is a former Soviet republic, which became an independent state in 1991. Life expectancy in Kazakhstan is among the lowest in the European

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WHO (World Health Organization) region with one of the greatest gender gaps in the world, i.e., 63.6 years for men and 73.5 years for women in 2009 (12). The diseases of the circulatory system were the main causes of death with an age-standardized mortality rate of 626.4 per 100 000 in 2009, which is higher than in most European countries (12). High alcohol consumption, high prevalence of smoking among men, high fat diet, and poor detection and treatment of hypertension are the main factors behind high cardiovascular mortality in Kazakhstan (13). The high levels of both cardiovascular mortality and risk factors for cardiovascular diseases, population aging, and rapid urbanization combined with a high variability of temperatures typical of continental and semiarid climates make the Kazakhstani population particularly vulnerable to the effects of climate change and warrant research on how the population of this Central Asian republic responds to the exposure of ambient air temperature.

The aim of this study was to assess the effect of air temperature on deaths from hypertensive diseases, ischemic heart disease, and cerebrovascular diseases during the warm period of the year in the city of Astana, Kazakhstan.

Material and Methods

This ecological study was performed in the city of Astana, which is located in the north-central part of Kazakhstan (51°10´N, 71°26´E), with a population of 709 000 inhabitants in 2010. According to the Köppen-Geiger classification, Astana is located on the border between a humid continental and semiarid climate and has cold winters and warm summers (14). The mean temperatures for January and July are −17.3°C and 20.2°C, respectively.

The daily counts of adult deaths from hypertensive diseases (ICD-10 codes, I10–I15), cerebrovascular diseases (ICD-10 codes, I60-I69), and ischemic heart disease (ICD-10 codes, I20–I25) for the warm periods (from April 1 through September 30) in 2000–2001 and 2006–2010 were obtained from the City Registry Office. This 6-month period was selected to ensure comparability with other similar studies. The data for the period between 2002 and 2005 were unavailable for the study. The data on maximum daily temperatures, humidity, barometric pressure, and wind speed in Astana for the whole study period were obtained from the National Hydrometeorological Service (Kazhydromet). The maximum apparent temperature was used as an index of discomfort related to the individual's perceived air temperature since it combines the effects of temperature and humidity and is associated with the body's ability to cool by perspiration and evaporation during hot days (9, 15). The maximum apparent temperatures were calculated using the formula:

$$AT = -2.653 + 0.994 \times T + 0.0153 \times DT^2;$$

where T is the maximum daily value of temperature, and DT is the dew point temperature (16). Given that the effect of hot weather on the deaths from the diseases of the circulatory system can be delayed, the average values for the maximum apparent temperature for lags 0–3 were used. Similarly, the average values for barometric pressure for lags 0–3 were calculated, while the data on wind speed were used with lag 0 as in other studies (9, 15).

The daily counts of deaths from the studied causes were used as dependent variables. An exploratory analysis using the countfit estimation function in the Stata software (17) revealed that the Poisson distribution provided the best fit for the data. In addition, the autocorrelations and partial autocorrelations of dependent variables showed that a first-order autoregressive regressive Poisson model should be selected for the assessment of the associations between temperature and daily mortality. Robust standard errors were used to account for heterogeneity (17). Months, years, and holidays were included in the models as binary variables, while barometric pressure and wind speed were used as continuous variables. First, a curvilinear relationship between temperature and each of the outcomes was modeled by fitting cubic splines with 7 knots from 5°C to 35°C spaced every 5°C using the UVRS program in the Stata software with a linear adjustment for covariates (18). Then, the most parsimonious model was selected by a stepwise reduction of the number of knots from 7 to the minimum using the 5% level of alpha error. The best fitting models were linear models (no knots) across the whole temperature spectrum. All analyses were performed separately by gender and age groups (18–59 years and 60 years and more).

