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Investigations into the Relations between Respiratory Illness in Children, Gas Cooking and Nitrogen Dioxide in the U.K.

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In 1977 an association was reported between the prevalence of respiratory illness and use of gas for cooking at home in a national sample of six to 11 year olds living in England and Scotland ($p < .10$). Other variables such as social class and number of cigarette smokers at home did not seem to explain the association. As the gas cooker is an unflued appliance emiting a variety of pollutants during gas combustion it was suggested that indoor air pollution might explain the finding. Nitrogen dioxide (NO_2) was suspected so a series of studies was conducted to investigate the distribution of levels of NO_2 in the home, the relative contribution of sources of NO_2 to indoor exposure and the relation between respiratory illness in six to 11 year olds and levels of NO_2 in the home. The gas cooker was found to be one of the main sources of NO_2 in the home. Winter weekly averages in kitchens with gas cookers had a mean of 112.2 ppb ($n = 428$, range 5–317 ppb). Levels in electric cooking kitchens were significantly lower ($n = 87$, mean 18 ppb, range 6–188 ppb). Studies of health indicated a relation between respiratory illness and bedroom levels of NO_2 over the range 4–169 ppb ($p \fallingdotseq .10$). Results for living room levels of NO_2 suggested a similar but non-significant relationship ($p > .10$). No relation was found for kitchen levels of NO_2.

For schoolchildren any effect on health from indoor NO_2 is likely to be weak. However other sections of the population such as infants and the elderly who may spend more time indoors and are particularly susceptible to respiratory illness need to be studied to assess fully the impact that NO_2 may be having on health.

(Key Words: Childhood respiratory illness, gas cooking, nitrogen dioxide)

INTRODUCTION

During the past decade we have become increasingly aware of the importance of the indoor environment to our health and of the variety of air pollutants to which we may be exposed indoors (14). In the U.K. research concentrated for many years on air pollutants found outdoors (15) but our interests have now extended to pollution indoors. The development of research into the effects on health from nitrogen dioxide (NO_2) in the U.K. will be described in this paper.

AN ASSOCIATION BETWEEN HEALTH AND GAS COOKING

In the first year of a longitudinal study of primary school children living in 28 randomly selected areas of England and Scotland an association was found between the prevalence of respiratory illness and use of gas for cooking in the home (6). After allowing for the effects of several variables including age, sex and father's social class, the prevalence of respiratory illness was significantly higher in gas cooking homes than electric cooking homes

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($p < 0.07$ for boys; $p < 0.001$ for girls). This finding has now been repeated in two other populations of school children. In the longitudinal study it was possiable to investigate a different group of children of the same age, six to 11 years, from the same study areas four years later (7). On this occasion data on cigarette smoking by family members were collected. After allowing for the effects of this as well as other variables an association was found between respiratory illness and gas cooking but only in urban areas ($p < 0.005$ for boys; $p \doteqdot .08$ for girls). In a different study of children aged six to seven years living in Middlesbrough in the north of England (4) the prevalence rate of respiratory illness was again higher in gas cooking homes than electric cooking homes ($p = 0.06$) after allowing for the effects of interfering variables.

Two possible explanations for the association between health and gas cooking were considered. As gas had been cheaper fuel than electricity poor social circumstances might have been related to the use of gas, independent of social class already allowed for in our analyses. However no relation was found between respiratory illness and heating fuels used at home which would have also been expected to be related to social circumstances. An alternative explanation was that, as the gas cooker was one of the few unflued appliances used indoors, air pollution was arising from the emissions of gas combusion. One suspect pollutant was nitrogen dioxide (NO_2) which has been shown to cause pulmonary oedema in adults at very high concentrations during agricultural accidents and increased susceptibility to respiratory infection in mice exposed to 500 ppb NO_2 for three months (3). Therefore studies were conducted to investigate the distribution of NO_2 concentrations (12), their relationship to factors inside the home (5), (8); and their relationship to measures of health (4), (9).

