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Cooking smoke exposure and respiratory symptoms among those responsible for household cooking: A study in Phitsanulok, Thailand

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ABSTRACT

Cooking smoke affects the health of millions of people worldwide. In Thailand, however, information in regard to household cooking and the effects of cooking smoke is scarce. The objective of this descriptive study was to explore the risk factors and respiratory symptoms in household members responsible for household cooking. Participants from 1,134 rural households in Phitsanulok province, Thailand were randomly selected, using multistage sampling. Data on cooking activities and chronic respiratory problems, and symptoms identified in the past 30 days were collected using a modified questionnaire from the British Medical Research. Most of the participants were women aged over 40 years, who were responsible for food preparation in the household, and who usually cook with vegetable oil, using LPG gas, without a ventilation hood, according to the responses that we received, and our particular knowledge of household cooking facilities in rural areas in Thailand.

The most common chronic respiratory symptoms were runny nose (24.5% males, 21.8% females), dyspnea (26.1% females, 19.0% males) and chronic cough (9.2% females, 6.4% males). The most common respiratory symptoms experienced in the past 30 days were having a cold (28.3% females, 18.7% males), coughing (25.5% females, 21.1% ,males) and having sputum (13.0% females, 8.2% males). These symptoms were associated with tears while cooking, the number of hours present in the kitchen grilling food, and the number of stir-fried and deep-fried dishes prepared. This study demonstrated that cooking even with a clean fuel can quantitatively increase the risk of respiratory difficulties and symptoms. Since cooking is undertaken in every household in Thailand, this is a serious public health matter that demands more attention.

1. Introduction

Smoke from cooking activities is so dangerous that it has been called "the killer in the kitchen". The World Health Organization (WHO) [1] estimated that 3.8 million people have died prematurely from indoor air pollution associated with inefficient cooking practices. Of these deaths, considered premature, 27% were from pneumonia, 18% from stroke, 27% from heart disease, 20% from chronic obstructive pulmonary disease (COPD), and 8% from lung cancer. Cooking pollutants are generated from the burning of fuel for cooking and also from the fumes emitted when cooking oil is overheated [2].

Kitchen smoke is comprised of particulate matter (PM) and a large number of toxic gases, including carbon monoxide, nitrogen dioxide, and several toxic volatile hydrocarbons, some of which are carcinogens [3, 4, 5].

Epidemiological studies have identified exposure to cooking smoke as being associated with increased occurrence of acute respiratory infection in children (OR = 3.53, 95%CI 1.94–6.43) and several chronic illnesses, such as chronic bronchitis, among adults, especially in women (OR = 2.52, 95%CI 1.88–3.38), chronic obstructive pulmonary disease in women (OR = 2.40, 95%CI 1.47–3.93) [6], and lung cancer [7, 8]. Using biomass fuel for cooking is also related to coronary heart disease, cataracts, stroke and allergic rhinitis [9, 10]. Studies have also linked kitchen smoke to several respiratory symptoms, including dyspnea, severe dyspnea [11], and cough, chest tightness and wheezing [12, 13]. Neghab et al. [14] found that exposure to cooking fumes increased respiratory symptoms (wheezing, shortness of breath, chest tightness, cough, phlegm and chronic bronchitis) and reduced lung function capacity (VC, FVC, FEV1).

Emission of cooking pollutants depends on several factors [15, 16]. Fine particle emissions vary with cooking method, type of cooking fuel, burner equipment, cooking pan, cooking oil, food type, food

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additives, source surface area, cooking temperature, pan position on the stove, and kitchen ventilation [17]. Stir-fry cooking, common in Chinese food preparation, has been reported to emit particulates to a concentration of 300-1,700 μg/m^3 [2]. A study on the relative contribution of PM emissions from grilled beef, the heated cooking pan, and burner equipment, revealed that for mass emission, grilled beef was the significant contributor with an emission rate of 7.6 × 10 (s.d. = 6.3 × 10) mg/min. However, for ultrafine particle concentrations, both the heated pans and the grilled meat contributed equally [18]. A simulation model for heating cooking oils showed that elevated heating temperature and relative humidity increased particle emission [19]. The type of cooking oil also played a critical role in particle generation. A recent experiment under a control condition on source surface area and ventilation reported a particle emission rate of 98.3 mg/min from heating corn oil and 44.9 mg/min from grilling beef [20].

