Human resilience to climate: mechanisms, adaptation and challenges

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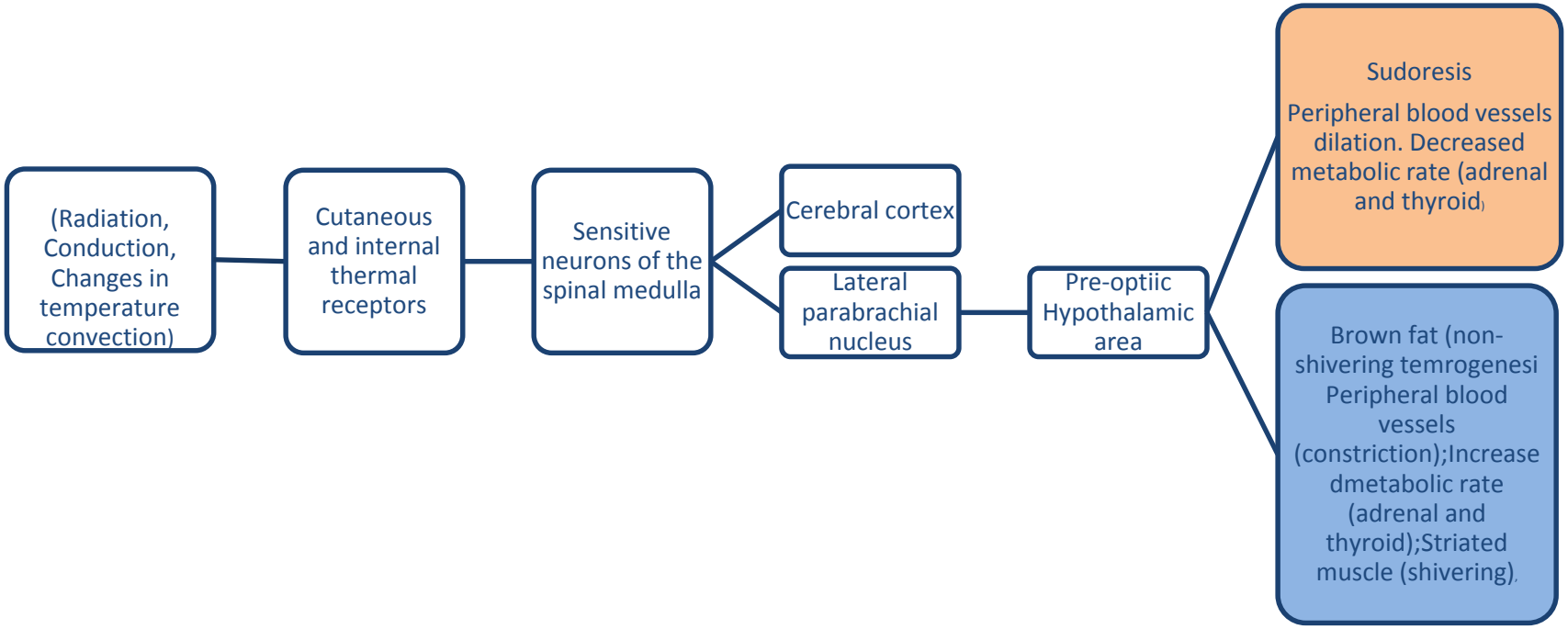
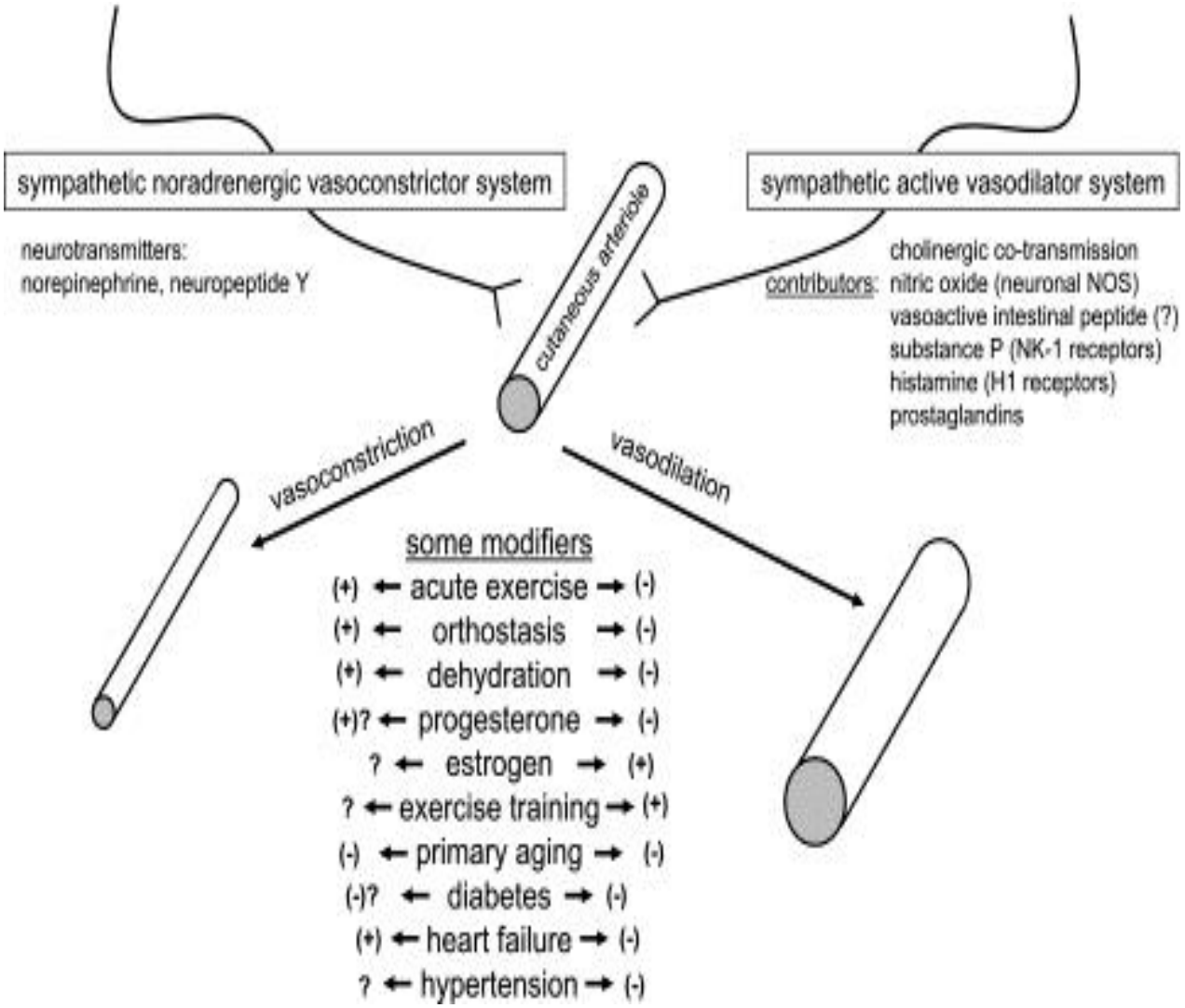
General considerations

- Adaptation to different ambient conditions made possible the consolidation of human species. The search for new habitats was associated with both genetic and epigenetic modifications of human physiology, as well as a driving force to boost human creativity, allowing opportunities to ingenuity to adapt housing, clothing and social habits;
- Along history, the process of conquering more living spaces, the migratory process to other latitudes, the capacity of adaption to cold and hot conditions, occurred within a time window of thousands of years. More recently, the migratory events produced by wars, famine and other factors, represent a new challenge to human adaptation to temperature, since people move globally in much faster speeds. In addition, global climate changes not only will promote more intense migratory events, but also, will change the regional climate in an unprecedented degree;
- Presentation of brief review of the mechanisms involved in the process of adaptation to changes in temperature, framed within the scenario of climate changes and urban heat islands. The underlying question is the how the time constant of adaptation to climate matches (or mismatches) the speed of climate changes expected to occur in a relatively short time window.


