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The impact of heatwaves on workers' health and safety in Adelaide, South Australia

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ABSTRACT

This study aims to investigate the impact of heatwaves on worker's health and safety; to identify workers at higher risk of prevalent illnesses and injuries due to heatwaves; and to provide evidence for policy-makers and service providers. South Australian workers' compensation claims data for 2001–2010 were transformed into time series format, merged with meteorological data and analysed using generalized estimating equation (GEE) models. For total injury claims there was no significant difference detected between heatwave and non-heatwave periods. However, for outdoor industries, daily claims increased significantly by 6.2% during heatwaves. Over-represented in hot weather were male labourers and tradespersons aged ≥ 55 years, and those employed in 'agriculture, forestry and fishing' and 'electricity, gas and water'. Occupational burns, wounds, lacerations, and amputations as well as heat illnesses were significantly associated with heatwaves. Similarly, moving objects, contact with chemicals, and injuries related to environmental factors increased significantly during heatwaves, especially among middle-aged and older male workers. With the predicted increase of extremely hot weather, there is a need for relevant adaptation and prevention measures at both practice and policy levels for vulnerable work groups.

1. Introduction

Many epidemiological studies have confirmed that heatwaves may result in excess morbidity and mortality in the general population (Nitschke et al., 2007; Hansen et al., 2008a, 2008b; Basu, 2009; Ye et al., 2012). Recently, there have been growing concerns about the impact of extreme heat on workers' health and safety (WHS) under the context of extreme heat and climate change (Kjellstrom et al., 2009a, 2009b), as exposure to extreme heat in the workplace can increase the risk of work-related injuries and accidents, particularly for those working outdoors or close to heat sources.

South Australia (SA) has a population of 1.65 million with labour force of 820,300 in 2012 (Australian Bureau of Statistics, 2013). The majority (77.1%) of the state's population lives within the Adelaide metropolitan area, which has an arid climate characterised in summer by hot daytime temperatures and mild nights. Although South Australians are likely acclimatized to extreme heat, several studies in Adelaide have found that heatwaves, which can be defined in a number of ways, have been associated with excess mortality and significant increases in hospital admissions and ambulance call-outs (Nitschke et al., 2007; Hansen et al., 2008a, 2008b).

Recently, the empirical association between daily ambient temperature and work-related injuries has been investigated in Australia and Italy (Morabito et al., 2006; Xiang et al., 2014). However, so far little is known about the extent to which workers are affected by heatwaves i.e. when ambient temperatures remain high over several consecutive days. It is possible this may have an effect on worker's level of fatigue and compromise health and safety. According to the weather projections for Adelaide, the average number of days with temperatures over 35 °C and the frequency of heatwaves will triple by 2070 (Commonwealth Scientific and Industrial Research Organization and Australian Bureau of Meteorology, 2007). Thus, extremely hot weather may present a growing challenge for occupational health and safety (Kjellstrom et al., 2009a, 2009b).

The aim of this study was to assess to what extent workers are impacted by heatwaves in Adelaide, to identify vulnerable workers, to examine which types of work-related illnesses and injuries are associated with heatwaves in the workplaces, and to compare the differences between two different heatwave definitions on effect estimates. Understanding the impact of heatwaves on WHS may provide valuable information to decision makers and relevant stakeholders to formulate extreme heat preparedness and emergency response plans in the workplace.

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2. Materials and methods

2.1. Workers' compensation claim data

Workers' compensation data have been used as a tool monitoring work-related injuries and diseases in South Australia since 1987. The Type of Occurrence Classification System (TOOCS2) for claims was introduced in 1999 as coding guidelines for describing details of reported workers' compensation cases (Australian National Occupational Health and Safety Commission, 2011), which includes the nature of injury (based on the International Classification of Diseases, ICD-9), bodily location, mechanism, and agency of injury/disease.

As in our previous study (Xiang et al., 2014), de-identified workers' compensation claim data were obtained from Safe Work South Australia (SWSA) for the period from 1st July 2001 to 30th June 2010. Compensation claims were restricted to those in the Adelaide metropolitan areas as identified by location postcode. The study was approved by the Human Research Ethics Committee of the University of Adelaide (H-111-2011) and the SWSA data custodian.

2.2. Meteorological data

Climatic data for Adelaide including daily maximum and minimum temperatures for the study period were obtained from the Australian Bureau of Meteorology. As in previous studies (Nitschke et al., 2007; Hansen et al., 2008a, 2008b; Xiang et al., 2014), an observation station near the central business district was selected to represent weather conditions across the Adelaide metropolitan area.

2.3. Heatwave definition

Currently, there is no universal definition of a heatwave although generally it can be broadly defined as a prolonged period of excessive heat. In this study, we have defined a heatwave as ≧3 consecutive days with daily maximum temperatures (T_{max})≧35 °C as in our previous studies (Nitschke et al., 2007; Hansen et al., 2008a, 2008b). We also used the Australian Bureau of Meteorology (BOM) definition of ≧5 consecutive days of $T_{max} \geq 35$ °C; or ≧3 consecutive days of $T_{max} \geq 40$ °C to compare findings (Australian Bureau of Meteorology, 2010).

