Health Impacts of Climate Change - What the Research Says

A Summary from the American Statistical Association
Advisory Committee on Climate Change Policy[†]

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Weather and mortality

- **Climate change is expected to lead to a substantial increase in summer deaths due to increased frequency of extreme hot weather events**.[1,2,3,4,5,6] The magnitude of the projected increase varies according to which climate model was used. For 2050 the models project a doubling or tripling of excess heatwave-related mortality compared to current trends.[1] Other findings were that hot weather events increase mortality risks; persistent high temperatures have a stronger impact than a short-lived peak at a very high temperature; and the time lag between high temperature and mortality is typically no more than 1-2 days.[6] There is need for further research integrating the latest epidemiological modeling with regional and global climate models.

- **Increases in mortality could be offset somewhat by "mortality displacement", increased use of air conditioning, decreases in cold-related mortality, and adaptation to temperature. However, the increase in heat-related mortality persists.** Some researchers argue that the public health impacts of temperature increases would be mitigated by factors such as acclimatization; increased availability of air conditioning; the fact that a portion of the current risk estimates may be due to mortality displacement (the question of whether individuals who die during a heatwave are already very sick and would have died in any case within a few days); and the possibility that increases in

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[1] Kalkstein, L.S. and Greene, J.S. (1997), "An evaluation of climate/mortality relationships in large U.S. cities and the possible impacts of climate change." Environmental Health Perspectives 105(1), 84-93.

[2] Anderson, B.G. and Bell, M.L. (2009), "Weather-related mortality: How heat, cold and heat waves affect mortality in the United States." Epidmiology 20(2), 205-213.

[3] Curriero, F.C., Heiner, K.S., Samet, J.M., Zeger, S.L., Strug, L. and Patz, J.A. (2002), "Temperature and mortality in 11 cities of the Eastern United States." American Journal of Epidemiology 155(1), 80-87.

[4] Hayhoe, K., Cayan, D., Field, C.B., et al. (2004), "Emissions pathways, climate change, and impacts on California." Proc Natl Acad Sci USA 101, 12422-12427.

[5] Knowlton, K., Lynn, B., Goldberg, R.A., et al. (2007), "Projecting heat-related mortality impacts under a changing climate in the New York City region." American Journal of Public Health 97, 2028-2034.

[6] Kalkstein, L.S. and Davis, R.E. (1989), "Weather and human mortality: An evaluation of demographic and interregional responses in the United States." Annals of the Association of American Geographers 79(1), 44-64.

deaths due to extreme summer events will be offset by a decrease in deaths due to extreme cold events in winter. However, even when taken together, these possible mitigating factors appear to explain less than half the projected future increases.[1,4,5] Two papers that examined potentially mitigating factors by Davis et al.[7,8] concluded that the impact of weather on mortality substantially decreases between the 1960s and the 1990s due to such factors. Other authors also looked at such mitigating factors without reaching the same conclusions as Davis et al. It is important to consider questions of acclimatization and adaptation, but this should only supplement, not replace, detailed projections of future climate conditions and their likely mortality impacts.

- **The largest effects of climate change on mortality are anticipated to be seen in large northern and eastern cities such as New York, Chicago, Philadelphia and Detroit.[1,3]** A separate study looking at the NYC metropolitan region found that summer heat-related mortality would increase between 71% and 95% by 2050 over levels of the 1990's depending on the climate scenario used.[5] Another group focused on health impacts in California in 2100. Using two extremes of the IPCC scenarios (B2 and A1F1), they found heat-related mortality in Los Angeles is estimated to increase by a factor of 2—3 under the B2 scenario and a factor of 5—7 under the A1F1 scenario.[4] These results are not affected by more than roughly 40% by the mitigating factors discussed previously.

