

Effects of exposure to gas cooking in childhood and adulthood on respiratory symptoms, allergic sensitization and lung function in young British adults

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Summary

Background There is evidence that people who use gas for cooking have reduced lung function and experience more respiratory symptoms than those who use other fuels for cooking.

Objectives To study the effect of the presence of a gas cooker in the home, during both childhood and adulthood, on respiratory symptoms, allergic sensitization and ventilatory function among young adults.

Methods A sample of 1449 young adults born in Britain 3–9 March 1958, who have been followed from birth to ages 7, 11, 16, 23 and 33 years, were examined at home at age 34–35 years. FEV₁ and FVC were measured before and 20 min after inhalation of 400 µg salbutamol, and skin prick tests performed with three allergen extracts (grass, Der p 1 and cat). An interview on respiratory symptoms and indoor environmental exposures was included.

Results No association was found between gas cooking in childhood or adulthood and incidence or prognosis of asthma/wheeze, allergic sensitization or current severity of respiratory symptoms. Subjects who currently used gas for cooking had a significantly reduced FEV₁ (–70 mL, 95% CI ± 56) but not FVC (–35 mL, 95% CI ± 61) compared with those who used electricity for cooking. This reduction in FEV₁ was concentrated among men and current asthmatics.

Conclusion The use of gas for cooking is unlikely to be a major influence on respiratory morbidity in young adults.

Keywords: allergic sensitization, gas cooking, lung function, respiratory symptoms

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Introduction

The most important indoor source of nitrogen dioxide is the use of unvented gas appliances [1,2]. In 1987 Samet and colleagues [1] considered the evidence for any association between NO₂ exposure and respiratory symptoms or lung function. Although most evidence related to children their review included a number of studies on the relation

between gas cooking and respiratory symptoms or lung function in adults [3–8]. Subsequently five studies have looked at the effect of gas cooking on respiratory symptoms and lung function in adults [9–13]. One of these studies [3] found no association between the use of gas cooking and respiratory symptoms or lung function, while other studies have reported an increase in respiratory symptoms [4,5,7,9–11,13] or reduced lung function [4,6,10,13] among adults using gas for cooking compared with other fuel users. An international multicentre study [13] found that the association between respiratory symptoms and the use of gas for cooking varied between countries. Two studies of

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asthmatics found that the use of gas cooking was associated with more severe disease [7,11]. One study reported a greater relative odds of respiratory symptoms and a lower FEV₁ among women who frequently use gas for cooking compared with those who use gas for cooking infrequently or not at all [12]. A study that measured NO₂ exposure directly [8] found a negative association between current NO₂ exposure and several pulmonary function indices, but no association between retrospectively estimated exposure to NO₂ and decline in pulmonary function over 17 years. One study [10] found no association between sensitization to house dust mite, grass or cat and the use of gas for cooking.

No previous study has explored the relationship of adult symptoms to cooking fuel used in childhood, although there is evidence that childhood exposure increases the risk of respiratory illness in children by about 20% [14]. In this paper we report the associations of both current and childhood exposure with respiratory symptoms, allergic sensitization and ventilatory function among a nation-wide sample of British adults (with and without wheezing illness) who have been followed periodically from birth to age 35 years.

Methods

Subjects

The origins of the National Child Development Study (British 1958 cohort) are described elsewhere [15]. Briefly, the cohort is based on persons born in Britain during 3–9 March 1958 ($n = 17414$) and immigrants with the same birth dates ($n = 1145$), who have been contacted at birth and ages 7, 11, 16, 23 and 33 years. Among 18 559 subjects who had participated in one or more follow-ups of this cohort, there were 5470 who contributed data at birth, and all five follow-ups. As described elsewhere we selected subjects with a history of asthma, wheezy bronchitis or pneumonia at any one of the postnatal follow-ups (1989 'cases'), and a random 20% sample of the remainder (626 'controls') and invited them to participate in a further study involving measurements of ventilatory function and allergic sensitization during August 1992 to June 1993 [16,17].

Among the 2615 subjects mailed, 1875 (72%) responded after a single reminder, 1594 (61%) agreed to take part and 1449 (55%) were examined in their home by one of 20 research nurses trained together prior to the study. Of the 1449 examined, 1119 subjects had a history of chest disease and 330 were controls. The characteristics of the subjects who were examined and those not examined have been compared elsewhere [16,17].

