



HOUSEHOLD FUEL COMBUSTION

Executive Summary



WHO indoor air quality guidelines: household fuel combustion. Executive summary.
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WHO guidelines for indoor air quality: household fuel combustion

EXECUTIVE SUMMARY

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Foreword

Energy use in the home is a vital and ubiquitous feature of human society. Energy is used for a wide variety of purposes, including cooking, space heating, lighting, small-scale income generation, various household tasks, and entertainment. Although all home energy use can impact health in various ways, globally by far the most important direct health risk is household air pollution caused by the incomplete combustion of fuel in low-efficiency stoves and lamps used for cooking, space heating and lighting. For the year 2012, the World Health Organization (WHO) estimated that close to 3 billion people, mostly in low- and middle-income countries (LMICs), lacked access to clean or modern energy services for cooking resulting in some 4.3 million premature deaths worldwide.

Clean air in and around the home is essential to a healthy life. WHO has a long tradition in synthesizing the evidence on health aspects of air quality and in preparing technical recommendations to ensure clean and healthy air both in the indoor and outdoor environments. This volume, the third in the series, following indoor air quality guidelines for selected pollutants and for dampness and mould, provides technical recommendations on the requisite performance of the fuels and technologies used in the home. These guidelines recognize the challenges faced by Member States when trying to implement household energy interventions, and provide guidance on the best approaches for securing rapid adoption and sustained use of low emission household energy technologies and fuels to protect health.

These new guidelines are particularly timely as the global community transitions toward a more sustainable and equitable future, guided by the post-2015 sustainable development framework. Currently, although there are many global and national initiatives aimed at ensuring access for all households to clean and modern energy, there is a lack of clarity about what technologies and fuels can be considered clean and safe.

Elimination of the substantial inequalities in energy access and air quality in and around the home that exist in the world today will bring substantial health and development benefits. These new guidelines will inform policy- and decision-makers in the health sector and in other sectors, as well as researchers and technical staff, when designing and implementing interventions to address this problem.

The guidelines were developed and peer-reviewed by scientists from all over the world and the recommendations were informed by a rigorous review of all currently available scientific knowledge on this subject. I would like to thank



these experts for their work in developing a product which I believe can stimulate a major new effort to improve global health.



Dr Margaret Chan
Director-General
World Health Organization



Overview

Almost 3 billion of the world's poorest people still rely on solid fuels (wood, animal dung, charcoal, crop wastes and coal) burned in inefficient and highly polluting stoves for cooking and heating, currently resulting in some 4 million premature deaths annually among children and adults from respiratory and cardiovascular diseases, and cancer. Together with widespread use of kerosene stoves and lamps, these household energy practices also cause many deaths and serious injuries from scalds, burns and poisoning. The use of solid fuel for heating in more developed countries is also common and contributes significantly to air pollution exposure. Air pollution from household fuel combustion is the most important global environmental health risk today.

These new guidelines bring together the most recent evidence on fuel use, emission and human exposure levels, health risks, intervention impacts and policy considerations, to provide practical recommendations to reduce this health burden, which build on existing WHO air quality guidelines for specific pollutants (AQG). Implementation of these recommendations will also help secure the additional benefits to society, development and the environment – including climate – that will result from wider access to clean, safe and efficient household energy.

Drawing on a broad range of newly commissioned, or recently published, systematic reviews of the scientific literature, the guidelines apply strict criteria for assessing the quality of available evidence and the suitability for developing recommendations. Among the key findings is that for several important health outcomes, including child acute respiratory infections, exposure to the key pollutant – fine particulate matter, or $PM_{2.5}$ – needs to be brought down to low levels in order to gain most of the health benefit. The other main finding is that most of the solid fuel interventions promoted in recent years have not even come close to these levels when in everyday use, and there is a need for much more emphasis on accelerating access to clean household fuels.

