Health Effects of Hot vs. Cold Temperatures in Asia

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CO2Science & SPPI Original Paper ♦ December 30, 2014

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Citation: Center for the Study of Carbon Dioxide and Global Change. "Health Effects of Hot vs. Cold Temperatures in Asia." Last modified December 30, 2014. http://www.co2science.org/subject/h/summaries/asiahotvcold.php.

Climate alarmists predict global warming will increase human death rates, and nary a heat wave occurs but what they are quick to blame any concurrent excess deaths on the high temperatures associated with it. Much more deadly than *hot* weather, however, is *cold* weather; yet climate alarmists typically ignore the excess deaths that are caused by low temperatures, even though they are far more numerous than those caused by high temperatures. In the present summary we examine a number of papers investigating the relationship between temperature and human health for various locations in Asia.

Climate alarmists predict global warming will increase human death rates. Much more deadly than hot weather, however, is cold weather; yet climate alarmists typically ignore the excess deaths that are caused by low temperatures, even though they are far more numerous than those caused by high temperatures.

The relationship between temperature and human health has been studied by multiple researchers for Shanghai, China. Kan *et al.* (2003)[1], for example, investigated the association between temperature and daily mortality from 1 June 2000 to 31 Dec 2001, finding a V-like relationship between total mortality and temperature that had a minimum mortality risk at 26.7°C. Above this optimum temperature, they observed "total mortality increased by 0.73% for each degree Celsius increase; while for temperatures below the optimum value, total mortality decreased by 1.21% for each degree Celsius increase." The net effect of a warming in Shanghai, China, therefore, would likely be reduced mortality on the order of 0.5% per degree Celsius increase in temperature, or perhaps even more, in light of the fact that the warming of the past few decades has been primarily due to increases in daily minimum temperatures, with much smaller increases at the high end of the temperature spectrum. Hence, it can be appreciated that the recovery of the Earth from the global chill of the Little Ice Age has had a positive effect on the health of the people of Shanghai that continues to this day, and it should continue into the foreseeable future if the planet continues to warm.

Tan *et al.* (2007)[2] used a multivariate analysis "to investigate the relationships between mortality and heat wave intensity, duration, and timing within the summer season, along with levels of air pollution," for the exceptional heat waves of 1998 and 2003. "For heat waves in both summers," in the words of the researchers, "mortality was strongly associated with the

[1] http://www.co2science.org/articles/V6/N40/C3.php.
[2] http://www.co2science.org/articles/V10/N17/B2.php.

duration of the heat wave." However, whereas the major heat wave of 2003 was of much greater duration than the major heat wave of 1998 (19 days in 2003 vs. 11 days in 1998), the mortality experienced in 2003 was much less than that experienced in 1998 (6.3 deaths/heat day in 2003 vs. 13.3 deaths/heat day in 1998). Given such, Tan *et al*. conclude "since the meteorological conditions and pollution levels for the two heat waves were alike, we conclude that improvements in living conditions in Shanghai, such as increased use of air conditioning [1.35/household in 2003 vs. 0.69/household in 1998], larger living areas [13.8 m^2/person in 2003 vs. 9.7 m^2/person in 1998], and increased urban green space, along with higher levels of heat awareness and the implementation of a heat warning system, were responsible for the lower levels of human mortality in 2003 compared to 1998."

Kan *et al*. (2007)[3] examined the association between Diurnal Temperature Range (DTR, defined as daily maximum temperature minus daily minimum temperature) and human mortality using daily weather and mortality data from Shanghai over the period 1 January 2001 to 31 December 2004 via a semi-parametric generalized additive model after controlling for covariates including time trend, day of week, temperature, humidity and outdoor air pollution levels. For cold days (below 23°C), according to Kan *et al*., "a 1°C increase of the 3-day moving average of DTR corresponded to 1.41%, 1.76% and 1.47% increases in total non-accidental, cardiovascular and respiratory mortality," while for warm days (above 23°C), "an increase of 1°C DTR corresponded to 1.13%, 1.91% and 0.54% increases in total non-accidental, cardiovascular and respiratory mortality."

