## ONLINE SUPPLEMENTARY MATERIALS

### Effect Modifiers

To identify potential factors which may increase people's susceptibility to the effects of temperature, we extracted information form the Discharge Abstract Database of the Canadian Institute of Health Information on each patient's date of birth and gender. In addition, we evaluated whether temperatures posed a greater impact on first-time hospital admissions than on recurring hospitalizations. Furthermore, we a priori ascertained five preexisting conditions, including AMI, cardiac dysrhythmias, congestive heart diseases, diabetes and hypertensive diseases (ICD-9 and ICD-10 diagnosis codes were listed in Supplementary Table S1 online),[1-5] using the records of hospitalizations from these conditions (based on all diagnostic codes) within five years before the hospitalizations under investigation. Finally, given that previous studies have suggested that persons taking certain medications (*e.g.*, anti-hypertensive drugs) are susceptible to cold or hot temperatures,[6-7] we obtained data from the Ontario Drug Benefits database on the intake of medications including statin, anticoagulants, all types of antihypertensive drugs, ACE inhibitors, and beta blockers within 90 days prior to hospital admissions. Because publicly funded prescription drugs are available to people aged 65 and above, the medication data contained claims for prescription for a subset of the study population.

### Definitions of Cold and Heat effects

Consistent with previous studies,[8,9] we estimated the cumulative effects of cold over a 21-day lag period by calculating the risk of hospitalization at the 1$^{st}$ percentile of temperature relative to the 25$^{th}$ percentile of temperature and to the optimal temperature, respectively. Heat effects were estimated at the 99$^{th}$ percentile of temperature relative to the 75$^{th}$ percentile of temperature and the optimal temperature, respectively.

### Calculations of Temperature-related Burden of Cardiovascular Hospitalizations

We estimated fractions and numbers of excess hospitalizations for CHD and stroke attributable to high and low temperatures, respectively. We used the fitted meta-analytical model to produce the best linear unbiased prediction of the overall cumulative exposure-response association in each health region, using a recently developed method.[10-12] The total attributable number of hospitalizations due to non-optimum temperatures was calculated by summing the contributions from all the days during the study period.[10,11] The total attributable fraction was calculated by dividing the total attributable number of hospitalizations by the total number of hospitalizations, and multiplying by 100. We calculated the components attributable to cold and heat by summing the contributions from days with temperatures lower and higher than the optimum temperature, respectively (see Figure S1). Further, we separated these components into moderate and extreme temperature conditions. We defined extreme cold and heat as temperatures from the minimum to the 2.5$^{th}$ temperature percentile and from the maximum to the 97.5$^{th}$ percentile.[10,12] Moderate temperatures were defined as the ranges between the optimum temperature and the two above mentioned cutoffs. The empirical confidential intervals (CIs) for attributable fractions were estimated using Monte Carlo simulations.[10,12]

**Calculations of medical costs of temperature-related cardiovascular hospitalizations**

According to a new report released recently by the Canadian Institute for Health Information (CIHI),[13] a patient being treated for a circulatory disease costs a hospital $11,260 on average in Canada. In our study, we estimated that 63,604 hospitalizations for coronary heart disease and stroke were associated with exposure to low and high temperatures during 18 years follow up. Therefore, these admissions would be associated with approximately CAD $39,787,836 medical costs per year.

**Supplemental References**


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daily mortality in the temperate climate of Montreal, Canada. *Environ Res* 2011;**111**:853-60.
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12. Gasparrini A, Leone M. Attributable risk from distributed lag models. *BMC Med Res Methodol* 2014;**14**:55.
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**Table S1.** International Classification of Diseases (ICD) codes of study conditions and selected comorbidities.

| | ICD-9 | ICD-10 |
|---|---|---|
| Coronary heart disease | 410-414 | I20-I25 |
| Acute myocardial infarction | 410 | I21 |
| Stroke | 430-438 | I60-I68 |
| ischemic stroke | 433, 434, 436 | I63-I64 |
| Cardiac dysrhythmias | 427 | I47 - I49 |
| Congestive heart failure | 428 | I50 |
| Diabetes | 250 | E10-E14 |
| Hypertensive diseases | 401-405 | I10-13, I15 |

