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PERSPECTIVE

Is climate change affecting human health?

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Abstract

First principles suggest that climate change is affecting human health, based on what is understood about the relationships between the mean and variability of temperature, precipitation, and other weather variables and climate-sensitive health outcomes, and the magnitude of climate change that has occurred. However, the complexity of these relationships and the multiple drivers of climate-sensitive health outcomes makes the detection and attribution of changing disease patterns to climate change very challenging. Nevertheless, efforts to do so are vital for informing policy and for prioritizing adaptation and mitigation options.

There is a growing body of research documenting the degree to which trends in changes in physical and biological systems are being affected by anthropogenic climate change, with more evidence for alterations in physical systems (cf. [1]). Studies of how anthropogenic climate change (not just climate variability) is affecting biological systems, including human health, are important to identify (1) local and regional impacts that will, in turn, support more robust projections of possible climate change impacts under different scenarios of future development, and (2) appropriately designed adaptation policies and measures to cope with current and prepare for future risks from climate change [2]. Attribution studies following best practice guidance provide credible evidence for policymakers when prioritizing and implementing adaptation and mitigation policies [3, 4].

Few studies have the required data to undertake formal detection and attribution of climate-sensitive health outcomes. Quality data are required not just of the number of cases of a particular outcome over long time periods; data also are needed for other factors that can affect changing health patterns. For example, the geographic range and seasonality of vectorborne diseases can be altered not just because of changing weather patterns, but also because of changes in vectors, pathogens, humans, and their interactions. However, appropriate datasets matched across spatial and temporal scales are uncommon.

Silva *et al* [5] make a valuable contribution to this limited literature by asking how concentrations of ground-level ozone and fine particulate matter (PM2.5) changed between 1850 and 2000, the air pollution-related mortality in 2000 that could have been due to modeled increases, and how much of this health burden was likely due to climate change. Ambient particulate matter pollution is one of the leading causes of premature mortality and disability-adjusted life years lost [6]. It is important for policymakers to understand what proportion of this health burden could be due to anthropogenic climate change and how the burden might alter as the climate continues to change.

Of course, air quality and mortality data are not available for 1850, so the authors used an ensemble of models to estimate the concentrations of ozone and PM2.5 in the years 1850 and 2000. They showed that increased concentrations in 2000 had large effects on annual premature human mortality: 470 000 (95% confidence interval, 140 000–900 000) premature respiratory deaths globally associated with anthropogenic ozone, and 2.1 (1.3–3.0) million deaths associated with anthropogenic PM2.5-related cardiopulmonary diseases (93%) and lung cancer (7%). A small fraction of these deaths were attributable to past climate change: 1500 (−20 000 to 27 000) deaths per year due to ozone and 2200 (−350 000 to 140 000) to PM2.5. The large ranges reflect different results from the models in the ensemble, with some models suggesting that climate change reduced air pollution-related mortality.

This practical approach to answering the question of how much climate change is affecting cardiorespiratory disease mortality associated with air pollution does not strictly follow the IPCC *Good Practice Guidance Paper on Detection and Attribution Related to Anthropogenic Climate Change* [3]. Not only were concentrations of ozone and PM2.5 not observed in 1850, but also there are limited current observations in many regions in low- and middle-income countries, hence the need for modeling. However, lack of data does not necessarily mean lack of impact. Waiting until there are sufficient data could lead to the misperception that climate change is not a current health risk.

The small global burden of premature mortality due to climate change-associated air pollution estimated by Silva *et al* is not surprising given the relatively small amount of climate change that has occurred. Even with the many uncertainties in the models, these numbers likely underestimate the attributable burden. Long-term exposure to ozone may affect premature mortality to a larger extent than Silva *et al* assume [7]. As the authors note, their analysis included only a limited set of health outcomes affected by high concentrations of ambient ozone and/or particulate matter, and was restricted to adults over the age of 30. Including a broader range of outcomes would increase the total health burden in the year 2000 as well as the estimated burden due to climate change. Some outcomes not included, such as asthma induction and aggravation, are important public health problems without much effect on mortality. Further, some particularly vulnerable groups, such as children [8], were excluded. Evidence is increasing that air pollution may have prenatal effects that may have life-long effects [9]. Including these vulnerable groups would increase the estimated health burden.

Using a concentration–response function based on data from the United States creates large uncertainties in the burdens estimated in other countries, particularly those with significantly higher concentrations of ozone and particulate matter. Additional research would further understanding of appropriate concentration–response functions to apply when estimating the global and regional health burdens of current and future climate change.

The estimate that climate change has had a limited global impact on air pollution-related mortality does not provide assurance that burdens under a changed climate will remain small. Regional patterns can be very different than global averages. For example, Orru *et al* [10] used a European-wide exposure–response function and country-specific baseline morbidity and mortality to compare ozone-associated health burdens in the period 1990–2009 with 1961–1990. There was a mixed pattern of up to 5% increases and decreases depending on the geographic region, with decreases in the northernmost countries. Mid-century burdens of ozone-related morbidity and mortality projected under the A2 scenario showed large increases and decreases, depending on location. Better understanding of differential impacts on morbidity and mortality is important when considering changes to emissions regulations.

Silva *et al* provide important input to understanding the extent to which climate change has contributed to current air pollution-related mortality. Additional research could reduce uncertainties and provide insights into all the health outcomes affected by air pollution, which would support more nuanced projections of how those burdens could change with additional climate change.

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