**ANALYSIS PLAN**

**Definition of heatwave**

Extreme heat poses a significant threat to population health, with heatwaves resulting in the largest number of excess deaths compared to any other natural hazard in Australia 1. The Bureau of Meteorology defines heatwaves as unusually high minimum and maximum temperatures that persist for 3 or more consecutive days at a certain location. Extreme heat is likely to cause adverse health effects on population health, as well as add pressure on health services due to sudden surges in demand 2.

We will use daily temperature data at a fine spatial resolution to identify heatwaves and categorise different levels of intensity (low, severe, extreme). We will use linked health outcomes data (ED presentations, hospitalisations, and deaths) in relation to heatwave intensity during spring-summer months, when extreme heat is more likely to occur. We will compare health outcomes and conditions that experience an increase during heatwave days (including a lag period of 3 days) and non-heatwave days.

**Step 1: Explore measures associated with sensitivity to heat**

We will explore the following measures as sensitivity to heat:

(1) As comorbidity is associated with adverse effects to heat, we will determine the level of comorbidity using validated indices such as the Charlson and Elixhauser comorbidity indices3 and the Multipurpose Australian Comorbidity Scoring System (MACSS) 4 We will calculate the comorbidity score (higher score = higher level of comorbidity) for each person using the principal and secondary diagnosis fields with a 10-year lookback from the date of the heatwave.

(2) We will use the self-controlled case series (SCCS) study design to ascertain the risk of occurrence of outcomes (all-cause and cause-specific emergency department (ED) presentation, admission to hospital or death) during the heatwave period compared to a defined comparable period preceding the heatwave. The SCCS design studies the temporal association between an exposure (i.e., exposure to heat) and outcome.5 This study design minimises confounding because each patient acts as their own control, thereby controlling for identified and unidentified confounders specific to each patient that do not vary over time. Investigator Lopez on this application has experience with the SCCS design.6 7

Heat-related illness is a spectrum of conditions rather than just heatstroke.8 Recording of these conditions in administrative data can vary depending on coding guidelines in each jurisdiction. Deaths may not be reported as heat-related if the cause of death was attributed to an underlying health condition that worsened during a heatwave. 10 For this study, cause-specific outcomes are conditions that are over-represented in the principal discharge diagnosis field during the heatwave (e.g. myocardial infarction, stroke).

(3) Using the rationale that people sensitive to heat are at higher risk of hospitalisation and death, we will use counts of all-cause and cause-specific ED presentations, emergency hospital admissions and deaths during the heatwave as indicators of sensitivity to heat. Results will be expressed initially as number per 1,000 population. To observe which conditions experience increase in ED presentations, hospital admissions and deaths

**Step 2: Selection of sensitivity to heat indicators**

The analysts will discuss with the research team which measures from Step 1 are valid indicator/s of sensitivity to heat. The research team will explore whether the selected measures could be summarised into a composite score by weighting different components of the measures. The research team will also explore whether the indicator/s has/have to be stratified by characteristics such as age and sex.

Based on the selected measures an Outcomes layer will be greated (e.g. hospitalisation, ED, deaths, and combined rates and ratios), as well as a comorbidity layer as part of the Sensitivity Indicator along other socioeconomic and demographic variables. ~~Indicator will be created, composed of several weighted sub-indicator layers (e.g. Comorbidity, risk of occurrence of outcomes, hospital admission rates etc.). The Sensitivity to Heat Indicator will be included in the Sensitivity component of the Heat Vulnerability Indicator, along other socioeconomic and demographic variables.~~ The research team will discuss and attribute appropriate weights to indicator layers.

**Step 3: Spatial smoothing**

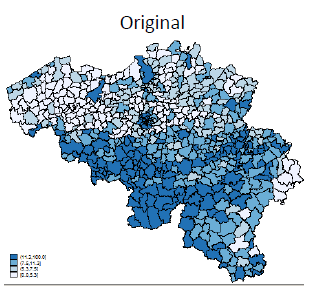
The reporting of statistical data by small geographical areas needs to consider two key issues: (i) data privacy and (ii) statistical stability. Data privacy relates to the responsibility to protect the identity of individuals in their data, and ensure that this is not compromised by the release of that data for reporting purposes. Statistical stability relates to the inherent random fluctuation of statistics based on small numbers of cases; the smaller the numbers, the more they fluctuate, potentially leading to incorrect interpretation. These issues are particularly relevant when considering geographical data. To address both these issues for geographical data, we will use a specific statistical method known as “spatial smoothing”. While standard methods typically only adjust for age and sex in each area, spatial smoothing recognises the geographical structure of the data and includes data from the neighbouring geographical areas when calculating the spatial estimates. This additional data provides greater stability to the estimates. In addition, because the spatial estimates are modelled, rather than observed, spatial smoothing reduces any risk of identifiability for specific individuals. Smoothed estimates are designed to reflect the real differences in the underlying rate or risk between areas.

For this study, the spatial smoothing will be adjusted for age, sex and comorbidities (determined from the principal and secondary discharge diagnosis fields).

Figure 1 is an example of spatial smoothing at two different levels of distance function (s=0.1 and s=0.5).

**Step 4: Presentation of indicators**

The final sensitivity to heat indicators will be reported as summary statistics (e.g., quartiles, quintiles) or range of values rather than absolute numbers.



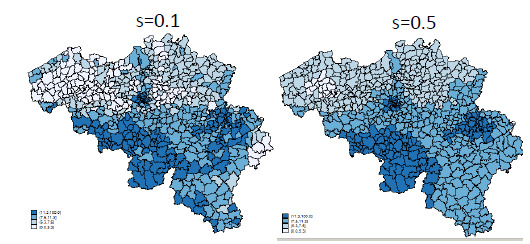


Figure 1: Example of spatial smoothing - adapted from Deschacht 2016 7

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