The recommendations focus particular attention on reducing emissions of pollutants as much as possible, while also recognizing the importance of adequate ventilation and information and support for households to ensure best use of technologies and fuels. They encompass general considerations for policy, a set of four specific recommendations, and a good practice recommendation for addressing both health and climate impacts. The general considerations address issues such as the need for community-wide action, as pollution from one house or other source affects neighbours, and vice-versa, and the fact that safety of new

fuels and technologies cannot be assumed and must be assessed. The specific recommendations address the following:

- Emission rate targets which specify the levels of emissions from household energy fuels and technologies that pose minimal health risks, and which are designed to guide assessment of how well various interventions can meet the air quality concentrations specified in WHO guidelines;
- Policies for the period of transition from current practices to community-wide use of clean fuels and household energy technologies, recognizing that intermediate steps will be needed for some time to come among lower income and more rural homes reliant on solid fuels;
- The need to avoid the use of unprocessed coal as a household fuel, in light of the specific health risks;
- The need to avoid the use of kerosene as a household fuel, in light of concerns about emissions and safety.

The good practice recommendation encourages policy makers to recognize that many of the pollutants from household fuel combustion lead to both health risks and climate change.

The guidelines are targeted at public health policy-makers and specialists working with the energy, environment and other sectors to develop and implement policy to reduce the adverse health impacts of household fuel combustion.

This publication is linked to ongoing work by WHO and its partners to provide technical support for implementation of the recommendations, as well as monitoring progress and evaluating programme impacts, for example, through the WHO database on household fuel combustion. Further details of the guidance, tools and other resources are available on the guidelines web pages: <http://www.who.int/indoorair/guidelines/hhfc>.

Rationale for these guidelines

Household air pollution (HAP) released by inefficient combustion of solid fuels for cooking and heating is currently responsible for the world's largest single environmentally-related disease burden. It has been calculated that household air pollution released during cooking causes around 4 million premature deaths (1, 2). WHO estimates that household air pollution caused 4.3 million deaths in 2012 (3). A further 0.4 million deaths are linked to the contribution HAP makes to ambient (outdoor) air pollution (2). Added to this, but as yet not quantified due to lack of sufficient research and weaker evidence, are deaths and disease from HAP derived from heating and lighting.

Use of inefficient fuels for household heating, cooking and lighting also puts household members, particularly children, at high risk of being burned (e.g. as a result of falling into fires, spilled fuel, etc.) and poisoning (caused by ingesting kerosene). While HAP from household fuel combustion is less serious in more developed countries, it remains an issue in settings where solid fuel (mainly wood and other biomass) and kerosene are used for heating.

To date, there have been no health-based guidelines with recommendations for policy to address this issue. Growing recognition that access to modern household energy is critical for the achievement of health, development and environmental (including climate) goals, has led to several ambitious United Nations (UN) and government-led initiatives to secure universal access to modern household energy over the next 15–20 years.

Against this background, it is important to have guidelines available to ensure that the potentially large health benefits of investment in, and policy for, household energy are realized.

Objectives and scope

These guidelines are designed to provide countries and implementing partners with practical information on the performance and characteristics of household combustion technologies and fuels needed to prevent the negative health effects currently attributable to this source of air pollution. Although the scope is global, the focus is on LMIC where the disease burden is by far the greatest. All household combustion sources are considered, especially those used for cooking, heating and lighting. The overall objective of these guidelines is to inform and support governments and their implementing partners to bring about the transition to modern household energy as quickly and equitably as is feasible. The guidelines focus on the following three areas of policy:

- What can realistically be done? This includes the development of a practical tool for selecting the best options for stoves and fuels based on their emission rates of key health-damaging pollutants.
- How clean is clean enough? This is a question of the best approach for ensuring that, during the transition from solid fuel to cleaner burning fuels and technologies, those who cannot make an immediate and complete transition to clean, modern fuels and technologies (e.g. gas, electricity) still obtain substantial health benefits in the interim.
- What fuels should be restricted or avoided?

Scoping questions

Four scoping questions covering the issues to be addressed by the guideline recommendations were developed as follows:

1. What device and fuel emission rates are required to meet the WHO (annual average) air quality guideline and intermediate target-1 for PM_{2.5}, and the (24-hr average) air quality guideline for carbon monoxide (CO)?
2. In light of the acknowledged challenges in securing rapid adoption and sustained use of very low emission household energy devices and fuels, particularly in low income settings, what approach should be taken during this transition?
3. Should coal be used as a household fuel?
4. Should kerosene be used as a household fuel?

During preparation of these guidelines, the scientific evidence underpinning levels set for pollutants in the WHO air quality guidelines (4,5) was considered

as valid, in accordance with the science update published by WHO in 2013 (REVIHAAP¹) (6). Values for particulate matter published in 2006 were accepted as applying both indoors and outdoors. Values published in 2010 for other specific indoor air pollutants were accepted as applying to all non-occupational indoor environments, in all populations.

