# Extreme heat and health in old age

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## Introduction

The predicted increase in hot days determined by climate change poses a challenge for human health. Several studies documented heat to increase the mortality rate in several climatic contexts (Barreca et al., 2016; Barreca, 2012; Gasparrini & Armstrong, 2011), as well as a link between extreme temperatures and morbidity (Bakhsh et al., 2018; Oudin et al., 2011; Ye et al., 2012; Zhao et al., 2019). Nevertheless, some sociodemographic groups are more exposed to the risks that exposure to heat entails.

Age increases the risk of cardiovascular diseases (CVDs) (Hassen et al., 2020). The weakening of the cardiovascular system with aging increases the likelihood of failures in thermoregulation following exposure to heat, that could lead to heat stroke (Ye et al., 2012) and cardiovascular mortality (Khraishah et al., 2022). In fact, high temperatures put the human body under additional stress as the body needs to perform an extra effort to keep the internal temperature at a comfortable level of 37°C (Cheshire, 2016).

Health deterioration and CVDs, but also vulnerability to high temperature, differ in the older population according to socio-economic status (SES) (Hajat & Kosatky, 2010). More precisely, disparities in exposure, sensitivity and social and medical support shape SES-related vulnerabilities (Hajat & Kosatky, 2010). Disparities in exposure are related to the higher likelihood of low SES individuals to live in the hottest neighbourhoods of cities (Hsu et al., 2021). Similarly, highly educated individuals are more resourceful and able to afford better housing and thermally controlled indoor environments (Gronlund, 2014). Disparities in sensitivity are expected as low SES individuals have a weaker cardiovascular system and are more likely to have pre-existing CVDs. Lastly, high SES individuals are more likely to have access to good quality medical care and social support that is critical with exposure to high temperatures. Overall, socio-economic status might be a crucial factor in the relation between extreme temperature and older individuals' health.

In the present work, we try to extend the current understanding of the impact of extreme temperatures on morbidity (Oudin et al., 2011) focusing on older populations, with an explicit focus on socio-economic background as moderating factor. We study individuals aged 65 years and older surveyed by the Survey of Health, Ageing and Retirement in Europe (2011-2015) data combined with precise meteorological data.

## Data & variables

For our study, we used data from the Survey of Health, Ageing and Retirement in Europe (SHARE), a biennial longitudinal survey that covers several key areas of life (health, socio-economic status, social and family networks, etc.) of roughly 140,000 people aged 50 or older from 28 European countries and Israel (Börsch-Supan et al., 2013). We pool together individuals from waves 4, 5, and 6 (2011-2015), to retain longitudinal respondents.

We select individuals aged 65 years and older who report valid information on the region (NUTS-2) of residence; since region of residence is surveyed only at the baseline interview, we select only individuals who declared they have not changed residence between two waves. Our analytical sample includes the following countries: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Italy, Netherlands, Slovenia, Spain, Sweden, and Switzerland.

We use temperature data provided by the E-OBS and available in the Copernicus Data Store (CDS). The meteorological information is gridded, at a resolution of 0.1° and available from 1950 to 2022. In our analysis, we create our exposure to temperature in the 12 months prior the interview in three steps. First, we calculate the average of the daily grid values falling within the NUTS2 administrative boundaries. Secondly, we constructed 7 monthly temperature bins. Respectively, these are <0°C; 0 to 5°C;5 to 10°C; 5 to 20°C; 20 to 25°C; 25 to 30°C; >30°C and count the number of days in which the daily temperature falls within these ranges. Thirdly, we summed the number of days of exposure to the temperature bins in 12 months, starting before the month of interview.

We employ a set of dependent variables aiming at measuring the short-term impact of extreme temperature. The respondents are asked whether, in the last twelve months, they (1) have been hospitalized (2) have been to the doctor for a visit (3) have taken medications for high blood pressure and (3) have taken medications for the heart.

