Smoke's increasing cloud across the globe

It is in the world's poorest regions that smoke is a major threat, including China, India and sub-Saharan Africa. On current trends, 200 million more people will rely on these polluting fuels by 2030. Women and children are exposed for up to seven hours a day to pollution concentrations 100 times and more above accepted safety levels. There is ample medical evidence that smoke from burning biomass fuels leads to killer diseases, such as penumonia, chronic bronchitis and lung cancer.

Smoke is a chronic problem in rural areas of developing countries. Most people who depend on biomass fuels live in the countryside where wood and agricultural residues are readily available.

However, there is a growing problem in cities as well, as many people moving from rural areas to urban settlements continue to use traditional fuels. There is a complex relationship between indoor and outdoor pollution in urban areas. In cities, indoor air pollution can be due partly to external pollution sources such as vehicle emissions. In turn, the outdoor air pollution in parts of cities can consist largely of the emissions from fires in people's homes.

On current trends, the number of people relying on biomass for cooking and heating is set to rise by 200 million, to 2.6 billion, by 2030. The majority of the rise will be in South Asia and sub-Saharan Africa. The actual percentage of the world's population relying on biomass is projected to decline, but the rate of decline will not keep up with population growth.[31]

It is not just countries that have never had access to more modern forms of energy that are suffering. Countries whose economies are in transition, for example Tajikistan and the Kyrgyz Republic, have, in rural areas, conditions that are rapidly becoming similar to those in developing countries.

Political change and economic downturn have resulted in the collapse of much of the infrastructure. People have lost access to the power grid and cleaner household fuels such as liquid petroleum gas (LPG). Rural populations are

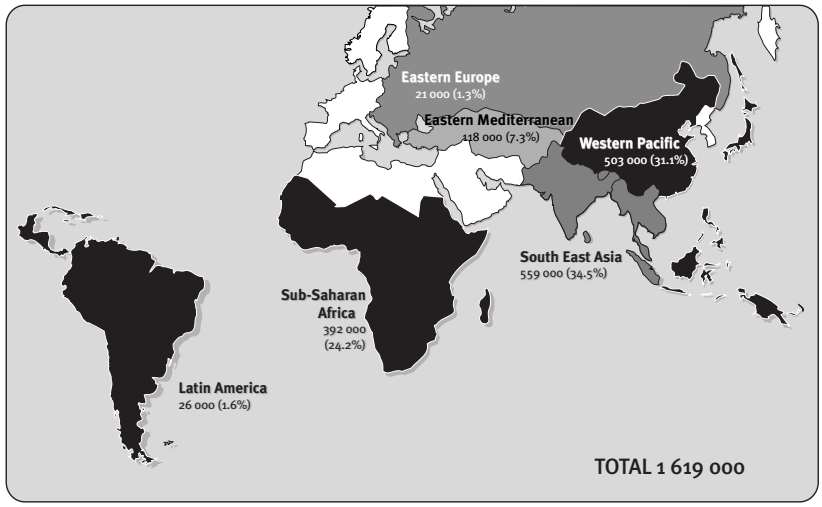

Figure 3: Map showing distribution of deaths from indoor smoke from solid fuels (2000). Source: The World Health Report 2002

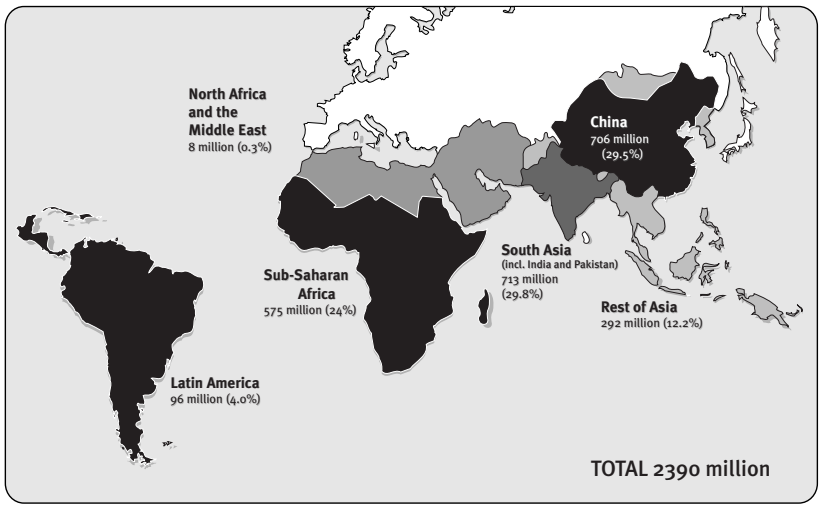

Figure 4: Map showing distribution of people depending on biomass fuels (2000). Source: IEA, World Energy Outlook, 2002