Other questions and topics

Three other related issues were reviewed for the guidelines:

- **Safety:** although not the result of poor air quality, injuries (burns, scalds, poisoning from ingestion of liquid fuel) associated with household energy use were identified as important. It cannot be assumed that interventions that reduce emissions of health-damaging pollutants are also safer. The findings of the systematic review on this topic (Review 10) were used to inform the ‘general considerations’ governing all of the specific recommendations. The safety review also contributed to the evidence used for the recommendation on the household use of kerosene.
- **Adoption:** There are significant policy challenges for achieving rapid and sustained adoption of much cleaner household energy interventions, particularly in low-income settings. The systematic review of factors influencing adoption and sustained use of improved stoves and clean fuels (Review 7) informs plans for the development and testing of guidance and tools to support implementation, described further in Section 5 of the guidelines, and available online at: <http://www.who.int/indoorair/guidelines/hhfc>.
- **Synergies between health and climate impacts:** household fuel combustion can have significant impacts on climate through both efficiency of combustion and the nature of the emissions. A review of evidence on the net climate impacts (warming) from inefficient use of non-sustainable biomass and emissions from incomplete fuel combustion was carried out (Review 11). This informs a good practice recommendation on maximizing health ‘co-benefits’ in climate change mitigation addressing household energy.

¹ Review of evidence on health aspects of air pollution.

Target audience for these guidelines

The primary audience for these guidelines is decision-makers developing, implementing and evaluating policy to secure health benefits in the area of household energy, with a primary (but not exclusive) focus on LMIC, as follows:

- Individuals in national government departments responsible for addressing this issue. This includes political, management and technical personnel from a range of ministries in charge of health, energy, environment, planning, infrastructure, forestry, etc.
- Testing, standards and certification agencies and providers.
- Public and private energy production and supply utilities.
- Health authorities and health practitioners engaged in planning and delivery of preventive services at national, regional and local levels.
- Multisectoral groups working to develop and implement country action plans and related investment strategies for improving access to cleaner, safer and more efficient household energy.
- Development cooperations and international nongovernmental organizations (NGOs) working to improve access to cleaner, safer and more efficient household energy.
- International initiatives working on improving access to cleaner, safer and more efficient household energy, including the UN Foundation's Global Alliance for Clean Cookstoves (GACC), and the UN Secretary-General's Sustainable Energy for All initiative (SE4All).
- Researchers whose work focuses on investigating the causes of disease and the effectiveness of preventive interventions.

The primary audience for the systematic evidence reviews are researchers and technical staff (working in the organizations and ministries noted above) in the fields covered, that is combustion science and emissions, air pollution, environmental health, safety (burns and poisoning risks), and policy for the adoption and sustained use of interventions.

The best practice recommendation addressing synergies between the health and climate impacts of household energy is intended for those formulating policy on climate change mitigation. This includes a wide range of partners engaged with climate change mitigation strategies, including the Climate and Clean Air Coalition (an initiative focused on the shorter-acting climate pollutants, which are the main concern in respect of incomplete combustion of household fuels).

Finally, it is intended that these guidelines should contribute to general raising of awareness of an issue that has not received the attention that the health burden and other impacts of current household fuel combustion practices would warrant.

How the guidelines were developed

Advisory and review groups

These guidelines are the third in a set of WHO guidelines for indoor air quality, planned in 2006 following completion of the WHO 2005 global air quality guidelines update (5, 7). Building on these outline plans, and following the rules and procedures of the WHO Guidelines Review Committee (GRC), the WHO steering group (SG, see Annex 1 of the guidelines) developed a proposal. This group then drafted key questions, and set up a Guidelines Development Group (GDG, Annex 1 of the guidelines) which first met in January 2011. An external peer review group (EPRG, Annex 1 of the guidelines) commented on evidence reviews and draft recommendations. Both groups were made up of people with relevant expertise, drawn from all WHO regions.

Management of conflicts of interest

All members of the GDG and the EPRG completed WHO declaration of interest forms. These were then reviewed by the secretariat for potential conflicts of interest (see Annex 2 of the guidelines). A number of conflicts of interest were declared, but none required any member of the GDG or EPRG to be excluded from their respective roles.

