EDITORIALS

Global Environmental Change as "Risk Factor": Can Epidemiology Cope?

This issue of the Journal includes 2 articles examining the relationship of health outcomes to aspects of climatic variability within the United States. One reports on hospitalizations for viral pneumonia and temperature fluctuations associated with the El Niño cycle,[1] and the other on waterborne disease outbreaks and extreme precipitation events.[2] Studies of this kind have been stimulated by the recent rise in interest in the climate–health nexus, which in turn has occurred largely in response to the prospect of global climate change. Yet as these and other investigators will acknowledge, such studies are somewhat, and unavoidably, tangential to the central question: What will be the population health consequences of a multidecadal-scale change in the world's climatic conditions?

The taxonomy of tasks for epidemiologists and other public health scientists in relation to the question of global climate change and health is becoming clear. The issues are complex and, in many respects, unfamiliar. The scale of environmental change, the fact that those changes will continue to increase and evolve, the indirectness of many of the putative causal pathways, and the expectation that the spectrum of health impacts will extend well into the future—all these ingredients pose a major challenge for epidemiologic research methods and collaborations.

First, though, it is important to understand the wider context within which this research and risk assessment narrative is unfolding. Indeed, this is particularly true when the president of the world's greatest greenhouse gas–emitting nation can, on behalf of narrow sectional interests and short-termism, abandon the fledgling international effort to avert serious global climate change. If these coming decades portend, as expected, widespread adverse health consequences of climatic change, then the sooner we estimate and communicate these consequences, the better will be our chance of averting future retrograde policy decisions.

RECENT FINDINGS ON CLIMATE CHANGE AND ITS CONSEQUENCES

Over the past several years, there has been a mounting stream of evidence that humans, in the aggregate, are overloading many of the planet's great biogeochemical systems.[3] These systems include, perhaps most prominently, Earth's climate system. The latest report from the Intergovernmental Panel on Climate Change, the international scientific body established within the United Nations system to advise governments on the processes and impacts of climate change, makes 3 things compellingly clear.[4]

First, human-induced warming has begun—the particular pattern of temperature increase over the past quarter-century has unequivocal "fingerprints" that implicate the buildup of greenhouse gases due to human industrial and land-use activities. Second, a coherent pattern of changes in simple physical and biological systems has become apparent across all continents—the retreat of glaciers, the melting of sea ice, the thawing of permafrost, earlier egg-laying by birds, the poleward extension of insect and plant species, earlier flowering of plants, and so on. Third, ominously, climate scientists now foresee an average surface-temperature rise this century within the range of 1.4° to 5.8°C. This is a faster increase than was predicted in the panel's previous major report, in 1996. Indeed, even if humankind manages to curb excess greenhouse gas emissions over the next half century, the world's oceans will continue to rise for up to a thousand years, reflecting great inertial processes as heat transfers from surface to deep water.

We should not, however, be preoccupied with global climate change. It is but one of a much larger set of destabilizing large-scale environmental changes that are now under way, reflecting the increasing human domination of the ecosphere.[3] All of these changes—stratospheric ozone depletion, loss of biodiversity, worldwide land degradation, depletion of fresh water, disruption of the elemental cycles of nitrogen and sulfur, and the global dissemination of persistent organic pollutants—have great consequences for the sustainability of ecological systems, for food production, for human economic activities, and for human population health.[5]

The realization is gradually dawning on modern societies that the sustainability of population health must be a central consideration in this sustainability transition discourse. For that reason, the public, policymakers, and other scientists show an increasing interest in hearing from epidemiologists about these matters. Reflecting this changing agenda, the World Health Organization now has a major section titled Healthy Environments and Sustainable Development. We are edging toward a view of population health as an ecological entity, as an index of the success of our longer-term management of social and natural environments. (And at long last some epidemiologists are beginning to shun textbook idiom and to use the word "ecological" in its correct, and more important, sense.)

