World Health Organization

Solutions to the Indoor Air Pollution Problem

INDOOR AIR THEMATIC BRIEFING 3

Over half of the world continues to rely on solid fuels including wood, dung, agricultural residues and coal. Indoor air pollution from cooking and heating with such fuels is estimated to be responsible for 1.6 million global deaths per year - that means nearly 5,000 lives lost to this neglected health risk every day. Yet, a wide range of interventions are available to curb indoor air pollution and reduce the health burden on women and children.

Available interventions

The largest reductions in indoor air pollution are achieved by switching from solid fuels to cleaner and more efficient fuels and energy technologies, such as liquid petroleum gas (LPG), biogas, electricity and solar power (see table). In poor rural communities, where access to alternative fuels is limited and biomass remains the most practical fuel, pollution levels can be lowered significantly by using improved stoves with a chimney. These stoves, provided they are adequately designed, installed and maintained, are effective in reducing smoke because of better combustion, lower emission levels, venting smoke through a flue and potentially also shorter cooking times. Improved ventilation of the cooking and living area, for example through eaves spaces, and extraction through smoke hoods can also contribute to reducing exposure to indoor smoke.

Interventions to Reduce Indoor Air Pollution Exposure

Source of pollution	Living environment	User behaviour
Improved cooking devices • Improved biomass stoves without flues • Improved stoves with flues attached **Alternative fuel-cooker combinations** • Briquettes and pellets • Charcoal • Kerosene • Liquid petroleum gas (LPG) • Biogas, producer gas • Solar cookers (thermal) • Other low smoke fuels (e.g. methanol, ethanol) • Electricity **Reduced need for fire** • Retained heat cooker (haybox) • Efficient housing design and construction • Solar water heating • Pressure cooker	**Improved ventilation** • Hoods/ fireplaces/ chimneys built into the structure of the house • Windows/ ventilation holes/ eaves spaces **Kitchen design and placement of the stove** • Kitchen separate from house reduces exposure of family (less so for cook) • Stove at waist height reduces direct exposure of the cook leaning over fire	**Reduced exposure through operation of source** • Fuel drying • Use of pot lids to conserve heat • Food preparation to reduce cooking time (e.g. soaking beans) • Good maintenance of stoves, chimneys and other appliances **Reduced exposure by avoiding smoke** • Keeping children away from smoke, e.g. in another room (if available and safe to do so)

Changes in user behaviour also play a role in reducing pollution and exposure levels. For example, drying fuel wood before use improves combustion and decreases smoke production. Keeping young children away from smoke reduces exposure of this most vulnerable age group to health-damaging pollutants. Such changes in user behaviour are unlikely to bring about reductions as large as those expected from a fuel switch or the installation of a hood or chimney. However, they should be seen as important supporting measures for other interventions.

From a health point of view, the primary objective of interventions is to reduce indoor air pollution and improve health. Yet, improved household energy practices can make multiple contributions to improving quality of life and opening up the road towards development. Consequently, interventions should also aim to achieve other benefits, such as minimizing the risk of burns, increasing fuel efficiency, reducing the time lost to fuel collection or cooking on inefficient stoves, improving women's status and their opportunities for income generation, reducing stress to the local environment and contributing to an overall improvement in the quality of the home environment.

Building the case for the effectiveness of interventions

Few studies have been undertaken to assess the effectiveness of the interventions described in the table above. As a result, current evidence is insufficient for drawing clear-cut conclusions about which interventions are most effective in reducing indoor air pollution and associated health effects.

Sophisticated research projects, such as the first-ever randomized controlled trial on indoor air pollution in the highlands of rural Guatemala, evaluate the impact of reduced indoor smoke levels on children's and women's health. There is a need to complement the results in the health literature by distilling the lessons learnt from local intervention projects around the world. A thorough evaluation of such intervention projects should assess the extent to which a given intervention has been adopted and retained by the target audience, and whether it has been effective in reducing indoor smoke and exposure. In addition, it would be worthwhile to assess some of the broader impacts brought about by household energy interventions, such as changes in time allocation to fuel collection or cooking, improved well-being of household members and reduced pressures on the local environment (see table).

Monitoring the impact of intervention projects

Process evaluation
• Adoption
• Market development
Outcome evaluation
• Performance of intervention
• Pollution levels and personal exposure
• Health and safety
• Time and socioeconomic impacts
• Environmental impacts

The evaluation of intervention experiences in different settings and countries will generate the evidence needed by local, national and international policy-makers and donors that interventions to reduce indoor air pollution make a positive difference to people's lives and are a worthwhile investment of scarce resources.