(Radiation, Conduction, Changes in temperature convection)
Cutaneous and internal thermal receptors
Sensitive neurons of the spinal medulla
Cerebral cortex
Lateral parabrachial nucleus
Pre-optiic Hypothalamic area
Sudoresis
Peripheral blood vessels dilation. Decreased metabolic rate (adrenal and thyroid)
Brown fat (non-shivering temrogenesi Peripheral blood vessels (constriction);Increase dmetabolic rate (adrenal and thyroid);Striated muscle (shivering)



J Appl Physiol (1985). 2010 Oct; 109(4): 1221–1228.

Anthropological aspects

- *Homo sapiens* emerged about 300,000 years ago in the African grasslands. Changes in body shape, partially induced by epigenetic and environmental factors, played a major role in the process of adaptation to temperature. For instance, an African cattle herder has a longilineous phenotype, with a high proportion of muscular tissue in body composition. The high surface to mass ratio helps in the process of heat dissipation during the intense outdoor physical activities, and the high muscular body composition helps to produce heat during the night due to high metabolic rate. On the other hand, the arctic hunter has a brevilineous body shape, with shorter legs and high proportion of fat tissue working as an efficient thermal insulator.
- Thermal stress also the response of peripheral vessels located in the body extremities. As general rule, cold induces constriction and the reverse situation occurs during exposure to hot conditions. These changes are transitory, lasting for few minutes. Arctic hunters have a more rapid dilation after exposure to cold, thus preventing ischemic damage to extremities, the frost bites.

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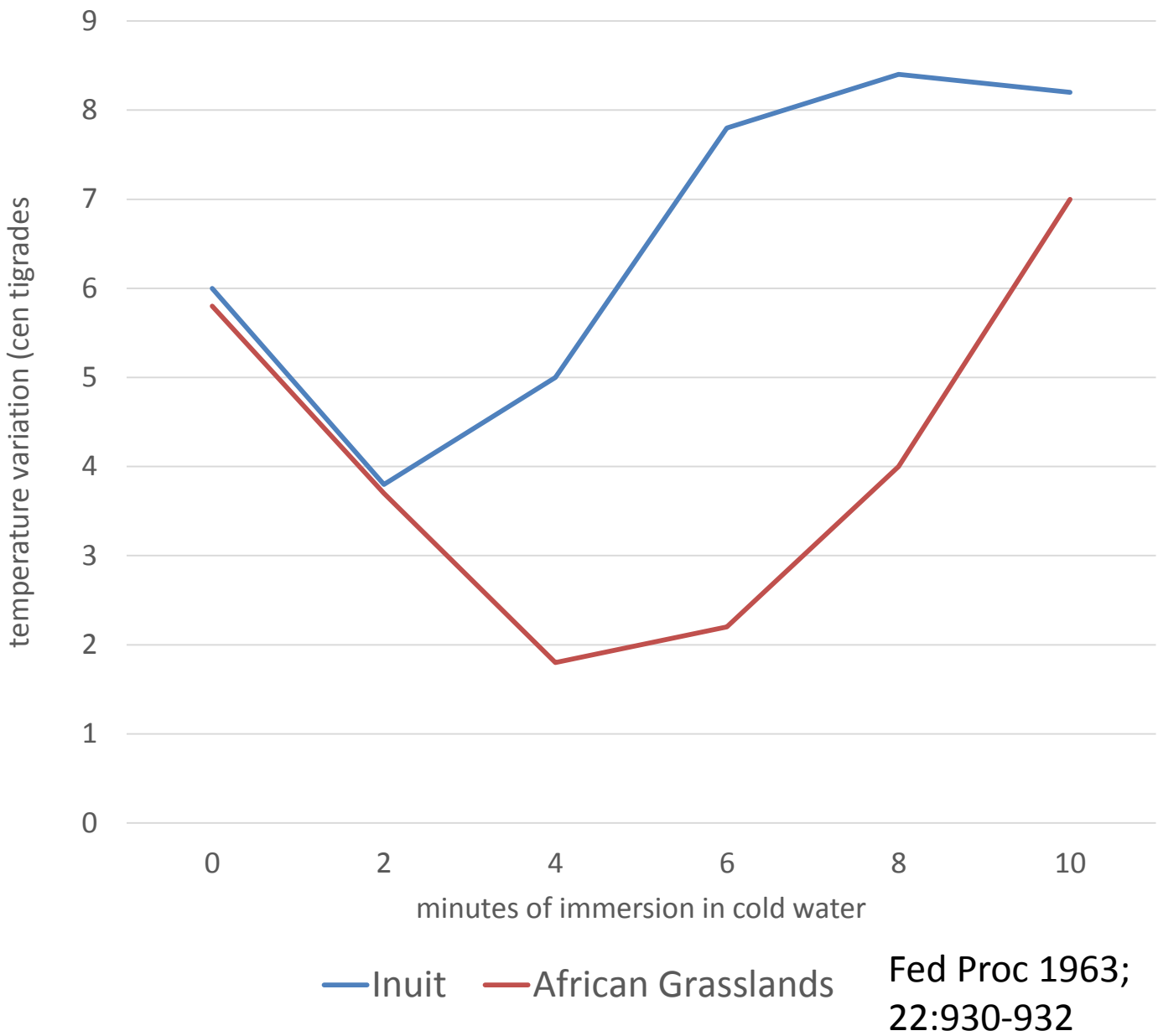
Foto: o.Ang. | 1911/1915 ca.

