

A Burden of Disease Approach to Prioritizing Environmental Policy Initiatives: A Case Study in the Middle East

Jacqueline MacDonald Gibson

The UNC–Chapel Hill Gillings School of Global Public Health completed a 2.5-year project to advise a rapidly developing Middle Eastern nation on strategies for reducing environmental risks to public health. The project design, which combined quantitative risk assessment with structured stakeholder engagement, provides a possible template for a strategic assessment of environmental effects on North Carolina medical care costs.

An interdisciplinary team from the University of North Carolina (UNC)–Chapel Hill Gillings School of Global Public Health recently completed a 2.5-year, multimillion-dollar project to advise a rapidly developing Middle Eastern nation on strategies for reducing its environmental burden of disease. For this project, we quantified the annual number of deaths and medical visits attributable to environmental risk factors in the sponsoring nation. Risk factors included outdoor air and indoor air pollution, drinking water and surface water contamination, heavy metals in seafood, pesticides on crops, workplace chemicals, leaking waste sites, electromagnetic fields, ozone-layer depletion, nonionizing radiation, and climate change. We then engaged local stakeholders in prioritizing risks on the basis of our quantitative assessments. We guided stakeholders in identifying and evaluating potential interventions and developing a comprehensive strategic plan for the highest-priority risks.

The methods we developed could serve as the basis for a similar project in North Carolina. A North Carolina environmental health strategic-planning exercise could identify ways to reduce state medical costs through improved environmental interventions.

This article describes how UNC–Chapel Hill became involved in this project, how we quantified the environmental burden of disease, and how we engaged stakeholders in prioritizing risks and interventions. Because of recent political changes in the Middle East, the leaders who commissioned our work wish to remain anonymous. Although they are proud of the results, they have requested that we not reveal details about their identities at this time.

Rankings Matter

Our project originated with an unanticipated request for

proposals from the sponsoring nation's environment agency that was hand-delivered to UNC–Chapel Hill in September 2007 by the agency's secretary general (the top administrator). The request for proposals reflected growing public fear about environmental effects on health, especially cancer. The project's original advocate was an agency staff person who had lost several relatives to cancer and was concerned, like many of her fellow citizens, about possible environmental causes.

The sponsoring nation has developed at an unprecedented rate because of the rapidly growing international demand for its petroleum. Oil has brought previously unimaginable wealth but has also transformed the environment—not always for the better. Environmental damage is not yet of the same magnitude as in long-developed nations, and overall life expectancy is among the highest worldwide. Nonetheless, environmental changes have occurred so rapidly that they are perhaps more striking than those in nations that developed at a more typical pace. Roadways, factories, and skyscrapers have sprouted from formerly open deserts in time spans as short as a few months. The local lifestyle has changed, in less than a generation, from one largely based on subsistence agriculture to one in which people eat out at restaurants, spend the bulk of their time in tightly sealed, air-conditioned buildings and private cars, and communicate via extensive cellular telephone networks.

The secretary general foresaw the need to quantify the burden of disease imposed by these rapidly occurring environmental changes and to identify strategies for minimizing the potential negative health effects of continuing development. He sought scientific support from top international schools of public health, including the following US schools ranked in the top 3 by *U.S. News & World Report*: Johns Hopkins (ranked first) and Harvard and UNC–Chapel Hill (tied for second). The secretary general solicited proposals

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Address correspondence to Dr. Jacqueline MacDonald Gibson, Department of Environmental Sciences and Engineering, Gillings School of Global Public Health, University of North Carolina–Chapel Hill, 162-B Rosenau Hall, 135 Dauer Dr, Campus Box 7431, Chapel Hill, NC 27599 (jackie.macdonald@unc.edu).

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from all 3 institutions, and several months later, we received word that UNC-Chapel Hill's proposal had been selected above the others.

Project Design

We designed a strategic planning process built on 2 key features: (1) quantitative estimates of annual deaths and illnesses attributable to each environmental risk and (2) engagement of local stakeholders in prioritizing risks and interventions. Our plan drew on methods developed in the natural and health sciences, environmental engineering, and social sciences. The Gillings School of Global Public Health is structured to minimize barriers to cross-disciplinary collaborations—a structure essential to the success of its research efforts.