Food additives can influence particulate emission types and levels. A recent study reported that the addition of salt to soybean oil can significantly reduce the emission rates of triglycerides, e.g. triolein (45.6%), trigadolein (47.1%) and triarachidin (48.3%) [20]. A similar result was also observed in corn oil where heated corn oil with added salt emitted 47.6% less total PM than the oil without the salt [17]. This, however, is not of particular importance in the current study as fish sauce is the more usual source of salt flavouring in Thai cooking, not salt.

Cooking smoke also contains harmful trace elements. A study found several trace elements in PM from heated cooking oil, from heated corn oil mixed with table salt and from heated low-fat ground beef meat using a PTFE-coated aluminum pan on an electric stove. The most abundant were Ba (24.4 μg/m3) during grilling meat and Ti (24.4 μg/m3) from heated oil with salt. Risk analysis showed an unacceptable carcinogenic risk from chronic exposure to some of those elements, such as Cr and Co [21].

Exposure to cooking smoke depended on occupational function (chef, waitress, or other roles involving presence in the kitchen), time staying in the kitchen, and frequency of deep-frying and stir-frying food [7, 11, 13]. It was reported that the lack of a ventilation hood was associated with an increased risk of lung cancer [8, 22]. Age at which cooking activities started was also influent health effects [23]. Women who cooked regularly at home, with frequent exposure to cooking smoke, are at risk of detrimental health effects [24].

While research into these matters has been undertaken in many countries, especially in developing countries, there is little information available specific to Thailand. In our previous study [13] we found that workers in Thai restaurants have a higher incidence of acute and chronic respiratory symptoms than their neighbors who did not work in a restaurant. We consider that the specifics of public health in Thailand, and Thai cooking style, required more research. This is seen as being especially important among those who are responsible for household cooking, which is obviously a more prevalent situation than restaurant cooking.

1.1. Study objectives

The objectives of this research were, therefore, to investigate the association between cooking pollution and respiratory symptoms among those who are responsible for household cooking. This research will be useful for informing policies and practices for disease prevention, as well as extending the reach of the body of literature.

1. To study health problems among persons responsible for household cooking in Phitsanulok, Thailand.
2. To explore risk factors that are associated with the respiratory symptoms among those responsible for household cooking

2. Materials and methods

2.1. Participants

This study was conducted in Phitsanulok Province, Thailand, which is a mid-sized province located in Lower Northern Thailand, about 380 km. north from Bangkok. There are 333,303 households in Phitsanulok, with a total population of 865,759, which includes 423,913 men, and 441,846 women [25].

The sample size was calculated using OpenEpi online version 3.01, with 95% confidence level. The study participants were selected using multistage sampling. Of the 9 districts in the province, 5 were randomly selected, and in each district, 1 sub-district was selected to be the target population. For each household, one participant, male or female, who was responsible for household cooking, and aged over 20, was selected. The participants were randomly selected from each sub-district. From a total contact list of 1,150 people, 1,134 (98.6%) agreed to participate in the study. At the sub-district level, a health-promoting hospital and village health volunteers were contacted to assist in data collection.

2.2. Data collection and instrument

Data on respiratory symptoms and cooking smoke exposure were collected, which included information on the type of fuel the was most often used for cooking (wood, charcoal, LPG gas), type of cooking oil (vegetable oil, lard), occurrence of tears while cooking (TWC), and use of a ventilation hood. Data on exposure frequency and duration were also collected. The number of hours spent each day in the kitchen and the number of days per week cooking was ascertained, and the two figures were multiplied to compute the so-called “hours per week staying in a kitchen”. Similarly, “grilling per week” was also calculated as the product of food grilling hours each day and the number of days per week to grill food. Stir-frying and deep-frying frequency were measured by “stir-fry-dishes per week” and “deep-fry-dishes per week” (the number of stir/deep-fry-dishes per day multiplied by the number of days stir-frying/deep-frying food in a week).

Data on chronic respiratory symptoms were collected using a questionnaire modified from the British Medical Research [26]. The symptoms identified included cough, sputum, dyspnea, severe dyspnea, wheeze and runny nose. Cough referred to those with chronic cough with or without sputum for as much as 4 to 6 times a day, 4 or more days out of the week. “Sputum” was those having only sputum but no cough for as much as twice a day, 4 or more days out of the week. “Wheeze” referred to those who breathe with whistling sound. “Dyspnea” was those with shortness of breath when exercising. “Severe dyspnea” means having shortness of breath even when undertaking ordinary activities. “Runny nose” was a symptom different to “stuffy nose with or without a cold”. Data on the prevalence of respiratory symptoms that had occurred during the past 30 days, including coughing, having sputum, sore throat, shortness of breath, wheezing, nose irritation, allergic symptom and having a cold. All health symptoms were self-reported.

