CLINICAL RESEARCH

The Tayside infant morbidity and mortality study: effect on health of using gas for cooking

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Abstract

The relation between respiratory illness and the use of gas for cooking was examined from data on 1565 infants born to mothers who were primigravidas living in Dundee in 1980. Episodes of, and admissions to hospital for, respiratory illness were recorded during the first year of life. Both admissions and episodes were more common in infants from families using gas for cooking or heating than in infants from families using any other type of cooking or heating, but the differences were not significant. Results from this and other studies show that there is probably a small relation between respiratory illness and the use of gas appliances without a flue. To show convincingly whether such a relation exists might require a survey of 18 000-23 000 subjects. Respiratory illness was, however, strongly and positively related to parental smoking, a finding that is often made even in small studies.

Introduction

A report in 1977 suggested that British primary school children who lived in homes where gas was used for cooking were at a greater risk of respiratory illness than those living in homes where electricity was used.[1] The authors thought that nitrogen dioxide produced principally by the heat of the gas flame might be the cause of this as nitrogen dioxide had been shown to reduce resistance to pulmonary infection in experimental animals.[2] Subsequent studies in primary school children showed that lung function was not related to the concentration of nitrogen dioxide in the home but that the incidence of symptoms and illness increased with increasing concentrations.[3 4] Some results from the United States of America substantiated the British findings,[4] but these significant associations were not found in later studies carried out in Britain and America.[5 6] Attention was drawn to the need to investigate the effects of nitrogen dioxide in infants as infants would be expected to have more sensitive lungs than school children.[7] A small study of infants whose mothers attended a general practice in south London, however, showed no relation between the use of gas for cooking and either the incidence of respiratory illnesses reported by the mother at the end of the infant's first year or the number of consultations for respiratory conditions recorded by the general practitioners.[8]

We report the relation between living in homes where gas is used for cooking and respiratory illness recorded in infants during the first year of life and admissions of infants to hospital for respiratory disease that was found in a study of nearly 1900 infants in Dundee.

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Subjects and methods

All women living in Tayside who made an initial booking at any of the region's antenatal clinics during 1980 and were either primigravidas, or virtual primigravidas, or pregnant for the fourth or subsequent time were asked to participate. The analyses presented concern only the infants of women who were primigravidas.

On the first or second visit to the antenatal clinic each respondent was interviewed by a research health visitor. Information was obtained on the mother's and father's ages, social class, ethnic groups, and smoking habits and on details of the household, including type of heating and method of cooking, number of adult residents, and whether the mother was working during pregnancy. A postnatal questionnaire was completed by the mother while she was in hospital to provide details of her smoking habits during pregnancy. Another form was completed later by the research health visitor based on the mother's and baby's medical records. This indicated whether the baby had survived and the type of feeding given. The child's health was monitored by obtaining copies of any SMR1 forms, which recorded details of discharge from hospital, and by the family health visitors completing a form during an interview with the mother one year after the child's birth. This form included a report on all the child's illnesses during its first year of life. The information at one year was supplemented by observations made by health visitors during their scheduled visits to see the infant and was scrutinised by a paediatrician who checked diagnostic criteria and validity.

Respiratory illness was defined in two ways. Firstly, the incidence was calculated as the number of infants who had at least one episode of respiratory illness recorded by the health visitor out of the total number of infants followed up to one year. An episode included infections of the upper and lower respiratory tract. Secondly, respiratory illness was measured as the number of admissions to hospital recorded during the first year of life for which one or more of the codes for respiratory illness in the International Classification of Diseases (460-519·9) were included among the diagnoses. As few children were admitted to hospital more than once children were classified as either never admitted or admitted at least once.

Information was obtained on the type of fuel used for cooking (electricity, gas, or other) and the principal method of heating the house (see table I). If gas heating was the secondary means of heating separate categories were assigned.

Information on the mother's smoking habit was obtained both at the initial interview and from the postnatal questionnaire completed by the mother. As only about 80% of mothers completed the postnatal questionnaire and there was a high consistency between the antenatal and postnatal responses we decided to rely on the antenatal information to characterise maternal smoking habits. Similar information was obtained on the smoking habits of the child's father and other people in the household. The data on parents' smoking habits were combined into a single binary classification: children with non-smoking parents and children with one or both parents who smoked. When data were not available on the father's smoking habits children were classified on the mother's smoking only.

