Does household use of biomass fuel cause lung cancer? A systematic review and evaluation of the evidence for the GBD 2010 study

Supplementary information file

Authors:
Nigel Bruce[1], Mukesh Dherani[1], Rui Liu[2], H. Dean Hosgood III[3,4], Amir Sapkota[5], Kirk R. Smith[2], Kurt Straif [6], Qing Lan[3], Daniel Pope[1]

[1] Department of Public Health and Policy, University of Liverpool, Liverpool, United Kingdom
[2] Environmental Health Sciences, School of Public Health, University of California Berkeley, California, USA
[3] Division of Cancer Epidemiology and Genetics, Department of Health and Human Services, National Cancer Institute, National Institutes of Health, Bethesda, MD, USA.
[4] Division of Epidemiology, Albert Einstein College of Medicine, Bronx, NY, USA.
[5] Maryland Institute for Applied Environmental Health, University of Maryland, College Park, School of Public Health, Maryland, USA.
[6] International Agency for Research on Cancer, Lyon, France

Corresponding author:
Nigel G Bruce
Department of Public Health and Policy, University of Liverpool, Whelan Building, Quadrangle, Liverpool, L69 3GB, United Kingdom
Email: ngb@liv.ac.uk
Fax: 01517945588

Contents

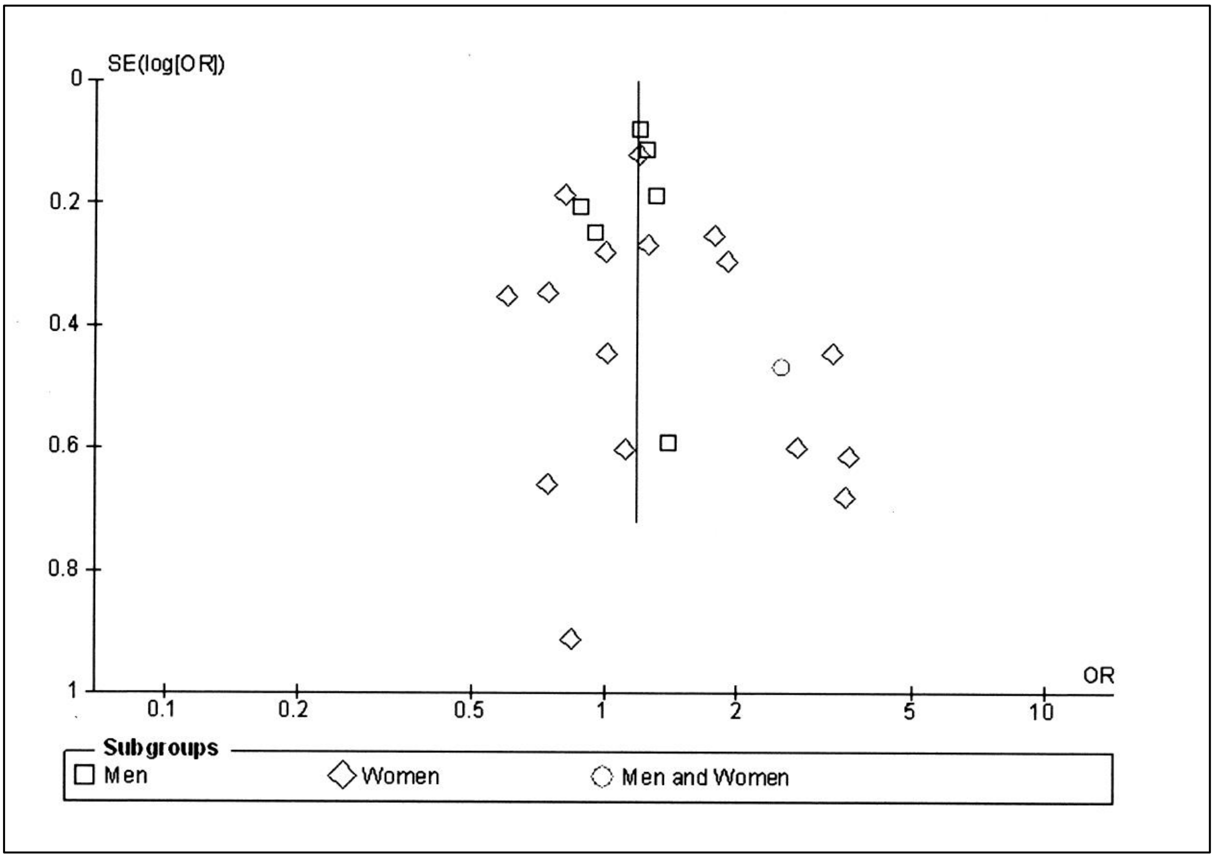
1. Selection of eligible studies

During the study selection process, it was found that, of the 21 manuscripts with information on biomass use, seven combined biomass and other solid fuels into one category such as 'traditional' or 'solid fuels'. Since these studies would not allow an assessment of the health risks of biomass fuel per se, these were excluded.[1-7]

2. Analysis of publication bias

2.1 Funnel plot

Figure S1: Funnel plot of 14 studies (25 estimates) of biomass and lung cancer, stratified by sex. See main text for statistical tests of funnel plot asymmetry.



2.2 Statistical tests of funnel plot asymmetry

- All studies: Begg's test p = 0.398; Egger's test p = 0.48
- Women: Begg's test p=0.59; Egger's test p=0.46
- Men: Begg's test p=0.46; Egger's test p=0.59.

3. Sensitivity analysis

3.1 Women

Nine of the studies used hospital controls, so there was little opportunity to study the effect of this aspect of design. Studies using population (n=2) and mixed (n=1 report, pooling 4 studies) controls did have lower ORs, but differences were small.

