The Relationship between Climate Variation and Selected Infectious Diseases: Australian and Chinese Perspectives

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“Those who continue to ignore the threat will be doing the greatest disservice imaginable to current and future generations.” - Marthinus van Schalkwyk, Environmental Affairs Minister for South Africa

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Peer-reviewed Journals:

1. Zhang Y, Bi P, Wang G and Hiller JE. *El Nino Southern Oscillation and dysentery in Shandong province, China.* Environmental Research. 2007, 103: 117-20.
2. Zhang Y, Bi P, Hiller JE, Sun Y and Ryan P. *Climate variation and bacillary dysentery in northern and southern cities of China.* Journal of Infection. 2007, 55: 194-200.
3. Zhang Y, Bi P and Hiller JE. *Climate variation and salmonellosis transmission: a comparison of regression models.* International Journal of Biometeorology. Published online 11 July 2007. DOI 10.1007/s00484-007-0109-4.
4. Zhang Y, Bi P and Hiller JE. *Climate variations and the transmission of bacillary dysentery in Jinan, northern China: A time-series analysis.* Public Health Reports. Article in press. Accepted July 2007.
5. Zhang Y, Bi P and Hiller JE. *Climate change and disability adjusted life years.* Journal of Environmental Health. Article in press. Accepted July 2007.
6. Zhang Y, Bi P and Hiller JE. *Climate change and the transmission of vector/rodent-borne diseases: A review.* Asia-Pacific Journal of Public Health. Article in press. Accepted March 2007.

Non-peer-reviewed Journals*:

1. Bi P and Zhang Y. *Climate change and water-borne diseases.* Public Health Bulletin South Australia. 2007, 4: 23-5.
2. Bi P and Zhang Y. *Vector-borne diseases in Australia.* Public Health Bulletin South Australia. 2006, 4: 9-11.

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Conference presentations:

1. Zhang Y, Bi P and Hiller JE. *Climate and transmission of bacillary dysentery in Jinan, Eastern China: a time-series analysis (Oral).* The Earth System Science Partnership (ESSP) Global Environmental Change Open Science Conference (OSC). Beijing, China, November 2006, p458.
2. Zhang Y, Bi P and Hiller JE. *Meteorological variables and the transmission of bacillary dysentery: any differences between northern and southern China (Oral)?* The 18th Conference of the International Society for Environmental Epidemiology. Paris, France, September 2006, p328.
3. Zhang Y, Bi P and Hiller JE. *Climate and transmission of malaria in Jinan, a temperate city in China (Oral).* The 15th Annual Scientific Meeting of the Australasian Epidemiological Association. Melbourne, Australia, September 2006, p62-3.
4. Zhang Y, Wang G, Bi P and Hiller JE. *Dysentery and Southern Oscillation Index (SOI) in Shandong, China: a time-series analysis (Oral).* The 14th Annual Scientific Meeting of the Australasian Epidemiological Association. Newcastle, Australia, October 2005, p54.
5. Zhang Y, Bi P and Hiller JE. *Climate variation and salmonellosis in Adelaide, South Australia: a time-series analysis (Oral).* The XVII International Scientific Meeting of the International Epidemiological Association (IEA). Bangkok, Thailand, August 2005, p156.

AWARDS RECEIVED DURING CANDIDATURE

- Chinese government award for outstanding self-financed students abroad. China Scholarship Council. 2007.
- Postgraduate travelling fellowship. Faculty of Health Sciences Research Committee, University of Adelaide. 2006.
- Travel grant. The International Society of Environmental Epidemiology and Exposure (ISEE/ISEA) Conference Committee. Paris, France. 2006.
- Travel grant. The Earth System Science Partnership (ESSP) Open Science Conference Committee. Beijing, China. 2006.
- Student bursary. The Australasian Epidemiological Association Annual Conference Committee. Newcastle, Australia. 2005.
- International postgraduate research scholarship (IPRS). Australian Government. 2004-2007.
- Postgraduate research awards. University of Adelaide. 2004-2007.

LIST OF ABBREVIATIONS

AIC:	Aikake Information Criterion
ARIMA:	Autoregressive Integrated Moving Average
CRA:	Comparative Risk Assessment
DALY:	Disability Adjusted Life Year
EBD:	Environmental Burden of Disease
ENSO	El Nino-Southern Oscillation
GBD:	Global Burden of Disease
GCM:	General Circulation Model
GHG:	Greenhouse Gas
GIS:	Geographic Information Systems
HFRS:	Haemorrhagic Fever with Renal Syndrome
IPCC:	Intergovernmental Panel on Climate Change
NBD:	National Burden of Disease
RRV:	Ross River Virus
SARIMA:	Seasonal Autoregressive Integrated Moving Average
SOI:	Southern Oscillation Index
UNEP:	United Nations Environment Programme
WHO:	World Health Organization
YLD:	Years Lost due to Disability
YLL:	Years of Life Lost

ABSTRACT

Background

Climate variation has affected diverse physical and biological systems worldwide. Population health is one of the most important impacts of climate variation. Although the impact of climate variation on infectious diseases has been of significant concern recently, the relationship between climate variation and infectious diseases, including vector-borne diseases and enteric infections, needs greater clarification.