The content validity of the questionnaire to be used was reviewed by 3 experts and the Index of Item Objective Congruence (IOC) was between 0.7-1.0. The questionnaire was tested with 30 people with a similar background to the intended participants to validate question sequencing and understanding.

Data were collected in the period May–June 2017, the raining season in Thailand, with moderate weather conditions which would not affect the health status of the participants. Interviews were carried out by 15 village health volunteers who attended a one-day training program on how to interview and use of the questionnaire, prior to commencement.

2.3. Data analysis

Demographic and health problems data were descriptively analyzed by IBM SPSS version 19. The association between health problems and

risk factors were analyzed by unconditional binary logistic regression, with a 95% confidence interval ($p < 0.05$). Odds ratio of respiratory symptoms and risk factors was adjusted by sex, age (continuous data), occupation (agriculture, housewife, etc.)), income (200-3,000; 3,001-6,000; 6,001-10,000; 10,001-200,000 Baht), cigarette smoking (yes, no), family member's smoking (yes, no), and colleague's smoking (yes, no).

2.4. Ethical consideration

The study was approved by the Ethical Committee of Naresuan University, COA No. 485/2016. Written informed consent was obtained before data collection and the participants were advised that they could refuse participation or withdraw from the study at any time.

3. Results

3.1. Demographic data

Most of the subjects were women (83.7%) (Table 1), most aged over 40 yrs. with the mean age of 53.44 ± 13.42. Most of them had finished primary school with only a small proportion having education at high school or above. Many of them worked as farmers (35.5%) and some were housewives (30.1%), with monthly income below 10,000 baht a month (US$ 300). About 10% of the participants were smokers, and 33.3% lived with a smoker.

LPG gas was used as a cooking fuel by 64.0%, with the others using mainly charcoal (Table 2). The majority cooked every day with average cooking hours of 5.8 ± 4.6 hrs./wk. About 50% of the participants experienced having tears while cooking occasionally. Most did not have a ventilation hood (97.6%). Vegetable oil was used by 98.2%. Food was grilled at least once a week by 34.3% of the participants, with grilled food once a week; stir-fried food 0.5–2 times/wk., and deep-fried food 1-2 times/wk.

Table 1
Demographic data of the study subject (n = 1,134).

Description	Number	Percentage
Gender		
Men	185	16.3
Women	949	83.7
Age (year)		
20–29	56	4.9
30–39	128	11.3
40–49	204	18.0
50–59	331	29.2
60–69	293	25.8
70+	122	10.8
Mean ± s.d. = 53.4 ± 13.4		
Median = 55.0		
Educational completion		
Primary school	795	71.8
Secondary school	261	23.6
Higher than secondary school	52	4.7
Missing	26	2.3
Occupation		
Farmer	403	35.5
Housewife	341	30.1
Agricultural laborer	224	19.8
Others	166	14.6
Family income per month (Baht)		
<3,000	331	31.3
3,001-6,000	261	24.7
6,001-10,000	230	21.8
>10,001	234	22.2
Missing	78	6.9
Cigarette smoking		
Yes	116	10.2
No	1018	89.8
Family member's smoking		
Yes	375	33.3
No	751	66.7
Missing	8	0.7
Co-worker smoking		
Yes	182	16.2
No	942	83.8
Missing	10	0.9

Table 2
Number and percentage of the study subject by risk factors.

Risk factors	number	%
Types of cooking fuel		
LPG	726	64.0
Charcoal	364	32.1
Wood	28	2.5
Electricity	7	0.6
Total	1125	100
Frequency of cooking		
Every day	1028	91.1
Some days	63	5.6
Seldom	26	2.3
Never	11	1.0
Total	1128	100
Cooking hour per week (n = 750) = 5.8 ± 4.6		
Tears while cooking		
Always	50	4.5
Sometimes	564	50.5
Never	503	45.0
Total	1117	100
Having a ventilation hood in a kitchen		
Yes	20	2.4
No	806	97.6
Total	826	100
Types of cooking oil		
Vegetable oil	1107	98.0
Lard	23	2.0
Total	1130	100
Cooking frequency in each method		
Grill		
Every day	18	1.6
Every other day	28	2.5
Twice a week	171	15.2
Once a week	385	34.3
<1 time per week	197	17.6
Never	323	28.8
Total	1122	100
Grilling hour per week = 0.73 ± 2.05		
Stir-fry		
Every day	147	13.1
Every other day	333	29.6
Twice a week	367	32.6
Once a week	220	19.5
<1 time per week	27	2.4
Never	32	2.8
Total	1126	100
Stir-fry dishes prepared per week = 2.56 ± 3.37		
Deep-frying		
Every day	162	14.3
Every other day	310	27.4
Twice a week	320	28.3
Once a week	279	24.6
<1 time per week	29	2.6
Never	32	2.8
Total	1132	100
Deep-fried dishes prepared per week = 2.66 ± 3.00		

