From Air Pollution to the Climate Crisis: Leaving the Comfort Zone

Patrick L. Kinney

While climate change poses existential risks to human health and welfare, the public health research community has been slow to embrace the topic. This isn't so much about a lack of interest as it is about the lack of dedicated funding to support research. An interesting contrast can be drawn with the field of air pollution and health, which has been an active and well-supported research area for almost fifty years. My own career journey started squarely in the latter setting in the 1980s, but transitioned to a major focus on climate and health starting around 2000. The journey has been punctuated with opportunities and obstacles, most of which still exist. In the meantime, a large body of evidence has grown on the health impacts of climate change, adding more urgency to the imperative for action. Institutionalization of climate and health within the federal regulatory and funding apparatus is now needed if we are to make the transition to zero carbon in ways that maximize health and equity benefits.

As a public health scientist with an interest in environmental factors affecting human health, there seem to be so many interesting problems to work on that one rarely finds the time to step back and ask, how did I get here? More personally, how did I make the transition from being a mainstream air pollution health scientist to one of the few public health researchers looking at climate change? Also, what opportunities and barriers molded my journey toward that outcome? These are questions I hadn't given much thought to before agreeing to participate in the May 2018 Witnessing Professionals and Climate Change Workshop at Princeton University.[1] I approach the questions that the conference posed from the perspective of my development as a public health scientist over a period in which the evidence for, and societal awareness of, climate change as an existential challenge grew exponentially from a very quiet beginning. Engagement by the public health field in the climate change discussion has grown proportionately, but remains surprisingly limited.

In many ways, the story of my career started in a small city in Pennsylvania. Donora is a steel town sitting low in the valley of the Monongahela River near Pittsburgh. October 27, 1948, was a foggy, smoggy Wednesday in Donora. In fact,

https://doi.org/10.1162/DAED_a_01820

the air was unusually thick even for Donora. The local steel mills and zinc smelter were spewing out noxious fumes as they always did. But on that Wednesday, the weather had changed in a way that made the pollution worse. A temperature inversion had formed over the valley. An inversion acts like a lid, preventing upward movement of pollutants emitted near the ground. Meanwhile, the hills ensured that nothing could move sideways either. As a result, pollution levels started to build up. By the next day, residents began to report severe respiratory problems. They were coughing and wheezing, and calling their doctors or trying to get to the hospital. There was no relief on Thursday, nor Friday. Pollution continued to build up. The air was so thick that driving became hazardous. Finally, on Sunday night, the rain came and cleared the air. However, during those few days when the air was unusually polluted, twenty of the town's fourteen thousand residents had died. In the weeks following, another fifty people died of respiratory causes. And about half the town, around seven thousand people, complained of respiratory problems as a result of the smog.

The Donora experience caught the public and many health professionals by surprise. Until then, most people thought of pollution as a sign of economic development and progress. Sure, it was annoying and could make your eyes burn, but nobody really thought pollution could kill you. A few years later in London, in 1952, there was an even more severe air pollution disaster, brought on under similar meteorological conditions as in Donora, a temperature inversion. However, the pollution was different. In London, the culprit was coal combustion: residents and businesses in London burned coal to warm their homes and buildings. But because of the inversion, all that coal pollution got trapped over the city. And London had a much larger population than Donora, Pennsylvania. Based on an analysis of death records in London before, during, and after the episode, epidemiologists have estimated that over ten thousand people may have died from exposure to air pollution.[2]

Like Donora, the 1952 London smog event drew a great deal of new attention to the health risks of air pollution from both the general public and policy-makers. This led in the following decade to the first regulations to limit air pollution levels in both the United Kingdom and the United States. In the United States, the Clean Air Act of 1963 called for setting National Ambient Air Quality Standards to protect human health, including for groups most sensitive to ill effects. The Clean Air Act also created new demands for knowledge generation, information systems, air quality planning and guidance, and air monitoring data. This soon evolved into a symbiotic regulatory-science ecosystem combining regulatory agencies, affected businesses, funding agencies, and academic researchers working together to clean the air. This would have profound and long-lasting impacts on the scientific and technical communities. And it was remarkably successful. Just since 1990, hourly sulfur dioxide concentrations decreased by nearly 90 percent; since 2000, average annual $PM_{2.5}$ (particulate matter) concentrations have dropped by nearly 40 percent.[3]

