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# Risk Factors for Primary Lung Cancer among Non-Smoking Women in Taiwan

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*Background.* Although cigarette smoking is considered to be the most important cause of lung cancer, smoking behaviour cannot fully explain the epidemiological characteristics of lung cancer in Taiwanese women, who rarely smoke but contract lung cancer relatively often. There are other causes of lung cancer that have produced variability in lung cancer incidence.

*Methods.* A case-control study involving interviews with 117 female patients (including 106 non-smoking) suffering from lung cancer and the same number of individually matched hospital controls was conducted in Kaohsiung, Taiwan between 1992 and 1993. The questionnaire administered to cases and controls collected information on cigarette smoking and suspected risk factors for lung cancer. Multivariate logistic regression analysis was applied to assess smoking for all women and suspected risk factors for non-smoking women.

*Results.* The relationship between cigarette smoking and lung cancer was statistically significant although only a small proportion (9.4%) of female patients had smoked. However, the risk of contracting cancer for non-smoking women appears to be associated with certain cooking practices, especially preparing meals in kitchens not equipped with a fume extractor at cooking age of 20–40 years (odds ratio [OR] = 8.3; 95% confidence interval [CI] : 3.1–22.7. These factors and a history of pulmonary tuberculosis plus low consumption of fresh vegetables explained 78% of the summary attributable risks for non-smoking women in a multivariate logistic regression model.

*Conclusions.* Exposure to fumes from cooking oils, when not reduced by an extractor, may be an important factor in causing lung cancer in non-smoking Taiwanese women.

*Keywords*: epidemiology, lung neoplasm, smoking, fume extractor, cooking oil fume, Taiwan

Since 1982, cancer has been the leading cause of mortality in Taiwan. Among all cancers, the lung is the second most frequently affected site for both men and women. Lung cancer has also been the leading cause of cancer death in women since 1986.[1] Although cigarette smoking is considered to be the most important cause of lung cancer, smoking behaviour cannot fully explain the epidemiological characteristics of lung cancer in Taiwanese women,[2,3] who, like Chinese women in the US,[4] Australia,[5] Hong Kong,[6] Singapore,[7] Malaysia,[8] and in some cities on mainland China;[9] smoke relatively rarely but contract lung cancer relatively often.

Epidemiological surveys worldwide have consistently shown that the overwhelming majority of male lung cancer patients (more than 97%) have a history of cigarette smoking. Among female lung cancer patients there are generally fewer smokers and the figures are more variable (6–92%).[10] The lower percentages of smokers among Chinese female lung cancer patients were reported from Hong Kong (56%), Singapore (52%), San Francisco (44%), mainland China (35%) and Hawaii (22%), compared with 70–90% in Europe and America.[10] In Taiwan, only 10% of smokers in female lung cancer patients was observed, whereas 86% male lung cancer patients had a history of smoking.[11] Furthermore, the prevalence rate of cigarette smoking was 55–60% in males, 3–4% in females aged over 16 years observed in the nationwide annual investigation.[12] The trend was steady over the past 30 years but there has been a small decrease in recent years possibly related to health education. If smoking was the sole major cause of lung cancer, then the above rate differences between male and female lung cancer patients and smoking behaviour in the general population of Taiwan appear to be contradictory. Thus, in addition to smoking there are

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other causes of lung cancer that produce variability in lung cancer incidence.

Passive smoking,[13,14] occupational exposure to carcinogens,[15,16] ambient air pollutants,[17,18] dietary factors,[19,20] cooking fuels[21,22] are risk factors that could independently cause lung cancer. This hospital-based, matched case-control study was designed to clarify the risk factors for lung cancer and their role among non-smoking women in Taiwan.

## MATERIALS AND METHODS

### Study Population

This study was conducted with a hospital-based, case-control design and the source population was geographically defined from the greater Kaohsiung area, which included a city and some suburban and rural communities.

