HEI Accountability Research

Public Health Benefits of Improved Air Quality

Air quality improvements and resulting public health benefits are typically achieved, in large part, through air quality regulations and the effective control of emissions from both mobile and stationary air pollution sources. As technologies and policies develop to address remaining concerns related to air pollution from new and legacy emissions sources, as well as other sources of environmental pollutants, it will be essential to produce science that helps understand the potential consequences for health and the environment. It will also be essential to produce science that documents which efforts to improve the environment have yielded demonstrable improvements in public health. One approach that decisionmakers rely on is accountability research, also known as outcomes research or research on regulatory effectiveness.

What is Accountability Research?

Accountability research examines whether actions to improve the environment, such as regulations, policies, interventions, and other planned or unplanned events (such as the closing of an industrial facility or power plant) were affective in improving public health. Air quality actions, for example, are often accompanied by predictions of public health benefits to justify the cost of such actions. Accountability research is unique because it examines the extent to which the implementation of the actions proceeded as planned, and whether the intended changes in releases, ambient concentrations, exposures, and public health have been achieved. This body of research has been instrumental in understanding the intended and unintended consequences of past actions, crafting effective policies, and informing technological advances to improve environmental quality.

Accountability studies are appealing because they are the closest equivalent to controlled experimental studies that can be achieved using real-world observations. Therefore, they can show whether the results of policies were as expected, and they can provide supporting evidence for causal relationships between exposures and health outcomes.

The Health Effects Institute (HEI) has been at the forefront of conceptualizing, supporting, and advancing accountability research in the air quality field. This document provides an overview of HEI's role in air quality-focused accountability research, including HEI's Accountability Framework and scientific contributions through past and ongoing studies. HEI has become a leader in accountability research by funding several rounds of accountability studies, 23 to date, that have and will continue to generate lessons learned that inform design and implementation of efforts to improve air quality and the environment.

HEI's Accountability Framework

HEI's air quality Accountability Monograph set out a groundbreaking conceptual framework (Figure 1) for accountability research by identifying the types of evidence required and the methods of obtaining and analyzing such evidence.

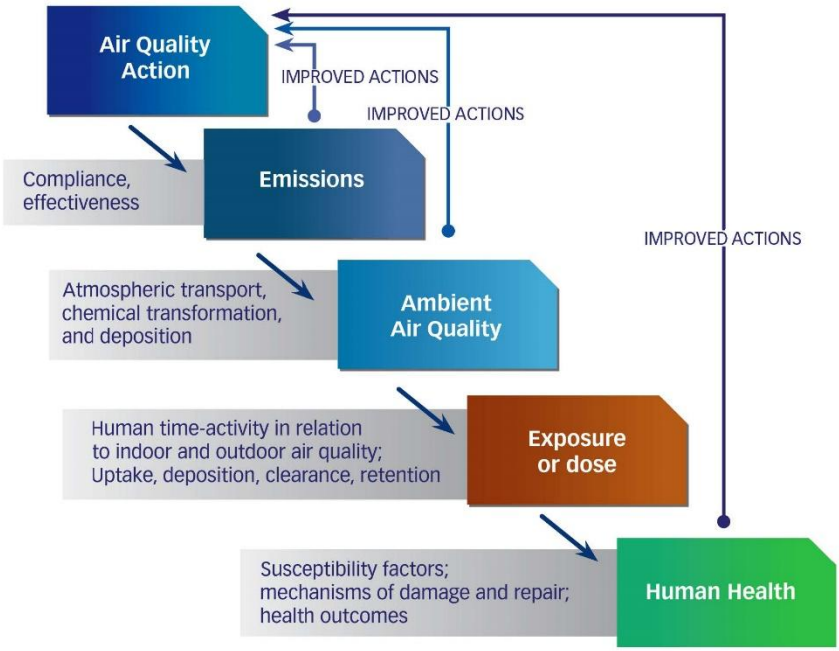

Figure 1. The chain of accountability. Each box represents subsequent stages between an air quality action and human health responses to air pollution exposure. At several stages, knowledge gained from accountability assessments can provide valuable feedback to inform future air quality actions. Source: HEI 2003.

