

ORIGINAL ARTICLE

Household gas cooking: a risk factor for respiratory illnesses in preschool children

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Aims: To explore the association of household gas cooking and respiratory illnesses in preschool children and their relation to outdoor air pollution.

Methods: Cross-sectional study among households that used gas stoves for cooking in two housing estates with contrasting air qualities in Hong Kong. A structured questionnaire was administered to parents of 426 children aged 0–6 years on their exposure to gas cooking and passive smoking, and the prevalence of respiratory illnesses.

Results: A total of 111 children (26.1%) were reported to have one or more respiratory illnesses (allergic rhinitis, asthma, bronchitis, sinusitis, and pneumonia). Of these, 21 (18.9%), 41 (36.9%), and 49 (44.1%) children were from households that cooked once, twice, and three times a day with gas. Hierarchical logistic regression models adjusting for socioeconomic, demographic, and indoor risk factors including passive smoking showed that household gas cooking was positively associated with respiratory illnesses. There was a dose-response relation between the frequency of gas cooking and the prevalence of respiratory illnesses in the estate with lower outdoor air pollution (OR=6.1 and 3.2 respectively, for cooking three and two meals a day, compared to one meal a day). This relation was not observed in the more polluted estate. The association between the presence of a cigarette smoker in the household and the prevalence of respiratory illnesses was not significant.

Conclusions: As gas cooking is common in urban households, the findings could have important public health implications.

In an urban community, the outdoor environment is widely contaminated by complex mixtures of gaseous and particulate air pollutants that are produced by combustion or industrial discharges. The indoor environment, besides being affected by air pollutants in the outdoor environment, also contains various chemicals released from human activities, furniture, and building materials. Because people spend more time indoors than outdoors, research interests have been focused on the potential hazards of indoor air pollution on respiratory health. Domestic combustion of fossil fuels, in particular, the use of gas appliances in a poorly ventilated kitchen, produces high indoor concentrations of particulates, nitrogen dioxide, and nitric oxide.¹ However, the extent to which cooking with gas is hazardous to human health still remains unclear, largely because of the difficulties in measuring individual exposures and the inconsistent epidemiological findings.

Evidence for an association between domestic gas cooking and heating, and respiratory illnesses is not consistent.^{2–4} Environmental tobacco smoke and outdoor air pollution are competing risk factors that affect respiratory health. These two factors may influence the association between household gas cooking and respiratory health. Most studies exploring this association were conducted in primary school children or adults.^{2–5–7} Both groups are susceptible to outdoor air pollution. Even if personal monitoring is used to assess exposure, it is often difficult to attribute the health outcome separately to indoor or outdoor air pollutants. The study of preschool children who spend most of their time indoors and are therefore less exposed to outdoor air pollutants, provides a good opportunity to identify the possible impact of household gas cooking on their respiratory health.

Hong Kong has a total area of 1100 km² and a population of 6.8 million. Most residents live in multi-storeyed apartment buildings. Piped "town gas" (consisting mainly of

methane and hydrogen derived from naphtha) and bottled liquid petroleum gas (mainly butane) are the most common fuels used for household cooking. The climate is sub-tropical, with hot humid summers and cool dry winters. Domestic heating is normally not required, except in the colder days of winter. Electric heaters (but not gas) are used for this purpose. To explore the association between household gas cooking and respiratory illnesses in preschool children and their relations to outdoor air pollution, we conducted a study on preschool children in two residential estates with contrasting levels of outdoor air pollution. We tested the hypothesis that frequent gas cooking was associated with a higher risk of respiratory illnesses among preschool children in these households, and that the level of outdoor air pollution may affect this relation.