The majority (n=10) had strong or moderate adjustment for confounding, with a summary OR of 1.25 (0.98, 1.61). Restriction to studies with a clean fuel reference group resulted in an OR of 1.95 (1.16, 3.27) (sub-analysis #2, Table 3 in main text), further increasing to 2.33 (1.23, 4.42) on exclusion of the one study with kerosene in the reference group.

There was some evidence of a larger effect in studies from less-developed countries, consistent with higher exposure, but only apparent when restricted to studies reporting a clean fuel reference group. In studies with a clean reference group, those from Asia had an OR of 2.33 (1.46, 3.72), p<0.001, compared to an OR of 1.19 (0.94, 1.51), p=0.15 for the pooled study carried out in Europe and North America.

Four studies with results for non-smoking women had an OR of 1.14 (0.78, 1.67), p=0.5, but only one of these reported a clean fuel comparison with an OR of 2.75 (0.85, 8.86), p=0.09.

Table S1: Results for meta-analysis of studies reporting estimates for cooking with biomass fuel, stratified by sex.

Group		**Number of studies**	**Heterogeneity (I^2; p-value)**	**OR (95% CI) FE=Fixed Effects**	**p-value**	**References**
All (men and women)		12	41% (0.02)	1.15 (0.97, 1.37)	0.10	[8-19]; IARC (personal communication)
Women	All	12	50% (0.009)	1.20 (0.93, 1.54)	0.15	[8-19]; IARC (personal communication)
	At least moderate adjustment and clean fuel reference group	5*	52% (p=0.06)	**1.95 (1.14, 3.34)**	**0.02**	[9 11 13 15 17]; IARC (personal communication)
	At least moderate adjustment and clean fuel reference group, excluding one study with kerosene in the reference group	4	57% (p=0.06)	**2.30 (1.22, 4.36)**	**0.01**	[11 13 15 17]; IARC (personal communication)
Men	All	4	0%	1.15 (0.98, 1.35) FE	0.08	[9-12]; IARC
	At least moderate adjustment and clean fuel reference group	2*	0%	**1.26 (1.04, 1.52) FE**	**0.02**	[9 11]; IARC (personal communication)

*One of these studies includes kerosene in the reference group[9]

3.2 Heating and mixed use of biomass fuel

Lissowska et al[11] reported a non-significant effect for risk of lung cancer in both men and women who used wood for heating compared to those who had never used solid fuels; men OR 1.2 (0.97, 1.49) and women OR 0.97 (0.62, 1.52). However most subjects were Eastern Europeans whose exposure to HAP will have been very different to those in developing country homes using open fires and traditional stoves. Gupta[10] also examined biomass fuel for heating in a case control study from Chandigarh, India, but the observed effects were non-significant for men and women.