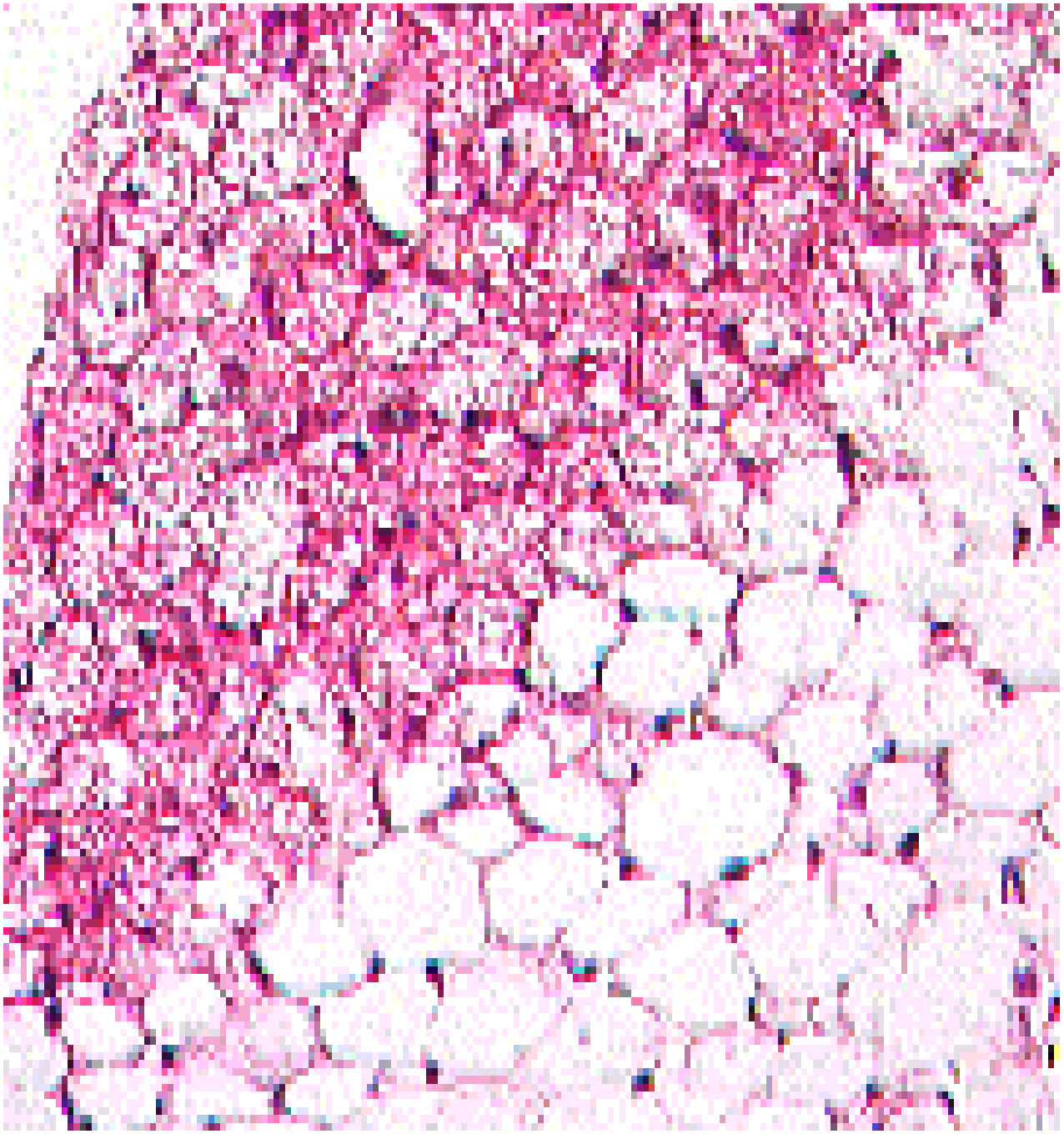


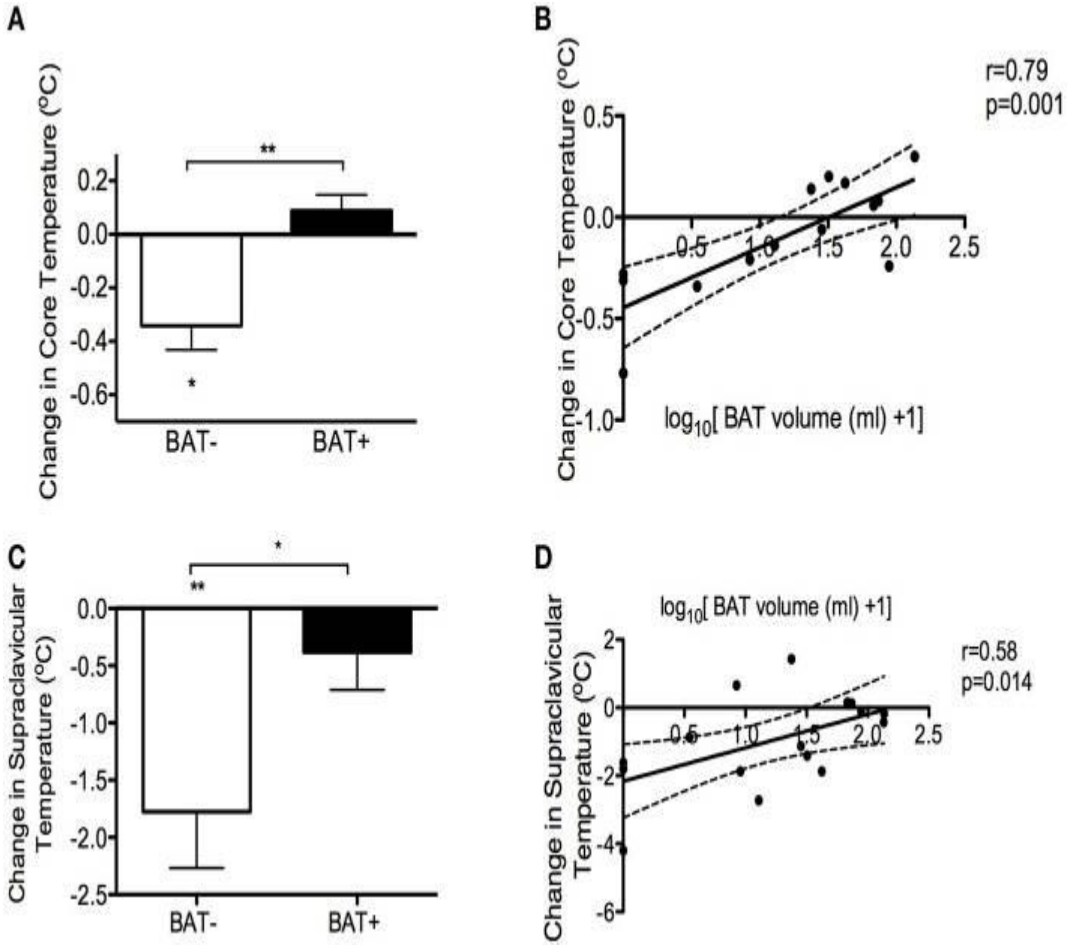
Fed Proc 1963; 22:930-932

Anthropological aspects

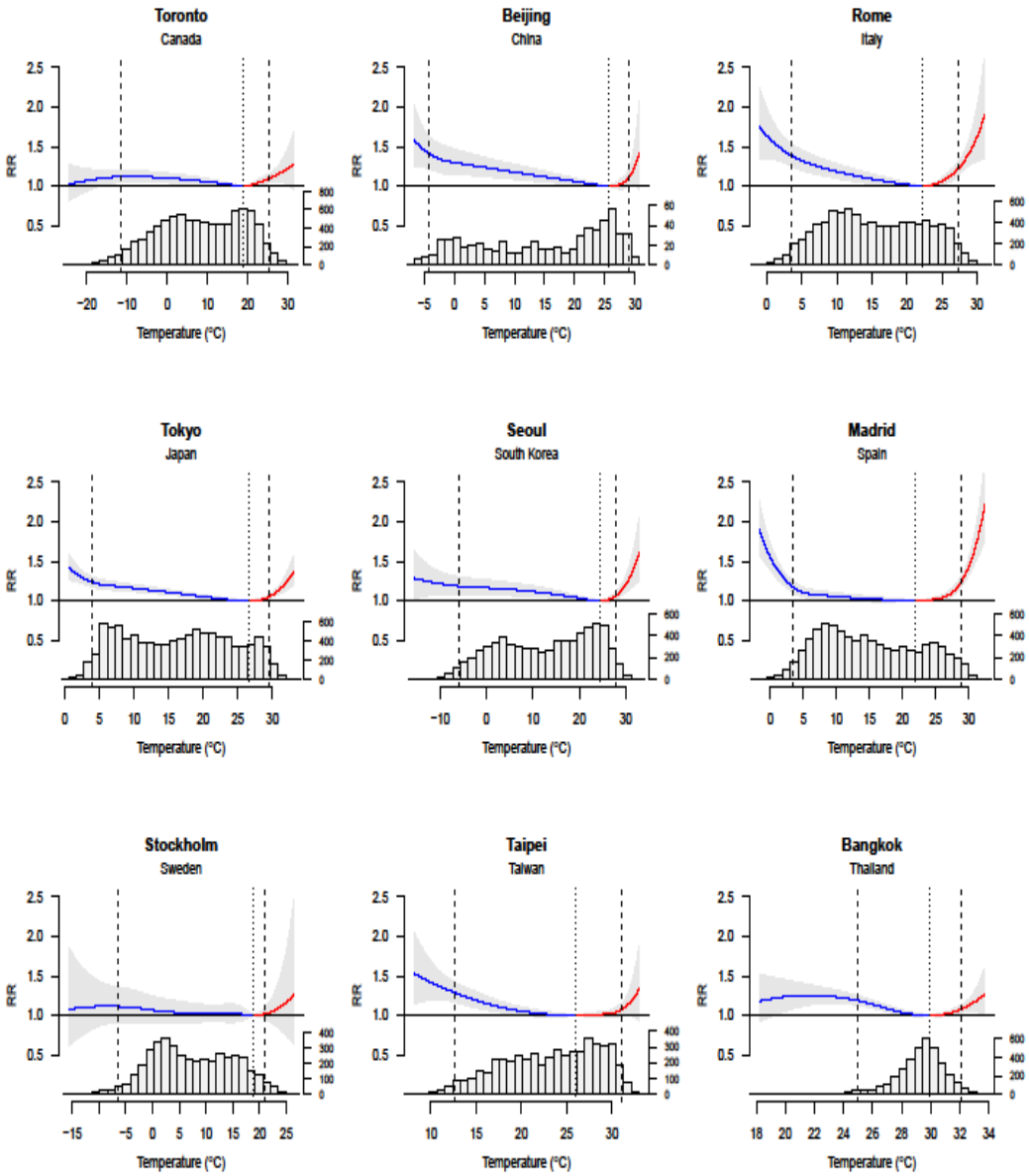
- Skin played a major role in thermal adaptation. Reduction of dermal hair to accommodate sudoriparous glands was a necessary event to adapt to the excess of sun light for first humans. In gaining an efficient sudomotor mechanism to adapt to heat, early humans had to adapt to the loss of the shield played by epidermal hair to UV radiation. Too much solar ration may oxidize dermal folate, essential for cell division, whereas too low solar radiation impedes the transformation of dermal tococalciferol in Vitamin D, a fundamental element for adequate