PERSPECTIVE

From Closing the Atmospheric Ozone Hole to Reducing Climate Change

Lessons Learned

Gary W. Ewart[1], William N. Rom[2], Sidney S. Braman[3], and Kent E. Pinkerton[4]

[1]American Thoracic Society, Washington, DC; [2]Pulmonary Critical Care and Sleep Medicine, New York University, and [3]Pulmonary Critical Care and Sleep Medicine, Icahn School of Medicine at Mount Sinai, New York, New York; and [4]Center for Health and the Environment, University of California, Davis, Davis, California

Abstract

Global warming presents U.S. and transnational leaders with enormous political and policy challenges. World leadership addressed a similar worldwide environmental challenge in the 1980s and 1990s when scientists advised that accelerating emission of man-made chlorofluorocarbons was depleting the ozone layer of the earth's atmosphere. The process that led to global agreement on reducing depletion of the ozone layer holds valuable lessons, and some ironies, for scientists and policy makers seeking now to address global climate change. By understanding the international treaty process, how science informed that process, and how the physician community played a constructive role in the transition away from commercial use of ozone-depleting gases three decades ago, environmental activists can better understand the challenges, opportunities, and potential solutions under current consideration in affecting global climate change.

Keywords: greenhouse effect; chlorofluorocarbons; American Thoracic Society; climate change

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Correspondence and requests for reprints should be addressed to Kent E. Pinkerton, Ph.D., Center for Health and the Environment, University of California, Davis, 1 Shields Avenue, Davis, CA 95616. E-mail: kepinkerton@ucdavis.edu

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In September 2014, the United Nations convened a summit in New York City on climate change that triggered the largest global warming protests in history. In New York City alone, more than 300,000 demonstrators took to the streets demanding that governments take action on the issue. The New York summit was in fact a prologue to the United Nations Climate Change Conference, which will be held near the end of 2015 in Paris. Leaders of the organizing committee for the 2015 conference aim to achieve a binding agreement of all nations to control the greenhouse gas emissions that are driving global warming. World leaders who are preparing for the Paris meeting are advised to study the response to another environmental threat that challenged transnational policy makers 30 years ago: depletion of the ozone layer in the earth's atmosphere. There are valuable lessons to be learned, as well as contrasts and ironies to be noted, in comparing the successful international effort to address ozone depletion with current efforts to mitigate the climate change—our next global environmental crisis (1–3).

The Ozone Layer

Ozone in the stratosphere (12–50 km above the surface of the earth) absorbs ultraviolet radiation that can lead to skin cancer and other adverse effects (4). In 1974, Molina and Rowland published a pivotal study that drew widespread attention to depletion of the stratospheric ozone layer due to emission of man-made chlorofluorocarbons (CFCs) (5). Under ultraviolet radiation, CFCs release chlorine atoms that react with ozone to generate oxygen. In a subsequent reaction, free chlorine is released again and made available to destroy another ozone molecule. By this repetitive chemical reaction cycle, 1 CFC molecule can destroy up to 100,000 ozone molecules in the outer atmosphere. The release of CFCs increased geometrically during the 1970s–1980s as a result of industrial use in air conditioners, refrigerators, and other industrial products, including medical inhalers.

In 1976, the U.S. National Academy of Sciences issued a report confirming the thinning of the stratospheric ozone layer (6). At that time, scientists were documenting a steady decline of about 0.4% per year in the volume of ozone in the earth's stratosphere. The 1976 report spurred the United States, Canada, Norway, and Sweden to ban the use of CFCs as propellants in consumer products. Despite early

unilateral action by the United States and the three other nations, the European community initially declined to take similar action.

In 1984, the British Antarctic Survey reported discovery of a gigantic hole in the ozone layer above Antarctica. This hole emerged during the Antarctic spring when polar stratospheric ice clouds released free chlorine to react with ozone. Satellite, high-altitude aircraft, and balloon measurements documented the presence of chlorine of anthropogenic origin in the stratosphere and that intermediate reactive compounds, including chlorine monoxide, were present. However, progress on restoring the ozone layer stalled because of the election of U.S. President Reagan, whose administration did not make solving the problem a priority, and lack of a global effort to address emission of CFCs of ozone-depleting substances.