The cases were drawn from Kaohsiung Medical College Hospital, which is regarded as a leading teaching hospital in South Taiwan, and is accessible to patients from all socioeconomic categories. All newly hospitalized women, suspected of suffering from primary carcinoma of the lung (ICD 9th Revision code 162) were verified by the pathologist and from hospital medical records. A total of 128 eligible lung cancer cases were identified between January 1992 and December 1993. Of these, five patients had died or been discharged by the time the interviewers visited the wards, two were too ill to participate, and four refused to be interviewed. In all 117 women suffering from lung cancer were interviewed.

The controls were selected from women presenting for a general health check or attending the ophthalmic department in the same hospital with non-smoking related disease. Of a total of 125 age-matched women, who were interviewed concurrently with the cases, 117 (94%) agreed to and completed the interview for the control group (62 female ophthalmic patients and 55 women presenting for a health check). A female control was matched to each case by age (± 2 years) and date of interview.

### Interviews

Two interviewers completed a questionnaire for all cancer cases and controls by the cross-over method (unaware of the hypothesis being explored). They collected information on demographic characteristics, smoking habit, exposure to environmental tobacco smoke, history of lung diseases, occupation, dietary factors, lifetime residence, and cooking practices and conditions. A field supervisor checked all completed questionnaires and medical abstracts which were then transferred to coding sheets for analysis.

### Data Specification

To minimize errors in quantitative data due to incorrect recall, we used a structured questionnaire in order to collect categorized information. A smoker was defined as someone who had smoked one cigarette or more per day for at least one year. To assess passive smoking, we asked each woman about lifetime exposure to environmental tobacco smoke generated by parents, husband, cohabitants or co-workers. Anyone who lived or worked with a smoker and was exposed to tobacco smoke was considered to be a passive smoker. A history of pulmonary tuberculosis was defined as a bout of tuberculosis confirmed by a chest physician at least 3 or 4 years before the diagnosis of lung cancer. Occupational history involved a lifetime list of jobs which were held for at least one year at a time. According to occupational exposure to airborne contaminants, each main job was classified into one of four categories: administration, hazardous industry, farmer, others, and the category of hazardous industry included iron foundries, and petroleum, chemical and cement factories. Information on daily diet habits was collected with 12 food items, which included the frequency and quantity of consumption of meat, vegetable, fruit, pulses, pickles, etc. The place of residence where the interviewee had resided for at least 5 years and/or longest, was considered as main residence (average duration is 47.9 ± 17.9 years for cases, and 45.4 ± 18.1 years for controls), and if this was within 3 km of a major industrial site, the interviewee was classified as living adjacent to an industrial district. Furthermore, we asked each housewife who had to cook for her family about cooking practices and conditions, such as the cooking fuel used, use of cooking oils and use of fume extractors, amounts, frequencies, personal preferences and dietary habits, etc. Cooking conditions were classified into three cooking ‘age stages’ according to a housewife’s lifetime cooking exposure: cooking before 20 years of age represents early cooking exposure (stage I exposure); cooking at 20–40 years of age represents main cooking exposure (stage II exposure); cooking after 40 years of age represents late cooking exposure (stage III exposure), and the age that cooking started was when a housewife cooked regularly on a daily basis.

### Statistical Analysis

The authors analysed the information by using the statistical software of STATA,[23] which included $\chi^2$ test for the similarity of demographic factors and a multivariate technique designed for matched case-control studies. The odds ratios (OR) of contracting lung cancer through associations with various factors and 95% confidence intervals (CI) of OR were estimated from

TABLE 1 *Demographic distributions of lung cancer cases and controls among non-smoking females, Taiwan, 1992–1993*

| Characteristic/category | Cases n = 105 % | Controls n = 105 % |
|---|---|---|
| Age (years) | | |
| <51 | 21.9 | 22.8 |
| 51–60 | 25.7 | 24.0 |
| 61–70 | 30.5 | 33.2 |
| >70 | 21.9 | 20.0 |
| Residential area | | |
| Urban | 35.2 | 41.0 |
| Suburban | 15.2 | 16.2 |
| Rural | 49.5 | 42.9 |
| Marital status | | |
| Single | 1.9 | 1.9 |
| Married | 79.1 | 80.0 |
| Others | 19.1 | 18.1 |
| Religion | | |
| Buddhism | 41.0 | 39.1 |
| Taoism | 18.1 | 12.4 |
| Folk religion | 32.4 | 37.1 |
| Others | 8.6 | 11.4 |
| Ethnicity | | |
| Fukienese | 90.5 | 87.6 |
| Mainland | 6.7 | 5.7 |
| Others | 2.9 | 6.7 |
| Years of education | | |
| None | 62.9 | 59.1 |
| 1–9 | 29.5 | 27.6 |
| 10+ | 7.6 | 13.3 |
| Socioeconomic status | | |
| Low | 14.3 | 18.1 |
| Median | 68.6 | 63.8 |
| High | 17.1 | 18.1 |