A briefing was provided at the beginning of the main GDG meeting in Delhi (April 2012) on the nature of all types of competing interests (i.e. financial, academic/intellectual and non-academic). Each member of the GDG was asked to discuss and declare to the meeting any conflicts they may have. The session took about an hour and was facilitated by a member of the WHO GRC secretariat. No further conflicts of interest were identified at this meeting. No member of the GDG was excluded from his or her respective role.

Evidence review and assessment

At the initial GDG meeting, key questions, the relevant important outcomes and the evidence review strategy were agreed. Where recent systematic reviews (those completed within the previous 2–3 years²) were not available, new evidence reviews were commissioned. A list of these reviews and the questions they addressed is provided in Annex 3 of the guidelines. Full reviews are available online at: <http://www.who.int/indoorair/guidelines/hhfc>.

² With the exception of the systematic review on impacts of smoke exposure reduction interventions on malaria, which was conducted up to June 2006, and has not been updated (see Review 4)

Systematic reviews were conducted by teams of authors, with input from those members of the GDG with relevant methodological expertise. Methods for evaluating and synthesizing the constituent studies varied between reviews. These are summarized in Section 2.2 of the guidelines, and they appear in detail in the full reviews. Where suitable recent systematic reviews were available, summaries were prepared. One topic – the costs and financing of interventions (including climate impacts and finance) – was prepared as a narrative review to better reflect the complex, wide-ranging nature of this topic, and incorporates key findings of existing comprehensive reviews. Each review underwent two rounds of external peer review, as described below.

A model was also developed to link emission rates to predicted levels of household air pollution. This model provided the basis for a practical tool to aid selection of alternative intervention options, addressing scoping question 1, and incorporated in Recommendation 1. Modelling was also used to generate exposure–response functions, which are reported in Review 4.

WHO uses the GRADE (Grading of Recommendations, Assessment Development and Evaluation) methodology for guideline development. Principles of GRADE (8) provided the basis for evidence review but to accommodate the range and type of evidence used to inform these guidelines, modifications to GRADE were developed. This revised methodology, called *Grading of Evidence for Public Health Interventions* (GEPHI), is summarized below, and described in detail in ‘Methods used for evidence assessment’ available online at: <http://www.who.int/indoorair/guidelines/hhfc>.

1. Non-randomized experimental studies which involved introduction of an improved stove or cleaner fuel into a set of homes with or without comparison group(s), were entered into the grading process at a higher level than purely observational studies.
2. Allowance was made for upgrading where there was consistency of the evidence obtained using different study designs and settings, and analogous evidence from other sources of combustion pollution, such as ambient air pollution, and second-hand and active smoking.
3. A ‘causal chain’ model was developed to account for the multiple sources of evidence informing the scoping questions. This model was used to assess the consistency of evidence as part of the overall evaluation of evidence quality.

The evidence reviewers used GEPHI to assess the quality of the evidence retrieved for those questions amenable to systematic review and meta-analysis. Evidence for other topics directly informing the recommendations but not amenable to quantitative summary by meta-analysis was analysed using GRADE domains as a guide (i.e. study design, risk of bias, indirectness, heterogeneity, imprecision and publication bias). The methods for assessment of evidence quality

are summarized in Table 2.3 (Section 2.2.3) of the guidelines, and described fully in the discussion of evidence for each recommendation in Annexes 4–7.

All evidence reviews were discussed at the GDG meeting in Delhi held in April 2012, together with benefits and harms, values and preferences, resource implications and feasibility. Decision tables used for setting the strength of each recommendation are presented in Annexes 4–7.

Draft recommendations developed at the meeting were refined (and their strength agreed) through two rounds of electronic consultation (using the web-based EZCollab tool) with the GDG and WHO SG. Comments from external reviewers were also considered by the GDG, using this mechanism.

Peer review procedure

Each evidence review underwent two rounds of peer review, to which the authors responded. Two external peer-reviewers were allocated to each specific evidence review based on their expertise. Peer-reviewers' comments were made available to authors prior to the GDG meeting, and major points raised discussed at that meeting, with a record of responses and revisions by authors being retained. The second round of peer-reviewers' comments on the revised drafts was managed through email. The draft recommendations were also reviewed by external reviewers and a record of responses was made.