To allow the comparisons with other studies, the analyses were repeated assuming a log-linear increase in risk above the threshold, which was set at the 90th percentile of the maximum apparent temperature as reported elsewhere (9, 15). Given the small numbers of deaths in the temperature interval above the 90th percentile, these analyses were performed without stratification by age.

All analyses were performed using the Stata 10.0 software (Stata Corp, TX, USA).

Results

Altogether, there were 282, 1177, and 2994 deaths from hypertensive diseases, cerebrovascular diseases, and ischemic heart disease, respectively, during the total study period of 1281 days. The daily counts of deaths from hypertensive diseases varied between 0 and 3 with an average of 0.22 deaths per day. The corresponding numbers for deaths from ischemic heart disease were 0, 8, and 2.34, while for deaths from cerebrovascular causes, they were 0, 5,

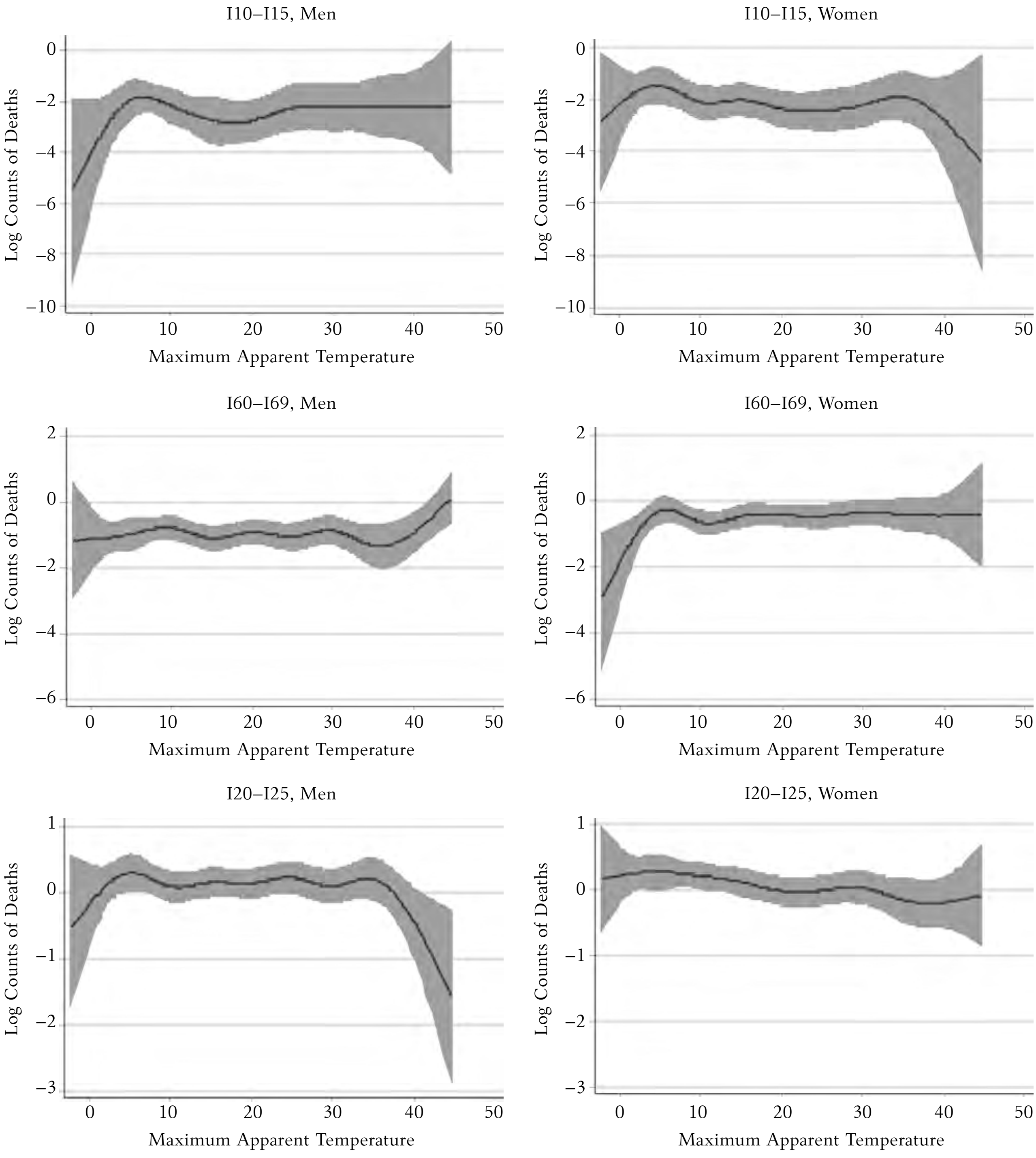

Fig. Associations between maximum apparent temperature and daily mortality from hypertensive disorders (top), cerebrovascular diseases (middle), and ischemic heart disease (bottom) during the warm season in Astana, Kazakhstan

and 0.92. The maximum apparent temperature varied between –2.2°C and 44.5°C (mean, 21.2°C). No clear pattern of the relationship between temperature and mortality from the selected diseases of the circulatory system was observed (Fig.).

When associations between temperature and mortality were assessed across the whole spectrum of temperatures, the significant effects of higher temperatures on daily death counts were found for hypertensive disorders (P=0.047) and cerebrovascular diseases (P=0.039). In the overall sample, an increase in temperature by 1°C was associated with a 1.2% (95% CI, 0.1–2.4) increase in the daily number of deaths from cerebrovascular diseases. At the same time, an increase in temperature by 1°C was associated with a 2.2% (95% CI, 0.03–4.3) decrease in the number of deaths from hypertensive diseases. No effect of temperature on mortality from ischemic heart disease was detected.