bone homeostasis. A particular polymorphism of the melanocortin receptor gene, that promotes a higher production of melanin and eumelanin, became the prevalent in Africa. When human migration started to reach Europe, single nucleotide changes of the SLC24A5 gene (important regulator of melanin production) became advantageous for the populations living in higher latitudes, by decreasing melanin production.
- When moving towards cold climates, it was important also to regulate the perception of temperature. Recent evidences pointed out that the role of *TRPM8*

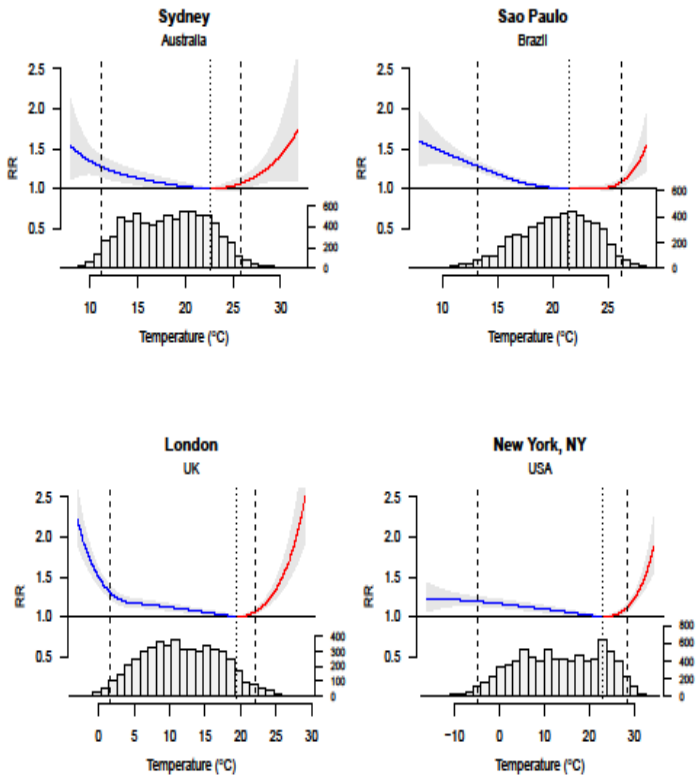
Type	Receptor	Peak Response (^{o}C)
Cold	TRPA1	5
	TRPM8	25
Warm	TRPV3	45
	TRPV4	45
Heat-pain	TRPV1	60
	TRPV2	60