**Table S2.** Descriptive statistics of daily mean temperature distribution for 14 health regions in Ontario, Canada, 1996 to 2013. The optimal temperatures for hospitalizations from congestive heart failure, acute myocardial infarction, stroke, and ischemic stroke were at the 79th, 94th, 74th, and 76th percentiles, respectively.

| Region | The number of weather monitoring stations | Temperature | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Min | 1st | 10th | 25th | 50th | 74th | 75th | 76th | 79th | 90th | 94th | 99th | Max |
| Ontario | 125 | 7.6 | -22.9 | -16.0 | -6.9 | -0.6 | 8.0 | 16.6 | 17.0 | 17.2 | 18.0 | 20.9 | 22.1 | 25.2 | 29.3 |
| Health regions | | | | | | | | | | | | | | | |
| 1. Erie St. Clair | 9 | 9.7 | -19.3 | -11.7 | -3.8 | 1.4 | 10.0 | 18.2 | 18.7 | 18.9 | 19.8 | 22.5 | 23.7 | 26.4 | 30.2 |
| 2. South West | 6 | 8.1 | -19.6 | -13.5 | -5.7 | 0.0 | 8.4 | 16.7 | 17.0 | 17.2 | 17.9 | 20.7 | 22.0 | 24.8 | 28.6 |
| 3. Waterloo Wellington | 2 | 7.8 | -22.3 | -15.1 | -6.4 | -0.4 | 8.2 | 16.5 | 16.9 | 17.2 | 17.9 | 20.9 | 22.5 | 25.7 | 29.8 |
| 4. Hamilton Niagara Haldimand Brant | 9 | 9.1 | -18.2 | -12.3 | -4.3 | 1.2 | 9.3 | 17.8 | 18.2 | 18.4 | 19.1 | 22.0 | 23.2 | 26.2 | 30.1 |
| 5. Central West | 4 | 8.5 | -20.9 | -14.2 | -5.6 | 0.4 | 8.8 | 17.4 | 17.8 | 18.0 | 18.7 | 21.8 | 23.1 | 26.5 | 31.0 |
| 6. Mississauga Halton | 1 | 9.4 | -17.9 | -11.4 | -3.5 | 1.8 | 9.3 | 17.8 | 18.2 | 18.4 | 19.2 | 22.2 | 23.6 | 26.8 | 31.2 |
| 7. Toronto Central | 3 | 9.2 | -19.3 | -12.1 | -3.6 | 1.9 | 9.1 | 17.4 | 17.9 | 18.1 | 18.8 | 21.7 | 22.8 | 25.7 | 30.5 |
| 8. Central | 1 | 8.4 | -21.9 | -14.8 | -5.8 | 0.2 | 8.6 | 17.3 | 17.7 | 17.9 | 18.7 | 21.7 | 23.0 | 26.8 | 32.2 |
| 9. Central East | 6 | 7.5 | -23.7 | -16.3 | -6.2 | 0.1 | 7.8 | 16.0 | 16.4 | 16.6 | 17.4 | 20.1 | 21.2 | 24.0 | 29.3 |
| 10. South East | 7 | 7.7 | -24.9 | -16.9 | -6.9 | -0.2 | 8.2 | 16.8 | 17.1 | 17.3 | 18.1 | 21.0 | 22.0 | 24.8 | 28.6 |
| 11. Champlain | 3 | 6.9 | -26.8 | -19.6 | -9.5 | -1.9 | 7.7 | 16.9 | 17.2 | 17.4 | 18.3 | 21.2 | 22.5 | 25.8 | 29.8 |
| 12. North Simcoe Muskoka | 9 | 7.0 | -24.7 | -17.7 | -7.5 | -1.0 | 7.4 | 16.1 | 16.4 | 16.6 | 17.3 | 20.2 | 21.5 | 24.7 | 27.4 |
| 13. North East | 31 | 4.6 | -28.4 | -22.0 | -11.7 | -4.3 | 5.4 | 14.6 | 14.9 | 15.1 | 16.0 | 18.8 | 20.0 | 22.7 | 26.2 |
| 14. North West | 34 | 2.2 | -33.1 | -25.8 | -16.1 | -7.4 | 3.4 | 13.0 | 13.4 | 13.6 | 14.5 | 17.6 | 18.7 | 21.8 | 24.8 |

