EXECUTIVE SUMMARY

This Summary Report describes the key findings of a major study[1] undertaken to investigate the combined and independent impacts of extreme weather (hot/cold) and air pollution on human acute mortality under historical, current and future climates for four selected cities (Montreal, Ottawa, Toronto, Windsor) in south-central Canada. The study was carried out in three steps:

- the development of a method to assign the *annual mean* burden of illness (in terms of elevated mortality) associated with extreme weather and air pollution using synoptic classification of air masses in the four cities;

- the development of a model system that can be used (for each air-mass) to assess the changing meteorological and air pollution factors that contribute to the *day-to-day variability* in mortality, and to use the coefficients from this assessment to forecast daily mortality risk based on current or forecast daily weather and air pollution information; and

- the application of the daily model, in conjunction with existing Global Climate Models (GCMs), suitably adapted, to assess the *impact of climate change* on public health associated with extreme weather and air pollution, in terms of elevated acute mortality and frequency of severe weather and air pollution episodes.

Given that the study methodology is very complex and relies on techniques used by diverse disciplines, the *Summary* explains some of the concepts essential to a better understanding of the methods used.

One important outcome of this work was the development of the methods described briefly above. The process analysed North American and Canadian national archives and models of climatological, weather, air pollution and mortality data, making use of a suite of climatological, meteorological and statistical techniques. The other important outcome was the results of the analysis. Using the methods that were developed, scientific information suitable for public policy risk identification and assessment was made available. This information can also be used for improvement of the adaptive capacity of the health infrastructure for these specific cities in south-central Canada, in response to projected human health impacts of climate change, and the process shows great promise for application in many other urban areas.

Toronto Acute Mortality from Extreme Weather and Air Pollution.
For the City of Toronto, over the1954-2000 period of analysis, the mean annual elevated acute mortality associated with hot weather was 120; with cold weather 105; and with air pollution was 822 excess deaths. When data specific to 1999 were analysed, Cheng *et al.* found that air pollution- related elevated mortality was 705, agreeing well with the 695 premature deaths attributed to acute air pollution exposure in 1999 determined by Toronto Public Health in 2004. These figures are consistent with the observation that air pollution levels were higher in the early part of the study period than they were in more recent times.

Development of a Heat-Health Alert System for Toronto.
The Toronto Heat-Health Alert System (HHAS) has been piloted by the City of Toronto, Environment Canada, University of Delaware and Kent State University since the summer of 2001. The existing Toronto

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[1] *Differential and Combined Impacts of Winter and Summer Weather and Air Pollution due to Global Warming on Human Mortality in South-Central Canada*. Chad Cheng, Monica Campbell *et al.* Health Canada, Environment Canada and Toronto Public Health; 2005

HHAS estimates the weather impact of heat on human health, but was not designed to include the effects of air pollution. The Cheng *et al.* model for a heat-health warning system is a different design from that currently being evaluated, since it also includes air quality.

Annual mean occurrence of elevated mortality events forecast by the three hot-weather-type prediction models and their agreement with observations were calculated for the whole period. The number of identified days with elevated mortality events depends on the strength of the prediction models. On the basis of the historical data, in Toronto the mean number of days with warnings (per year) would be: (90% probability) 2.5; (80% probability) 4.5; and (60% probability) 22. The stronger the model, the greater the number of days with elevated mortality that are identified correctly. For 80 and 90% probability there was 85% agreement with observations, but with 60% probability only 66% agreement. For the purposes of development of alert systems for other cities, it is recommended that various cut-off probability thresholds be evaluated to balance the number of "advisories" or "warnings" given (and reduce the number of "false alarms").

Effects of Climate Change in Toronto

<u>Air Pollution</u>
Changes in air pollution levels were projected according to the expected changes in CO2 levels during this century. The projection (according to an air pollution emission policy scenario in which air pollution emissions increase 32% by 2080) showed that for all pollutants, by the 2080s days in the "Low" categories are reduced, and days in "High" categories are increased substantially.

<u>Heat "alerts" and associated hot-weather mortality</u>
The climate change models project a fourfold increase in the number of hot weather warnings by the 2080s, which if not responded to could lead to a tripling of heat-related deaths from 120 to 360 per year. On the other hand, cold related mortality could decrease from 105 to 35 per year.

<u>Air pollution-related elevated mortality</u>
Climate change models project from 25 to 30% increase in acute air pollution-related mortality by the 2080s for Toronto, going from current levels of 822 to1070 per year.

<u>Acute mortality by the 2080s due to extreme weather and air pollution</u>
Summation of the numbers above for Toronto would indicate elevated mortality from acute effects of severe weather and air pollution by the 2080s to be 1465 per year. Cheng *et al.* projected acute mortality changes for both the 2050s and 2080s. For the sake of brevity only the 2080s projections appear in this Executive Summary. It should also be pointed out that these estimates have <u>not</u> taken into account either expected future population growth or age structure changes, and may represent the lower bound of the mortality estimate.

Implications of the study

The information is now available. The task is to implement the changes in policy that must be carried out to protect public health. The evidence is strong that the continuance of the industrialized world's dependency on fossil fuels will lead to increased death and disease for all the world, especially the urban areas which are increasingly becoming magnets for population growth. This dependency, if not eliminated entirely, must be reduced to a sustainable level which does not harm public health.