CLEAN COOKING TO PROTECT MATERNAL AND CHILD HEALTH

Household air pollution is a leading risk factor for disease and death, especially among women and children. In 2016, over 2.6 million premature deaths were from household air pollution.\(^1\) Burning biomass, coal, and kerosene to cook, heat, and light homes is the main cause.

Approximately 3 billion people around the world are still regularly exposed to household air pollution (HAP) despite declines in the proportion of households using biomass, coal and kerosene stoves.\(^1\) *Almost one in seven children is exposed to health-damaging levels of outdoor air pollution, to which HAP substantially contributes.*\(^2\)\(^,\)\(^3\) Reducing HAP can be an effective approach to protecting the health of women and children.

Household air pollution remains a leading risk factor for disease and premature death worldwide. Women and children are at highest risk of exposure.
Household air pollution (HAP) is a leading contributor to disease and premature death among adults and children. Children may be particularly susceptible to the health impacts of air pollution due to faster breathing rates and developing systems. Evidence of the maternal and child health outcomes associated with exposure to HAP comes from observational studies and a small number of randomized controlled trials, which are the gold standard for evaluating interventions. These studies evaluate health impacts among users of traditional biomass stoves and open fires compared with users of clean stoves and fuels such as liquefied petroleum gas (LPG).

HAP comprises levels of particulate matter (including fine particular matter PM$_{2.5}$) and gases that can exceed air pollution exposures in even the most polluted urban settings. PM$_{2.5}$ can penetrate deep into the lungs and trigger systemic inflammation and oxidative stress, and is considered the best indicator air pollutant to estimate the negative health impacts of air pollution. Exposure-response relationships between PM$_{2.5}$ and risk of pneumonia, lung cancer, COPD, and cardiovascular outcomes estimate that exposure to HAP is detrimental to the health of infants, children, and adults.

To minimize the disease burden of HAP, the WHO recommends achieving an interim indoor air quality target of 35 μg/m$^3$ for annual mean PM$_{2.5}$, although adverse health outcomes occur at concentrations well below this target. The WHO also advises against the indoor use of coal and kerosene.
Risk of childhood pneumonia at different levels of PM$_{2.5}$ exposure

The exposure-response curve for PM$_{2.5}$ and risk of childhood pneumonia is steep at low levels of exposure and flattens at ~200 μg/m$^3$ of PM$_{2.5}$. Average HAP exposures are 2-15 times higher (~70-500 μg/m$^3$) than the WHO interim target of 35 μg/m$^3$ of PM$_{2.5}$. A stove intervention that reduces PM$_{2.5}$ exposure from 500 to 200 μg/m$^3$ is predicted to reduce the relative risk of childhood pneumonia by just 0.5 whereas a substantially clean intervention that reduces PM$_{2.5}$ exposure from 500 to 35 μg/m$^3$ is predicted to decrease the relative risk by 1.8. Clean stove and fuel interventions that substantially reduce PM$_{2.5}$ exposures to levels that meet or improve upon the WHO target are required to achieve the desired health benefits.

HAP remains a leading risk factor for premature death

HAP is the 8th leading risk factor for early death globally and the second leading risk factor for early death in low-income countries where its ranking has remained relatively stable since 1990 and exceeds major risk factors including smoking and unsafe water and sanitation.$^{11}$

Leading risk factors for premature death in low-income countries,$^9$ 1990 and 2016$^{11}$

<table>
<thead>
<tr>
<th>1990</th>
<th>2016</th>
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<tbody>
<tr>
<td>1. Child growth failure</td>
<td>1. High systolic blood pressure</td>
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<tr>
<td>2. Low birth weight and short gestation</td>
<td>2. Household air pollution from solid fuels</td>
</tr>
<tr>
<td>3. Household air pollution from solid fuels</td>
<td>3. Low birth weight and short gestation</td>
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Figure note: The estimates do not include additional deaths from outdoor air pollution emitted from household biomass and coal burning.

“I have seen firsthand the importance of access to energy and clean cookstoves... it must play a central role in our work to ensure the realization of human needs and fundamental rights.”

