Module 2.7

Understanding the health impacts of household air pollution at the primary health care level
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INTRODUCTION

Globally, 3.8 million deaths were attributable to household air pollution (HAP) in 2016, almost all of them in low- and middle-income countries (LMICs). The South-East Asia and Western Pacific regions of WHO bear most of the burden, with 1.5 and 1.2 million deaths, respectively. The diseases included in the assessment are acute lower respiratory infection (ALRI), lung cancer, chronic obstructive pulmonary disease (COPD), ischaemic heart disease and stroke. Noncommunicable diseases (NCDs) account for 73% of these deaths.

The aim of this module is to train primary health care workers to make them aware of the health impacts of HAP. It also aims to train them to effectively communicate the health risks associated with HAP to the people who seek care at their centres, and advise individuals and communities, on a scientific basis, of the need to move to cleaner fuels in order to mitigate the health risks associated with HAP.

LEARNING OUTCOMES

At the end of the session, participants should be able to do the following:

- Understand the potential sources of HAP and its hazards, and identify those individuals who are at risk.
- List the diseases that are influenced by particulate matter (PM) from HAP.
- Use communication skills to explain the importance of reducing exposure to HAP.

TOPICS COVERED

- Introduction to air pollution.
- Sources of HAP.
- Key pollutants from the burning of biomass fuels.
- PM (sources, size) and PM toxicology.
- Cardiovascular disease, chronic respiratory disease (e.g. COPD), lung cancer, childhood pneumonia, low birth weight, asthma, cataract and other diseases linked to exposure to HAP.
COMPETENCY

Ability to identify people who come to primary health centres and who are at risk from exposure to HAP and explain to them the importance of moving to cleaner fuels in order to protect their health.

TEACHING AND LEARNING ACTIVITIES

Total session time: 90 minutes

Activity 1. Introducing HAP: 45 minutes

Step 1. Assess the participants’ background knowledge on air pollution and HAP by discussing the following:

- What they understand by the term “air pollution” and whether they can differentiate between ambient (or outdoor) air pollution and household (indoor) air pollution

Why would HAP be a matter of concern? How might smoke coming from burning wood and other forms of biomass harm humans?

In the discussions, emphasize some of the key points arising from step 1 with some of the following key messages:

Many people do not understand that HAP is a risk factor for many NCDs. People, especially women, may often complain about headache and eye irritation when cooking, but they never realize the smoke from the burning fire, to which they are exposed day after day, can lead to premature death and life-threatening chronic diseases.

Some people may see the smoke coming from wood as a normal part of burning something, and part of tradition and therefore harmless. Others may think that because it comes from the burning of materials such as wood or animal dung it is “natural” or “organic” because it is not manufactured. Few people understand that the burning of any organic matter, be it wood, animal dung or crop residue, is incomplete at temperatures found in fires and produces harmful pollutants such as carbon monoxide (CO) and fine particulate matter that are detrimental to human health.

Step 2. Ask the participants:

What are the health consequences of the use of unclean fuels? What are the plausible disease-causing mechanisms of HAP?
Many trainees would answer that the health consequences of exposure to HAP are eye irritation, headache, cough and other minor ailments, and a small minority might even add COPD.

After appreciating the answers given by the trainees, ask the participants to list down the diseases that are causally linked with PM and CO, and further explain how PM and CO are postulated to be producing those diseases.

**Step 3. Ask the participants the following:**

What are the different substances burned in the house that could be sources of HAP?

Ask the participants to identify the cleaner fuels from among wood, dung, coal, kerosene, liquefied petroleum gas (LPG), electric and solar stoves.

Asking this question to the trainees is necessary for judging any a priori assumptions that they may have. Trainers can then explain why they are not considered to be clean fuels.