METHODS

Study sites and subjects

Two private residential estates (estates A and B) in Hong Kong were selected as study sites. Estate A was located at a town centre adjacent to an industrial area, a main road, and a municipal incinerator. Estate B was situated along the seashore off the main road, and was much further away from similar industrial areas and other sources of pollution (fig 1). The mean annual concentrations of several major air pollutants (PM₁₀, SO₂, NO₂, NO) in the air quality monitoring station closest to estate B were about 30% lower than that adjacent to estate A (table 1). We considered estate A to be a high air pollution area, and estate B as a low air pollution area. Both estates consisted of several similar buildings, each made up of multi-storeyed apartments. Residents of both estates were typically middle-class families. One building was randomly selected from each estate and all households in the selected block were included in the survey. The buildings in the two estates were similar in their design layout. The area

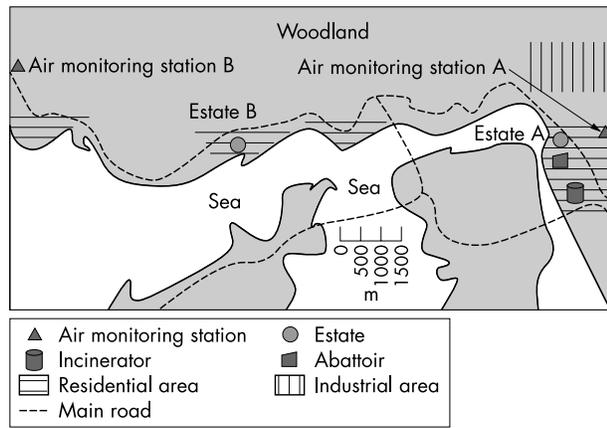


Figure 1 Location of the two estates and air monitoring stations.

of each apartment ranged from 50 to 70 m², where three to five family members lived. In both estates, all households used piped gas for cooking. Parents of preschool children aged 6 or less, who had lived in the estates for at least one year, were recruited in the study.

Study design

A cross-sectional study was conducted among residents in the two estates over a 10 week period (mid April to early July 1994). A structured questionnaire was used in a face-to-face interview of the children’s parents at their residence. Information on children’s exposures to sources of indoor air pollutants (passive smoking and gas cooking), their point prevalence of respiratory illnesses (that is, current illnesses at the time of the interview), and the sociodemographic characteristics of the households were obtained. Respiratory illnesses included allergic rhinitis, bronchitis, bronchial asthma, and pneumonia. To minimise potential misclassification of these illnesses in the interpretation of these diseases, only doctor confirmed respiratory illnesses were recorded. The frequency of household gas cooking was defined as the number of meals cooked per day at home in the past month. Children’s exposure to passive smoking was defined as the presence of one or more household members who were regular smokers up to the month before the interview. Information on other possible indoor pollutants—burning joss sticks (incense) and mosquito coils, and keeping furry stuffed soft toys and pets at home—and other potential confounders (whether residents usually kept their windows open, and their subjective assessment of the indoor air quality in their homes) were also obtained. This study was approved by the Ethical Committee of The Chinese University of Hong Kong.

Statistical analysis

All data were entered into a computerised database. Bivariate analysis and multivariate logistic regression analysis were performed to estimate crude odds ratios (OR), adjusted odds

Table 1 Annual mean concentrations of air pollutants (µg/m³)

Air pollutant	Estate A	Estate B
SO ₂	30	23
NO ₂	59	45
NO	60	24
PM ₁₀	62	41

ratios, and their 95% confidence intervals (95% CI) with SAS software (version 8.01; SAS Institute, Cary, NC). To assess the effect of household gas cooking on the risk of respiratory illnesses, four hierarchical models were built with various combinations of covariates. Model 1 only included two exposure variables (gas cooking frequency and passive smoking). In model 2, sociodemographic variables (gender, age, and parents’ occupation) were added. In model 3, we adjusted for other possible indoor sources of pollution (incense burning, the use of extraction fans or hoods in the kitchen, keeping pets and soft toys), whether windows were usually kept open, and the outdoor environment (which estate they lived in) to estimate the adjusted ORs. In model 4, apart from all the variables in model 3, we added the respondents’ subjective self-satisfaction with their indoor air quality to adjust for the potential recall bias in reporting their children’s illnesses. We also performed multiple regression analyses stratified by estate in order to assess whether the relation between gas cooking and the risk of respiratory illnesses would be different in children living in estates with different levels of outdoor air pollutants. The analyses were limited to 426 children for whom complete information was available on respiratory illnesses; 14 children (3.3%) were excluded for this reason. We also performed similar analyses with allergic rhinitis (the predominant illness reported among the children) as the dependent variable.

