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The use of Bayesian inference to inform the surveillance of temperature-related occupational morbidity in Ontario, Canada, 2004–2010

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ABSTRACT

Purpose: To assess the associations of occupational heat and cold-related illnesses presenting in emergency departments in south western Ontario, Canada, with daily meteorological conditions using Bayesian inference.

Methodology: Meteorological and air pollution data for the south western economic region of Ontario were gathered from Environment Canada and the Ministry of Environment. Daily heat and cold-related emergency department visits clinically attributed to work from 2004 to 2010 were tabulated. A novel application of Bayesian inference on a flexible Poisson time series model was undertaken to examine linear and non-linear associations between average, regional meteorological conditions and daily morbidity rates, to adjust for relevant confounders and temporal trends, and to consider potential interactions.

Results: Bilinear associations were observed between regional temperatures and morbidities resulting from extreme temperature exposures. The median increase in the daily rate of emergency department visits for heat illness was 75% for each degree above 22 °C (posterior 95% credible interval (CI) relative rate = 1.56–1.99) in the daily maximum temperature. Below 0 °C, rates of occupational cold illness increased by a median of 15% for each degree decrease in the minimum temperature (posterior 95% CI 0.80–0.91); wind speed also had a significant effect.

Conclusions: The observed associations can inform occupational surveillance and injury prevention programming, as well as public health efforts targeting vulnerable populations. Methodologically, the use of Bayesian inference in time series analyses of meteorological exposures is feasible and conducive to providing accurate advice for policy and practice.

1. Introduction

The environmental hazard posed by extreme temperature is well recognized (Cheng et al., 2005; Field et al., 2007; Health Canada, 2011). At especially high and low ambient temperatures, the human body becomes susceptible to temperature-related morbidity and mortality, including heat stress disorders (i.e. heat stroke, exhaustion) and cold-related conditions (i.e. hypothermia, frostbite). As the frequency of extreme temperature exposures is predicted to increase due to climate change, there is rising concern about possible health impacts (Cheng et al., 2005; Field et al., 2007).

The susceptibility of the elderly, those with chronic illness and children to extreme temperature is frequently studied, although our understanding of the working population is less developed

Abbreviations: CI, credible interval; ICD-10-CA, Canadian implementation of the International Classification of Diseases, 10th Revision; FTE, full-time equivalent; IQR, interquartile range; O_3, ozone; NO_x, nitric oxides; $PM_{2.5}$, particulate matter smaller than 2.5 μm in diameter; CO, carbon monoxide; SO_2, sulfur dioxide; MCMC, Markov Chain Monte Carlo; INLA, Integrated Nested Laplace Approximations.

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(Health Canada, 2011; Jay and Kenny, 2010; Nelson et al., 2011). It is possible that since the working population's vulnerability relates to exposures from warm or cold industrial processes in indoor settings (Hajat and Kosatsky, 2010; Health Canada, 2011; Jay and Kenny, 2010; Nelson et al., 2011), workers may be less vulnerable to the variation of ambient temperature. Existing studies of occupational heat and cold-related morbidities have been largely limited to specific industries (Carter et al., 2005; Donoghue, 2004; Hassi et al., 2000; Jackson and Rosenberg, 2010; Makinen and Hassi, 2009), have examined associations with categories of temperature exposures and frequently have not controlled for relevant meteorological confounders and temporal variation (Morabito et al., 2006; Sinks et al., 1987). As a result, it is unknown whether non-linear effects of temperature observed in the general population (Kovats and Hajat, 2008; Martiello and Giacchi, 2010; Ye et al., 2012) are present amongst the occupational population.

Further, time series studies of temperature-related illnesses have largely used a generalized additive modeling approach to study non-linear associations with meteorological conditions (Ye et al., 2012). Using Bayesian inference is advantageous as it provides more accurate effect and uncertainty estimates (Brezger and Lang, 2006). As software advances, Bayesian inference is becoming an increasingly accessible methodology and can be particularly useful to study continuous environmental variants like temperature (Brezger and Lang, 2006; Rue et al., 2009).

The primary objective of this study is to evaluate the associations between meteorological conditions and occupational, temperature-related morbidity, adjusting for relevant confounders and temporal trends. These associations have implications for worker health and productivity and can inform prevention programming and policy.