In gender-stratified analysis, the significant associations between temperature and mortality were observed for the same groups of causes of death, but only among women. While the observed association between temperature and deaths from hypertensive diseases was attributed mostly to a strong inverse effect of temperature among those aged 18–59 years (Table 1), the association between temperature and deaths from cerebrovascular diseases was mainly attributed to the effect of temperature on mortality in the oldest age group (Table 2). Moreover, an inverse association was found between temperature and ischemic heart disease, but only among women in the age group of 18–59 years (Table 3). All the other coefficients for ischemic heart disease were close to zero with relatively narrow confidence intervals.

The effect of temperature on mortality from hypertensive diseases among men in the younger age group was similar to that observed among all women, but the results did not reach the level of statistical significance because of a small number of deaths among the former (n=36, Table 1). Similarly, the coefficient for the association between temperature and the daily counts of deaths from cerebrovascular diseases among younger men was even greater than among women (Table 2), but the small number of cases resulted in a wide confidence interval that included zero.

No significant effect of the maximum apparent temperature above the 90th percentile threshold on any of the studied outcomes was found (Table 4).

Table 1. Associations Between Maximum Apparent Temperatures (Average of Lags 0–3) and Daily Counts of Deaths From Hypertensive Diseases (IDC10 Codes, I10–I15) Across the Whole Temperature Spectrum

Age Group, Years	Gender	Number of Deaths	Changes in Daily Mortality per 1°C		
			% Change*	95% Confidence Intervals	
				Lower Limit	Upper Limit
18–59	Men	36	–3.1	–8.6	2.5
	Women	28	–10.9	–17.9	–4.0
60 and more	Men	78	0.1	–4.0	4.1
	Women	140	–2.0	–5.2	1.3
All ages	Men	114	–1.1	–4.3	2.2
	Women	168	–3.1	–6.1	–0.2

*Adjusted for barometric pressure (average of lags 0–3), wind speed, month, year, holidays, and weekends.