We measure socio-economic status with the level of education of the respondent. Education is measured in SHARE with the International Standard Classification of Education (ISCED-1997) in 7 categories. The lowest category refers to individuals with less than primary education and the highest category to tertiary education or more. Given the very different distribution of education across countries, we use a strategy similar to Reardon (2011). We consider education as a latent characteristic in a population having a country-specific cumulative distribution (rank), which we can only observe with a measurement, ISCED-97 in this case. For each ISCED category, we compute the average percentile of the country-specific educational distribution, and we assign it to each individual. By doing so, we create the rank (the percentile) each observation is in the country-specific educational distribution. We consider as low educated individuals at the bottom 20th percentile of the country-specific educational distribution, and as high educated individuals those at the top 80th percentile.

We add a control at the individual level for age.

**Empirical strategy**

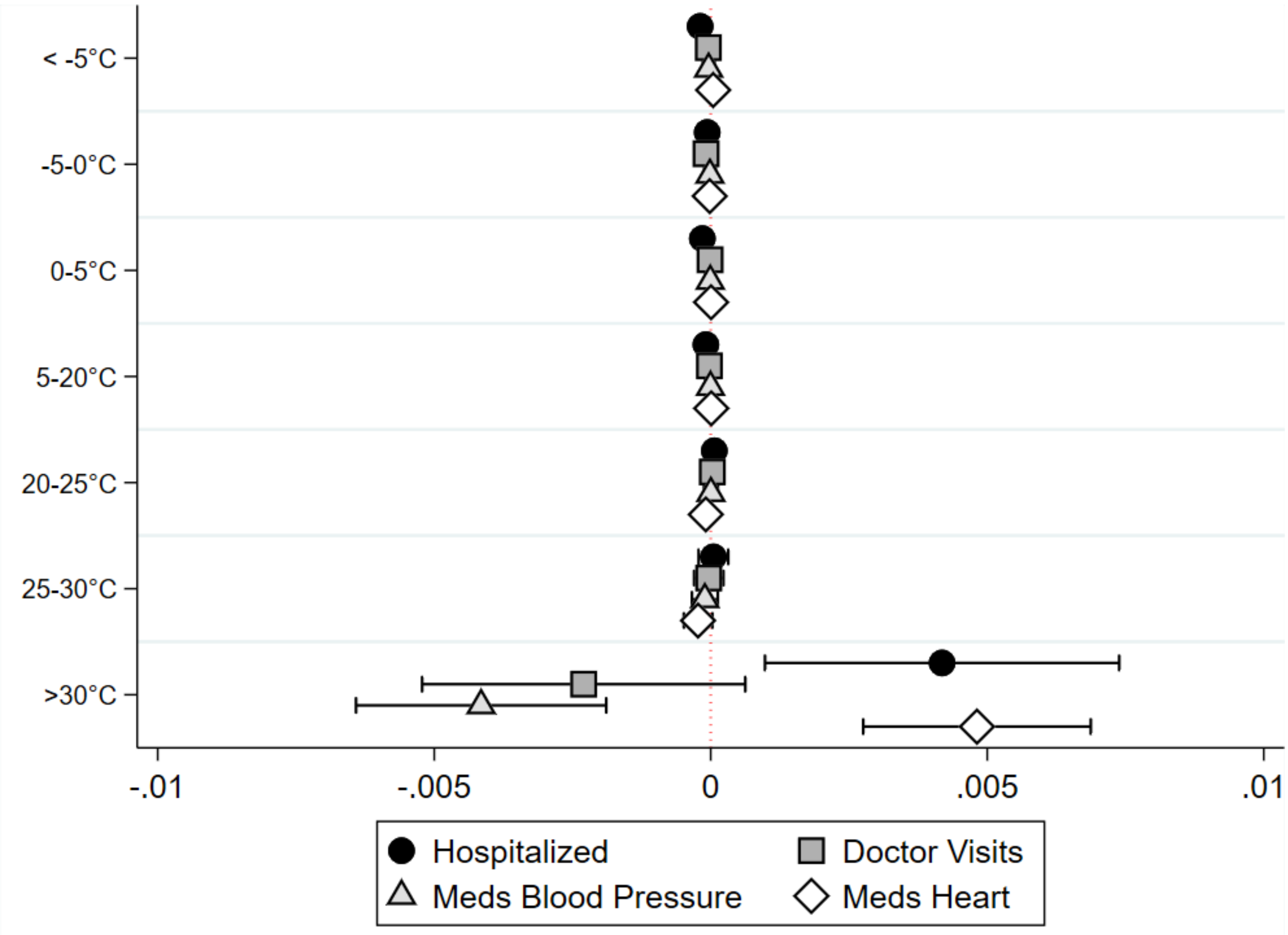
In the analysis, we use a Linear Probability Model (LPM) with fixed effects at the individual level, at the interview-year level, and at the month-level. This longitudinal approach allows us to measure the impact of temperature exposure on the DVs in the following wave, net of confounding. Standard errors are clustered at the NUTS 2 region in which the individual resides.