Vienna Convention and the Hole in the Ozone Layer

In 1985, the U.S. Environmental Protection Agency (EPA) provided the leadership needed to convene a meeting of the 20 nations representing the major economic powers. Those nations reached an accord known as the Vienna Convention that created a negotiating platform aimed at substantially reducing emission of ozone-depleting substances. Shortly afterward, scientists confirmed the discovery of the "hole" in the ozone layer. This announcement moved the issue from a vague environmental concern discussed by leading atmospheric scientists and global leaders to a "kitchen table" concern held by many citizens of the world.

Montreal Protocol

In 1987, the Vienna Convention, combined with public pressure generated by the discovery of the hole in the ozone layer, provided the right combination of circumstances for negotiators to establish the Montreal Protocol. The Montreal Protocol was an international treaty that bound major industrial powers to a 50% reduction in the emission of ozone-depleting substances by 1999. After additional scientific evidence further confirmed the hole in the ozone layer, the Montreal Protocol was revised and strengthened in 1990. In a particular stroke of legislative genius, ratification of the Montreal Protocol was combined with the acid rain agreement and the 1990 amendments to the U.S. Clean Air Act. This complex legislative vehicle was then presented to the U.S. Senate.

The combination of the Montreal Protocol with the Clean Air Act amendments enabled the treaty to gain strong bipartisan support that existed for environmental legislation at that time, and many of the "loss of U.S. sovereignty" fights that often accompany congressional consideration of global treaties were avoided. When finally adopted by the United States, the Montreal Protocol established a timeline to eliminate the use of CFCs and halons (another ozone-depleting substance) in developed nations by 2000 and in developing nations by 2010. The only exception in the CFC phase-out was the use of CFC as propellants in respiratory medications.

Respiratory Medications and the American Thoracic Society

The American Thoracic Society (ATS) was asked by the EPA to convene a U.S. taskforce charged with managing the phase-out of CFC propellants from respiratory medications. As the convener of the stakeholders group, the ATS brought together medical professionals, patients, chemical manufacturers, and the pharma industry to negotiate a transition process for phasing out the CFCs in respirator mediations.

To no one's surprise, patient and physician groups were concerned about the cost and effectiveness of reformulated asthma medications. The technical aspects of creating a reformulated product, gaining U.S. Food and Drug Administration (FDA) approval and understanding how the new product would impact market share influenced pharma's attitude toward the transition of removing CFCs from medical inhalants. However, those pharmaceutical companies that had already developed a reformulated product became strong proponents of an accelerated transition. Conversely, those companies that did not have a reformulated product strongly fought rapid transition within the stakeholder process in addition to seeking FDA and congressional support to either delay or stop the transition timetable. The ultimate driver of the transition process was the chemical companies themselves, who were working quickly to get out of the CFC business. As the availability of CFCs rapidly dried up, the pharmaceutical industry was forced to reformulate respiratory drugs delivered by inhalation.

Despite periodic interference from FDA officials and Congress, the stakeholder process convened by the ATS was able to successfully manage the CFC transition in respiratory medications. Two billion U.S. dollars and 20 years later, the pharmaceutical industry has completely converted metered-dose inhaler products for asthma and chronic obstructive pulmonary disease (COPD) to those containing ozone-protecting agents. Today, there are no asthma or COPD drugs in the United States that use CFC as a propellant.

Back to the Ozone Hole

Although the hole in the ozone layer (and general thinning of the ozone layer) still persists, the good news is that it is recovering. The 2014 Scientific Assessment of Ozone Depletion report, written and reviewed by 350 scientists, states that the ozone hole has shrunk from just under 30 million square kilometers in 2006 to 21 million square kilometers in 2013 (7). The report highlights many thousands of measurements of chemical species in the stratosphere that discern trends, such as chlorine and bromine compounds declining 10–15% from peak levels 10–15 years ago (3,522 to 3,210 parts per trillion, respectively).

This year, the World Metrological Organization issued a report stating, "(t)here are several indications that the ozone layer is beginning to recover…" (3). The report further notes that the implementation of the Montreal Protocol has led to a stabilization in atmospheric concentration of ozone-depleting substances and that the overall ozone layer will begin to heal measurably in 2050 and reach pre-1980s level by 2075.

Lesson Learned from Fixing the Ozone Hole

The success story of reversing expansion of the atmospheric hole in the ozone layer over

Antarctica three decades ago has important parallels, contrasts, and ironies for those concerned today about climate change.

