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# The Clinico-Radiological and Pathological Profile of Lung Cancer Patients Exposed to Indoor Pollution by Cooking Fumes

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## Abstract

***Background:** Incidence of lung cancer is increasing in the developing world. Combustion byproducts from heating and cooking are major sources of indoor air pollution causing lung cancer in non-smokers. Predominance of adenocarcinoma due to cooking fumes exposure, shown in Chinese and western literature, but lacking in India.*

***Methods:** This is an observational cross-sectional study conducted on lung cancer patients, caused by cooking fumes exposure. Detailed information was taken about duration of cooking, frequency of frying, fuel used for cooking and cooking oil used. Type and size of kitchen with use of exhaust fan/fume extractor were also recorded.*

***Results:** Total seventy lung cancer patients, 37 (52.8%) male and 33(47.2%) female, histologically proven, exposed to cooking fumes were enrolled. Their mean age was 56.88 years.bbbbAdenocarcinoma was seen in 34 (48.57%), followed by squamous cell carcinoma (SCC) 8 (11.42%) and small cell carcinoma in 6 (8.57%). Cumulative effects of cooking fumes exposure and its relationship with histopathology of lung cancer was evaluated. On comparing cooking time years, less than 40 years with more than 40 years, significant predominance of adenocarcinoma (20/14) noted over non-adenocarcinoma group (9/3, $p < 0.043$).*

***Significant predominance of adenocarcinoma was seen in kitchen smokiness group on comparison with non-smokiness group ($p < 0.053$).***

***Conclusions:** Exposure of fumes, generated by burning of cooking fuel and heating of cooking oil are linked with adenocarcinoma lung. Awareness for use of clean fuel, cooking at lower temperatures and installing a suitable kitchen fume extractor is useful.*

***Key words:** Cooking fumes, cooking oil-fumes, adenocarcinoma, smokiness.*

## Introduction

According to GLOBOCON 2020 report, lung cancer is responsible for 18% of all cancer related death[1]. It is well known that cigarette smoking is the major cause of lung cancer, but previous studies have demonstrated that worldwide 15% of male patients and 53% of female patients with lung cancer were not due to smoking[2]. Asian women have a relatively high lung cancer rate compared to women of other ethnicities, despite low prevalence of smoking[3]. Cigarette smoking alone cannot fully explain the high incidence rates of lung cancer among women[4].

Indoor air pollution is a public health problem in both developed and developing countries[5], and it played a critical role in the development of lung cancer among non-smoking females[6]. In recent years, indoor particulate matter (PM 2.5), housing characteristics, home passive smoking exposure, indoor air pollution, cooking oil fume exposures, and previous respiratory diseases have been demonstrated as the causes of lung cancer[7]. Combustion by products from heating and cooking is one of the major sources of indoor air pollution[8]. Studies in the past have shown that long-term exposure to cooking oil fumes (COFs) may be linked to lung cancer[9-14] and may increase the risk of lung cancer[15,16]. A previous meta-analysis also supports an association between cooking oil fumes and a high-risk of lung cancer among Chinese non-smoking women[17].

In the present study, we investigated the association between lung cancer and fumes emitted from Indian style cooking among adults using a composite index for lifetime cumulative exposure and taking into account the influence of various potential confounding factors. We evaluated possible associations between heating and cooking oil fumes sources, and the lung cancer with its histological typing.

## Material and Methods

This is a observational cross-sectional study conducted over a period of six years (from 2014 to 2020) on patients who attended outdoor patient department of Pulmonary

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Medicine at ESI-PGIMSR Hospital, Basaidarapur, New Delhi. Histologically confirmed cases of lung cancer were included in the study.