To investigate whether types of heating and cooking were significant in explaining differences in the incidence of respiratory illness the data were analysed using a logistic regression model, in which allowance was made for possible confounding of these with other factors studied. The type of heating used in the home was grouped into six categories on the basis of the main type of heating used. The type of fuel used for cooking was grouped as electric, gas, or other. Maternal age was coded in four five year groups (15-19, 20-24, 25-29, and 30+). The incidence of respiratory disease (I) was calculated for each cell defined by the combinations of these factors. A multiple regression equation was then calculated relating the logarithm of the odds of the incidence of respiratory disease (log I/(1-I)) to these factors using the computer program generalised linear interactive modelling (GLIM).

Results

Of 2822 mothers who made initial bookings during the year, 2711 were interviewed. Exclusion of mothers of high parity and mothers who had had multiple pregnancies left 1981 singleton infants, of whom 30 died during the first year. Of these, 11 were still births and 19 infant deaths. Of the infant deaths, 10 were due to congenital defects, four to asphyxia, two to extreme prematurity, and one to trauma, and two were cot deaths. Forty one infants with black mothers were also excluded from the analysis, leaving 1910 infants for whom data from the initial interview were available. Collection of follow up data was incomplete because some families had left the region and some health visitors were unable to obtain information at the one year follow up. Complete data up to one year were obtained on 1565 infants.

Of 42 children admitted to hospital, 32 were admitted only once, nine twice, and one three times. Of the diagnoses recorded, 28 were upper respiratory infection (ICD 465·9) and 12 acute or unspecified bronchitis (ICD 466 and 490). The remaining diagnoses included croup, asthma, pneumonia, and tonsillitis, for which there were only one or two cases each.

Health visitors recorded an episode of respiratory illness in 494 cases. Table I shows the incidence of respiratory illness and admission to hospital according to maternal age, type of feeding on discharge from hospital, parental smoking habits, and cooking and heating facilities. Maternal age and breast feeding at discharge from hospital were significantly associated with better health of the infant on both outcome measures. The social class of the father (not shown) was not significantly associated with either outcome measure.

Among smokers there was no evidence of a trend of increasing incidence with the number of cigarettes smoked daily. The parents were therefore classified simply as smokers or non-smokers. Children had a lower incidence of disease if neither parent smoked, but there was no significant increase in the incidence in infants from families where one parent smoked and from families where both parents smoked.

The associations between the method of cooking and incidences of respiratory illness and of admissions to hospital were not significant ($p > 0·1$), but the trends were in the expected direction. Infants from homes with gas heating had a relatively high incidence of respiratory illness as reported by the health visitor at one year. Children in homes with electric heating alone or plus gas also had a higher incidence of illness than those with central heating, storage heating, or coal fires. The use of gas as a secondary means of heating did not influence the incidence of respiratory disease. Admissions to hospital were too few in these categories for firm conclusions to be drawn.

Table II gives the results of the logistic regression analysis of the incidence of respiratory illness. When the factors were fitted singly all except the type of fuel used for cooking showed a significant association with the incidence of respiratory illness, which was consistent with the results given in table I. Parental smoking habits showed the strongest correlation. When the other factors were introduced individually in addition to parental smoking the type of feeding had no significant effect but the type of heating and maternal age showed weak effects ($p < 0·1$ in each case). Maternal age, type of feeding, and parental smoking were all correlated with each other so that adjusting for parental smoking also explained much of the difference in the incidence of respiratory illness associated with maternal age and feeding habits.

Table III shows the results of fitting parental smoking, maternal

TABLE I—*Number (%) of infants with respiratory illness and of admissions to hospital for respiratory illness in first year of life*