reverting to the use of wood, dung, crop residues and low-quality coal for fuel. There are concerns that, as the tradition of using such energy sources has been interrupted for several decades of subsidized access to cleaner fuels, there will be a deterioration in health due to indoor air pollution.[23]

The most striking example of this is in Tajikistan where the coverage of gas and electricity has reduced. People are now reverting back to using biomass. The impact of this is all too familiar – between 1991 and 2000 there has been a dramatic 35% increase in cases of acute respiratory infection, 'largely as a result of burning wood indoors'.[24]

Why has so little been done?

Given that half of humanity is at risk from burning solid fuels and that in the world's poorest countries indoor air pollution is the fourth greatest risk factor for death and disease, it would be expected that there would have been significant action to address this crisis. But this is not the case.

Indoor air pollution persists as a problem because of many interacting factors; not least are:

- **Largely not understood or ignored**

Until very recently there was insufficient evidence to link indoor air pollution and ill health or death. However, there are now a growing number of health studies clearly demonstrating this link, which has recently been quantified for the first time by the WHO. An increasing number of international health professionals are recognizing that indoor air pollution is a problem.

- **Cure not prevention**

Responses to childhood acute lower respiratory infection (ALRI) so far have focused on treatment rather than on removing one of the major causes of the illness – smoke in the home. Over the past decade, the United Nation's Children's Fund (UNICEF) has been monitoring the progress of the aims of the World Summit for Children (1990 to 2000). One aim was to reduce by one-third deaths due to ALRI in children under five. This target has not been hit. The main method used to prevent ALRI deaths was treatment by the selective use of antibiotics, but the findings showed that in half the 80 countries reviewed, fewer than 50% of the children with ALRI were taken to the health care provider.[25]

Demonstrating the link between indoor air pollution and ill health in Tamil Nadu, India[39]

The Indira Gandhi Institute of Development has carried out a detailed survey of the household energy use and health of 5028 households in 30 villages in Tamil Nadu. In about ten per cent of these households the research team monitored the direct exposure to smoke of the family members.

The survey showed that in 96% of the households in the survey, biomass fuels were the main cooking source. Direct exposure to smoke of the cook in each household was very high, with exposure to particulate matter ranging from 500 to 2000 $\mu g/m^3$ during cooking periods (noting that typical standards for maximum exposure to particulates are about 50 to 100 $\mu g/m^3$). In addition, concentrations of particulates in areas adjacent to the cooking area were also extremely high, which is important considering that children and older people are likely to be in the home during these periods.

Incidence of respiratory illness was measured, showing that prevalence of obstructive disorders amongst women cooks using biofuels was around 22%. Incidence of cough, phlegm, breathlessness, wheezing and eye irritation are also significantly higher in households using biomass fuels compared to those using LPG.

- **Low status of women**

Smoke mainly affects those perceived to be the lower status members of a community – women and children. Their work and contribution to society and the economy is rarely calculated in national economic planning. Therefore, the poverty alleviation benefits of improved, clean cooking have not been fully recognized.

- **Focus on environment not health**

There has been a great deal of work done on improving stove design, with the goals of energy efficiency and fuel saving, lifting the burden of women's time and effort, and with the environmental motive of saving forests. It is only in the last few years that attention has turned to the issue of indoor air pollution.

- **Other pressing problems**

Policy makers are slowly beginning to recognize smoke as a problem, but it has the disadvantage of being viewed as less significant than more acute issues, such as food, HIV/AIDS, water and sanitation and malaria. However, the impact of indoor air pollution can be as acute and dramatic as malaria. A young child getting pneumonia, for example, and having no access to hospital, will be as acutely in need of help to prevent death as if they had malaria.