3.2. Prevalence of self-reported respiratory symptoms

The most common chronic respiratory symptoms among men were runny nose (24.5%), dyspnea (19.0%) and coughing (9.2%), and among women were dyspnea (26.1%), runny nose (21.8%) and severe dyspnea (8.3%) (Table 3).

Respiratory symptoms experienced in the past 30 days, among men, were having a cold (28.3%), coughing (25.5%) and having sputum (13.0%), and among women were coughing (21.1%), having a cold

Table 3
Prevalence of respiratory symptoms of the participants.

Symptom	Men	Women
Chronic symptoms		
Runny nose	45 (24.5)	205 (21.8)
Dyspnea	35 (19.0)	245 (26.1)
Chronic coughing	60 (6.4)	17 (9.2)
wheezing	61 (6.5)	12 (6.5)
Severe dyspnea	78 (8.3)	11 (6.0)
Having sputum	31 (3.3)	8 (4.3)
Symptoms in the past 30 days		
Having a cold	176 (18.7)	52 (28.3)
Coughing	198 (21.1)	47 (25.5)
Having sputum	77 (8.2)	24 (13.0)
Sore throat	121 (12.9)	14 (7.6)
Shortness of breath	52 (5.5)	12 (6.5)
Nose irritation	77 (8.2)	11 (6.0)
Wheezing	30 (3.2)	6 (3.3)
Allergic symptoms	72 (7.7)	3 (1.6)

(18.7%) and sore throat (12.9%) (Table 3).

3.3. Risk factors for self-reported chronic respiratory symptoms

Tears while cooking was associated with all respiratory symptoms, with significant statistics for wheezing (OR = 2.89, 95%CI 1.07–7.84), dyspnea (OR = 1.56, 95%CI 1.15–2.13) and severe dyspnea (OR = 2.91, 95%CI 1.19–7.12) (Table 4). Cooking inside the home was statistically associated with dyspnea (OR = 1.85, 95%CI 1.34–2.55) and runny nose (OR = 1.58, 95%CI 1.14–2.19), when comparing with cooking outside. However, type of fuel, use of a ventilation hood and type of cooking oil were not associated with any symptoms.

Cooking frequency was associated with some chronic symptoms. Every additional hour cooking food increased the risk of a runny nose (OR = 1.05, 95%CI 1.01–1.09). An additional hour per week spent grilling food was associated with cough (OR = 1.10, 95%CI 1.01–1.19), dyspnea (OR = 1.08, 95%CI 1.01–1.16), severe dyspnea (OR = 1.12, 95%CI 1.03–1.22) and runny nose (OR = 1.08, 95%CI 1.01–1.16). One additional stir-fry dish in a week was associated with an increased risk of cough (OR = 1.04, 95%CI 1.03–1.16). However, deep-frying dish per week was not associated with any symptoms.

3.4. Risk factors for symptoms in the past 30 days

When usage of LPG gas and wood was compared, use of wood was shown to related to all symptoms, but this was statistically significant only for nose irritation (OR = 2.90, 95%CI 0.99–8.49) (Table 5). However, for charcoal, the relationship with any respiratory symptoms was not significant. Tears while cooking (TWC) was associated with the survey health outcomes with dose-response relationship. Those who always had TWC had a higher OR of all symptoms and the risk was higher than those who had TWC occasionally. Having a ventilation hood was negatively associated with health symptoms, which was statistically significant for cough (OR = 0.27, 95%CI 0.10–0.73), and sputum (OR = 0.21, 95%CI 0.07–0.66). Cooking inside the house was associated with most of the survey symptoms but statistically significant for coughing (OR = 1.68, 95%CI 1.20–2.36) and sore throat (OR = 1.91, 95%CI 1.25–2.92). Type of cooking oil was not associated with any symptoms.

Cooking frequency was significantly associated with some symptoms in the past 30 days. An additional hour per week of cooking food was

Table 4
Odd Ratio (OR)* of chronic respiratory symptoms by risk factors.