Summarize with the following message:

Some people, even when they understand that burning wood or animal dung is dirty, may think that coal, charcoal and kerosene have been processed in some way to clean them up. On the contrary, coal contains many impurities such as arsenic, fluoride, mercury, lead and selenium, which are not destroyed on combustion. Kerosene use can result in particulate levels that far exceed WHO air quality guidelines and is burned in a wide range of devices for lighting and heating. The presence of a wick in many devices causes a slower burn with dirtier smoke and release of toxins such as CO, and oxides of sulfur and nitrate. Household use of kerosene has also been associated with an increased incidence of burns and scalds, and accidental poisoning when ingested.

A range of solid fuel stoves can be used, with and without chimneys, some used in the open and some indoors. Not all stoves marketed as “improved” or “clean” actually deliver the improvements in emissions needed to protect health. Only LPG, electricity and solar energy are considered as clean fuels.

**Step 4. Ask the participants:**

How do we know that the air inside our home is polluted?

Summarize with the following message:

Many trainees would say that there is a lot of smoke inside the house if biomass fuel is being used for cooking or heating, and that is how one can appreciate that the air inside the home is polluted. However, the trainers can further explain about how PM and CO, which are present in the smoke, can be quantitatively measured.
Step 5. Ask the participants:

How much would you think the PM levels are inside the house when biomass fuel is used for cooking?

Summarize:

Show the WHO indoor air quality guideline and also the estimated exposure levels for family members who cook with biomass fuels.

Step 6. Ask the participants:

What can be done to prevent or minimize exposure to HAP?

Ask the trainees to come up with their own answers quickly. Some might say cooking outside (if the weather allows it) or making a vent to the biomass stove or increasing the ventilation inside the kitchen by having more windows or doors, etc. might help. Some might even say switching over to cleaner fuels like electricity or LPG would solve the problem.

Now, explain to them that completely switching to cleaner fuels is a good solution and it would be even better if everybody in that community switches to the use of cleaner fuel. (Show evidence as to why reducing exposure to 50% will not even work as far as human health is concerned.) However, explain to them why this is not possible in the near future as unless economic conditions improve many cannot afford cleaner fuels. However, in some countries, Government are aggressively promoting cleaner fuels through various schemes to protect the health of the citizens.

Step 7. Summarize the above discussion by presenting powerpoint slides containing on HAP.

Activity 2. Communicating the health risks of HAP: 20 minutes

Role-play one

Context: Two women are presenting at the primary health care facility with some respiratory symptoms.

Step 1. Ask participants to act in the role play as the above women. Request the first one to act as a woman who cooks with biomass and the second one as a woman who cooks with cleaner fuel (e.g. liquefied petroleum gas).

Step 2. Request another volunteer among the participants to communicate with clear and concise message regarding the health risks associated with cooking with biomass.
Role-play two

Case of child presenting at the health centre

Context: A baby girl of 2 years who has been brought by her mother to the PHC several times during the past 1 year for the treatment of ALRI.

Step 1. Ask for two volunteers; one to act as the patient's mother at the PHC and another as a primary health care worker, while the remaining participants observe the session. Ask the acting mother to pose as a person who cooks with biomass fuel in her household.

Step 2. Ask the health worker to tell the patient the possible health risks of HAP on her daughter’s health and advise her to avoid HAP.

The possible contents of the message are given below:

Apart from giving general advice related to improving nutrition, personal hygiene and sanitation, health-care workers can assess the HAP at patients’ homes by asking a simple question – what fuel is she using for cooking? If biomass fuel is being used, as in this case, the risk of ALRI can be effectively communicated subsequently.

The health-care worker could show comparative pollution levels in the house of the mother who cooks with biomass and the other mother who cooks with cleaner fuel. This can be done by showing two pictures, one of a smoke-filled house that uses biomass and a relatively smokeless house that uses cleaner fuel. Then communicate the risk for ALRI faced by the girl whose mother cooks with biomass compared to the other girl whose mother cooks with cleaner fuel.

The health-care worker can tell her that research has shown that the air quality levels inside her house are several fold higher than the WHO guideline and that the increased level of smoke is detrimental to the lungs, which probably predisposes her daughter to ALRI. The evidence for this comes from research studies done across LMICs. Finally, the health-care worker can discuss the options for moving to cleaner fuels or reducing HAP, such as improving ventilation to further reduce the chances of COPD for her.