Guatemalan study

Professor Kirk Smith from the University of California is leading a team embarking on the most thorough analysis of the impacts of biomass generated indoor air pollution yet conducted. The four-year, US$2 million Guatemalan programme started in 2002 and hopes to learn whether reducing indoor air pollution will decrease the incidence of pneumonia among young children.

Working in the highlands of Guatemala the international team are conducting a randomized intervention trial that will increase confidence in indoor air pollution risk estimates.

There are 500 households taking part in the trial. Each is randomly assigned to receive either an improved stove (a *plancha*) or to continue to use a three-stone fire and receive no intervention (these households receive a stove at the end of the experiment). The *plancha* is a relatively expensive wood-burning stove constructed from brick and concrete blocks, with a three pot-holed steel top plate and a metal chimney. It was developed locally and is well accepted.

Each week, trained field workers visit all the households taking part in the study and ask questions about the health of the children. Sick children are referred to the study physicians for clinical assessment. While the principal focus is on the incidence of ALRI/pneumonia, they are also recording other important health outcomes, including diarrhoea, nutritional status, scalds/burns along with child growth and development.

Time-activity patterns of the householders are monitored, as well as quality of life indicators, to establish whether the new stoves affect cooking practices and other household routines. Asthma, the incidence of low birth weight as well as women's respiratory and cardiac health are also monitored.

Levels of exposure to indoor air pollution are assessed periodically. While monitoring small particles is the best indicator, the measuring devices are cumbersome and noisy, so carbon monoxide is measured as a proxy using a small tube attached to the child's clothing for 48-hour intervals. Particulates are measured directly in a sub sample with state of the art machinery. Additionally, outdoor pollution levels are measured to quantify any relationships with indoor pollution.[34,35]

How smoke kills and injures

Smoke is the result of the incomplete combustion of fuel. The composition of smoke produced by cooking stoves varies with factors such as fuel quality or stove design. One of the most detailed reviews of indoor air pollution was led by Professor Kirk Smith from the University of California:

> 'Biomass fuel smoke contains significant quantities of several pollutants for which many countries have set outdoor air quality standards – for example, carbon monoxide, particles, hydrocarbons, and nitrogen oxides. In addition, the aerosol contains many organic compounds considered to be toxic or carcinogenic, such as formaldehyde, benzene, and polyaromatic hydrocarbons.'[29]

It is instructive to see what a kilogram of wood will generate. On a typical three-stone wood-fired stove about 18% of the energy goes into the pot, 8% into the smoke and 74% is waste heat.[26] But it is the pollutants that are of more concern. A kilogram of burning wood can produce significantly harmful levels of gases, particles and dangerous compounds.

Significant information about how much smoke people are exposed to can be gained from measuring the pattern of emissions from cooking fires in the home. This is shown clearly in the work of environmental health researchers Ezatti and Kammen in rural Kenya. Figure 6 indicates the high intensity emissions that commonly occur when using biomass fuels. The mean PM_{10} measurement near the fire was 1250 µg/m^3 – yet levels actually peaked at over 50 000 µg/m^3.[27]

Emissions in the kitchen can vary from day to day and from season to season, due to the moisture content and density of the fuel, the amount of airflow, the type of food being cooked and any changes in the stove or fuel used.[27]

Exposure in poor homes far exceeds accepted safety levels

It is not as if the world is unaware of the impact of smoke-based pollution. Ample evidence has been collected of the impact of relatively low levels of particulate pollution on health in the industrialized world. There is now evidence showing that levels of pollution previously considered to be safe are having adverse effects.[29] This is why the European Commission is introducing new targets to further lower levels of particulate pollution. Council Directive 1999/30/EC states that a PM_{10} 24-hour limit value of 50 µg/m^3 should not be exceeded more than 35 times per year by 1 January 2005 and no more than seven times per year by 1 January 2010 in the member states. Also, a PM_{10} annual limit value should not exceed 40µg/m^3 by 1 January 2005 and 20 µg/m^3 by 1 January 2010.[30]

