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Lung Cancer and Indoor Pollution from Heating and Cooking with Solid Fuels

The IARC International Multicentre Case-Control Study in Eastern/Central Europe and the United Kingdom

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Exposure to fuel from cooking and heating has not been studied in Europe, where lung cancer rates are high and many residents have had a long tradition of burning coal and unprocessed biomass. Study subjects included 2,861 cases and 3,118 controls recruited during 1998–2002 in the Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, and the United Kingdom. The odds ratio of lung cancer associated with solid fuel use was 1.22 (95% confidence interval (CI): 1.04, 1.44) for cooking or heating, 1.37 (95% CI: 0.90, 2.09) for solid fuel only for cooking, and 1.24 (95% CI: 1.05, 1.47) for solid fuels used for both cooking and heating. Risk increased relative to the percentage of time that solid fuel was used for cooking ($p_{trend} < 0.0001$), while no risk increase was detected for solid fuel used for heating. The odds ratio of lung cancer in whole-life users of solid cooking fuel was 1.80 (95% CI: 1.35, 2.40). Switching to nonsolid fuels resulted in a decrease in risk. The odds ratio for the longest duration of time since switching was 0.76 (95% CI: 0.63, 0.92). The data suggest a modest increased risk of lung cancer related to solid-fuel use for cooking rather than heating.

air pollution, indoor; case-control studies; cookery; Europe; fossil fuels; heating; lung neoplasms

Abbreviations: CI, confidence interval; OR, odds ratio.

One lifestyle factor associated with urbanization is the use of cleaner fuels for domestic cooking and heating. Urbanized areas are increasingly likely to use modern fuels and energy sources, such as kerosene, gas, and electricity. In

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contrast, rural communities in poor countries still rely heavily or exclusively on biomass fuels, such as wood and dung. Of the four components of indoor pollution (combustion products, chemicals, radon, and biologic agents), combustion-generated pollutants, principally those from solid-fuel (wood, charcoal, crop residues, dung, and coal) cooking and heating stoves, have been the focus of research in developing countries.

A number of studies have been carried out to address the health effects of use of such stoves. Exposure to combustion products from solid fuels has been considered an important cause of several diseases in developing countries, including acute respiratory infections, chronic obstructive pulmonary disease, and cancer of the lung, nasopharynx, and larynx (1–5). Biomass and coal smoke contain a large number of pollutants, including particulate matter, carbon monoxide, nitrogen dioxide, sulfur oxides, formaldehyde, polycyclic organic compounds, and metals, such as arsenic (6). In addition, some coal produces substantial indoor exposure to arsenic (3). Smoky coal has been found to be more carcinogenic than cleaner coal and wood smoke when tested on mouse skin (7).

A consistent body of evidence, particularly from China, has shown that women exposed to smoke from coal fires in their homes have an elevated risk of lung cancer (5, 8–10). Several studies in China have found cooking stove smoke to be a strong risk factor for lung cancer among nonsmoking women (11, 12). There is also some evidence that stove improvements can substantially reduce indoor air pollution and the risk of lung cancer (13).

One study outside a developing country context addressed the cancer risk from domestic coal burning. Wu et al. (14), in a population-based case-control study of lung cancer among White women in Los Angeles County, California, reported elevated risks for lung cancer in relation to reporting heating or cooking with coal burned on a stove or fireplace during childhood and the teenage years. For adenocarcinoma, the smoking-adjusted odds ratio was 2.3 (95 percent confidence interval (CI): 1.0, 5.5) and, for squamous cell carcinoma, it was 1.9 (95 percent CI: 0.5, 6.5).

Exposure from stove use has not been studied in Europe where lung cancer rates are high and many residents have had a long tradition of burning coal and unprocessed biomass (wood, crop residues) for heating and cooking.

We report the results of a large case-control study conducted in six Central and Eastern European countries and one center from the United Kingdom to evaluate the contribution of combustion fumes from cooking and heating at home to the development of lung cancer. The center in the United Kingdom, located in Liverpool, was included in the study because of its similarities in both the prevalence of lung cancer and the prevalence of the main risk factors for lung cancer (high tobacco smoking, low educational level, and low socioeconomic status) to the studied Central and Eastern European countries.