RESULTS

Description of subjects, prevalence of risk factors, and respiratory illnesses

There were 616 households in the two estates: 225 (36.5%) households from estate A and 391 (63.5%) from estate B. All were invited to participate. A total of 520 households (response rate 85.3%) responded: 199 households in estate A (response rate 88.6%), and 321 households in estate B (response rate 82.1%). Of these, 359 households (134 in estate A and 225 in Estate B) had preschool children aged 6 and below. Parents of 426 preschool children from these households were interviewed; 154 (36.2%) children came from estate A and 272 (63.8%) from estate B. On average, there were 1.1 children per household in estate A and 1.2 children per household in estate B; 74.9% of households had only one child, 23.8% had two, and 1.3% had three. Table 2 presents their demographic characteristics, the frequency of gas cooking, exposure to passive smoking, and other sources of indoor air pollution. Apart from gender, the distributions of these variables were broadly similar between the children from the two estates. Among all subjects, 95 (22.3%) children were from households with a frequency of gas cooking of one meal per day, 185 (43.4%) with two meals per day, and 146 (34.3%) with three meals per day. Ninety two (21.6%) children were exposed to passive smoking. Gas was the only fuel used for cooking in all the households surveyed.

A total of 111 children (26.1%) reportedly had one or more doctor confirmed respiratory illnesses at the time of the interview (point prevalence). Among those children with respiratory illnesses, 99 (89.2%) reported having allergic rhinitis, 10 (9%) bronchitis, eight (7.2%) asthma, four (3.6%) sinusitis, and two (1.8%) pneumonia.*

Relation between risk factors and respiratory illnesses

In the bivariate analysis, the odds of respiratory illnesses were associated with being male, an older age, parents’ dissatisfaction with the indoor air quality, and residing in estate A. Interestingly, the prevalence of respiratory illnesses among children in estate A was almost three times that in estate B (table 3). Hierarchical logistic regression analyses

*Data referred to in this paragraph are not shown in the tables.

Table 2 Sociodemographic characteristics of subjects in two estates

	Estate A		Estate B		Total*	p value
	No.	%	No.	%		
Gender						0.04
Female	63	42.9	144	53.5	207	
Male	84	57.1	125	46.5	209	
Subtotal	147		269		416	
Age (years)						0.63
0-1	27	17.5	61	22.4	88	
2-3	53	34.4	106	39.0	159.0	
4-6	74	48.1	105	38.6	179	
Subtotal	154		272		426	
Parents' job						0.92
White collar	71	46.1	124	45.6	195	
Blue collar	83	53.9	148	54.4	231	
Subtotal	154		272		426	
Household gas cooking frequency						0.94
1 meal/day	35	22.7	60	22.1	95	
2 meals/day	65	42.2	120	44.1	185	
3 meals/day	54	35.1	92	33.8	146	
Subtotal	154		272		426	
Exposure to passive smoking						0.80
Yes	32	21.1	60	22.1	92	
No	120	78.9	211	77.9	331	
Subtotal	152		271		423	
Respiratory disease						<0.001
Yes	68	45.3	43	16.4	111	
No	82	54.7	219	83.6	301	
Subtotal	150		262		412	

*Some variables have missing values.

