Final Workshop Summary
Preventing Air Pollution-Related Cardiopulmonary Illnesses - 
Innovative, Cross-Disciplinary Solutions

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U.S. Environmental Protection Agency
Washington, D.C.
Final Workshop Summary
Preventing Air Pollution-Related Cardiopulmonary Illnesses: Innovative, Cross-Disciplinary Solutions

On September 28 and 29, 2016, the EPA hosted a two day, multi-stakeholder workshop including federal officials, environmental health scientists, health care professionals, public health officials and others, to discuss barriers and identify opportunities for preventing air pollution-induced cardiovascular and pulmonary diseases. The first day of the workshop aimed to provide an overview of the medical evidence, how various institutions regard this public health issue and barriers they face in addressing it. The second day of the workshop was an open discussion on future opportunities and next steps.

Air Pollution and Cardiovascular Disease

Outdoor air pollution has long been recognized as affecting the respiratory system, but many people don’t know that air pollution also impacts cardiovascular health. Scientific research provides strong evidence of the cardiovascular effects of particle pollution and ground-level ozone. These pollutants are known for increasing risks of morbidity and mortality, from both short and long-term exposures.1,2

Thousands of scientific studies have documented the health effects of air pollution and how they occur.1,2 Exposures to elevated levels of particle pollution in the short-term can worsen heart failure and trigger heart attacks, strokes and some arrhythmias.3 Over the longer-term, exposure to air pollution can have more insidious effects, such as accelerating the development of atherosclerosis4, and contributing to premature death.1 Scientists have explored how these effects occur, and have found that changes in circulating proteins in the blood and activation of neural responses are among the biological mechanisms that link air pollution to disease.5

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Globally, the second leading cause of illness is household air pollution from the burning of solid fuels for cooking and heating, while outdoor air pollution causes approximately 3.7 million deaths each year.\(^6\) In the US, EPA estimates that particle and ozone pollution causes about 130,000 premature deaths and 180,000 non-fatal heart attacks annually.\(^7\) This means that air pollution-induced death is on the same order of magnitude as other common diseases, such as diabetes, Alzheimer’s disease, kidney, and respiratory disease. And yet there has been little attention from the healthcare community to prevent these impacts.

Despite significant gains in reducing cardiovascular disease over the last several decades, it is still the leading cause of death in the United States and since 2011, the trend in decreasing mortality has leveled off.\(^8\) New strategies are needed if progress is to continue. The “traditional” risk factors for cardiovascular disease, such as high blood pressure, cholesterol, and smoking, account for about 75 to 90% of disease risk. That leaves about 10 to 25% of the risk unaccounted for, and addressing environmental factors could make a difference.\(^9,10\)

Under the Clean Air Act, EPA sets National Ambient Air Quality Standard (NAAQS) for the most common pollutants, and re-evaluates each standard every five years. States are responsible for ensuring that the standards are met, and for developing plans to meet the standards in areas that are out of compliance. As new science comes out on air pollution and its effects, that information is considered in the cyclical review of the standards designed to protect public health.

The NAAQS have helped to achieve significant reductions in air pollution in many areas of the country. According to the federal Office of Management and Budget, EPA’s standards for air particle pollution provide the largest benefits of any federal regulation. Several studies have demonstrated that as air pollution levels decline, mortality rates decrease, and life expectancy increases.\(^11,12,13\)

But, achieving the standards can be difficult – places like Southern California and Pittsburgh still have stubborn air pollution problems. In many cases, it takes a long time to reduce air pollution to meet the standards. Approximately 121 million people nationwide lived in counties with pollution levels above the primary NAAQS in 2015; about 31 million people nationwide lived in counties exceeding the primary NAAQS for PM$_{2.5}$. Additionally, not everyone is equally affected; older persons, and those with established cardiopulmonary disease and diabetes, are more susceptible to the adverse health effects of air particle pollution and represent at-risk adult populations.