**Table S3.** Comparison of Akaike Information Criteria for quasi-Poisson (Q-AIC) values for the relationships between temperature and cause-specific hospitalizations in Ontario, Canada, 1996-2013, using distributed lag non-linear models.*

| | **Natural cubic spline for temperature with two different knot locations** | |
|---|---|---|
| | 10th, 50th and 90th | 10th, 35th, 65th and 90th |
| Coronary heart disease | 426495 | 426498 |
| Acute myocardial infarction | 333541 | 333548 |
| Stroke | 312577 | 312611 |
| Ischemic stroke | 278954 | 279002 |

*Models were fitted using natural cubic for lags (3 degrees of freedom) with one internal knots and adjusting for seasonality and long-term trend using natural cubic spline for time (7 degrees of freedom per year), relative humidity, nitrogen dioxide, ozone, statutory holidays, a day-of-week indicator, and daily influenza activity.

**Table S4.** Cumulative relative risks (RRs) and 95% confidence interval (CIs) for the cold and heat effects on daily cause-specific hospitalizations over 21 lag days, using different degrees of freedom (*df*) for temperature and lag.

| ***Df* for temperature** | **No. of internal knots for lag** | **Cold Effect* RR (95% CI)** | **Heat Effect† RR (95% CI)** |
|---|---|---|---|
| CHD | | | |
| 4 | 1 | 1.06 (1.01-1.10) | 1.06 (1.01-1.11) |
| 5 | 1 | 1.07 (1.02-1.11) | 1.03 (0.98-1.08) |
| 4 | 2 | 1.06 (1.01-1.10) | 1.06 (1.01-1.12) |
| AMI | | | |
| 4 | 1 | 1.09 (1.03-1.16) | 0.99 (0.92-1.06) |
| 5 | 1 | 1.07 (1.00-1.13) | 1.07 (0.96-1.19) |
| 4 | 2 | 1.09 (1.03-1.16) | 0.99 (0.92-1.07) |
| Stroke | | | |
| 4 | 1 | 1.09 (1.01-1.18) | 1.08 (0.99-1.17) |
| 5 | 1 | 1.10 (1.01-1.20) | 1.06 (0.97-1.15) |
| 4 | 2 | 1.09 (1.01-1.19) | 1.07 (0.98-1.17) |
| Ischemic stroke | | | |
| 4 | 1 | 1.06 (0.96-1.17) | 1.07 (0.96-1.19) |
| 5 | 1 | 1.07 (0.97-1.18) | 1.06 (0.96-1.18) |
| 4 | 2 | 1.06 (0.96-1.17) | 1.07 (0.96-1.19) |

*Relative risks associated with the $1^{st}$ percentile of temperature relative to the $25^{th}$ percentile of temperature.

†Relative risks associated with the $99^{th}$ percentile of temperature relative to the $75^{th}$ percentile of temperature.

CHD=coronary heart disease; AMI=acute myocardial infarction

**Table S5.** Cumulative relative risks (RRs) and 95% confidence interval (CIs) for the cold and heat effects on daily cause-specific hospitalizations over 21 lag days, with and without adjusting for ambient fine particles ($PM_{2.5}$).*

| $PM_{2.5}$ | Cold Effect† RR (95% CI) | Heat Effect‡ RR (95% CI) |
|---|---|---|
| CHD | | |
| With | 1.04 (0.97-1.12) | 1.04 (0.97-1.10) |
| Without | 1.05 (0.98-1.13) | 1.03 (0.97-1.10) |
| AMI | | |
| With | 1.10 (1.00-1.22) | 0.89 (0.80-0.99) |
| Without | 1.10 (1.00-1.22) | 0.89 (0.80-0.99) |
| Stroke | | |
| With | 1.17 (1.01-1.35) | 1.09 (0.96-1.23) |
| Without | 1.17 (1.01-1.34) | 1.09 (0.96-1.23) |
| Ischemic stroke | | |
| With | 1.13 (0.99-1.30) | 1.03 (0.89-1.19) |
| Without | 1.13 (0.99-1.29) | 1.03 (0.89-1.19) |

*This analysis was restricted to the period from 2003 to 2010 when the data of $PM_{2.5}$ was available.