conditional logistic regression analysis.[24] Statistical significance of trends for matching pairs was calculated by categorizing the exposure variable and treating the scored variable as a continuous variable. All estimates of OR were adjusted for educational level (no formal education, 1–9 years, 10 or more years) as well as for residence area (urban, suburban, rural) and socioeconomic status (high, medium, low; a ranking score that combines income per family member, place of residence and residence conditions), in order to reduce residual confounding. To focus our regression analysis on the subgroup of non-smoking women, the few interviewees who smoked (11 cases, 3 controls) and their matching pairs were omitted from the computations (leaving 105 non-smoking matched pairs). Interaction effects of any two suspected risk factors were evaluated by incorporating two binary interaction terms for joint effects of two risk factors in the logistic regression models. The judgement of interaction was then performed by comparing observed with expected OR under the assumptions of additive and multiplicative models.[25] The authors employed Buzzi *et al*.'s method for estimating the proportion of lung cancer cases attributable to one or all risk factors considered (population attributable risks: PAR).[26]

## RESULTS

### *Cigarette Smoking*

Before the smoking matched pairs were deleted in data computation, the effect of cigarette smoking associated with female lung cancer was assessed. The few female smokers (9.4%) were compared with patients who never smoked. The smokers were adjusted for socioeconomic status, residential area and educational status, and were found to be at a 4.2 fold (95% CI : 1.1–15.6) increased risk of lung cancer (data not shown).

### *Distribution of Cancer Types*

The average age of non-smoking case interviewees (61.3 ± 12.6 years) was somewhat greater than that of controls (60.1 ± 13.2 years), but the age patterns of case-control pairs were closely matched. Non-smoking cancer patients mostly suffered from adenocarcinoma (64.8%), as well as from squamous cell carcinoma (17.1%), small cell carcinoma (15.2%) and large cell carcinoma (2.9%).

### *Demographic Characteristics*

The demographic distribution of cases and controls was tabulated by age and six characteristics for non-smoking females (Table 1). There were no statistical differences between cases and controls observed in this population. The demographic similarity of the two sources of controls was also examined for non-smoking patients, but no statistical differences were apparent.

### *Suspected Factors*

The risk of a non-smoking woman contracting lung cancer, whose husband was a smoker, was 30% higher than for a non-smoking woman whose husband never smoked, but this was not statistically significant. There were no case-control differences for having other cohabitants who smoked or being exposed to environmental tobacco smoke in the workplace (Table 2). The risk was significantly elevated for non-smoking women living near industrial districts. A significant dose-response relationship was constructed for risks versus duration of residence near a major industrial

TABLE 2 *Odds ratios (OR) and 95% confidence intervals (CI) of lung cancer associated with suspected factors among non-smoking females, Taiwan, 1992–1993*