Epidemiologists are thus beginning to engage, albeit tentatively, in this important arena of research, assessment, and policy advice. Recently, an international project on biodiversity loss and health was jointly initiated by Harvard University and the World Health Organization. This April the first meeting of the Millennium Ecosystem Assessment, to be conducted along the lines of the Intergovernmental Panel on Climate Change, brought together scientists from around the world and from diverse disciplines to begin assessing the consequences of ecosystem disruption. In these new initiatives, and in the continuing assessments of stratospheric ozone depletion coordinated by the United Nations Environment Program, epidemiologists have begun to play an important role.

TASKS FOR EPIDEMIOLOGISTS

What are epidemiologists' research tasks, then, in relation to global climate change and health? Three types of studies are needed. First, analyses of data from the recent past can clarify the basic relationships between climate and health, including elucidating how short-term variations in climatic conditions can affect health outcomes—as in the 2 studies reported here. Some of these studies may provide analogs for confidently anticipated future climatic changes, in which case their findings can be applied by direct extrapolation or modeling to estimate future impacts.

Second, we have now reached the stage in global climate change at which we should expect some early health effects to become apparent. We need, therefore, to sensitize our antennae and to undertake well-directed monitoring and research activities. Third, we must continue to carry out scenario-based health risk assessments, using, where possible, mathematical models that are well grounded in theory and that have been validated against recent and present observations. This third task is the least familiar to epidemiologists. It entails moving out of the comfort zone of empiric studies—and also relinquishing any residual professional delusions that epidemiologic research is exclusively about the discovery of novel risk factors.

The second of these categories of research is tantalizing. Why, given the other nonhuman evidence now accruing, is there a relative paucity of evidence of early human health impacts? After all, *Homo sapiens* is not immune to climatic stresses—plenty of studies have reported acute health effects of heat waves, floods, and storms and of interannual climatic variations (El Niño and vector-borne diseases, for example). However, research on free-living human populations involves additional complexities that do not apply to studies of glaciers, butterflies, ticks, or wheat. Not only are there nonclimatic confounding factors, but there is the uniquely human capacity for social and technological adaptation. Hence, the challenge for epidemiologists is to pick the settings offering the best chance of both detecting early effects and attributing them to climate change. Early impacts are likely to be seen most clearly for relationships in which the exposure–outcome gradient is steep, human adaptive capacity is weak, and there are few competing explanations.

The best bets for epidemiologic studies of early effects include these 4 possibilities[6]:

- Vector-borne diseases may be relatively sensitive indicators, since transmission involves intermediate organisms, such as mosquitoes, that are open to environmental influences.
- Enteric infections (food poisoning) show very strong seasonal patterns, suggesting a powerful effect of climate variability, and in some jurisdictions seasonal outbreaks have been routinely reported for many years. Changes in the pattern of seasonal occurrence are a likely consequence of climate change.
- Variations in daily and weekly mortality and hospitalization rates, as a function of extremes of temperature, are likely to change their patterns as summers become hotter, winters become milder, and regional climatic patterns become more variable.
- Deaths, injuries, and illnesses caused by extreme events (such as heat waves, cold spells, floods, and storms) satisfy the condition of "few competing explanations." However, in many populations it may be difficult to distinguish the climate change signal from the modulating effects of social and economic development.

ENTERING THE ARENA

Momentum in this area is growing. The European regional branch of the World Health Organization has commissioned a working group to recommend research and monitoring strategies for the detection of early health effects of climate change in European populations.[7] Annual conferences of bodies such as the International Society for Environmental Epidemiology and the Society for Epidemiologic Research now include regular symposia on research methods in this topic area. One textbook dealing with concepts and research methods in this area has just been published,[8] and another is in press.[9] And, most encouraging, funding agencies at national and international levels are now supporting research in this domain.

The studies by Ebi et al. and Curriero et al. add to our store of empiric knowledge about relationships between short-term climate and health. Such studies invite further exploration of climate–health relationships and, by analogy, suggest research that should be done on other health outcomes. They also provide potential input for studies that model how future changes in climatic variability—a characteristic that is increasingly confidently forecast by climatologists as part of the global climate change phenomenon—will affect human population health. Thus do we feel our way forward, as epidemiologists come to terms with these unusually large, complex, and important environmental health research and risk assessment issues. ■

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