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Temperature changes and ischemic heart disease mortality: global trends, 1990-2019†

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Abstract: Joinpoint regression analysis was applied to calculate the average annual percent change (AAPC) with 95% confidence interval (CI) to evaluate global ischemic heart disease (IHD) mortality trends in 1990-2019. In 2019, there were disparities by sex in terms of the contribution of non-optimal temperature to global IHD mortality: for low temperature (5.99% in males and 6.19% in females, respectively) and high temperature (0.50% in males and 0.44% in females, respectively). A decreasing trend for global IHD mortality attributed to low temperature was observed in males (AAPC= -1.7%; 95%CI= -1.8 to -1.6) and females (AAPC= -2.1%; 95%CI= -2.1 to -2.0).

Keywords: ischemic heart disease; global mortality; temperature changes.

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1. Introduction

Ischemic heart disease is the top leading single cause of death worldwide [1-3]. The World Health Organization estimated that ischemic heart disease (IHD) was responsible for 16% of the world's total deaths, i.e. IHD caused 8.9 million deaths in 2019 globally [2]. The burden of IHD, in number of deaths, continues to increase globally [1, 2]. A large increase in mortality has been reported for IHD, and this disease was responsible for over 2 million deaths more in 2019 compared to 2000 [2]. The increasing number of IHD cases and deaths is partly due to population growth and aging [4].

On the other hand, trends in IHD mortality rates in the last decade showed a progressive decline, especially in the western countries in contrast to a rapid increase in IHD burden in developing countries [5, 6]. An overall decreasing trend in IHD mortality may be explained by improvements in therapy and prevention of cardiovascular disease as well as by better health care access [5].

The Global Burden of Disease 2019 study showed that a newly included determinant, i.e. non-optimal temperature, accounted for 1.01 million deaths in males and 0.946 million deaths in females [6]. Some previous studies have indicated that non-optimal temperature is an important environmental risk factor for IHD, with both high and low temperature associated with risk of mortality from IHD [7, 8].

Climate change, including non-optimal temperature, is a large health issue humanity faces. There have only been a few studies that examined the impact of temperature variations on the global and regional variations in IHD mortality [9, 10]. The purpose of this study was to assess the association between global ischemic heart disease (IHD) mortality and temperature changes.

2. Materials and Methods

2.1. Study design

A descriptive epidemiological study design was used.

2.2. Data source

Data on deaths of IHD were extracted from the Global Burden of Disease (GBD) 2019 database [11]. The GBD 2019 database contains data for 204 countries and territories. Data for global and regional level were extracted and analyzed for the years from 1990 to 2019. Ischemic heart disease as a cause of death was defined according to the International Classification of Disease (X revision) codes I20-I25. Age-standardized rates (ASRs, per 100,000) of IHD mortality were calculated by the direct method using the GBD standard population. Also, data on contribution (%) of high and low non-optimal temperatures to IHD mortality were extracted from the GBD 2019 study [11].

2.3. Statistical analysis

Joinpoint regression analysis was applied to identify magnitude and direction in temporal trends of IHD mortality rates in 1990-2019 [12]. The Monte Carlo permutation method was used. The average annual percentage change (AAPC) with corresponding 95% confidence interval (95% CI) was calculated. Additionally, to evaluate pairwise differences, the comparability test (test of parallelism) was used to determine whether two regression mean functions were parallel. A two-sided significance level set at $P < 0.05$ for all tests was used.

3. Results

The contribution of non-optimal temperature to global IHD mortality in both sexes together in 2019 was 6.53% (for low temperature it was 6.08% and for high temperature 0.47%) (Figure 1). There were disparities by sex in terms of the contribution of non-optimal temperature to global IHD mortality in 2019: for low temperature (5.99% in males and 6.19% in females, respectively) and high temperature (0.50% in males and 0.44% in females, respectively) (data not shown).

Trend from global IHD mortality rates attributable to high temperature significantly increased both in males (AAPC= +10.9%; 95%CI= 8.2 to 13.7) and females (AAPC= +9.3%; 95%CI= 7.1 to 11.5) (Figure 2).