Australia is grappling with developing politically acceptable responses to global warming. In China, few studies have been conducted to examine the effect of climate variation, including global warming, on population health. As residents of developing countries may suffer more from climate change compared with people living in more developed countries, this thesis has significance for both countries.

Aims

This study aims to contribute to a better understanding of the impact of climate variation on population health, and to provide scientific evidence for policy makers, researchers, public health practitioners and local communities in the development of public health strategies at an early stage, in order to prevent or reduce future risks associated with ongoing climate change.

The objectives of this study include:

(1) to quantify the association between climate variation and selected vector-borne diseases and enteric infections in different climatic regions in Australia and China;

(2) to project the future burden of selected vector-borne diseases and enteric infections based on climate change scenarios in different climatic regions in Australia and China.

Methods

This ecological study has two components. The first uses time-series analyses to quantify the relationship between meteorological variables and infectious diseases, whereas the second projects the burden of selected infectious diseases using future climate and population scenarios.

Temperate and subtropical climatic zones in both Australia and China were selected as the primary study areas, and a study of an Australian tropical region was also conducted. Study of Australia's temperate zones was conducted in Adelaide, South Australia, as well as the Murray River region in that State. The study of China's temperate zone was carried out in Jinan, Shandong Province. Subtropical studies were conducted in Baoan, Guangdong Province, China, and Brisbane in Queensland, whilst research for the tropics centred on Townsville, also in Queensland, Australia.

The selected infectious diseases - one vector-borne disease and one enteric infection in each country - are Ross River Virus (RRV) infection and salmonellosis in Australia, and malaria and bacillary dysentery in China. Study periods vary from eight to sixteen years (depending upon the availability of data). Climate data, infectious disease surveillance data and demographic data were collected from local authorities.

Data analyses conducted in the ecological studies include Spearman correlation analysis, time-series adjusted Poisson regression and the Seasonal Autoregressive Integrated Moving Average (SARIMA) model with consideration of lag effects, seasonality, long-term trends, and autocorrelation, on a weekly or monthly basis depending on data availability, and Hockey Sticky model to detect potential threshold temperatures. In the burden of disease component, analyses include the calculation of an indicator of the burden of disease - Years Lost due to Disabilities (YLDs) - and use scenario-based models to project YLDs for the selected diseases in 2030 and 2050 in Australia and 2020 and 2050 in China respectively. The projections consider both different scenarios of projected temperature and future population change.

Results

Relationship between climate variation and selected infectious diseases

In all the study regions in Australia, maximum temperature, minimum temperature, rainfall and humidity are all significantly related to the number of RRV infections, with lag effects varying from 0 to 3 months. Additionally, high tides in the two seaside regions with tropical (Townsville) or subtropical (Brisbane) climates, and river flow in the temperate region (Murray River region), are related to the number of cases without any lag effects. A potential 1°C increase in maximum or minimum temperature may cause 4%~23% extra cases of RRV infection in the temperate region, 5~8% in the subtropical region, and 6%~15% in the tropical region.

Maximum temperature, minimum temperature, humidity and air pressure are significantly related to malaria cases in the temperate city Jinan and subtropical city Baoan in China, with a lag effect range of 0 to 1 month. An association between rainfall and malaria cases was not detected in either region. A potential 1°C increase in maximum or minimum temperature may lead to 4%~15% extra malaria cases in the temperate region, and 12%-18% in the tropical region in China.

Maximum temperature, minimum temperature, rainfall and humidity are all significantly related to the number of salmonellosis cases in the three study cities in Australia, with lag effects varying from 0 to 1 month. A potential 1°C increase in maximum or minimum temperature may cause 6%~19% extra salmonellosis cases in the temperate region (Adelaide), 5%~10% in the subtropical region (Brisbane), and 4%~15% in the tropical region (Townsville). The thresholds for the effects of maximum and minimum temperatures are 20ºC and 12ºC respectively in Adelaide. No threshold temperatures are detected in Townsville and Brisbane.