Pollution and climate change

- **Studies indicate that climate change is expected to result in increases in tropospheric ozone which in turn will result in more ozone-related deaths.[9,10,11]** The formation of this common urban air pollutant is a function of solar radiation; and ozone production is correlated with temperatures. In one study of the New York City metropolitan region modeled for five summers in the 2050s, the mortality associated with short-term exposure to ozone due only to climate change increases approximately 4.5%.[9] A study of ozone levels for 50 eastern U.S. cities from the 1990s to the 2050s found, on average, the daily 1-hour maximum ozone level increases about 5 parts per billion (ppb), with the largest increase in any city at approximately 10 ppb.[10] The study also found a higher number of days exceeding health-based ozone regulations with the changing climate. A third study examined how both particulate matter ($PM_{2.5}$) and ozone respond to a changing climate and projected $PM_{2.5}$ and ozone levels in 2050, assuming air pollution emissions inventories and population characteristics

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[7] Davis, R.E., Knappenberger, P.C., Novicoff, W.M. and Michaels, P.J. (2002), "Decadal changes in heat-related human mortality in the eastern United States." Climate Research 22, 175-184.

[8] Davis, R.E., Knappenberger, P.C., Michaels, P.J. and Novicoff, W.M. (2003), "Changing heat-related mortality in the United States." Environmental Health Perspectives 111(14), 1712-1718.

[9] Knowlton, K, Rosenthal, J.E., Hogrefe, C, Lynn B, Gaffin, S, Goldberg, R, Rosenzweig, C, Civerolo, K, Ku, J.K., Kinney, P.L. (2004). "Assessing ozone-related health impacts under a changing climate." Environmental Health Perspectives.

[10] Bell M.L., Goldberg, R., Hogrefe, C., Kinney, P.L., Knowlton, K., Lynn, B., Rosenthal, .J, Rosenzweig, C., Patz, J.A. (2007) "Climate change, ambient ozone, and health in 50 US cities." Climatic Change.

[11] Tagaris, E., Liao, K.-J., Delucia, A.J., Leland, D., Amar, P., Russell, A.G. (2009) "Potential impact of climate change on air pollution-related human health effects. Environmental Science and Technology.

remained constant.[11] The authors estimated an additional 3711 $PM_{2.5}$-related deaths and 279 ozone-related deaths nationally in 2050 relative to conditions in 2001. The results are geography related, with $PM_{2.5}$ levels increasing more in the Great Lakes area and ozone levels increasing more in the south.

- **There are multiple pathways through which a changing climate could impact air pollution levels and thereby affect human health.** While most studies to date of climate change's effect on air pollution have focused on chemical formation of tropospheric ozone, there are many other pathways to be studied further. For example, changes in atmospheric dispersion patterns could affect the movement of air pollution. Increased air conditioning use in response to higher temperatures could affect exposure patterns and raise energy production, in turn producing more pollutants. As the authors of the three papers cited here note,[9,10,11] future additional research is needed to explore a wide range of assumptions for tropospheric ozone and to investigate the potential health impacts of other air pollutants.

Infectious disease and climate change

- **There is not a consensus among scientists regarding an increase of infectious diseases under climate change.** The lack of consensus is due largely to the likelihood that the spread of infectious diseases due to climate change would likely be into developed countries where renewed or existing control activities in those areas would help to thwart their impact.[12] Nonetheless, climate change is likely to expand the range of areas potentially suitable for infection disease habitation, thereby affecting geographical distribution of infectious diseases.[13] While the above refers to infectious disease in humans, Harvell et al. argue there is now clear evidence for a link between climate change and dramatic pathogen outbreaks in several groups of ectothermic – controlling body temperature through external means – wildlife hosts, including amphibians, shellfish, and corals.[14]
- The impact of climate change on infectious disease is an area of intense scientific scrutiny. With more than 4000 papers published in 2008 alone, more definitive scientific conclusions are likely to appear soon.

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[12] Lafferty, K.D. (2009). "The ecology of climate change and infectious diseases." Ecology 90, 888-900.

[13] Pascual, M., Bouma, M.J., (2009) "Do rising temperatures matter." Ecology 90(4), 906-912.

[14] Harvell, D., Altizer, S., Cattadori, I.M., Harrington, L., Weil, E. (2009) "Climate change and wildlife diseases: When does the host matter the most?" Ecology: 90(4), 912-920.