ANTÓNIO GUTERRES
Secretary-General of the United Nations

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Household air pollution was responsible for an estimated 2.6 million premature deaths in 2016.1

**STRONG AND SUPPORTIVE EVIDENCE**

**OF CHILD AND NEWBORN HEALTH IMPACTS FROM HAP EXPOSURE**

- Increased risk of all-cause mortality in young children4,13
- Increased risk of acute lower respiratory infections in children — a leading cause of child death13
- Greater risk of low birthweight (<2,500 grams) and lower birthweight by an average of 86 grams12

**EMERGING EVIDENCE**

**OF CHILD AND NEWBORN HEALTH IMPACTS FROM HAP EXPOSURE**

- Increased risk of moderate-to-severe anemia1,14 which can impact child growth and development
- Increased risk of severe and moderate childhood stunting14, 15, 16 indicators of poor growth and development
- Increased risk of impaired child cognitive development17 including lower performance on visual-spatial integration, memory recall, and fine motor performance

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1 Strength of evidence is based on the Bradford Hill criteria in the WHO Guidelines (http://apps.who.int/iris/bitstream/10665/141496/1/9789241548885_eng.pdf?ua=1).
2 Based on five studies in India and Pakistan.12
3 Pooled odds ratio from five studies with 10 independent estimates for all-cause mortality was 1.27 (95% CI: 1.07, 1.50). Based on five studies in Tanzania, India, Indonesia, and South Africa.19
4 Pooled odds ratio from 26 studies of HAP exposure and non-fatal, severe, and fatal ALRI in children was 1.73 (95% CI: 1.47, 20.03).1 HAP accounted for 41.6% of deaths from lower respiratory infections (pneumonia) in children under five years.18
5 Reduction in birthweight (95% CI: 55.5-117.4). Based on 13 studies in Guatemala, Peru, Serbia, Zimbabwe, Ghana, Pakistan, India, the Gaza Strip.9 Low birthweight is increases the risk of newborn mortality 2-5 fold compared with normal birthweight infants.12, 19, 15
6 Emerging evidence is limited to individual studies on these topics.
7 Based on a national family health survey from 1998-99 in India among children 0-35 months. An estimated 31% of anemia in children is attributable to exposure to HAP.14
8 Pooled odds ratio from three studies of fuel type (solid fuel use vs. LPG or kerosene) was 1.27 (95% CI: 1.12, 1.43) for moderate stunting, and 1.55 (95% CI: 1.04, 2.30) for severe stunting.6 Kerosene was characterized as a “clean fuel,” which could have led to an underestimate of the odds ratio. Based on two studies in India and data from population-based surveys compiled from Cambodia, Dominican Republic, Haiti, Jordan, Moldova, Namibia, and Nepal.14, 15, 16
9 Based on a study of infants with exposure to woodsmoke in Guatemala.17
HEALTH BENEFITS OF REDUCING HAP

Emerging data suggest that introducing clean stoves and fuels can reduce HAP and protect maternal and child health.

Successful cookstove interventions that reduced PM$_{2.5}$ in kitchens include a 41% reduction with an advanced combustion stove intervention and an 83% reduction with two ethanol stoves that replaced biomass fuel stoves. Personal exposures to PM$_{2.5}$ were reduced by 55% after replacing open fires with wood-burning chimney stoves. Though none of the improved biomass burning stove interventions reduced indoor PM$_{2.5}$ to levels that met the WHO interim indoor air quality target of 35 μg/m$^3$, they still showed considerable reductions in HAP.

A small number of randomized controlled trials show that clean cooking can reduce the leading causes of child mortality and chronic disease in women:

**Reduction in severe pneumonia in young children**
Reduction in physician-diagnosed severe pneumonia by 33% among young children <18 months in Guatemala after a wood-burning chimney stove with enclosed combustion chamber was installed in kitchens, compared with children in households with open woodfires.

**Reduced duration of respiratory infections in children**
Reduced duration of upper and lower respiratory infections in Mexican children living in homes that received a wood-burning chimney stove, compared with children in homes using an open fire.

**Lower blood pressure in pregnant women**
Lower diastolic blood pressure by 2.8-3.6 mmHg and hypertension prevalence by 4.5-7% among pregnant women in Nigeria who received ethanol cookstoves, compared with pregnant women using firewood or kerosene stoves.