Again, it should be borne in mind that the levels experienced by women and small children in developing countries for up to seven hours every day are frequently

Table 1: Pollutants generated from burning one kilogram of wood.[26]

Pollutant	Typical concentrations*	Typical standards set to protect health	Number of times in excess of guidelines
Carbon monoxide (ppm†)	129	8.6	15
Particles (µg/m^3)	3300	100	33
Benzene (µg/m^3)	800	2	400
1-3 Butadiene (µg/m^3)	150	3	50
Formaldehyde (µg/m^3)	700	100	7

* From burning 1 kg of wood in a traditional stove in a 40 m^3 kitchen with 15 air changes per hour.
† parts per million.

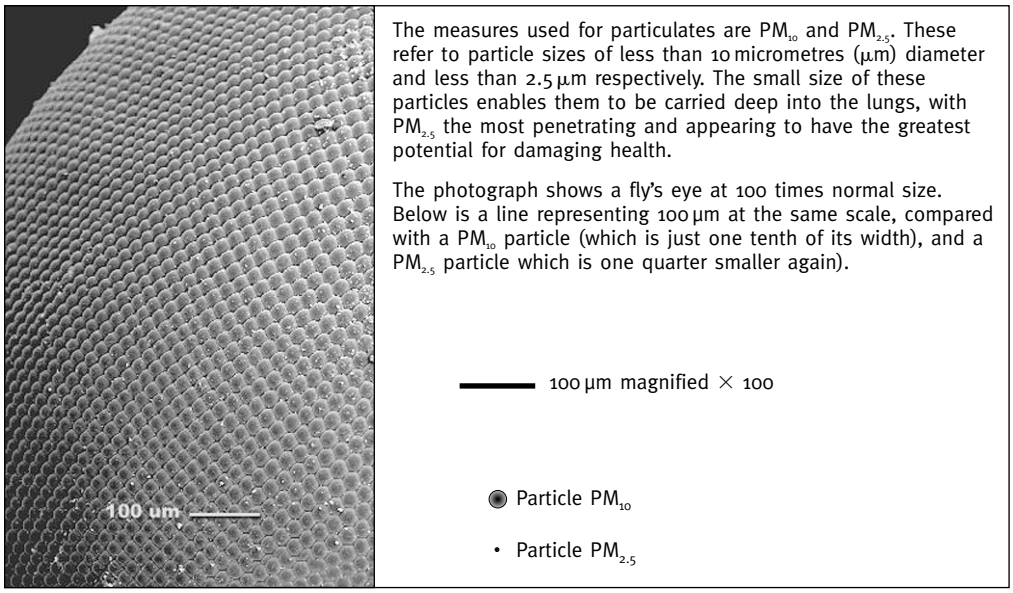

Figure 5: Measuring particulates PM_{10} and $PM_{2.5}$.

in excess of one hundred times these levels.

There are sophisticated devices placed on streets in many of Europe's cities monitoring levels of pollution, including the levels of particulates. There is a great deal of certainty about the levels experienced by people living in the relatively particle-free environments of North American and European cities, yet there is a dearth of information about levels experienced in the kitchens of developing countries.[31]

It is valuable to compare these figures with the latest results from a European wide investigation of outdoor air pollution. The APHEIS (Air Pollution and Health: a European Information System) study surveyed the levels of air pollution of 19 cities and also monitored the health of the 32 million inhabitants of these cities. The conclusions of this health