Taking Action

We learned that action by one or a few nations can catalyze global action. In the mid-1970s, when the United States, Canada, Norway, and Sweden agreed to ban CFCs from consumer products, other European nations did not follow suit at that time; however, the bold action of those leading nations did capture the attention of European leaders and helped set the stage for later multilateral action. Countries concerned about climate change should consider whether adoption of model national policies for mitigation of global warming might generate pressure for future multinational action, as occurred for ozone layer depletion. We hope that the recently announced United States–China agreement to limit carbon emissions will serve as a starting point for more global cooperation.

A Picture Can Be Worth a 1,000 Words

Dissemination of satellite images (*see* Figure 1) that visibly mapped seasonal thinning of the ozone layer over Antarctica transformed the otherwise abstract notion of overall atmospheric ozone depletion into a graphically dramatic threat that could be easily communicated and understood globally as a growing hole in an ozone protective layer. To date, no comparably alarming image has emerged to rally unified worldwide action on climate change. Regionally threatening shared experiences attributed by scientists to global warming, such as Hurricanes Katrina and Sandy, California drought, and European heat waves and flooding, have not had similar impact, in part because skeptics have been effective in explaining them away ("extreme weather events have always happened; what is so different now?"). Identification of a universally appreciated graphic image of global warming might stimulate action on climate change the same way that images of the ozone hole previously accelerated action on ozone depletion. Perhaps a suitable rallying image will be found again at the

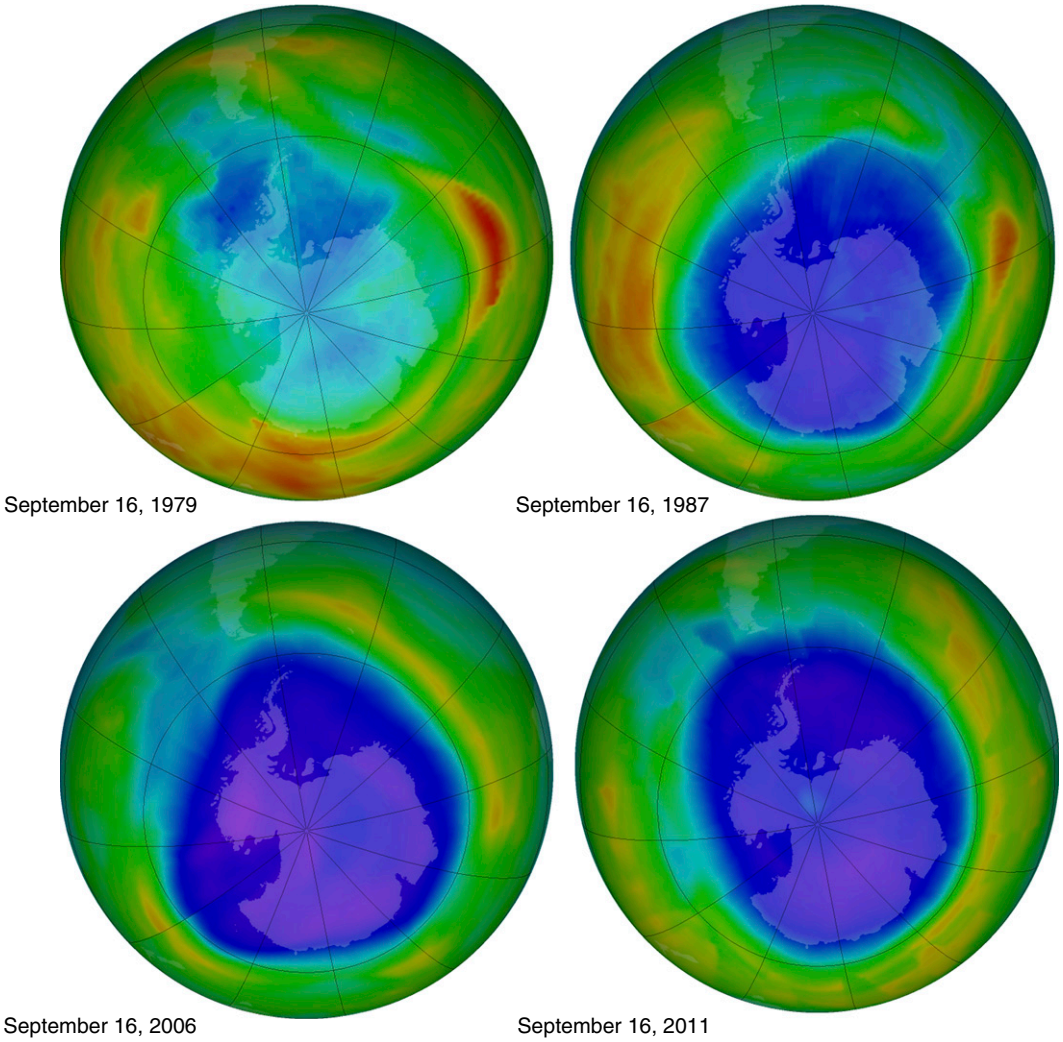

Figure 1. Satellite images of the ozone hole over the Antarctic on September 16 in 1979, 1987, 2006, and 2011. Credit: NASA Ozone Hole Watch.