| Factor/category | Cases No. | Controls No. | OR[a] (95% CI) |
|---|---|---|---|
| Parent smoking | | | |
| No | 80 | 77 | 1.0 |
| Yes | 25 | 28 | 0.8 (0.4–1.6) |
| Spouse smoking | | | |
| No | 32 | 37 | 1.0 |
| Yes | 73 | 68 | 1.3 (0.7–2.5) |
| Cohabitant smoking | | | |
| No | 85 | 85 | 1.0 |
| Yes | 20 | 20 | 1.0 (0.4–2.3) |
| Passive smoking from workplace | | | |
| No | 93 | 94 | 1.0 |
| Yes | 12 | 11 | 1.1 (0.4–3.0) |
| Occupations | | | |
| Administration | 54 | 56 | 1.0 |
| Hazardous industry | 6 | 5 | 1.2 (0.3–5.1) |
| Farmer | 30 | 30 | 0.9 (0.5–1.9) |
| Others | 15 | 14 | 1.1 (0.5–2.8) |
| Living adjacent to industrial district (years) | | | |
| None | 78 | 90 | 1.0 |
| 1–20 | 7 | 7 | 1.3 (0.4–3.8) |
| 21+ | 20 | 8 | 2.8 (1.2–6.5) |
| Chronic bronchitis | | | |
| No | 91 | 96 | 1.0 |
| Yes | 14 | 9 | 1.8 (0.7–4.8) |
| Tuberculosis | | | |
| No | 89 | 101 | 1.0 |
| Yes | 16 | 4 | 4.7 (1.5–14.7) |
| Alcohol drinking | | | |
| No | 98 | 98 | 1.0 |
| Daily | 7 | 7 | 1.0 (0.4–3.1) |
| Tea drinking | | | |
| No | 94 | 85 | 1.0 |
| Daily | 11 | 20 | 0.4 (0.2–1.1) |

[a] Odds ratios were derived from matched analyses adjusted for socioeconomic status, residential area and education.

complex ($P$ trend = 0.021). Risks of contracting lung cancer were also elevated for women who had had pulmonary tuberculosis, although chronic bronchitis and alcohol consumption appeared to be irrelevant.

*Cooking Practices and Dietary Factors*

Over 96% of non-smoking women participants stated that they regularly cooked the family meals, in accordance with Taiwanese tradition. The majority of cases (65.0%) and 55.4% of controls began cooking before they were 20 years old (Table 3). The risk of contracting lung cancer for women who began cooking before they were 20 years old was raised 1.6 fold compared with those who started after the age of 20 years. Chinese cooking involves frying ingredients in oil, which produces ample oil fumes to which the cook is exposed. The authors explored the carcinogenic risks to a housewife for three out of four normal cooking techniques involving frying in oil. Cancer risks were found to be independently related to stir frying, the way most Chinese food is prepared, and to frying, but not to deep frying (Table 3). After accounting for differences in socioeconomic status, area of residence and educational level, cancer risks for housewives who reported daily consumption of vegetables were found to be somewhat reduced.

TABLE 3 *Odds ratios (OR) and 95% confidence intervals (CI) of lung cancer associated with cooking practices and dietary factors among non-smoking females, Taiwan, 1992–1993*

| Factor/category | Cases No. | Controls No. | OR[a] (95% CI) |
|---|---|---|---|
| Age when first cooking (years)[b] | | | |
| 21+ | 36 | 45 | 1.0 |
| 7–20 | 67 | 56 | 1.6 (0.8–3.0) |
| Stir frying | | | |
| 0–4/week | 14 | 27 | 1.0 |
| 5+/week | 91 | 78 | 2.4 (1.1–5.2) |
| Frying | | | |
| 0–4/week | 29 | 44 | 1.0 |
| 5+/week | 76 | 61 | 2.3 (1.2–4.6) |
| Deep frying | | | |
| 0–4/month | 82 | 79 | 1.0 |
| 5+/month | 23 | 26 | 0.9 (0.5–1.9) |
| Consumption of meat | | | |
| 0–6/week | 47 | 47 | 1.0 |
| Daily | 58 | 58 | 0.9 (0.5–1.7) |
| Consumption of vegetables | | | |
| 0–6/week | 35 | 18 | 1.0 |
| Daily | 70 | 87 | 0.4 (0.2–0.8) |
| Consumption of fruit | | | |
| 0–6/week | 33 | 28 | 1.0 |
| Daily | 72 | 77 | 1.0 (0.5–1.7) |

[a] Odds ratios were derived from matched analyses adjusted for socio-economic status, residential area and education.
[b] No cooking housewives (2 cases and 4 controls) were excluded in the analyses.