In the second part of the analysis, to investigate the differential risk by educational level, we interact the temperature-exposure variables with the educational level.

**Preliminary results**

In figure 1, we show the results for the probability of hospitalization, doctor visit, medications for blood pressure and heart, given exposure to the temperature ranges in the pooled sample. We observe an increase in the probability of experiencing hospitalization and taking medicines for the heart only with exposure to temperatures above 30°C. Interestingly, the probability to use medicines for blood pressure decreases. We do not detect any (sizeable) other relation between exposure to temperature and the dependent variables.

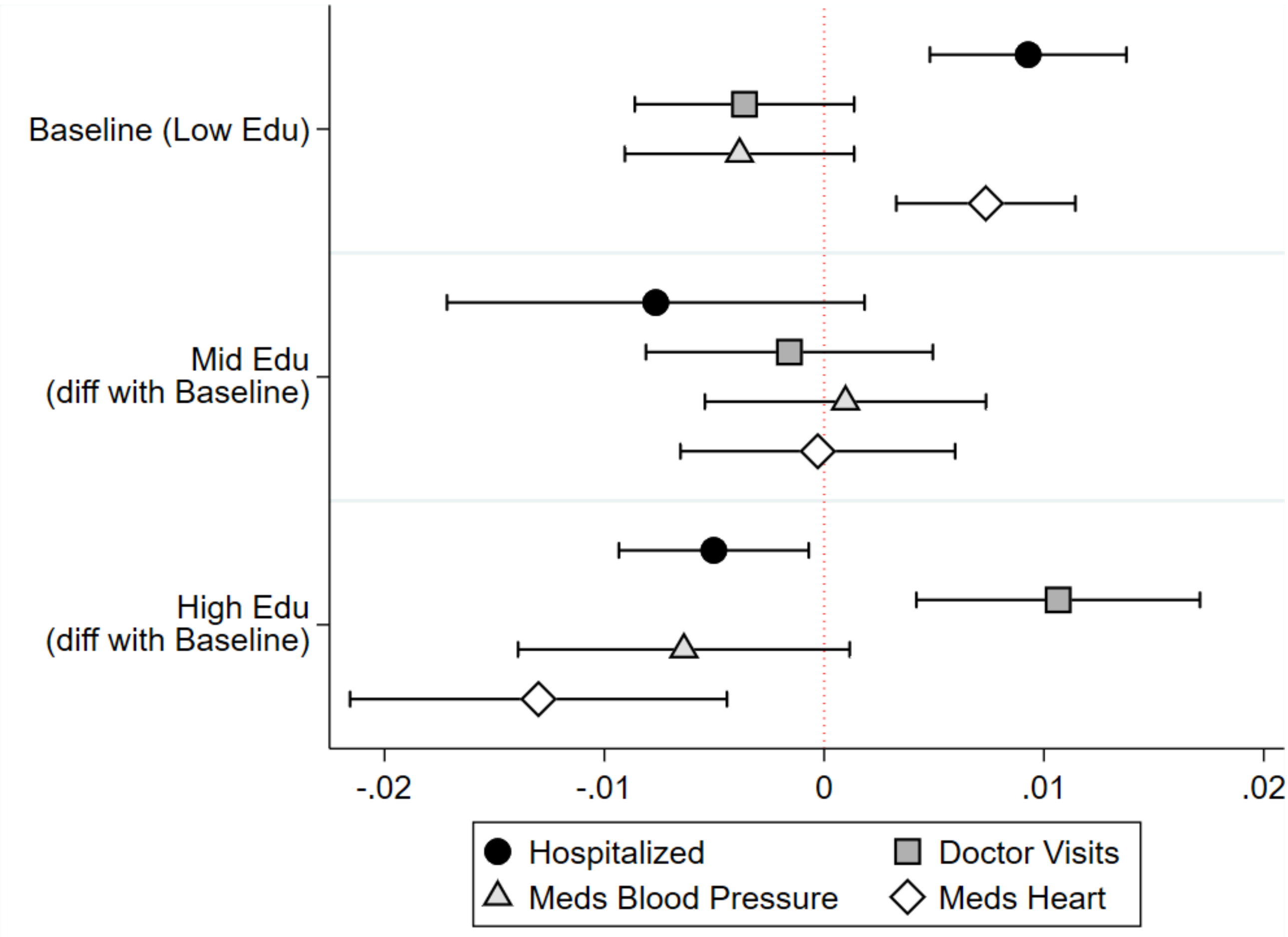
**Figure 1. Percentage point change in the probability of hospitalization, doctor visits, medications for blood pressure, and for the heart, by exposure to temperature in the preceding 12 months**




