Extreme Heat and Workers' Health in South Australia: Association, perceptions, and adaptations in the workplace

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1. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Health Impacts of Workplace Heat Exposure: An Epidemiological Review. *Ind Health* (impact factor: 1.045). 2014, 52: 91-101.
2. ***Xiang J***, Bi P, Pisaniello D, Hansen A, et al. Association between high temperature and work-related injuries in Adelaide, South Australia, 2001–2010. *Occup Environ Med* (impact factor: 3.234). 2013, doi:10.1136/oemed-2013-101584.
3. ***Xiang J***, Bi P, Pisaniello D, Hansen A.The impact of heatwaves on workers' health and safety in Adelaide, South Australia, 2001-2010.*Environ Res* (impact factor: 3.951). 2014, 133: 90-95. doi: 10.1016/j.envres.2014.04.042.

Manuscript in draft

4. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Extreme heat and occupational heat heat illness in South Australia, 2001-2010. (Submitted)
5. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Workers' perceptions on workplace heat exposure in South Australia.
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Conference presentations

1. ***Xiang J***, Bi P, Pisaniello D, Hansen A, et al. Association between high temperature and work-related injuries in Adelaide, South Australia, 2001–2010 (*Oral presetation*).The 23rd International Conference on Epidemiology in Occupational Health (EPICOH), Utrecht, Netherlands, 2013.
2. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Association between high temperature and work-related injuries in Adelaide, South Australia, 2001–2010 (*Poster presentation*). The

Faculty of Health Science Postgraduate Research Conference, The University of Adelaide, SA, 2013.

3. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Association between high temperature and work-related injuries in Adelaide, South Australia, 2001–2010 (*Poster presentation*). The Australian National Climate Change Adaptation Research Facility (NCCARF) Conference, Sydney, Australia, 2013.

4. ***Xiang J***, Bi P, Pisaniello D, Hansen A. The impact of heatwaves on workers' health and safety in Adelaide, South Australia (*Poster presentation*). The 24th International Conference on Epidemiology in Occupational Health (EPICOH), Chicago, USA, 2014.

5. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Climate change and workplace heat exposure: Perceptions from occupational hygienists. The Australian National Climate Change Adaptation Research Facility (NCCARF) Conference (*A synthesis talk and poster presentation*), Gold Coast, Australia, 2014.

6. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Climate change and occupational heat stress: Perceptions from workers. The Australian National Climate Change Adaptation Research Facility (NCCARF) Conference (*Poster presentation*), Gold Coast, Australia, 2014.

7. ***Xiang J***, Bi P, Pisaniello D, Hansen A. Extreme heat and occupational heat illness in South Australia, 2001-2010. The Australian National Climate Change Adaptation Research Facility (NCCARF) Conference (*Poster presentation*), Gold Coast, Australia, 2014.

8. ***Xiang J***, Bi P, Pisaniello D, Hansen A. The impact of heatwaves on workers' health and safety in Adelaide, South Australia (*Poster presentation*). The Faculty of Health Science Postgraduate Research Conference, The University of Adelaide, SA, 2014.

AWARDS RECEIVED DURING PhD CANDIDATURE

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACGIH	American Conference of Governmental Industrial Hygienists
AIOH	Australian Institute of Occupational Hygienists
ASCO	Australian Standard Classification of Occupation
AT	Apparent Temperature
BOM	Bureau of Meteorology
CEN	European Committee for Standardization
CFMEU	Construction, Forestry, Mining and Energy Union
CI	Confidence Interval
FIFO	Fly-in/fly-out
GEE	Generalized Estimating Equation
H/W	Heatwave
ICD	International Classification of Diseases
IRR	Incidence Rate Ratio
ISO	International Organization for Standardization
NIOSH	National Institute for Occupational Safety and Health
OH&S	Occupational Health & Safety
OLS	Ordinary Least Square
OR	Odd Ratio
PPE	Personal Protective Equipment
SA	South Australia
SAWIC	South Australia WorkCover Industrial Classification
SWSA	SafeWork South Australia
TAFE	Technical and Further Education
TLV	Threshold Limit Value
T_{max}	Maximum Temperature
TOOCS	Type of Occurrence Classification System
UK	United Kingdom
USA	United States of America
USG	Urine Specific Gravity
UTCI	Universal Thermal Climate Index
WBGT	Wet Bulb Globe Temperature
WHS	Workers' health and safety