	Cough	Sputum	Wheeze	Dyspnea	Severe dyspnea	Runny nose
Tears while cooking						
Always	1.03 (0.30–3.56) p = 0.97	1.39 (0.30–6.48) p = 0.67	2.89 (1.07–7.84) p = 0.04**	1.91 (0.98–3.72) p = 0.06	2.91 (1.19–7.12) p = 0.02**	1.23 (0.60–2.50) p = 0.57
Sometimes	1.05 (0.63–1.77) p = 0.84	1.33 (0.66–2.70) p = 0.43	1.84 (1.05–3.24) p = 0.03**	1.56 (1.15–2.13) p < 0.01**	1.54 (0.93–2.56) p = 0.09	1.12 (0.81–1.53) p = 0.50
Never	referent					
Types of fuel						
Wood	-	-	2.68 (0.90–7.93) p = 0.08	0.93 (0.37–2.35) p = 0.89	1.62 (0.50–5.31) p = 0.42	1.01 (0.39–2.64) p = 0.99
Charcoal	0.71 (0.41–1.25) p = 0.24	0.65 (0.30–1.42) p = 0.28	0.97 (0.55–1.71) p = 0.91	1.04 (0.76–1.44) p = 0.80	1.00 (0.60–1.67) p = 1.00	0.75 (0.53–1.07) p = 0.11
LPG	referent					
Cooking location						
Inside a house	1.67 (0.94–2.96) P = 0.08	1.60 (0.75–3.41) P = 0.22	1.34 (0.77–2.31) P = 0.30	1.85 (1.34–2.55) P < 0.01**	1.54 (0.92–2.57) P = 0.10	1.58 (1.14–2.19) P < 0.01**
Inside and outside a house	1.39 (0.38–5.02) p = 0.62	1.01 (0.12–8.27) p = 0.99	0.79 (0.18–3.56) p = 0.76	0.76 (0.31–1.88) p = 0.55	0.85 (0.19–3.81) p = 0.83	0.70 (0.30–1.65) p = 0.42
Outside a house	referent					
Having ventilation hood						
No	0.45 (0.09–2.14) p = 0.32	0.67 (0.08–5.46) p = 0.71	0.43 (0.12–1.61) p = 0.21	1.64 (0.46–5.93) p = 0.45	1.76 (0.22–13.89) p = 0.59	0.29 (0.11–0.77) p = 0.01**
Yes	referent					
Types of cooking oil						
Vegetable oil	0.89 (0.20–4.05) p = 0.88	1.12 (0.14–8.84) p = 0.91	-	1.12 (0.42–2.95) p = 0.83	0.97 (0.21–4.42) p = 0.97	1.25 (0.41–3.84) p = 0.69
Lard	referent					
Cooking frequency						
Cooking hour/wk.	1.03 (0.98–1.09) p = 0.22	0.94 (0.83–1.06) p = 0.28	1.01 (0.94–1.09) p = 0.83	1.02 (0.98–1.06) p = 0.26	1.02 (0.96–1.07) p = 0.60	1.05 (1.01–1.09) p = 0.01**
Grilling hour/wk.	1.10 (1.01–1.19) p = 0.02**	1.08 (1.00–1.17) p = 0.06	1.03 (0.93–1.14) p = 0.58	1.08 (1.01–1.16) p = 0.02**	1.12 (1.03–1.22) p = 0.01*	1.08 (1.01–1.16) p = 0.02**
Stir-fry dishes/wk.	1.09 (1.03–1.16) p < 0.01**	0.98 (0.86–1.12) p = 0.76	0.95 (0.85–1.06) p = 0.32	1.03 (0.98–1.07) p = 0.24	1.02 (0.95–1.10) p = 0.54	0.99 (0.94–1.04) p = 0.59
Deep-fry-dishes/wk.	1.04 (0.97–1.12) p = 0.27	0.91 (0.79–1.06) p = 0.23	1.00 (0.91–1.09) p = 0.92	1.01 (0.96–1.06) p = 0.67	1.05 (0.98–1.12) p = 0.19	1.00 (0.96–1.05) p = 0.92

* Adjusted for: sex, age (continuous data), occupation (agriculture, housewife, etc.)), income (200-3000, 3001-6000, 6001-10000, 10001-200000 baht), cigarette smoking (yes, no), family member's smoking (yes, no), college's smoking (yes, no).

** Significant with p-value <0.05.

Table 5
Odd Ratio (OR)* symptoms in the past 30 days by risk factors.