The monograph also identified common methodological challenges inherent in accountability studies that a well-conducted accountability study would be poised to address, including:

- Lack of statistical power due to small improvements in air quality or a small population that is affected by the action taken;
- Transferability of findings to other locations and populations;
- Identification of a control population that is not included in the action but is otherwise very similar to the affected population;
- Ability to adjust for background trends in the environment, health, and socioeconomic indicators, and
- Direct attribution of changes in air pollution and health to a single intervention among many regulatory actions.

HEI designed each accountability research solicitation to build on findings and lessons learned from the previous round of funded research (Figure 2). Based on the conceptual framework, the first group of HEI accountability research, solicited in 2004, included nine studies that covered a range of mostly short-term interventions. In 2009, HEI hosted a workshop with a multidisciplinary group of leaders to review accountability studies conducted to date, and recommended strategies, methods, and targets of opportunity for further research (Communication 15). To address the workshop recommendations and contribute to ongoing U.S. policy needs, HEI funded a second group of studies on longer-term, multi-year air quality regulations. In 2017, HEI published an article on findings from the compilation of HEI

accountability studies and described directions for future research (Boogaard et al 2017). This article fueled HEI's third group of research in 2018, which focused on local air quality actions and ports. In 2023, a fourth group of accountability studies commenced that focus on the exposure and health benefits for specific populations in both rural and urban areas.

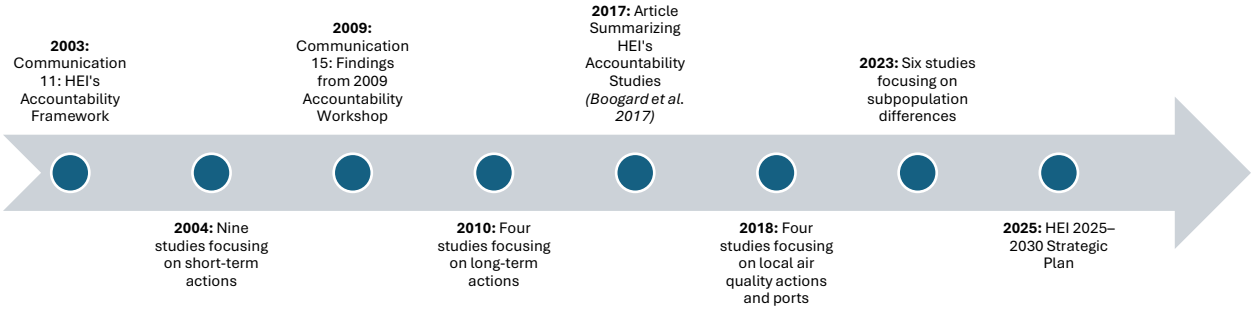

Figure 2. Timeline of HEI's accountability work.

The research has covered a wide array of national, regional, and local air quality actions, with varying scopes and methods. HEI-funded studies have focused on air quality actions in the United States, Canada, Ireland, China, Germany, and the United Kingdom, providing both a national and global perspective (Figure 3).

In recent decades, HEI staff and committees have produced prominent peer reviewed articles summarizing HEI's experiences and the challenges researchers encountered in the accountability studies HEI has funded to date, as well as lessons learned from those and other studies (Boogaard et al. 2017; van Erp et al. 2008, van Erp et al. 2012; Burns et al. 2019, Burns et al. 2020). Other investigators have built on the accountability monograph by describing additional complexities, factors, and datasets in and approaches to conducting air pollution accountability studies not previously considered (Henneman et al. 2017; Ebelt et al. 2023; Rich 2017).

