Air Quality, Energy and Health
Science and Policy Summaries

Household air pollution and related health impacts

Technical brief

Key messages

More than a quarter of the global population still cook meals over open fires and/or on simple stoves fuelled by firewood, agricultural waste, dried dung, charcoal, and coal. This practice results in the emission of harmful and dangerously high levels of household air pollution. Exposure to this household air pollution has been estimated to cause around 3.2 million deaths annually in 2019; these emissions also worsen ambient air quality, alter the global climate, have gendered livelihood impacts, and degrade the local environment. Lower-emission and exposure-reducing alternatives – like gas and electricity – are widely used among middle- and upper-income households globally but have not yet been made available or affordable to poorer households at scale. It is also important to tackle household air pollution in refugee and migrant communities, where people are often forced to burn harmful materials like trash and plastics for their basic needs. This exacerbates health risks for already vulnerable groups, especially given the growing conflicts and climate change.

Transition to clean cooking is occurring globally, albeit at different rates; in many places, especially in Africa, too slowly to meet Sustainable Development Goal (SDG) 7, which calls for "affordable, reliable, sustainable and modern energy for all" by 2030. Some countries, including India and Indonesia, have had success increasing access to cleaner fuels like liquefied petroleum gas (LPG). Others, for example, Ecuador, are undergoing a second transition – from LPG to electric cooking. In all cases, financial instruments have enabled poorer households to access and, in some cases, afford and adopt cleaner stoves and fuels. Clean household energy transitions are slowed primarily by issues of affordability and accessibility; addressing this dual challenge can unlock health, economic, environmental, and climate benefits. The durability of these transitions relies on the stability of mechanisms to ensure consistent affordability until clean fuels and technologies are viewed as indispensable to users and households.

World Health Organization

Key definitions

Household air pollution: This arises from the combustion of polluting fuels, such as wood, dung, coal and crop residues, with inefficient technologies for cooking, heating and lighting.

Clean household energy: Clean household energy refers to fuels and technologies which attain the fine particulate matter ($PM_{2.5}$) and carbon monoxide levels recommended in the WHO global air quality guidelines and WHO guidelines for indoor air quality: household fuel combustion. Such energy includes solar, electric, biogas, LPG, alcohol (i.e. ethanol) and biomass stoves classified as Tier 4 or 5 for $PM_{2.5}$ emissions and Tier 5 for carbon monoxide emissions *(1)*.

Woman in Africa cooking with a clean cookstove.
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Overview

Current status

Access to clean household energy has improved in recent decades yet still lags behind global goals. According to the latest Tracking SDG 7 report, as of 2023, approximately 74% of the global population has access to clean fuels and technologies for cooking, a 17% improvement since 2010 *(2).* Despite this progress, 2.1 billion people still depend heavily on polluting fuels and technologies for cooking. If the current trajectory continues, only an estimated 78% of the world's population will have access to clean cooking fuels and technologies by 2030 (relative to 1990), failing to achieve the SDG 7 target of universal access to clean cooking *(3).*

Household air pollution exposures remain high in many parts of the world. Burning polluting fuels such as wood, dung, charcoal, coal and kerosene in inefficient devices for cooking, heating and lighting in poorly ventilated homes releases dangerous levels of air pollutants including $PM_{2.5}$, black carbon, carbon monoxide, polycyclic aromatic hydrocarbons, volatile organic compounds, and hundreds of other health-damaging compounds (termed household air pollution) to which the inhabitants are highly exposed *(4)*. Pollutant levels vary widely depending on fuel type, fuel moisture content, forms of combustion, etc.

Measurements of household air pollution have focused on indoor concentrations and exposure monitoring (that is, pollution monitors worn by people that follow them through space and time). The WHO Global Database of Household Air Pollution Measurements,[1] with a focus on $PM_{2.5}$ and CO levels, contains 1,000+ measurements from 196 studies performed in 53 countries. Kitchen concentrations of and personal exposure to $PM_{2.5}$ in households using solid fuels varied widely, ranging between approximately 150 and 1,200 $\mu g/m^3$ – 30 to 240 times higher than the $PM_{2.5}$ guideline value of 5 $\mu g/m^3$. *(5)* Recent measurements – in Guatemala, India, Peru and Rwanda, Peru, and Guatemala as part of a large multi-country trial *(6)* and in Ghana *(7)*, Cameroon, and Kenya as part of the CLEAN-Air(Africa) study *(8)* – found lower exposures among biomass users than previously reported, but still substantially higher than exposures among LPG users. Exposure reductions from other clean fuels – like ethanol and electricity – have been less well characterized.