The study was approved by the local research committees of 215 health districts in England and Wales. All subjects gave written consent to examination.

Interview

All subjects completed an interview about past and current respiratory symptoms and indoor environmental exposures.

The questions on fuel used for cooking were as follows:

- What type of fuel is used for cooking in this home?
- What type of fuel was used for cooking in the home in which you lived when you were 11 years old? (Cooking fuel was not ascertained directly during childhood.)

The following questions were asked relating to recent asthma/chest symptoms:

- How many attacks of asthma or wheezing have you had in the past 12 months?
- Over the past 12 months, how often, on average, has your sleep been disturbed due to asthma or wheezing?
- Over the past 12 months, have you had any attacks of asthma or wheezing so severe that you could speak only one or two words at a time between breaths?
- Over the past 12 months have you used any inhalers or taken any medicines to treat or prevent asthma, wheezing or other chest trouble?
- Do you ever get short of breath walking with other people of your own age on level ground?
- Do you usually cough first thing in the morning in the winter?
- Do you usually cough during the day or at night during the winter?

If yes to either of the above:

- Do you cough like this on most days for as much as three months each year?
 - Do you usually bring up any phlegm from your chest first thing in the morning in winter?
 - Do you usually bring up any phlegm from your chest during the day or at night in winter?
- If yes to either of the above:
- Do you bring up phlegm like this on most days for as much as 3 months each year?

The incidence and age at onset of asthma or wheezing illness (asthma/wheeze) was determined prospectively from parental reports of asthma or wheezy bronchitis occurring before 7, 11 and 16 years of age, and interviews with subjects themselves at 23, 33 and 34–35 years of age (at examination) as described in greater detail elsewhere [16]. Report of asthma/wheeze in the 12 months prior to examination was used as an indicator of prognosis at 34–35 years of age. The number of attacks of asthma or wheezing, number of times sleep disturbed by wheezing and number of speech-limiting attacks in the past 12 months, breathlessness on exertion, frequency of cough and phlegm were used as measures of disease severity.

Measurements of ventilatory function

Forced expiratory manoeuvres were performed according to the criteria of the American Thoracic Society [18], in the standing position, without nose clips. After a period of instruction and practice attempts, at least three (and up to eight) spirometers were recorded by dry bellows spirometer (Vitalograph R-model or S-model, Vitalograph Ltd, Buckingham, UK) until two measurements of forced expiratory volume in one second (FEV₁) within 5% of each other were obtained.

A further set of spirometers, using the same criteria, were recorded 20 min after inhalation of 400 µg salbutamol by dry powder inhaler. Further detail is provided in an earlier report [16].

Skin prick tests

Skin prick tests were performed on the volar aspect of the forearm using 1 mm flanged lancets and extracts of mixed grass pollen; house dust mite (*Dermatophagoides pteronyssinus*); cat fur; histamine (1:999, positive control) and diluent (negative control). The test solutions used by each nurse were prepared from single batches by Allergopharma, Germany. Skin prick reactions to each extract were recorded

after 10 min as the maximum weal diameter and the diameter perpendicular to the maximum. The average of these two diameters was calculated. Weals of 3 mm or greater mean diameter were considered positive, and a positive reaction to any of the three allergens was used to define 'atopy' [17].

Statistical analysis

Tabulations were derived by the FREQ procedure and multiple regression models were fitted by the GLM procedure in Statistical Analysis System (SAS) [19]. Associations of asthma incidence, prognosis and severity with gas cooking were expressed as odds ratios which were calculated using Epi Info [20].

Measurements of FEV₁, FVC and the FEV₁/FVC ratio were used, in turn, as outcome variables in multiple regression models after adjusting for observer, month of examination, gender, height, cigarette smoking (ever smoked, smoke now, number of cigarettes smoked per day), asthma/wheeze history (never, past, current) and pneumonia history (never, ever). No adjustment for age was necessary because all subjects were either 34 or 35 years old at examination. Observer, month of examination, asthma/wheeze history and pneumonia history were fitted as categorical variables.

