Human Mortality, Seasonality and Climate in Khabarovsk, Russian Far East

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1. Background

Human health and well-being are in part a result of the complex influences of many factors, one of which is the thermal state of the climatic environment.

Negative health consequences (mortality and /or morbidity) are increasingly influenced by climate change because of increases in mean temperature. The association between heightened temperature and mortality rates is enormously important especially in regions with highly variable temperate climates.

U- or V-shaped temperature-mortality relationship is found. Optimal temperature with minimum mortality depends on climate (McMichael et al., 2008), Netherland: 16,5°C (Huynen et al., 2001); Arkhangelsk, Moscow: 18°C (Revich, 2008; Varakina et al., 2011); Montreal: 21°C (Frost et al., 1992); Brisbane: 24°C (Frost et al., 1992); etc.

The “Heat wave” approach: The impact of heat waves on human mortality in cities has been widely studied. However, little work has focused on climates characterized by very hot summers and extremely cold winters.

2. Objectives

The current research examines mortality seasonality and influence of temperature and heat waves on mortality in a thermally extreme climate zone, namely the southern part of Russian Far East (RFE) where urban climate is characterized by extremes of heat and cold. The aim is to determine the best definition of heat wave in terms of mortality, based on data for Khabarovsk, administrative center of the RFE.

3. Methods and Data

Time series plot of Index of Seasonility (IS) for all-cause mortality for Khabarovsk, 2000-2012, based on mean daily mortality for a given month.

IS = (mean mortality for a given month/mean mortality for study period) * 100

The study area has a mid-latitude monsoon climate, characterized by an extreme continental annual temperature regime.

Mortality for a heat wave: values are derived from three daily temperature statistics (1960 – 2012): minimum temperature, maximum temperature, mean temperature based on 8 three-hourly observations (Table 1).

Table 1: Khabarovsk, temperature and mortality statistics, 2000 – 2012

Index	Mean*	Stand Dev	Min	Percentile			Max
				5	50	95	
Warm period (May – September)							
Min temperature, °C	12.7	5.20	-2.4	3.4	13.2	20.5	25.9
Mean temperature, °C	17.5	4.94	2.1	8.9	18.0	24.8	30.6
Max temperature, °C	23.1	5.11	6.3	14.1	23.6	30.5	36.4
Mortality	21.9	5.00	9.0	14.0	22.0	30.0	40.0
Summer (June – August)							
Min temperature, °C	15.5	3.75	2.2	8.9	15.7	21.2	25.9
Mean temperature, °C	20.1	3.47	9.1	14.3	20.2	25.7	30.6
Max temperature, °C	25.5	3,87	12.5	18.8	25.7	31.4	36.4
Mortality	21.7	5.00	9.0	14.0	22.0	30.0	40.0