All subjects had verbally agreed individually to participate in the study. Having assured the confidentiality of all information about the subjects, patients were interviewed face to face in the presence of their close relatives. Details were recorded in a structured questionnaire at the time of the interview. The questions were asked in Hindi and answers given by the patients in Hindi were recorded in English in the proforma (Proforma attached). Information about their education, occupation, income, family history of cancer, present and past medical history, diet pattern, smoking habit, history of alcohol intake, present and past heating and cooking system at home, exposure to any environmental pesticides/carcinogens, were obtained. Detailed history of cooking was taken as number of cooking years, frequency of frying, fuel of cooking used for heating like coal, gas, kerosene and wood. Information about type of cooking oil used like peanut, mustard, coconut, and refined was collected. Type and size of kitchen as closed or open, small or medium and use of exhaust fan/fume extractor were also recorded. Eye irritation during frying as rare or frequent were noted. Smog formation or smokiness during frying was also recorded. For each participant who had cooked at least six months continuously were included. We evaluated the cumulative exposure to COFs through an index of cooking time-years, defined as follows: cooking time-years = Órdr× yr, where dr = average daily times of cooking, and yr = years of cooking. A smoker was defined as someone who smoked at least 100 cigarettes in his or her lifetime; a former smoker was defined as someone who stopped smoking at least one year before the interview.

## Results

Total 70 cases of histologically proven lung cancer were enrolled in our study, including 37 (52.8%) male and 33 (47.2%) female. Majority of patients were from lower socio-economic class. They all were having exposure to indoor air pollution by cooking at home or at workplace. The baseline characteristics of these 70 patients are shown in Table I. Their mean age was 56.88 years. About 65.71% of our patients (31 male and 15 female) had smoking history with 31.42% current smokers and 34.2% ex-smokers. The mean pack years of smoking was 25 including 18 for females and 28 for male. Average age of starting smoking was 19.97 years. Passive smoking exposure was found in 37 patients (52%).

The most common presenting symptoms were cough (72.85%) and chest pain (65.71%). The other symptoms were anorexia 50.29%, weight loss 47.95%, breathlessness 38.01% and haemoptysis in 31.57% patients. Average duration of symptoms were cough since 5.04 months, chest pain since 4.22 months, anorexia since 3.34 months, weight loss since 3.5 months, breathlessness since 4.3 months and haemoptysis since 4.45 months. Ten (14%) patients had history of other chronic respiratory diseases. The common associated respiratory diseases were COPD and tuberculosis. The other systemic medical diseases were seen in 20 (28%) cases. The family history of cancer was present in 7 (10%) cases.

On histopathology, adenocarcinoma was seen in 34 (48.57%) of our patients followed by squamous cell carcinoma (SCC) 8 (11.42%) and small cell carcinoma in 6 (8.57%). Cancer histological sub-typing was not established in 22 cases (31.42%). Regarding location of tumours, 41.42% cases had central location of tumour whereas 44.42% had peripheral location.

**Table I: Baseline characteristics of patients with cooking fume exposure (CFO).**

| Characteristic (N = 70) | Number (%) |
|---|---|
| Age in years (mean ±SD) | 56.88 ± 13.06 |
| Gender | |
| Male | 37 (52.8%) |
| Female | 33 (47.2%) |
| Smoking status | |
| Non smoker | 24 (34.28%) |
| Current smoker | 22 (31.42%) |
| Former smoker | 24 (34.28%) |
| Mean years of cooking | 22.81 ± 12.74 |
| Mean cooking-time years | 59.07 ± 7.18 |
| Fuel used for cooking | |
| Coal | 5 (7.14%) |
| Gas | 36 (51.42%) |
| Kerosene | 15 (21.42%) |
| Wood | 14 (20.00%) |
| Type of kitchen | |
| Closed | 41 (58.57%) |
| Open | 29 (41.42%) |
| Cooking oil used | |
| Peanut oil | 03 (4.28%) |
| Mustard oil | 42 (60%) |
| Coconut oil | 01 (1.4%) |
| Refined oil | 24 (34.28%) |
| Presence of family history of cancer | 7 (10%) |
| Presence of industrial occupational exposure | 31(44.28%) |
| Histopathological type | |
| Squamous cell carcinoma | 8 (11.42%) |
| Adenocarcinoma | 34 (48.57%) |
| Small cell carcinoma | 6 (8.57%) |
| Others/sub-typing not available | 22 (31.42%) |
| Location of lesion | |
| Peripheral | 31 (44.28%) |
| Central | 29 (41.42%) |
| Others | 10 (14.28%) |