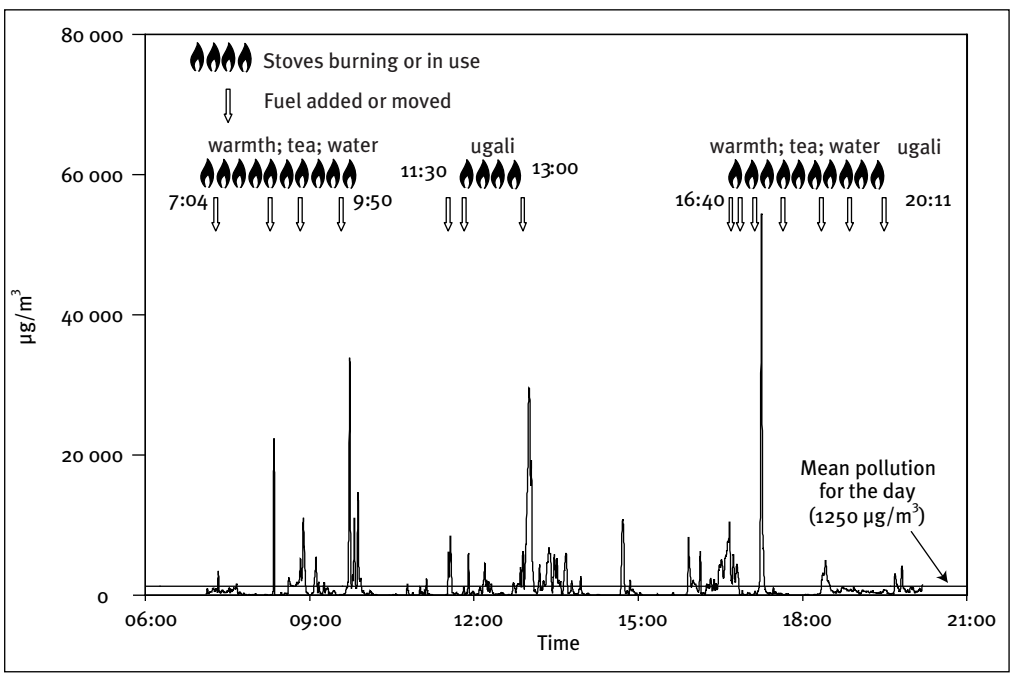

Figure 6: Day-long monitoring of pollution and cooking activities showing PM_{10} concentration (at a distance and height of 0.5 m) in a household that used a three-stone stove inside. The lower horizontal line indicates the mean pollution for the day. Ugali is the staple maize or sorghum flour meal. It requires active stirring from the cook during preparation, therefore keeping her close to the fire.[27]

impact assessment were that 5547 deaths (with a range of 3368 to 7744) could be prevented annually if long-term exposure to outdoor concentrations of PM_{10} were reduced by 5 μg/m^3.[30]

Researching how smoke affects health

The health impacts of ambient particulate pollution in industrialized countries have been researched thoroughly and have given rise to the guidelines in Figure 7. But these results are only applicable to the relatively small range of exposures examined, mostly less than 200 μg/m^3. The exposure-response relationship at concentrations of thousands of μg/m^3 is relatively unknown. Yet these are the levels experienced indoors in developing countries where around 80% of global exposure to particulate pollution occurs.[32]

An on-going study in Guatemala is the most likely to give a clear answer to the links between exposure and disease, as well as the impact that interventions can have (see page 7). It is a collaboration between the University of California in Berkeley, the University of Liverpool and del Valle University in Guatemala, and is the largest study of its kind.

In addition, the Shell Foundation are sponsoring a substantial project, called 'Standard Monitoring Packages for Household Energy and Health Field Projects', to develop a package of standardized monitoring methods for indoor air pollution. This package will allow those working in the field to monitor both exposure levels and health impacts effectively, and to compare results internationally.[33]

Health effects of indoor air pollution

There is a substantial body of evidence clearly showing that exposure to smoke in the home is a huge health hazard. As with most medical knowledge there are difficulties in drawing exact conclusions as to what levels of exposure to smoke will cause what levels of disease, as there are so many other factors which contribute to ill health. However the evidence is clear that smoke in the home is a major risk.

Acute lower respiratory infection (ALRI)

The WHO estimates that, in terms of DALYs, 35.7% of all acute lower respiratory infections are caused by exposure to solid fuel smoke.[7]

Acute lower respiratory infection, such as pneumonia, is the world's greatest killer of children under the age of five. It accounts for around 2.1 million deaths annually in this age group. More than 50% of deaths due to ALRI are caused by

