Carcinogenicity of household solid fuel combustion and of high-temperature frying

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In October, 2006, 19 scientists from eight countries met at the International Agency for Research on Cancer (IARC) in Lyon, France, to assess the carcinogenicity of household solid fuel combustion (coal and biomass) and of high-temperature frying. These assessments will be published as volume 95 of the IARC Monographs.1

About half of the world’s population, mostly in low-resource and medium-resource countries, use solid fuels for cooking or heating, often in poorly ventilated spaces.2 WHO identified indoor smoke from combustion of solid fuels as one of the top ten risks for worldwide burden of disease.3 Products of incomplete combustion contain respirable (coarse, fine, and ultrafine) particles and many volatile and non-volatile organic compounds, including carcinogens such as benzo[a]pyrene, formaldehyde, and benzene. Average indoor concentrations of particulate matter (<10 µm) can be as high as several milligrams per cubic metre, with peak concentrations an order of magnitude higher.4 Women and young children who are at home for most of the day are most highly exposed.

Although occupational exposure to the combustion products of coal by inhalation is known to cause lung cancer;5 many studies, mostly from China, now show similar effects from household use of coal. The problem was first noted in the county of Xuan Wei, China,6 where the type of coal used produces especially smoky emissions. Two case–control studies from Xuan Wei reported a strong exposure–response relationship between years of use of a coal stove and lung cancer.7 With peak concentrations an order of magnitude higher.4 Women and young children who are at home for most of the day are most highly exposed.

In experiments with animals, inhalation of emissions from coal, burned under conditions similar to those in Xuan Wei, increased the incidence of various types of malignant lung tumours in male and female Kunming mice and of squamous-cell carcinomas in male and female Wistar rats.8 In another study,9 the incidence of adenocarcinoma of the lung was increased in male and female Kunming mice exposed to combustion emissions of coal obtained from Harbin.

On the basis of sufficient evidence in both humans and experimental animals, the Working Group concluded that indoor emissions from household combustion of coal are “carcinogenic to humans (Group 1)”.10 Mechanistic data from studies of humans and animals are consistent with this conclusion.11 Biomass fuel is much more widely used than coal but the adverse health effects have been studied less. In Taiwan, women who burned wood for cooking had a threefold increase in the risk of lung cancer after adjusting for potential confounders.2 Additionally, a large multicentre European case-control study15 recorded an adjusted 20–30% increased risk of lung cancer in people who burned wood but not coal, compared with people who never used coal or wood for cooking or heating. Studies in Japan16 and Mexico17 also found an increased risk of lung cancer in non-smoking women, which was related to their exposure to smoke from wood or straw. These studies suggest that exposure to smoke from wood combustion is associated with an increased risk of lung cancer; however, the results on exposure duration and intensity are difficult to interpret.

In animal experiments, exposure to emissions from wood, burned under conditions similar to those in Xuan Wei, increased the incidence of lung adenocarcinomas in male and female Kunming mice, but not in Wistar rats.12 Extracts from wood smoke, applied to the skin or given subcutaneously, produced cancer in mice and rats.

Combustion emissions from wood are mutagenic because of the presence of compounds from various chemical classes, including polycyclic aromatic hydrocarbons and acidic or polar substances.1314 Molecular data, which include changes in expression and phosphorylation of PS3 in patients with lung cancer who were exposed to wood smoke,15 and systemic genotoxicity in charcoal workers16 and in women who burn cow dung or wood,17 supports evidence of carcinogenicity of emissions from burning wood.

On the basis of limited evidence of carcinogenicity of biomass combustion emissions (mainly from wood) in humans and experimental animals; sufficient evidence of carcinogenicity of wood-smoke extracts in experimental animals; and strong evidence of mutagenicity,
the Working Group concluded that indoor emissions from household combustion of biomass fuel (mainly wood) are "probably carcinogenic to humans (Group 2A)." 14

Stir-frying, deep-frying, and pan-frying, which involve heating oil to high temperatures, are practiced worldwide, especially in China. A study from Hong Kong15 estimated the total number of dishes prepared by these frying methods and showed a significant increase in the risk of lung cancer associated with moderate or high frequency of frying. In two other studies from Shanghai,16,16 the risk of lung cancer was increased by stir-frying, deep-frying, or pan-frying. In a study in Gansu,17 although the risk of lung cancer increased significantly with increasing frequency of stir-frying, it did not increase with deep-frying. However, potentially confounding factors, such as combustion of solid cooking fuels, cannot be ruled out in the latter three studies. No consistent differences in risk patterns emerged with regard to the effects of the different types of frying or the use of a specific type of cooking oil.

Two experiments with animals investigated the carcinogenicity of emissions from rapped oil heated to high temperatures (>260°C), and showed the incidence of lung carcinoma (mainly adenocarcinoma) increased in mice18 and rats.19 The exposure-response relationship was significant in male and female mice, in female rats, but not in male rats.

Positive results for mutagenicity of emissions from various cooking oils heated to high temperatures (>240°C) were recorded in almost every category of an in vivo-rat test assay.20 Mechanistic data show the probable involvement of peroxidation products of polysaturated fatty acids;21,22 however, the involvement of poly cyclic aromatic hydrocarbons, which have also been detected in cooking oil emissions, cannot be discounted.

On the basis of limited evidence in humans and sufficient evidence in experimental animals, the Working Group concluded that emissions from high-temperature frying are "probably carcinogenic to humans (Group 2A)." 14

The IARC authors declare no conflicts of interest. 1