TABLE 4 *Odds ratios (OR) and 95% confidence intervals (CI) of lung cancer associated with cooking conditions and cooking age stages among non-smoking females, Taiwan 1992–1993*

| Factor/category | Before 20 years of age | | 20–40 years of age | | After 40 years of age | |
|---|---|---|---|---|---|---|
| | Cases/controls No. | OR[a] (95% CI) | Cases/controls No. | OR[a] (95% CI) | Cases/controls No. | OR[a] (95% CI) |
| Cooking fuels | | | | | | |
| No cooking or gas | 40/53 | 1.0 | 38/50 | 1.0 | 94/90 | 1.0[d] |
| Coal or anthracite | 9/17 | 0.5 (0.2–1.6) | 14/16 | 1.1 (0.4–3.0) | 2/2 | 1.1 (0.1–8.0) |
| Wood or charcoal | 56/35 | 2.5 (1.3–5.1) | 53/39 | 2.5 (1.1–5.7) | 4/4 | 1.0 (0.2–3.9) |
| Cooking oils | | | | | | |
| No cooking | 38/49 | 1.0 | 2/4 | –[b] | 2/4 | –[b] |
| Lard | 51/44 | 1.6 (0.8–3.1) | 38/42 | 1.0 | 7/4 | 1.0[d] |
| Vegetable oil | 16/12 | 2.0 (0.8–4.8) | 65/59 | 1.4 (0.8–2.6) | 91/88 | 0.5 (0.1–2.2) |
| Kitchen with fume extractor | | | | | | |
| Yes[c] | 7/19 | 1.0 | 25/66 | 1.0 | 76/82 | 1.0[d] |
| No | 60/37 | 5.3 (1.1–25.6) | 78/35 | 6.4 (2.9–14.1) | 22/10 | 2.3 (1.1–5.1) |

[a] Odds ratios were derived from matched analyses adjusted for socioeconomic status, residential area and education.
[b] Because of the small number of no cooking housewives in age stage II and III, lard was referred to as reference category.
[c] Housewives who had kitchens with fume extractors were referred to as reference category, and no cooking housewives (cases/controls number are 38/49, 2/4, 2/4 by age stage of cooking) were excluded from the analyses.
[d] The matched sets aged <40 years either for cases or controls were excluded from the calculation.

*The Cooking Age*

In stage I exposure (cooking before 20 years of age) housewives tended to use wood or charcoal as fuels and animal oils (mainly lard) for frying; in stage II (cooking at 20–40 years of age) gas replaced wood and vegetable oils (mainly peanut or soybean oil) replaced animal oils; and in stage III (cooking after 40 years of age) gas cookers were equipped with fume extractors. After adjusting for demographic factors, housewives exposed in stage II without a fume extractor were 6.4 times more likely to develop cancer than in the other two stages. The protective effects of fume extractors during cooking before 20 years of age and after 40 years of age was also observed (Table 4).

*The Interaction Effects*

The combined effects of any two suspected risk factors were evaluated in the logistic regression equations. The OR thus obtained were compared with the risk estimates calculated under the assumption of additive and multiplicative effects. There were no significant findings for potential interaction effects, except between stir frying and the use of a fume extractor at cooking age of 20–40 years. Moreover, the high risk of stir frying, frying and deep frying using cooking oils was found to be dependent on a kitchen not being equipped with a fume extractor when cooking at 20–40 years of age. An additive interaction model is shown in Table 5.

*Multivariate Analyses*

Factors indicated by univariate analysis to be involved in the aetiology of lung cancer were evaluated simultaneously within a multivariate conditional logistic model. Cooking conditions and parameters of suspected risk factors for non-smoking women were entered into the regression model (Table 6). Of these, a history of pulmonary tuberculosis and the use of a fume extractor during cooking age of 20–40 years plus consumption of fresh vegetables were found to improve significantly the predictiveness of the regression model, i.e. these factors were significantly and independently associated with lung cancer.