Kan *et al*. say their data suggest "even a slight increase in DTR is associated with a substantial increase in mortality." In addition, they correctly note that over the course of the past century, global warming has been characterized by "the daily minimum temperature increasing at a faster rate ... than the daily maximum, resulting in a decrease in the DTR for many parts of the world." Consequently, their results suggest that in addition to the reduction in human mortality typically provided by the increase in daily mean temperature, the accompanying decrease in DTR should also have been tending to reduce human mortality. The result thus adds up to a truly phenomenal (double-barreled) health benefit for most of the world's inhabitants.

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Working with weather data they obtained from the Shanghai Meteorological Bureau, Ma *et al*. (2011)[4] investigated the impact of heat waves and cold spells on hospital admissions in

[3] http://www.co2science.org/articles/V10/N20/B1.php.
[4] http://www.co2science.org/articles/V15/N2/B1.php.

Shanghai, China. For their study they defined heat wave as a period of at least seven consecutive days with daily maximum temperature above 35.0°C and daily average temperatures above the 97th percentile during the study period, while they defined cold spell as a period of at least seven consecutive days with daily maximum temperature and daily average temperatures below the 3rd percentile during the study period. Then, for one heat wave (24 July to 2 August, 2007) and one cold spell (28 January to 3 February, 2008), they obtained daily hospital admission data for these periods from the Shanghai Health Insurance Bureau.

The four researchers report the number of excess (above normal) hospital admissions during the eight-day heat wave was 352—driven by a 2% increase in all-cause admissions, an 8% increase in admissions due to cardiovascular problems, and a 6% increase in admissions related to respiratory problems—while during the ten-day cold spell there were 3725 excess admissions, driven by 38%, 33% and 32% increases in admissions due to all-cause, cardiovascular and respiratory problems, respectively. In a rather low-key discussion of their findings, Ma *et al*. say "the cold spell seemed to have a larger impact on hospital admission than the heat wave in Shanghai."

Cheng and Kan (2012)[5] employed a generalized additive model with penalized splines to analyze mortality, air pollution, temperature and covariate data over the period 1 January 2001 through 31 December 2004 in Shanghai, focusing on particulate matter of diameter 10 μm or less (which is commonly referred to as PM_{10}) and ozone (O_3). In so doing, Cheng and Kan report they "did not find a significant interaction between air pollution and higher temperature [>85th percentile days]," but they say "the interaction between PM_{10} and extreme low temperature [<15th percentile days] was statistically significant for both total and cause-specific mortality." More specifically, they found that compared to normal temperature (15th-85th percentile days), a 10-μg/m^3 increase in PM_{10} on extreme low temperature days led to all-cause mortality rising from 0.17% to 0.40%. And they add "the interaction pattern of O_3 with low temperature was similar," noting their finding of "a stronger association between air pollution and daily mortality on extremely cold days confirms those of three earlier seasonal analyses in Hong Kong, Shanghai and Athens," citing the studies of Touloumi *et al*. (1996), Wong *et al*. (1999, 2001) and Zhang *et al*. (2006).

In a paper published in the journal *PLOS ONE*, Zhang *et al*. (2014)[6] set about to quantitatively evaluate the short-term effects of daily mean temperature on adult asthma hospital admissions in Shanghai, stating "there is limited evidence for the impacts of meteorological changes on asthma hospital admissions in adults." The seven scientists say that during their study period January 2005 through December 2012, there were 15,678 hospital admissions for adult asthma for Shanghai residents, which worked out to an average of 5.6 per day. And they indicate there was a significant negative correlation between asthma hospitalizations and daily mean temperature (DMT), "with lower temperatures associated with a higher risk of hospital admission for asthma," wherein "the cold effect appeared to be relatively acute, with duration lasting several weeks, while the hot effect was short-term." In fact, they say they actually found

[5] http://www.co2science.org/articles/V15/N24/C3.php.
[6] http://www.co2science.org/articles/V17/dec/a1.php.

that "warmer temperatures were not associated with asthma hospital admissions," and they ultimately conclude that their findings suggest "cold temperature may trigger asthma attacks." As a result, Zhang *et al*. say that "effective strategies are needed to protect populations at risk from the effects of cold."