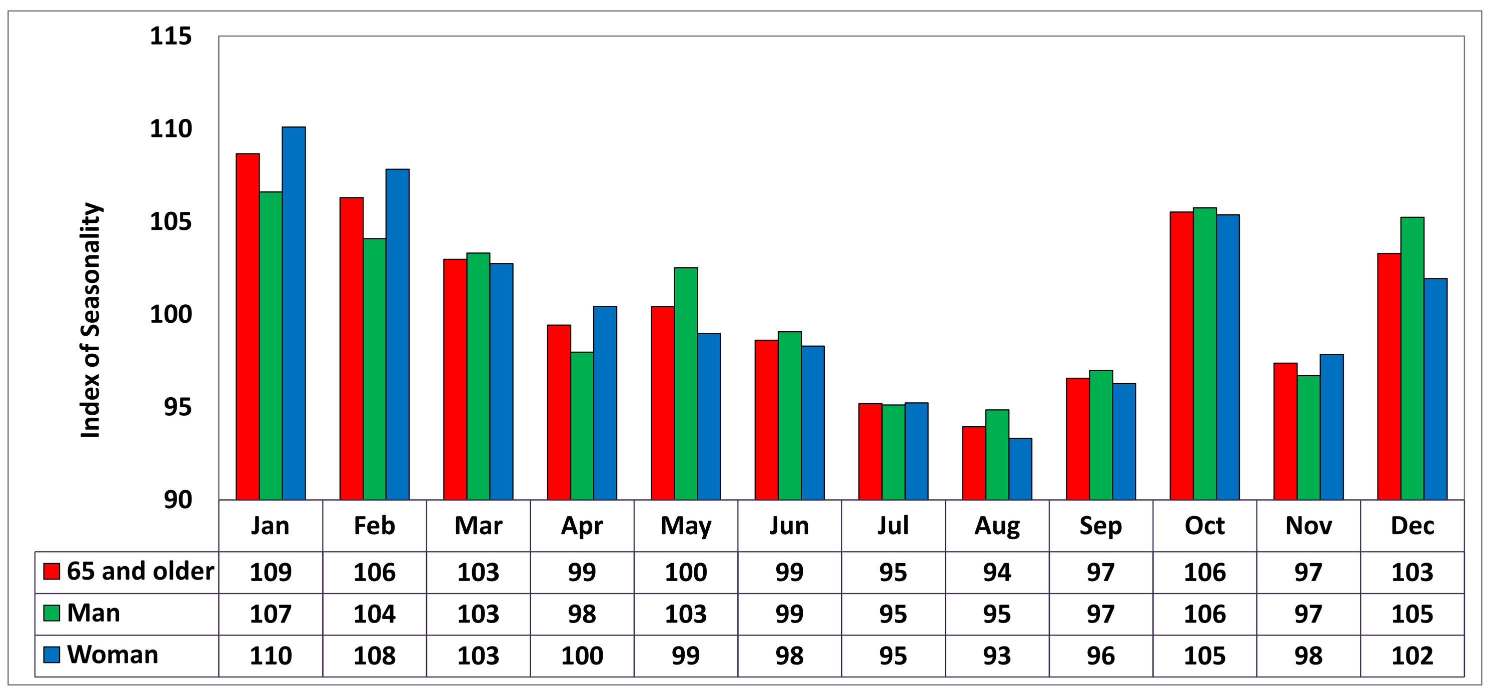

Fig. 1: Monthly Index of Seasonality (IS) for Khabarovsk for the period 2000-2012 based on mean daily all-cause mortality for men, women and both men and women, 65+

$M_1 = 23{,}28 – 0{,}110 * T_{mean}$ ($R^2 = 0{,}699$) $M_2 = 7{,}335 + 0{,}675 * T_{mean}$ ($R^2 = 0{,}842$)