ASSOCIATIONS BETWEEN HEALTH AND NITROGEN DIOXIDE

Two main investigations were carried out on young school children living in a small, well-defined area of Middlesbrough in the north of England. We had wished to study initially those particularly at risk from respiratory disease so the study populations came mainly from poor social class groups in an urban area. In the first study (4), (5) all 808 children aged six to seven years living in the study area were included in the sample. NO_2 was measured by the diffusion tube method (11). Weekly average outdoor levels of NO_2 measured during the winter were low (range 14 to 24 ppb, mean 18.5 ppb) across the area compared with weekly average levels of NO_2 measured indoors, particularly for homes where gas was used for cooking (Table 1). The gas cooker was the main factor associated with high levels of NO_2 indoors and as most children walked to schools within the study area the cooker was likely to be main the source of NO_2 to which children were exposed on days when they remained within the study area. However, of the two measures of health taken, lung function and questionnaire data on respiratory symptoms and diseases, only the latter showed some relation to indoor levels of NO_2. The prevalence of having one or more respiratory conditions was positively associated with bedroom levels of NO_2 in gas cooking homes ranging from four to 169 ppb ($p \doteqdot 0.10$, Table 2). Neither measure of health was related to kitchen levels of NO_2 and lung function was also unrelated to bedroom levels of NO_2.

In the second study conducted on five and six year olds from the same area (8), (9) similar results were found for the distribution of winter weekly average levels of NO_2 inside homes where gas was used for cooking but we could not repeat the previous finding of an association between respiratory illness and bedroom levels of NO_2. The prevalence of respiratory illness appeared to be positively associated with living room levels of NO_2 but this finding was not significant for each sex (for boys $p > 0.10$; for girls $p < .10$). We concluded that while a harmful effect on health from NO_2 cannot be totally dismissed, it is likely to be weak and difficult to detect in small groups of children.

DISCUSSION

The future needs of research into the effects on health from indoor exposure to NO_2 are varied. One of the simplest needs is to investigate other groups of the population besides primary schoolchildren. Results from the USA (12) have already indicated that respiratory illness in infants may be related to use of gas for cooking at home. Infants have also been shown to be particularly susceptible to the effects of another indoor air pollutant, tobacco smoke (2). Among the more complex needs is the necessity to improve our methods of measurement of both NO_2 and health. There are strong arguments for monitoring personal exposure to pollution rather than using stationary sites, and for measuring peak rather than average levels of NO_2 but both face practical difficulties at present if large numbers of children are to be studied. There is also the need to disentangle the effects of NO_2 from those of other pollutant arising from the same source. Other methods for monitoring exposure and effects of NO_2 on the body are being explore (16) but the link between their measures of urinary hydroxyproline:creatinine ratio and respiratory health have not been analysed. Preliminary results from a study of a small sample of infants in London indicated no relation between respiratory illness and use of gas for cooking at home (10) but improvement in methods of measurement may produce a more consistent pattern of results from which some conclusion may be made about the effects of this cooking fuel.

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Table 1 Weekly average levels of NO_2(ppb) measured in the winter by type of fuel used for cooking and room in home. (Goldstein et al, 1979).

ROOM IN HOME		COOKING FUEL	
		Electricity	Gas
Kitchen	mean	18.0	112.2
	SD	2.4	2.7
	range	6 ~ 188	5 ~ 317
	number	87	428
Bedroom	mean	13.9	30.5
	SD	2.0	2.6
	range	3 ~ 37	4 ~ 169
	number	18	107

Table 2 Prevalence rate (%) of respiratory illness in boys and girls by type of fuel used for cooking at home and bedroom levels of NO_2 (ppb).
(total number of children given in brackets) (Florey et al, 1979).

	Electric cooking homes	Gas cooking homes		
	3 ~ 37 ppb	4 ~ 19 ppb	20 ~ 39 ppb	40 ~ 169 ppb
BOYS	40	43	58	69
	(42)	(23)	(19)	(13)
GIRLS	47	44	60	75
	(34)	(25)	(15)	(8)