MATERIALS AND METHODS

A multicenter case-control study was conducted during 1998–2001 in seven countries: the Czech Republic (three centers), Hungary (four centers), Poland (two centers), Romania (one center), Russia (one center), Slovenia (three centers), and the United Kingdom (one center). Incident cases of lung cancer between the ages of 20 and 79 years were identified through the main hospitals in participating centers. Only cytologically or histologically confirmed cases were eligible for study. Apart from two centers, hospital-based controls were selected and used from a prespecified list of persons with diseases that excluded other cancers or tobacco-related diseases. Population-based controls were selected from residents of the Warsaw, Poland, and Liverpool, United Kingdom, study areas for those centers. Controls were frequency matched to cases by geographic area (15 centers), 5-year age group, and gender. The study protocol was approved by the relevant ethical review committees, and participants gave written, informed consent according to the local regulations.

In-person, structured interviews were conducted on subjects to obtain information on demographic characteristics, tobacco and alcohol use, second-hand smoking, medical history and history of lung-related diseases, family history of cancer, dietary habits, occupational history, and residential history. For each residence of more than 1 year, we queried subjects about the principal fuel types used for heating and cooking in each home. Before the start of data collection, we tried to eliminate an effect of intercenter differences in both questionnaire translation (we conducted backward and forward translations) and questionnaire administration (coordinators of interviewers were trained by the International Agency for Research on Cancer).

About 10 percent of the subjects invited to participate in the study were excluded because they refused (5.9 percent of cases and 7.0 percent of controls), the diagnosis of primary lung cancer was not confirmed (2.7 percent of cases), the patients were discharged from the hospital, were too ill, or had died (1.5 percent of cases), or data about age, tobacco consumption, or fuel use were missing (1.7 percent of cases and 0.9 percent of controls). The total study population included in the analysis comprised 2,861 cases and 3,118 controls.

For the purpose of current analyses, we distinguished between modern nonsolid fuels (gas and kerosene), including electricity, and traditional solid fuels (coal and biomass, mainly wood). Initially, the effect of ever having used solid fuels (vs. only modern fuels) was analyzed by use of a binary exposure indicator for cooking and heating, respectively (relative to never used either fuel type). To assess dose-response relations, we estimated cumulative exposure as the percentage of subjects' lives spent in homes using solid fuel for cooking or heating, respectively. The effects of individual fuels (biomass or coal) and the effects of switching from solid fuels to modern fuels were also assessed.

We fitted unconditional logistic regression models to estimate the odds ratios and their 95 percent confidence intervals of lung cancer for exposure to solid fuels and the percentage of the subjects' lifetimes that solid fuels were used in their homes. Individuals who reported never using any solid fuel at home comprised the referent (unexposed) group. The odds ratios were adjusted by including terms for gender, age (nine categories), study center, educational level (five categories), and cumulative tobacco smoking (expressed in pack-years). Other smoking variables were evaluated as alternative adjustments for tobacco but did not materially change results (data not presented). In addition, further adjustments for consumption of fresh fruits or vegetables and for prior chronic diseases did not change results. As the fuels used for cooking and for heating were correlated, some models included both exposures. Tests for trend were performed by scoring the categories and entering these ordinal variables in the regression analysis. We assessed heterogeneity by comparing regression models with and without interaction terms, based on the likelihood ratio test.

RESULTS

Table 1 shows the characteristics of the 5,979 subjects included in the analysis. Comparison of the demographic variables revealed that cases tended to be slightly older and less educated than controls. They were more likely to have smoked tobacco than were controls.

About 82 percent of the study population ever used any solid fuel for cooking or heating in their homes (80.5 percent for cooking and 88.7 percent for heating), the most common fuel being coal (table 2). Modern fuels were usually used in combination with solid fuels, with only 377 individuals reporting exclusive use of modern fuels. Gas was the most commonly used modern fuel for cooking (87.4 percent), and electricity was the most common fuel for heating (74.3 percent).

The odds ratio of lung cancer was significantly increased for ever used solid fuel (either for cooking or heating) (odds ratio (OR) = 1.22, 95 percent CI: 1.04, 1.44) (table 3). Risk was higher for those using solid fuel for cooking than for heating. The odds ratio of lung cancer rose with the increasing percentages of time that solid fuel was used for cooking (ORs = 1.10, 1.18, 1.52; $p < 0.0001$) and heating (ORs = 1.08, 1.13, 1.35; $p < 0.0002$) compared with never using solid fuels for both cooking and heating. Slightly increased estimates were seen for cooking, but the effect for heating with solid fuel disappeared when additional adjustment was made for the time solid fuel was used for heating or cooking, respectively. Among those who used only wood for cooking, the odds ratio of lung cancer was 1.23 (95 percent CI: 1.00, 1.52). The odds ratio for exclusive use of wood for heating was 1.31 (95 percent CI: 1.06, 1.61).

