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Mapping the vulnerability to heat: an application in the city of Bern

Sujung Lee[1,2], Moritz Burger[2,3], Moritz Gubler[2,3], Stefan Brönnimann[2,3], and Ana Maria Vicedo-Cabrera[1,2]

[1]Institute of Social and Preventive Medicine, University of Bern, Bern, Switzerland
[2]Oeschger Center for Climate Change Research, University of Bern, Bern, Switzerland
[3]Institute of Geography, University of Bern, Bern, Switzerland

Background: Heat is widely acknowledged as one of the most hazardous climate-related risk factors affecting human health. Increasing urban development has led to an amplification of its health impacts due to the Urban Heat Island (UHI) effect. However, our understanding of neighbourhood-level vulnerability to the UHI effect remains limited. This information can be crucial for policymakers to identify high-risk areas in cities and develop more targeted public health interventions. Thus, we propose a comprehensive approach to map the vulnerability to UHI in the city of Bern (Switzerland) by (1) assessing the demographic and socio-economic factors contributing to increased UHI exposure and (2) analysing the spatial distribution of vulnerability to the UHI effect.

Methods: We collected population and household statistics at the individual level from 2012 to 2021 from the Federal Statistical Office of Switzerland. Firstly, we calculated the intensity of UHI (representing the temperature difference between the inner city and the rural surroundings) in each district of Bern using high-resolution (50mx50m) modelled urban temperature data. Next, we performed univariate logistic regression models to estimate the association between UHI exposure and population characteristics, reporting odds ratio (OR) and 95% confidence intervals (CI). We defined UHI exposure as individuals being exposed to UHI intensity exceeding the city-mean for the corresponding census year. Subsequently, we established the Heat Vulnerability Index (HVI) by selecting key determinants: 1) the elderly population (aged ≥65 years), 2) females, and 3) individuals with low socio-economic status. The overall percentile ranks for districts were calculated by summing variable rankings.

Result: First, our study identified several factors contributing to increased UHI exposure, in particular, single individuals had 60% higher odds of UHI exposure (OR:1.60; CI:1.59-1.62) compared to married individuals, and individuals aged 26-44 (1.71; 1.70-1.74) compared to those aged 0-17. Also, wealthier individuals appeared to have higher odds of UHI exposure (medium: 2.32; 2.30-2.35, high: 1.66; 1.64-1.67) compared to the lowest group. In the context of the work environment, individuals in large-size companies (≥250 employees) had an increased risk (1.85; 0.77-6.05) of UHI exposure compared to those in micro-size companies (<10 employees) and employees of public companies (1.17; 0.88-1.62) compared to their counterparts in private companies. Our results highlighted varying vulnerability patterns in different districts. In the city

centre, despite a medium HVI, UHI intensity surpassed other areas, intensifying vulnerability to heat. The western part showed lower UHI but had high HVI due to a concentration of individuals with the lowest socio-economic status.

Conclusion: Our preliminary results emphasize the importance of considering demographic and socioeconomic characteristics when assessing the impact of UHI exposure on population health. Building upon these findings, we plan to develop a heat vulnerability map of the city of Bern by applying a more advanced epidemiological analysis using Bayesian methods to assess the spatial distribution of the UHI mortality risk. This investigation will provide valuable evidence and methods to improve our understanding of the impact of UHI on health and aid in developing targeted interventions to protect at-risk communities.