**Reductions in blood inflammatory biomarker in pregnant women**
Reductions in the blood inflammatory biomarker (TNF-α) in pregnant women in Nigeria after switching to an ethanol cookstove, compared with a subgroup of pregnant women using firewood stoves. Elevated levels of TNF-α may increase risk of obstetric complications.

**Improved neurological development in children**
Improved neurological development among children 6-7 years old in Guatemala with reduced in utero exposure to HAP from their mother’s use of a wood-burning chimney stove with enclosed combustion chamber, compared with children whose mothers used open woodfires.
Lessons from previous cookstove interventions show the importance of addressing cooking behaviors and other sources of air pollution to achieve anticipated health benefits of reduced HAP.

Clean cooking interventions may achieve greater health benefits if other factors are addressed in addition to promoting clean fuels and improved stoves. Effective implementation includes assuring the availability of fuels, reliable cookstoves, long-term service, and replacement; promoting consistent and exclusive use; and, reducing community sources of air pollution. The figure below shows various challenges to overcome to help reduce HAP and protect health.

- Recipients of new stoves may start to cook more often or for longer, which reduces the air pollution benefit.
- Neighbors’ burning trash, biomass fuel or coal can impact other households.
- Many people cook using open fires outside of the home.
- Other local sources of air pollution may keep household exposures high, such as neighbors’ biomass combustion, industry, traffic, generators, and agricultural and trash burning.

Households continue using traditional stoves alongside clean fuels and improved stoves; this mixed stove use diminishes the health benefits since HAP levels remain high.

Some “improved” biomass fuel stoves did not burn cleanly, and thus did not reduce HAP.

Emissions from a neighbor’s generator can impact other households.

Recipients of new stoves may start to cook more often or for longer, which reduces the air pollution benefit.

Other local sources of air pollution may keep household exposures high, such as neighbors’ biomass combustion, industry, traffic, generators, and agricultural and trash burning.
Policies to Reduce HAP

Policymakers’ role in reducing air pollution in homes and outdoors.

Policy initiatives, particularly those that improve energy access, can encourage communities to use clean fuels, such as LPG, ethanol, biogas, processed biomass, and well-implemented, low-emission biomass stoves. Policy initiatives can also take a broader approach to regulate other sources of outdoor air pollution, which in turn affect exposures.

Examples of country-level policies that could have an impact for reducing household and outdoor air pollution:

<table>
<thead>
<tr>
<th>Policies</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Low-income Subsidies</td>
<td>Ghana&lt;br&gt;The Rural LPG Promotion Programme: energymin.gov.gh/brief-background&lt;br&gt;India&lt;br&gt;MyLPG.in</td>
</tr>
<tr>
<td>Campaigns</td>
<td>India&lt;br&gt;The “give it up” campaign that asks wealthier households to voluntarily give up their LPG subsidy to the poor: givitup.in&lt;br&gt;The Pradhan Mantri Ujjwala Yojana campaign to provide LPG connections to the poor: pmujjwalayojana.com&lt;br&gt;Nigeria&lt;br&gt;The “Upgrade to Gas” campaign.</td>
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<tr>
<td>Frameworks</td>
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Ongoing Studies on the Benefits of Clean Cooking

A multi-country randomized controlled trial of LPG stoves began in 2017.

The trial is taking place in India, Guatemala, Peru, and Rwanda, and is known as the HAP Investigation Network (HAPIN). This ongoing study is jointly-funded by the U.S. National Institutes of Health and the Bill and Melinda Gates Foundation. HAPIN is evaluating whether introducing LPG stoves to homes can improve health outcomes and establish biomarkers for both acute and chronic conditions in infants and adults.

Community transition to clean cookstoves and fuels can dramatically reduce air pollution exposures and reduce disease burden in children and women. Effecting this transition will require appropriate programs and policies.
RESOURCES AND REFERENCES

This brief focused on maternal and child health impacts of household stove interventions in low- and middle-income countries. Findings were synthesized from systematic reviews and resulting meta-analyses, exposure-response associations, and publications from individual randomized controlled trials and observational studies.


PHOTO CREDITS: all: Global Alliance for Clean Cookstoves

This brief was made possible by the support of the American People through the United States Agency for International Development (USAID) under the terms of the Coordinating Implementation Research to Communicate Learning and Evidence (CIRCLE) contract AID-OAA-M-16-00006.

Views expressed are not necessarily of USAID or other affiliated institutions.