Household air pollution imposes substantial health impacts globally. Household air pollution was responsible for around 3.2 million deaths in 2019,[2] including over 332 000 among children under 5 years *(9)*. Exposure to household air pollution is a leading risk factor for noncommunicable diseases, including ischaemic heart disease, stroke, chronic obstructive pulmonary disease and lung cancer. Emerging evidence also suggests that household air pollution exposure may be associated with non-lung cancers, diabetes, cognitive impairment, decreased renal function and cellular ageing.

Household air pollution has also been identified as a top risk factor for children's health, with an estimated 45% of deaths due to pneumonia in children aged under five attributed

[1] WHO Global Database of Household Air Pollution Measurements (https://www.who.int/data/gho/data/themes/air-pollution/hap-measurement-db).

[2] The estimated household air pollution-related deaths are from five causes: ischaemic heart disease, stroke, lower respiratory infection, chronic obstructive pulmonary disease and lung cancer.

to household air pollution *(10)*. Epidemiological studies also support the role of prenatal household air pollution exposure on impaired child lung function development and respiratory infections in young children *(11, 12)*. There is also observational evidence linking household air pollution exposure to child growth faltering (e.g., stunting and undernutrition) and adverse birth outcomes, including low birth weight, preterm birth, and small for gestational age births.

See SPS[3]: *Health effects of air pollution – evidence and implications*

See SPS: *Air pollution and vulnerable populations*

Provision of clean household energy at scale can help achieve environmental, climate and gender-related goals. Household solid fuel combustion contributes to degraded ambient air quality; an estimated 20% of ambient air pollution arises from such sources *(13)*. Mitigating such combustion thus can reduce exposures both for polluting fuel users and household and community members, amplifying the importance of clean household energy transitions. Similarly, more rapid transitions away from biomass fuel – to a combination of electricity and LPG – were recently estimated to lead to net climate cooling relative to a baseline with modest increases in LPG and electric cooking based on current trends *(14)*. Finally, the full impacts of solid fuel use – including its collection, processing, storage and combustion – often fall on women. Substantial time savings can be achieved by moving towards cleaner household energy sources.

Studies on clean cooking solutions have demonstrated significant reductions in household air pollution exposure, while the immediate health outcomes have been less consistent. Recent clean cooking intervention studies have reported meaningful reductions in exposure, highlighting substantial potential health benefits. However, some studies have not observed consistent impacts of the intervention on measured health effects. In some cases, the observed health benefits may have been influenced by factors such as insufficient exposure reductions *(7, 15–19)*; residual exposure to unmeasured pollutants, like ultrafine particles and nitrogen dioxide; and other factors that may mask the impact of the intervention, such as maternal nutritional status. However, further follow-up of children born during a study in Ghana found meaningful benefits on lung function *(20)* and child blood pressure *(21)* for participants using LPG.

[3] Science and Policy Summary

Barriers, drivers and enablers of clean household energy transitions

Evidence from recent household energy intervention trials and observational studies have indicated substantial exposure reductions when cooking with clean fuels. Multiple recent studies have measured exposures to and kitchen concentrations of PM, black carbon and carbon monoxide. One of the largest exposure assessment studies to date was undertaken as part of the Household Air Pollution Intervention Network randomized controlled trial of an LPG stove and fuel intervention in four low- and middle-income countries (LMICs): Guatemala, India, Peru and Rwanda. Across both measurements made on pregnant primary cooks during and after pregnancy and non-pregnant household members, LPG led to substantial reductions in PM, black carbon and carbon monoxide exposure (ranging from 60–80%) *(6).* Similar results were found in randomized controlled trials and observational studies in Cameroon, Ghana and Kenya, and for both electricity and LPG in Ecuador *(7, 8, 21–23).*

