HEI STATEMENT

Synopsis of Research Report 235

Air Quality and Health Benefits from a Household Clean Heating Policy

BACKGROUND

Accountability research evaluates the extent to which actions or interventions aimed at improving air quality produce the intended reductions in pollutant concentrations and improvements to public health. A major challenge in this research field is isolating changes that can be attributed to the actions in question from improvements that might be due to other unrelated actions or long-term trends. In its 2018 research solicitation, *RFA 18-1* Assessing Improved Air Quality and Health from National, Regional, and Local Air Quality Actions, HEI aimed to fund real-world studies on the effects of air quality actions, including those that were implemented over multiple years or that focused on areas with well-documented air quality problems.

This Statement highlights a study by Jill Baumgartner and Sam Harper (McGill University) and colleagues that was funded under RFA 18-1. The investigators proposed to assess the effects of a household clean heating policy that mandated and subsidized villages in the Beijing region of China to switch from highly polluting residential heaters fueled by coal to efficient electric- or gas-powered heat pumps. They evaluated changes in winter-time air quality and the health of people in 50 villages before any of the villages had the policy and in the first 3 years of staggered policy roll-out in 20 of the villages. They also assessed whether any observed effects of the policy on health could be explained by changes in air quality or indoor temperature in winter.

What This Study Adds

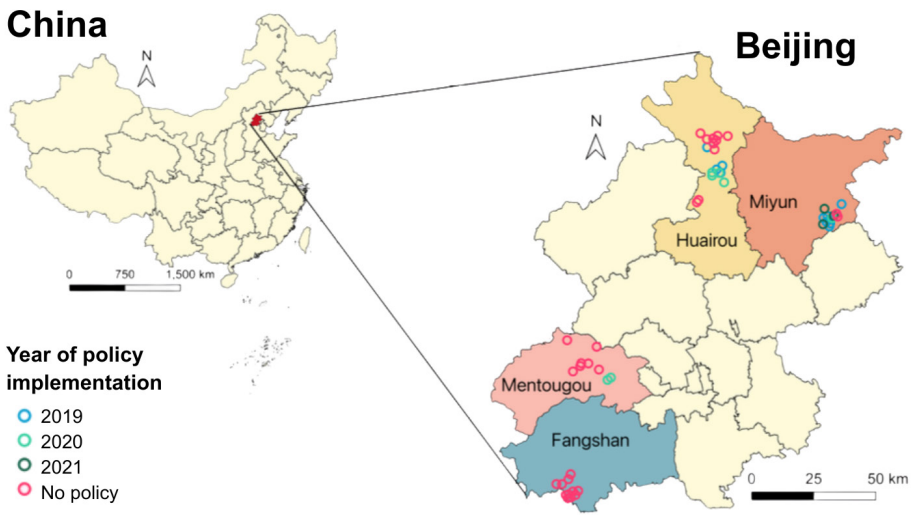
- This accountability study evaluated the effects on air quality and health of a clean heating policy that stipulated and subsidized the conversion of household heating from coal to electric heaters in Beijing-region villages.
- The investigators visited 50 villages in winter and compared changes in air quality, indoor temperatures, and heart and lung health in 20 villages where the policy was implemented with 30 villages where it was not.
- Implementation of the clean heating policy was associated with reduced indoor fine particle concentrations, blood pressure, and respiratory symptoms. The results suggest that the policy's impacts on blood pressure were largely attributable to improvements in air quality and indoor temperature.
- The overall approach was a major strength of this study because it accounted for differences between villages and changes in fuel use, air pollution, and health during the study.
- These results are encouraging for other countries seeking to implement policies to replace highly polluting residential heating sources.

APPROACH

Baumgartner, Harper, and colleagues evaluated changes in 50 Beijing-region villages that were eligible for but not currently participating in the clean heating program in the first year of the study (**Statement Figure**). About half of the villages were expected to enter the program between 2018 and 2022. The clean heating policy was implemented in a subset of those villages each year, in an order determined by various factors related to policy priorities and local capacity. In each village, the investigators recruited about 20 participants living in different households.

The investigators collected data on many parameters in four consecutive winters, starting in late 2018 and finishing in early 2022. They measured fine particles outdoors, indoors in the homes of participants, and with samplers carried by about half of the study participants. They also measured temperature in the participants' homes. For health outcomes, they measured participants' blood pressure and markers of their overall health in blood samples. Additionally, they asked the participants whether they experienced any respiratory symptoms such as shortness of breath or phlegm.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by co-principal investigators Dr. Jill Baumgartner and Dr. Sam Harper at McGill University, Montréal, Canada, and colleagues. Research Report 235 contains the detailed Investigators' Report and a Commentary on the study prepared by the HEI Review Committee.