There were disparities by sexes in terms of the global IHD mortality rates that attributed to non-optimal temperature in 2019: for high temperature, ASR was 0.69 per 100,000 in males and 0.41 per 100,000 in females, while for low temperature ASR in males was 8.78 per 100,000 person and in females was 5.88 per 100,000 person (Figures 2 and 3).

A significantly decreasing trend for global IHD mortality attributable to low temperature was observed both in males (AAPC= -1.7%; 95%CI= -1.8 to -1.6) and females (AAPC= -2.1%; 95%CI= -2.1 to -2.0) in 1990-2019 (Figure 3).

According to the comparability test, trends in mortality of IHD by each mode of temperature change in males and females were not parallel (final selected model rejected parallelism, $p < 0.05$).

In both sexes together, a significant increase in age-standardized rates of IHD mortality attributed to high temperature was described in all regions in 1990-2019, whereby the highest rise was seen in the South-East Asia (by +13.8% per year) and African region (by 13.3% per year), followed by the Western Pacific region (by 11.9% per year) (Figure 4). A significant decrease in age-standardized rates of IHD mortality attributed to low temperature was described in almost all regions, while the only exception was the Western Pacific region where a non-significant increase was reported. The highest decline was reported in region of the Americas (by -3.2% per year) and European region (by -2.4% per year).

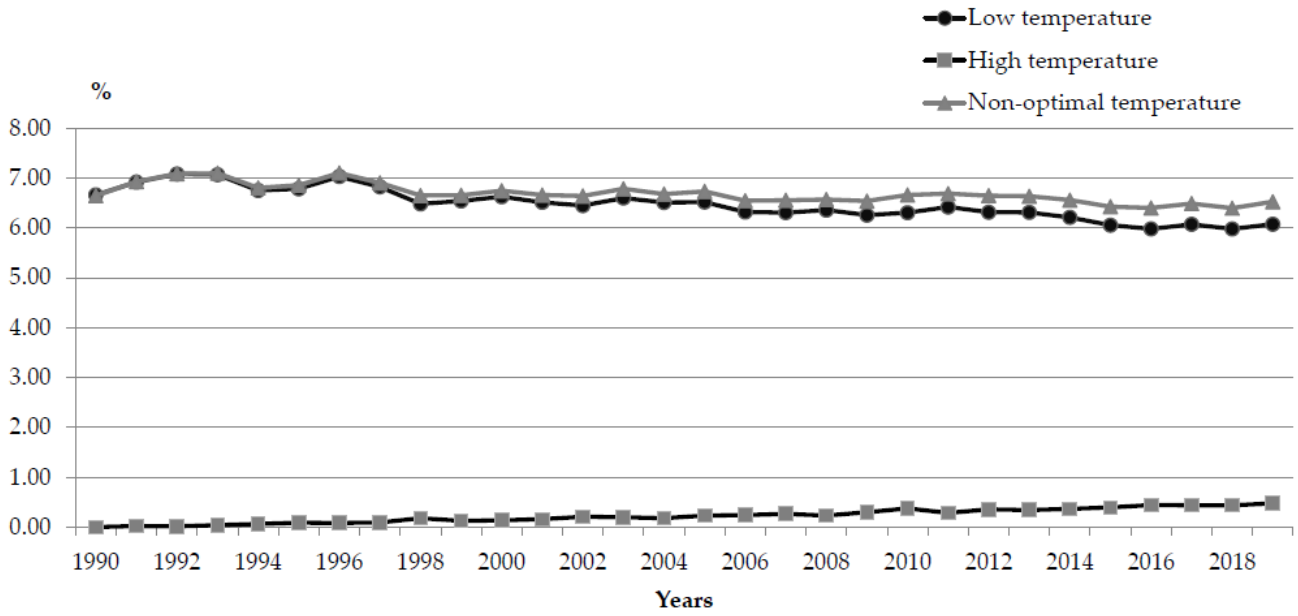

Figure 1. The contribution (%) of non-optimal temperature to global ischemic heart disease mortality in both sexes together, 1990-2019.