Table 3 Factors associated with having a respiratory illness

	Estate A				Estate B			
	Having illness				Having illness			
	n	%*	OR	95% CI	n	%*	OR	95% CI
Gender								
Female	25	35.7	1		22	15.0	1	
Male	43	51.2	1.89	0.99 to 3.61	21	16.8	1.15	0.60 to 2.20
Age (years)								
0-1	7	25.9	1		7	11.5	1	
2-3	23	43.4	2.19	0.79 to 6.06	15	14.2	1.27	0.49 to 3.32
4-6	38	51.4	3.02	1.14 to 7.99	21.0	20.0	1.93	0.77 to 4.85
Parents' job								
Non-white collar	34	40.9	1		29	19.6	1	
White collar	34	47.9	1.32	0.70 to 2.51	14	11.3	0.52	0.26 to 1.04
Household gas cooking frequency								
1 meal/day	16	45.7	1		5	8.3	1	
2 meals/day	24	36.9	0.70	0.30 to 1.60	17	14.2	1.82	0.64 to 5.19
3 meals/day	28	51.6	1.27	0.55 to 3.00	21	22.8	3.25	1.15 to 9.18
Exposure to passive smoking								
No	53	43.4	1		33	15.6	1	
Yes	15	46.9	1.14	0.53 to 2.51	10	16.7	1.08	0.50 to 2.35
Extraction fan/hood in kitchen								
No	4	80.0	1	1	1	16.7	1	
Yes	64	42.9	0.19	0.02 to 1.72	42	15.8	0.93	0.11 to 8.23
Usually open window								
No	12	40	1		7	11.9	1	
Yes	56	45.2	1.51	0.64 to 3.59	36	16.9	1.23	0.55 to 2.78
Burn joss sticks								
No	45	42.9	1		29	14.2	1	
Yes	23	46.9	1.18	0.60 to 2.33	14	20.6	1.56	0.77 to 3.17
Stuffed soft toys at home								
No	32	45.1	1		24	17.5	1	
Yes	36	43.4	0.93	0.49 to 1.77	19	14.1	0.77	0.40 to 1.49
Pets at home								
No	65	43.3	1		38	14.9	1	
Yes	3	75.0	3.92	0.40 to 38.4	5	27.8	2.19	0.74 to 6.49
Self-satisfied with indoor air quality								
Yes	36	41.9	1		16	8.6	1	
No	32	47.1	1.23	0.65 to 2.34	27	31.8	4.98	2.50 to 9.88

*Proportion of those who had a respiratory illness.

showed that the odds of household gas cooking were positively and monotonically associated with respiratory illnesses after controlling for the other covariates (table 4). For example, in model 4, controlling for all covariates, children in households in which three or more meals per day were cooked were 2.6 times more likely to have a respiratory illness at the time of interview compared to children in households where only one meal per day was cooked. Reference groups in this model were: the absence of risk factors (passive smoking, extraction fan or hood, burning joss sticks, keeping stuffed toys and pets), windows usually kept closed, female gender, age group 0–1 years, a non-white collar job of the parent, estate B, and being satisfied with the indoor air quality.

Table 5 shows the adjusted ORs and the 95% confidence intervals of the frequencies of household gas cooking for respiratory illnesses stratified by estate. The two models were adjusted for all the other variables listed in model 4 (as shown in table 4). In the model for estate B, the estate with a lower concentration of outdoor air pollutants, exposure to household gas cooking was a risk factor for respiratory illnesses. A monotonic, dose-response relation with the frequency of gas cooking was observed, with the OR increasing from 3.2 (at cooking two meals a day) to 6.1 (at cooking three meals a day), and the latter reaching statistical significance. By contrast, no significant association between gas cooking and respiratory illnesses was observed in the model for the more polluted estate A, although the OR was above unity (at 1.7) for children exposed to cooking three meals a day. When we separately analysed the association

between gas cooking and allergic rhinitis in the models described above, the results were similar to those for all respiratory illnesses.