Table 2. Associations Between Maximum Apparent Temperatures (Average of Lags 0–3) and Daily Counts of Deaths From Cerebrovascular Diseases (IDC10 Codes, I60–I69) Across the Whole Temperature Spectrum

Age Group, Years	Gender	Number of Deaths	Changes in Daily Mortality per 1°C		
			% Change*	95% Confidence Intervals	
				Lower Limit	Upper Limit
18–59	Men	128	2.5	–1.3	6.4
	Women	76	1.1	–4.3	6.5
60 and more	Men	374	–0.2	–2.2	1.9
	Women	599	2.0	0.4	3.6
All ages	Men	502	0.4	–1.3	2.2
	Women	675	1.9	0.3	3.5

*Adjusted for barometric pressure (average of lags 0–3), wind speed, month, year, holidays, and weekends.

Table 3. Associations Between Maximum Apparent Temperatures (Average of Lags 0–3) and Daily Counts of Deaths From Ischemic Heart Disease (IDC10 Codes, I20–I25) Across the Whole Temperature Spectrum

Age Group, Years	Gender	Number of Deaths	Changes in Daily Mortality per 1°C		
			% Change*	95% Confidence Intervals	
				Lower Limit	Upper Limit
18–59	Men	540	0.3	–1.4	2.0
	Women	120	–4.5	–8.2	–0.7
60 and more	Men	999	0.5	–0.6	1.6
	Women	1335	–0.6	–1.5	0.4
All ages	Men	1539	0.4	–0.5	1.4
	Women	1455	–0.9	–1.8	0.1

*Adjusted for barometric pressure (average of lags 0–3), wind speed, month, year, holidays, and weekends.

Table 4. Associations Between Maximum Apparent Temperatures (Average of Lags 0–3) and Daily Counts of Deaths From Selected Groups of Diseases of Circulatory System Above the Temperature Threshold

Group of Diseases	Gender	Total Number of Deaths	Changes in Daily Mortality per 1°C		
			% Change*	95% Confidence Intervals	
				Lower Limit	Upper Limit
I10–I15 (all ages)	Men	12	3.1	–16.9	23.1
	Women	20	2.6	–12.2	17.4
I60–I69 (all ages)	Men	53	7.7	–2.9	18.3
	Women	77	4.5	–5.4	14.3
I20–I25 (all ages)	Men	151	0.2	–5.3	5.7
	Women	137	0.5	–4.7	5.6

*Adjusted for barometric pressure (average of lags 0-3), wind speed, month, year, holidays, and weekends.

Discussion

To our knowledge, this is the first study on the effects of temperature on the daily counts of deaths from the selected diseases of the circulatory system in Central Asia. The results suggest a positive association between the maximum apparent temperature and mortality from cerebrovascular diseases and an inverse association with mortality from hypertensive diseases, but the association was significant only among women. A similar inverse association was found for ischemic heart disease, but it was limited only to younger women.

The main strength of this study is the use of a relatively large data set, i.e., the total number of deaths from the selected causes for each day during a relatively long period of 7 complete years using the most reliable source of information in Astana, i.e., the City Registry Office, to avoid potential bias, which might be present when only hospital data are used. Moreover, the use of the methods similar to those used in most international studies ensures the comparability of the findings. Maximum apparent temperature used in this study as the main exposure reflects both temperature and humidity (15, 16) and is a more appropriate indicator of discomfort than mean or maximum daily temperatures. Moreover, our study is among the first that assessed the effect of temperature on deaths from hypertensive diseases, while most other researchers have studied deaths from all the diseases of the circulatory system (8, 9, 19) or cardiorespiratory mortality (3, 8), although deaths from ischemic heart disease and cerebrovascular diseases have also been studied (10). The use of combination of deaths from cardiovascular and respiratory diseases considerably increases statistical power, and given that the coefficients for the association between temperatures are usually greater than for cardiovascular deaths alone, these studies are more likely to produce statistically significant results. However, we opted for a more detailed analysis of the diseases of the circulatory system because the effects of temperature may differ within this broad group of diagnoses as reported in elsewhere (2).