When we stratified the analysis by country, gender, education, smoking status, years since tobacco quitting, and occupation, we did not find significant differences in odds ratio (table 4). The association between percent of lifetime using solid fuel for cooking and lung cancer risk was strong in Hungary, Poland, and Romania; weak in Russia; and absent in the Czech Republic, Slovakia, and the United Kingdom. The odds ratio for exposure to solid cooking fuel was significantly increased among smokers but not among never smokers. Separate analyses for the main histologic types of lung cancer showed similar dose-response relations across the three main histologic types (squamous cell carcinoma, adenocarcinoma, small cell carcinoma). The results shown in tables 3 and 4 were not altered by adjustment for consumption of fresh vegetables and fruits or for prior chronic lung diseases. Similarly, exclusion of the Liverpool center from the analysis did not appreciably affect the results (data not presented).

TABLE 1. Characteristics of the study population, Eastern/Central Europe and United Kingdom, 1998–2002

	Cases (n = 2,861)		Controls (n = 3,118)		χ^2 p value
	No.	%	No.	%	
Gender					
Men	2,205	77.1	2,305	73.9	
Women	656	22.9	813	26.1	0.005
Country					
Czech Republic	304	10.6	494	15.8	<0.001
Hungary	402	14.0	331	10.6	
Poland	800	28.0	847	27.2	
Romania	181	6.3	258	8.3	
Russia	600	21.0	600	19.2	
Slovakia	346	12.1	354	11.4	
United Kingdom	228	8.0	234	7.5	
Age (years)					
<40	30	1.0	64	2.1	0.012
40–49	356	12.4	389	12.5	
50–59	848	29.6	911	29.2	
60–69	1,097	38.3	1,133	36.3	
≥70	530	18.5	621	19.9	
Educational level					
1 (lowest)	275	9.6	249	8.0	<0.001
2	1,049	36.7	970	31.1	
3	664	23.2	788	25.3	
4	562	19.7	633	20.3	
5 (highest)	308	10.8	478	10.8	
Tobacco (pack-years)					
Never	223	7.8	1,039	33.5	<0.001
0.1–5.0	42	1.5	221	7.1	
5.1–11.0	88	3.1	185	6.0	
11.1–16.5	129	4.5	226	7.3	
16.6–21.0	157	5.5	204	6.6	
21.1–26.0	245	8.6	210	6.8	
26.1–30.0	244	8.6	188	6.1	
30.1–35.5	347	12.2	215	6.9	
35.6–41.5	414	14.5	207	6.7	
41.6–50.0	443	15.5	210	6.8	
≥50.1	520	18.2	199	6.4	
Histology					
Squamous cell carcinoma	1,140	39.8			
Adenocarcinoma	592	20.7			
Small cell carcinoma	395	13.8			
Large cell carcinoma	75	2.6			
Mixed cell carcinoma	91	3.3			
Other or not otherwise specified	561	19.6			

TABLE 2. Fuel use (percent of ever use by country), Eastern/Central Europe and United Kingdom, 1998–2002

Fuel	Romania	Hungary	Poland	Russia	Slovakia	Czech Republic	United Kingdom	Total
Cooking								
Ever modern								
Gas	91.6	68.1	92.2	93.1	83.1	82.6	97.2	87.4
Electricity	0	8.9	8.9	36.5	22.3	31.5	42.9	21.0
Kerosene	0	0.7	0	0	0	0.1	0	0.1
Ever traditional								
Coal	0	37.1	86.2	4.6	48.1	60.8	14.7	44.1
Wood	76.1	44.1	12.4	70.4	43.6	21.1	0	36.4
Unknown	0	8.9	0	0	24.0	0.8	1.5	4.1
Heating								
Ever modern								
Gas	22.6	47.1	5.1	2.8	28.4	35.0	16.9	18.7
Electricity	67.9	22.5	88.5	99.0	68.4	65.8	71.4	74.3
Kerosene	0.5	3.3	0	11.8	0	3.8	0	3.3
Ever traditional								
Coal	0.5	48.0	90.0	5.1	63.0	76.1	14.1	50.4
Wood	87.9	39.0	12.6	74.3	41.9	18.7	16.5	38.3
Unknown	0	9.8	0.2	0	3.9	0.6	0	1.8