DISCUSSION

We found a significant, dose-response association between household gas cooking and the prevalence of respiratory illnesses in preschool children in a residential estate with low outdoor air pollution, after controlling for potential confounding factors. Our study provides additional evidence that household gas cooking increases the risk of respiratory illnesses among preschool children.

Most previous studies addressing the relation between household gas cooking and respiratory illnesses were based on a dichotomous variable of the exposure, that is, gas stove users and non-users.^{3 8 9} In this study, we studied the frequency of gas cooking and evaluated the dose-response relation between the frequency of gas cooking and the prevalence of respiratory illnesses among preschool children. The lack of a clear association reported in some studies may be partly due to a crude estimate of exposure. Different cooking methods might also have explained the discrepancies in the study results. In contrast to the cooking habits in other countries, stir frying with a strong flame, which generates large amounts of cooking oil fumes,¹ is a favourite Chinese cooking style.

Our subjects were preschool children who spent most of their time in the home environment and who were more susceptible to respiratory illnesses than older children. This

Table 4 Adjusted odds ratios and 95% confidence intervals relating various combinations of variables to respiratory illnesses

	Model 1		Model 2		Model 3		Model 4	
	OR	95% CI						
Household gas cooking frequency								
1 meal/day	1		1		1		1	
2 meals/day	0.99	0.54 to 1.79	0.98	0.53 to 1.83	1.07	0.54 to 2.10	1.28	0.64 to 2.59
3 meals/day	1.68	0.92 to 3.05	1.87	1.00 to 3.47	2.19	1.09 to 4.39	2.64	1.28 to 5.43
Exposure to passive smoking								
No	1		1		1		1	
Yes	1.09	0.65 to 1.85	0.99	0.57 to 1.71	0.95	0.52 to 1.72	0.92	0.50 to 1.67
Gender								
Female			1		1		1	
Male			1.66	1.05 to 2.62	1.50	0.92 to 2.46	1.67	1.00 to 2.77
Age (years)								
0–1			1		1		1	
2–3			1.66	0.83 to 3.33	1.55	0.75 to 3.23	1.67	0.79 to 3.52
4–6			2.37	1.22 to 4.63	1.94	0.96 to 3.92	2.03	0.99 to 4.17
Parents' job								
Non-white collar			1		1		1	
White collar			0.86	0.54 to 1.38	0.91	0.55 to 1.51	1.00	0.60 to 1.68
Extraction fan/hood in kitchen								
No					1		1	
Yes					0.36	0.09 to 1.48	0.27	0.06 to 1.19
Usually open window								
No					1		1	
Yes					1.16	0.63 to 2.15	1.26	0.67 to 2.35
Burn joss sticks								
No					1		1	
Yes					1.43	0.83 to 2.44	1.35	0.77 to 2.35
Stuffed soft toys at home								
No					1		1	
Yes					0.88	0.54 to 1.44	0.82	0.50 to 1.37
Pets at home								
No					1		1	
Yes					1.66	0.57 to 4.81	1.76	0.61 to 5.13
Estate								
B					1		1	
A					4.49	2.74 to 7.34	4.09	2.47 to 6.77
Self-satisfied with indoor air quality								
Yes							1	
No							2.95	1.76 to 4.96

Table 5 Adjusted odds ratios and 95% confidence intervals of exposure to household gas cooking in respiratory illnesses, stratified by estate*

	Estate A		Estate B	
	OR	95% CI	OR	95% CI
Household gas cooking frequency				
1 meal/day	1		1	
2 meals/day	0.78	0.31–1.98	3.19	0.92–11.04
3 meals/day	1.72	0.64–4.60	6.12	1.73–21.59
Exposure to passive smoking				
No	1		1	
Yes	1.11	0.46–2.68	0.81	0.33–1.97

*Adjusted for gender, age, parents' job, extraction fan/hood in kitchen, burning joss-sticks, stuffed soft toys, pets at home, opening windows, and self-satisfaction with indoor air quality.

reduces potential confounding effects due to exposures to other environments such as the school.