The results of the present study are in line with most other studies, which have reported positive associations between temperature and mortality from cerebrovascular diseases or cardiovascular diseases in general. However, we did not observe a V- or J-shaped association as in most European and North American studies (4–6, 9, 10, 19). The association between temperature and cerebrovascular deaths followed a linear pattern, similarly to what was observed in Beijing (2), although the effect in Astana was considerably greater. While a 5°C increase in temperature in Beijing was associated with a 6.4% increased risk, our results suggest an increase in the number of cases by 9.5% for the same increase in temperature. As in most other studies, the effect of temperature on cerebrovascular deaths was more pronounced in the oldest age group. Interestingly, an increase in the number of cases was nearly twice as high in the oldest age group in comparison with the age group of 18–59 years, while in other countries the difference was much less pronounced (7, 9, 19). The oldest age group in our study comprised persons aged 60 years and more, while in most other studies, the lower limit for the oldest group was 65 years and more (2, 3, 10, 19) or 75 years (9) complicating direct comparisons with these studies. The choice of the oldest age group can be justified by the fact that life expectancy in Kazakhstan is nearly 10 years shorter than in most countries where similar studies were performed (12). Given that the elderly are considered more sensitive to the effects of heat, the inclusion of younger cases in our study was likely to have resulted in some underestimation of the effect. A larger difference in the effects of temperature on cerebrovascular deaths between younger and older age groups in Astana combined with the fact that the older age group was younger than in other studies suggests that the elderly in Astana seem to be even more vulnerable to the effects of heat than the elderly in high-income countries. Given that the elderly have poorer health in general and the fact that elderly people in Kazakhstan are among the most socially disadvantaged and live mostly in old houses often without air conditioners may partly explain a high sensitivity of this group to the effect of hot temperatures.

From the public health point of view, the results are particularly important because cerebrovascular diseases are more common in Kazakhstan than in most European and Asian countries with an age-standardized mortality rate of 181.4 per 100 000.

No association between air temperature and deaths from ischemic heart disease was observed, which is in line with the Chinese study (2), but contradicts the results of a few European studies (10, 19), which showed an increase in mortality from ischemic heart disease parallel to an increase in temperature. Moreover, the study showed an inverse association among younger women. It is known that high temperature facilitates sweating, and the loss of fluid and salts leads to hemoconcentration (20). Heat also provokes the release of interleukin 1 and interleukin 6 into the circulatory system leading to the damage of endothelial cells that may facilitate acute cardiac events. However, no associations were found between heat and hospitalizations from cardiovascular diseases in general (15) or from acute coronary syndromes (21) in Europe, while a positive association was observed in the United States, particularly among the elderly (22). A recent review of the effects of temperature on the incidence of myocardial infarction has concluded that more research is needed to show which populations and individuals are vulnerable (23).

A similar inverse association was found between temperature and deaths from hypertensive diseases, which was also most pronounced among younger women, although negative coefficients were obtained for all age groups and both genders, except older men, suggesting robustness of this finding. It is well established that the association between the absolute values of systolic blood pressure and both indoors and outdoors air temperature is inverse (24–26), but the present study seems to be the first showing an inverse association between mortality from hypertensive diseases and air temperature on the population level.

We suggest interpreting the results of the present study and comparing them with other studies with caution taking into account its limitations. Although the design of the study was in general similar to most of the previous studies, direct comparisons are difficult due to different cutoffs of temperature, adjustments factors, and modeling techniques. Moreover, different temperatures were used in different studies, i.e., maximum temperatures (3), mean apparent temperatures (19), or maximum apparent temperatures (9). Although the data on all deaths during 7 years were collected, there was a 4-year gap for which no data were available. However, this is unlikely to bias the results because the adjustment was made for the effects of years and months using dichotomous variables; thus, the effects of each year were estimated independently. Moreover, the adjustment for years as dummy variables at least partly controls the effect of rapidly growing population of Astana. Nevertheless, even during a 7-year period, there were relatively a few cases of deaths in the days when temperature exceeded the threshold resulting in low statistical power reflected by wide confidence intervals. Another limitation is unavailability of the data on potential confounders such as ozone, black smog, suspended particles, nitrogen dioxide, and other pollutants that may be associated with both exposure and outcomes. The adjustment for ozone and PM10 levels has been shown to reduce associations between apparent temperature and mortality in both Europe (19) and North America (27). However, the effect was more pronounced in more polluted cities (9), while in Stockholm, the effect of adjustment was negligible. Given that the levels of air pollution in Astana are low, the associations observed in this study may remain the same even after the adjustment for pollutants.