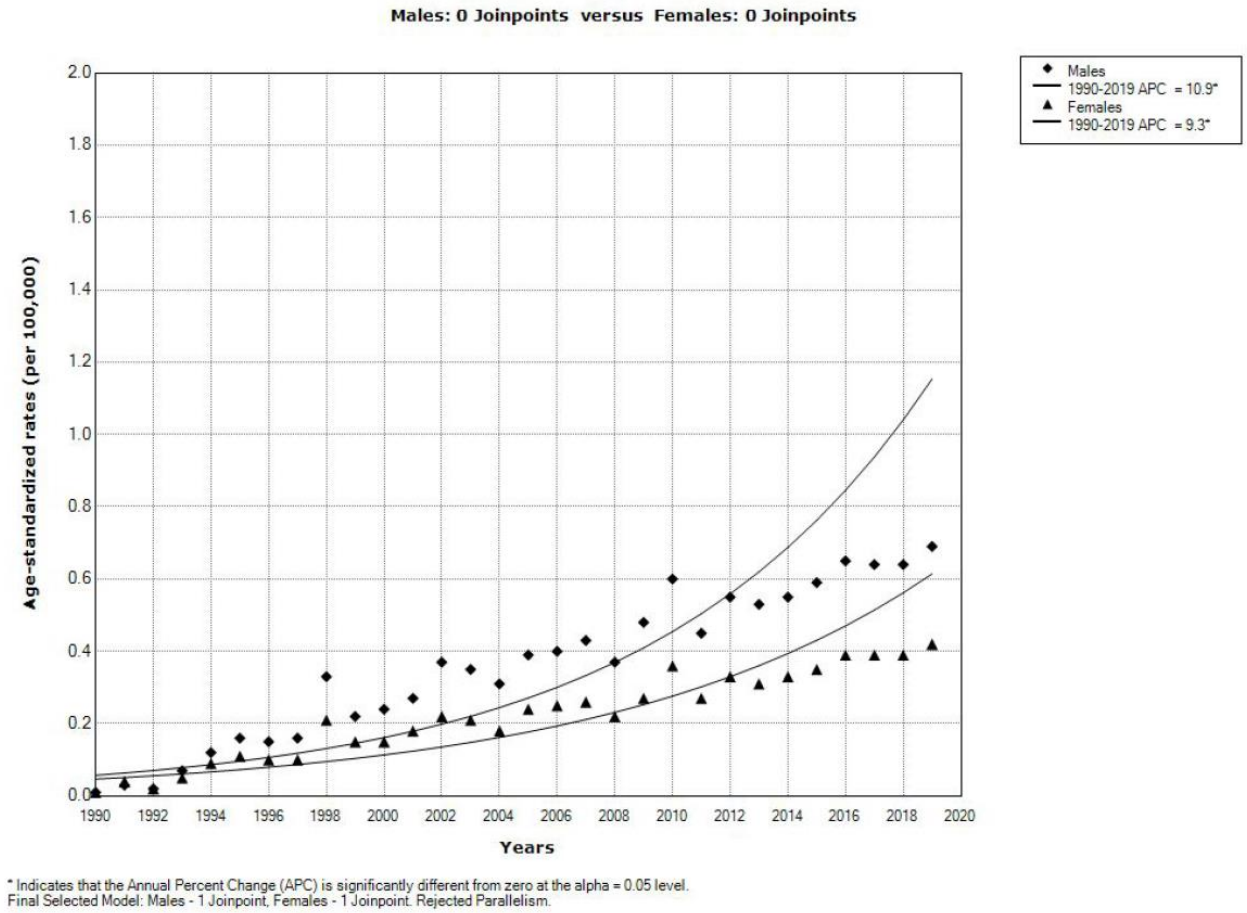

Figure 2. Global ischemic heart disease mortality rates (per 100,000 person) attributed to high temperature, by sex, 1990-2019; a joinpoint regression analysis