Risk factors	Cough	Having sputum	Sore throat	Shortness of breath	Wheezing	Nose irritation	Allergic symptom	Having a cold
Tears while cooking								
Always	1.78 (0.86–3.68) p = 0.12	2.37 (0.95–5.94) p = 0.07	2.82 (1.29–6.16) p = 0.01**	3.02 (1.04–8.80) p = 0.04**	1.88 (0.36–9.83) p = 0.45	4.58 (1.92–10.92) p < 0.01**	1.86 (0.69–5.03) p = 0.22	1.69 (0.84–3.39) p = 0.14
Sometimes	1.69 (1.22–2.34) p < 0.01**	1.62 (1.00–2.62) p = 0.05**	1.76 (1.17–2.66) p < 0.01**	1.74 (0.95–3.17) p = 0.07	2.26 (1.01–5.04) p = 0.05**	1.84 (1.09–3.13) p = 0.02**	1.13 (0.67–1.92) p = 0.65	1.12 (0.81–1.54) p = 0.51
Never	ref							
Types of fuel								
Wood	1.59 (0.67–3.77) p = 0.29	1.09 (0.30–3.91) p = 0.90	1.68 (0.60–4.70) p = 0.32	1.95 (0.52–7.25) p = 0.32	1.35 (0.16–11.78) p = 0.79	2.90 (0.99–8.49) p = 0.05**	2.13 (0.63–7.19) p = 0.22	1.08 (0.42–2.81) p = 0.87
Charcoal	0.77 (0.55–1.09) p = 0.14	0.66 (0.40–1.09) p = 0.10	1.23 (0.82–1.87) p = 0.32	1.27 (0.70–2.30) p = 0.43	1.68 (0.80–3.55) p = 0.17	1.36 (0.82–2.26) p = 0.23	1.25 (0.71–2.18) p = 0.44	0.94 (0.67–1.32) p = 0.72
LPG	ref							
Cooking location								
Inside the home	1.68 (1.20–2.36) p < 0.01**	1.32 (0.81–2.14) p = 0.26	1.91 (1.25–2.92) p < 0.01**	0.97 (0.54–1.74) p = 0.92	1.43 (0.64–3.19) p = 0.38	1.57 (0.94–2.61) p = 0.08	1.64 (0.95–2.83) p = 0.07	1.32 (0.94–1.84) p = 0.11
Inside and outside the home	0.73 (0.30–1.81) p = 0.50	0.49 (0.11–2.15) p = 0.34	0.46 (0.11–2.01) p = 0.30	1.02 (0.22–4.61) p = 0.99	2.13 (0.42–10.86) p = 0.37	0.62 (0.14–2.74) p = 0.52	0.37 (0.05–2.88) p = 0.34	0.83 (0.35–1.96) p = 0.67
Outside the home	ref							
Having ventilation hood								
No	0.27 (0.10–0.73) p = 0.01**	0.21 (0.07–0.66) p < 0.01**	0.43 (0.13–1.39) p = 0.16	0.42 (0.09–1.98) p = 0.27	0.48 (0.06–4.08) p = 0.50	1.78 (0.23–14.15) p = 0.58	0.39 (0.10–1.52) p = 0.17	0.39 (0.14–1.07) p = 0.07
Yes	ref							
Types of cooking oil								
Vegetable oil	0.46 (0.19–1.11) p = 0.08	0.76 (0.21–2.72) p = 0.67	1.55 (0.35–6.82) p = 0.56	0.81 (0.18–3.71) p = 0.78	NA	1.01 (0.23–4.53) p = 0.99	1.62 (0.20–12.96) p = 0.65	1.02 (0.37–2.87) p = 0.96
Lard	ref							
Cooking frequency								
Cooking hours per week	1.04 (1.00–1.08) p = 0.03**	1.05 (1.01–1.10) p = 0.02**	1.02 (0.98–1.07) p = 0.33	0.98 (0.90–1.07) p = 0.65	1.03 (0.93–1.15) p = 0.53	0.98 (0.91–1.05) p = 0.50	0.99 (0.92–1.07) p = 0.83	1.04 (1.00–1.08) p = 0.06
Grilling Hour per week	1.12 (1.03–1.22) p < 0.01**	1.14 (1.05–1.25) p < 0.01**	1.15 (1.06–1.24) p < 0.01**	1.08 (1.00–1.16) p = 0.05**	1.06 (0.96–1.16) p = 0.25	1.12 (1.04–1.20) p < 0.01**	1.06 (0.95–1.18) p = 0.34	1.12 (1.03–1.22) p < 0.01**
Stir-fry-dishes prepared per week	1.01 (0.97–1.06) p = 0.58	1.06 (1.00–1.11) p = 0.05**	1.06 (1.01–1.11) p = 0.03**	0.85 (0.72–0.99) p = 0.04**	0.96 (0.81–1.12) p = 0.59	1.05 (0.99–1.11) p = 0.13	1.01 (0.94–1.09) p = 0.73	1.04 (1.00–1.09) p = 0.06
Deep-fried dishes prepared per week	0.96 (0.91–1.02) p = 0.15	1.01 (0.94–1.08) p = 0.88	1.02 (0.96–1.08) p = 0.53	0.92 (0.81–1.04) p = 0.20	0.87 (0.72–1.05) p = 0.15	1.01 (0.94–1.09) p = 0.80	0.97 (0.89–1.06) p = 0.53	1.01 (0.95–1.06) p = 0.85