Quantifying the environmental burden of disease. To quantify the environmental burden of disease, we expanded on an approach advocated by the World Health Organization and based on the attributable fraction (AF) concept, which is a long-standing method for analyzing health threats on a population scale [1, 2]. In brief, the fraction of disease incidence attributed to a specific risk factor is estimated as follows:

$$AF = \frac{\sum_i P_i \times RR_i - 1}{\sum_i P_i \times RR_i}$$

To apply this equation, the population is divided into n exposure levels (eg, n pollutant concentration ranges). P_i refers to the fraction of the population that experiences exposure level i , and RR_i is the relative risk of the particular disease at exposure level i .

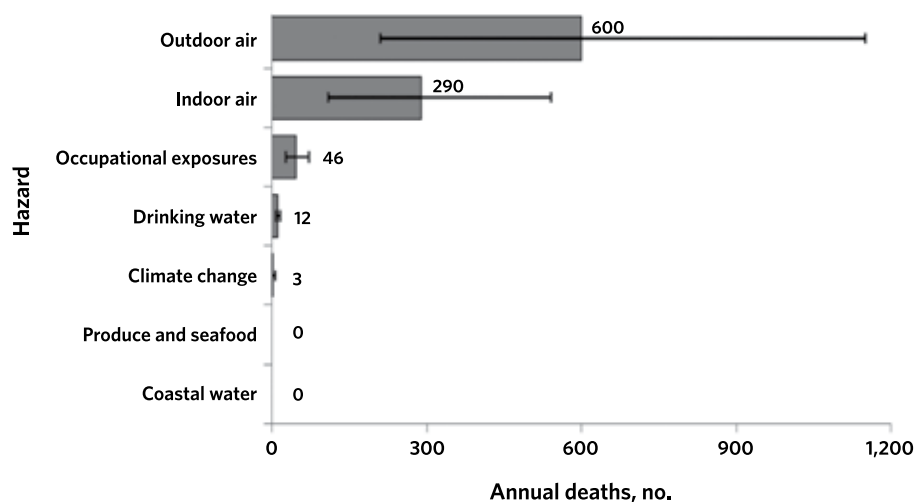
We estimated exposures by a combination of spatial analysis of environmental data (eg, pollutants measured in

ambient air and water); environmental modeling; and, when insufficient local information was available to support either of these approaches, measurement of pollutant concentrations from similar locations elsewhere in the region (eg, concentrations of methylmercury in seafood from nearby ports in other countries that fish in the same bodies of water). We obtained relative risk values from meta-analyses of global epidemiologic literature, because no epidemiologic data from the case nation existed. We combined exposure and relative risk information in a Monte Carlo simulation model that expressed uncertainty and variability in each input variable and the resulting uncertainty in our estimates. A complete description of the methods and results will be available in a forthcoming book [3].

The final step in characterizing the disease burden for a risk factor was to multiply observed disease rates by the attributable fraction. We obtained complete baseline health statistics for 2008 from the local public health agency.

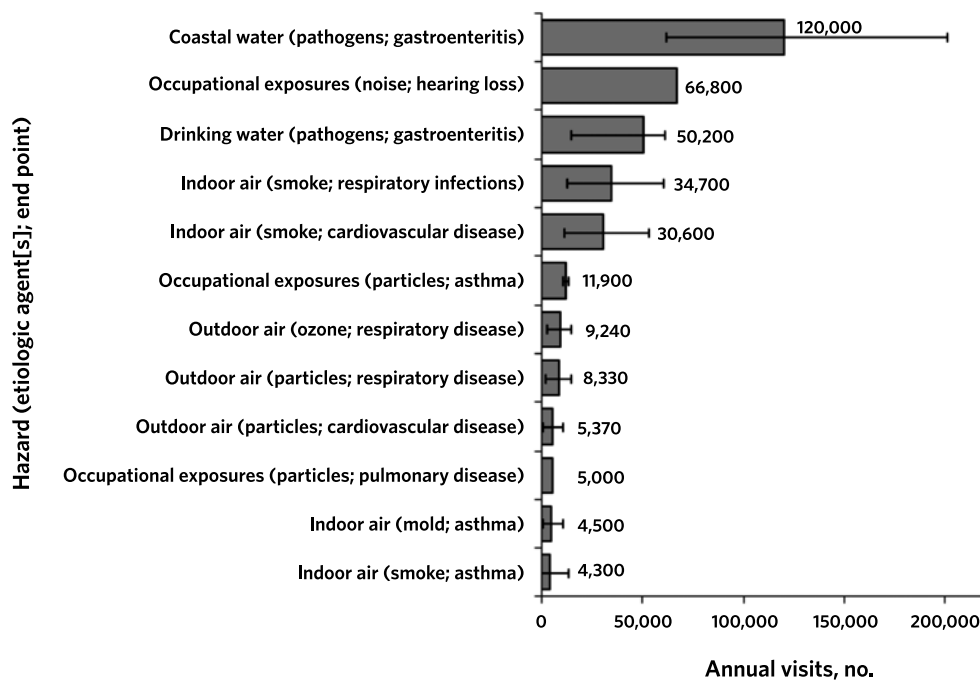
Engaging stakeholders. To reflect the full range of local values, we engaged stakeholders from the case nation in prioritizing risks on the basis of the quantitative risk information we had developed. We used a state-of-the-art structured stakeholder engagement process known as the Deliberative Method for Ranking Risks. This method emerged from previous comparative risk projects in the United States and is described in detail elsewhere [4, 5]. In brief, stakeholders read 4-page "risk-summary sheets" that present information about each risk factor in a standardized format. The first page includes a table displaying the number of premature deaths and the number and severity of illnesses attributed to each risk factor, including uncertainty ranges. The summary table also includes information about individuals' ability to control their exposures, latency periods, and other attri-