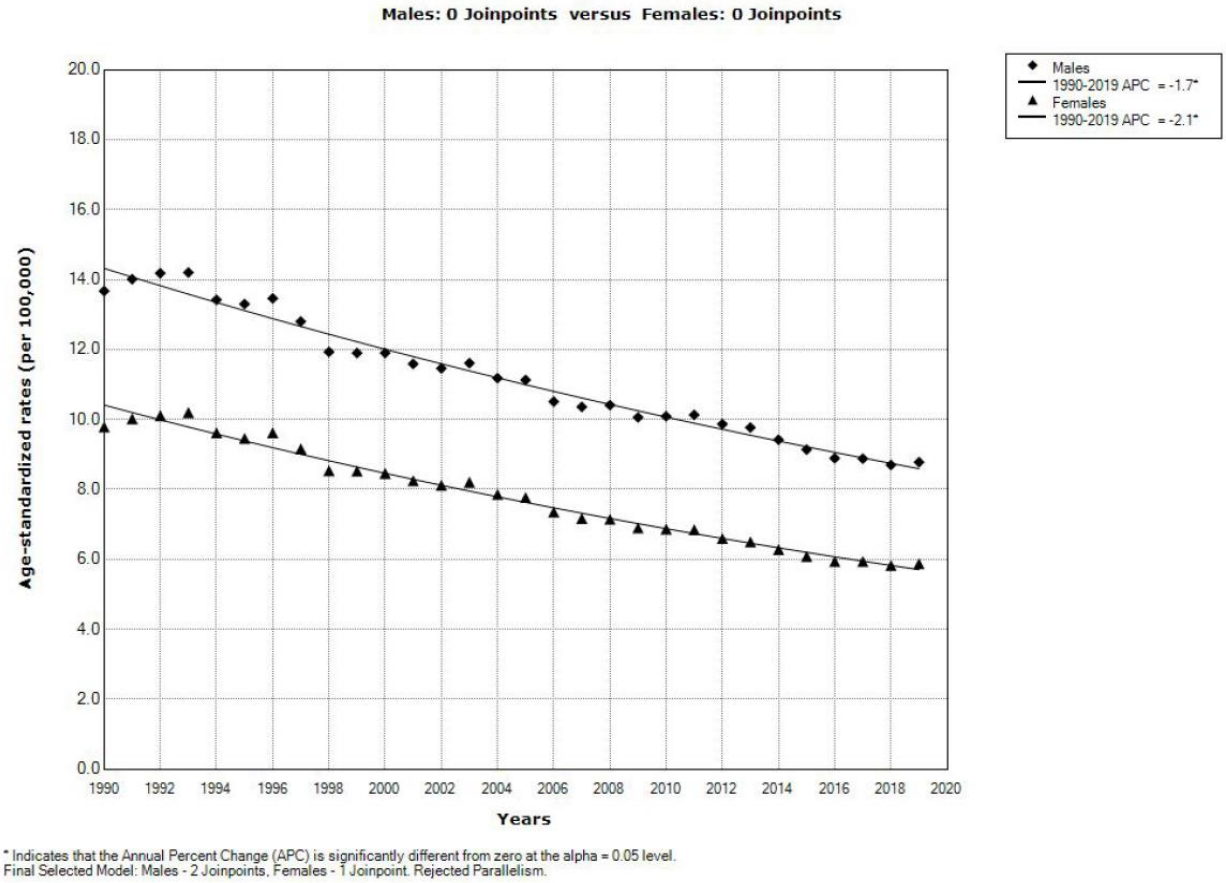

Figure 3. Global ischemic heart disease mortality rates (per 100,000) attributed to low temperature, by sex, 1990-2019; a joinpoint regression analysis