Affordability and accessibility remain substantial barriers to exclusive cooking with clean fuels and technologies. Global evidence suggests that the primary barriers to clean household energy transitions are the availability and accessibility of solutions and the affordability of both up-front and recurrent costs. In India, enthusiasm around vastly improved access to LPG – enabled by PMUY[4] and other government programmes – has been somewhat muted by incomplete usage by households, driven in part by increasing costs and changes in subsidy deployment and amount. Contrastingly, in Ecuador, LPG use has remained high in part due to its very low price, despite efforts by the government to transition from LPG to electric cooking with induction stoves *(24).* A recent study across South Asia *(25)* found that precarious livelihoods, with low and irregular incomes and inadequate awareness about possible risk reduction measures, leave the urban poor unable to reduce their overall exposure to air pollution. They also found that secondary impacts of air pollution (inability to work, health care expenditures) may trap the individual and the household in a cycle of continued exposure and vulnerability.

Electric cooking – arguably the cleanest cooking solution for households – faces substantial challenges as an alternative for households reliant on biomass. Under ideal circumstances, households reliant on biomass could leapfrog gas and transition directly to cooking with clean, renewable electricity. Currently, this is challenging: grid connections for many rural homes provide sufficient energy for lighting but not for cooking; many homes in LMICs are not wired for the relatively heavy load drawn by cooking appliances; efficient appliances, like induction stoves, are expensive and may require new pots and pans; and the recurrent cost of electricity is high (e.g. LPG refills, albeit likely less expensive). In the policy domain, conversations about electrification targets often leave out cooking – an omission that has substantial implications for health and climate.

Strong government programmes can improve clean household energy access, but sustained commitment is required to drive long-term, near-exclusive usage. Evidence from Ecuador, India and Kenya suggests that policy mechanisms can help decrease fuel and stove costs and drive the adoption of modern cooking solutions. In both India and Kenya, however, changes in the financial instruments used to promote usage, including smaller consumer subsidies in India and fluctuations in taxes in Kenya, have decreased affordability and yielded suboptimal usage rates.

[4] Pradhan Mantri Ujjwala Yojana (PMUY) is an Indian Government scheme that provides LPG connections to women from below the poverty line households (https://www.pmuy.gov.in/).

Way forward

Member States

Mobilize political commitment at the highest level. High-level political commitment is needed to ensure that clean energy transitions become a national priority, with the potential to mobilize resources, streamline policy-making and enable cross-sector collaboration.

Develop country-specific roadmaps toward universal access to clean cooking and achieve net-zero in the household energy sector. To facilitate a just and inclusive clean household energy transition, a tailored approach is needed in recognition of the diverse socioeconomic and cultural contexts of countries. Countries are encouraged to customize the global roadmap[5] according to their unique needs to develop national-specific roadmaps. For LMICs, the priority is to ensure access to clean cooking, especially among vulnerable populations. On the other hand, for high-income countries, the focus is on decarbonizing their cooking and heating sectors to align with the net-zero emission goal by 2050. As an example, in Nepal – where over 50% of the population still use biomass fuels and open fires for cooking – the Clean Cooking Alliance has been working with the Government of Nepal towards an ambitious target of universal access to clean cooking by 2030 *(26)*. This goal is a core component of Nepal's Country Action Plan for Transforming the Cookstoves and Fuels Market in Nepal. The Government of Nepal has previously committed to ensuring that 25% of households nationwide adopt electric cooking by 2030.

Incorporate clean cooking and heating into national energy planning and nationally determined contributions (NDCs). Reducing emissions from the cooking and household energy sector is critical to achieving climate goals. The inclusion of clean cooking in NDCs is a significant step forward in using clean cooking to mitigate climate change, while also taking advantage of adaptation and development co-benefits. It is important to integrate household energy into broader energy planning that supports the scaling up of clean energy technologies and aligning with climate commitments like NDCs to ensure coherence in policy implementation and maximize the impact of emission reductions.

Expand strategic investments and mechanisms of public and private financing for clean household energy transition. Financial barriers often hinder the adoption of clean fuels and technologies. Overcoming these barriers requires increased funding for clean household energy solutions research and development; creating financial incentives for consumers and businesses; and leveraging public and private investments to support the clean energy market to make it more affordable, efficient and accessible to a wider population.

[5] Achieving universal access and net-zero emissions by 2050: a global roadmap for just and inclusive clean cooking transition. WHO; 2023 (https://www.who.int/publications/m/item/achieving-universal-access-by-2030-and-net-zero-emissions-by-2050-a-global-roadmap-for-just-and-inclusive-clean-cooking-transition).