Procedure for group consensus

All decisions were reached by consensus, either at the GDG meeting or through the EZCollab web facility. The latter was used for agreeing on final wording of the recommendations and for responding to external reviewers' comments on the recommendations. It was agreed at the beginning of the GDG meeting that should there be disagreement a vote would be taken and a two thirds majority would be required for a decision to be carried.

Strength of recommendations

The GDG used decision tables summarizing the evidence on harms and benefits, values and preferences, and feasibility of recommendations to set the strength of each recommendation, defined as follows:

- **'strong'**: the guideline development group agrees that the quality of the evidence combined with certainty about the values, preferences, benefits and feasibility of this recommendation means it should be implemented in most circumstances; or
- **'conditional'**: there was less certainty about the combined quality of evidence and values, preferences, benefits and feasibility of this type of recommendation meaning there may be circumstances in which it will not apply.

Recommendations

The recommendations are presented under the headings of General considerations, Specific recommendations, and a Good practice recommendation relating to health and climate co-benefits.

The four main recommendations are presented here in the executive summary with the scoping questions and the strength of the recommendation, remarks (providing additional details relating to the recommendation and a summary of the quality of contributing areas of evidence), and key supporting data, in the form of a table or graph. The main guidelines text additionally includes a narrative summary of the evidence, implementation guidance and research recommendations.

General considerations

Important issues that apply to all of the specific recommendations were identified during the evidence review process. All have major implications for the content and implementation of policy.

- i. Emissions to the outdoor environment reduce ambient air quality, which in turn contributes to lower indoor air quality. Maximizing the cleanliness of combustion in household energy devices is therefore critical for both unvented **and** vented sources.
- ii. Local ambient air quality conditions must be considered if indoor air quality is to reach WHO AQGs given the possibility of infiltration of outdoor air into the indoor environment. Given consideration (i) (above), household energy interventions of low emission technologies will be more likely to result in achieving WHO AQGs if they are undertaken comprehensively at the community level, and ensuring that contributions to ambient air from other non-household sources are successfully mitigated.
- iii. In view of the multiple energy needs of households (cooking, heating, lighting, etc.), account should be taken of compensatory actions in response to, for example, introduction of an enclosed, low emission and well-insulated cookstove to replace an open fire, in respect of heating and lighting needs. Such compensatory action should not result in increased use of sources of heating and lighting with high levels of emissions.
- iv. Policy directed at increasing access to alternative, cleaner household combustion devices and fuels should ensure these products are available and affordable. If such fuels and devices are priced beyond the reach of the poorest groups, and/or supply is insufficient, harms may result from energy poverty, including inadequate food preparation, space heating and lighting.

- v. A systematic approach to monitoring and evaluation (M&E), with feedback to government, manufacturers, suppliers, development groups, the research community and the public, is critical to ensure progress towards meeting these guidelines. Further consideration of approaches to M&E is provided in Section 5 of the guidelines.
- vi. Safety: Household fuel combustion, particularly in developing countries, is associated with a substantial risk of injury, including through burns, scalds, and house fires. Technologies and fuels introduced with the purpose of reducing emissions have the potential to reduce these risks, but such risk reduction should not be assumed. Accordingly, approaches to minimize exposure to emissions should be taken in a way that incorporates safety concerns, and efforts (including during design and through testing and field-based evaluation) should be made to reduce such risk of injury as much as possible.

Specific recommendations

Recommendation 1: Emission rate targets

Recommendation	Emission rate targets		Strength of recommendation
Emission rates from household fuel combustion should not exceed the following emission rate targets (ERTs) for PM_{2.5} and CO.	PM _{2.5} (unvented)	0.23 (mg/min)	Strong
	PM _{2.5} (vented)	0.80 (mg/min)	
	CO (unvented)	0.16 (g/min)	
	CO (vented)	0.59 (g/min)	

Remarks

1. These emission rate targets will result in 90% of homes meeting WHO Air quality guideline values for PM_{2.5} (annual average) and CO (24-hr average). This assumes model inputs for kitchen volume, air exchange rate and duration of device use per 24 hours, as set out in Table R1.1.
2. Intermediate emission rate targets (IERT) show the rates that will result in 60% of homes meeting interim target-1 (IT-1) for PM_{2.5} (Table R1.2) and 60% of homes meeting the 24-hr AQG for CO (Table R1.3). The value of 60% is arbitrary, but was selected so that a majority of homes would meet the specified guideline level.
3. Separate guidance is provided for unvented and vented stoves as those technologies with chimneys or other venting mechanisms can improve indoor air quality through moving a fraction of the pollutants outdoors.