†Relative risks associated with the $1^{st}$ percentile of temperature relative to the $25^{th}$ percentile of temperature.

‡Relative risks associated with the $99^{th}$ percentile of temperature relative to the $75^{th}$ percentile of temperature.

CHD=coronary heart disease; AMI=acute myocardial infarction

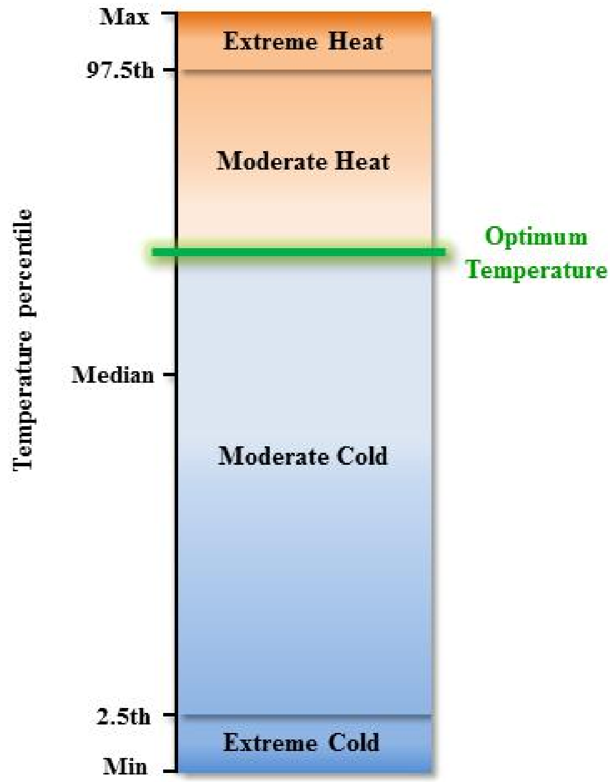


**Figure S1**. Definitions of extreme cold, moderate cold, extreme heat, and moderate cold. The optimal temperature refers to the temperature of the lowest risk based on the temperature-hospitalization curve. The optimal temperatures for hospitalizations from coronary heart disease, acute myocardial infarction, stroke, and ischemic stroke were at the 79$^{th}$, 94$^{th}$, 74th, and 76$^{th}$ percentiles, respectively.