	No at risk	Respiratory illness	Admissions to hospital
Age of mother (years):			
15-19	334	126 (37·7)	13 (3·9)
20-24	703	222 (31·6)	24 (3·4)
25-29	385	105 (27·3)	5 (1·3)
30 +	143	41 (28·7)	0
		$\chi^2_3 = 9·70$*	$\chi^2_3 = 10·7$*
		$\chi^2_T = 7·82$**	$\chi^2_T = 9·13$**
Feeding on discharge from hospital:			
Breast	757	221 (29·2)	10 (1·3)
Bottle	769	265 (34·5)	29 (3·8)
Other (not known, mixed)†	39	8 (20·5)	3 (7·7)
		$\chi^2_Y = 4·63$*	$\chi^2_Y = 8·24$**
Parents' smoking habits:			
Neither	588	146 (24·8)	10 (1·7)
Father only	338	112 (33·1)	5 (1·5)
Mother only	177	68 (38·4)	6 (3·4)
Both	439	160 (36·4)	20 (4·6)
		$\chi^2_3 = 21·44$***	$\chi^2_3 = 10·37$*
Father's habit unknown:			
Mother non-smoker†	7	3 (42·9)	0
Mother smoker†	16	5 (31·3)	1 (6·3)
Cooking facilities:			
Electric	1174	358 (30·5)	29 (2·5)
Gas	370	130 (35·1)	12 (3·2)
Other†	21	6 (28·6)	1 (4·8)
		$\chi^2_Y = 2·59$	$\chi^2_Y = 0·39$
Heating facilities:			
Central heating	354	103 (29·1)	9 (2·5)
Storage heating	153	41 (26·8)	4 (2·6)
Coal	200	55 (27·5)	6 (3·0)
Gas	172	66 (38·4)	6 (3·5)
Electric	481	168 (34·9)	16 (3·3)
		$\chi^2_4 = 10·25$ ($p < 0·05$)	
Others and not known	25	9 (36·0)	0
Central heating and gas	77	21 (27·3)	0
Electric and gas	62	22 (35·5)	1 (1·6)
Other and gas	41	9 (22·0)	0
		$\chi^2_8 = 13·42$	

$\chi^2_T = \chi^2$ for linear trend (1 df); $\chi^2_Y = \chi^2$ with Yates's correction.
*$p < 0·05$, **$p < 0·01$, ***$p < 0·001$.
†Not included in calculation of χ^2.

TABLE II—*Improvement in goodness of fit (approximate χ^2 statistic) after inclusion of parental smoking alone and parental smoking plus an additional factor in multiple logistic regression analyses of incidence of respiratory illness*

Factor	Degrees of freedom	No other factor fitted	Parental smoking fitted first
Parental smoking	1	18·9***	
Maternal age	3	8·5*	3·9 NS
(Linear trend)	1	6·9**	2·6†
Feeding type	2	6·8*	3·4 NS
Heating method	5	12·5*	9·7†
Cooking fuel‡	2	2·7 NS	2·3 NS

Overall goodness of fit for model with no other factors fitted $\chi^2 = 265·9$; df = 198.
‡Only those using either gas or electricity for cooking are included (n = 1544).
NS: $p > 0·10$, †$p < 0·10$, *$p < 0·05$, **$p < 0·01$, ***$p < 0·001$.

age, type of cooking, and type of heating in a multiple logistic regression equation. The coefficient for gas cooking compared with electric cooking was 0·13 (SE 0·141); its antilog gave a relative risk of 1·14 (95% confidence interval = 0·86-1·5).

A parallel analysis for the data on admissions to hospital was not possible because of the small number of cases. Table IV shows the incidence of admission to hospital classified by parental smoking habits and types of heating and cooking. Although there was a large difference in the incidence of admission according to smoking habit, the effects due to cooking and heating were small and not significant.

TABLE III—*Regression coefficients for multiple logistic analyses of incidence of respiratory illness on four factors*

	Parental smoking (1 dummy variable)		Age of mother (1 variable)		Cooking fuel (2 dummy variables)		Type of heating (5 dummy variables)	
Mean	Response	Coefficient	Response	Coefficient	Response	Coefficient	Response	Coefficient
−0·928	No	0	Age group†	−0·094	Electric	0	Central heating	0
	Yes	0·429**			Gas	0·130	Storage heating	−0·232
							Coal	−0·144
							Gas	0·249
							Electric	0·183
							Other	0·106

Dummy variables were coded 0 for factor absent or 1 for factor present.
†Coded: 1 = age 15-19, 2 = 20-24, 3 = 25-29, 4 = 30+.
**p < 0·01.