Differences between the findings from different locations may reflect sociodemographic, cultural, economic, and technological differences among the settings that result in the different proportions of people susceptible to the effects of heat. International experience shows that heat-warning systems are of ultimate importance to reduce heat-associated mortality (28). Public health interventions targeting hospitals, pharmacies, and social services that deal with the elderly will be the key in reducing population vulnerability (7). Universal understanding of health hazards related to heat, planning of the built environment, and installation of air conditioners in hospitals, social care units, office buildings, and private houses may also reduce the effect of hot temperatures on mortality.

Sensitivity to hot temperatures has declined in recent decades parallel to economic improvements in high-income countries (29) and may be expected to decrease in the most developed high-income settings. Astana is a rapidly developing capital of the oil-rich Republic of Kazakhstan with considerable capital investments, newly built residential areas, and well-functioning infrastructure. Moreover, the population of Astana is generally younger, better educated, and wealthier in comparison with most other Central Asian cities. All these factors complicate the generalization of our findings to other cities in the region. Studies from larger cities in Central Asia such as Tashkent and Almaty are warranted to corroborate our findings. Moreover, further research using the data on hospitalizations or ambulance calls may further improve our understanding on the effects of hot temperatures on the diseases of the circulatory system in Central Asia. More evidence from research on urban design, housing quality, local topography, and population behavior is needed for planning effective adaptive strategies for cities in Central Asia.

Conclusions

The results suggest a positive association between the maximum apparent temperature and the daily counts of deaths from cerebrovascular diseases and an inverse association between temperature and mortality from hypertensive diseases and ischemic heart disease. These effects of temperature were observed only among women for the former two outcomes and only among younger women for the latter. Factors behind these associations warrant further research with a further-going aim to develop strategies to mitigate the effects of climate change on population health in the urban settings of Central Asia.

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Statement of Conflicts of Interest

The authors state no conflict of interest.