When I entered graduate school in 1981, this regulatory-science ecosystem for air pollution and health was well established. I quickly learned that scientists did the research to quantify health effects of air pollution, and then the Environmental Protection Agency (EPA) used those findings to periodically update air quality standards. States would clamp down on responsible local emission sources, and would also put out air sensors as part of a nationwide air monitoring network that tracked compliance with the standards. Interestingly, that same monitoring network became the key source of exposure data for the research community doing epidemiologic studies, such as a seminal study linking mortality rates to long-term particulate matter concentrations in U.S. cities.[4]

There was a lot to do. There were many questions to ask, and as a graduate student, I was eager to design studies to answer them. During my graduate training and for several years afterward in the department of environmental medicine at New York University (NYU), and later at Columbia, I helped design epidemiologic studies to answer questions like: Is ozone acutely associated with mortality? Do long-term ozone exposures lead to chronic respiratory diseases, as suggested in some animal studies? Do transportation sources such as diesel vehicles create hot spots of unhealthy air near roadways? (The answers turned out to be yes in all cases.)

After five years as a junior faculty member in an NYU department completely devoted to air pollution and health research, in 1994, I was presented with an opportunity to move to Columbia University. At NYU, I had been part of a very productive but narrowly focused air pollution research laboratory set in Sterling Forest, forty-five miles north of the George Washington Bridge, an easy fifteen-minute commute on country roads from my upstate home. As I think back on it, the idea of moving away from my comfortable niche at NYU was daunting. In fact, it took almost a year for me to finally decide to accept Columbia's offer. One of the key factors that finally pushed me over the edge was that Columbia University was in the process of forming the Earth Institute (EI), a novel effort to coordinate environmental sustainability scholarship across Columbia University. The EI's launch in 1995 was spearheaded by then Executive Vice-Provost Michael Crow, who sought to create "a community of environmental and social scientists, lawyers, policy and management analysts, health experts and engineers to collaborate across schools and disciplines."[5] This holistic view of environmental science was inspirational, holding the promise to open new research doors.

Moving to Columbia at that time turned out to have a profoundly positive effect on my future scholarship. Joseph Graziano, my new chair and the person who recruited me, was among the senior faculty launching the EI. As soon as I moved to Columbia, I was immediately connected to a remarkably rich network of potential new colleagues. I kept working on my air pollution and health studies, but I also kept one ear open for interesting new opportunities.

A door opened early in 1999 when I was invited to a meeting at the EI to discuss joining a team to assess potential climate change impacts in the New York City (NYC) metropolitan region. This was to be one of eighteen regional components of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change. Led by Cynthia Rosenzweig, senior staff at the NASA Goddard Institute for Space Studies (GISS) in NYC and the Columbia Center for Climate Systems Research, the EI team was seeking a faculty member who knew something about public health to complement a team of climate science and impact modelers. At the first meeting at the EI, I met several new colleagues, including Drew Shindell, a climate modeler at GISS. He told me about the model he used to project future climate and air pollution under a range of greenhouse gas scenarios. Drew was particularly interested in how climate change could affect ground-level ozone concentrations. Ozone was something I knew a lot about. I had been doing epidemiology studies to understand ozone health effects ever since graduate school. It seemed like it would be fairly straightforward to project future ozone-related health impacts if Drew's model could estimate what the ozone concentrations might be under future climate scenarios. I enthusiastically agreed to be part of the team. Working with two master of public health students at the Mailman School of Public Health, we developed a report on potential health impacts of climate change in the region, which was published in 2000 as part of the Metro East Coast report.[6]

This was my first research on the health effects of climate change. A key precursor for such a transition was the existence of the interdisciplinary framework of the EI that made possible the random connections that could lead to creative collaborations, like mine with Cynthia and Drew. Cynthia was key in organizing the Metro East Coast project, which was an intentionally interdisciplinary team. Climate change is so complex a challenge that it naturally called for multidisciplinary teams. In the early stages, there weren't too many people in any one discipline working on it, so the teams would have one health person, one modeler, one impact assessor, a government stakeholder, and so on. There was not yet a critical mass of people in any one discipline at the table (especially true for public health) to make it easy to stay in one's comfort zone. You were likely to be the only person from your field on the team. Thus, one was forced to reach across and learn how to talk and collaborate with the others. To take on this sort of challenging collaboration I think calls for a certain openness to taking risks, a personality that is attracted to new things. Why was I receptive to this? For one thing, there's something deeply invigorating about meeting new scientists in other fields and trying to understand what they do and how that might intersect with what you do. It's like a puzzle to solve. My doctoral training in environmental health was similarly multidisciplinary, so I was used to this. Environmental health was and is a very broad domain, unlike biology or chemistry or economics, perhaps.