Table 1. Frequencies and unadjusted odds ratios of age-specific incidence of asthma, wheezy bronchitis (AW) and pneumonia (Pn) by cooking fuel in childhood

	Cooking fuel in childhood			P-value
	Electric (n = 528)	Gas (n = 841)	OR gas vs electric*	
<i>All</i>				
Never	113	199		
Pn only by 7	3	14	2.65 (0.72–14.65)	0.12
AW 0–7 years	213	323	0.86 (0.64–1.16)	0.31
AW 8–16 years	70	115	0.93 (0.63–1.38)	0.72
AW 17–23 years	39	63	0.92 (0.56–1.49)	0.71
AW 24–35 years	90	127	0.80 (0.55–1.16)	0.22
Ever AW	412	628	0.87 (0.66–1.13)	0.28
<i>Males</i>				
Never AW	58	97		
Ever AW	188	308	0.98 (0.66–1.45)	0.91
<i>Females</i>				
Never AW	55	102		
Ever AW	224	320	0.77 (0.52–1.13)	0.17
<i>Nonatopic</i>				
Never AW	93	162		
Ever AW	243	408	0.96 (0.71–1.32)	0.81
<i>Atopic</i>				
Never AW	20	37		
Ever AW	169	220	0.70 (0.38–1.30)	0.23

* Relative to 'never' as baseline category.

The adjustment for gender and height involved fitting separate intercepts and slopes for each sex. Terms for smoking included smoking history and the number of cigarettes currently smoked each day.

A variable representing the fuel each subject used for cooking currently and a variable representing the fuel that was used in the home of the subject when they were 11 years old were used to compare the ventilatory function (both before and after salbutamol) of those who use/used gas for cooking with the ventilatory function of those who use/used electricity for cooking (reference group).

The regression coefficients from each of these models represent the absolute difference in mean FEV₁, FVC or FEV₁/FVC ratio between each group and the reference group, adjusted for observer, month, gender, height, smoking habit, asthma/wheeze and pneumonia history.

We hypothesized that interactions by gender would be present due to differences in exposure and susceptibility and hence analysis has been carried out for males and females separately. We also investigated whether the associations with lung function differed in those with and without recent asthma symptoms.

Results

Among the 1449 subjects examined, 651 (45%) currently used only gas for cooking, 505 (35%) used only electricity for cooking and 272 (19%) used both gas and electricity for cooking. These 272 subjects who used both cooking fuels are excluded from Tables 1–4 in the interests of clarity and only included in the analysis of lung function (Table 5). It made little difference to the results whether or not they were

included in the group using gas for cooking. Fifteen (1%) subjects who currently used other fuels for cooking and six subjects for whom the fuel used for cooking was unknown were excluded from all further analyses.

When asked what fuel was used for cooking in the home in which the subject lived when they were 11 years old, 841 (58%) reported gas and 528 (36%) reported electricity. Ten (1%) subjects who reported that both gas and electricity were used, 45 (3%) reported that other fuels were used, 13 (1%) could not remember and 12 subjects for whom the fuel that was used was unknown were excluded from all further analyses.

Of the 651 subjects who currently used gas for cooking, 430 (66%) reported that gas was used for cooking in the home in which the subject lived at 11 years of age, compared with 247 (49%) of the subjects who currently used electricity for cooking.

The proportion of smokers is very similar between the group who currently used gas for cooking and the group who used electricity. Among gas users, 458 (70%) have ever smoked and 220 (34%) were current smokers, the corresponding figures among electricity users were 351 (70%) and 155 (31%).

Parental smoking was slightly more common in current gas users amongst whom 73% were exposed to parental smoke at 16 years of age and 33% of their mothers smoked during pregnancy. The corresponding figures among current electricity users are 69% and 26%.

There was a similar pattern in relation to cooking fuel in childhood. Among subjects who at 11 years lived in homes where gas was used for cooking, 74% were exposed to parental smoke at 16 years of age and 33% of their mothers

Table 2. Frequencies and unadjusted odds ratios of asthma/wheeze (AW) by age at onset wheezing illness, cooking fuel in adulthood and childhood

