District-level analysis of temperature-related excess mortality risks in the Netherlands

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Objective:
While most epidemiological studies have assessed temperature-mortality associations at broad geographical scales, recent research highlights that temperature-mortality risks are spatially heterogeneous due to local differences in exposure, vulnerability, and adaptive capacity. The aim of this study was to assess the impact of daily ambient air temperature on all-cause mortality at the district level in the Netherlands.

Materials and Methods:

A three-stage design was applied to assess the association between daily average air temperature and mortality across 3,116 districts and two age groups (0–74, 75+) for the period 2010-2019 in the Netherlands. First, a case time series design with distributed lag non-linear models was used to estimate temperature-mortality associations for each of the 355 Dutch municipalities. Second, municipality-level estimates were pooled using a meta regression. Finally, the meta regression model was used to downscale the risk estimates to the district level and to assess standardized excess heat- and cold-related mortality rates.

Results:
Cold-related excess mortality was more pronounced in northern and southern districts of the Netherlands, while heat-related excess mortality was elevated in urban and highly populated areas. During the study period, heat was associated with an average of 346 excess deaths per year (empirical 95% CI: 44–558), and cold with 11,988 excess deaths per year (7,554–15,609). This corresponds to standardized excess mortality rates of 2.2 (0.3–3.5) and 73.3 (46.8–94.7) per 100,000 persons-year for heat and cold, respectively. Effect modification was significant for age, with the 75+ group showing more pronounced mortality risk for heat and cold.

Conclusion:
Our results indicate geographical heterogeneity in temperature-related standardized mortality rates, with higher heat-related mortality in urban areas and more pronounced regional clustering of cold-related mortality. These findings can help local governments to implement climate adaptation measures to prevent heat- and cold-related excess mortality according to location-specific vulnerabilities.