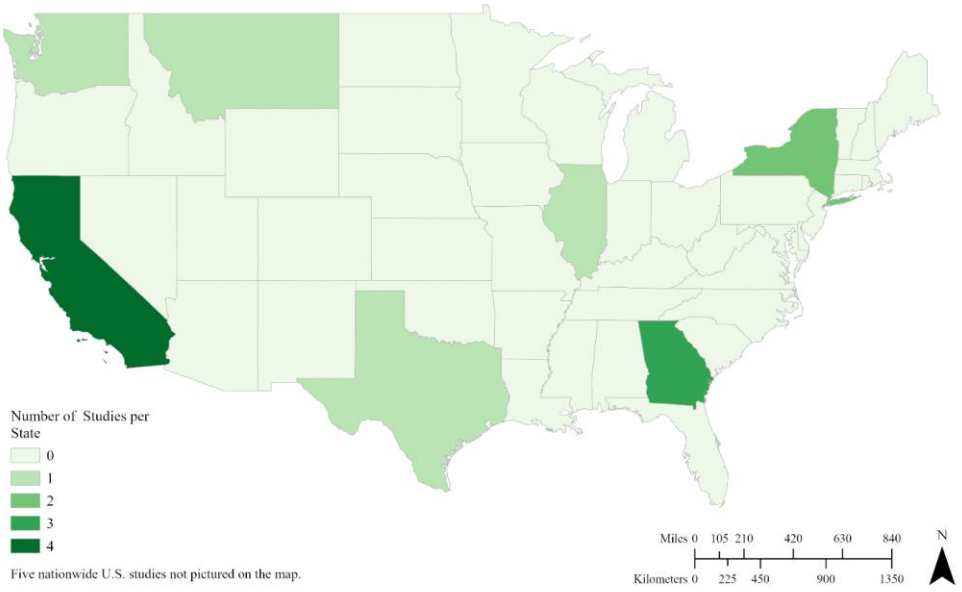

Figure 3. HEI-funded accountability study locations across the United States. Studies have also taken place in Canada, Ireland, China, Germany, and the United Kingdom.

HEI's Role in Advancing Accountability Science

Collectively, the research has provided an understanding as to how large anticipated public health benefits may be (compare to what was projected) and whether they outweigh potentially costly and complex regulations. In turn, the research has been instrumental in informing the design and implementation of future efforts to improve air quality. The studies also developed and implemented methods that helped inform the conduct of future accountability studies. Below we provide some examples of HEI's accountability studies and their impacts.

Examples of HEI's Accountability Studies

An interactive StoryMap of the following studies can be found here.

Replacing diesel-powered school buses.

- Location: United States, Nationwide
- Summary: This study investigated the U.S Environmental Protection Agency's (EPA) School Bus Rebate Program—a large program for replacing old diesel school buses with new, lower-emitting buses across the United States. The study took advantage of the randomized allocation of funds, making it a powerful study design to examine causal relationships.
- Results: The study showed that replacing older diesel-powered school buses resulted in improvements in school attendance and educational achievement of children, with the largest benefits for the replacement of the oldest (i.e., pre-1990) diesel school buses.
- Impacts: This study was used by the US EPA in their third and fourth Clean School Bus reports to Congress, and highlighted in the fourth Report to emphasize the need to replace older diesel buses as early as possible.

Congestion Charging and Low Emission Zones.

- Location: London, England
- Summary: HEI funded two studies examining air quality actions in London
    - Congestion Charging: In 2003, London implemented a Congestion Charging Scheme in the inner city. It was a world leading traffic intervention aimed at controlling excessive vehicle flows in Central London. The HEI funded accountability study assessed its effects on air quality and health.
    - Low Emission Zones: Based on the results of the congestion charging study, investigators conducted a baseline study to investigate the impacts of the London Low Emission Zone, which was at that time (2008) the world's largest vehicle emissions control zone restricting entry of the oldest and most polluting vehicles.
- Results:
    - Congestion Charging: The study demonstrated reductions in traffic volume and congestion. However, it found little evidence for improvements in air quality, partly due to the limited size of the zone and a concurrent increase in diesel-fueled taxis and buses due to the policy
    - Low Emission Zones: The study describes the monitoring, data, and analysis infrastructure that is needed to lay the groundwork for studying air quality and health outcomes in advance of the Low Emission Zone and future phases of the scheme.
- Impacts: Based on the Low Emission Zones study, Transport for London enhanced existing monitoring sites by adding additional equipment and established a completely new site placed at a roadside location where the impacts of the Zone are likely to be most visible. Since both studies, numerous health and demographic datasets have been linked to the resulting measurements, including hospital admissions, mortality rates, social deprivation indices, school attendance, and medical prescription rates, leading to evidence linking many disease end points with air quality and traffic data. The network has also formed the foundation of evaluation of future traffic emission reduction policies in London, including the 2019 Ultra Low Emission Zone.