In introducing their study, Zhou *et al*. (2014)[7] indicate that an increase in diurnal temperature range (DTR) has been found to lead to an increase in daily mortality in several Chinese cities, including Shanghai (Kan *et al*., 2007), Guangzhou (Luo *et al*., 2013; Yang *et al*., 2013), Taiwan (Liang *et al*., 2009), and Hong Kong (Tam *et al*., 2009). And, therefore, they decided to search out still further evidence for this relationship across a broader north-south swath of the country that included, moving from north to south, the cities of Anshan, Tangshan, Xi'an, Nanjing, Suzhou, Wuhan, Shanghai and Guangzhou.

As a result of this massive undertaking, which they describe as "the largest epidemiologic study to date in China to examine the association of DTR with daily mortality," the seven scientists found that "the increased risk of mortality from total, cardiovascular diseases and respiratory diseases in a full year attributable to a 1°C increase in DTR were 0.18%, 0.25% and 0.38%, respectively." Most interestingly, however, the work of Karl *et al*. (1984, 1991) indicates that the global warming of Earth's recent past was characterized by daily *minimum* temperatures rising *three times more* than daily *maximum* temperatures, thereby significantly *reducing* the DTR and *saving* a significant number of lives worldwide, revealing a significant benefit of modern global warming.

The global warming of Earth's recent past was characterized by daily minimum temperatures rising three times more than daily maximum temperatures, thereby significantly reducing the DTR and saving a significant number of lives worldwide, revealing a significant benefit of modern global warming.

Still in China but focusing on Beijing, Wang *et al*. (2013)[8] introduce their work by writing that "a large change in temperature within one day may cause a sudden change in the heart rate and circulation of elderly people, which all may act to increase the risk of cardiopulmonary and other diseases, even leading to fatal consequences." And they further note, "it has been shown that a rise of the minimum temperature has occurred at a rate three times that of the maximum temperature during the twentieth century over most parts of the world, which has led to a decrease of the diurnal temperature range (Karl *et al*., 1984, 1991)." Realizing the significance of these related facts, Wang *et al*. decided to evaluate the short-term effect of diurnal temperature range (DTR) on emergency room (ER) admissions among elderly adults in Beijing." As they describe it, "after controlling the long-time and seasonal trend, weather, air pollution and other confounding factors, a semi-parametric generalized additive model (GAM) was used to analyze the exposure-effect relationship between DTR and ER admissions among elderly adults with

[7] http://www.co2science.org/articles/V17/dec/a20.php.
[8] http://www.co2science.org/articles/V16/N40/C3.php.

different lag structures from 2009 to 2011 in Beijing," where they "stratified groups by age and gender."

In describing their findings, the nine researchers report "significant associations were found between DTR and four major causes of daily ER admissions among elderly adults in Beijing." More specifically, they state "a 1°C increase in the 8-day moving average of DTR (lag 07) corresponded to an increase of 2.08% in respiratory ER admissions and 2.14% in digestive ER admissions," while "a 1°C increase in the 3-day and 6-day moving average of DTR (lag 02 and lag 05) corresponded to a 0.76% increase in cardiovascular ER admissions, and a 1.81% increase in genitourinary ER admissions, respectively." And they add "people aged 75 years and older were associated more strongly with DTR than the 65–74 age group."

Introducing their work, Wu *et al*. (2013)[9] note "numerous studies have reported the association between ambient temperature and mortality," but they say "few multi-city studies have been conducted in subtropical regions in developing countries." Hence, they proceed to make up for this neglect.

