STATEMENT

Synopsis of Research Report 195

HEALTH EFFECTS INSTITUTE

Impacts of Regulations on Atlanta Air Quality and Emergency Department Visits

INTRODUCTION

Accountability research evaluates whether regulatory and other actions aimed at improving air quality have resulted in the intended decreases in air pollutant concentrations and improvements in public health. Such studies are complicated by the fact that simply comparing the changes in air pollution before and after an action may not capture what might have happened to air pollution in the absence of a regulation altogether.

A relatively recent approach to accountability research is to compare changes in air quality and health after the regulation went into effect with projected scenarios that estimate what the air quality and health outcomes would have been without the intervention. Dr. Ted Russell from the Georgia Institute of Technology and colleagues at the Georgia Institute of Technology and at Emory University proposed to examine whether national and state regulations targeting power plants and mobile sources were effective in reducing pollutant emissions, improving air quality, and ultimately reducing emergency department visits in the Atlanta area, using both measurements and modeling approaches.

APPROACH

Russell and colleagues identified major regulatory actions implemented between 1995 and 2010 and then assessed the effects of those regulations along the HEI chain of accountability by evaluating changes in emissions, effects of changes in emissions on air quality, and finally changes in air quality on emergency department visits for the period 1999–2013. The investigators estimated projected scenarios to compare what actually happened with what likely would have happened without the regulations. They focused on six sets

What This Study Adds

- This accountability study examined the extent to which national and state regulations targeting power plants and mobile sources were effective in reducing pollutant emissions, improving air quality, and ultimately reducing cardiorespiratory emergency department visits in the Atlanta area.
- Actual conditions in the period 1999–2013 were compared with estimated quantitative projections of emissions, air quality, and emergency department visits that likely would have occurred in the absence of regulations (called a "counterfactual scenario").
- The study demonstrated that both the emissions and levels of all evaluated pollutants decreased by 14% to 91% over the study period. There were fewer emergency department visits for asthma and other cardiorespiratory outcomes than would have been expected without the regulations.
- Regulations targeting power plants appeared more effective in improving air quality than those targeting mobile sources. The HEI Review Committee had more confidence, however, in the results that were attributed to all regulations combined than to individual regulatory programs.
- This is one of few accountability studies to follow changes of individual regulations on emissions all the way through health outcomes, using scenarios with and without regulation. The approach is valuable and worth considering for future accountability studies.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr. Armistead (Ted) G. Russell at the Georgia Institute of Technology, Atlanta, Georgia, and colleagues. The complete report, *Impacts of Regulations on Air Quality and Emergency Department Visits in the Atlanta Metropolitan Area*, 1999–2013 (© 2018 Health Effects Institute), can be obtained from HEI or our website (see last page).

of national- and state-level regulatory programs that they thought were likely to affect air pollutant emissions and air quality in Atlanta, Georgia: three national program sets to reduce emissions from power plants (electricity-generating units [EGUs]), and three program sets targeting motor vehicle fuel and emissions standards (mobile sources) adopted in response to national requirements.

To evaluate the effect of the regulations on emissions, the investigators used two approaches. First, they compared emissions before the regulations (from 1995 for power plants and 1993 for mobile sources) to emissions at the end of the study period (2013) for the southeastern United States. Second, because emissions could have changed for reasons unrelated to the regulations, they used daily records of how much electricity was generated by power plants and how far cars were driven in order to estimate how much higher the emissions at the end of the study period would have been if the regulations had not been implemented (called a "counterfactual scenario").

Similarly, to evaluate the effects of regulations on air quality, they compared measured levels of a large number of pollutants at a monitoring site near downtown Atlanta at the beginning of the study period (1999) with their levels at the end of the study period (2013). Because meteorology could affect the results, they adjusted the air quality measurements for the potential influence of daily meteorology. They again used a counterfactual scenario approach to project what the air pollutant levels would have been without the regulations and compared those projected levels with measured levels in order to estimate the effects of the emissions changes on air quality.

Finally, Russell and colleagues used time-series models to relate the daily numbers of Atlanta area emergency department visits to daily air pollutant levels for outcomes related to diseases of the heart (all cardiovascular disease and the subset from congestive heart failure) and lung (all respiratory disease and the subset from asthma). Following the counterfactual scenario approach, they compared actual numbers of emergency department visits with the numbers that likely would have occurred without the regulations. They presented results for the impact of each set of regulations, the three sets of regulations affecting power plants, the three sets of regulations affecting motor vehicles, and all six sets combined.