4. Table R1.2 illustrates the percentage of homes that would meet IT-1 (35 µg/m³) for PM_{2.5}.
5. Devices should meet both PM_{2.5} and CO emission rate targets to be considered to have met the recommendation.
6. For this recommendation, a high quality of evidence was available on the average concentrations of PM_{2.5} and CO at which health risks are minimal, as described in previously published WHO Air quality guidelines (i.e. WHO Air quality guidelines, 2005 update, WHO guidelines for indoor air quality: selected pollutants (4, 5)). A moderate quality of evidence was available for laboratory testing of emissions from fuel and technology combinations, and for the emissions model. A low quality of evidence was available for field testing of emissions from fuel and technology combinations.

Table R1.1: Input distributions for air exchange rates, kitchen volumes and device burn times used in the development of the ERTs

Parameter	Unit	Geometric mean	Range		SD*
			minimum	maximum	
Air exchange rate (α)	per hour	15	5	45	7.5
Kitchen volume (V)	m ³	30	5	100	15
Device burn time	hours per day	4	0.75	8	2

* Standard deviation

Table R1.2: Emission rate targets for meeting WHO annual mean AQGs for PM_{2.5}

Emissions rate targets (ERT)	Emission rate (mg/min)	Percentage of kitchens meeting AQG (10 µg/m ³)	Percentage of kitchens meeting AQG IT-1 (35 µg/m ³)
Unvented			
Intermediate ERT	1.75	6	60
ERT	0.23	90	100
Vented			
Intermediate ERT	7.15	9	60
ERT	0.80	90	100

Table R1.3: Emission rate targets for meeting WHO 24 h. AQGs for CO

Emissions rate targets (ERT)	Emission rate (g/min)	Percentage of kitchens meeting 24 h. AQG
Unvented		
Intermediate ERT	0.35	60
ERT	0.16	90
Vented		
Intermediate ERT	1.45	60
ERT	0.59	90

Recommendation 2: Policy during transition to low emission technologies

Recommendation	Strength of recommendation
Governments and their implementing partners should develop strategies to accelerate efforts to meet these air quality guidelines ERTs (see Recommendation 1). Where intermediate steps are necessary, transition fuels and technologies that offer substantial health benefits should be prioritized.	Strong

Remarks

1. Implementing agencies should work to increase access to, and sustained use of, clean fuels as widely and rapidly as is feasible. Selection of optimal ‘interim’ technologies and fuels should be made on the basis of evidence provided in these guidelines, as outlined below.
2. Evidence provided in the systematic review of ‘Intervention impacts on HAP and exposure’ (Review 6) demonstrated that despite achieving large percentage reductions of PM_{2.5} compared to baseline (solid fuels with traditional stoves) none of the improved solid fuel stoves reviewed reached the WHO IT-1 for annual average kitchen PM_{2.5} (and therefore did not meet the AQG). A few types of vented (chimney) stoves did reach levels close to WHO IT-1, in the range of 40–60 µg/m³. These findings can be used as a guide to the current ‘in field’ performance of a range of technology and fuel options.
3. Evidence provided on the relationship between exposure and risk of child acute lower respiratory infection described in the systematic review ‘Health risks of HAP’ (Review 4) can be used as a guide to assessing the magnitude of the health benefit from the intervention under consideration.

4. Technologies and fuels being considered for promotion should have emission rates tested (See Recommendation 1), and where possible, actual air pollution levels in everyday use in homes should be measured.
5. Plans for the development of guidance and tools to assist with the assessment of optimal interventions are described in Section 5 of the guidelines.
6. For this recommendation, quality of evidence was moderate for health risks, the integrated exposure response (IER) functions and population levels of exposure to HAP. The quality of evidence for impacts of interventions on HAP was moderate for natural draft solid fuel stoves, but low for advanced solid fuel stoves and clean fuels. The quality of evidence available for factors influencing adoption was moderate.