It pays to invest in interventions

The economic evaluation of health and environmental interventions is becoming increasingly important. In light of funding constraints, such evaluations can provide an important tool for demonstrating the economic return on investments in interventions, comparing the effectiveness of one intervention against another and helping policy-makers allocate limited budgets.

Cost-effectiveness analysis (CEA) is one tool that policy-makers can use to assess which interventions provide the highest "value for money". A recent CEA, conducted by WHO, investigated different intervention scenarios in reducing two major health outcomes: acute lower respiratory infections in children under five and chronic obstructive pulmonary disease in adults.

The intervention scenarios assessed were:

1. providing 100% of the population with access to liquefied petroleum gas
2. providing 100% of the population with access to kerosene
3. providing 100% of the population with improved stoves
4. providing 50% of the population with liquefied petroleum gas and 45% with improved stoves
5. providing 50% of the population with kerosene and 45% with improved stoves.

The results for WHO epidemiological sub-regions (classified according to their geographical location and mortality profile - see footnote) are illustrated in the table below. The cost-effectiveness ratio (CER) describes the average yearly cost per healthy year gained. The lower the CER, the higher the return for the investment.

From this analysis, improved stoves appear to offer the most cost-effective way of improving health per unit of investment, in particular in regions where the majority of the population continues to cook with solid fuels, such as Africa and South-East Asia. The CER for cleaner fuels are substantially higher, as these require a shift in cooking technology as well as additional expenditures on cleaner fuels.

Cost effectiveness ratios for interventions to reduce indoor air pollution (I$ per healthy year gained)

Intervention scenarios	Africa		The Americas		Eastern Mediterranean		Europe	South-East Asia		Western Pacific
	AfrD	AfrE	AmrB	AmrD	EmrB	EmrD	EurB	SearB	SearD	WprB
1	6,270	11,050	14,050	7,500	24,200	11,020	17,740	15,120	7,350	1,410
2	1,000	2,000	2,410	1,180	16,200	1,800	3,010	2,450	1,380	260
3	500	730	-	5,880	-	7,800	-	1,180	610	32,240
4	3,750	6,440	16,330	6,770	-	9,780	19,870	8,970	4,280	1,570
5	840	1,530	8,080	3,120	-	4,500	9,510	1,950	1,040	780

The major drawback of the above CEA is that it only considers the benefits of interventions from a health sector point of view, yet other sectors, such as energy or environment, play a key role in implementing household energy interventions. Cost-benefit analysis offers a method of economic evaluation that values all benefits against all costs, using various valuation techniques to assign monetary value to benefits that are not bought or sold, for example women's unpaid time. The resulting cost-benefit ratio gives an indication of whether or not the benefits of an intervention outweigh the costs, and hence provides a decision-making tool with a broad societal perspective. There is an urgent need to conduct such cost-benefit analyses in different settings to demonstrate the wide range of benefits of household energy interventions in relation to health, environment and poverty reduction.

Experience to date and lessons learnt

Household energy programmes, conducted over the past decades, range from small-scale NGO- and community-led initiatives to very ambitious national programmes, such as the Indian and Chinese National Improved Stove Programmes. Their evaluation led to the identification of several "elements of success": a decentralized administration, a good commercialization strategy, quality control of the intervention while allowing for the design to be modified in response to specific user needs, and marketing of the intervention as a prestigious asset.

Overall, a few general lessons learnt emerge:

- Interventions must respond to the users' needs to ensure appropriate and continued use and maintenance. Consequently, it is important to involve users, particularly women, in assessing needs and developing suitable interventions.
- Low awareness of the health risks of indoor air pollution, low demand and limited financial resources among potential users means that both willingness and ability to pay can be major barriers to adoption. Putting into place and promoting targeted subsidies and/or micro-credit facilities can help overcome financial barriers. Where a viable market is in place, it is important to ensure wide availability of a choice of appropriately priced interventions.
- Local projects should not operate in a vacuum but be supported by appropriate policies at the national and/or local level that take an inter-sectoral approach (i.e. energy, health, environment, finance) and result in coordinated action.

WHO Regions:
African Region (Afr); Region of the Americas (Amr); Eastern-Mediterranean Region (Emr); European Region (Eur); South-East Asian Region (Sear); Western Pacific Region (Wpr). WHO also distinguishes between the following mortality strata: very low child, very low adult (A); low child, low adult (B); low child, high adult (C); high child, high adult (D); high child, very high adult (E). For a more detailed explanation of WHO Regions and epidemiological sub-regions based on mortality strata, see World Health Report 2002.

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