*Population Attributable Risks*

Following multivariate analysis, the relative attributable fraction of a number of risk factors for lung cancer were assessed for non-smoking women (Table 6). The overall effects of risk due to the factors investigated accounted for 78% of summary attributable risk among non-smoking women, even though adjustment was made for other suspected risk factors. Although a history of pulmonary tuberculosis caused a higher OR estimate (5.9 fold), only a small proportion of non-smoking women had had tuberculosis and less than 13% of cases may be attributable to it. Frequent consumption of vegetables may protect 20% of non-smoking women against lung cancer. However, the greatest attributable

TABLE 5 *The interaction effects of lung cancer associated with cooking practices and the use of a fume extractor among non-smoking females, Taiwan, 1992–1993*

| Factor/category | Presence of fume extractor[a] | | | |
|---|---|---|---|---|
| | Yes | | No | |
| | Cases/controls No. | OR[b] (95% CI) | Cases/controls No. | OR[b] (95% CI) |
| Stir frying | | | | |
| 0–4/week | 7/20 | 1.0 | 5/3 | 8.6 (1.2–61.3) |
| 5+/week | 18/46 | 2.2 (0.7–7.6) | 73/32 | 13.3 (3.4–52.4) |
| Frying | | | | |
| 0–4/week | 11/33 | 1.0 | 16/17 | 9.8 (1.9–49.3) |
| 5+/week | 14/33 | 1.8 (0.5–6.3) | 62/28 | 9.2 (2.8–29.9) |
| Deep frying | | | | |
| 0–4/month | 21/52 | 1.0 | 59/23 | 5.9 (2.6–13.4) |
| 5+/month | 4/14 | 0.5 (0.1–2.3) | 19/12 | 5.9 (1.9–18.2) |

[a] The use of a fume extractor during cooking at 20–40 years of age.
[b] Odds ratios were derived from matched analyses adjusted for socioeconomic status, residential area and education.

TABLE 6 *Adjusted odds ratios (OR) and population attributable risks (PAR) for lung cancer associated with independent factors indicated by univariate analyses among non-smoking females, Taiwan, 1992–1993*

| Factor/category | OR[a] (95% CI) | PAR[b] % |
|---|---|---|
| Living near industrial district (years) | | |
| None | 1.0 | –[c] |
| 1–20 | 0.8 (0.2–3.9) | |
| 21+ | 2.7 (0.9–7.8) | |
| Cooking fuels (20–40 years) | | |
| No cooking or gas | 1.0 | –[c] |
| Coal or anthracite | 1.3 (0.3–5.8) | |
| Wood or charcoal | 2.7 (0.9–8.9) | |
| Tuberculosis | | |
| No | 1.0 | 12.9 |
| Yes | 5.9 (1.3–25.9) | |
| Use of fume extractor (20–40 years) | | |
| Yes | 1.0 | 66.7 |
| No | 8.3 (3.1–22.7) | |
| Consumption of vegetables | | |
| 0–6/week | 1.0 | 20.4 |
| Daily | 0.4 (0.1–0.9) | |
| Summary attributable risk | | 77.9 |

[a] Odds ratios were derived from multivariate logistic regression model adjusted for covariates, as well as socioeconomic status, residential area and education.
[b] Population attributable risks were derived from case proportion (relative to all cases) and logistic regression model adjusted for covariates.
[c] Not calculated.

risk for a non-smoking woman was the lack of a fume extractor at cooking age of 20–40 years, when the greatest amount of time was spent cooking.

## DISCUSSION

This study confirms the well-established association between smoking and lung cancer, even though smoking prevalence is relatively low in the Taiwanese female population (about 3–4%).[12] The authors demonstrated significant relationships between smoking habit and lung cancer in Chinese women, that was consistent with evidences of studies from mainland China,[9] Hong Kong[6] and Singapore.[27]

Kaohsiung is a heavily industrialized city in south Taiwan, which covers approximately 153 $km^2$ with a population of about 1.4 million inhabitants. Heavy air pollution which prevails on most days of the year in the city is caused by emissions from industry and city traffic. The annual average concentration of particles with an aerodiameter of 10 μm or less ($PM_{10}$) was reported to be as high as 90–100 $\mu g/m^3$ in the past 10 years.[28] Industrial factories in this densely populated city are commonly situated in the middle of residential areas. Any emission from a plant or an accidental event may directly affect residents, and an excess of cancer mortality at certain sites has been identified.[29] In this study residence near a heavy industrial site was used as a proxy measure for exposure to air pollution; iron foundries, petrochemical installations and cement factories were the main industries in the area. Although we had no available data for individual air pollution measurements, the finding that living within 3 km of an industrial complex independently elevates the risks of contracting lung cancer has also been observed in other studies,[18,21] although their measures of pollution exposure were different. Air pollution should not be dismissed as a negligible risk factor for lung cancer in Kaohsiung city.