**Table II: Various COFs exposure parameters in relation to lung cancer histopathology.**

| Characteristic | Adenocarcinoma | Non-adenocarcinoma | P value |
|---|---|---|---|
| Cooking time years (N = 46) | | | |
| ≥ 40 | 14 | 9 | |
| > 40 | 20 | 3 | 0.043 |
| Mean cooking time years | 64.79 ± 6.81 | 51 ± 7.25 | 0.372 |
| Smokiness while cooking (smog) (N = 48) | | | |
| Frequently | 30 | 9 | |
| Never | 4 | 5 | < 0.053 |
| Location of lesion (N = 40) | | | |
| Peripheral | 18 | 3 | |
| Central | 11 | 8 | < 0.049 |

**Table III: Relationship of histological type among females with exposure to only cooking fumes and total cases.**

| | Female cases (N = 12) | Total (available histopathology) cases (N = 48) | P value |
|---|---|---|---|
| Adenocarcinoma | 12 | 34 | |
| Non-adenocarcinoma | 0 | 14 | 0.051 |

## Discussion

Majority of patients in our study were exposed to traditional heating and cooking sources when they were much younger, especially those who grew up in rural areas. Till early 2016, around 43% of the Indian population were dependent on solid fuels for cooking, heating, and other household energy services[18]. Residential cooking contributes 20 - 50% of all household PM 2.5 emission across all districts in India. Largest (> 100 μg $m^{-3}$) exposure of PM 2.5 observed over the Delhi/National Capital Region (Delhi/NCR)[19]. A European cohort study indicated that PM 2.5 exposure increased the risk of lung cancer, particularly lung adenocarcinoma[20].

In cooking activities, both combustion of fuel and heating of cooking oil produce carbonyl compounds. Cooking oil fumes (COFs) are mainly composed of two types of chemical compounds, including polycyclic aromatic hydrocarbons and aldehydes[21].

In this study, we used a composite index, "cooking time-years," to measure the magnitude of exposure to COFs, combining both cooking frequency (cooking times per day) and duration (years). This is a composite measurement to combine both cooking intensity and length. Similar measurement has been used in previous study[22].

The cumulative effects of cooking fumes exposure and its relationship with histological typing of lung cancer had been documented in the past. On comparison of cooking time years less than 40 years with more than 40 years (Table II), significant predominance of adenocarcinoma (20/14) noted over non-adenocarcinoma group (9/3, $p < 0.043$) in our study which is consistent with the previous studies[23].

In our study, the role of COFs in lung carcinogenesis has been significantly proven on comparison of COF exposed, non-smokers, with COFs exposed smokers. After excluding the occupationally exposed cases of lung cancer, we compare the COF exposed 17 non-smokers with remaining 17 COF exposed smokers. We found that cooking time years was more (66.22) in non-smokers than (45.23) in smokers ($p < 0.0301$). After excluding the smoking and occupation as confounders in COFs exposed non-smokers group, more cooking time years indicates the possible role of only COFs in development of lung cancer.

Studies in the past have shown that women who waited to cook (stir fry, fry, and deep fry) food until the cooking oil has reached the high temperature had an independently higher risk of adenocarcinoma, but not of squamous/small cell carcinoma[24]. Methanolic extract of heated COFs can apparently lead to cytotoxicity and oxidative DNA damage in human lung carcinoma pulmonary type II-like epithelium cells causing adenocarcinoma[15]. Recently a large number of in vivo studies have revealed the mechanism by which COFs improve lung adenocarcinoma cell survival[7]. A study done in Hongkong among non-smoking women had found strong evidence that cumulative exposure to cooking by means of any form of frying could increase the risk of lung cancer[25].

Smokiness (smog formation) during frying occurs on cooking with heavy temperature. Experimental studies have shown that temperature is the most important factor for mutagen formation[25,26]. Over 50 volatile organic compounds have been identified from heated oil as well as cooked foods, and some of these agents in emissions of cooking oils are mutagens and human carcinogens, such as 1,3-butadiene, benzene, benzo(a)pyrene, dibenzo (a, h) anthracene, acrolein, and formaldehyde[27-32].