Reducing air pollution comes down to addressing local sources. Even in areas that, on average, meet the federal requirements, some neighborhoods can be exposed to higher pollution levels than others; for example, locations near highways, railyards, industrial facilities or ports may have elevated levels of air pollution. Compounding the problem, these neighborhoods may also be impacted by other factors that disproportionately affect health, such as lack of healthy food options, limited access to medical care, and stress due to crime and violence. Addressing air pollution is only one component of solving the larger problem of how to improve health.

The issues of air pollution and cardiovascular health are converging. From the air pollution side, we see that the regulatory approach alone is not enough to protect health. From the health side, the evidence is that additional factors need to be addressed to reduce the burden of cardiovascular disease. Public Health 3.0, the Nation’s public health plan for the next decade, is very clear in its emphasis on including social determinants of health to improve the health of all people. And so, we need to combine our clean air regulatory approach with a preventive public health and health care approach so that we can reduce the illnesses and deaths attributable to air pollution and their attendant societal burdens.

WHAT ARE THE BARRIERS TO INTEGRATING AIR POLLUTION EVIDENCE INTO CARDIOVASCULAR DISEASE HEALTH PRACTICE?

A major focus of the workshop was identifying barriers to reducing the cardiovascular health effects due to air pollution exposures. The following issues are drawn from the presentations and discussion among participants.

Many health care professionals and patients may not be aware of the connection between air pollution and cardiovascular effects. For example, in a survey of 500 patients in a Michigan cardiology clinic, 92% of cardiac patients reported that they were not informed of health risks related to air pollution. The lack of knowledge among medical practitioners is not surprising, because the training in medical and nursing schools provides very limited content on public health, environmental

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health, and community medicine, thus creating a divide between public health and personalized health care. Additionally, there are no national recommendations for medical education on what should be the core content on air pollution or other environmental issues. Neither do the tests for medical licenses and credentials include questions about air pollution. A larger issue, for air pollution and other factors, is that clinicians’ education also lacks emphasis on public health. Physicians, nurses and allied health professionals could be great allies in addressing environmental and social impacts on health. Yet, medical school curricula rarely encourage students to engage in “environmental public health” issues.

Health care professionals are also unaware of individual-level recommendations that may be helpful to their patients. The American Heart Association’s Scientific Statement provides recommendations for health care professionals to educate their cardiovascular disease patients about the risks of air pollution. This advice focuses on EPA’s Air Quality Index, the primary tool available to promote behavioral changes in response to air quality conditions. The AQI reports daily local air quality and informs the general public and high-risk individuals about when it is prudent to avoid outdoor activity.

Other personal level interventions with the potential to reduce air pollution exposures include: installing air filtration and/or air conditioning systems for rooms, buildings, and motor vehicles; wearing face masks; closing windows; and modifying indoor technologies to reduce emissions (e.g., from cookstoves). In one study, for example, HEPA filters reduced indoor particle pollution concentrations by over 50% and significantly reduced several blood inflammatory markers in young healthy adults. While there is some evidence that such interventions can reduce air pollution exposures, there are relatively few studies providing direct evidence that specific interventions also reduce individual cardiovascular risks and improve cardiovascular outcomes. Significant unknowns of these and other interventions include: comparative effectiveness, who benefits, when interventions should occur, the actual risk/cost/benefit, and the overall public health impact.

Another barrier is that, while the air pollution-related health risks of cardiovascular disease are significant for the overall population, the risk for any single individual is quite small. Thus, it may be difficult to convince people to take preventive measures, just as it was initially challenging to convince people to use seatbelts.

