**eAppendix**

**The impact of temperature variability on years of life lost**

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**MATERIALS AND METHODS**

**Data collection**

Brisbane is the capital city of Queensland. It is located in the east coast of Australia (27 o 30' S, 153 o 00' E). It has the highest population density in subtropical Australia. Daily deaths from non-external causes during 1st January 1996 and 30th November 2004 were retrieved from Office of Economic and Statistical Research of the Queensland Treasury. Date of death, cause of death, sex and age were included in this dataset. Ethical approval was obtained from the Ethic Review Board of Queensland University of Technology prior to the data being collected. Years of life lost were assessed by matching each death by age and sex to the Australian national life tables for the years 2002 to 2004. The daily years of life lost were calculated by summing the years of life lost on the same day, and separate sums were made for cardiovascular deaths, respiratory deaths, men and women. To better calculate the health costs of temperature in monetary terms, a concept of “statistical life” was adopted in this study. To date, a number of ways have been developed to value a statistical life, using human capital or willingness-to-pay approaches. In Australia, a year of life is usually considered equals to AUD $ 40,000, suggested by Australian resource allocation committees, which means that interventions saving a year of life in Australia for every AUD $ 40,000 are cost-effective and are very likely to be funded.

Daily data on minimum temperature and relative humidity were provided by Australian Bureau of Meteorology. In this study, we calculated the standard deviation of minimum temperature in each week (weekly minimum temperature SD) as the indicator of temperature variability. Data on particular matter ≤ 10µm (PM10) (µg/m3), nitrogen dioxide (NO2) (µg/m3) and ozone (O3) (ppb) were obtained from the Queensland Department of Environment and Heritage Protection.

**Data analysis**

A quasi-Poisson regression model combined with a distributed lag non-linear model (DLNM) was used to examine the effect of weekly minimum temperature SD on years of life lost. Weekly average values of minimum temperature, relative humidity, NO2, PM10 and O3 were calculated, and these variables were controlled for in the model using a natural cubic spline with three degrees of freedom (*df*). Minimum temperature was controlled for in the model because the effect of minimum temperature on years of life lost was considered as a possible confounder and this study aimed to look at the effect of temperature variability in a consecutive way. We also ran the model without controlling for the minimum temperature and found the effect of minimum temperature SD on years of life lost almost did not change (results not given). Seasonality was adjusted for by month, and long-term trend was controlled for using a natural cubic spline with three *df* per year of data. Previous studies reported that there usually was a lagged effect of temperature on mortality, and a three-week lag was used in this study to capture any harvesting effects due to weeks with large temperature variability. The following equation was used to calculate the weekly cost due to 1°C increase in minimum temperature SD in different sub-groups (total, men and women etc.) (Table 2).

Mi = (RRi-1) \*YLLi \*40000

Where Mi is the weekly cost due to 1°C increase in minimum temperature SD in group i, RRi is the relative risk of 1°C increase in minimum temperature SD, and YLLi is the average of weekly years of life lost in group i. Annual cost due to 1°C increase in minimum temperature SD was calculated by multiplying the weekly cost with 52.14.

All data analysis was conducted using the R statistical environment (version 2.15) with the “dlnm” package used to fit the regression model. A sensitivity analysis was performed by varying the *df* for minimum temperature and humidity.

**Results**

Table 1 shows the summary statistics of weekly climate variables, air pollutants, and years of life lost in the total populations and different sub-populations. In Brisbane, weekly minimum temperature SD ranged from 0.6 °C to 6.7 °C, with a mean value of 2.2 °C. Average value of weekly years of life lost was 1532.6 in the total population in the same study period of Brisbane, and mean value of years of life lost in men (825.0) was higher than it was in women (707.6). Further, the mean value of years of life lost in elderly (817.9) was higher than that in younger population (714.7). Years of life lost due to cardiovascular causes accounted for a large proportion in the total amount.

