

Air Pollution and Wood Consumption in Burkina Faso¹

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Abstract: Analyzing a sample of approximately 800 households, this study measures the extent of household air pollution in Burkina Faso and assesses the relationship between exposure to fine particles and the consumption of wood as a fuel used for cooking.

Keywords: Air Pollution, Cooking, Africa

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1. INTRODUCTION

In 2021, one-third of the global population, approximately 2.3 billion people, primarily used solid fuels for cooking their food (IEA et al., 2022). Recent waves of the Global Burden of Diseases (GBD) study have shown that household air pollution, mainly due to the combustion of wood, charcoal, or agricultural residues, is a major public health issue. This pollution was responsible for 2.3 million deaths in 2019, according to Bennitt et al. (2021). One limitation of the simulations from the GBD study is their reliance on a limited number of studies to estimate individual exposure levels to atmospheric pollutants in sub-Saharan African countries (Bede-Ojimadu and Orisakwe, 2020).

In this short article, we present results from one of the most extensive campaigns measuring exposure to fine particles and household fuel consumption conducted in sub-Saharan Africa to

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date. We evaluate the relationship between air pollution and wood consumption for cooking, with state-of-the-art methods in a large sample of approximately 800 households.

The article is structured as follows: Section 2 presents the data and methods, Section 3 describes the results, and the final section concludes.

2. DATA

Sample

The study was conducted in three medium-sized cities in the Centre-Sud region of Burkina Faso: Kombissiri, Manga, and Pô. Approximately 800 households were surveyed in June 2021, just before the start of the rainy season. Random sampling was done by selecting GPS points and following a random-walk procedure to identify one household per GPS point. Eligible households for the study were those without access to gas or electricity for cooking at the time of the first survey between December 2019 and March 2020⁵. Our analysis in this short article is based on a sample of 782 households for which we have data on exposure to fine particles and wood consumption, with extreme values removed (values above the 99th percentile of each distribution). 84.9% of the surveyed households reported wood as the main fuel used in the 7 days preceding the survey, followed by charcoal for 14.4% of households. Only 31.3% of households were headed by an educated person.

Air pollution and fuel consumption measurements

The two variables of interest in this short article are individual exposure to fine particles and household wood consumption.

In each household, a person responsible for cooking activities wore a gravimetric air quality measurement device for 24 consecutive hours. The survey revealed significant levels of exposure to fine particles (PM_{2.5})⁶. The average level measured in our sample of cooks is 171.7 µg/m³, more than 11 times the World Health Organization's recommendations for 24-hour exposure to PM_{2.5}⁷. It is likely that exposure levels are lower for other household members not involved in cooking tasks.

Wood consumption was weighed by the investigator. The surveyor asked households to prepare the equivalent of one day's consumption of all fuels needed for cooking. Each fuel was weighed 24 hours apart to measure the initial stock and the remaining stock, with the difference corresponding to consumption. Here, we focus on wood consumption, as it is the most particle-emitting fuel. The average consumption is around 5.2 kg per household.

⁵ A detailed description of the sampling criteria is presented in De Vreyer et al., 2022 (available upon request).

⁶ Particles less than 2.5 microns in aerodynamic diameter.

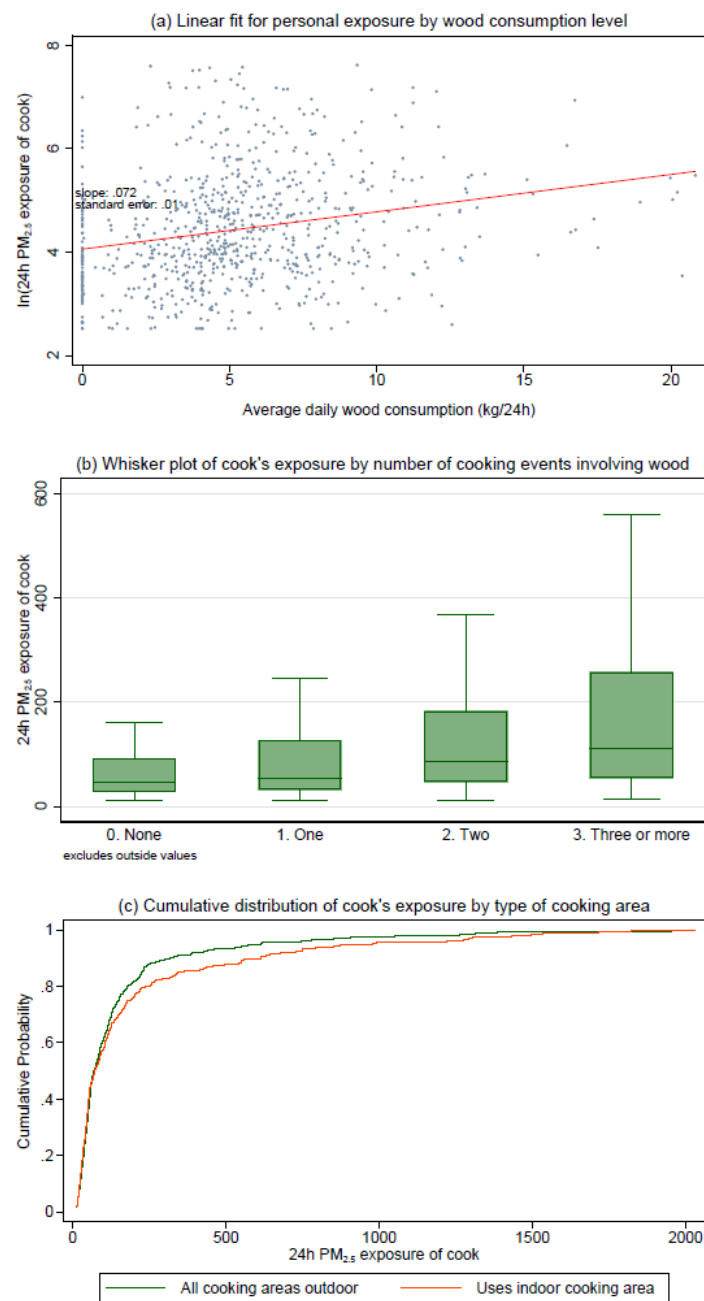
⁷ The World Health Organization's global recommendations for air quality regarding individual exposure to PM_{2.5} are 5 µg/m³ for the annual average exposure and 15 µg/m³ for the 24-hour average exposure (World Health Organization 2021).