Maximum temperature, minimum temperature, humidity, air pressure and rainfall are significantly related to bacillary dysentery cases in the temperate city Jinan and subtropical city Baoan in China, with the lag effect range of 0 to 2 months. A potential 1°C increase in maximum or minimum temperature may cause 7%~15% extra bacillary dysentery cases in the temperate region and 10% ~ 19% in the subtropical region in China. The thresholds for the effects of maximum and minimum temperatures on bacillary dysentery are 17ºC and 8ºC respectively in Jinan. No threshold temperatures are detected in Baoan.

Projection of YLDs from target diseases

In Australia, considering both climatic and population scenarios, if other factors remain constant, compared with the YLDs observed in 2000, the YLDs for salmonellosis might increase by up to 48% by 2030, and nearly double by 2050 in South Australia, while the YLDs might double by 2030 and increase by up to 143% by 2050 in Brisbane, Queensland. The YLDs for RRV infection might increase by up to 66% by 2030, and nearly double by 2050 in South Australia. They might increase by up to 61% by 2030 and double by 2050 in Brisbane, Queensland.

In China, considering both climatic and population scenarios, if other factors remain constant, compared with the YLDs observed in 2000, the YLDs for bacillary dysentery might double by 2020 and triple by 2050 in both Jinan and Baoan. The YLDs for malaria might increase by up to 108% by 2020 and nearly triple by 2050 in Jinan, the temperate city, and increase by up to 144% by 2020 and nearly triple by 2050 in Baoan, the subtropical city.

Conclusions

1. Both maximum and minimum temperatures are important in the transmission of vector-borne diseases in various climatic regions in both Australia and China. River flow or high tides may also play an important role in the transmission of such diseases.
2. Both maximum and minimum temperatures play an important role in the transmission of enteric infections in various climatic regions in both Australia and China, with a threshold temperature detected in the temperate regions but not in subtropical and tropical regions.
3. The effects of rainfall and relative humidity on selected infectious diseases vary in different study areas in Australia and China.
4. The burden of temperature-related infectious diseases may greatly increase in the future if there is no effective preventive intervention.

Public health implications

1. Implication for health practice
    - Public health practitioners, together with relevant government organisations, should monitor trends in infectious diseases, as well as other relevant indexes, such as vectors, pathogens, and water and food safety. They should advise policy makers of the potential risks associated with climate change and develop public health strategies to prevent and reduce the impact of infectious disease associated with such change.
    - Doctors and other clinical practitioners should be prepared and supported in the provision of health care for any expected extra cases associated with climate variation and should play an important role in relevant health education on climate change.
    - Community participation is of significance to adapt to and mitigate the risk of climate change on population health. Community involvement helps to deliver programmes which more accurately target local needs. Therefore, community should be involved in the partnerships of climate change as early as possible.
    - Relevant education programs on the potential health impact of climate change should be conducted by government at all levels for different stakeholders, including industries, governments, communities, clinicians and researchers.
    - Advocacy for adapting to and mitigating climate change should be a longstanding public health activity.

2. Implication for researchers
    - The main task for researchers is to identify the independent contribution made by key climatic variables and whether there are exposure thresholds for infectious disease transmission. Further studies should include various infectious diseases in different climatic regions.
    - Developing countries and rural regions are more vulnerable to the impact of climate change so more research should be conducted for people living in those regions.
    - Studies using summary measures that combine prevalence of disease, quality of life and life expectancy, such as Disability Adjusted Life Years (DALYs),

to assess the burden of disease due to climate change is necessary to assist in decision making.

- More research should be conducted on the assessment of adaptive strategies and mitigation to future climate change.

3. Implication for policies
   - Public and preventive health strategies that consider local climatic conditions and their impact on vector and food borne diseases are important in reducing such impact due to climate change in the future.
   - The extra health burden that may be caused by future climate change may have a great impact on the currently overloaded public health system in both developed and developing countries. Long-term planning about health resource allocation, infrastructure establishment, and relevant response mechanisms should be developed at relevant government levels.
   - Effective prevention and intervention strategies will be possible only if the efforts of relevant sectors, including governments, communities, industries, research institutions, clinical professionals and individuals, have coordinated responses
   - International and regional collaborations are necessary to address this global issue. In addition, strategies of an international dimension should be translated into regional and local actions. This is extremely important to developing countries such as China and India.
   - Sustainable development policies with consideration given to reducing green house gases and environmental degradation need immediate action which will benefit future generations. Health priorities should include the prevention of climate change.

DECLARATION

I certify that this thesis does not incorporate any material previously submitted for a degree or diploma in any university. It does not contain any material previously published or written by another person except where due reference is made in the text. I give consent to a copy of my thesis being available for loan and photocopy in the University Library.

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