THESIS ABSTRACT

Background

Occupational heat exposure may lead to adverse health effects and contribute to work-related injury, illness or even death. With the predicted increase in the frequency and intensity of extremely hot weather in South Australia, workplace heat exposure is presenting a growing challenge to workers' health and safety. This thesis aims to examine the effects of workplace heat exposure on workers' health and safety in Adelaide, South Australia, to investigate perceptions of risks associated with workplace heat exposure, and to provide scientific evidence for the development of heat necessary heat prevention and adaptation strategies particularly in a warming climate.

Methods

This study can be broadly divided into two parts. The first part is the analyses of workers' compensation claim data and weather data, obtained from the SafeWork South Australia and the Bureau of Meteorology, respectively for 2001-2010. Time-series analysis approach was used to quantify the effects of heat exposure on workers' health and safety. Heat-related claims were identified according to the Type of Occurrence Classification System coding information and text-based diagnosis-related descriptions. Case-crossover analytic approach was undertaken to estimate the risk of occupational heat illnesses during heatwaves. The second part of this study comprises two cross-sectional questionnaire surveys to investigate how workers and occupational hygienists perceive the risk of workplace heat exposure and health impact.

Results

Analyses of workers' compensation claim data

Generally, there was a reversed U-shaped relationship between daily maximum temperature (T_{max}) and daily injury claims in Adelaide. With increasing T_{max} below certain threshold temperatures ranging from 31.8℃ to 38.9℃, significant temperature-injury claims associations were found in the following sub-groups: young workers aged ≤24 years; those working in some outdoor industries such as 'agriculture, forestry and fishing', 'construction', and 'electricity, gas and water'; or employed as labourers, production and transport workers, and tradespersons in small and medium sized businesses. When the temperature was extremely hot, almost all industries had a decrease in injury claims, except the 'electricity, gas and water' industry.

During heatwave (≥3 consecutive days with T_{max} ≥35℃) periods, outdoor male labourers and tradespersons aged ≥55 years in 'agriculture, forestry and fishing' and 'electricity, gas and water' industries were found to be at higher risk of work-related injuries. Occupational burns, lacerations, amputations, and heat illnesses were found to be significantly associated with extreme heat, together with injuries resulting from moving objects, chemical exposures, and environmental factors.

There were 306 heat-related injury claims reported during the 9-financial year period in South Australia, with an incidence rate of 4.5 per 100,000 workers. Relatively high heat illness incidence rates were observed in 'mining' and 'electricity, gas and water' industries, and those employed as labourers and tradespersons across the state during the study period. When T_{max} was above 35.5℃, a 1 ℃ increase of T_{max} was associated with a 12.7% increase in occupational heat illness claims. During heatwave periods the risk of occupational heat illness was about 4-7 times higher than that of non-heatwave periods.

Workers and occupational hygienists' perceptions on heat exposure

Surveyed workers were moderately concerned about heat exposure. Young workers (≤24 years) were less concerned than older workers. Workers undertaking very physically demanding work, wearing personal protective equipment, or having had a previous heat illness/injury were found to be more concerned about heat exposure.

The majority (90%) of occupational hygienists and specialists surveyed showed great concerns over heat stress, but they did not show strong willingness to amend heat prevention recommendations to management or companies. From the occupational hygienists' point of view, Australian workplaces may not be well-prepared for the likelihood of increasing heat stress due to climate change.

Conclusions

Findings from this study will provide essential epidemiological evidence for policy makers and relevant stakeholders to develop regulations and guidelines locally and /or internationally to reduce the impacts of extreme heat on workers' health and safety, particularly in the susceptible subgroups identified. Industrial specific workplace hot weather alerts and response mechanisms need to be developed via multi-sectoral cooperation between stakeholders to improve vulnerable groups' risk perceptions and knowledge about harm minimisation strategies during extremely hot weather. In a warming climate, there is a need to develop specific and clear enforceable heat regulations to ensure the implementation and compliance of heat policies.

DECLARATION

I certify that this work is original and contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and brief, contains no material previously published or written by another person, except where due acknowledgement is made in the text. No part of the work will be used in a submission for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the join-award of the degree except where due reference has been made in the text.

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