Malats et al[20] reported an increased risk for lung cancer among men and women (combined) associated with biomass use for either heating or cooking after adjustment for age, sex, ETS, residential history and coal use among non-smokers with an OR of 2.5 (1.0, 6.2). The pooled analysis of four European and North American studies[21] found an elevated odds ratio among men and women of 1.21 (1.06, 1.38) for wood use for heating and/or cooking.

4. Exposure-response evidence

Five studies included information on exposure duration, which can be used a proxy for lifetime dose, and the evidence relating to exposure-response relationships for biomass fuel use and risk of lung cancer is considered here.

One Japanese study[18] retrospectively asked non-smoking women if they had used wood/straw for cooking at ages of 15 and 30 years. Use of wood/straw at age 30 was associated with an unadjusted OR for lung cancer of 1.89 (1.16-3.06) when compared with those who did not use biomass. Use of wood/straw at age 15 was associated with an odds ratio of 1.24 (0.86, 1.81). Ninety percent of women who were using wood at age 30 had also been using wood for cooking when they were 15 years old, implying a longer duration of use and consistent with a dose-response effect. These effect estimates were not adjusted, however, and the higher effect seen at age 30 might be accounted for by confounding from other factors, including ETS.

A study from Taiwan[22] investigated the risk of lifetime exposure to wood or charcoal by analysing fuel use in three discrete periods of life; before 20 years of age, ages from 20 to 40 and after the age of 40. The ORs (age-matched, and adjusted for socio-demographic variables) for the first two periods were 2.5 (1.3, 50.1) and 2.5 (1.1, 5.7), when compared to matched controls who did no cooking or used gas for cooking. Only four women cooked with wood beyond the age of 40 and this was not associated with an increased risk of lung cancer. Further interpretation of these results is difficult as the women lived through each of the cooking-period categories (each includes the full sample of cases and controls), and information is not given on the total number of years each woman cooked with biomass.

Three studies constructed the exposure variable to take into account the duration of exposure. A multi-centre case-control study from India[9] categorised subjects into those who had always used modern fuels and those who had used wood for fuel for <30, 30- 50 and >50 years; although the <30 year group had the lowest OR, there was no evidence of a significant trend in risk ($P_{trend} = 0.86$). It is worth noting that 88% of the subjects in this study were men who may have had lower exposures to cooking smoke than women.

A study of women in Chandigarh India[10] reported a higher risk of lung cancer associated with wood used for cooking for more than 45 years [OR 1.11 (0.34, 3.60)], compared to use for less than 45 years [OR 0.74 (0.2, 2.65)]. Although adjusted for age, education and cumulative tobacco smoking, the numbers of female cases was small (n=30) and the results non-significant. Larger numbers of cases were available for men, but analysis by duration of exposure to wood for cooking showed no evidence of a trend.

The case-control study from Mexico City with 113 female lung adenocarcinoma cases [14] divided exposure to cooking with wood into four categories; none, 1-20 years, 21-50 years and >50 years of cooking. An increased risk was only found in women who had used wood for cooking for > 50 years (adjusted OR 1.9, 1.1, 3.5)(Table 2).

See main text for discussion on the contributions to evidence on exposure-response relationships of findings from (i) re-analysis of Lissoswska et al (2005), and (ii) geographical variations in risk.

