



RESEARCH SUMMARY

Straw Burning, PM_{2.5} and Death: Evidence from China

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KEY TAKEAWAYS

1. Straw burning on agricultural land can be a major source of seasonal air pollution in some parts of the world, particularly developing countries dependent on agriculture.
2. The study investigates the impacts of agricultural straw burning on particulate air pollution and mortality in China, and finds that 10 additional straw fires within 50 km of a county center will lead to a 7.6 percent increase in monthly particulate pollution (PM_{2.5}) levels and a 1.6 percent increase in mortality in Chinese counties. Two-thirds of the deaths are caused by cardiorespiratory diseases.
3. Those who are more vulnerable and are more intensively exposed to the straw burning smoke are more likely to die due to straw burning. Straw burning impacts rural and poor populations the most, suggesting better socio-economic conditions can mitigate the impact of air pollution on mortality. Further, nearly 80 percent of the deaths were among people over 60 years old, and males account for around 58 percent of deaths.
4. In evaluating China's straw recycling subsidy policy, the study shows that providing subsidies to farmers incentivized them to recycle, which reduced air pollution by 7.3 percent and averted about 18,900 premature deaths.
5. The benefits of subsidizing straw recycling—figured to be about 55 billion Chinese yuan (around 7.85 billion USD)—are substantially larger than the costs—at most 2.6 billion Chinese yuan each year (around 367.6 million USD). Other countries facing similar particulate pollution problems from straw burning may also benefit from a similar subsidy policy.

Introduction

Straw burning is a particularly prevalent practice in developing countries that rely heavily on agricultural production. Farmers burn agricultural straw residues from crops such as wheat, rice, maize, and cotton for several reasons. First, they need to clear their fields for the next round of cultivation, but straw does not decompose quickly. Second, fires kill pests, weeds, fungi and bacteria that can be harmful to new crops. Third, the ashes can fertilize the farmland. Finally, alternative measures (such as straw returning and straw recycling) require additional labor work that is not economically rewarding.

In China alone, open straw burning accounts for about 8 percent of particulate pollution emissions—as much as 56 percent in eastern China during the summer months. While a major source of seasonal air pollution in some regions, regulations on straw burning are rare and the lack of scientific evidence on how straw burning affects people's health can make the government reluctant to design and enforce strict regulations.

In the past two decades, the Chinese government tried a variety of policy instruments to control straw burning activities. The government historically relied on command-and-control regulations, and straw burning was officially banned in the 1990s. Some local governments required village leaders to patrol and do surveillance; some educated farmers through propaganda; and some applied administrative sanctions to local village leaders (such as dismissal or suspension) if villagers were found burning straw. Unfortunately, most of these regulations were too difficult and costly to implement. The reality is that rural households continued to burn straw regardless of various bans, with the number of straw fires increasing significantly from 2012 to 2015.

Seeing that the command-and-control regulations were ineffective, starting in 2016, the central government turned to an incentive-based policy that provides subsidies to farmers and enterprises for straw recycling. The top 10 provinces with the most intensive straw burning activities—Henan, Anhui, Heilongjiang, Shandong, Jilin, Hebei, Jiangsu, Liaoning, Shanxi and Inner Mongolia—each received 100 million Chinese yuan (around 14.2 million USD) in 2016 to recycle straw. The policy continued in 2017, with the total amount of subsidy increasing to 1.3 billion Chinese yuan (around 186 million USD).

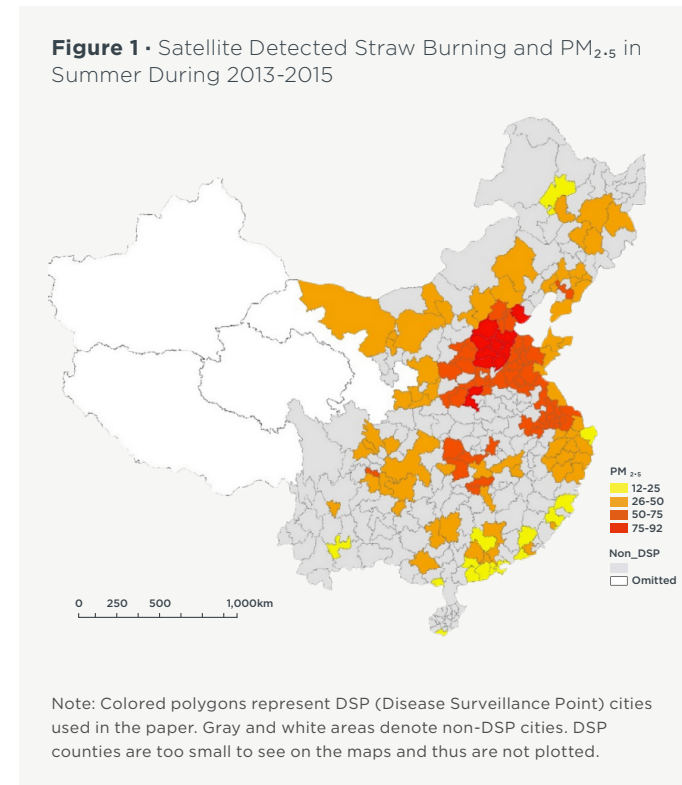
Research Design

The researchers sought to estimate how straw burning affects air pollution and mortality. To do so, they collected detailed information on straw burning, air pollution, and mortality in China from 2013 to 2015. There were 2540 straw fires detected by the satellites during the period studied, an average of two fires within 50 km of each county's center. Straw fires were equally distributed along different wind directions, suggesting that wind patterns are largely random during the burning seasons. Both urban districts and rural counties had straw burning detected.