Recommendation 3: Household use of coal

Recommendation	Strength of recommendation
Unprocessed³ coal should not be used as a household fuel.	Strong

Remarks

1. This recommendation is made for the following three reasons, over and above the documented health risks from products of incomplete combustion of solid fuels.
 - i. Indoor emissions from household combustion of coal have been determined by the International Agency for Research on Cancer (IARC) to be carcinogenic to humans (Group 1).
 - ii. Coal – in those parts of the world where coal is most extensively used as a household fuel and the evidence base is strongest – contains toxic elements (including fluorine, arsenic, lead, selenium and mercury) which are not destroyed by combustion and lead to multiple adverse health effects.
 - iii. There are technical constraints on burning coal cleanly in households.
2. For this recommendation, a high quality of evidence was available from the IARC assessment of carcinogenicity, while a moderate quality of evidence was available for the risk estimates for lung cancer and toxic contaminants.

³ 'Unprocessed' coal refers to forms of this fuel that have not been treated by chemical, physical, or thermal means to reduce contaminants. Unless otherwise specified, this applies throughout the discussion of this recommendation, as the great majority of the available evidence reviewed draws on studies in which households used unprocessed coal. Where reference is made to one of the few studies on the use of coal which has been processed to reduce toxic emissions this is stated.

Recommendation 4: Household use of kerosene

Recommendation	Strength of recommendation
The household use of kerosene is discouraged while further research into its health impacts is conducted	Conditional

Remarks

- Existing evidence shows that household use of kerosene can lead to PM levels that exceed WHO guidelines, substantially so in developing country homes using simple unvented combustion technologies (e.g. wick cookstoves and lamps). Levels of CO, nitrogen dioxide (NO₂), polyaromatic hydrocarbon (PAH) and sulfur dioxide (SO₂) may also exceed guideline levels provided in the WHO Air quality guidelines: 2005 update and the WHO guidelines for indoor air quality: specific pollutants (4, 5).
- Epidemiological evidence on risks of respiratory and other health outcomes is currently not conclusive.
- The risk of burns, fires and poisoning, associated with the use of kerosene in developing countries is a cause for concern.
- For this recommendation, a low quality of evidence was available for disease risks from kerosene combustion emissions, and a moderate quality of evidence for safety risks with kerosene use.

Good practice recommendation: Securing health and climate co-benefits

Good practice recommendation

Considering the opportunities for synergy between climate policies and health, including financing, we recommend that governments and other agencies developing and implementing policy on climate change mitigation consider action on household energy and carry out relevant assessments to maximize health and climate gains.

Remarks

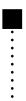
- Evidence reported in these guidelines, in particular the IER functions describing risk of important health outcomes with increasing levels of PM_{2.5} exposure, provide an initial basis for assessing the health benefits of specific climate change mitigation actions on household energy.
- Guidance and tools for further characterization of health impacts of climate change mitigation strategy that involves household energy, including both benefits and harms, need to be developed.

Implementation of the guidelines

Although these guidelines are global, the main focus of the evidence review has been on LMIC where the health burden from household fuel combustion is by far the greatest. WHO is also focusing technical support for implementation of the guidelines in LMIC, recognizing that higher income countries will have mechanisms and resources to address the risks identified – mainly from use of solid heating fuels – more easily.

Implementing these recommendations may be challenging, particularly for lower income and/or more rural populations. This will require a coordinated effort by ministries, other national stakeholders (NGOs, public and private sectors), supported by international development and financial organizations.

WHO will work with countries to support this process through its regional and country offices, and is preparing web-based guidance and tools that build on the evidence reviews used to inform these guidelines, available at: <http://www.who.int/indoorair/guidelines/hhfc>. In addition to general support provided in this way, WHO will work closely with selected countries to learn from initial implementation of the guidelines, and use this experience to revise the guidance and tools.