We have investigated the relationship between cooking habits and histological typing. Out of 70 cases, 51 reported frequent smokiness during their daily cooking while 19 denied. In 51 cases with frequent exposure to smokiness (smog) while cooking, 39 were proved histologically as lung cancer, out of which 30 were adenocarcinoma and 9 were non-adenocarcinoma. In other group (non-smokiness) of 19 patients, only 9 cases were proven histologically (4 adenocarcinoma and 5 non-adenocarcinoma). On comparison with non-smokiness group, significant ($p < 0.053$) predominance of adenocarcinoma was seen in smokiness group.

In a study comparison to smokeless cooking, both normal exposure and above-average exposure to COFs were significantly associated with lung cancer[33]. Prolonged cumulative exposure of COFs causes predominant development of adenocarcinoma lung cancer documented in previous studies, has been proved in our study also.

After excluding the occupation and smoking as confounder in our study cases, we have evaluated the relationship between cooking fumes exposure and histological typing of lung cancer in females. We found only 12 female lung adenocarcinomas cases, without any non-adenocarcinoma case. (Table III). On comparison of these 12 adenocarcinomas with total histologically proven 34 adenocarcinoma cases and 14 non adenocarcinoma, statistically significant evidence shows that non-smoker females develop more adenocarcinoma on cooking fumes exposure. ($p$ value $< 0.032$), as noticed in previous Indian study also[34].

Kitchen size was small in 50 (71.42%) and medium in 20 (28.51%) cases. Kitchen was closed in 41 (58.57%) and open in 29 (41.4%). Most of our cases cooked in small and closed kitchens. Effect of COFs with or without smokiness is more in small and closed kitchens. In an Indian study, cooks cooking in the open outdoors, experience lower exposures compared to those in enclosed kitchens[35]. Proximity to the stove during cooking times is thus a good indicator of exposures for both men and women non-cooks, who stayed at home during cooking. The results of that study had shown that living area concentrations in households with kitchens without partitions are often greater than kitchen concentrations. This would put young children and the elderly, in addition to the cooks, at high-risk of suffering adverse consequences, as they are most likely to be indoors during cooking times.

In our study more than half the patients cooked food on gas stoves and one-fifth on kerosine and one-fifth on wood. A study was also shown that cooking with wood for prolonged periods is a risk for development of adenocarcinoma[24]. Potential carcinogen formaldehyde and benzo(a) pyrene has been found in wood charcoal[36]. Prolonged past exposure to coal fumes due to poor kitchen ventilation increases the risk of lung cancer[37].

On radiological investigations, location of lesion was ascertained in 40 cases with the help of chest radiograph and computerised tomography of thorax (Table II). Peripheral located lesion was seen in 18 adenocarcinoma group and 3 in non-adenocarcinoma group. While 11 adenocarcinoma cases were centrally located and 8 non adenocarcinoma group, statistically significant ($p > 0.049$) predominance of lung cancer lesion in peripheral location seen in adenocarcinoma group in our study is similar to the previous studies.

## Limitations of the study

One of the major limitations of our study is the small sample size and enrolled patients were from a confined region, i.e., Delhi/NCR. Another limitation of our study was smoking as confounding factor. Some diagnosed lung cancer cases were migrants from rural areas from surrounding states of Delhi/NCR and they livea alone in a single room. They also used this single room for cooking food and had a prolonged exposure of indoor air pollution due to cooking fumes exposure. Many subjects were initially exposed to wood, coke at open kitchen in rural areas and then kerosine, LPG in closed small kitchens during their stay at Delhi/NCR.

## Conclusion

Indoor air pollution due to heating and cooking at home is a global problem, causing various diseases including lung cancer. Cooking oil fumes are linked to adenocarcinoma, a commonly occurring lung cancer. Awareness for use of clean fuel, changing cooking habits, or cooking at lower temperatures and installing a suitable well designed fume extractor in the home kitchen should be encouraged. Provision of large kitchen should be focussed to prevent the lung cancer.

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