		Cooking fuel currently				Cooking fuel in childhood			
		Electric	Gas	OR gas vs electric	<i>P</i> -value	Electric	Gas	OR gas vs electric	<i>P</i> -value
<i>AW 0–7</i>									
<i>AW at 35</i>	No	119	144	1.26 (0.84–1.88)	0.24	129	185	1.15 (0.78–1.66)	0.45
	Yes	73	111			84	138		
<i>AW 8–23</i>									
<i>AW at 35</i>	No	66	76	1.15 (0.67–1.98)	0.58	58	102	0.85 (0.51–1.41)	0.50
	Yes	46	61			51	76		
<i>AW 24–35</i>									
<i>AW at 35</i>	No	23	28	1.01 (0.50–2.04)	0.97	25	43	0.75 (0.40–1.41)	0.34
	Yes	60	74			65	84		
<i>Ever AW</i>									
<i>AW at 35</i>	No	208	248	1.15 (0.88–1.52)	0.30	212	330	0.96 (0.74–1.24)	0.73
	Yes	179	246			200	298		

Table 3. Frequencies and unadjusted odds ratios of respiratory symptoms in current asthmatics by current smoking habit and cooking fuel

	Non-smokers				Current smokers			
	Electric	Gas	OR gas vs electric	P-value	Electric	Gas	OR gas vs electric	P-value
<i>Number of attacks in the past 12 months</i>								
≤ 12	91	115	1.35 (0.55–3.34)	0.48	61	88	1.16 (0.36–4.08)	0.79
> 12	10	17			6	10		
<i>Sleep disturbed by wheezing in past 12 months</i>								
No	56	79	0.91 (0.53–1.59)	0.73	50	78	0.83 (0.40–1.74)	0.60
Yes	45	58			20	26		
<i>Speech-limiting attack in the past 12 months</i>								
No	84	125	0.50 (0.21–1.20)	0.09	66	94	1.76 (0.48–7.97)	0.35
Yes	16	12			4	10		
<i>Prescribed treatment for asthma in the past 12 months</i>								
No	40	55	0.98 (0.56–1.72)	0.95	44	66	1.17 (0.58–2.36)	0.63
Yes	60	81			22	37		
<i>Breathlessness on exertion</i>								
No never	83	111	1.10 (0.55–2.22)	0.77	61	86	1.01 (0.45–2.31)	0.97
Freq./occasionally	19	28			14	20		
<i>Cough on most days for as much as 3 months a year</i>								
No	91	114	1.47 (0.67–3.26)	0.30	57	74	1.41 (0.69–2.92)	0.31
Yes	13	24			18	33		
<i>Phlegm on most days for as much as 3 months a year</i>								
No	92	119	1.34 (0.57–3.17)	0.47	62	81	1.47 (0.66–3.33)	0.31
Yes	11	19			13	25		

smoked during pregnancy. The corresponding figures among subjects who at 11 years lived in homes where electricity was used for cooking are 70% and 27%.

Incidence, prognosis and severity of asthma/wheeze

Table 1 shows the distribution of age at onset of asthma/wheeze by fuel used for cooking at 11 years of age. Subjects who at 11 years lived in a house where gas was used for cooking had a slightly decreased risk of developing asthma/wheeze at all ages, however, none of these associations were statistically significant. There was no association between fuel use in adulthood and onset of asthma/wheeze at age 24–35, odds ratio = 0.94 (0.63–1.40).

Table 2 relates cooking fuel, both currently and at age 11, to the prognosis of wheezing illness. Subjects who developed asthma/wheeze aged 0–7 years and used gas for cooking (currently or 11 years) had a non-significant increased risk of still having asthma/wheeze at 35 years of age. The increased risk of persistence associated with current gas cooking was significant among female subjects, odds ratio = 1.82 (95% CI: 1.02–3.26) and among non-atopic subjects, odds ratio = 1.84 (1.05–3.22). The corresponding odds ratio among males was 0.86 (0.48–1.54) and the odds ratio among atopic subjects was 0.76 (0.39–1.49).

However, these interactions by gender and atopic status were not significant ($P > 0.05$).

Table 3 shows the relationship between current cooking fuel and indicators of severity among subjects with asthma/wheeze in the past year at examination by smoking habit. No significant association was found between fuel used for cooking and the prevalence of any respiratory symptom among current asthmatics in either smokers or non-smokers. This was also true when analysing males and females separately.

Allergic sensitization

Sensitization to house dust mite, grass or cat was not significantly associated with current fuel use (Table 4). Subjects who at 11 lived in homes where gas was used for cooking had a reduced risk of sensitization to house dust mite, grass, cat and any of the three allergens (atopy), although this reduced risk was only statistically significant for cat (Table 4).