Research community

Evaluations of electric cooking can help build the evidence base for grid-based or off-grid cooking solutions. Trials of electric cooking solutions will establish potential exposure reductions. Targeting peri-urban areas, where electricity may already be available and of sufficient supply, may help enable evaluations of electric cooking solutions. Partnering with ongoing off-grid efforts may enable robust study designs in areas undergoing substantial infrastructure upgrades for electrification. Performing qualitative research and understanding the drivers of and barriers to adoption of electric cooking can help ensure future transition – where grids are greener and more reliable.

Better targeting subsidies can help eliminate leakage and ensure just energy transitions. Targeted and sufficient subsidies can help ensure that energy transitions benefit all households, not just those who can afford new stoves and recurrent fuel costs. Additional research working to understand the level of subsidy required can help with subsidy design.

Focused, country-specific research to support the development of a national roadmap for clean household energy transition. As cities move towards clean fuels like piped natural gas and electricity, there is an opportunity to repurpose existing energy supplies such as LPG to serve as a suitable interim fuel in areas where clean energy infrastructure has not been established. Developing a population prioritization and fuel map that considers geographical, socioeconomic and infrastructural feasibilities will assist countries in their strategic planning for electrification and the transition to universal access to clean household energy.

Subnational focus on household air pollution and energy access. Currently the national view of the impacts of indoor and outdoor air pollution predominates. We need to tackle the subnational level down to the urban level to better identify environmental inequities and support subregions in tailoring more specific policies.

Health community

Understand, identify and communicate the health risks of household air pollution and "prescribe" clean household energy solutions. Frontline health care workers, including clinical and public health professionals, have frequent contact with community members. This puts them in a unique position to provide recommendations on how to avoid exposure to air pollution and to encourage the use of clean household energy, especially among sensitive or vulnerable populations such as children, older people and those with underlying health conditions.

Increase public awareness to stimulate demand for clean air at home and clean household energy solutions. The health sector has the potential to play a crucial role in identifying and communicating effective policy/intervention options to communities and generating widespread interest and demand for such policies. By effectively interacting with other sectors, the health sector can also ensure that health concerns are integrated into the decision-making and evaluation processes of national/subnational policies. This will help increase the overall demand for compliance and enforcement of related measures.

Woman cooking with an open fire stove
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Methodology

WHO, in collaboration with a member of the Global Air Pollution and Health – Technical Advisory Group (GAPH-TAG), defined the scope of the document during a series of planning discussions. An initial draft was developed based on expert knowledge and synthesis of existing evidence on the exposure and health impacts of household air pollution. A structured literature search was conducted in PubMed and additional sources, including WHO reports and relevant grey literature. The search strategy included keywords related to household air pollution and household energy (e.g., “exposure,” “solid fuels,” “clean cooking,” etc.) and health outcomes (e.g., “cardiovascular disease,” “respiratory disease,” and “child health,” etc.). Priority was given to systematic reviews, meta-analyses and large-scale epidemiological studies published between 2014 and 2024. Expert advice further guided the selection and interpretation of evidence to develop the document.

The draft underwent peer review by a group of GAPH-TAG experts, covering a wide range of expertise including environmental health, epidemiology, exposure science and public policy. It was reviewed and discussed by experts from WHO Collaborating Centers and participants in the joint WHO GAPH-TAG and Scientific Advisory Group (SAG) meetings held in Beijing, China (October 2024).

All peer review comments, and feedback were addressed by the main contributors. A final internal review was carried out by WHO staff and consultants from the WHO Air Quality, Energy and Health Unit to ensure technical accuracy and alignment with the WHO requirements for the collections of Air Quality, Energy and Health Science and Policy Summaries. This series synthesizes current knowledge and evidence on air quality, energy access, climate change links and health, primarily to inform intergovernmental discussions.

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Declarations of interest

All external experts submitted a declaration of interest to WHO disclosing potential conflicts of interest that might affect, or might reasonably be perceived to affect, their objectivity and independence in relation to the subject matter of the report. WHO reviewed each of the declarations and concluded that none could give rise to a potential or reasonably perceived conflict of interest related to the subjects covered by the report.

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