As I began to research the implications that climate change could have for human health, I soon realized how little was yet known about this important topic. To be sure, there were pioneers, including Anthony McMichael, Andy Haines, Paul Epstein, Jonathan Patz, and Kristie Ebi, who had raised the alarm about potential public health risks of climate change.[7] However, the mainstream environmental health research community had not yet engaged with the topic. The lack of research on climate and health was shocking, and a little awe-inspiring. I hadn't before had the opportunity to catch an early glimpse of a whole new discipline that was as-yet unstudied, like an unexplored wilderness. It surprised me, but also motivated me to start working in this field. For one thing, it's interesting to learn new stuff, and to be a pioneer in an uncrowded field. But more important, it was clear that climate change was going to be a huge problem for both Earth and society, and one that everybody would soon start to care about.

I began to build on that initial collaboration to expand my research on likely health impacts of climate change. The connections I had made through the EI formed an excellent foundation for an expanding network of collaborators. One of the first questions we asked was: to what extent will climate change affect future air pollution, holding everything else constant? And given those changes, what would be the health impacts? I had a special interest in ground-level ozone, which gets worse when temperatures increase. Ozone of course is desirable to have in the upper layers of our atmosphere because it's effective at blocking health-damaging UV radiation. But you don't want to breathe ozone, a strong oxidant gas that has been associated with a wide range of adverse health effects, including premature deaths. Ground-level ozone is formed through reactions between nitrogen dioxide gas and volatile organic compounds in the atmosphere, in the presence of sunlight. Ozone formation is greater at higher temperatures, and ozone is the main component of summer smog episodes.

By early 2000, when the EPA issued a request for applications for research projects to quantify health impacts of climate change, I was ready to jump in. We proposed and were soon funded to model climate in the 2020s, 2050s, and 2080s, and analyze what that might mean for ozone and fine particle pollution.[8] We were able to show that increasing health risks might occur in the NYC metro region and throughout the Eastern United States.[9] And that knowledge – early knowledge that we began to generate – had some impact; for example, in supporting the EPA's endangerment finding of 2009. In order to regulate carbon dioxide as an air pollutant, the EPA needed to make the case that carbon dioxide and related greenhouse pollutants have adverse health effects. But unlike ozone or fine particles, most greenhouse gases (GHGs) don't directly harm health at ambient concentrations. What the EPA was able to show, however, was that GHGs, by driving climate change, could result in adverse health effects from heat waves, worsening air pollution, and other pathways. Our findings on climate-induced increases in ozone-related mortality were part of the rather sparse set of evidence available for the EPA to bolster its arguments in support of the endangerment finding. Witnessing this direct use of our research for policy development reinforced my commitment to continue working in this field. Even though the U.S. climate and health research enterprise remained quite limited at that point, it was gratifying to see that the findings that had emerged to date were directly useful for policy-making. Making the link to adverse health impacts was a critical piece of evidence that the EPA needed. In addition to the EPA regulatory developments, findings on public health impacts were used in periodic climate impact assessment reports, including those of the U.S. Global Change Research Program.[10]

The transition I made from air pollution epidemiology to climate health impacts research was relatively easy on the technical front. It turned out that the research tools needed to quantify impacts of climate on health are the same as those used to study the effects of air pollution on health. These include epidemiology and biostatistics (used to estimate exposure-response relationships using empirical data) and risk assessment (used to explore potential health impacts or benefits of hypothetical scenarios of change). To be sure, climate change does present unique methodological challenges to epidemiology, especially related to its long-term gradual nature (something that epidemiology is not well suited to). However, for the most part, there aren't significant technical barriers to public health scientists entering the field.

The challenge had more to do with the lack of a research "ecosystem" of the sort we had for air pollution. Missing was a cadre of like-minded colleagues, supportive departments, reliable federal funding agencies, receptive government regulators, and so on. Most prominent among these as a barrier for public health researchers has been the lack of federal research funding.[11] Research on the health effects of climate change doesn't fit easily within the National Institutes of Health (NIH), where molecular and mechanistic biological questions are of paramount funding interest. Nor does it fit well at the National Science Foundation, where health effects are of limited interest. Two key federal agencies, the Centers for Disease Control and Prevention and the EPA, historically played a central role in filling this gap by supporting work at the intersection of climate change and health. However, both agencies have seen their climate and health research operations eviscerated under twelve years of oil-industry-infused presidential leadership since 2000, assisted by powerful climate deniers in Congress. The result is a lost generation of critical scientific knowledge and expertise, which is now urgently needed to develop cost-effective policies that both build health resilience to worsening climate extremes and also maximize health and social equity cobenefits of rapid decarbonization strategies. To catch up will require a massive, ongoing federal effort to generate the needed knowledge.