References

1. Menne B, Ebi K, editors. Climate change and adaptation strategies for human health. Darmstadt: Steinkopff Verlag; 2006.
2. Liu L, Breitner S, Pan X, Franck U, Leitte AM, Wiedensohler A, et al. Associations between air temperature and cardio-respiratory mortality in the urban area of Beijing, China: a time-series analysis. Environ Health 2011;10:51.
3. McMichael AJ, Wilkinson P, Kovats RS, Pattenden S, Hajat S, Armstrong B, et al. International study of temperature, heat and urban mortality: the 'ISOTHURM' project. Int J Epidemiol 2008;37:1121-31.
4. O'Neill MS, Ebi KL. Temperature extremes and health: impacts of climate variability and change in the United States. J Occup Environ Med 2009;51:13-25.
5. Curriero FC, Heiner KS, Samet JM, Zeger SL, Strug L, Patz JA. Temperature and mortality in 11 cities of the eastern United States. Am J Epidemiol 2002;155:80-7.
6. Braga AL, Zanobetti A, Schwartz J. The effect of weather on respiratory and cardiovascular deaths in 12 U.S. cities. Environ Health Perspect 2002;110:859-63.
7. Hajat S, Kovats RS, Lachowycz K. Heat-related and cold-related deaths in England and Wales: who is at risk? Occup Environ Med 2007;64:93-100.
8. Guo Y, Punnasiri K, Tong S. Effects of temperature on mortality in Chiang Mai city, Thailand: a time-series analysis. Environ Health 2012;11:36.
9. Baccini M, Biggeri A, Accetta G, Kosatsky T, Katsouyanni K, Analitis A, et al. Heat effects on mortality in 15 European cities. Epidemiology 2008;19:711-9.
10. Laaidi M, Laaidi K, Besancenot JP. Temperature-related mortality in France, a comparison between regions with different climates from the perspective of global warming. Int J Biometeorol 2006;51:145-53.
11. Revich B, Shaposhnikov D. Temperature-induced excess mortality in Moscow, Russia. Int J Biometeorol 2008;52:367-74.
12. Katsaga A, Kulzhanov M, Karanikolos M, Rechel B. Kazakhstan health system review. Health Systems Transit 2012;14:1-154.
13. McKee M, Chenet L. Patterns of health. In: McKee, Healey J, Falkingham J, eds. Health care in Central Asia. Buckingham: Open University Press; 2002.
14. Peel MC, Finlayson BL, McMahon TA. Updated world map of the Köppen-Geiger climate classification. Hydrol Earth Syst Sci 2007;11:1633-44.
15. Michelozzi P, Accetta G, De Sario M, D'Ippoliti D, Marino C, Baccini M, et al. High temperature and hospitalizations for cardiovascular and respiratory causes in 12 European cities. Am J Respir Crit Care Med 2009;179:383-9.
16. Kalkstein LS, Valimont KM. An evaluation of summer discomfort in the United States using a relative climatological index. Bull Am Meteorol Soc 1986;67:842-8.
17. Long S, Freese J. Regression models for categorical dependent variables using stata. Texas, USA: Stata Corp; 2006. p. 527.
18. Royston P, Sauerbrei W. Multivariable modelling with cubic regression splines: a principled approach. Stat J 2007;7:45-70.
19. Almeida SP, Casimiro E, Calheiros J. Effects of apparent temperature on daily mortality in Lisbon and Oporto, Portugal. Environ Health 2010;10:9-12.
20. Näyhä S. Cold and the risk of cardiovascular diseases. Int J Circumpolar Health 2002;61:373-80.
21. Goerre S, Egli C, Gerber S, Defila C, Minder C, Richner H, et al. Impact of weather and climate on the incidence of acute coronary syndromes. Int J Cardiol 2007;118:36-40.
22. Lin S, Luo M, Walker RJ, Liu X, Hwang SA, Chinery R. Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. Epidemiology 2009;20:738-46.
23. Bhaskaran K, Hajat S, Haines A, Herrett E, Wilkinson P, Smeeth L. Effects of ambient temperature on the incidence of myocardial infarction. Heart 2009;95:1760-9.
24. Jehn M, Appel LJ, Sacks FM, Miller ER 3rd; DASH Collaborative Research Group. The effect of ambient temperature and barometric pressure on ambulatory blood pressure variability. Am J Hypertens 2002;15:941-5.
25. Iwabu A, Konishi K, Tokutake H, Yamane S, Ohnishi H, Tominaga Y, et al. Inverse correlation between seasonal changes in home blood pressure and atmospheric temperature in treated-hypertensive patients. Clin Exp Hypertens 2010;32:221-6.
26. Woodhouse PR, Khaw KT, Plummer M. Seasonal variation of blood pressure and its relationship to ambient temperature in an elderly population. J Hypertens 1993;11:1267-74.
27. O'Neill MS, Hajat S, Zanobetti A, Ramirez-Aguilar M, Schwartz J. Impact of control for air pollution and respiratory epidemics on the estimated associations of temperature and daily mortality. Int J Biometeorol 2005;50:121-9.
28. Haines A, Kovats R, Campbell-Lendrum D, Corvalan C. Climate change and human health: impacts, vulnerability, and mitigation. Lancet 2006;367:2101-9.
29. Barnett AG. Temperature and cardiovascular deaths in the US elderly: changes over time. Epidemiology 2007;18:369-72.

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