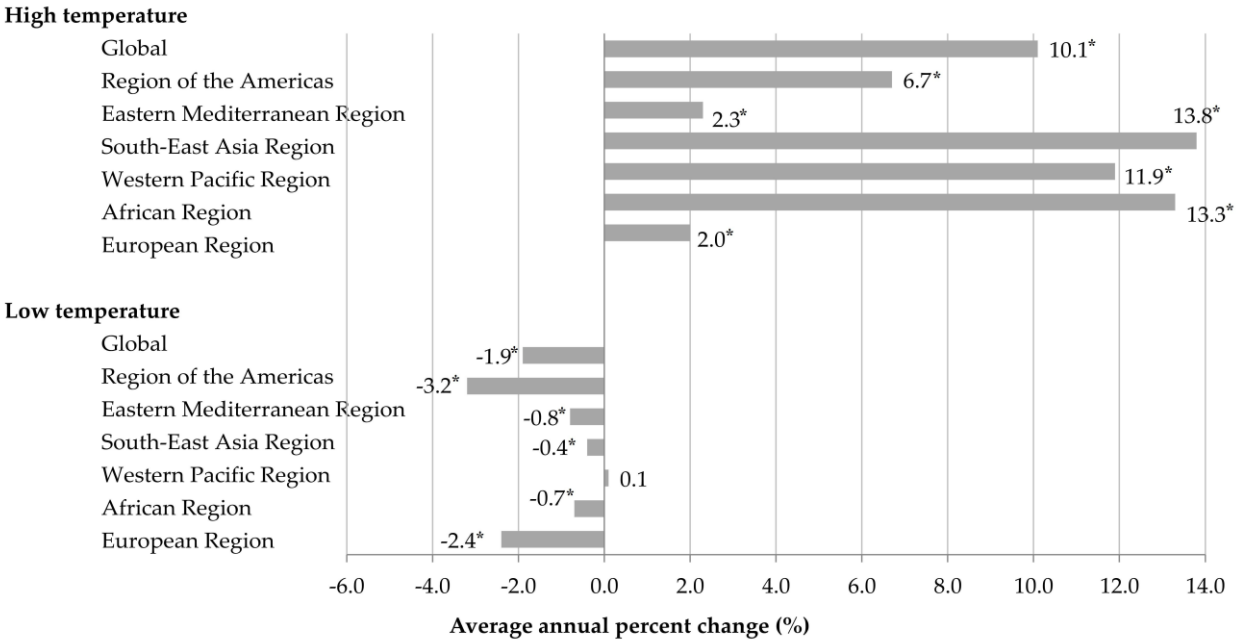

Figure 4. Global and regional trends of ischemic heart disease mortality rates (per 100,000) attributed to non-optimal temperature, in both sexes together, 1990-2019; a joinpoint regression analysis

4. Discussion

IHD due to non-optimal temperature remains a large concern to public health, because despite a decline in the last three decades it still contributes with a share of over 6% to the global burden of IHD in both sexes together. At the global level in 1990-2019, substantially higher ASRs of IHD mortality due to non-optimal temperature were experienced by men than women, both for high and low temperature.

Similar to our results, several reports indicated that both low and high temperatures were associated with increases in cardiovascular disease mortality, and constituted it among the largest global environmental risk factors for premature mortality [6-8, 13]. A previous study suggested that globally 596.8 thousand deaths from IHD were attributable to suboptimal temperature (including 555.5 thousand deaths attributed to low temperature and 43.300 thousand deaths attributed to high temperature) [7]. Using a tool from the GBD 2019 study for comparative risk assessment, Wang and coauthors assessed that the IHD deaths attributable to high temperature ranked 26th and mortality attributable to exposure to low temperature got ranked 12th among all risk factors for the IHD deaths globally from 2000 to 2019 [7].

Our study showed that regional trends in IHD mortality attributable to high and low temperature were consistent with global patterns in trends, which were found in some other studies [7, 8, 14]. Certain disparities in regional trends could be partly due to differences in incidence of IHD, implementation of prevention measures and availability of health care, but also regional differences in socio-economic status, technical adaptation to cold and heat influence across countries, other climate factors influence, via negative effects of non-optimal temperature on air pollution, etc [1, 3].

Our findings show that global IHD mortality attributed to exposure to high and low temperature among males and females significantly differs by magnitude of trends, although the trends showed similar direction. The gender disparities in IHD mortality attributed to temperature changes in the observed period could be partly linked to differences in exposure to the well-established cardiovascular risk factors, incidence of IHD, diabetes mellitus, arterial hypertension and other comorbidities, biological differences between the sexes, professional exposure, especially in developing countries [1, 3]. In conclusion, the effects of non-optimal temperature on IHD mortality need to be further elucidated in longitudinal research.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the Faculty of Medical Sciences, University of Kragujevac (Ref. No.: 01-14321, November 13, 2017), entitled "Epidemiology of the most common health disorders".

Informed Consent Statement: Not applicable. No patient approvals were sought nor required for this study. Namely, as our model-based analysis used aggregated data, patients were not involved in the research.

Data Availability Statement: Data is contained within the article.

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Conflicts of Interest: The authors declare no conflict of interest.

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