Rates of cardiovascular disease and related mortality are not uniform across the US population – for example, African-Americans have the highest rate of coronary heart disease deaths, while Asian/Pacific Islanders have the lowest. Researchers are exploring the factors that contribute to these disparities, such as the socioeconomic environment, health-related behaviors, and psychosocial stress. While few studies have addressed the relationship with air pollution, recent data from the MESA-Air study suggest African Americans are more susceptible to air pollution considering measures such as left ventricular

16 Information on AQIs can be found at https://www.airnow.gov/.

More research is needed to understand the role of air pollution and other environmental factors, for example:

- Where do people spend their time and how is their “environment” measured -- what are people really exposed to?
- How do early life exposures impact future cardiovascular outcomes?
- How do environment and genes interact, and what is the role of epigenetics in cardiovascular risk?
- How can we leverage some newer modeling techniques and use available data for identifying potential risk factors?
- Considering the complexity of interaction of social factors, access to health care, built environment, air pollution, and others – what are the most promising interventions?

WHAT ARE THE OPPORTUNITIES?

Health Care Delivery System Reform: Opportunities for Prevention, Population Health, and Care Redesign

The Affordable Care Act (ACA) and on-going health care reform efforts have presented opportunities for incorporating environmental health into primary care and thus improving cardiovascular health. Understanding the continuing changes in health care systems is essential for developing approaches to integrate environmental health evidence into health care practice and personalized public health.

Many innovations focus on achieving better health outcomes and reduced costs through coordinated care that benefits patients. For example,

- Pay Providers -- Alternative payment models promote health system innovation beyond fee-for-service care to invest in programs that demonstrate improvement in the health of people—value-based care.
- Deliver Care – Prevention and population health models provide evidence for the benefits of integrating prevention and population health programs within health systems.
- Distribute Information – Connected health data systems provide data to monitor population health at the practice, health system, community, state and national level.

The Center for Medicare and Medicaid Services (CMS) Innovation Center was created to develop, test and implement new payment and delivery models to improve quality care. The gold standard for these activities involves improving quality of care while decreasing the cost of care, with a goal of 50% of

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Medicare funds going toward alternative goals and not toward fee-for-services. By early 2016, that proportion reached 30%. Examples of new approaches being tested include:

Accountable care organizations (ACO)—An entity formed by providers—for example primary care physicians, hospitals, specialists, and nursing homes—that agree to work together and take responsibility for the quality and total costs of care for a designated patient population. Greater health outcomes at less cost means the ACO receives a share of the savings. If it exceeds target levels resulting in expensive care and poor health of patients, the ACO owes money back. One topic of discussion at the workshop was how incorporation of environmental health evidence into primary care practice could improve health outcomes and demonstrate lower cost.

The Bundled Payments for Care Improvement—This initiative aims to reduce the wide variation in quality of patient care across the U.S. That variation means a lot of Americans aren’t receiving treatments that are recommended by national guidelines. It also means costs are often much higher than they should be. The bundled payment approach is designed to help recently discharged patients stay out of the hospital. Providers receive a lump sum sufficient to cover all the care required for, say, a hip or knee replacement, or for treating a heart attack. Providers that manage to keep expenses below a target and meet performance benchmarks can keep all or some of the savings, with a higher share going to those that are willing to assume the cost of going over budget. The Medicare program benefits, too, since the bundled price is lower than what it would otherwise pay. Reducing air pollution exposure has potential to bring down costs for cardiac patients through improved outcomes. A thorny issue continues to be specifying the most effective air pollution intervention for individual patients.

Innovation Center models are providing 70% of funding through ACOs. All are showing signs of improved cost and health outcomes. In four years (2010-2014), these efforts reduced 17% of hospital acquired conditions, saved 87,000 lives, prevented 2 million harmful events to patients and saved $20 billion.

Another dimension to health reform includes a clause in the Medicaid program on providing community benefits. The goal is to work with communities to enable healthy living. Health care systems are just beginning to identify funding for uses within the community. Workshop participants noted tremendous opportunities for bringing environmental health and upstream social determinants of health into health care systems. A stronger connection between the health care system and communities can lead to health equity and greater health overall. The extent to which these reforms and initiatives will be changed as health care continues to evolve is not clear.