Role-play three

A woman with chronic cough

Context: A woman aged 40 years has been visiting the PHC a few times during the past 6 months for the treatment of frequent cough. She uses firewood for cooking. The health-care worker suspects that she might develop COPD. The health-care worker wants to discuss the health risk for COPD.
Step 1. Ask for two volunteers, one to act as a patient at the PHC and another to act as a primary health care worker while the remaining participants observe the session. Ask the acting patient to pose as a person who cooks with biomass fuel in her household.

Step 2. Ask the health-care worker to tell the patient the possible impacts of HAP on her health and advise her to avoid HAP.

Facilitator’s explanatory notes

The health-care worker should show comparative pollution levels in the house of a woman who cooks with biomass and the other woman who cooks with cleaner fuel. This can be done by showing two pictures, a smoke-filled house where biomass is used and relatively a clear house where cleaner fuel is used. Then communicate the health risk for COPD to the woman who uses biomass as compared to the other woman who uses a cleaner fuel by the following method.

The health-care worker can tell her that research across LMICs has shown that the air quality levels inside her house are severalfold worse than the WHO guideline and that the increased level of smoke is detrimental to the lungs, which probably predisposes her to frequent cough that can lead to COPD. Finally, the health-care worker can discuss the options of switching to cleaner fuels or reducing HAP, such as by improving ventilation to further reduce her chances of developing COPD.

The facilitator may optionally use the following material to further increase her or his understanding on HAP risks associated with various diseases. The first table gives the expected PM2.5 exposure levels for different types of persons staying in a house when biomass is used for cooking. The table also shows the WHO indoor air quality guideline, which is the expected level of pollution that is not harmful to human beings.

The second table shows the relative risks of HAP for various diseases. Given the large number of people who still rely on biomass for cooking and heating, even a twofold increase in the risk for such diseases would mean a huge public health impact.

Table 1: Comparison between the expected PM2.5 exposures for families cooking with biomass fuel and the WHO indoor air quality annual mean for PM2.5

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean PM$_{2.5}$ (95% CI)</th>
<th>WHO IAQ Annual mean for PM$_{2.5}$</th>
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<tbody>
<tr>
<td>Children</td>
<td>285 µgm/m$^3$ (201, 405)</td>
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PM$_{2.5}$: particulate matter <2.5 microns in diameter; 95% CI: 95% confidence intervals; Women, resp. men, refer to adult women, resp. men aged ≥25years. Children refer to children under 5 years. IAQ: indoor air quality

Source: Adapted from Burden of disease from household air pollution for 2012, WHO
Table 2: Expected relative risks for selected diseases for various family members when exposed to PM$_{2.5}$ due to cooking with biomass fuel

<table>
<thead>
<tr>
<th>Disease</th>
<th>RR (95% CI) women</th>
<th>RR (95% CI) men</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALRI</td>
<td>2.9 (2.0–3.8) for children</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>2.3 (1.7–3.1)</td>
<td>1.9 (1.2–3.1)</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>2.3 (1.5–2.8)</td>
<td>1.9 (1.4–2.3)</td>
</tr>
<tr>
<td>IHD</td>
<td>(1.4–2.2)</td>
<td>(1.4–2.2)</td>
</tr>
<tr>
<td>Stroke</td>
<td>(1.4–2.4)</td>
<td>(1.3–2.4)</td>
</tr>
</tbody>
</table>

PM$_{2.5}$: particulate matter <2.5 microns in diameter; 95% CI: 95% confidence intervals.

RR: Relative risks; CI: Confidence interval; ALRI: Acute lower respiratory disease; COPD: Chronic obstructive pulmonary disease; IHD: Ischaemic heart disease. Women, resp. men, refer to adult women, resp. men aged ≥25 years. Children refer to children under 5 years.

For stroke and IHD, there is an age-gradient for the relative risks, but presented here are the 95% confidence interval over their predicted values from the integrated exposure response functions over all ages.