* Adjusted for: sex, age (continuous data), occupation (agriculture, housewife, etc.)), income (200-3000, 3001-6000, 6001-10000, 10001-200000 baht), cigarette smoking (yes, no), family member's smoking (yes, no), college's smoking (yes, no).

** Significant with p-value <0.05.

statistically associated with coughing (OR = 1.04, 95%CI 1.00–1.08), having sputum (OR = 1.05, 95%CI 1.01–1.10) and having a cold (OR = 1.04, 95%CI 1.00–1.08). There was also a relationship between duration of grilling food and the survey health symptoms. An additional stir-fry dish per week was associated with having sputum (OR = 1.06, 95%CI 1.00–1.11) and sore throat (OR = 1.06, 95%CI 1.01–1.11) but a lower chance for dyspnea (OR = 0.85, 95%CI 0.72–0.99). However, cooking by deep-frying did not have any relationships with the survey symptoms.

4. Discussion

In this study, the most commonly found chronic respiratory symptoms were runny nose with a prevalence of 24.5% among men and 21.8% among women, dyspnea (19.0% among men and 26.1% among women) and chronic cough (9.2% among men and 6.4% among women). These levels of prevalence were much lower than those observed among restaurant workers, which reported a prevalence of 30.7% among men and 52.3% among women for dyspnea, 48.0% among men and 45.8% among women for stuffy nose, and 32.0% among men and 32.5% among women for chronic cough [13]. A similar trend was also found for symptoms in the past 30 days. The most common symptoms in this study were having a cold (28.3% among men and 18.7 among women), coughing (25.5% among men and 21.1% among women) and having sputum (13.0% among men and 8.2% among women). However, in the previous study, the top three symptoms found among restaurant worker were coughing (54.7% among men and 42.5% among women), having a cold (29.3% among men and 25.2% among women), and sore throat (34.7% among men and 25.2% among women) [13].

Overall, our results can be explained by the fact that cooking smoke contains hundreds of pollutants and some of them are respiratory irritants, such as nitrogen dioxide, particulate matter, acrolein and formaldehyde [7, 24, 27]. Exposure to these pollutants can cause lung and respiratory inflammation leading to chronic respiratory symptoms [28]. A recent study reported that those who cooked ≥21 times per week had a higher risk of chronic bronchitis than those who cooked <14 times per week (OR = 4.73, 95%CI 1.65–13.53) [29].

The risk factors found to be significantly associated with chronic respiratory symptoms were tears while cooking (TWC), place of cooking, and cooking frequency. Having TWC constantly was significantly associated with wheezing (OR = 2.89, 95%CI 1.07–7.84) and severe dyspnea (OR = 2.91, 95%CI 1.19–7.12). For those with occasional TWC, the OR was 1.84 (95%CI 1.05–3.24) for wheezing and 1.56 (95%CI 1.15–2.13) for dyspnea (Table 4). For health symptoms in the past 30 days, TWC was also related to sore throat (OR = 2.82; CI 1.29–6.16), dyspnea (OR = 3.02; 95%CI 1.04–8.80) and nose irritation (OR = 4.58; 95%CI 1.92–10.92) (Table 5). This was consistent with previous studies which reported that TWC is a good indicator for cooking smoke exposure [13, 30].