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Public Health Outreach Programs
The timing for collaborations to reduce air pollution-related cardiopulmonary illness could not be better. The Centers for Disease Control, and Medicare, are leading Million Hearts – a broad, five-year partnership-based initiative to prevent a million heart attacks and strokes by 2017.\(^21\) CDC and Medicare are now gearing up to begin Million Hearts 2022. Since this workshop, the Million Hearts 2022 Framework includes information on improving outcomes for priority populations. Specifically, people who have had a heart attack or stroke are advised to increase cardiac rehabilitation participation and avoid exposure to PM\(_{2.5}\).\(^22\) Similarly, the national campaign, Public Health 3.0 has just launched and its goal is to create lasting improvements for the health of everyone in America.\(^23\) It has several recommendations for doing so, including an emphasis on “structured, cross-sector partnerships.” This opens the door for more vigorous collaboration between environmental and public health activities.

Collaborations across Healthcare, Social Science and Environmental Professions
The Workshop participants represent large networks of professions, organizations and other voices with an interest in improving cardiovascular health. This variety of networks provides great potential for highly effective collaborations going forward. Examples include collaboration among environmental and public health organizations in promoting the Million Hearts 2022 initiative and Public Health 3.0.

Opportunities to address disparities in cardiovascular health can come from any number of potential partnerships represented at the workshop including state and local health agencies, medical educators, social scientists with strong ties to community based organizations, academic and government researchers, data innovators, and the insurance industry. One example of such a successful partnership was presented in describing the work of EPA, with the Departments of Housing and Urban Development and Health and Human Services, working with local agencies, community groups and others to expand access to in-home asthma care services. This collaboration spotlighted and spread best practices, equipped and connected communities and pursued sustainable financing for in-home asthma care.

Research
EPA, the American Heart Association and others have shared materials and raised awareness about the Air Quality Index\(^24\) as a source of information for those with cardiopulmonary disease. Fact sheets and other communications materials provide individuals at risk with prudent recommendations for reducing personal air pollution exposures.\(^25\) To enhance patient education and adoption of most effective measures for reducing personal exposures, there is a need for further research:

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\(^{21}\) https://millionhearts.hhs.gov/
\(^{23}\) https://www.healthypeople.gov/2020/tools-resources/public-health-3
\(^{24}\) https://airnow.gov/index.cfm?action=aqibasics.aqi
\(^{25}\) https://www.epa.gov/air-research/healthy-heart-toolkit-and-research
• At the individual level, understanding what behavioral changes and personal interventions (e.g., changes in activity patterns, home and car air filters) most effectively lower cardiovascular risks.
• For health care and provider systems, understanding the biggest drivers in the areas of clinician education, electronic medical record alerts, access to care and environmental health messaging.
• At the community level, determining the types of outreach and education that have the greatest impact and understanding how air pollution-related illness is affected by built environments, healthy food access, and exercise facilities.

Using Health Data with Environmental Data at the Community Level
The Centers for Disease Control and Prevention uses public health tracking (or surveillance) to systematically collect, analyze and interpret health outcome data to help inform public health practice to prevent and control disease. CDC’s National Environmental Public Health Tracking program provides information from a nationwide network of integrated health and environmental data that drives actions to improve the health of communities. Tracking programs allow researchers to see how environmental changes affect health.

A major opportunity to integrate data on health outcomes with environmental data is occurring with the advent of electronic health records. They have the potential to improve the timeliness, population coverage, and geographic resolution for tracking, while filling important data gaps, such as other risk factors. Pilot efforts using electronic health records are promising, but challenges remain, including variability across outcome and data sources, need for validation, and remaining administrative barriers. Although there is more work to be done, there are tremendous opportunities with electronic health records and the Internet of Things to foster greater integration of health and environmental data that can be used to better inform public and environmental health decisions at the community level.

Using Health Data with Environmental Data at the Individual Level
With the shift to value-based care, data analytics are more important than ever to help health care systems use the best information available to ensure improved health outcomes at lower cost. Health care analytic companies are providing these services through various modeling approaches to better predict a patient’s risk of readmission to the hospital, higher health risks, complications, etc. While medical records and/or claims data are a major source of information, some companies are trying to pull in other risk factors that capture social determinants of health, including environmental factors, zip code-level census information, and other factors that could affect an individual’s risk.