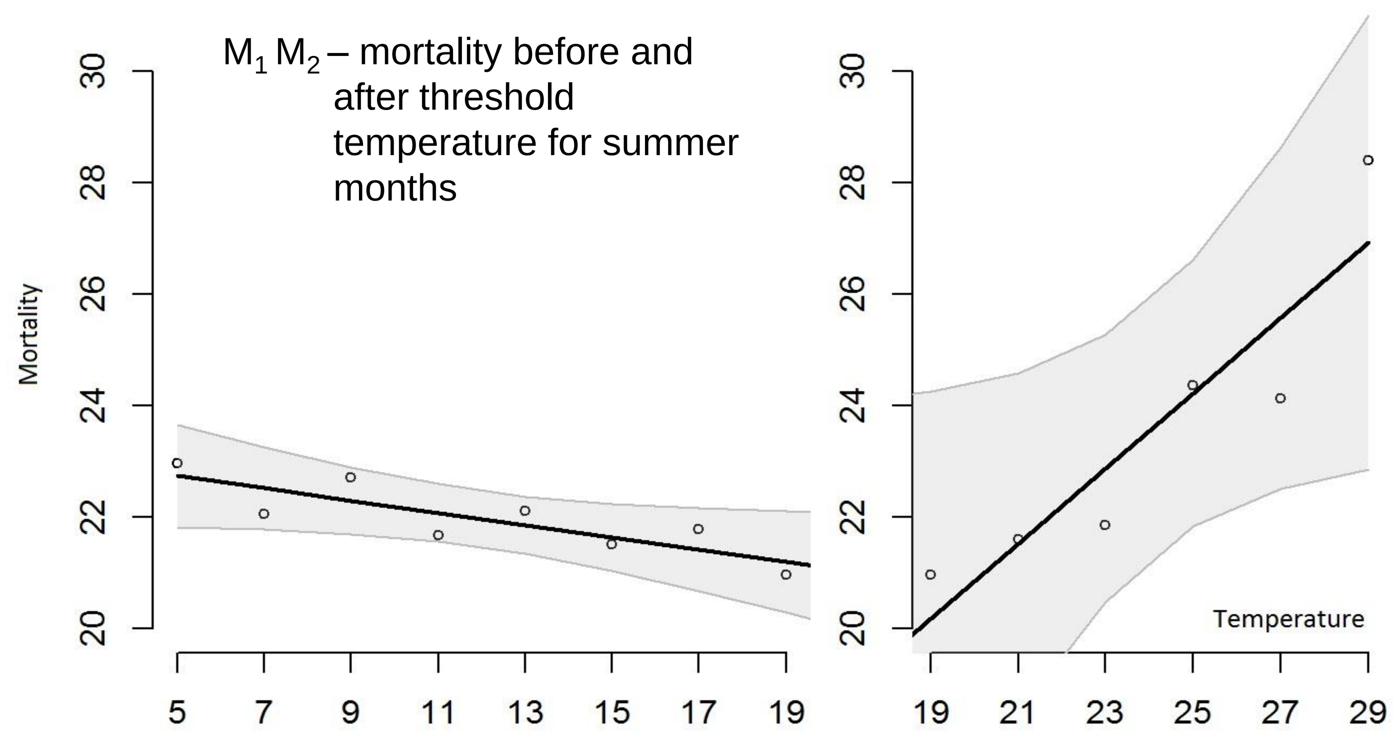

Fig. 2: Daily temperature and mortality, Khabarovsk, summer months, 2000-2012

4. Results

Female mortality is 44 %, male 56 % and elderly (65 and over) is near 51 % of all-cause mortality. The death rate is rising with age for both men and women.

Maximum level of total mortality is typical for winter with minimum values in summer. In cold period seasonality for female mortality is almost 10 % higher than for male death, in summer higher values are observed for the male population. Detailed analysis for two age groups showed maximum death rate for people of working age in the autumn period, for those aged 65 and older – in winter (Fig. 1).

A U-shaped temperature-mortality relationship for Khabarovsk is shown with minimum mortality at a threshold temperature of +19°C (Fig. 2).

A heat wave is defined as more than three days when mean daily temperature exceeds the 95% percentile for the summer months; heat wave intensity as a cumulative mean temperature excess.

A pilot study shows that summer heat wave mortality in Khabarovsk can be as much as 30% higher than the average. Heat waves of five days duration produce the highest death rates (Table 2). The fewest heat waves occurred 1960-1969. Number of heat waves is highest in the decade 1980-1989. In all cases, the longest heat waves were the most intense (Fig. 3)

Table 2: Summer Mortality and heat waves (June – August)

Different Criteria	Mortality	Excess (%)
1-day heat wave – no lag/1day lag		
Tmax_95%	**24.6/25.0**	14/16
Tmean_95%	**25.2/25.8**	17/20
Tmin_95%	**24.2/24.0**	12/11
2-day heat wave – no lag/1day lag		
Tmax_95%	**25.1/24.5**	16/13
Tmean_95%	**25.4/26.6**	18/24
Tmin_95%	**24.5/24.0**	13/11
3-day heat wave – no lag/1day lag		
Tmax_95%	**25.1/24.7**	16/14
Tmean_95%	**26.0/27.4**	20/27
Tmin_95%	**22.6/23.1**	4/11
4-day heat wave – no lag/1day lag		
Tmax_95%	**24.2/24.4**	11/12
Tmean_95%	**25.8/27.5**	19/27
Tmin_95%	-	-
5-day heat wave – no lag/1day lag		
Tmax_95%	**22.0/20.4**	1/-6
Tmean_95%	**27.8/29.5**	28/36
Tmin_95%	-	-