The gap in federal research funding has hobbled progress in this field and presented a substantial entry barrier to public health researchers who might otherwise be highly motivated to generate urgently needed new knowledge. Most public health schools reside in medical centers and operate on a soft-money model, where the bulk of one's salary must be funded from outside grants, ideally from the federal government with full overhead. If the federal government isn't funding research on the health effects of climate change, too few public health researchers can enter the field, in spite of the growing evidence of increasingly severe storms and heat waves.

On the positive side, I've witnessed over the past decade a slow but steady transition toward climate research among a small number of open-minded, well-established senior investigators who have reached points in their careers where they have the freedom to shift away from what they've been doing to focus on the crisis of climate change. At the other end of the career ladder, there has been an influx of young predoctoral and postdoctoral climate investigators. What is missing so far are the midlevel, highly productive academic researchers whose career advancement depends on a track record of NIH grants.

After my initial EPA STAR grant in 2000, much of my scholarly work on climate and health has been carried out without dedicated funding. While that has made things a little challenging, the work has continued apace due largely to a steady influx of highly motivated and extremely productive graduate students and postdocs. For many years running, many of the very best students who applied to our departmental Ph.D. program at Columbia wanted to study climate and health. And we had funding to support both grad students and postdocs. Our trainees made important discoveries about climate change and ozone, heat, pollen, and other factors.[12] Along the way, we created at Columbia the first dedicated program on climate and health in the country, including a master of public health certificate. Of course, the kinds of research studies that can be done with student labor are limited to those where readily available data sets could be analyzed, or where small-scale field studies could be carried out with small supply budgets and lots of student footwork. That has limited the scope of work that I have been able to do. Also, given the bleak funding landscape, it remains uncertain whether students who graduate with training in climate and health can expect to find jobs where they will be able to apply their unique knowledge. The gap in institutionalization and political defunding conspire to create dangerous currents against which climate and health practitioners will need to swim.

Still, we're seeing more and more students wanting to work in climate and health now, as the reality of climate change becomes ever more apparent. We've seen so much evidence of change around us, and the lack of global or federal action in the face of those changes has been deeply alarming to young people who will inherit our world.

Publishing scientific papers and working to inform policy developments are important aspects of being an effective witness to the climate change crisis. Another way we can witness is by being better at communicating our knowledge outside the academy. Most public health scientists publish research results in papers in scientific journals. We go to conferences among our peers, and we talk about our research with peers. Journals and scientific conferences have seen a steady rise in climate and health research related studies. Those findings are sometimes picked up and used by regulators and policy-makers. But for an issue of the magnitude of climate change, the audience we need to reach is much larger. Health concerns can be a big motivator of public support for environmental regulations. Though we haven't been trained to do it, there is an urgent need for health scientists to communicate more directly with the public about the health effects of climate change. Climate change remains a politically divisive topic, partly due to the lack of knowledge among the general public about the many direct connections with human health. Survey research has shown that attitudes toward alternative energy sources among Americans are informed by environmental health risks as well as cost considerations.[13]

While climate change itself remains a politically divisive topic, improved public knowledge about the health implications of our energy choices could help lead us toward strategies that are good for both health and the planet. Filling the knowledge gap calls for different kinds of communication tools than most researchers have been trained for. Researchers will increasingly need to make the effort to tell the story of climate and health in words that convey greater feeling and meaning to more people.

ABOUT THE AUTHOR

Patrick L. Kinney is the Beverly Brown Professor of Urban Health at the Boston University School of Public Health. He has recently published in such journals as *New England Journal of Medicine, Nature Climate Change, The Lancet Planetary Health, Science of the Total Environment*, and *BMC Pregnancy & Childbirth*.

ENDNOTES

[1] Witnessing Professionals and Climate Change Workshop at Princeton University, May 12, 2018, https://uchv.princeton.edu/events/witnessing-professionals-and-climate-change-workshop.

[2] See, for example, Michelle L. Bell, Devra L. Davis, and Tony Fletcher, "A Retrospective Assessment of Mortality from the London Smog Episode of 1952: The Role of Influenza and Pollution," *Environmental Health Perspectives* 112 (1) (2004): 6–8.

[3] The U.S. EPA trends reports are a good source. See, for example, Environmental Protection Agency, *Our Nation's Air* (Washington, D.C.: Environmental Protection Agency, 2018), https://gispub.epa.gov/air/trendsreport/2019/#introduction.

