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Assessment of Heatwave Impacts

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Abstract

The frequency and intensity of urban heatwaves (UHWs) have been growing worldwide due to climate change and the exacerbating effects of urban heat islands (UHIEs). UHWs have many negative impacts, including excess negative health outcomes (e.g. morbidity), energy (consumption and peak demand) and water consumption. Most studies have evaluated these impacts separately even though there is an interplay between them. The study assessed the daily excess morbidity, energy demand and consumption, and water supply in the Adelaide metropolitan region during heatwaves, between January 2008 and March 2014. The assessment quantifies the thresholds and the increase in each impact relative to temperature increase. The demonstrated negative impacts on public health, and energy and water resources, potentially exacerbated by UHIEs, justify the importance of interdisciplinary research and integrated policy changes on the mitigation of and adaptation to heatwaves.

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Keywords: Heatwave; Electricity demand; Water supply; Morbidity; Resilience.

1. Literature about the Negative Impacts of Heatwaves

Heatwaves have received a growing interest in research on climate change, public health, the built environment and social life recently. The increasing level of attention has been attracted by the media-reported, high number of heat-related fatalities. Heatwaves account for more deaths than all other natural hazards combined in Australia [1].

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Meanwhile, fewer studies have been concerned with other negative impacts of heatwaves such as electricity and water demand. Power outages are triggered by the disproportionally high electricity demand due to air-conditioning during heatwaves. The normalised peak electricity demand is the highest in South Australia (SA) from amongst the Australian States, where the top 30% of electricity demand occurs in less than 2% of the time [2]. During peak demand, the generation costs can rise from a normal \$30/MWh to \$12,000/MWh in the electricity market [3]. Rising electricity prices lead to energy poverty, describing the householders' financial inability to heat or cool their homes to an appropriate level [4]. Extensive air-conditioning by others exacerbates UHIEs and the increasing dependence on air-conditioning raises further concerns based on the assumption that air-conditioning can become addictive [5].

Excess water use due to heatwaves can be detrimental in cities suffering from water scarcity [6], especially in the context of climate change. SA is exposed to water scarcity, facing water management issues now and increasingly in the future [7]. Nonetheless, to our knowledge no study has yet been undertaken about the association between excess water use and heatwaves.

In general, an interdisciplinary approach has been missing from research into heatwaves. This study argues for the importance of understanding the magnitude of heatwave impacts collectively, particularly since morbidity, excess electricity demand and water use are intertwined. For instance, the excess electricity use for air-conditioning has been acknowledged in the literature as a preventative measure against morbidity [8]. Cooling demand can be ameliorated, meanwhile, by the increased irrigation of green spaces resulting in the decrease of urban air temperatures. Such an integrative assessment of negative impacts would be the essential first step towards a more comprehensive evaluation of heat stress resilience. Furthermore, there is a need for predictive capability of heatwave impacts to more efficiently utilise scarce resources. This paper aims to analyse: (1) which weather parameters best predict the magnitude of heatwave impacts and (2) how the sensitivities and thresholds of the impacts are related to heatwaves.

Adelaide, with a population of almost 1.3 million [9] is the capital city of SA. The climate is temperate with hot and dry summer months [10]. The highest normalised heat-related mortality within Australia has occurred in SA since the middle of 19th century [1]. As a city suffering from regular severe heatwaves, the Adelaide metropolitan region was selected for the data analysis.

2. Data Sources and Analyses

The Adelaide metropolitan region was defined according to the current Australian Statistical Geography Standard (Australian Bureau of Statistics 2015b). The water and electricity datasets, therefore, include energy and water used by the built environment during operation and construction, infrastructure, industry and urban agriculture.

The daily number of ambulance call-outs and water supply were obtained from the SA Department for Health and Ageing and the SA Water, respectively, for the time period between 1st January 2008 and 31st March 2014. Research ethics approvals have been granted from the University of SA and the SA Department for Health and Ageing. The electricity demand data at thirty-minute intervals were obtained from the SA Power Network for each substation in the Adelaide metropolitan region and aggregated to calendar days within the same time period. The daily consumption figures were calculated from the half-hourly power demand data, assuming that the demand was constant in that half an hour. The daily weather parameters, collected at the Kent Town station, SA, were obtained from the Australian Bureau of Meteorology. Kent Town station has been widely used as a representative weather station for Adelaide in earlier studies [11,12].

The original daily datasets were decomposed using an additive model comprising of exponential smoothing to eliminate the seasonal changes and longitudinal trends, and Fourier series to deduct the weekly cycles detected. A more elaborate description of the method is available in an earlier study [13]. National public holidays were excluded from the analyses of electricity demand and morbidity because of the significant differences found between public holidays compared to normal days presumably due to the changes in population.

The predictive powers of different weather parameters – daily maximum and mean temperatures (DMaxTs and DMTs) and excess heat factors (EHFs) – were probed and compared in case of the four heatwave impacts, including daily morbidity, electricity demand and consumption, and water supply. The EHF is a metric for heatwave intensity, devised by Nairn et al. [11] and proved to be a better indicator of excess morbidity than other widely used weather parameters in Adelaide [13]. Linear regression with linear and polynomial models, scatterplot, bar and linear diagrams were applied for the analyses. The p values of the regression analyses were statistically significant at $p<0.05$ in the