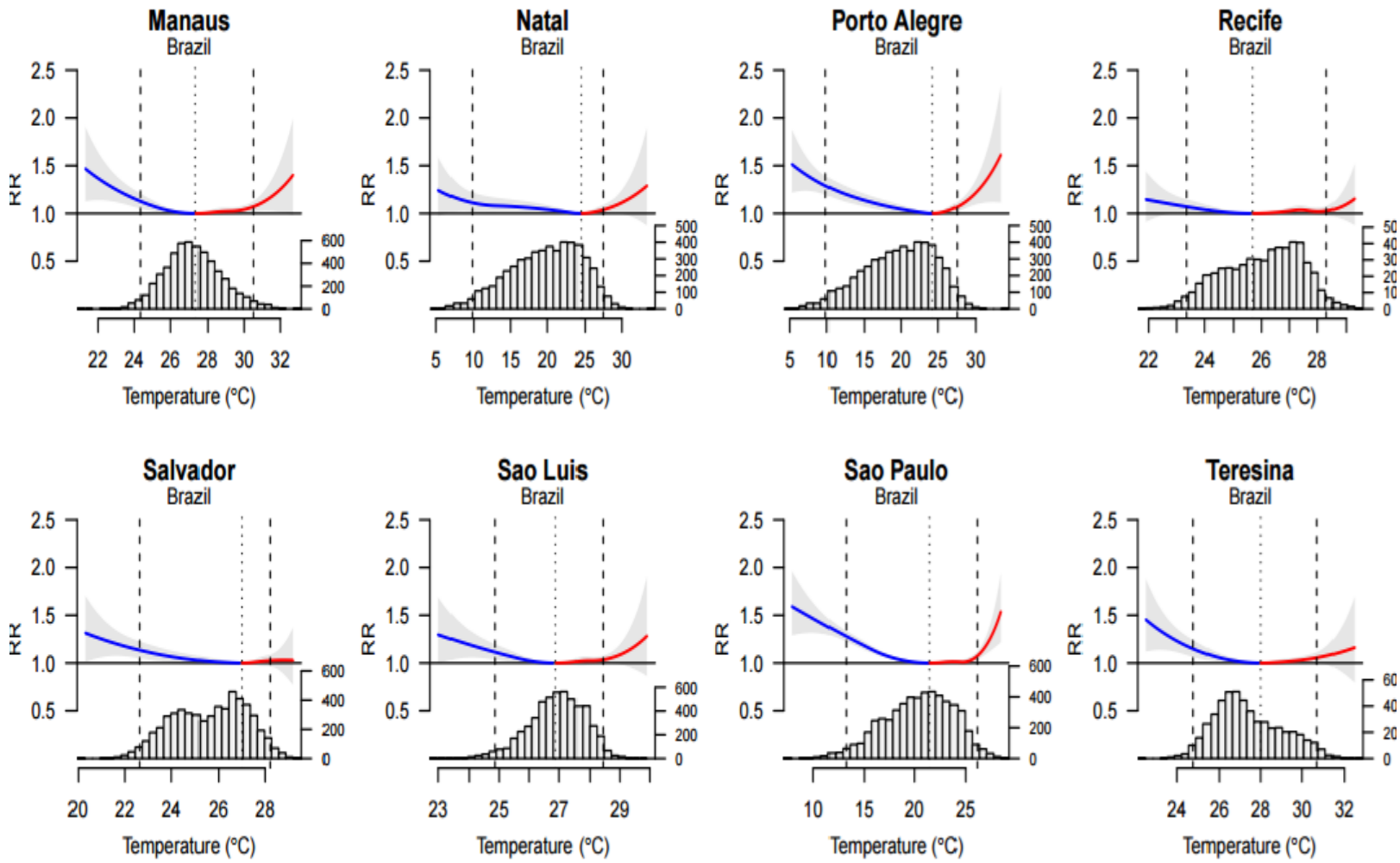


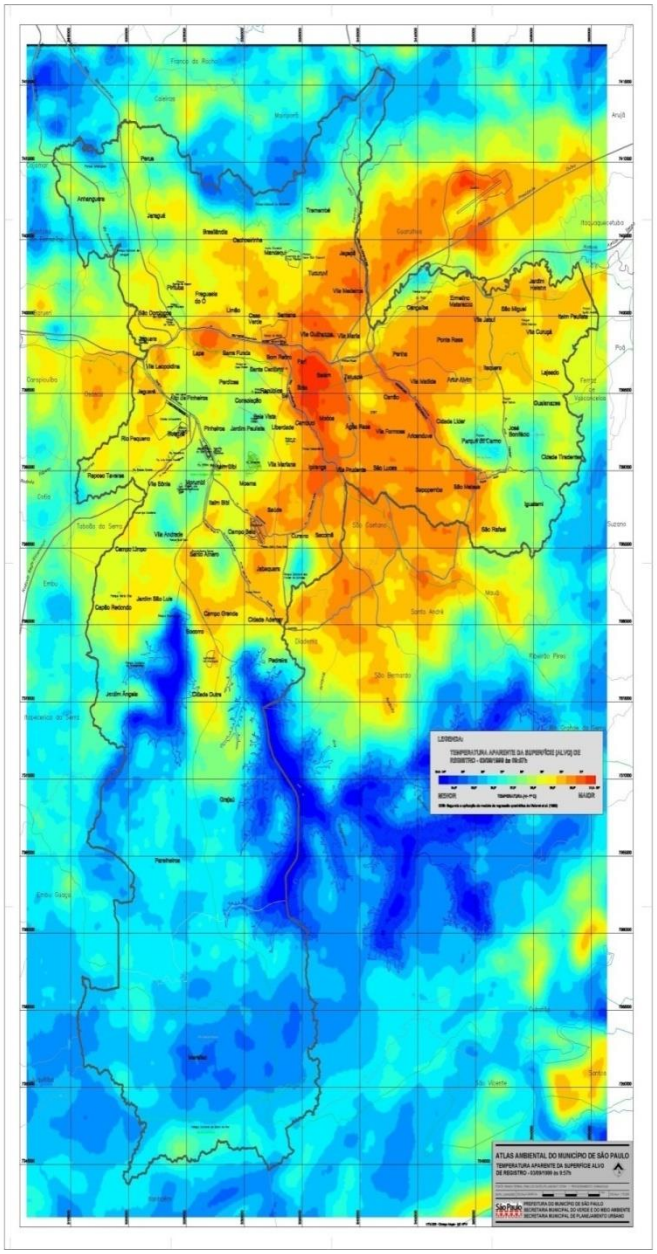
Front Physiol. 2016; 7: 129.





Lancet. 2015 Jul 25;386(9991):369-75.


Manaus
Brazil
Natal
Brazil
Porto Alegre
Brazil
Recife
Brazil
Salvador
Brazil
Sao Luis
Brazil
Sao Paulo
Brazil
Teresina
Brazil
RR
Temperature (°C)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MENOR
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PREFEITURA DO MUNICÍPIO DE SÃO PAULO
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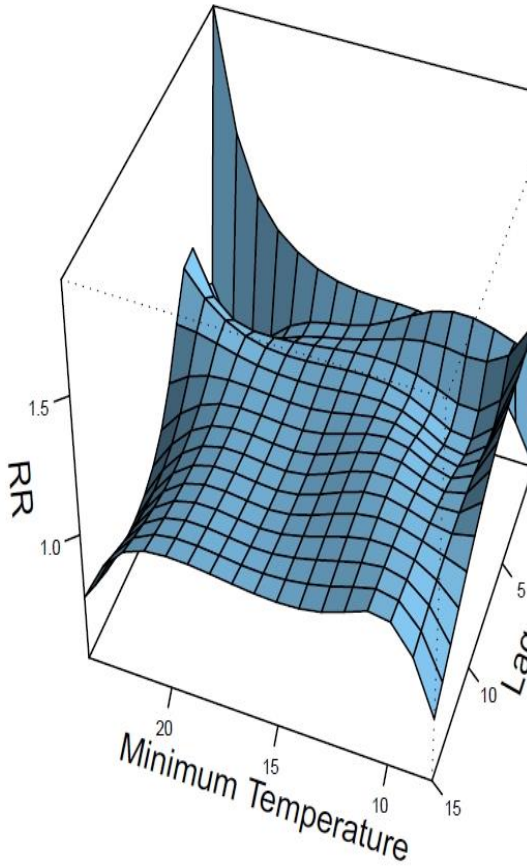