Ventilatory function

Table 5 shows the associations of current cooking fuel with spirometric measurements at 34–35 years of age. Subjects

Table 4. Frequencies and unadjusted odds ratios of skin prick positivity allergens by cooking fuel used currently and in childhood

	Cooking fuel currently				Cooking fuel in childhood			
	Electric	Gas	OR gas vs electric	P-value	Electric	Gas	OR gas vs electric	P-value
<i>All</i>	(<i>n</i> = 498)	(<i>n</i> = 636)			(<i>n</i> = 521)	(<i>n</i> = 820)		
Dust	93	121	1.02 (0.75–1.40)	0.88	107	145	0.83 (0.62–1.11)	0.19
Grass	119	143	0.92 (0.69–1.23)	0.58	129	184	0.88 (0.67–1.14)	0.32
Cats	47	67	1.13 (0.75–1.71)	0.54	63	70	0.68 (0.47–0.99)	0.03
Any of 3 allergens	167	211	0.98 (0.76–1.27)	0.90	190	260	0.81 (0.64–1.02)	0.07
<i>Males</i>	(<i>n</i> = 239)	(<i>n</i> = 314)			(<i>n</i> = 242)	(<i>n</i> = 404)		
Any of 3 allergens	95	113	0.85 (0.59–1.22)	0.37	102	146	0.78 (0.55–1.09)	0.13
<i>Females</i>	(<i>n</i> = 259)	(<i>n</i> = 322)			(<i>n</i> = 279)	(<i>n</i> = 416)		
Any of 3 allergens	72	98	1.14 (0.78–1.66)	0.49	88	114	0.82 (0.58–1.16)	0.24
<i>Number of older siblings</i>								
0	(<i>n</i> = 190)	(<i>n</i> = 233)			(<i>n</i> = 208)	(<i>n</i> = 293)		
Any of 3 allergens	69	85	1.01 (0.66–1.53)	0.97	80	108	0.93 (0.64–1.37)	0.72
1	(<i>n</i> = 153)	(<i>n</i> = 196)			(<i>n</i> = 181)	(<i>n</i> = 257)		
Any of 3 allergens	59	67	0.83 (0.52–1.32)	0.40	71	80	0.70 (0.46–1.06)	0.08
2 +	(<i>n</i> = 144)	(<i>n</i> = 198)			(<i>n</i> = 124)	(<i>n</i> = 254)		
Any of 3 allergens	37	54	1.08 (0.65–1.82)	0.74	37	66	0.83(0.50–1.37)	0.43

who used gas for cooking at the time of study had a significantly lower FEV₁ and FEV₁/FVC ratio than those who use electricity for cooking after adjustment for observer, month of examination, gender, height, cigarette smoking (ever smoked, smoke now, number cigarettes smoked per day), asthma/wheeze history and pneumonia history. The ventilatory function of subjects who used both gas and electricity for cooking was intermediate.

After additional adjustment for social class, fathers social class, breast feeding, birth weight, height at 7 years, maternal smoking during pregnancy, exposure to tobacco smoke at work and at home, birth order, region at birth, exposure to occupational fumes and whooping cough history, the results were only slightly affected. The reduction in FEV₁ for gas users compared with electricity users became 68 mL (95% CI; $\pm$ 59) compared with 70 mL ($\pm$ 56) before the additional adjustment and the reduction in FEV₁/FVC ratio became 1.1% ($\pm$ 0.8) compared with 1.0% ($\pm$ 0.8).

After salbutamol the above differences were slightly reduced. For all subjects the gas users had a reduction in FEV₁ of 51 mL ($\pm$ 54) and a reduction in FEV₁/FVC ratio of 0.9% ($\pm$ 0.7) compared with electricity users.

After restricting the model to 418 lifelong non-smokers, the differences became non-significant. Gas users had a reduction in FEV₁ of 14 mL ($\pm$ 111) and a reduction in FEV₁/FVC ratio of 0.4% ($\pm$ 1.4) compared with electricity users.

No significant association was found between FVC and fuel currently used for cooking (Table 5). No significant

association was found between any of the ventilatory function measures and fuel used for cooking at 11 years of age, in either male or female subjects.