3. RESULTS

In Graph 1, we present a descriptive analysis of the relationship between wood consumption on the one hand and individual exposure to fine particles on the other, including three key characteristics of wood use: the quantities consumed, the frequency of wood cooking events, and the characteristics of the location where cooking activities take place. Several results from these graphs are noteworthy:

- The scatter plot illustrates the relationship between household wood consumption and the personal exposure to $PM_{2.5}$ of cooks in our sample (Panel a). The dependent variable is expressed in natural logarithm, and ordinary least squares regression indicates that exposure to $PM_{2.5}$ increases by 7.2% for each 1-kilogram increase in wood consumption. The coefficient is significantly different from zero. It is important to note that the R-squared of this regression is 0.053, suggesting the presence of many other sources of exposure in addition to household wood smoke.
- The exposure of cooks is also associated with the frequency of wood cooking activities (Panel b). The interquartile range of exposure to $PM_{2.5}$ is about four times higher among participants who cooked with wood at least three times during the 24-hour sampling period compared to those who did not use wood during the same period. While this may simply reflect a linear relationship between the frequency of wood use and wood consumption, it could also mean that frequently lighting a wood stove increases the probability of encountering smoke peaks that result in extreme exposure levels. This is reflected in the amplitude of the maximum value for participants who cooked with wood several times during the sampling period.
- Finally, panel c describes the association between the type of space used for cooking activities and the exposure of cooks. 34% of the surveyed households have a closed kitchen (which they use at least occasionally). Between $100 \mu g/m^3$ and $1500 \mu g/m^3$, the cumulative distribution function of exposure to $PM_{2.5}$ for households without access to a closed cooking space dominates the distribution for households using a closed cooking space at least occasionally. This could indicate that people who always cook outdoors are less likely to encounter smoke peaks and highlights the important role of the cooking environment in the exposure level of cooks.

Graph 1. Graphical analysis of the relationship between households' wood consumption and cooks' individual exposure to fine particles



CONCLUSION

This short article quantifies the extent of the relationship between wood consumption for cooking and fine particle exposure levels in Burkina Faso. The data collected in this project and used in the analysis are original. This is the first database combining measurements of exposure to fine particles and wood consumption for such a large sample of households. The presented results confirm that the use of firewood and exposure to fine particles are correlated in the African context. They also emphasize that the association between wood consumption and PM_{2.5} exposure depends not only on the volumes consumed but is also partly determined by household preferences and constraints that influence the frequency of wood use or the type of place where it is used. These potential determinants of exposure deserve consideration in strategies to combat domestic air pollution related to solid fuels. The article presented at the ICDE 2023 conference (De Vreyer et al., 2023) explores the relationship between air pollution and the risk of COVID-19 infection.

REFERENCES

- Bede-Ojimadu, O., and Orisakwe, O.E. (2020). “Exposure to Wood Smoke and Associated Health Effects in Sub-Saharan Africa: A Systematic Review.” *Annals of Global Health* 86 (1): 32.
- Bennitt, F.B., Wozniak S.S., K. Causey, K. Burkart, M. Brauer, and GBD Risk Factor Collaborators (2021). “Estimating disease burden attributable to household air pollution: new methods within the Global Burden of Disease Study”. *Lancet Global Health* 9(S1), S18.
- De Vreyer, P., Djemaï, E., Thivillon, T., Sana, A., Badolo, H., Berthé, A., and Kania, D. (2023). “Wood Fuel Cooking, Air Pollution, and the Risk of COVID-19 Infection in Burkina Faso”, mimeo.
- De Vreyer, P. Djemaï, E., and Thivillon, T. (2022). “A randomized evaluation of the demand for LPG stoves and of the associated effects on household air pollution, greenhouse gas emissions and well-being in Burkina Faso”. Social Science Registry : AEA RCT Registry. May 10, 2022. <https://doi.org/10.1257/rct.5024-4.0>.
- IEA, IRENA, UNSD, World Bank and WHO (2022). Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC.
- World Health Organization (2021). WHO global air quality guidelines. Particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization. 300 pages.