Wu *et al*. first assessed the health effects of temperature on mortality in four subtropical cities of China (Changsha, Kunming, Guangzhou and Zhuhai) by means of a "double threshold-natural cubic spline" distributed lag non-linear model at different temporal lags, after which they used the combined results to conduct a meta-analysis to estimate the overall cold and hot effects on mortality at different lag days. In doing so the eleven researchers report a U-shaped relationship between temperature and mortality was found in the four cities, which indicates "mortality is usually lowest around a certain temperature and higher at lower or higher temperatures," as they say has also been found to be the case by Alberdi *et al*. (1998), Huynen *et al*. (2001), Curriero *et al*. (2002), O'Neill *et al*. (2003), Armstrong (2006), Laaidi *et al*. (2006) and Kan *et al*. (2007). In addition, they found "the hot effect peaked at the current day, and then diminished with lag days; whereas "the cumulative cold effect increased gradually with lag days, with the highest effect at lag 0–27."

Although "both low and high temperatures were associated with increased mortality in the four subtropical Chinese cities," according to Wu *et al*., they state the "cold effect was more durable and pronounced than the hot effect." And these observations clearly indicate that global warming leads to a net reduction in human mortality, which is just the opposite of what the IPCC and others are promoting.

Yang *et al*. (2013)[10] examined the effects of Diurnal Temperature Range (DTR) on human mortality rates, as well as whether the effects were different for different individual characteristics, such as gender, age and education level. This was accomplished using daily meteorological data for the period 1 January 2003 through 31 December 2010 obtained from the China Meteorological Data Sharing System, which included daily mean temperature plus minimum and maximum temperatures collected from a single station located in the heart of the urban area of Guangzhou City (the largest metropolis in Southern China), along with

[9] http://www.co2science.org/articles/V16/N39/B3.php.
[10] http://www.co2science.org/articles/V16/N27/B1.php.

individual data for all 189,379 registered deaths that occurred over the same time period, which they obtained from the Guangzhou Center for Disease Control and Prevention.

Results indicate there was "a linear DTR-mortality relationship, with evidence of increasing mortality with DTR increase," where "the effect of DTR occurred immediately and lasted for four days," such that over that time period, a 1°C increase in DTR was associated with a 0.47% increase in non-accidental mortality. They also found "the elderly, females and residents with less education have been identified as more vulnerable to rapid temperature change within a single day." In addition, they report there was a joint adverse effect with temperature "when mean temperature was below 22°C, indicating that high DTR enhanced cold-related mortality."

In light of their several findings, the eight researchers speculate the expected "decrease in DTR in future climate scenarios might lead to two benefits: one from decreasing the adverse effects of DTR [which is reduced due to greater warming at night than during the day], and the other from decreasing the interaction effect with temperature [which is expected to rise with greenhouse warming]."

Moving to a different region of Asia, Guo *et al*. (2012)[11] note that knowledge of the health effects of extreme temperatures on mortality comes mainly from developed countries, particularly from regions with temperate climates; and they say "few studies have been conducted in developing countries, particularly in tropical regions." Thus, they go on to conduct one such study for Chiang Mai, Thailand (18°47'N, 98°59'E), with a population of 1.6 million people as of 2008. For their analysis, Guo *et al*. used a Poisson regression model combined with a distributed lag non-linear model to examine the non-linear and delayed effects of temperature on cause-specific and age-specific mortality, employing data from 1999 to 2008, while controlling for season, humidity, ozone and particulate matter (PM_{10}) pollution. In doing so the three researchers found "both hot and cold temperatures resulted in immediate increase in all mortality types and age groups," but they say "the hot effects on all mortality types and age groups were short-term, while the cold effects lasted longer." And, of course, the cold effects were greater, with more people dying from them than from the effects of heat.

Lin *et al*. (2013)[12] write as background for their work that "high temperatures have garnered considerable attention in Europe and the U.S. because of their short-term adverse health impacts." However, they say that several studies have reported that "the adverse health effects of cold temperatures may be more significant than those of high temperatures in Spain, Canada, Shanghai and Taiwan (Gomez-Acebo *et al*., 2010; Lin *et al*., 2011; Ma *et al*., 2011; Martin *et al*., 2012; Wang *et al*., 2012)," while also noting that "mortality risk associated with low temperatures is likely underestimated when studies fail to address the prolonged effect of low temperature (Martin *et al*., 2012; Mercer, 2003)."