**Table 1.** Summary statistics for weekly climatic variables, air pollutants, and years of life lost in Brisbane, Australia, 1996–2004

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variables | Mean | Standard deviation | Minimum | Percentile | Maximum |
| 25 | 50 | 75 |
| Minimum temperature SD (°C) | 2.2 | 0.9 | 0.6 | 1.6 | 2.1 | 2.7 | 6.7 |
| Minimum temperature (°C) | 14.47 | 3.5 | 2.1 | 10.4 | 15.1 | 18.4 | 24.3 |
| Relative humidity (%) | 52.25 | 10.0 | 23.3 | 46.3 | 52.4 | 58.9 | 90.1 |
| O3 (ppb) | 31.97 | 7.3 | 15.6 | 26.6 | 30.9 | 37.4 | 62.4 |
| PM10 (µg/m3) | 18.50 | 5.0 | 9.0 | 15.5 | 17.7 | 20.5 | 52.4 |
| NO2 (µg/m3) | 22.63 | 6.7 | 9.1 | 17.2 | 22.4 | 27.3 | 43.0 |
| Total YLLs | 1532.6 | 232.4 | 983.2 | 1368.8 | 1519.0 | 1680.2 | 2339.4 |
| YLLs in men | 825.0 | 163.3 | 437.1 | 714.3 | 814.6 | 927.1 | 1327.0 |
| YLLs in women | 707.6 | 146.8 | 369.7 | 603.5 | 695.0 | 807.1 | 1356.0 |
| YLLs in 0–64 years | 714.7 | 162.2 | 336.7 | 641.3 | 740.2 | 859.2 | 1230.0 |
| YLLs in ≥65 years | 817.9 | 134.3 | 503.9 | 725.6 | 806.2 | 896.6 | 1273.0 |
| Cardiovascular-related YLLs | 456.9 | 110.3 | 128.2 | 380.8 | 444.0 | 522.1 | 954.5 |
| Respiratory-related YLLs | 99.4 | 51.4 | 4.6 | 61.5 | 89.4 | 128.4 | 303.6 |

Figure 1 shows the associations between weekly minimum temperature SD and years of life lost, underscoring that years of life lost in Brisbane in the study period increased rapidly with the increase of weekly minimum temperature SD. In terms of the vulnerability to weekly minimum temperature SD among different sub-populations, we found that women (Figure 2) and young population (0-64 years) (Figure 3) were more sensitive. Cardiovascular-related years of life lost increased rapidly with weekly minimum temperature SD increased, while respiratory-related years of life lost were not very sensitive to the increase of weekly minimum temperature SD (Figure 4).

Table 2 shows the impact of 1 °C increase in weekly minimum temperature SD on years of life lost. Weekly years of life lost increased by 8% (95% confidence interval: 1% ­– 15%) with 1 ºC increment of weekly minimum temperature SD. Further, it indicates that every year government needs to spend more than AUD$ 255 million if yearly average value of weekly minimum temperature SD increases by 1 ºC.

**Table 2.** Monetary estimates of annual health cost due to 1 °C increase in minimum temperature SD impact on years of life lost in Brisbane, 1996-2004 (AUD $ million)

|  |  |  |  |
| --- | --- | --- | --- |
|  | RR (95% confidence interval (CI)) | Weekly cost (95% CI) | Annual cost (95% CI) |
| Whole population | 1.08 (1.01,1.15)\* | 4.90 (0.61,9.20) | 255.50 (31.81, 479.71) |
| Men | 1.07 (0.97,1.17) | 2.31 (-0.99,5.61) | 120.45 (-51.62, 292.52) |
| Women | 1.10 (1.01,1.20)\* | 2.83 (0.28,5.66) | 147.56 (14.60, 295.13) |
| 0–64 years | 1.05 (1.01,1.10)\* | 1.43 (0.29,2.86) | 74.56 (15.12, 149.13) |
| ≥65 years | 1.02 (0.97,1.08) | 0.65 (-0.98,2.62) | 33.89 (-51.10, 136.61) |
| Cardiovascular-related | 1.09 (1.01,1.18)\* | 1.64 (0.18,3.29) | 85.51 (9.39, 171.55) |
| Respiratory-related | 1.01 (0.90,1.15) | 0.04 (-0.40,0.60) | 2.09 (-20.86, 31.29) |

\**P* > 0.05

**Figure 1.** The association between temperature variability (standard deviation of minimum temperature within one week) and years of life lost, no reference value was set.

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**Figure 2.** The association between temperature variability and years of life lost by gender

 Men Women



**Figure 3.** The association between temperature variability and years of life lost by age

 ≤64 years ≥65 years



**Figure 4.** The association between temperature variability and years of life lost due to respiratory and cardiovascular deaths

 Respiratory-related Cardiovascular-related