polar zones of the earth. Accelerated melting of the Arctic and Antarctic ice caps is not so easily dismissed as an ordinary extreme, regionally confined weather event.

Creative Solutions Can Be Found

Global coordination on environmental and health problems will meet resistance, but progress is possible within democratic nations by creative generation of legislative vehicles that can earn the broad support of opposing parties. Opponents in the United States of fixing the ozone hole were worried about the adverse financial impact of the proposed regulations and loss of U.S. sovereignty through international treaties. Despite those concerns, Congress ratified the Montreal Protocol and committed the United States to action on the ozone layer by combining the Montreal Protocol with the Clean Air Act Amendment, a legislatively popular initiative. Similar political compromises and trade-offs may be necessary to drive action on climate change through national legislative bodies.

Industry Matters

Perhaps the most important difference between the ozone hole and climate change is the position of key industry leaders on the need for action. During the drive to reduce emission of ozone-depleting substances, the major manufacturers of CFC took an early public stand in favor of transitioning away from dependence on the chemical. Their advocacy for reform put pressure on industries that made other ozone-depleting substances to follow suit. At present, certain key industry leaders, especially from those industries that emit major greenhouse gases, are funding an aggressive campaign to thwart climate change policy by attacking the strong scientific evidence documenting climate change. Counterbalancing advocacy in favor of climate policy by those industries that stand to benefit from reduction of dependency on carbon-based fuels may be needed to effect policy changes in the United States and elsewhere.

Consumers Matter

In the CFC transition, consumers had to make relatively small changes in personal habits in response to policy on ozone-depleting substances. Switching from one propellant to another in inhaled respiratory medicines, switching from spray can hairsprays to pump hairsprays, and paying a little more for Freon-free refrigerators were relatively painless changes in consumer habits. In contrast, implementing policies to reduce greenhouse gas emissions will likely require more profound changes in consumer behavior.

Ironies and Outliers

The story of the ozone hole is not without irony and outliers. Chief among the ironies is that the migration from CFCs in many products—including respiratory medications—led to substituted use of hydrofluorocarbons and hydrochlorofluorocarbons (HFCs and HCFCs). Although these compounds do not catalyze ozone destruction, they are potent greenhouse gases that promote climate change. Respiratory medications are not immune from this irony. The current primary propellants for respiratory medications—HFC 134a and HFC 227ea—are potent greenhouse gases with carbon dioxide equivalents of 1,320 and 3,660, respectively (8). Thus, we have replaced one environmental hazard with another (9).

In 2013, the United States and China announced an agreement to phase down HFCs and the European Union drafted regulations to phase down HFCs. Although the E.U. regulation requires reporting of medical HFC emissions, as of yet, no country is suggesting the phase-out of HFCs for respiratory medications. So another environmentally forced reformulation of respiratory products does not seem to be in the immediate future.

As for outliers in the ozone hole story, China and India, and to a lesser extent Russia, until recently continued to petition for additional allotments of CFCs for use in their economy—undermining some of the global progress on limiting emission of ozone-depleting substances. In 2014, China was the only party to the Montreal Protocol seeking an exemption for medical use CFCs (10). Accusations of undocumented, and hence illegal, use of ozone-depleting substances in these countries persist. Despite less than complete compliance of these major economies, the world has continued to make progress on reducing ozone-depleting substance emissions.

Conclusions

History repeats. Lessons learned from successful control of atmospheric ozone depletion in the 1980s and early 1990s may be applicable to current efforts aimed at controlling greenhouse gas emissions. History can repeat for the ATS also. The ATS made an important contribution to healing the atmospheric ozone hole through responsible advocacy and seeking alternative methods for the delivery of inhalant medicines. The ATS and its members can make similarly positive contributions to formulation of global policy on climate change. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

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