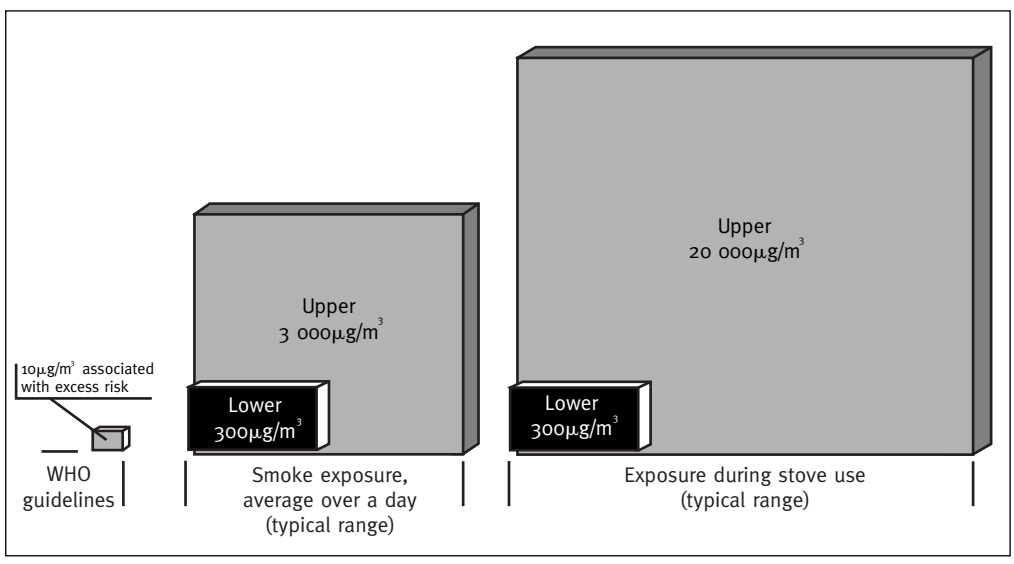

Figure 7: Comparison of typical levels of PM_{10} in developing country homes with WHO guidelines.[15]

indoor air pollution, lack of adequate heating and other precarious living conditions.[4]

Evidence from a series of studies in developing countries indicates that young children living in homes using solid fuel have two to three times more risk of suffering from ALRI than unexposed children. This figure is reached after other factors, such as socio-economic status, have been taken into consideration.[36]

Indoor air pollution can increase the incidence of ALRI by affecting the body's defence systems. For example, the ability to filter and remove particles in the upper airways and the immune system can be compromised.[29]

In the early part of the twentieth century ALRI, in the form of pneumonia, was a major cause of death in industrialized countries. Its decline as a major killer began with improvements in housing and nutrition before the advent of vaccines and antibiotics.[29]

Chronic obstructive pulmonary disease (COPD)

In industrialized countries, tobacco smoking accounts for over 80% of chronic obstructive pulmonary disease – the progressive and incompletely reversible obstruction of the airflow, such as chronic bronchitis.

However in the developing world this disease also occurs in areas where tobacco smoking is rare.[15] A woman who cooks over a biomass fire has between two and four times more chance of suffering from COPD than a woman who remains unexposed.[36] The WHO estimates that 22% of all COPD is caused by exposure to indoor smoke from biomass fires.[7]

Lung cancer

The most important cause of lung cancer is tobacco smoke. But in developing countries, women who do not smoke form an unexpectedly high proportion of lung cancer patients. For example, around two-thirds of women with lung cancer in China and India are non-smokers.[13] It is now clearly demonstrated that cooking with open coal stoves in China causes lung cancer in the women who use them.[36]

So far a clear link between lung cancer and wood smoke exposure has yet to be demonstrated. And while the rates of lung cancer in rural areas where there is a lot of exposure to wood smoke are low, this could be due to a variety of factors. As biomass smoke contains known carcinogens, such as benzoapyrene, 1,2 butadiene and benzene, it would not be possible to dismiss the lung cancer risks of exposure.[37,15]

If exposure to all carcinogens in wood smoke parallels exposure to particulates, then cooking with traditional biomass stoves is equivalent to smoking several cigarettes per day. And it has been estimated that in some homes women who cook for three hours per day are exposed to similar amounts of benzoapyrene as if they had smoked two packs of cigarettes.[38]

Pulmonary tuberculosis

There have been three studies published that suggest that people in homes using wood for cooking are at 2.5 times more risk of active tuberculosis.[37] This increase in risk may result from a reduced resistance to infection as exposure to smoke interferes with the proper functioning of the lungs.[15] Studies on animals have shown declining immune function with exposure to wood smoke.[36]

Low birth weight and infant mortality

Low birth weight is a key factor in infant mortality and morbidity. Exposure to tobacco smoke is known to be a significant contributor to decreased birth weight. Active smoking is associated with a mean reduction in birth weight of up to 200 grams and passive smoking has a smaller effect, estimated at between 20 and 120 grams.[40] Can any parallels be drawn with the impact of indoor air pollution?