5. References

1. Chen CJ, Wu HY, Chuang YC, et al. Epidemiologic characteristics and multiple risk factors of lung cancer in Taiwan. Anticancer Res 1990;**10**(4):971-6.
2. Mzileni O, Sitas F, Steyn K, et al. Lung cancer, tobacco, and environmental factors in the African population of the Northern Province, South Africa. Tobacco Control 1999;**8**:4.
3. Pisani P, Srivatanakul P, Randerson-Moor J, et al. GSTM1 and CYP1A1 polymorphisms, tobacco, air pollution, and lung cancer: a study in rural Thailand. Cancer Epidemiol Biomarkers Prev 2006;**15**(4):667-74.
4. Ramanakumar AV, Parent ME, Siemiatycki J. Risk of lung cancer from residential heating and cooking fuels in Montreal, Canada. Am J Epidemiol 2007;**165**(6):634-42.
5. Shen M, Chapman RS, He X, et al. Dietary factors, food contamination and lung cancer risk in Xuanwei, China. Lung Cancer 2008;**61**(3):275-82.
6. Shen XB, Wang GX, Huang YZ, et al. Analysis and estimates of attributable risk factors for lung cancer in Nanjing, China. Lung Cancer 1996;**14 Suppl 1**:S107-12.
7. Hosseini M, Naghan PA, Karimi S, et al. Environmental risk factors for lung cancer in Iran: a case–control study. International Journal of Epidemiology 2009;**38**(4):989-96.
8. Gao YT, Blot WJ, Zheng W. Lung cancer among Chinese women. International Journal of Cancer 1987 1987;**40**:5.
9. Sapkota A, Gajalakshmi V, Jetly DH, et al. Indoor air pollution from solid fuels and risk of hypopharyngeal/laryngeal and lung cancers: a multicentric case-control study from India. Int J Epidemiol 2008;**37**(2):321-8.
10. Gupta D, Boffetta P, Gaborieau V, et al. Risk factors of lung cancer in Chandigarh, India. Indian J Med Res 2001;**113**:142-50.
11. Lissowska J, Bardin-Mikolajczak A, Fletcher T, et al. Lung cancer and indoor pollution from heating and cooking with solid fuels: the IARC International Multicenter Case-Control Study in Eastern/Central Europe and the United Kingdom. American Journal of Epidemiology 2005;**162**(4):326-33.
12. Liu Q, Sasco AJ, Riboli E, et al. Indoor air pollution and lung cancer in Guangzhou, People's Republic of China. Am J Epidemiol 1993;**137**(2):145-54.
13. Behera D, Balamugesh T. Indoor air pollution as a risk factor for lung cancer in women. J Assoc Physicians India 2005;**53**:190-2.
14. Hernandez-Garduno E, Brauer M, Perez-Neria J, et al. Wood smoke exposure and lung adenocarcinoma in non-smoking Mexican women. Int J Tuberc Lung Dis 2004;**8**(3):377-83.
15. Ko YC, Lee CH, Chen MJ, et al. Risk factors for primary lung cancer among non-smoking women in Taiwan. Int J Epidemiol 1997;**26**(1):24-31.
16. Koo LC, Lee N, Ho JH. Do cooking fuels pose a risk for lung cancer? A case-control study of women in Hong Kong. Ecol Dis 1983;**2**(4):255-65.
17. Lee CH, Ko YC, Cheng LS, et al. The heterogeneity in risk factors of lung cancer and the difference of histologic distribution between genders in Taiwan. Cancer Causes Control 2001;**12**(4):289-300.

18. Sobue T. Association of indoor air pollution and lifestyle with lung cancer in Osaka, Japan. Int J Epidemiol 1990;**19 Suppl 1**:S62-6.
19. Tang L, Lim W-Y, Eng P, et al. Lung cancer in Chinese women: evidence for an interaction between tobacco smoking and exposure to inhalants in the indoor environment. Environ Health Perspect 2010;**118**(9):1257-60.
20. Malats N, Camus-Radon A-M, Nyberg F, et al. Lung Cancer Risk in Nonsmokers and GSTM1 and GSTT1 Genetic Polymorphism. Cancer Epidemiology Biomarkers & Prevention 2000;**9**(8):827-33.
21. Hosgood DI, Boffetta P, Greenland S, et al. In-Home Coal and Wood Use and Lung Cancer Risk: A Pooled Analysis of the International Lung Cancer Consortium. Environ Health Perspect 2010;**118**(12):1743-47.
22. Chan WC, Colbourne MJ, Fung SC, et al. Bronchial cancer in Hong Kong 1976-1977. Br J Cancer 1979;**39**(2):182-92.