The statistical interaction between gender and fuel currently used for cooking was significant for both FEV₁ (P = 0.0012) and FEV₁/FVC ratio (P = 0.0344). Males and females were therefore analysed separately (Table 5). Unexpectedly, the use of gas for cooking was not associated with a significant reduction in FEV₁ or FEV₁/FVC ratio in females, whereas males who used gas for cooking had poorer ventilatory function than those who used electricity for cooking. The trends across three categories of cooking fuel were significant (P < 0.05) for both FEV₁ and FEV₁/FVC ratio. After the additional adjustment for social class, fathers social class, breast feeding, birth weight, height at 7 years, maternal smoking during pregnancy, exposure to tobacco smoke at work and at home, birth order, region at birth, exposure to occupational fumes and whooping cough history, the results were only slightly affected. Among male subjects, gas users had a reduction in FEV₁ of 114 mL ($\pm$ 97) compared with electricity users, while the same reduction among female subjects was 18 mL ($\pm$ 69).

The statistical interaction between asthma/wheeze history and current cooking fuel was significant for both FEV₁ (P = 0.0213) and FEV₁/FVC ratio (P = 0.0115) and therefore subjects were analysed separately according to their asthma/wheeze history. No statistically significant association was found between gas cooking and ventilatory function among past asthmatics or those who had never had

Table 5. Adjusted* mean difference in spirometric indices before salbutamol between groups with different cooking fuel in adulthood

		FEV ₁ (mL) (mean = 3723 mL)			FVC (mL) (mean = 4533 mL)			FEV ₁ /FVC (%) (mean = 82%)		
	<i>n</i>	Diff.	95% CI	<i>P</i> -value	Diff.	95% CI	<i>P</i> -value	Diff.	95% CI	<i>P</i> -value
<i>All</i>										
Gas	626	− 70	± 56	0.01	− 35	± 61	0.26	− 1.0	± 0.8	0.01
Mixed	262	−37	± 72	0.31	+ 16	± 79	0.69	− 1.2	± 1.0	0.02
Electric	488	0	(ref)		0	(ref)		0	(ref)	
Test for trend	1376			0.01			0.23			0.01
<i>Males</i>										
Gas	312	−141	± 93	0.003	−106	± 100	0.04	− 1.2	± 1.1	0.03
Mixed	134	− 87	± 119	0.15	− 36	± 128	0.58	− 1.3	± 1.4	0.10
Electric	237	0	(ref)		0	(ref)		0	(ref)	
Test for trend	683			0.003			0.03			0.04
<i>Females</i>										
Gas	314	+ 0.2	± 66	0.99	+ 29	± 73	0.43	− 0.7	± 1.1	0.21
Mixed	128	+ 37	± 85	0.40	+ 93	± 94	0.05	− 1.0	± 1.5	0.18
Electric	251	0	(ref)		0	(ref)		0	(ref)	
Test for trend	693			0.96			0.48			0.21
<i>Never AW</i>										
Gas	149	− 62	± 108	0.26	−95	± 133	0.16	+ 0.2	± 1.4	0.77
Mixed	66	+ 62	± 29	0.35	+ 112	± 160	0.17	− 0.7	± 1.6	0.39
Electric	115	0	(ref)		0	(ref)		0	(ref)	
Test for trend	330			0.28			0.17			0.76
<i>Past AW</i>										
Gas	240	−28	± 89	0.54	+ 34	± 102	0.51	− 1.1	± 1.1	0.06
Mixed	110	− 72	± 112	0.21	− 5	± 128	0.94	− 1.3	± 1.4	0.07
Electric	196	0	(ref)		0	(ref)		0	(ref)	
Test for trend	546			0.58			0.50			0.07
<i>Current AW</i>										
Gas	237	−129	± 105	0.02	− 86	± 101	0.10	− 1.7	± 1.6	0.04
Mixed	86	− 39	± 144	0.59	− 10	± 138	0.88	− 1.0	± 2.2	0.38
Electric	177	0	(ref)		0	(ref)		0	(ref)	
Test for trend	500			0.01			0.08			0.03

*Adjusted for sex, height, sex by height interaction, observer, month of examination, asthma/wheeze history (AW), pneumonia history and smoking history.

asthma/wheeze. Current asthmatics who used gas for cooking had a significant reduction in FEV₁ and FEV₁/FVC ratio compared with current asthmatics who used electricity for cooking (Table 5). These differences persisted after salbutamol: current asthmatics who used gas for cooking still had a significant reduction in FEV₁ (−102 mL; ± 93) and FEV₁/FVC (−1.9%; ± 1.4) ratio compared with current asthmatics who used electricity for cooking.