[4] A good example of a study that took advantage of air pollution data that had been collected for other purposes is C. Arden Pope III, Richard T. Burnett, Michael J. Thun, et al., "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particle Air Pollution," *Journal of the American Medical Association* 287 (9) (2002): 1132–1141.

[5] See the Earth Institute at Columbia University, "About Us," https://www.earth.columbia.edu/articles/view/3341 (accessed November 14, 2019).

[6] "U.S. National Assessment of the Potential Consequences of Climate Variability and Change–*Region: Metro East Coast*," Climate Impacts, http://www.climateimpacts.org/us-climate-assess-2000/regions/metro-east/default.htm (accessed November 14, 2019).

[7] Examples of early reviews on climate and health include: Jonathan A. Patz, Michael A. McGeehin, Susan M. Bernard, et al., "The Potential Health Impacts of Climate Variability and Change for the United States–Executive Summary of the Report of the Health Sector of the U.S. National Assessment," *Journal of Environmental Health* 64 (2) (2001): 20–28; Paul R. Epstein, "Is Global Warming Harmful to Health?" *Scientific American* 283 (2) (2000): 50–57; and Andrew Haines, Anthony J. McMichael, and Paul R. Epstein, "Environment and Health: 2. Global Climate Change and Health," *Canadian Medical Association Journal* 163 (6) (2000): 729–734.

[8] Christian Hogrefe, Barry Lynn, Kevin Civerolo, et al. "Simulating Changes in Regional Air Pollution over the Eastern United States Due to Changes in Global and Regional Climate and Emissions," *Journal of Geophysical Research: Atmospheres* 109 (D22) (2004).

[9] Two papers that emerged from that work that specifically focus climate impacts on the health effects of ozone were Michelle L. Bell, Richard Goldberg, Christian Hogrefe, et al., "Climate Change, Ambient Ozone, and Health in 50 U.S. Cities," *Climatic Change* 82 (1–2) (2007): 61–76; and Kim Knowlton, Joyce E. Rosenthal, Christian Hogrefe, et al., "Assessing Ozone-Related Health Impacts under a Changing Climate," *Environmental Health Perspectives* 112 (15) (2004): 1557–1563.

[10] U.S. Global Change Research Program, *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (Washington, D.C.: U.S. Global Change Research Program, 2016).

[11] Kristie L. Ebi, John Balbus, Patrick L. Kinney, et al., "U.S. Funding Is Insufficient to Address the Human Health Impacts of and Public Health Responses to Climate Variability and Change," *Environmental Health Perspectives* 117 (6) (2009): 857–862.

[12] Examples include Katrin Burkart and Patrick Kinney, "Is Precipitation a Predictor of Mortality in Bangladesh? A Multi-Stratified Analysis in a South Asian Monsoon Climate," *Science of the Total Environment* 553 (2016): 458–465, https://doi.org/10.1016/j.scitotenv

.2016.01.206; Kai Chen, Arlene M. Fiore, Renjie Chen, et al., "Future Ozone-Related Acute Excess Mortality under Climate and Population Change Scenarios in China: A Modeling Study," *PLOS Medicine* 15 (7) (2018); Kim Knowlton, Barry Lynn, Richard A. Goldberg, et al., "Projecting Heat-Related Mortality Impacts under a Changing Climate in the New York City Region," *American Journal of Public Health* 97 (11) (2007): 2028–2034; Tiantian Li, Radley M. Horton, and Patrick L. Kinney, "Projections of Seasonal Patterns in Temperature-Related Deaths for Manhattan, New York," *Nature Climate Change* 3 (2013): 717–721; Jaime Madrigano, Kazuhiko Ito, Sarah Johnson, Patrick L. Kinney, and Thomas Matte, "A Case-Only Study of Vulnerability to Heat Wave-Related Mortality in New York City (2000–2011)," *Environmental Health Perspectives* 123 (7) (2015): 672–678; Elisaveta P. Petkova, Antonio Gasparrini, and Patrick L. Kinney, "Heat and Mortality in New York City since the Beginning of the 20th Century," *Epidemiology* 25 (4) (2014): 554–560; and Perry E. Sheffield, Kim Knowlton, Jessie L. Carr, and Patrick L. Kinney, "Modeling of Regional Climate Change Effects on Ground-Level Ozone and Childhood Asthma," *American Journal of Preventive Medicine* 41 (3) (2011): 251–257.

[13] Stephen Ansolabehere and David M. Konisky, *Cheap and Clean: How Americans Think about Energy in the Age of Global Warming* (Cambridge, Mass.: The MIT Press, 2014).