TABLE IV—*Incidence of admissions to hospital according to parents' smoking habits and type of heating or cooking*

	Non-smokers		Smokers	
	No	No (%) admitted	No	No (%) admitted
Type of heating:				
Central heating	217	1 (0·5)	214	8 (3·7)
Storage heaters	70	0	100	4 (4·0)
Coal	80	1 (1·3)	135	5 (3·7)
Gas	60	3 (5·0)	117	3 (2·6)
Electric	160	5 (3·1)	383	12 (3·1)
Other	8	0	21	0
Total	595	10 (1·7) (not tested)	970	32 (3·3) χ^2_5 = 1·30 NS
Type of cooking:				
Electric	457	7 (1·5)	717	22 (3·1)
Gas	129	3 (2·3)	241	9 (3·7)
Other	9	0	12	1 (8·3)
Total	595	10 (1·7) p = 0·46*	970	32 (3·3) p = 0·67*

*Two tailed value from Fisher's exact test.

Discussion

Since 1970 there have been several analyses of epidemiological studies in the United States of America and the United Kingdom, some of which have shown an association between the use of gas (or raised concentrations of nitrogen dioxide) and respiratory illness while others have not.[9-21] Samples from populations of children and adults have been studied, and pollution has been defined from nitrogen dioxide measured outdoors and indoors and from knowledge of whether or not gas was used for cooking. Respiratory illness has been assessed by questionnaires recording either acute day to day changes in symptoms or general state of health (with such questions as "Does your child usually cough during the day or at night?"). Lung function has been used as an objective measure in many studies, but tests have been confined principally to peak expiratory flow rate, forced expiratory flow rate in a given time, and forced vital capacity.

The American six city study is particularly relevant. School children aged 6-10 were studied, and two surveys were reported. The first showed that children living in homes where gas was used for cooking had respiratory illness more often before the age of 2 and had lower lung function than children from homes where electricity was used (p <0·01).[4] These cross sectional and retrospective data appeared to confirm initial findings in the United Kingdom.[1] Four years later a survey in the same schools showed positive but non-significant relations between living in homes where gas was used and respiratory illness before the age of 2 (p = 0·14) and lung function. This relation has also been difficult to prove in the United Kingdom. The first report of the relation came from a study of over 5000 primary school children in 1973.[1] Although consistent for boys and girls, after adjustment for various interfering factors, the association was weak (p = 0·1). A weaker result, inconsistent between the sexes in children living in homes with smokers of tobacco, was obtained from a new group of children who entered the study over the next four years.[21]

In an attempt to isolate the effect of nitrogen dioxide two studies were carried out in primary school children in Middlesbrough.[3 5 22 23] Nitrogen dioxide was measured over a week in the children's bedrooms, the kitchens, and living rooms.[22 23] No relation between lung function and nitrogen dioxide could be found.[3] The incidence of respiratory illness did, however, increase with increasing concentrations of nitrogen dioxide in the bedroom and living room.[3 5]

These inconclusive studies were followed by an analysis of data on infants in a general practice in London that had been collected for a different purpose.[8] The sample was too small to detect differences of the order suggested by studies in primary schools, but it was thought that the infants might be more susceptible than older children to the effects of living in homes where gas cooking was used. In fact, the incidence of respiratory illness, as stated at the end of the first year by the mother or as recorded in the general practitioner's notes, was unrelated to the use of gas for cooking.

Our findings were consistent with the general trend of results from other studies. They showed an increase in the incidences of respiratory illness and admissions to hospital for respiratory illness in those infants who lived in homes where gas was used for cooking, though the increase was small and not significant. We believe that the results of all the studies fit into a single pattern. If in the general population, or any subsection within it, there is no relation between the use of gas for cooking and the incidence of respiratory illness then if many samples of the same size were taken from this population and each sample divided into two groups of people, according to their use of gas or electricity for cooking, the differences between the groups would be small for most samples but occasionally quite large. Some of the differences would be so large that the null hypothesis might be rejected. It is conventional to reject the null hypothesis if the chance of finding the observed difference would occur in only one out of 20 samples. The first time the null (and in this hypothetical case, correct) hypothesis is wrongly rejected the finding would probably be reported, as negative findings would previously have been ignored. Subsequent studies would probably show no significant association because for each sample drawn there would always be a 95% chance of accepting the null hypothesis. These negative findings would provide evidence to refute the original observation. An analysis of the results of many studies of the relation between respiratory illness and the use of gas for cooking would be expected to show examples of the association, some of which would be negative and others positive and most not significant. The average effect would be zero.

