Which cooking fuels and stoves are most beneficial to global health?


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Governmental policies should focus on promoting greater use of clean cooking fuels, rather than "improved" biomass stoves, to improve global health.

A systematic review of the evidence has demonstrated the key role of clean household energy in improving global health, reaffirming the importance of United Nations' Sustainable Development Goal (SDG) 7, to achieve worldwide access to affordable, modern and clean energy by 2030.

An analysis of 50 household air pollution exposure studies, conducted in real life cooking conditions, found that reductions in kitchen and personal exposure levels to $PM_{2.5}$ and CO were greater for clean fuel interventions (ethanol, LPG, electricity) than improved biomass stoves. While most interventions achieved CO levels at or below the WHO interim target 1 for CO, only clean fuel interventions came close to achieving the WHO interim target 1 for $PM_{2.5}$.

Health impacts of household air pollution

Approximately 2.3 billion people, mostly in low- and middle-income countries, primarily cook with 'polluting' fuels, including biomass (e.g. wood, dung, charcoal), coal and kerosene. [1,2] These fuels are burned in open fires or simple stoves, leading to high levels of household air pollution (HAP). Exposure to HAP is estimated to cause millions of deaths annually due to respiratory, cardiovascular, and other diseases, including low birth weight and tuberculosis.[3] Almost half (44%) of all pneumonia deaths among children are due to HAP.[3]

One of the most studied pollutants in HAP known to cause adverse health effects is fine particulate matter ($PM_{2.5}$), which is about 20 times smaller than the width of a human hair. $PM_{2.5}$ can penetrate deep into the lungs and cross into the bloodstream. Carbon monoxide (CO), another pollutant found in high levels in the smoke generated from burning biomass, also contributes to damaging health outcomes.

Climate impacts of household air pollution

Cooking with polluting fuels is responsible for approximately 2% of global greenhouse gas emissions from human activity.[4] This is roughly the same percent of climate forcing pollutants as are emitted by the aviation industry. In particular, black carbon, which is the second largest contributor to global warming following only carbon dioxide (CO_2), is a pollutant of concern for climate.[5] Black carbon (or soot) has a much shorter atmospheric lifetime than CO_2, meaning reductions in black carbon would provide immediate climate benefits. This can buy valuable time for achieving larger-scale decarbonization and for the longer-term effects of CO_2 reductions to occur.

What level of air quality is needed to protect health?

The World Health Organization (WHO) has developed Air Quality Guidelines,[6] which establish guideline levels of $PM_{2.5}$ and CO that must be reached to protect health, as well as interim target levels that provide some health benefits on the pathway toward achieving the lower guideline values. For $PM_{2.5,}$ the guideline level is an annual mean of 5 µg/m³, with an interim target 1 level of 35 µg/m³. For CO, the 24-hour average guideline level is 4 mg/m³ , with an interim target 1 level of 7 mg/m³.

From a health perspective, it is important to understand which stove and fuel interventions are effective at reducing pollutants found in HAP to the guideline and interim target levels in the WHO Air Quality Guidelines. The impact of a wide variety of "improved" biomass combustion stoves and cleaner cooking fuels on reducing $PM_{2.5}$ and CO in the cooking area (kitchen concentrations) and breathed by individuals in the home (exposure, usually female cooks) has thus been increasingly investigated over the last few years.

Reviewing the evidence

A systematic review and meta-analysis of 50 HAP exposure assessment studies, conducted in real life cooking conditions, was carried out to identify the impacts on concentrations of and exposure to $PM_{2.5}$ and CO from clean and improved cooking technologies and fuels.[7] The review covered clean fuels, including ethanol, liquefied petroleum gas (LPG) and electricity, as well as "improved" biomass stoves, which were categorized as vented (e.g. through a chimney or flue), non-vented, or advanced combustion (i.e. gasifiers that convert biomass into a gaseous fuel to increase combustion efficiency).