2.4. Statistical analyses

The impacts of heatwaves on daily workers' compensation claims were assessed by using generalized estimating equation models with negative binominal distribution accounting for over-dispersion, a log link function and a first order autocorrelation structure. A goodness-of-fit test was applied to the model. The analyses were stratified by gender, age group, industrial sector, occupation and nature and mechanism of illness/injury. Seasonality was controlled for by restricting the analysis to the warm season (1 October–31 March). Relative humidity was not adjusted, as Adelaide is characterized as dry hot weather (Xiang et al., 2014).

As work-related compensation claims reduced significantly during weekends and public holidays, all analyses were focused on week days. Confounding factors were adjusted for including day of the week, calendar month, and long term trends (with calendar year as a categorical variable). As those working outdoors are presumably at high risk of weather-related heat exposure, the impact of temperature on 'outdoor industries' was analysed. These were defined as 'agriculture, forestry and fishing', 'construction', and 'electricity, gas and water' and were combined into one variable named 'outdoor industries'. Accordingly, data for remaining other industries were named 'indoor industries'. As almost all mine sites are located in remote areas of the state, mining claims were therefore excluded from the analysis to avoid misrepresentation.

The 0.05 level of statistical significance was adopted for each test. Results are expressed as incidence rate ratios (IRR) with 95% confidence interval (CIs), and interpreted as per cent change in the number of daily work-related injury claims during heatwave periods compared with non-heatwave periods. All analyses were conducted using Stata v12.0 (StataCorp LP, College Station, Texas).

3. Results

The mean daily T_{max} during the period of 1st July 2001–30th June 2010 was 22.8 °C, with the corresponding mean T_{max} during the cool season (1 April–30 September), warm season (1 October–31 March) and heatwaves being 18.6 °C, 27.0 °C and 38.8 °C, respectively. A total of 21 heatwaves (≧3 consecutive days over 35 °C) were identified during the 9-financial year period, with a maximum of four heatwaves in one calendar year. The highest temperature was 45.7 °C on 28 January, 2009 during a 9-day heatwave with six continuous days over 40 °C. The duration of individual heatwaves ranged from 3 to 15 days, with a mean of 4.9 days.

This study included 252,183 accepted workers' compensation claims recorded during the 9-financial year period in Adelaide metropolitan area, accounting for 76.7% of all claims in South Australia during the same period. Of these, 7043 (2.8%) claims occurred during 103 heatwave days (21 heatwaves), representing a daily mean of 95 claims compared with 100 during non-heatwave periods in the warm season. By contrast, using the stricter heatwave definition of the BOM, 3885 (1.5%) claims occurred during 59 heatwave days (8 heatwaves), with a daily mean of 91 claims compared with 100 during non-heatwave periods.

3.1. Effect estimates by gender, age, occupation and industry

As shown in Table 1, the number of compensation claims for male workers was more than twice that for female workers. During heatwaves, there were no significant changes in the number of compensation claims among male workers. By contrast, female workers had a significant decrease of 6.5% (95% CI 2.6%–10.3%) in claims during heatwaves. Almost half of the claims were from middle-aged workers (35–54 years). Overall no particular age group showed a significant increase of compensation claims during heatwave periods compared with control periods.

Regarding occupations, 'tradespersons and related workers' had the highest number of claims during heatwaves, followed by 'intermediate production and transport workers' and 'labourers and related workers'. The latter showed a significant increase in claims during heatwaves of 5.4% (95% CI 2.3–8.6%) compared to 5.6% (95% CI 2.8–8.4%) for 'tradespersons and related workers'. Significant decreases of 11.6% (95% CI 5.9–16.9%) were observed in claims for 'intermediate clerical and service workers' and 9.4% (95% CI 1.5–16.7%) for 'professionals' during heatwaves. In terms of industries, overall 'outdoor industries' showed a 6.2% (95% CI 2.2–10.3%) increase in claims during heatwaves. 'Agriculture, forestry and fishing' and 'electricity, gas and water' had increases of 44.7% (95% CI 12.5–86.1%) and 29.7% (95% CI 4.9–60.4%) respectively.

Table 2 shows the age and gender specific analyses for 'agriculture, forestry and fishing' and 'electricity, gas and water' industries. An increase of 65.3% (95% CI 19.8–228.1%) was observed for claims among male workers in 'agriculture, forestry and fishing'; and a significant increase of 67.3% (95% CI 4.9–266.7%) was seen among workers aged ≥ 55 years. In the 'electricity, gas and water' industry, male workers had a 38.7% (95% CI 16.5–65.2%) increase in claims during heatwaves;