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## **Effects of ambient temperature on non-communicable disease health outcomes in vulnerable populations**

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Increasing global average temperatures and growing prevalence of non-communicable disease (NCD) pose significant public health challenges. Existing evidence indicated that elderly people and populations with low adaptive capacity, such as in rural Sub-Saharan Africa are particularly vulnerable to temperature exposure. In this context, it is important to build epidemiological evidence so preventive and targeted interventions can be developed. This thesis addressed this need and presented two case studies: *i*) Study 1: a SLR/MA on the effects of ambient hot and cold temperature (excluding heat/cold wave only studies) on elderly (65+ years) NCD outcomes, and *ii*) Study 2: an empirical analysis on the impact of 11-years of heat exposure on premature death from NCDs in rural Sub-Saharan Africa.

A rigorous search strategy was applied in Study 1 (SLR/MA) to identify time series or case-crossover studies comprising cause-specific cases of elderly mortality ( $n = 3,933,398$ ) or morbidity ( $n = 12,157,782$ ). City-specific estimates were pooled to obtain a percent change (%) in risk for temperature exposure on cause-specific NCD outcomes using a random-effects meta-analysis. Study 2 was conducted at the Nouna Health and Demographic Surveillance System, Burkina Faso. 18,367 NCD-YLL corresponding to 790 NCD deaths were recorded between 2000-2010. Daily time series regression analysis was applied using distributed lag non-linear models, assuming a quasi-Poisson distribution of years of life lost. Excess mean daily NCD-YLL were generated from the relative risk of maximum daily temperature on daily NCD-YLL, including effects delayed up to 14 days. The analysis controlled for trend, season, day of the week and heaping effect.

For Study 1 (SLR/MA) a 1°C temperature rise increased cardiovascular (3.44%, 95% CI 3.10 to 3.78), respiratory (3.60%, 3.18 to 4.02), and cerebrovascular (1.40%, 0.06 to 2.75) mortality. A 1°C temperature reduction increased respiratory (2.90%, 1.84 to 3.97) and cardiovascular (1.66%, 1.19 to 2.14) mortality. The greatest NCD risk was associated with cold-induced respiratory morbidity (4.93% 1.54 to 8.44). A 1°C temperature rise increased cardiovascular, respiratory, diabetes mellitus and genitourinary morbidity in the elderly.

Temperature risks for elderly populations in Africa, Middle East, Asia and South America were severely under-represented.

For Study 2 (empirical analysis) daily average NCD-YLL over the study period were 4.6, 2.4 and 2.1 person years for the all-age, male and female groups respectively. A 4-day cumulative rise in maximum temperature from 36.4°C (50<sup>th</sup> percentile) to 41.4°C (90<sup>th</sup> percentile) resulted in 4.44 (95% CI 0.24 to 12.28) excess daily NCD-YLL for all-ages. Further elevation of maximum temperature to 41.7°C (95<sup>th</sup> percentile) increased the excess daily mean NCD-YLL to 4.98 (0.38 to 13.38). The onset of heat effects was rapid, diminishing in statistical significance after 4 days at the 95<sup>th</sup> percentile; the strongest health effects manifested on the day of heat exposure (lag 0), where 0.81 (0.13 to 1.59) excess mean NCD-YLL occurred daily at 41.7°C compared to 36.4°C. At lag 0, daily excess mean NCD-YLL were higher for males 0.58 (0.11 to 1.15) compared to females 0.15 (-0.25 to 0.93) at 41.7°C versus 36.4°C.

The results in these two vulnerable groups revealed that temperature is an important environmental exposure, associated with death (including premature death) or illness from NCDs in the elderly or inhabitants of Nouna. A wide range of NCDs including cerebrovascular, cardiovascular, diabetes, genitourinary, and respiratory outcomes were associated with increased death or illness in the elderly. These risks will likely increase with climate change and global ageing. In rural Sub-Saharan Africa, where NCDs are not the main cause of premature death, moderate and extreme heat exposure were found to increase excess daily premature mortality from NCDs. As NCD prevalence grows in Africa owing to demographic, dietary and lifestyle changes, climate change will increasingly contribute as a risk factor towards the burden of deaths from NCDs. Subsistence farming communities in Africa, such as Nouna, would therefore benefit from the development of early preventive measures to curb heat-associated NCD deaths.