In areas with high ambient concentrations of NO₂, children might be exposed to higher NO₂ levels originating from outdoor sources by diffusion, even in the absence of gas cooking.¹⁰ By contrast, gas cooking may be an important source of NO₂ in homes with low outdoor levels. The contribution of gas cooking to the total NO₂ exposure in a high outdoor NO₂ environment is less important than in a low one.⁸ In effect, outdoor NO₂ would act as a competing risk factor for respiratory illnesses with indoor NO₂ generated from gas cooking. Our study supports this hypothesis. The frequencies of household gas cooking showed a dose-response relation with respiratory illnesses only in the less polluted estate B.

The lack of a significant association between passive smoking and respiratory illnesses in preschool children have been reported elsewhere.^{11–13} Our findings might be explained by a voluntary abstinence of smoking by parents in the presence of their preschool children.

Because most households used either an extraction fan or hood, the statistical power to detect a reduction in the risk of respiratory illnesses with the regular use of an extraction fan or hood in kitchen was low. Likewise, the adjusted OR of respiratory illness among children from households where windows were usually kept open were statistically insignificant.

Limitations to the study

Confounding factors

The presence of siblings in the household, the use of day care centres by the children, and a history of allergic diseases are potential risk factors for respiratory illnesses. Seventy five per cent of households had only one child. The crude prevalence of respiratory illnesses among single children was almost the same as that among children with siblings, and separate analysis of the former yielded similar results. The use of day care centres is an uncommon practice among working mothers. After adjusting for working mothers, we found little change in our results. However, we have not sought specific histories of allergic diseases. To address subjective perception of air pollution as a possible source of recall bias, we compared the results in the models with and without the variable "self-satisfaction with indoor air quality". After this adjustment, the dose-response relation between gas cooking and respiratory illnesses persisted.

Biases and validity

Recall bias or misclassification of the children's respiratory illnesses is difficult to assess. Assuming that the frequency of gas cooking was unlikely to change during the one month period when data on cooking frequency were sought, any inaccuracies in the recall of the "exposure" data should be

small. Systematic differences between the residents in the two estates are unlikely to have accounted for our findings. Residents of both estates, apart from their exposures to different levels of air pollutants, were similar in the floor areas of their apartments and their socioeconomic and demographic characteristics. Hence, our results are internally valid. As only preschool children were studied in two purposively chosen estates with contrasting levels of outdoor air pollutants, our results may not be generalisable to other estates, or to other subjects such as older children or adults.

Exposure assessment and causal relation

We lack measurement data on NO₂ and other indoor air pollutants. However, it is reasonable to assume that a higher frequency of gas cooking produces a higher concentration of indoor NO₂. Besides generating NO₂, gas cooking also produces cooking oil fumes and other thermal combustion products. Therefore, the health impact of gas cooking on the children's respiratory health might have resulted from co-exposure to both NO₂ and cooking fumes. Good household ventilation can reduce the level of both pollutants,¹⁰ and the OR of using exhaust fans or hoods is below unity (but statistically insignificant). The lack of a temporal relation between exposure and health consequences is an inherent limitation in a cross-sectional study, and the association between the respiratory illnesses and gas cooking cannot be interpreted as a causal relation. Nevertheless, it is unlikely that an increased prevalence of respiratory illnesses in children would cause a higher frequency of domestic cooking. In the absence of other explanations, our findings support the hypothesis of a causal relation between gas cooking and respiratory illnesses among preschool children.

In summary, we have observed a significant, dose-response relation between the frequency of household gas cooking and the risk of respiratory illnesses among preschool children living in a low pollution estate in Hong Kong. As household gas cooking is common in most urban communities, the findings could have important public health implications. Further studies on the nature and chemical composition of fumes generated by cooking and their influence on health should give more insight in the research on indoor air pollution.

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