Discussion

This study is the first to explore the relationship of cooking fuel in both adulthood and childhood to prospectively

ascertained incidence, prognosis and current severity of asthma, and to objective measures of allergic sensitization and ventilatory function in adult life. We found no association between incidence or prognosis of asthma, allergic sensitization or current severity of respiratory symptoms and the use of gas for cooking in childhood or adulthood. The use of gas for cooking in adulthood was found to be associated with reduced ventilatory function, this effect being significant in males.

The main limitation to this study is the use of presence of a gas cooker in the home as a surrogate for indoor NO₂ exposure. This may not be an accurate reflection of actual NO₂ exposure because of a possible wide variation in how

often subjects use the cooker and in ventilation in the home. No information was obtained on duration of cooker use by the subjects examined in our study. NO₂ levels vary widely with time and space in homes using domestic gas appliances and it may be short-term peaks rather than average exposure levels that determine the respiratory health effects [21]. The use of gas for cooking is arguably a better proxy for peak exposures than for long-term average NO₂ levels.

Another limitation to this study is that the cooking fuel used in the home the subject lived in was not ascertained directly during childhood, instead we rely on accuracy of recall from the subjects at ages 34–35 years. However, only 13 out of 1449 subjects (1%) said they could not remember what cooking fuel was used in the home they lived in at 11 years of age suggesting that cooking fuel use during childhood can be accurately recalled. Subjects were asked what cooking fuel was used in the home they lived in at 11 years of age only, as subjects could not be expected to recall earlier fuel use, so this may not be an accurate measure of exposure during infancy for some subjects.

Studies of the relationship between the use of gas for cooking and respiratory symptoms in adults have reported conflicting results. Our finding that there is no significant relationship between gas cooking and respiratory symptoms among asthmatics is in agreement with two studies by Keller *et al.* [3,22] but other studies have observed a significant relationship between use of gas for cooking and respiratory symptoms [4,5,7,9–11]. Two of these studies [7,11] found an increase in certain respiratory symptoms among asthmatics who used gas for cooking. Studies are inconsistent with respect to gender-specific association [4,10]. In the European Community Respiratory Heath Survey [13], gas cooking was positively (but non-significantly in all but two centres) associated with wheeze in women in most European countries, but inverse associations were observed in Australia, New Zealand and the USA.

Our observation that there is no relationship between allergic sensitization and the use of gas for cooking is in line with another British study [10]. Two chamber studies [23,24] have shown that exposure to nitrogen dioxide, alone or in combination with sulphur dioxide, enhances the airway response to common allergens. However, we did not find any increase in asthma incidence (or more adverse prognosis) in atopic subjects exposed to gas cooking.

Current use of gas cooking in our cohort was associated with a significant reduction in FEV₁ and FEV₁/FVC ratio. Consistent with other literature [7] this impairment among current gas users was strongest in current asthmatics. Although these observations suggest an 'obstructive' pattern of airflow limitation, the lung function deficit in gas users was not substantially reversed by inhalation of salbutamol.

Jarvis *et al.* [10] reported that the use of gas for cooking is associated with an impaired lung function (FEV₁% predicted and %FEV₁/FVC) among women only. Hasselblad *et al.* [25] in a study of children found a reduction in FEV_{0.75} associated with gas cooking among older girls (9–13 years). The authors of these studies postulate that these relationships arise because women generally spend more time cooking than men and girls spend more time helping in the kitchen than boys do. Gender differences in exposure to gas cooking fumes are unlikely to explain the findings of our study in which there was no association between the use of gas for cooking currently and impaired ventilatory function among females, the association being concentrated among male subjects, as also reported by Comstock *et al.* [4]. Our finding is also supported to a certain extent by recent results from the European Community Respiratory Heath Survey [13] which found that in females there was no association between the use of gas for cooking and lung function, while among males there was a significant negative association between the use of gas for cooking and FEV₁% predicted but not %FEV₁/FVC.

Although our findings do not exclude a weak adverse effect of gas cooking on asthma incidence, prognosis or severity, they are more consistent with no association, and argue against as strong a relationship as reported in some previous studies. The association of current gas cooking with impaired lung function in men but not in women or in lifelong non-smokers also argues against a causal relationship. We conclude that past and current use of gas for cooking is unlikely to be a major influence on respiratory morbidity in young adults.

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