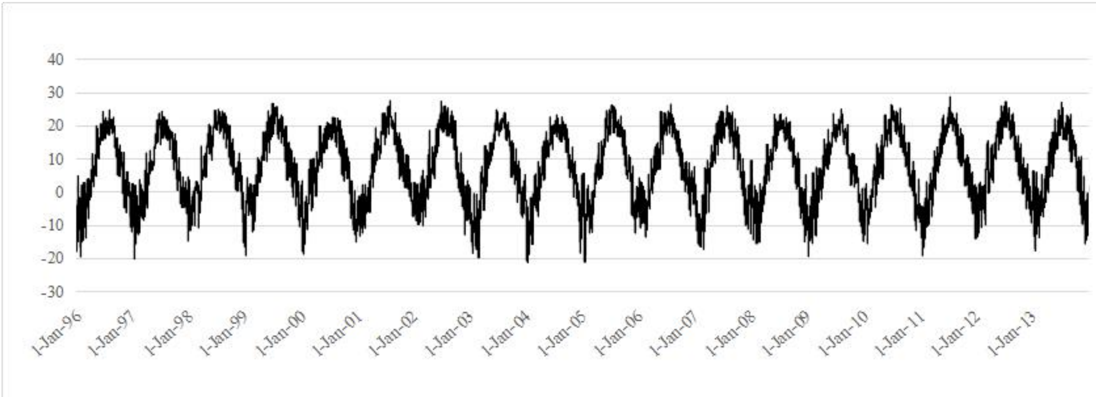


**Figure S2**. Daily mean temperatures (°C) in Ontario from January 1, 1996 to December 31, 2013

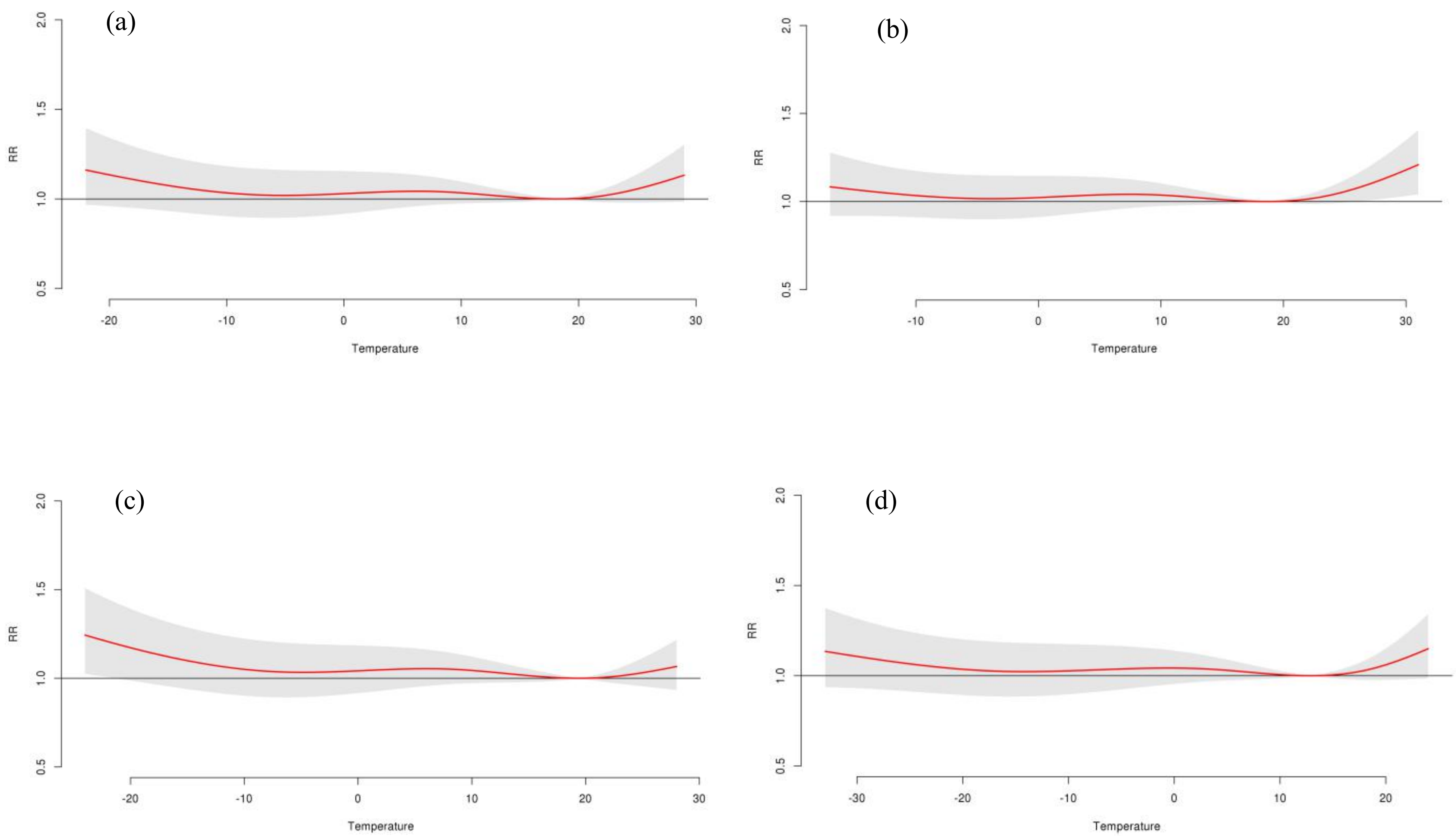


**Figure S3.** Cumulative exposure–response associations of daily mean temperatures and daily hospital admissions for coronary heart disease over a lag of 21 days in (a) Waterloo Wellington, (b) Mississauga Halton, (c) South East, and (d) North West, 1996-2013