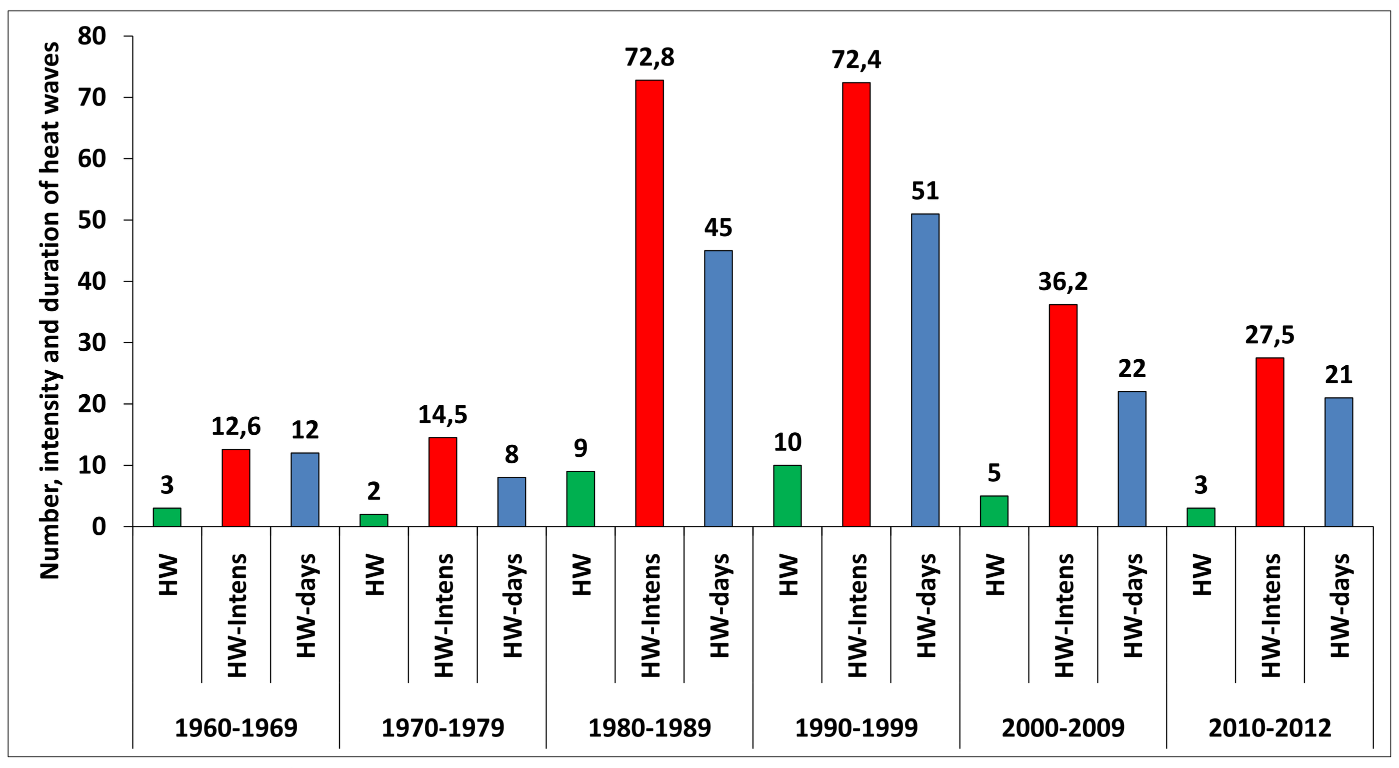

Fig. 3: Number, intensity (°C) and duration (days) of heat waves per decade for Khabarovsk, 1960 – 2012

5. Conclusion. The results show the influence of weather on indicators of population health – the definition of “optimal” or “threshold” temperature minimum mortality, characteristics of the mortality in the warm season, and during heat waves – can be used to mitigate the negative impact of weather and climate on human well-being and health.

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