Parelheiros

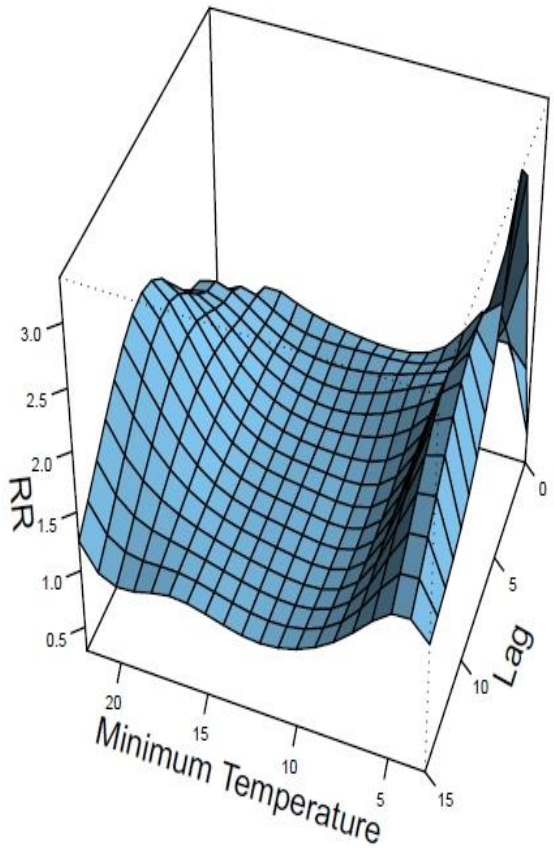
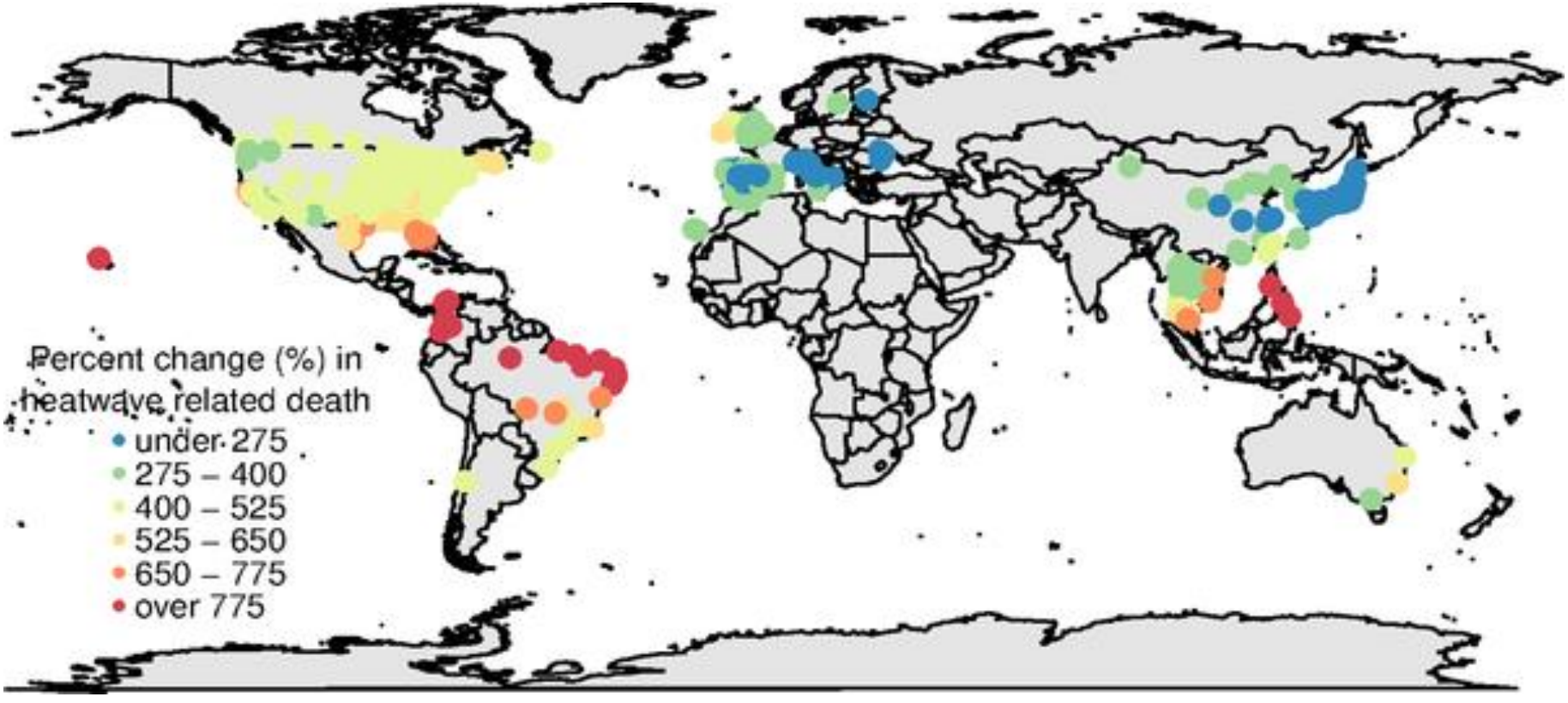
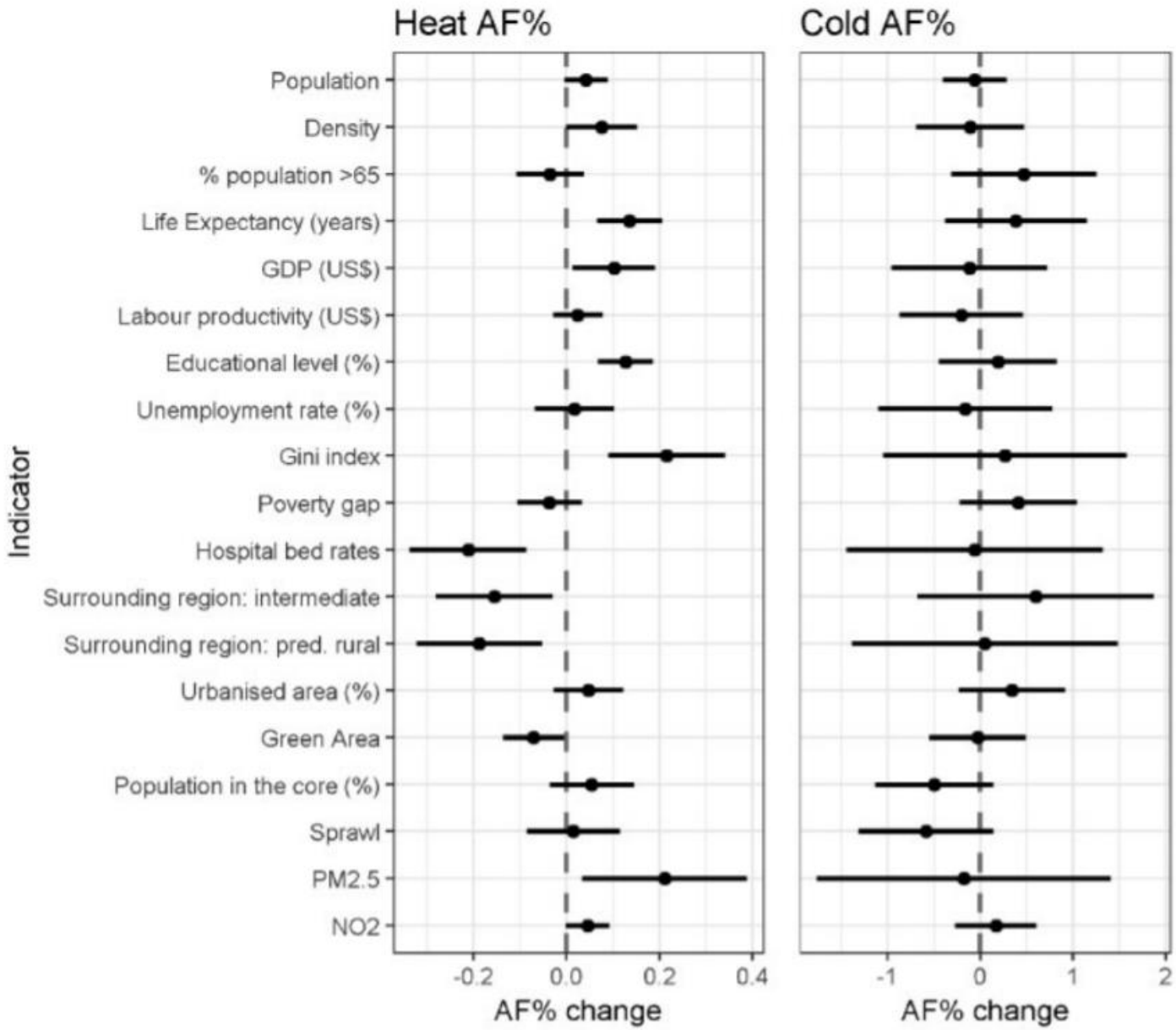
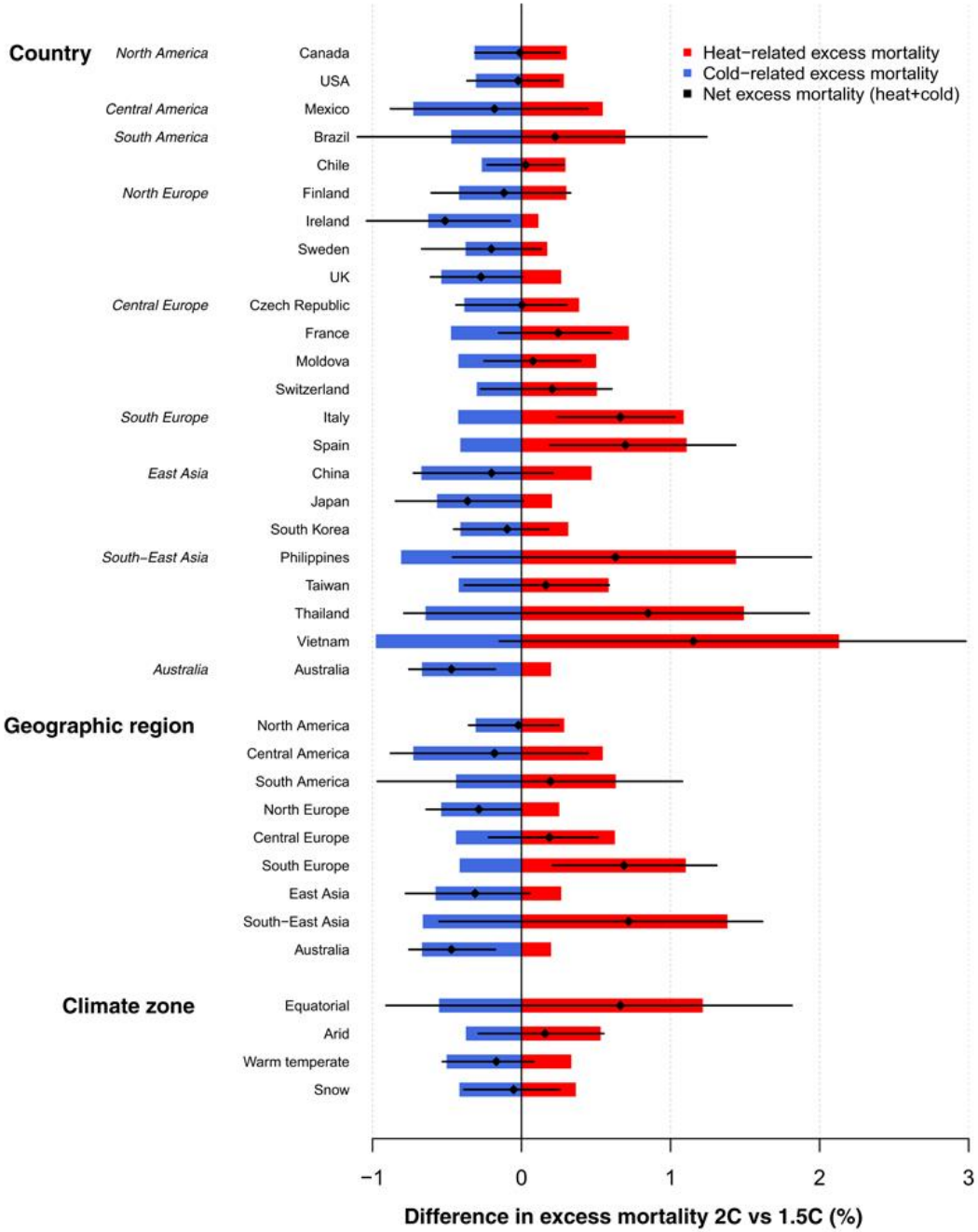