It was clear that cooking inside a home is associated with respiratory symptoms, such as dyspnea (OR = 1.85; CI 1.05–3.24), runny nose (OR = 1.58; 95%CI 1.05–3.24), coughing (OR = 1.68; 95%CI 1.20–2.36) and having a sore throat (OR = 1.91; 95%CI 1.25–2.92). Where the cooking activity occurs outside the home, in an open area, cooking smoke will dissipate quickly thereby reducing exposure. It has also been reported that children aged 0–4 yrs. in residences with predominantly outdoor cooking had 9% less respiratory disease than those children in residences with predominantly indoor cooking spaces [31].

It was also found that cooking frequency was associated with both acute and chronic respiratory symptoms. An additional hour per week of grilling food was associated with several symptoms, including runny nose, coughing, having sputum, sore throat, dyspnea, nose irritation, and having a cold. One additional instance per week of preparing stir-fried food was associated with coughing (OR = 1.09, 95%CI 1.03–1.16). This was consistent with studies previously done among restaurant workers [11, 13]. In the restaurant setting it was reported that every extra hour spent in a kitchen was associated with a higher incidence of runny nose and chronic coughing [7, 22].

It has now been established that deep-frying, stir-frying, and grilling, produce PM and VOC substances that affect health [32]. Stir-frying Thai food usually causes a large amount of smoke containing a pungent smell and irritant fumes from high-temperature frying of chili paste, garlic and other traditional herbal ingredients. This smoke often causes acute respiratory symptoms, such as coughing, sneezing, tearing.

However, the study failed to associate respiratory symptoms to cooking oil and using a ventilation hood as has previously been reported in the literature [14, 33]. This can be explained by the fact that 98.0% of the participants used vegetable oil, and 97.6% have no ventilation hood (Table2) so this homogeneity of the data limited comparative analysis.

The association between cooking fuel and health outcomes was also limited. We only found a marginal association between nose irritation and wood use (OR = 2.90, 95%CI 0.99–8.49). This contradicts previous publications which reported a much higher volume of pollutants and higher associated risk from using biomass fuel as compared to using LPG [1, 4]. However, a close look at the data revealed that 56% of the participants reported using both clean heating (with LPG or on an electric stove) and biomass (charcoal or wood). This practice is quite common in Thai rural communities where people have been gradually switching from biomass to modern fuels, such as LPG. A study in China reported that in households with average assets and income, an increase in asset values of 0.007, or income increased by 0.002 units, 10% of those households choose clean fuels [34]. We also found that cooking fuel was strongly correlated with kitchen location ($p < 0.001$). Those who use dirty fuel (52.3% for charcoal and 50.0% for biomass) tended to cook outside their house whereas only 31.6% of households using LPG gas or an electric stove cooked outdoors. However, with limited data on historical fuel use and the comparative use of fuel, as well as the small sample size, the interaction and confounding effect of these factors cannot be quantified or adjusted.

A limitation inherent in this study is that of the small sample size which can affect the power of detection of associations between factors. Moreover, by using a survey method in one study group, most of the participants tended to have similar risk factors making it harder to find a risk factor. This study also utilized a cross-sectional design, where exposure data and health outcome data were collected at the same time. In this type of study, there was no evidence of prior exposure occurring, or being the cause of health outcomes. Therefore, the result should be interpreted with caution. However, based on the nature of disease development, it is reasonable to believe that those chronic respiratory symptoms were indeed the result of long-term exposure in the past. The study also lacked pollutant measurement data which would have provided a better indicator of the exposure effects. As well, all of the health problems were self-reported rather than being medical diagnoses and this could cause information bias and lower the associated risk.

This study might also have recall bias, which often occurs when past data is collected. It is not unusual to have differences in recall ability among those participants with and without the symptoms, if they are aware of a causative exposure. However, in this study, it is reasonable to believe that the recall ability should be the same among the participants because the information on the association between cooking smoke exposure and health effects is rather new in Thailand. Future research should focus on using a larger sample size from different parts of the country, with more variety of cooking fuels and oils, and measurement of related pollutants.

5. Conclusions

The results of this study support previous findings that exposure to cooking smoke, even with modern ‘clean’ fuels, increases the risk of respiratory symptoms. Those with more exposure to cooking activities had a higher risk of either acute or chronic health effects or both. Risk factors found to be significantly associated with the symptoms were cooking method and cooking frequency. Time spent in the kitchen and

grilling or stir-frying food increased the risk of respiratory symptoms. Cooking inside a home, indicating poor ventilation, was also a risk factor. Public education on the health effects of cooking smoke seems to be an essential element of public health and should be provided together with effective advice on preventive measures.

Declarations

Author contribution statement

Yuwayong Juntarawijit, Chudchawal Juntarawijit: Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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