Updating and review

The following two mechanisms will be used to update these guidelines:

Web-based updates

Periodic updating of details that do not change the recommendations will be carried out online. This will include the following two aspects:

- **Air quality guidelines for specific pollutants.** The existing WHO AQGs are fundamental to the recommendations (and in particular the emission rate targets in Recommendation 1), and are subject to periodic review – see for example the recently conducted ‘Review of evidence on health aspects of air pollution’ (REVIHAAP)(8). If, and when, new air quality guidelines and interim targets for PM_{2.5} and/or CO are published by WHO, the emission rate targets will require updating. As this does not change the principles or methods underlying these recommendations, such updating will be made available via the website.
- **Emissions model.** Some of the key data used for the model, namely kitchen volume, air exchange rates and duration of use, were obtained only from studies in India. Although validation against studies carried out in several regions of the world shows the model performs moderately well, one research priority identified is to obtain and test data that may better reflect housing and energy use practices in different regions. When available, this information, together with the emission rates from these ‘regionally adapted’ models, will be made available on the website. Development of an interactive version of the model is also recommended. This would allow users to input their own locally-sourced data (kitchen volume, air exchange, duration of use per day) and provide a user-friendly software platform for applying the emission rate model in practice.

Updates in the light of substantial new evidence

Where important new evidence becomes available on health risks in areas where there is uncertainty (for example on household use of kerosene, for which evidence was limited and therefore rated as providing a low quality of evidence, and additional studies recommended), a formal process for systematic assessment of this evidence will be established to determine whether the recommendations should be revised. It is expected that this will be carried out within 2–3 years following publication of the guidelines.

When new evaluation-based evidence is available on the process for strengthening the implementation guidance and tools described in Section 5 of the guidelines, this material will be systematically reviewed and updated. It is expected that this will be carried out within 3–5 years following publication of the guidelines.

References

1. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2224–60. doi: 10.1016/s0140–6736(12)61766–8.
2. Smith KR, Bruce NG, Balakrishnan K, Adair-Rohani H, Balmes J, Chafe Z, et al. Millions dead: how do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. *Annu Rev Public Health*. 2014;35:185–206. doi: 10.1146/annurev-publhealth-032013–182356.
3. Deaths from household air pollution, 2012. Geneva: World Health Organization; 2014 (<http://apps.who.int/gho/data/node.main.140?lang=en>, accessed 17 July 2014).
4. WHO air quality guidelines global update 2005: particulate matter, ozone, nitrogen dioxide and sulfur dioxide Copenhagen: World Health Organization; 2006 (http://www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf, accessed 17 July 2014).
5. WHO guidelines for indoor air quality: selected pollutants. Bonn: World Health Organization; 2010 (http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf, accessed 17 July 2014).
6. WHO guidelines for indoor air quality: dampness and mould. Bonn: World Health Organization; 2009 (http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf, accessed 18 July 2014).
7. Balshem H, Helfand M, Schunemann HJ, Oxmand AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011;64(4):401–6. doi: 10.1016/j.jclinepi.2010.07.015.
8. Review of evidence on health aspects of air pollution – REVIHAAP project: final technical report. Copenhagen: World Health Organization; 2013 (<http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report>, accessed 18 July 2014).

WHO GUIDELINES FOR INDOOR AIR QUALITY

HOUSEHOLD FUEL COMBUSTION

Executive summary

Well into the 21st century, almost 3 billion of the world's poorest people still rely on solid fuels (wood, animal dung, charcoal, crop wastes and coal) burned in inefficient and highly polluting stoves for cooking and heating, resulting in some 4 million premature deaths among children and adults. Together with widespread use of kerosene stoves and lamps, these household energy practices also cause many deaths and serious injuries from scalds, burns and poisoning. Use of solid fuel stoves for heating in more developed countries is also common and contributes significantly to air pollution exposure. Air pollution from household fuel combustion is the most important global environmental health risk today.

Building on existing WHO indoor air quality guidelines for specific pollutants, these guidelines bring together the most recent evidence on fuel use, emission and exposure levels, health risks, intervention impacts and policy considerations, to provide practical recommendations to reduce this health burden. Implementation of these recommendations will also help secure additional benefits to society, development and the environment – including climate benefits that will result from wider access to clean, safe and efficient household energy.

The guidelines are targeted at public health policy-makers and specialists working with the energy, environment and other sectors to develop and implement policy to reduce the adverse health impacts of household fuel combustion. This publication is linked to ongoing work by WHO and its partners to provide technical support for implementation of the recommendations, monitoring progress and evaluating programme impacts.



World Health Organization (WHO)

Department of Public Health, Environmental and
Social Determinants of Health (PHE)

Family, Women's and Children's Health (FWC)

Avenue Appia 20
CH-1211 Geneva 27
Switzerland
<http://www.who.int>