Users of solid fuels for cooking throughout their entire lives were at elevated risk of getting lung cancer (OR = 1.80, 95 percent CI: 1.35, 2.40), while those who had switched to modern fuels had only a moderately increased risk (OR = 1.16, 95 percent CI: 1.00, 1.34) compared with those who never used solid fuels (table 5). The odds ratio of lung cancer decreased significantly with time since switching to modern fuels (for the longest time: OR = 0.76, 95 percent CI: 0.63, 0.92). We did not find a significantly increased risk for those who were exposed to solid cooking fuels only during their childhood (OR = 1.05, 95 percent CI: 0.89, 1.25); however, risk significantly increased with adult use of solid fuels for cooking (OR = 1.32, 95 percent CI: 1.11, 1.57).

DISCUSSION

We detected a modestly elevated risk of lung cancer among subjects who used solid fuels for cooking, but we did not detect a similar association with solid fuels used for heating. The risk of lung cancer increased with percentage of the lifetime that solid fuels were used for cooking and decreased with time since switching from solid fuels to modern fuels. In addition, when comparing cooking by coal with cooking by wood, we found a significant increase in risk related to wood. However, we cannot rule out that the association was due to some mixed (wood and coal) exposures, because subjects provided their principal fuel (if they used mainly coal but some wood, they would have indicated coal).

The results from our study are generally consistent with those from previous studies; however, ours is unique in that we can separate the effects of cooking and heating. Our results suggest that the lung cancer risk was principally due to cooking. It might be that the exposures from cooking and heating differ because of different conversion technologies. Although studies from China and India dominate the exposure literature, the high risks relate to burning coal in an open stove with no chimney, and so the relevance to exposure situations in both Eastern and Central Europe and the United Kingdom is limited. In these latter countries with a cold climate and relatively higher living conditions, there is a long tradition of household use of solid fuel, and vented stoves with better energy technologies were developed.

A weakness of previous indoor air pollution studies has been the inadequacy with which confounding factors have been assessed and adjusted for, because confounding presents a particular problem for observational studies of this topic (2, 15). In this study, models included terms for potential confounders, such as smoking, education, consumption of fruits/vegetables, and the presence of occupational diseases (the last two did not change estimates appreciably and so were not included in the final models). We also examined the effect of indoor air pollution from solid-fuel use in different strata defined by country, gender, age, education, tobacco, and histologic type. A significant increase in risk due to cooking with solid fuels was observed only among smokers. The lack of an effect in nonsmokers can be explained (in addition to low power) by an interaction between air pollutants and carcinogens in tobacco. Residual confounding is also a possible explanation, but we

TABLE 3. Lung cancer risk by solid-fuel use for cooking and heating, Eastern/Central Europe and United Kingdom, 1998–2002

	Cases (no.)	Controls (no.)	Odds ratio*	95% confidence interval	Odds ratio†	95% confidence interval
Ever solid fuel (cooking or heating)						
No	482	588	1.00‡			
Yes	2,379	2,530	1.22	1.04, 1.44		
Solid heating only	215	250	1.08	0.84, 1.38		
Solid cooking only	58	54	1.37	0.90, 2.09		
Solid cooking/heating	2,106	2,226	1.24	1.05, 1.47		
Cooking fuel						
Ever coal/never wood	872	896	1.13	0.94, 1.38		
Ever wood/never coal	1,065	1,124	1.23	1.00, 1.52		
Ever both	166	203	0.98	0.74, 1.29		
% of lifetime used solid fuel for cooking						
>0–25	452	523	1.10	0.89, 1.35	1.16	0.90, 1.51
>25–50	1,003	1,151	1.18	0.98, 1.42	1.29	
>50	709	606	1.52	1.23, 1.82	1.73	
p_{trend}			<0.0001		<0.0001	
Heating fuel						
Ever coal/never wood	772	819	1.08	0.89, 1.31		
Ever wood/never coal	1,105	1,153	1.31	1.06, 1.61		
Ever both	226	251	1.04	0.82, 1.35		
% of lifetime used solid fuel for heating						
>0–25	377	433	1.08	0.87, 1.35	1.00	0.79, 1.25
>25–50	1,040	1,205	1.13	0.95, 1.36	0.95	0.76, 1.19
>50	904	838	1.35	1.12, 1.64	1.07	0.82, 1.39
p_{trend}			0.0002		0.42	

* Adjusted for center, age, gender, education, and tobacco pack-years.
† Additionally adjusted for duration of solid-fuel use for heating or cooking, respectively.
‡ Referent category for all odds ratios in this table.

have tried to address it by incorporating different smoking variables into the regression model.