The association between the use of gas for cooking and respiratory illness does not seem to fit this null hypothesis well. Nearly 20 studies have been reported: most of them show a positive association, and significant findings have probably been observed more often than would be expected if the null hypothesis were correct (though only a small proportion of the total analyses carried out are reported). There has been no significant negative association reported, although it would be expected on statistical grounds from at least one of the studies. This pattern of findings would fit better with a hypothesis that concerned a small but real effect of gas, so small that none of the previous studies could show it with any reliability—for example, if respiratory illness occurs in 30% of infants in homes where electricity is used for cooking and in 32% of infants in homes where gas is used then the size of the sample for each of these groups needed for this difference to be detected at the 5% level in 80% of samples studied would be 8500 (a total of 17 000). If, as in our study, only a quarter of homes have gas installed then the total size of the sample needed is 22 700. Rather than undertake so large a study, which would pose difficulties of quality control of measurement and of collection and verification of data, it is more reasonable to accept that the use of gas for cooking may have an effect: if it does it is small and evidence indicates that the effect is outgrown or hidden by other damage to the lung by the age of 10-20[21] (A V Swan, personal communication).

The most noticeable finding in this analysis was the strong relation between respiratory illness in infants and parental smoking, and there was some evidence of a dose response relation. Among the infants in homes where there were smokers the lowest rate of respiratory illness occurred when only the father smoked (he would probably spend less time with the infant than the mother). If the mother or both parents smoked the rate was higher. An effect of smoking was also detected in the study carried out in London,[8] even though only a small sample was studied. Assuming that the association is causal, the case for discouraging smoking in the presence of children from conception onwards is further strengthened.

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100 YEARS AGO

The complaints which were made in the English newspapers against the medical arrangements of the expeditionary army in Egypt in 1882 are now being repeated in a portion of the French press, with regard to the administration of the sanitary service of the French army in China; with this difference, however, that if the deficiencies in the medical *personnel* and equipment, supplied to the French forces, are correctly reported, the complaints regarding them have a solid foundation; while, in the case of the British expedition, they were proved to be baseless. The *Progrès Militaire*, a French newspaper of considerable authority on military topics, recently published a letter from a correspondent, dated Hanoë, December 14th, 1884, describing a complete dearth of everything connected with the hospital service. There was not only a deficiency of surgeons, but of hospital attendants; and although the general in command had been making requisitions for additions to their number since the month of October, the transports from France had arrived without bringing any of the needed accessions to the hospital establishments. Certain medicines, such as quinine and bismuth, which had been distributed as preventives of disease, were on the verge of being altogether expended. The articles of bedding for the ill-developed hospitals were quite insufficient, while there was a scarcity of everything in the linen stores. "Our surgeons," writes this correspondent, "have proved their devotion beyond all praise; they have multiplied themselves, as it were, in their work, and have shown great ingenuity in improving the condition of the wretched barracks which serve as hospitals; but all their efforts cannot make up for the absence of suitable material means of assistance." The official surgical establishment supplied to the British expeditionary army in Egypt in 1882 is quoted by way of contrast with the surgical strength of the French force in Tonquin. "For the military operations which preceded the battle of Tel-el-Kebir, the English sent to Egypt 162 army medical officers. Our effective force in Tonquin is larger than that of the English army in Egypt, and of naval and military surgeons together we count at the most 60 practitioners, and of these, 15 have not attained their doctorate." From all the facts reported, the *Progrès Militaire* is led to conclude that it is not merely a few surgeons and hospital attendants that are required, but that several fully constituted field-hospitals, with adequate establishments of hospital *personnel*, ought to be at once dispatched to Tonquin. (*British Medical Journal* 1885;i:391.)

At the crematory erected by the Cremation Society of England, built some years ago to plans which proved satisfactory to Sir Henry Thompson and other eminent persons, the first human cremation took place Wednesday, and proved eminently successful. The body was that of a lady of an advanced age, who had become a member of the Cremation Society, and expressly, in her last testament, declared her desire by this method of burial. A necropsy had also been previously made. The reduction of the body was accomplished in one hour, and the resulting ashes were perfectly white. The arrangements were in entire accordance with the wishes of the representatives of the deceased. (*British Medical Journal* 1885;i:667.)