After evaluating the impact of the straw burning on mortality, the researchers analyze the role the subsidy policy might have played. To do so, they compare the changes in the number of straw fires between those who received and those who did not receive the subsidy before and after 2015.

Findings

1. Straw burning increases particulate pollution, and the risk of death. The researchers discovered that that 10 additional straw fires within 50 km of a county center will lead to a 7.6 percent increase in monthly particulate pollution (PM_{2.5}) levels and a 1.6 percent increase in mortality in Chinese counties. Further, the researchers found that a 10 µg/m³ change in particulate pollution led to a 3.3 percent increase in mortality, and a 3.8 percent increase in cardiorespiratory mortality. Around two-thirds of the total deaths are caused by cardiorespiratory diseases.



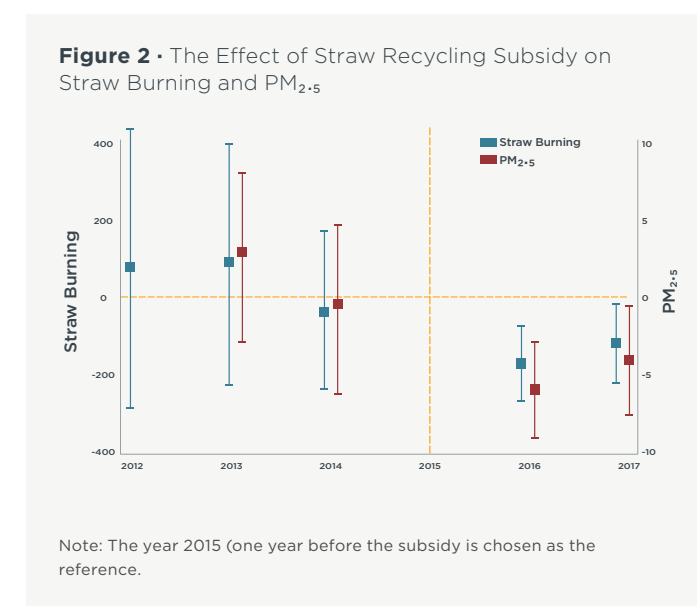
“Our research shows that agricultural straw burning leads to more pollution and an increased rate of mortality, especially among those who are rural, poor and elderly. Policies like China's straw recycling program can be effective in reversing this trend. Not only was it a policy well worth implementing, but it can serve as a model for other countries wrestling with the problem of straw burning.”

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2. Middle and older aged males in rural areas are most at risk. The analysis found that straw burning and air pollution significantly increase the mortality of rural residents and poor residents, but not that of urban or rich residents. These results together suggest that better socio-economic conditions can mitigate the health damage of air pollution. Middle and older aged men are also more at risk. The researchers found that nearly 80 percent of the deaths are among people above 60 years old, and males account for around 58 percent of deaths. Meanwhile, straw burning had no statistically significant impact on younger people.

3. Subsidizing straw recycling improves air quality, and the health benefits outweigh the policy costs. Evaluating the subsidy program, the researchers find that the number of straw fires in subsidized provinces dramatically declined after the policy by 153 a year, relative to the non-subsidized provinces, and this change brought down the annual average particulate pollution level by 4.33 µg/m³ or 7.3 percent. As a result of these improvements, about 18,900 premature deaths could have been averted each year in China.

Using back-of-the envelope calculations, the researchers compare the benefits and costs of the policy. They estimate that the health benefit from the 18,900 avoided deaths would translate to about 55 billion Chinese yuan (around 7.85 billion USD). On the cost side, they look at the cost of the subsidy, additional work to enforce the policy and encourage farmers to recycle straw, and the potential changes in agricultural production. Together, they estimate that the cost of the policy would be at most 2.6 billion Chinese yuan each year (around 367.6 million USD)—far less than the benefits. To put these numbers in another way, it costs at most 137,600 Chinese yuan (19,700 USD) to avert a premature death when the government subsidizes straw recycling.



Policy Recommendations

China's straw-recycling subsidy significantly reduced straw burning activities, which provides important insights into designing effective straw burning regulations. Historically, the Chinese government relied on command-and-control regulations to reduce straw burning. Due to the high enforcement costs, however, these policies were not very successful. In contrast, providing subsidies to farmers and recycling companies immediately led to less burning and improved air quality. These are important findings for other countries that rely heavily on agriculture and suffer from the similar challenge of pollution from straw burning.

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