Source: Adapted from Burden of disease from household air pollution for 2012, WHO.

**Activity 3. Community-level interventions to improve household air quality: 25 minutes**

**Step 1.** Divide the participants into convenient groups.

**Step 2.** Ask each group to discuss the following:

- Identify situations where fuels such as wood, animal dung and kerosene are typically used in a community – how frequently and the location
- Propose feasible options for the community to minimize exposure from harmful HAP.
- What are some of the sources of support available in the community for moving to cleaner fuels?
Step 2. Ask each group to make a quick summary of the discussions.

Facilitator’s explanatory notes

This could identify everyday use of biomass fuel during festivals, heating in winter, etc. – each situation could then be discussed to see how to minimize exposure.

Primary health care workers need to educate communities on the risk of poor household air quality and suggest options and advocate for switching from solid fuels to cleaner and efficient fuels and energy technologies such as LPG, electricity, solar and smokeless stoves.

Additional reading resources

2. WHO indoor air quality guidelines: household fuel combustion

Pre- and post-tests

Pre-test

(1) Humans have been using wood fire to cook food ever since they learnt to make fire artificially. Given that wood is a natural product, do you think the smoke coming from the wood when it is burnt does not cause harm to human health? Explain your answer.

(2) What do you think are the sources of household air pollution?

(3) What do you think are the key diseases associated with burning wood, animal dung or crop residues in the house as a source of energy?

Post-test

(1) Under what circumstances do you think household air pollution would contribute to the levels of outdoor air pollution? Explain.

(2) As a primary health care worker, what could be your role in improving household air quality?

(3) What do you think are the reasons for people not switching to cleaner fuels like LPG, electricity and solar? Please give reasons for your answers.

(4) Which are some of the stakeholders who could be approached for getting support to move towards the use of clean fuel?
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Activity 1: Step 7

What is air pollution?

- Natural versus anthropogenic
  - Natural – Volcanoes, forest fires
  - Man made – Anthropogenic – Industrial, Vehicular
- Outdoor versus indoor
  - Outdoor (or Ambient) air pollution – e.g. industrial, vehicular, burning of waste
  - Indoor air pollution e.g. tobacco smoking by household members inside the house, smoke coming out of cook stoves,
  - Household air pollution is also a part of indoor air pollution. However, it specifically refers to air pollution inside the house due only to household activities like cooking, heating and lighting etc.
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Outdoor air pollution

Household air pollution

- Till recent times, the pollution from household sources have not been given the attention that it warranted
- Till 150 years ago the entire world used solid fuels for cooking and heating (biomass and coal)
- In South-East Asia, in 2016 60% of the population are still reliant on use of polluting fuels for cooking purposes.

Household air pollution definition

- **Household air pollution (HAP)**
  - air pollution due to household cooking

- **Key pollutants**
  - Particulate matter (PM$_{10}$ or PM$_{2.5}$)
  - Carbon monoxide (CO).
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Particulate matter (PM)

- PM affects more people than any other pollutant.
- It is a complex mixture. The major components of PM are:
  - Sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water.
- It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air.
- Vary in size (10 μg/m³ or 2.5 μg/m³), composition, and origin.

![Particulate matter size](https://www.epa.gov/sites/production/files/2016-09/pm2.5_scale_graphic-color_2.jpg)

PM – size matters

- PM$_{10}$ - Coarse particles (2.5–10 micrometres) deposited in the upper respiratory tract and large airways
- PM$_{2.5}$ - Fine particles (< 2.5 micrometres) may reach terminal bronchioles and alveoli

Understanding the health impacts of household air pollution

Household air pollution and health

- Around 3 billion people around the world still cook with unclean fuels and technologies
- Each year close to 4 million people die prematurely from illness attributable to HAP
- Close to half the premature deaths due to pneumonia among children <5 years are caused by the PM inhaled from HAP
- HAP contributes significantly to non-communicable disease burdens including stroke, ischaemic heart disease, COPD and lung cancer
- Fuel gathering consumes considerable time for women and children and takes away children from educational activities.