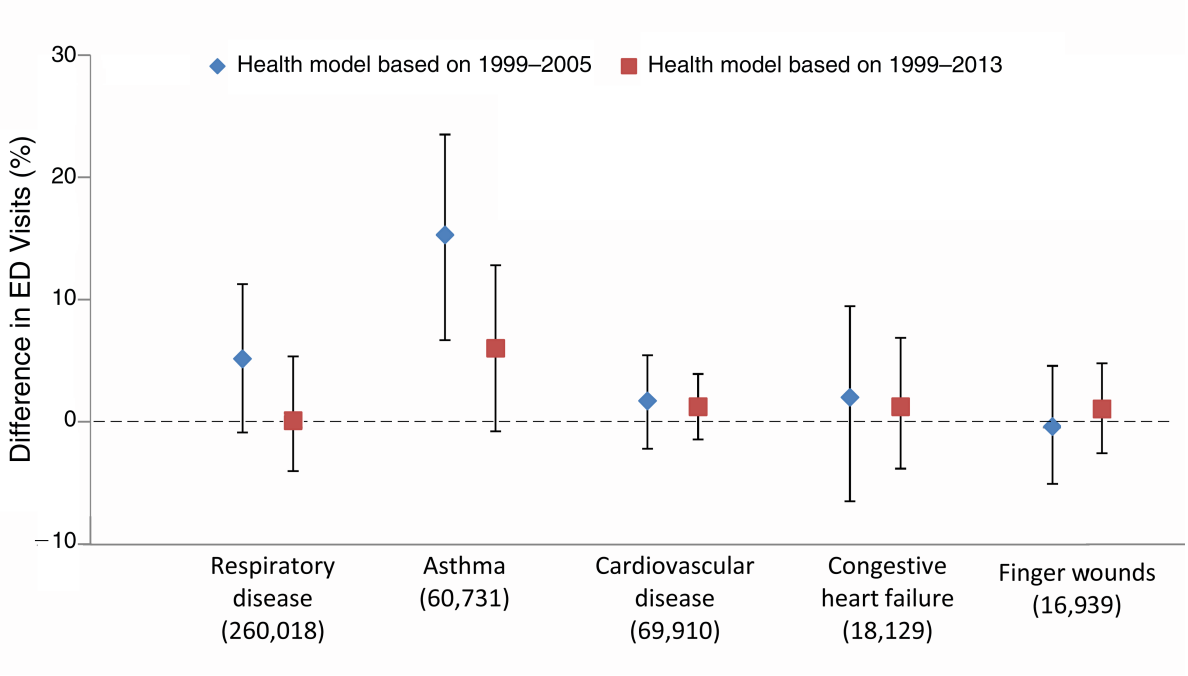
Unlike many other such studies, the uncertainty reported for the numbers of emergency department visits also included uncertainty carried forward from the emissions and air quality models, respectively. They also tested the effects of a number of assumptions on the results, including the number of pollutants (1, 5, 7, or 9) included in the health models; which years were considered when constructing the health models (1999–2005 vs. 1999–2013); and the size of the study area (5 or 20 counties in the Atlanta area).

MAIN RESULTS AND INTERPRETATION

The investigators reported that air pollutant emissions and ambient concentrations decreased over the study period 1999–2013 for most pollutants evaluated, and estimated that the pollutant levels were lower than what would have been expected without regulatory actions. Their modeling suggested that the observed improvements in air quality were associated with fewer emergency department visits for asthma and other lung outcomes compared with what would have been expected without the regulations (see Statement Figure). The health results were robust to the geographical scale of assessment (5 or 20 counties) and number of pollutants (1, 5, 7, or 9) in the health models. These results were less robust to the period evaluated. Estimates of effects of air pollutant changes on emergency department visits were larger for results with models of relationships between emergency department visits and air quality based on data from 1999 through 2005 than for models of relationships between emergency department visits and air quality based on data from 1999 through 2013. Although both analyses reported improvements in health with declining air pollution, the HEI Review Committee thought the differences in estimates for ED visits using data from two different periods suggested there was uncertainty that was not fully accounted for, and that perhaps the results for the two periods should be weighted more equally since it is not clear which health model was more appropriate.