FIGURE 1.
Annual Deaths Attributed to Select Pollutants and Global Climate Change in the Case Nation



Note. Whiskers indicate 95% confidence intervals.

FIGURE 2.
Annual Visits to Health Care Facilities Attributed to Environmental Exposures in the Case Nation



Note. Whiskers indicate 95% confidence intervals.

butes that risk perception research has shown are pertinent to people's judgments about risks. Then, trained facilitators lead small focus groups (size, 10-12 people) through daylong sessions, to discuss and rank the risks, both individually and as a group. Results are then analyzed statistically, to determine areas of agreement and disagreement. Typically, a few high and low priorities emerge, along with areas about which stakeholders disagree, despite having access to the same risk information (reflecting differences in value judgments).

After ranking the risks, we held 3 separate workshops, each involving multiple focus groups, to prioritize interventions recommended by UNC-Chapel Hill and local scientists with expertise relevant to each risk. Interventions focused on the risks that stakeholders universally viewed as high priorities and on those about which they disagreed substantially. Some risks (eg, electromagnetic fields, nonionizing radiation, and ambient noise) dropped off the list because of lack of public health and environmental evidence that these risks occur in the population and/or because of a universally low rating of the risk by all participating stakeholders.

Results

Figures 1 and 2 summarize our estimates of annual premature deaths and hospital visits attributable to risks retained for analysis after the ranking exercise. The predominant mortality risks are ambient and indoor air pollution—the latter primarily attributable to secondhand tobacco smoke. Leading contributors to excess illness include microbial con-

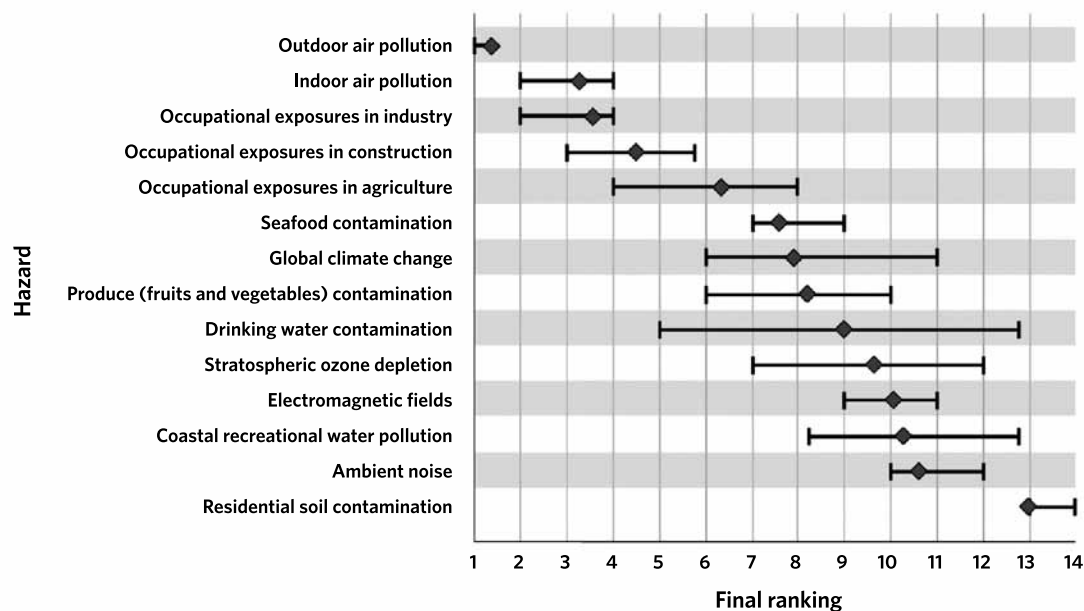
tamination of surface water (although the uncertainty range is large) and occupational exposures.