Global burden of disease due to HAP 2016

Household air pollution is the world’s leading environmental health risk

- Ischaemic Heart Disease, Pneumonia, Chronic Obstructive Pulmonary Disease, Stroke and Lung cancer contribute the biggest burdens

- Evidence of links between HAP and low birth weight, tuberculosis, cataract, nasopharyngeal and laryngeal cancer are also significant.

- Without a substantial policy change the total number of persons lacking access to clean fuels and technologies will remain largely unchanged to 2030


Deaths per capita attributable to HAP in 2016, by region

HAP: Household air pollution; Afr: Africa; Amr: America; Emr: Eastern Mediterranean; Eur: Europe; SeAr: South-East Asia, Wpr: Western Pacific; LMIC: Low- and middle-income; HIC: High-income.

Source: Burden of Disease from household air pollution for 2016. 13 April 2018, World Health Organization.
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### Biologically plausible mechanisms of PM

- Oxidative stress and inflammation – infiltration of PM2.5 deep into the lung
- Endothelial dysfunction - vasoconstriction
- PAHs present in PM can induce DNA damage and mutagenic effects - neoplasms – lung cancer
- Hemodynamic changes - changes in blood pressure, heart rate and rhythm.

### Carbon monoxide (CO)

- CO has a greater binding affinity than oxygen
- When CO is inhaled it replaces O₂ in the blood by displacing O₂ and forms carboxyhaemoglobin (COHb)
- CO also binds with myoglobin in muscle tissue.
- High levels of carboxyhaemoglobin/myoglobin cause poor oxygenation of cells/tissues (tissue hypoxia)
- Short term health effects - headache, dizziness, vomiting, and nausea.
- High levels cause unconsciousness and death
- Long term exposure to moderate and high levels of CO has been linked with increased risk of heart disease.
Assessing exposures from household air pollution

Household air pollution when cooking with biomass
Sources: http://islandbreath.blogspot.com; http://www.who.int

Some different household cooking fuels and technologies

Opportunities for measuring exposure to HAP

http://www.who.int/indoorair/interventions/antiguamod22.pdf

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Different techniques used for measuring exposures to HAP

1. Biomarkers
2. Direct EA of HH members with personal monitoring
3. Indirect EA of HH members using time activity & microenvironment measurements
4. HH IAP in one or more microenvironments without time activity
5. HH Fuel use, housing & stove characteristics in purposeful surveys
6. HH fuel use from large-scale general surveys, such as the census
7. Regional/National Fuel Use

Exposure assessment pyramid

http://www.who.int/indoorair/interventions/antiguamod22.pdf

Expected PM$_{2.5}$ exposures for families cooking with biomass fuel and the WHO indoor air quality annual mean for PM$_{2.5}$

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Source: Adapted from Burden of Disease from household air pollution for 2012, WHO – Accessed from http://www.who.int/indoorair/health_topics/biomass/factsheet_FINAL_HAP_AQI_8d0_3_848a25034.pdf

Levels of exposure reduction needed to bring about health benefits

Critical role of health professionals

- Be informed about HAP
- Recognize HAP exposures and relation to health conditions
- Research and publish
- Prescribe solutions, educate families and communities
- Educate colleagues and students
- Advocate to policy and decision-makers.

Interventions to reduce HAP

- **Switch to alternative fuels**
  - Liquid petroleum gas (LPG), Biogas, Electricity, Solar power
- **Avoid the use of kerosene**
- **Ensure proper ventilation** during cooking. Eaves spaces and extraction through smoke hoods, opening windows & doors will be a partial help
- **Keep children away** from smoking hearths.
- **Keep pregnant women away** from smoking hearths
- **Encourage interventions by communities and local agencies**
  - Resources and information regarding relevant government and non-profit programmes to help reduce exposure and provide clean fuels
  - NGOs to advocate on the benefits moving away from dirty fuels
  - Assistance to family members to stop tobacco smoking to reduce additional household exposures.