Goods movement.

- Location: California, United States
- Summary: Starting in 2006, California's Air Resources Board (CARB) implemented the Emissions Reduction Plan for Ports and Goods Movement, a series of actions taken to reduce pollution from California goods movement activities — targeting emissions from various marine, on-road, and off-road vehicles used to transport traded goods into, out of, and across the state.
- Results: HEI funded an accountability study that demonstrated reduced exposure to air pollution and emergency room visits for individuals enrolled in Medi-Cal, California's Medicaid program, in the years following the implementation of the plan. The results showed that people who had asthma and chronic obstructive pulmonary disease had the largest improvements in health due to the policy. It was one of the first studies that showed that the Goods Movement Plan not only improved air quality but also improved health, especially for at-risk individuals.

- Impacts: The study provided health evidence to support the case for further regulatory actions at CARB in a state with some of the largest goods-movement corridors in the world, including the 2024 Proposition 1B Goods Movement Emission Reduction Program.

Major sporting event (2008 Olympic Games).

- Location: Beijing, China
- Summary: This HEI study evaluated the "largest natural experiment in air cleaning" in Olympic history, where the Chinese government issued a series of aggressive short-term policies to reduce emissions in Beijing and surroundings leading up to and during the 2008 Beijing Olympic Games. At the time, Beijing suffered from very high air pollution concentrations and many international athletic organizations had expressed concern about unhealthy air quality that would impair athletes participating in Olympic competition. The policies included shutting some polluting factories near Beijing and taking half of the city's cars off the roads for several weeks before, during, and after the games.
- Results: The study documented that air quality and heart health improved immediately in a carefully monitored group of young Beijing adults during the 2008 Olympic Games who traveled to the games and then returned home.
- Impacts: The study was the beginning of a series of studies documenting the health impacts of high air pollution levels, which added to a broader, growing public health concern so that several years later a "war against pollution" was declared by the World Health Organization. In a separate HEI-funded study, investigators conducted a similar analysis for the 1996 Olympic Games in Atlanta, Georgia.

The full reports of all accountability studies and the Commentaries of the HEI Review Committee can be found at the HEI website.

Strengthening Accountability Research to Support Health-Driven Environmental Decisions

Assessing health effects of environmental actions is of ever increasing interest, and HEI will continue its longstanding commitment to accountability research, as described in HEI 2025-2030 Strategic Plan. The cost of pollution control technologies and mechanisms needed to implement policies and enforce regulations can be substantial. It can be particularly compelling for decision-makers to convert estimates of health effects into monetary measures because it allows for the comparison of an action's impacts across several dimensions (e.g., financial costs versus health benefits).

HEI's Strategic Plan identifies ample accountability research needs as technologies and fuels continue to change, the vehicle fleet turns over, mobility transforms, and technologies in various sectors advance. Moreover, there is growing recognition that climate mitigation and adaptation efforts can result in near-term health co-benefits. Those health benefits might accrue quickly and locally, and to document those might help decision makers prioritize investments based not only on mitigation potential but also on expected health benefits. Further, recent advances in artificial intelligence and causal methods, as well as the availability of high-resolution environmental quality and health data provide unprecedented

opportunities for new accountability research to play a pivotal role in shaping future environmental actions that improve health.

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