Figure 3 shows the average rankings given by focus group participants. Nearly all the stakeholders ranked ambient air pollution as the leading risk, while nearly all ranked soil contamination as of low importance. Stakeholders disagreed about priorities for drinking-water pollution, coastal water pollution, and stratospheric-ozone depletion. For drinking water, the disagreement reflected different views about the importance of water as a resource. The case nation boasts a modern public water supply that is treated with advanced European technologies, and thus the risk of waterborne disease is extremely low, causing some stakeholders to rate risks due to contamination of potable water as low. On the other hand, others said they viewed the continued protection of this vital resource as an enduring priority, particularly since fresh water is scarce in the region.

Participants at the planning workshops enumerated more than 216 actions that the nation could pursue to reduce environmental health risks. Recommended actions included strengthening environmental enforcement programs, building public rail systems, and overhauling occupational protection programs. The recommendations are summarized in a 104-page strategic plan.

Overall, the planning process and results were widely embraced by the participating stakeholders, the environment agency's leadership, and prominent national politicians. Stakeholders, on average, gave the following statement a 4.36

FIGURE 3.
Rankings of Environmental Health Hazards in the Case Nation, by 56 Environmental Health Stakeholders



Note. Diamonds indicate the average of separate rankings (rather than group rankings) given by the stakeholders. Whiskers indicate interquartile ranges.

ranking on a scale of 0 (strongly disapprove) to 6 (strongly approve): “How strongly would you approve of submitting your group’s rankings to the environment agency for use in making decisions?” Unit directors at the environment agency told us the project was the best they had ever funded. We were asked to present the results to the country’s leading politician (the equivalent of a prime minister). After our presentation, he directed the secretary general to form an organization to implement the plan. The envisaged organization would have coordinated implementation across all the relevant government agencies and would have sponsored research through a new research center to improve on our initial burden of disease estimates.

Unfortunately, a major change in the government funding mechanism for such centers, combined with a change in leadership and top management at the environment agency, has derailed plans to establish the environmental health research center and implement the strategic plan. Whether the agency’s new leadership will embrace the strategic plan remains to be seen.

Lessons for North Carolina

This project offers lessons—both cultural and political—for North Carolinians. First, we learned that citizens of this distant Muslim nation share the same desires as we do. They want a clean, safe, and healthy environment for themselves and their families. They appreciate opportunities to express their opinions about environmental health risks. Our stake-

holder engagement workshops generated vigorous debates, and to our surprise, the most outspoken participants were often women dressed in traditional veils.

Second, from a population perspective, the leading environmental risks to health are those that cause or complicate common diseases and to which exposure is widespread: cardiovascular and respiratory diseases attributable to indoor and outdoor air pollution. The fear of environmentally caused cancer, which prompted this project, while potentially important, is not the main driver of this nation’s environmental burden of disease, when considered from a population perspective. These findings are consistent with decades of research in risk perception, showing that the risks people fear the most are rarely the biggest threats to their health—that people universally underestimate high risks because they are familiar and therefore less evocative than rare events [6, 7].

At a time of unprecedented budget pressure, North Carolina should revisit the question of whether the state is investing enough in disease prevention through environmental protection. The process described in this article could provide a framework for analyzing opportunities for North Carolina to save money on medical care (eg, by reducing cardiovascular and respiratory diseases) through new or improved environmental interventions. NCMJ

Jacqueline MacDonald Gibson, PhD Department of Environmental Sciences and Engineering, Gillings School of Global Public Health, University of North Carolina-Chapel Hill, Chapel Hill, North Carolina.

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