There are thousands of substances emitted in both tobacco smoke and wood smoke. However, analysis of cigarette smoke isolates just a few dozen as particularly important to health. The

The United Nations Development Programme (UNDP) states that the use of poorly ventilated, inefficient stoves 'can have the same adverse health impacts as smoking two packs of cigarettes a day'.[2]

'Many older women go blind or have bad eyesight... it has a lot to do with all the smoke from fires, which they cook over.'

Umana Tesfasellasie, Oxfam project officer, Eritrea[41]

chemical most responsible for retarding intrauterine growth is believed to be carbon monoxide (CO). Carbon monoxide results from the incomplete combustion of biomass and fossil fuels. When inhaled it combines with the haemoglobin in the blood to form carboxyhaemoglobin (COHb) – a molecule that does not readily release oxygen to the body, or the foetus.[40] This is the main reason for the warnings published on cigarette packets in the UK linking smoking with harm to the unborn child.

The combustion of wood and other biomass is qualitatively similar to burning tobacco. Studies have shown that exposure to biofuels can result in COHb levels ranging from those seen in passive smoking up to those experienced in heavy active smoking. However, there is very limited data published on the effects of burning biomass on foetal growth.

The most rigorous study comes from Guatemala. It concluded that, when a number of other factors, such as socio-economic status are taken into consideration, women who use wood fuel have babies weighing an average of 63 g less than those who use cleaner fuels. This places the level of impact at least on a par with passive smoking. This is the first study of its kind, and more research is needed to support these findings.[40]

Cataracts

One of the most frequently reported complaints about exposure to smoke is that it affects the eyes of the cooks.[46] While the majority of complaints are about red, watering eyes and other relatively superficial irritations, there is growing evidence that indoor air pollution causes cataracts. Hospital-based studies in India have shown an increased incidence of cortical, nuclear and mixed cataracts. Studies on the eyes of rats have shown that wood smoke, like cigarette smoke, causes damage to the lens.[15]

Asthma

Asthma in poor rural communities in developing countries has not been studied in much detail. In industrialized countries, the influence of air pollution remains complex – and sometimes inconsistent. However there is evidence that wood smoke pollution may be a trigger for asthma or exacerbate it when combined with tobacco smoke and other ambient pollutants.[37]

Risks to women from fuel collection

Throughout the developing world it is women who provide fuel for the home and actually carry out most tasks that require energy at home. The average amount of time spent each day collecting fuel is between one half and two hours. Where it is scarce fuel wood collection can take much longer. Other than the opportunity costs associated with this time burden, there are significant risks linked with this activity.

Transporting large loads of wood exposes women to injuries such as fractures and miscarriages from falls and carrying weight when pregnant. In areas of war and civil unrest women will be exposed to violence and injury from landmines and other unexploded ordnance as they collect fuel.

The Great Smog

Indoor concentrations of particulate pollution in developing countries are typically in the region of 300–3000 mg/m^3 and may reach 30 000 mg/m^3 or more during periods of cooking.[4] When the smoke-laden fog – the Great Smog – enveloped London in December 1952 it exacted a death toll of an estimated 4000. Mortality from bronchitis and pneumonia increased sevenfold due to the smog. For six days, from 5–10 December, the people of London were exposed to levels of particulate pollution comparable to that experienced by women and children in developing countries for up to seven hours a day, every day. This smog event was a key factor in the creation of the UK's Clean Air Act in 1956 that for the first time controlled domestic smoke emissions.[28]

The UK's Clean Air Act shows that when faced with a dire public health crisis government can act quickly and decisively. Similar swift and purposeful action is required on a global scale if indoor air pollution is be tackled.