In China, the odds ratios for lung cancer among women exposed to coal smoke at home, particularly that of smoky coal, were in the range of 2–5 (16, 17). A recent meta-analysis suggested overall a twofold risk in relation to domestic coal use in cooking and heating (18).

There is one study addressing the potential reduction of risk of lung cancer resulting from improvement of stoves used in homes. A retrospective cohort study in China found a statistically significant drop in lung cancer rates associated with the introduction of improved stoves with chimneys (13). The lag between the intervention and the reduction in lung cancer was about 10 years, which is consistent with that observed after smoking cessation. In our study, we confirmed the reversibility of the effect of smoke from cooking by solid fuel on lung cancer risk. In contrast, a population-based, case-control study among White women in Los Angeles County, California, suggested that the increased risk persists over a very long period of time (14). Elevated risks for lung cancer were reported in relation to heating or cooking with coal burned in a stove or fireplace during childhood and teenage years. We did not confirm this result. Instead, we found that the increased risk appeared to result from long-term exposure and that the decreased risk seemed to occur according to the timing of a switch to less polluting, nonsolid fuels. One of the limitations of the Los Angeles study was that they collected information on fuel use only during childhood and teenage years, not on lifetime use.

Most of the previous positive studies were conducted on female populations, although other studies conducted on both sexes have not found significant differences in risk by gender (5). We did not reveal any heterogeneity by gender in our study, although it is expected that women in traditional Eastern European families had more opportunities for exposure than did males, because the latter did not cook. On the other hand, typical houses and apartments in this area were very small, and the kitchen was an important

TABLE 4. Odds ratios for duration of solid-fuel use stratified by country, gender, tobacco use, and histology (adjusted by center, age, gender, education, and tobacco pack-years), Eastern/Central Europe and United Kingdom, 1998–2002

	% of time cooking with solid fuel						Test for heterogeneity (*p* value)
	>0–25		>25–50		>50		
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	
Country							0.25
Czech Republic	1.27	0.76, 2.15	1.40	0.89, 2.20	1.12	0.67, 1.87	
Hungary	1.16	0.73, 1.83	1.40	0.93, 2.11	2.23	1.45, 3.44	
Poland	1.00	0.54, 1.84	1.29	0.83, 2.00	1.73	1.15, 2.60	
Romania	2.05	0.96, 4.37	1.57	0.86, 2.85	1.82	1.00, 3.32	
Russia	1.04	0.74, 1.47	1.03	0.77, 1.39	1.45	0.87, 2.42	
Slovakia	0.66	0.36, 1.21	0.82	0.50, 1.32	1.11	0.64, 1.94	
United Kingdom	1.03	0.54, 1.94	0.87	0.26, 2.86			
Gender							0.58
Males	1.04	0.84, 1.29	1.18	0.98, 1.43	1.64	1.33, 2.03	
Females	1.17	0.78, 1.76	1.09	0.77, 1.56	1.38	0.93, 2.04	
Educational level							0.62
1 (lowest)	0.99	0.45, 2.19	0.95	0.51, 1.76	1.54	0.85, 2.81	
2	1.06	0.82, 1.35	1.09	0.88, 1.36	1.38	1.09, 1.74	
3 (highest)	1.09	0.81, 1.46	1.17	0.91, 1.52	1.70	1.18, 2.43	
Tobacco smoking							0.11
Never smokers	1.04	0.61, 1.75	0.93	0.60, 1.45	1.06	0.64, 1.76	
Ever smokers	1.06	0.87, 1.28	1.14	0.96, 1.35	1.65	1.36, 2.01	
Light smokers (≤20 pack-years)	1.25	0.81, 1.91	1.03	0.71, 1.49	1.73	1.15, 2.61	0.14
Heavy smokers (>20 pack-years)	0.96	0.77, 1.21	1.19	0.97, 1.45	1.60	1.22, 2.03	
Years since tobacco quitting							0.27
Nonquitters	0.99	0.78, 1.27	1.31	1.05, 1.62	1.77	1.38, 2.27	
Short-term quitters (<20 years)	1.35	0.86, 2.11	1.09	0.73, 1.64	1.61	1.03, 2.51	
Long-term quitters (≥20 years)	0.94	0.42, 2.08	0.87	0.41, 1.84	1.92	0.84, 4.36	
Longest held occupation							0.58
Nonindustrial	1.25	0.87, 1.80	1.22	0.89, 1.68	1.64	1.14, 2.38	
Industrial	0.99	0.80, 1.24	1.13	0.93, 1.37	1.49	1.19, 1.85	
Histology							
Squamous cell carcinoma	1.00	0.76, 1.30	1.28	1.02, 1.60	1.72	1.34, 2.22	
Adenocarcinoma	1.17	0.87, 1.60	1.10	0.85, 1.43	1.59	1.19, 2.13	
Small cell carcinoma	1.22	0.81, 1.85	1.14	0.79, 1.64	1.66	1.15, 2.42	
Large cell carcinoma	1.81	0.85, 3.38	1.09	0.54, 2.22	1.24	0.59, 2.63	