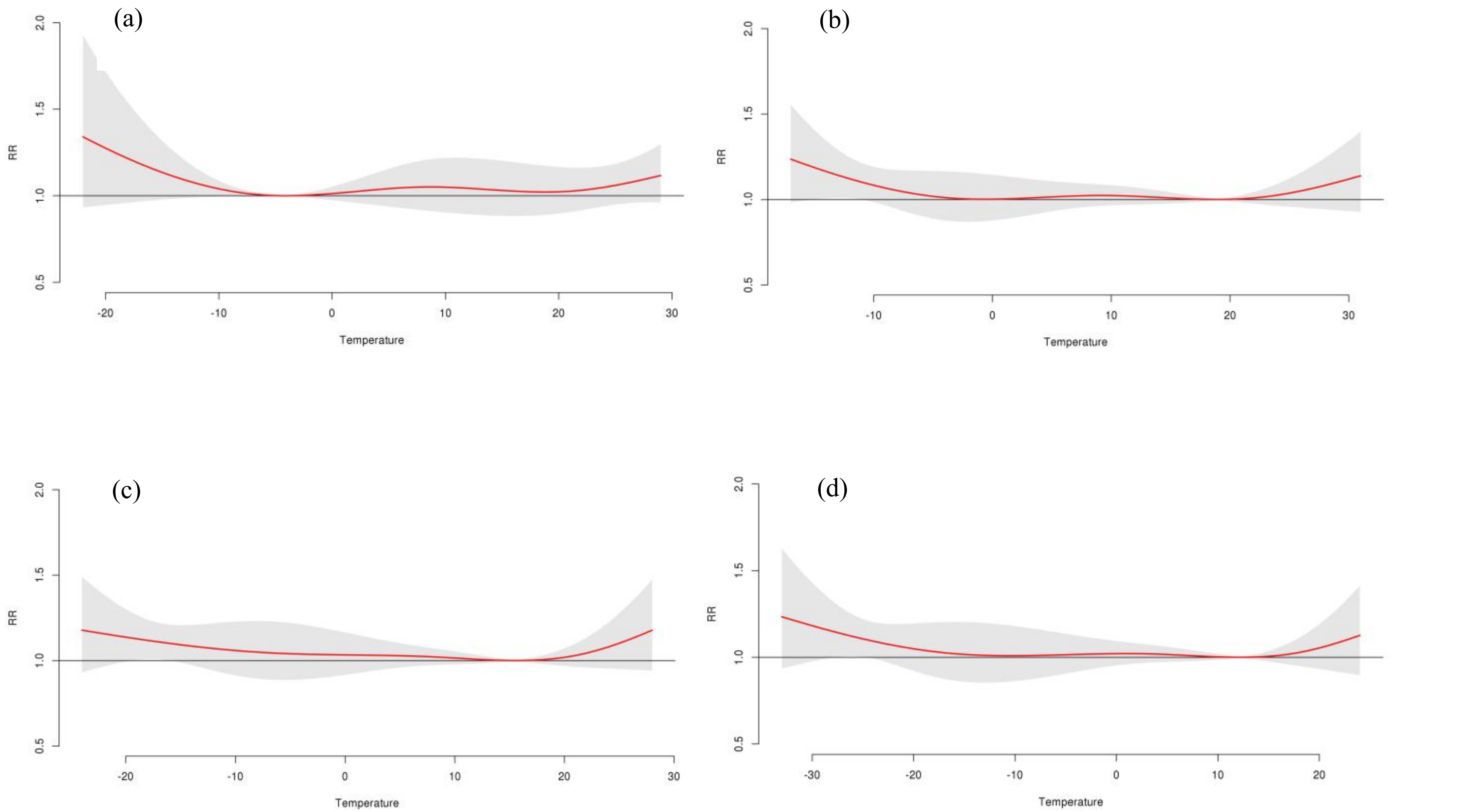


**Figure S4.** Cumulative exposure–response associations of daily mean temperatures and daily hospital admissions for stroke over a lag of 21 days in (a) Waterloo Wellington, (b) Mississauga Halton, (c) South East, and (d) North West, 1996-2013