Including air pollution exposure as a risk factor for individual patients with cardiovascular disease presents new opportunities for data analytics to enhance predictive outcomes. Merging environmental data into these systems is only just beginning. Yet more importantly, in response to predictions of increased risk, actionable behaviors can be implemented having the potential to decrease risk and improve clinical outcomes.
**Integrating Environmental Health into Medical Education**
In one new model, medical students at George Washington University spend a few days each spring addressing a clinical public health challenge, for example, how to eliminate childhood asthma in Washington, DC. The student teams research the problem from a variety of perspectives, and then make substantive policy proposals, ranging from changes to reduce air pollution from transportation sources, to expanding community asthma education, to improving indoor air quality in public schools. This model helps provide real-world solutions to existing public health problems, and it helps train medical professionals to be active in community health.

**New Advances in Air Monitoring Technologies**
Air monitoring technology is evolving rapidly in the US and internationally. Measurement technologies are being miniaturized with ever-improving performance. This new field can create business opportunities and engage communities and citizen scientists, giving the most vulnerable communities real-time information about their environment. Low-cost sensors have the potential to provide greater temporal and geographic coverage of measurements than the network of air quality monitoring stations used in most studies. Sensors can connect healthcare to the whole environment and provide detailed, real-time information to meet local needs.

As air and water sensors become better, cheaper, and more ubiquitous, many individuals and communities are seeking to become involved in monitoring their environment, are posting their data on the internet, and are expecting action. This trend provides a great opportunity to engage with the public on the protection of human health and the environment.

In summary, workshop discussions of opportunities for improving air pollution-related cardiopulmonary led to a number of suggestions for action. The list was much longer than anyone anticipated, but provides a jumping off point for different organizations to move forward and implement. The EPA organizers intend to keep communication going among the participants to increase the likelihood of success for the suggested actions, to enhance partnerships and collaborations, and focus priorities.
ACTIONABLE APPROACHES

1. Million Hearts 2022 Initiative –
   a. The Million Hearts initiative could address particulate matter air pollution as part of the new program.
   b. EPA and other agencies participate in outreach activities of Million Hearts 2022.

2. Research Interventions –
   a. Collaborate with health care provider systems to use electronic medical records and “big data” to provide precision-level services.
   b. Conduct community outreach and engage community gate-keepers (key, influential community members) to increase intervention implementation.
   c. Conduct clinical studies of cardiovascular at-risk groups to aid physicians in identifying patients who may need information and protection from harmful environmental factors, such as particulate matter.
   d. Conduct intervention trials on existing intervention strategies so physicians may recommend patient-specific interventions.
   e. Develop standard operating procedures, best practices, guidelines, and intervention recommendations for insurance agencies and health care providers to relay to their patients.
   f. Propose that communities and organizations work together to address poor air quality-related cardiovascular and pulmonary diseases through a collaborative research endeavor, much like the American Heart Association, Verily, and AstraZeneca supported “One Brave Idea” research enterprise.
   g. Identify key investors or research funding for intervention trials. A partnership of NIH, Million Hearts initiative and EPA would help to advance discussions of research opportunities. Working with the Patient-Centered Outcomes Research Institute is another recommended partnership.
h. Provide information on short- and long-term interventions to reduce air pollution exposure, including evidence of an intervention’s success.