Note: Figure 1 shows the percentage points increase in the probability of experiencing hospitalization, doctor visits, medications for blood pressure and hearth, in the previous 12 months (X-axis), given the exposure of an additional day at a certain temperature (Y-axis). LPMs with individual, month, and year fixed effects; standard errors are clustered at the NUTS-2 level. 95% CI. Source: SHARE survey (2011-2015).

In figure 2, we report the results of the interaction between the exposure to days > 30°C and the three educational categories. Please notice that propobabilities are reported for low educated individuals, the baseline; for mid and high education, Figure 2 reports the marginal change from the baseline. Accordingly, we detected an increase of the risk of hospitalization and medications for the heart for low educated individuals. While mid-educated individuals do not differ from the baseline, the risk of the aforementioned outcomes is lower for high-educated individuals. Interestingly, highly educated individuals are more likely to attend doctor visits when the temperature exceeds 30°C.

**Figure 2. Percentage point change in the probability of hospitalization, doctor visits, medications for blood pressure, and for the heart, by exposure to temperature above 30°C in the preceding 12 months, and educational level**




Note: Figure 2 shows the percentage points increase in the probability of experiencing hospitalization, doctor visits, medications for blood pressure and hearth, in the previous 12 months (X-axis), given the exposure of an additional day > 30°C, for low educated individuals. For mid- and high-educated individuals, changes from the baseline (low educated individuals) are reported. LPMs with individual, month, and year fixed effects; interaction term between temperature exposure and education is included; standard errors are clustered at the NUTS-2 level. 95% CI. Source: SHARE survey (2011-2015).

## Conclusions and future steps

In this abstract, we investigated how exposure to extreme temperatures affects morbidity for individuals aged above 65, and how the relation is moderated by educational level. Exposure to temperatures above 30°C increases the risk of hospitalization and medications for the heart; this result is driven by low- and mid-educated individuals, while the risk is lower for high-educated individuals. Moreover, highly educated individuals are more likely to go to the doctor with temperatures above 30°C; this is in line with the higher propensity of highly educated individuals to attend health check-ups. One piece of evidence contrasts our expectations and must be further explored: high temperature seems to decrease the risk of assuming medicines for blood pressure. In the next steps of the analysis, we will explore possible mechanisms behind the shown associations: individuals from higher socio-economic status may be those owning air conditioning, houses with garden, or holiday houses, which make them more resilient to the exposure to high temperatures.

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