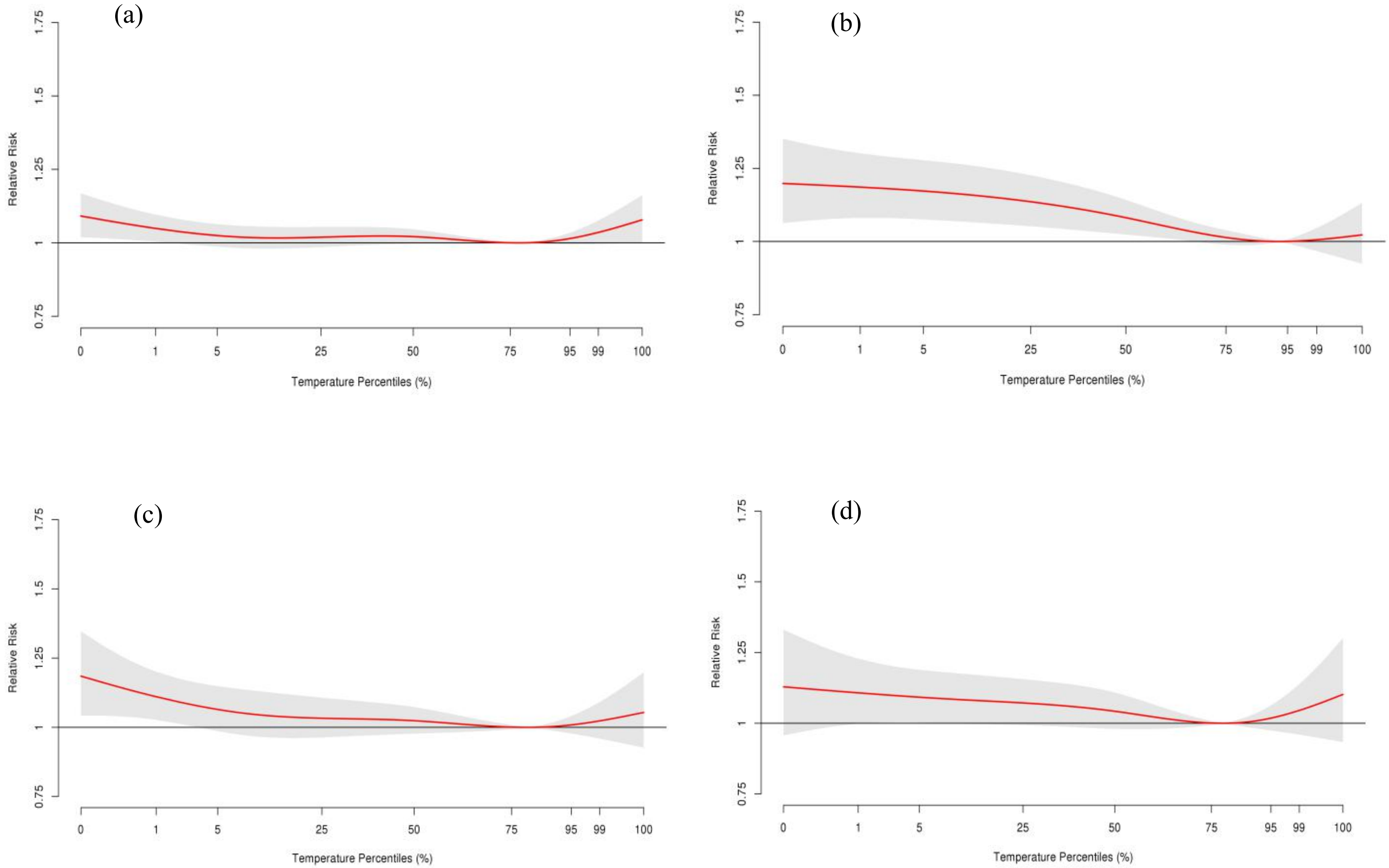


**Figure S5.** Cumulative exposure–response associations of daily mean temperatures and daily hospital admissions for (a) coronary heart disease, (b) acute myocardial infraction, (c) stroke, and (d) ischemic stroke over a lag of 14 days in Ontario, Canada, 1996-2013.