Statement Figure. Map of village implementation of the clean heating policy. (Source: Adapted from Investigators' Report Figure 1.)

They used sophisticated statistical models to track changes in air pollution and health over time. The models allowed them to compare changes between villages that had implemented the policy each year and those that might implement it in the future. Where they found that the policy led to changes in both air quality and health, they tested whether the changes in health were caused by the changes in air quality or by some other factor related to the policy.

KEY RESULTS

During the study, the investigators evaluated changes in 1,438 participants from 1,236 households in 50 suburban and rural villages of Beijing over four consecutive winters between 2018 and 2022. By the end of the study, the policy had been implemented in 20 of the villages, and there was nearly complete compliance in those villages. Heat pump usage increased from about 2% to about 95% of households in villages where the policy was implemented, and to only about 16% of households where the policy was not implemented. There were corresponding decreases in the amount of coal used by households.

There were some air quality and health improvements in the villages where the policy was implemented. Implementation of the policy reduced indoor fine particle concentrations by about 20 μg/m^3. There were no reductions in outdoor fine particle concentrations and in fine particles measured by samplers carried by participants. At the same time, seasonal average indoor temperatures during winter increased by about 2°C after implementation of the policy. Blood pressure decreased by about 1.5 mm Hg, and respiratory symptoms decreased by about 7.5% when the policy was implemented. Using a statistical approach known as causal mediation analysis, the investigators demonstrated that almost all the effect of the policy on blood pressure could be explained by the improvements in air quality and indoor temperature. In contrast, the improvements in respiratory symptoms could not be explained by these factors and would benefit from further exploration. The policy did not appear to affect the health biomarkers measured in blood.

Because the study included the years of the COVID-19 pandemic, the investigators were forced to make some changes in the measurements and when they were performed. Among the main changes were a partial campaign in winter 2020–2021 and the addition of a fourth full winter data collection campaign (including surveys, air pollution, and health measurements) in winter 2021–2022.

INTERPRETATION AND CONCLUSIONS

In its independent evaluation of the study, the HEI Review Committee thought that Baumgartner, Harper, and colleagues had completed a thorough and important accountability study to evaluate the benefits of a clean energy policy on air quality and health. The Committee identified the overall approach as a major strength of the study because it accounted by design for

differences between villages that did not change over time, which helped isolate the effects of changes in fuel use on air pollution levels and health outcomes.

Other explanations for the causes of different exposures and outcomes over time were also considered by the investigators. For example, the fuel use policy was implemented over a period spanning years before, during, and after the COVID-19 pandemic. If the severity of COVID-19 or the community preventative measures against the pandemic, by chance or due to features of the town, were different in the communities with and without the intervention, then bias could occur. Fortunately, this concern was alleviated by the findings that no documented COVID-19 cases were observed in these suburban and rural villages during the study, and that regional restrictions (e.g., travel restrictions, lockdowns, and quarantines) equally affected all the studied communities. They also reported no important differences in pre-intervention trends for personal exposures and health between those groups that did and did not have the clean heating policy, suggesting that their findings were unlikely to be sizably affected by factors that changed over time and could potentially distort the relationship between the policy and its effects. The Committee thought that these and other aspects of the investigators' careful application of complex statistical models to real-world changes contributed to robust main results.

The use of causal mediation analysis was also felt to be a constructive addition. However, the Committee thought that the analyses to understand whether the policy affected health through its effects on air quality and indoor temperature should be treated as exploratory because assumptions had to be made when air pollution and health were not measured at the same time.

Overall, the study demonstrated that the clean heating policy achieved its intended goals to electrify household heating in the villages where it was implemented and that it dramatically reduced residential coal burning and improved indoor environmental quality in the first years after implementation. The policy also provided some benefits to heart and lung health, some of which (blood pressure) appeared to be connected to improvements in air quality.

Although there is an abundance of evidence that air pollution is related to negative health outcomes, it is important to quantify (rather than assume) the effects of specific actions on air quality and health. Here, we have evidence that replacing coal-fueled heaters with heat pumps reduces indoor air pollution and improves health. The results of this study are encouraging for other countries seeking to implement policies to replace highly polluting residential heating sources.