3. Nursing, Physicians’ Assistants, Medical Students, CME – Environmental Health Training, including fellowships

Promoting environmental health hazard consideration within medical, physician assistants (PA) and nursing school programs would ensure the next generation of physicians, physician assistants and nurses understand how air pollution affects health outcomes and how patients may benefit from reduced exposure. Academic integration could be accomplished in several ways during medical, PA and nursing education, post-graduate fellowships and practice:
   a. Incorporate environmental health into the curriculum such as including air pollution education within the medical pulmonary health block.
   b. Incorporate field-based education, with environmental and social determinant consideration into the curriculum.
   c. Incorporate environmental determinants of health, including air pollution, in post-graduate medical training curricula, e.g. medical residencies in family medicine, internal medicine, obstetrics/gynecology, pediatrics, rehabilitation medicine.
   d. Require medical schools to incorporate environmental health hazards as part of their accreditation process and workforce development.
   e. Use journals, websites, seminars, and educator and public health professional organizations (such as APHA) to increase environmental public health awareness, to generate more medical-public health champions. Create air pollution-related cardiopulmonary disease fellowships for medical, PA and nursing students. The fellowship is envisioned to be a preventive medicine fellowship with an emphasis on environmental factors that drive health outcomes.

4. Community Engagement/Outreach - Each workshop participant reach out to their disciplines/communities
   a. Conduct community outreach and engage community gate-keepers (key, influential community members) to increase intervention efforts.
   b. Frame the issue on how poor air quality impacts the “food, faith, family, health and jobs” model.
   c. Design multi-level research studies and interact with the social science community to ensure all modifiable agents are captured.
   d. Use social media to spread awareness, guidance. Consult with social entrepreneurs.

5. Data

Increasing the use of predictive analytics in the medical community would help generate personalized health care services for patients that incorporate personal health history and environmental influences. However, to better refine the science behind predictive analytics, the following improvements must be made:
a. Establish a baseline of community environmental influences.
b. Incorporate social determinants into predictive models.
c. Identify accurate drivers of local, public health.
d. Inform physicians and nurses of the “right” questions to ask patients in order to provide person-specific treatments and preventions.

6. Collaborations
   a. Develop tools and communication materials that can be disseminated to various stakeholders (e.g., through the American Heart Association, American Lung Association, American College of Cardiology, American Thoracic Society, American Public Health Association, the Association of State and Territorial Health Officials, etc).
   b. Connect with state health directors on local needs and activities.
   c. Use the existing workshop participant network to continuously identify data gaps that inhibit progress in different public health sectors.
   d. Leverage social media and partner with media outlets to develop education material, such as an air pollution focused documentary or a simulation video game.
   e. Cardiovascular rehabilitation centers have the ability to inform sensitive populations of environmental factors that may impact personal health. Providing them with communication tools and recommended interventions would increase patient understanding of their environmental risks.
   f. Engage architecture and planning associations to disseminate information on the health risks of living/working in areas with high particulate matter concentrations and to push for air pollution to be included in smart and connected city designs.
   g. Activate behavioral sciences (APHA).
   h. Tap early career professionals to engage them in air pollution related cardiovascular health issues now and to promote thought on technological opportunities.

7. Empower communities with citizen science
   a. While the National Ambient Air Quality Standards are nation-wide standards, air pollution exposures vary by community and cumulative stressors (chemical, psychosocial, etc.) are not captured. Therefore, providing information on community-specific interventions would be beneficial and would effectively complement nation-wide interventions.
   b. Encourage insurance agencies to use personal health monitoring sensors to inform their policies and practices. This would enable an insurance company to cater to community-specific concerns and needs.
   c. Develop accurate, low-cost air sensors for communities to monitor their local air quality and provide information on how to use this information.
CONCLUSION

The long list of potential actionable items reflects the degree of enthusiasm and productivity that was evident at this workshop. The dynamics of interacting with colleagues from such different disciplines than participants routinely encounter proved to be very stimulating and resulted in a very creative and successful meeting. The follow-up plans for this workshop entail keeping participants up-to-date on opportunities for increasing awareness on the role of air pollution in cardiopulmonary disease, progress on actionable items, and sharing information on new publications, meetings, and funding opportunities that may be of interest to all. We hope to keep track of collaborations that form as a result of the meeting and progress toward improving outcomes for air pollution-related cardiovascular illnesses.
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