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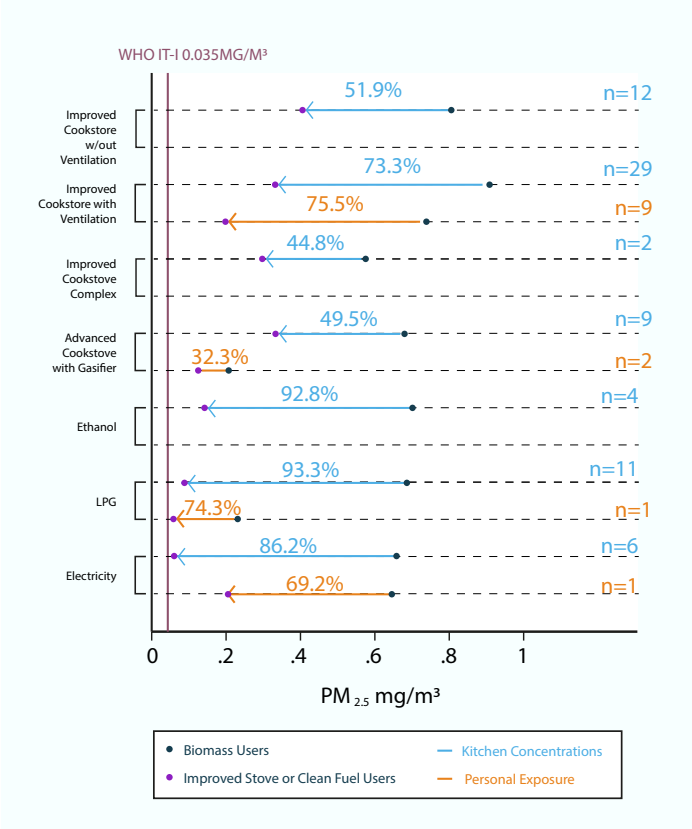
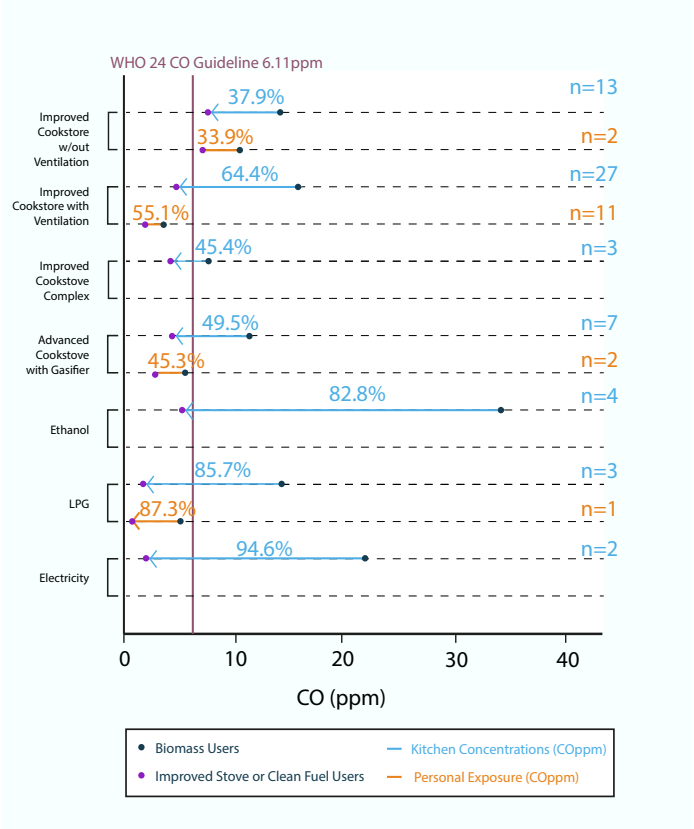
Kitchen concentrations

On average, improved biomass stove interventions reduced $PM_{2.5}$ levels in the cooking area by at least 50%. However, the $PM_{2.5}$ concentrations in households remained well above the WHO interim target 1 level of 35 µg/m³. Clean fuel interventions (i.e., ethanol, LPG, electricity) reduced $PM_{2.5}$ concentrations by 85% on average. Some households using clean fuels achieved average $PM_{2.5}$ kitchen concentrations that met the WHO interim target 1 level. The majority of interventions for both clean and improved biomass stoves achieved CO kitchen concentration levels at or below the WHO interim target 1 level of 7 mg/m³.

Kitchen concentrations and personal exposure ($PM_{2.5}$)



Kitchen concentrations and personal exposure (CO)



Personal exposures

In addition to characterizing air pollution levels in the cooking area, measuring personal exposure to $PM_{2.5}$ and CO is important to directly assess levels breathed in by the cook and other family members. For CO exposures, the systematic review found that clean cooking fuels generally resulted in lower CO exposure among cooks compared to "improved" biomass stoves, but all stove types (in most studies) achieved the WHO 24-hour average air quality interim target 1 for CO.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For $PM_{2.5}$ exposure, on the other hand, "improved" biomass stove interventions generally did not lower $PM_{2.5}$ exposures enough to reach the WHO interim target 1. Conversely, participants in 75% of studies using LPG stoves had average $PM_{2.5}$ exposure levels that met the WHO interim target 1 level. It is likely that some households using clean fuels did not reach the WHO target due to concurrent use of polluting stoves and fuels, as well as outdoor air pollution from other sources, such as neighbouring households using polluting fuels, trash burning, agricultural crop burning, industry, and traffic.

Which fuels and stove technologies are best for improving health?

This systematic review and meta-analysis shows that overall, clean fuels and technologies are needed in order to achieve WHO air quality interim and guideline levels of $PM_{2.5}$ for both kitchen concentrations and personal exposure levels.[5] Rapid and increased investment in clean fuels is essential to ensure that families can breathe cleaner air in their homes and SDG 7 can be met. Time is of the essence to scale up clean household energy, while concurrently reducing outdoor air pollution from other residential, industrial and transportation sources.


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WHO's leadership

Additional household air pollution studies are being conducted in understudied, resource-poor settings to investigate the effectiveness of various cleaner stoves and fuels in different environments with varying levels of outdoor air pollution. WHO is collaborating with other public health organizations, intergovernmental agencies and academia to monitor progress toward achieving SDG 7, develop evidence-based recommendations on the most efficient pathways for reducing household air pollution, and provide tools and resources to facilitate increases in access to clean household energy to protect global health.

Acknowledgments

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