2. Materials and methods

An ecologic time series analysis was conducted to examine the associations between occupational, temperature-related emergency department visits and meteorological data in the south western economic region of Ontario, Canada between January 1, 2004 and December 31, 2010.

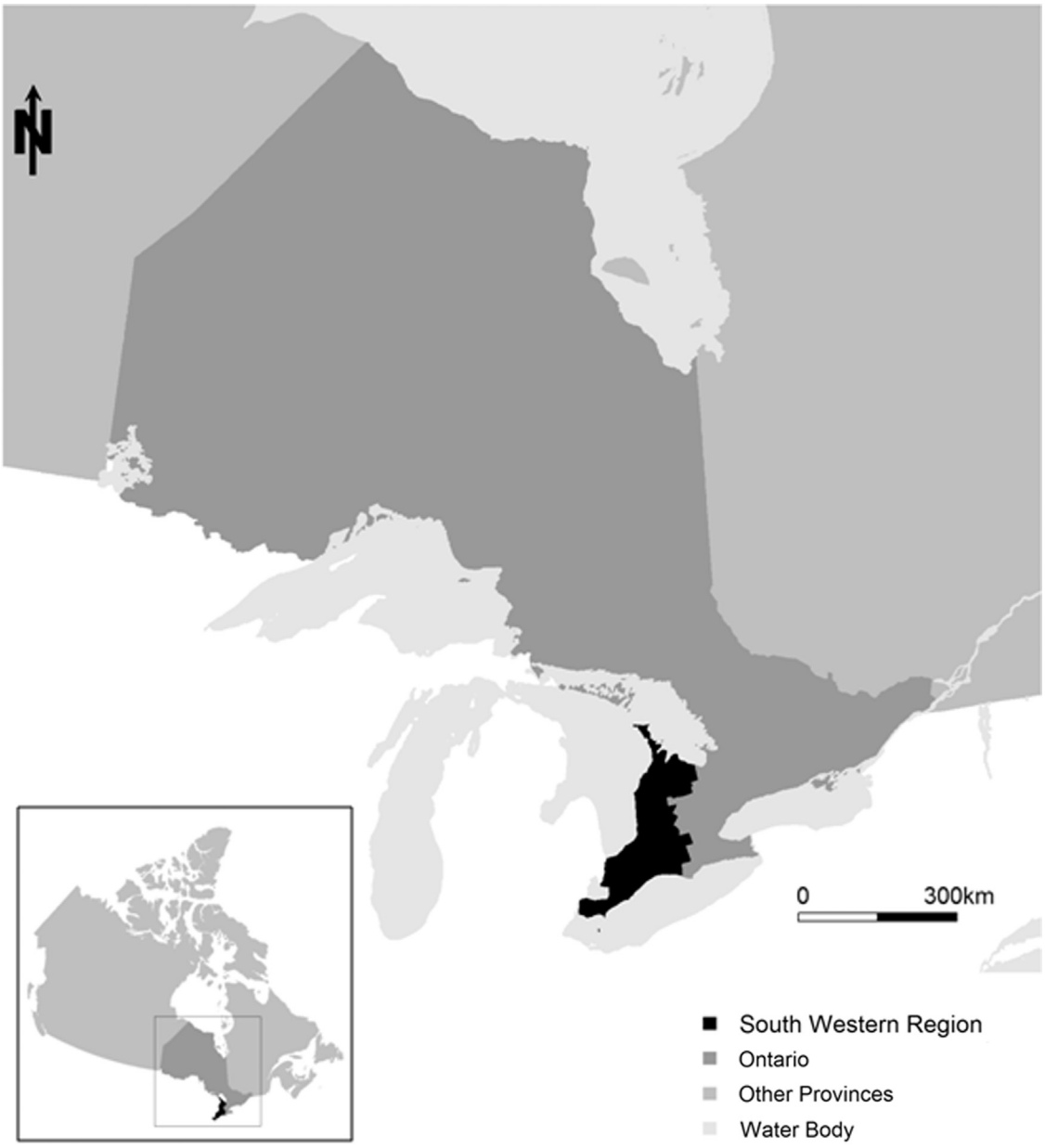

Fig. 1. Map identifying Ontario's south western economic region within Canada.