The investigators also reported that regulations targeting power plants had a greater impact than those targeting mobile sources in improving air quality and health.

In its independent review of the report, the HEI Review Committee noted that the study was an ambitious application of HEI's accountability framework as it encompassed a broad suite of regulatory programs designed to reduce multipollutant emissions from power plants and mobile sources in Georgia and nearby states over the period from 1999 to



Statement Figure. Estimated emergency department visits in Atlanta in 2012–2013 for all regulations combined compared with a scenario without the regulations for two different models. Positive numbers indicate there were fewer emergency department visits with regulatory programs in place. Whiskers represent the 95% confidence intervals. Actual numbers of emergency department visits are listed in parentheses.

2013. The Committee thought that the investigators had tackled an important public health question, examining whether the regulations had individually or collectively reduced emissions, improved air quality, and ultimately reduced ED visits for respiratory and cardiovascular outcomes in the Atlanta area.

The Review Committee concluded that the investigators had thoughtfully applied a counterfactual scenario approach to compare actual observations after the regulations were implemented to without-regulation scenarios. The study built on large and well-characterized data sets of air pollutant concentrations and emergency department visits from the Atlanta area. It addressed some concerns of earlier studies, such as the influence of meteorology on air quality. One of the difficulties encountered was that regulations were implemented in different years; the investigators handled this by comparing actual conditions to counterfactual conditions for each day of the study period. Together with the extensive sensitivity and uncertainty analyses in the development and application of the health models, these were all clear strengths of the study.

The Review Committee had the most confidence in the results for the link between changes in emissions and air quality because the investigators were able to rule out meteorology as an alternative explanation for the changes in air quality. The Committee thought that the link between regulations and emissions also appeared strong, although exploration of the potential effect on emissions of factors other than regulations, such as market-induced efficiency improvements, would have enhanced the analysis.

The Review Committee noted some limitations in the linkages between air quality and health effects (and therefore also in the estimates of changes in the numbers of emergency department visits). One of the strengths of the study is that it was conducted over a long period of time (i.e., 15 years); however, this leads to the possibility that potentially important factors that also changed over time were not fully captured, such as changes in healthcare access and practice.

This could explain why the health models based on data from different periods yielded different results.

Overall, the Committee had more confidence in the results attributed to all regulations combined than to individual regulatory programs. The investigators' finding that regulations targeting power plants had more impact on improving air quality and reducing emergency department visits than regulations targeting mobile sources needs further study. Direct comparisons may not be appropriate because a single monitor would be more suitable to capture the regional impact of power plant regulations than the more spatially heterogeneous impact of mobile source regulations. In addition, measurements of mobile emissions were not available and some of the mobile source regulations did not go into effect until the later part of the study period (e.g., heavy-duty diesel rules targeting particulate matter and oxides of nitrogen emissions from new vehicles beginning in 2007 and 2010). The separation of attribution to different programs is inherently more difficult than linking overall emissions reductions to health outcomes, because it requires the separation of changes that overlapped in time. It is also possible that slow turnover of the vehicle fleet and lack of compliance may have hampered reaching full implementation of the fuel and technology changes by the end of the study period (2013), and further improvements may have continued since then. Thus, the ultimate effectiveness of mobile source regulations may actually be better — even if more gradual — than what the investigators were able to estimate in their study.

The Committee thought that this report by Russell and colleagues was a valuable addition to the accountability literature. It is one of few studies to follow changes of regulations on emissions all the way through to health outcomes, using scenarios based on actual observed data. This is a valuable approach worth considering for future accountability studies, though this sort of work is labor and computationally intensive. In addition, this work provides a detailed protocol for how to conduct similar investigations in other areas of the world.

In the future, other researchers could apply similar approaches to the long-term impacts of regulations on health outcomes in other locations, although it would be recommended to more thoroughly account for changes in medical practice and healthcare access, where possible. In particular, although efforts to disentangle the effects of specific regulations among a suite of regulations remain challenging, such efforts are important and should continue. This study is a strong and important contribution to HEI's accountability research portfolio because it sequentially and carefully addressed multiple links in the accountability chain. The results suggesting that reductions in emissions and improved air quality were linked to health benefits are important in terms of continued evaluation of the public health benefits of air pollution regulation in the context of implementation and compliance issues that may hamper achievement of the intended benefits.

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