Fig 1. Locations of communities and mean percent change of heatwave-related excess deaths in 2031–2080 comparing to 1971–2020, under RCP8.5 scenario and high-variant population scenario, with assumption of nonadaptation.

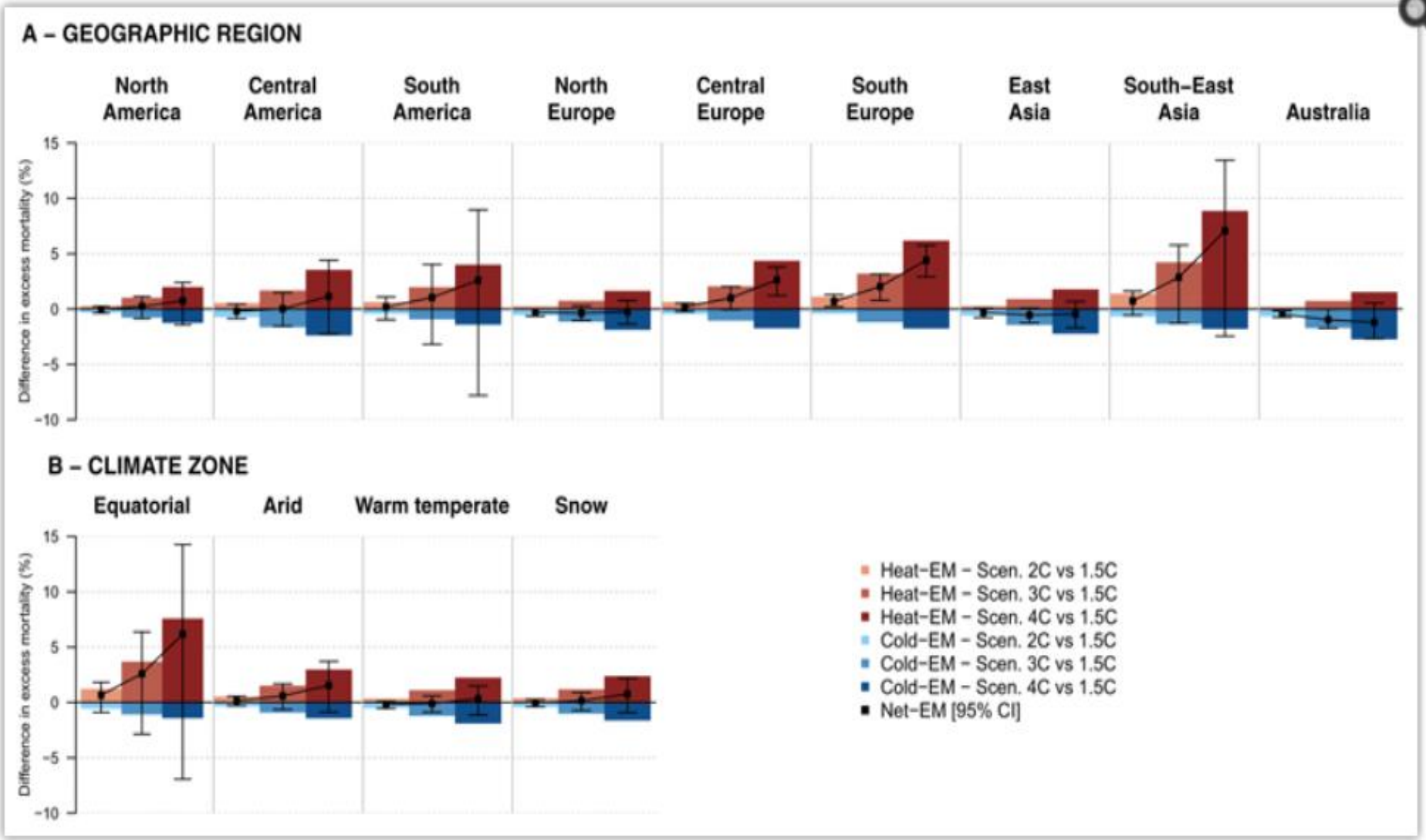


Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, et al. (2018) Quantifying excess deaths related to heatwaves under climate change scenarios: A multicountry time series modelling study. PLOS Medicine 15(7): e1002629. https://doi.org/10.1371/journal.pmed.1002629
https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1002629


Heat AF%
Cold AF%
Indicator
Population
Density
% population >65
Life Expectancy (years)
GDP (US$)
Labour productivity (US$)
Educational level (%)
Unemployment rate (%)
Gini index
Poverty gap
Hospital bed rates
Surrounding region: intermediate
Surrounding region: pred. rural
Urbanised area (%)
Green Area
Population in the core (%)
Sprawl
PM2.5
NO2
-0.2
0.0
0.2
0.4
-1
0
1
2
AF% change
AF% change



Clim Change. 2018 Oct; 150(3-4): 391–402



Clim Change. 2018 Oct; 150(3-4): 391–402.