place for family meetings and often for sleeping. Another explanation might come from the possible bias arising from the indirect approach to exposure estimation, that is, asking about the fuel type used. Ezzati et al. (19) have shown that, after including high-intensity exposure episodes into the analyses (by controlling for the amount of cooking activity), gender was no longer a significant predictor of acute respiratory infection. This finding would suggest that the role of gender is a substitute for exposure patterns (that is a proxy for the variable of high-intensity exposure).

The limitations of our study include the absence of individual air pollution exposure levels in homes and the possible misclassification of exposure. It was not possible to separate completely the effects of traditional solid fuel and modern nonsolid fuel, because subjects were exposed to different fuels at different times in their lives.

TABLE 5. Effect of switching from solid cooking fuels to nonsolid cooking fuels, Eastern/Central Europe and United Kingdom, 1998–2002

	Cases (no.)	Controls (no.)	Odds ratio*	95% confidence interval
Solid fuel used for cooking				
Never user	728	859	1.00†	
Former user	1,919	2,114	1.16	1.00, 1.34
Whole-life user	196	145	1.80	1.35, 2.40
Years since switching to nonsolid fuels‡				
<35 years	805	780	1.00†	
35–44 years	514	593	0.85	0.71, 1.00
≥45 years	600	741	0.76	0.63, 0.92
p_{trend}			0.001	
Period solid fuel used for cooking				
Never	728	859	1.00†	
Only childhood (<20 years of age)	678	795	1.05	0.89, 1.25
Only adult (≥20 years of age)	695	731	1.32	1.11, 1.57
Childhood and some adult	564	588	1.23	1.02, 1.49
Whole life	196	146	1.81	1.36, 2.41

* Adjusted for center, gender, age, education, and tobacco.
† Referent.
‡ Computed among those who switched from solid to nonsolid fuels.

Although direct measurements were not available to estimate quantitative exposure levels in the areas of our study, some information is available. In the Global Burden of Disease study recently undertaken by the World Health Organization, the relative potential of exposure to various factors including indoor air pollution was estimated by country and region. For the countries of Eastern Europe and the former Soviet Union, their rounded estimate was that the exposures would be one fifth of the poorly ventilated solid-fuel burning situations, per unit of solid fuel burned (18). In the same review, they conducted meta-analyses of studies published up to 1999, looking at reported coal use. Based on five Chinese studies, the estimated odds ratio for lung cancer (males and females), adjusted for smoking or restricted to nonsmokers, was 1.86 and 2.55 when adjusted for smoking and chronic airway disease. These results are comparable in magnitude to the US study of women (14).

Despite the well-recognized methodological limitations of indirect assessment of indoor pollution, to our knowledge, this is the largest and most informative study on indoor pollution ever conducted on non-Asian populations. Our data suggest a modestly increased risk of lung cancer related to solid-fuel burning in the home, possibly due to cooking rather than heating. Shifts to higher quality, low-emission fuels, such as kerosene, gas, or electricity, reduced the health impact of household use of solid fuel. In Europe, we are observing a steady decrease in the use of solid fuel, as economic development and urbanization proceed in this region. This shift has occurred most rapidly in the United Kingdom, the Czech Republic, and Slovakia. An observed lack of effect in the Czech Republic and the United Kingdom might be due to use of different types of coal or different types of stoves in these countries. There is a long tradition of using brown coal in the former Czechoslovakia and anthracite (a cleaner, black coal) in the United Kingdom, compared with other countries of this study. Alternatively, given the lack of significance of the test for heterogeneity across countries, the differences might be a chance finding.

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