Epidemiological studies on concurrent pulmonary tuberculosis and lung cancer was reviewed by Aoki, who stated in 1993 that patients with active pulmonary tuberculosis had a higher risk of dying from lung cancer or other malignancies, despite the high mortality from tuberculosis.[30] Our findings support these observations, although there was insufficient information about tuberculosis scars and cavities to confirm a suspected relation between tuberculosis and lung cancer. Furthermore, the mortality trends of tuberculosis in Taiwan had been well-described by age-period-cohort analysis; early birth cohorts were seen to have a relatively higher risk of mortality.[31] Thus the antagonistic hypothesis between the two diseases may have been based on the fact that tuberculosis patients had mostly died young, i.e. they did not survive long enough to contract cancer before the advent of modern tuberculosis treatments. Additionally, lack of an adequate disease registration system may have contributed to the failure to reveal an association between tuberculosis and lung cancer.

Recent epidemiological investigations revealed a number of sources of indoor air contamination that may explain the elevated risks of lung cancer among non-smoking Chinese women. Smoke and fumes arising from certain cooking practices were evaluated in several case-control studies in selected areas of China,[9,21,22,32] as well as the present study in Taiwan. A high risk of contracting lung cancer among Shenyang or Harbin women was related to use of coal-burning stoves (Kang) in north-east China;[21,22] similarly elevated risks to women who used wood or charcoal as cooking fuels were observed in early and main cooking exposure stages (stage I and stage II) of this study. Wood or charcoal was the commonest fuel used for cooking and heating in Taiwanese homes before about 1950, and the vast majority of stage I kitchens (89.6% for cases and 66.1% for controls) were without air conditioning or fume extractors. Correspondingly, in north-east China, women living in houses without separate kitchens or effective ventilation were found to be at increased risk of contracting lung cancer.[32] The heavy use of coal-burning stoves and regularly burning wood or charcoal contributed part of the increased risk for lung cancer in Shenyang[21] and in Taiwan women.

Women with prolonged exposure to fumes from rapeseed oil in Shanghai,[9] soya oil in Shenyang or Harbin,[22] and stir frying, frying or deep frying using cooking oils made from animal fats (mainly lard) or vegetable oils (mainly peanut or soybean oil) within kitchens with no fume extractors in Taiwan, were all found to contract lung cancer at an increased frequency. These observations from different parts of China suggest that exposure to fumes from several types of cooking oil may be linked to increased risk of lung cancer. The fact that cooks, whether women or men, are also at higher risk provides further evidence to incriminate cooking fumes.[33]

Our interaction and multivariate analysis have indicated that the use of fume extractors in the kitchen, that were wider spread in Taiwan by 1970 but not on mainland China, explained the majority of differences between cases and controls, even if cooking fuels, oils and techniques (stir frying, frying, deep frying) were covered in the multivariate logistic regression model (data not displayed). The authors suspect that substances absorbed by the fume extractors, including some specific toxic compounds derived from all cooking oils at high temperatures associated with frying, were strongly related to the risks of lung cancer for non-smoking women. The nature of these compounds in the hope of revealing the cause and mechanism of lung cancer in non-smoking women requires further study.

In summary, the present matched case-control study has confirmed that cigarette smoking is associated with lung cancer in Taiwanese women. However, the risk of contracting cancer for non-smoking women appears to be associated with certain cooking practices, especially preparing meals in kitchens not equipped with fume extractors when aged 20–40 years. Combined with a history of pulmonary tuberculosis and low consumption of fresh vegetables, these risk factors account for 78% of the attributable risks of contracting lung cancer and provide a rationale for preventive programmes for lung cancer in women in Taiwan.

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