From: **Assessment of Intraseasonal Variation in Hospitalization Associated With Heat Exposure in Brazil**

JAMA Netw Open. 2019;2(2):e187901. doi:10.1001/jamanetworkopen.2018.7901

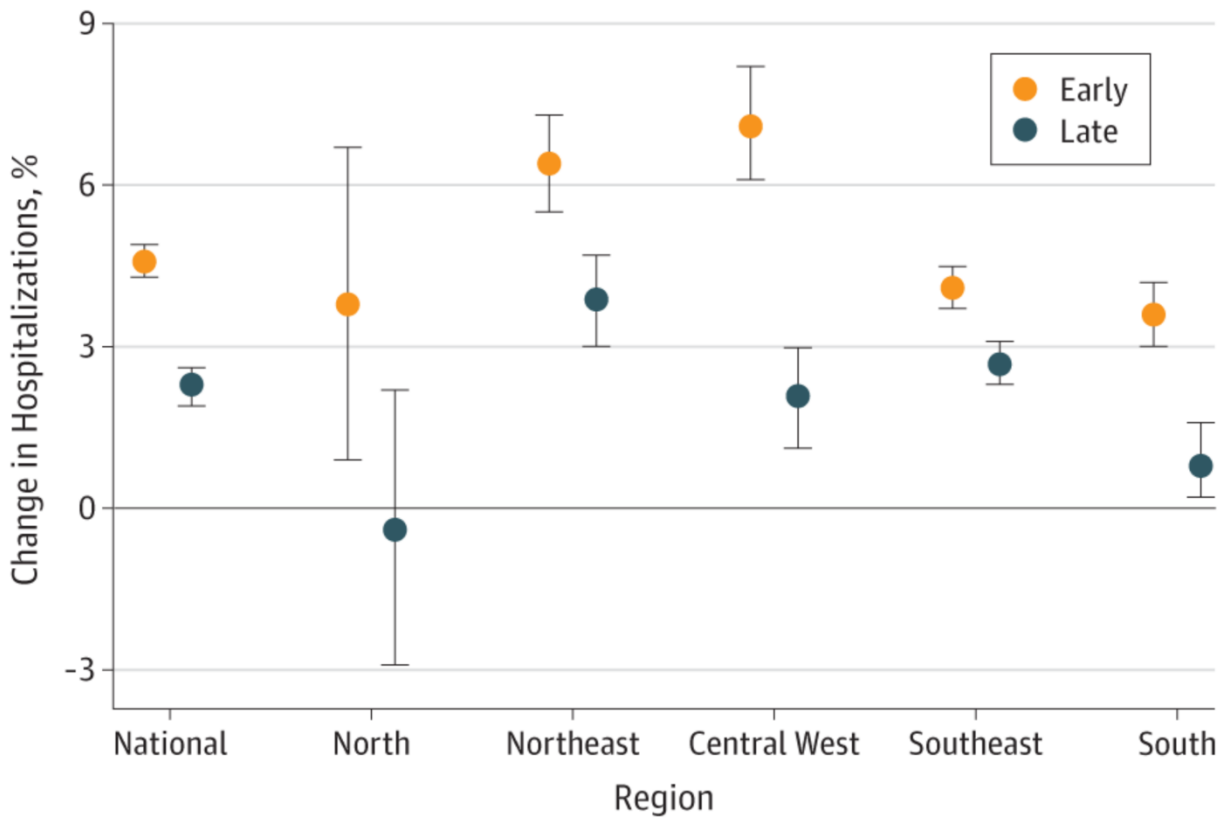


Figure Legend:

Association Between Heat Exposure and Hospitalization During the Early and Late Hot Season by RegionAssociation was described as the percentage change in the risk of hospitalization for every 5°C increase in daily mean temperature. Error bars represent 95% confidence intervals.

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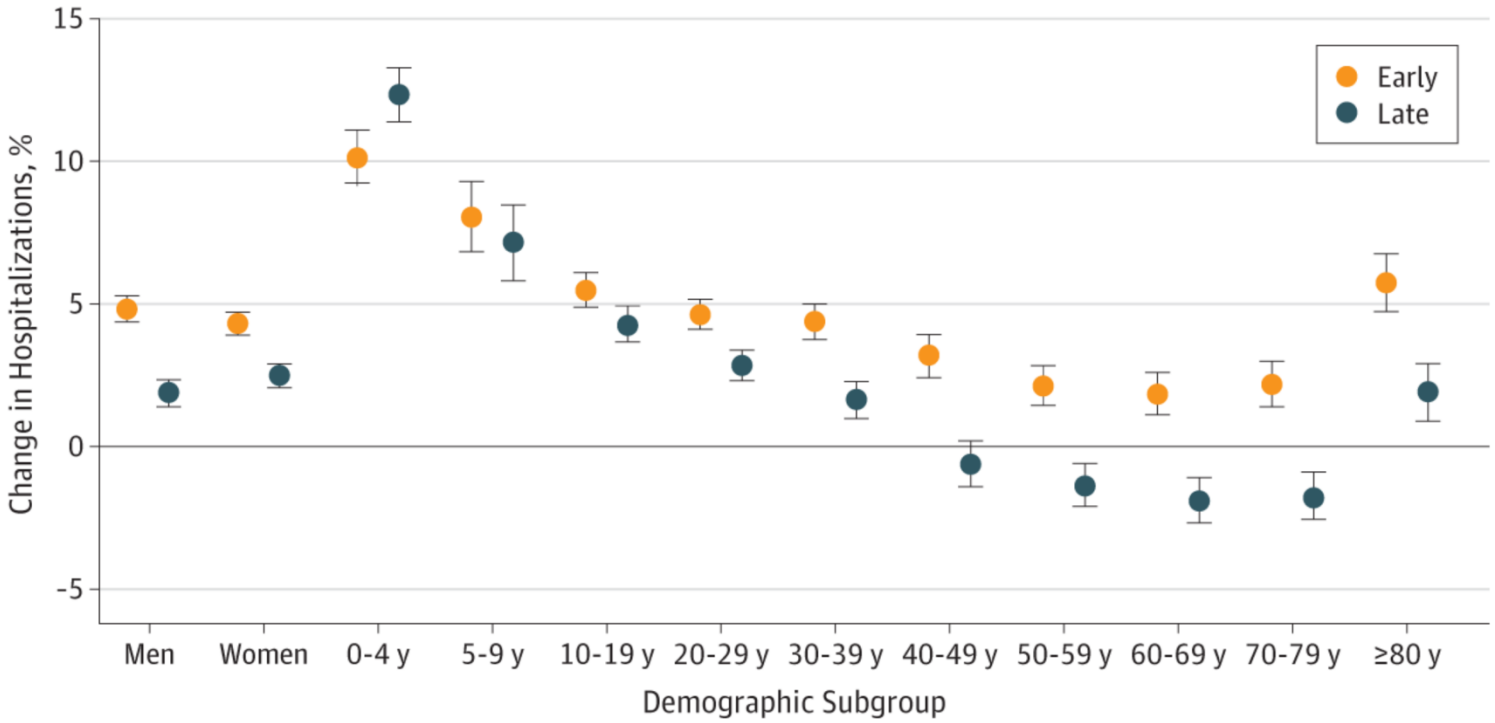

Figure Legend:

Association Between Heat Exposure and Hospitalization During the Early and Late Hot Season by Sex and AgeAssociation was described as the percentage change in the risk of hospitalization for every 5°C increase in daily mean temperature. Error bars represent 95% confidence intervals.