Working with data pertaining to daily area-specific deaths from (1) all causes, (2) circulatory diseases and (3) respiratory diseases, Lin *et al*. developed relationships between each of them and a number of different cold-temperature related parameters for the period between 2000

[11] http://www.co2science.org/articles/V15/N52/B1.php.
[12] http://www.co2science.org/articles/V16/N52/C1.php.

and 2008. In doing so the five researchers discovered that "mortality from [1] all causes and [2] circulatory diseases and [3] outpatient visits of respiratory diseases has a strong association with cold temperatures in the subtropical island, Taiwan." In addition, they found that "minimum temperature estimated the strongest risk associated with outpatient visits of respiratory diseases."

Behar (2000)[13] studied sudden cardiac death (SCD) and acute myocardial infarction (AMI) in Israel, concentrating on the role that temperature may play in the incidence of these deadly health problems. The review aspect of this effort revealed "most of the recent papers on this topic have concluded that a peak of SCD, AMI and other cardiovascular conditions is usually observed in low temperature weather during winter." As one example, he cites an Israeli study by Green *et al*. (1994), which revealed that between 1976 and 1985 "mortality from cardiovascular disease was higher by 50% in mid-winter than in mid-summer, both in men and women and in different age groups," and in spite of the fact that summer temperatures in the Negev, where much of the work was conducted, often exceed 30°C, while winter temperatures typically do not drop below 10°C. Behar thus concludes these results "are reassuring for populations living in hot countries."

Introducing their work, Lindeboom *et al*. (2012)[14] write that, "while the association of weather and mortality has been well documented for moderate climate zones, little is known about sub-tropical zones, particularly Bangladesh." And, therefore, they conducted a study of that country that "aims to assess the short-term relationship of temperature and rainfall on daily mortality after controlling for seasonality and time-trends." More specifically, working with daily mortality and weather data for the period 1983–2009 pertaining to Matlab, Bangladesh, where a rigorous health and demographic surveillance system (HDSS) has been operational since 1966, Lindeboom *et al*. applied time series Poisson regression with cubic spline functions that allowed for lagged effects of weather on mortality, while controlling for time trends and seasonal patterns.

> The warming of the past century has likely led to a decrease in temperature-related deaths, which phenomenon represents one of the many indirect benefits of atmospheric CO_2 enrichment that climate alarmists have long downplayed and ignored.

In discussing their findings the four researchers report "mortality in the Matlab surveillance area shows overall weak associations with rainfall, and stronger negative association with temperature." Concentrating on the more important temperature, therefore, they highlight the fact that they determined there was "a 1.4% increase in mortality with every 1°C decrease in mean temperature at temperatures below 29.2°C," but that there was only "a 0.2% increase in mortality with every 1°C increase in mean temperature." In addition, they note the "elderly, aged 60 years and above, seem to be most affected at lower temperatures, with a 5.4% increase in mortality with every 1°C decrease in

[13] http://www.co2science.org/articles/V3/N36/C1.php.
[14] http://www.co2science.org/articles/V16/N15/C3.php.

temperature below 23°C." Lindeboom *et al*. further report the Bangladesh Meteorological Department data on both minimum and maximum temperatures observed in 1950–2010 "showed an increasing trend," but they note the increase was faster for minimum temperature, as opposed to maximum temperature. And thus it can be appreciated the net effect of that half-century of warming had to have had the positive effect of a net decrease in mortality in Matlab, Bangladesh.

In conclusion, as illustrated in the many findings referenced above, it is clear that unseasonable cold temperatures cause far more health-related maladies and deaths than do unseasonable warm temperatures. Further, it would appear that the warming of the past century has likely led to a decrease in temperature-related deaths, which phenomenon represents one of the many indirect benefits of atmospheric CO_2 enrichment that climate alarmists have long downplayed and ignored.

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