The prevalence of asthma and heart disease in transport workers: a practice-based study

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SUMMARY
Background: *There has been widespread concern that the increasing incidence of asthma observed during the late 1980s might have arisen because of environmental pollution, and in particular vehicle pollution. The General Practice Morbidity Survey in 1991/92 (MSGP4) collected data on occupation, employment status, and smoking habit linked individually to each patient record.*
Objectives: *To examine whether people with occupations that have high exposure to vehicle exhaust fumes have an increased prevalence of asthma, acute respiratory infections, and ischaemic heart disease (IHD).*
Method: *Men aged 16 to 64 years were grouped by Standard Occupational Classification codes; 93 692 employed and 20 858 not-employed men were studied separately. Those with likely high occupational exposure were grouped together ('all-exposed') — the remainder occupations in corresponding chapters of the code were used as controls. We compared 12-month age and smoking standardised disease prevalence ratios for asthma, chronic obstructive pulmonary disease (COPD), acute respiratory infections (IHD), and all circulatory disorders in the all exposed and individual exposed occupations with their matching controls. Also the mean frequency of consultations per person consulting was calculated for each occupational group and disease.*
Results: *For employed persons, the prevalence ratio (PR) for asthma in the all-exposed, (116, 95% confidence interval [95% CI] = 101–130) exceeded that for all employed persons (100); however, the difference compared with chapter-matched controls (PR = 97, 95% CI = 92–103), was not statistically significant. Results for COPD were similar. Prevalence ratios in motor mechanics, a high-exposure group, were 98 (95% CI = 70–127) 96 (95% CI = 70–123) for asthma and COPD respectively. Among the employed, prevalence ratios for IHD in all but one of the individual occupation groups examined did not differ from the average, however among those not employed the ratio in the all-exposed (PR = 152, 95% CI = 128–174) exceeded that in the controls (PR = 112, 95% CI = 104–120).*
Conclusion: *Occupational groups exposed to motor vehicle pollution have a marginally increased prevalence of asthma compared with working males generally, though not compared with occupation matched controls. This study has demonstrated a methodology for using GP data to examine occupation-related disease. This could be used in future by augmenting GP data with occupation and smoking information.*
Keywords: *asthma; ischaemic heart disease; occupational medicine; environmental pollution; General Practice Morbidity Survey.*

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Introduction

IT is generally accepted that the prevalence of asthma increased substantially during the 1980s and early 1990s. Questionnaires about asthma symptoms used mainly among school children suggest increased prevalence.[1-4] Health care utilisation data, including contacts with general practitioners (GPs), showed increases in all age groups[5,6] and the prescribing of asthma treatments has increased in children.[7] Of particular concern is the possibility that this increase may be related to atmospheric pollution,[8] most especially from particulate pollution[9,10] but possibly also from the oxides of sulphur[11] and nitrogen.[12] Some evidence of the adverse effects of poor quality air can be found in the increases in morbidity when smogs have occurred,[13] although these were intense short-term exposures. There is also evidence that other transient factors, such as weather conditions influence asthma,[14] and climatic conditions causing thunderstorms at times of high grass pollen counts precipitate asthma attacks.[15] The majority of studies linking atmospheric pollution with asthma have concentrated on immediate post-exposure effects. However, in the American Six Cities Study, an association was established between the prevalence of asthma in adolescent children and the effects of continuing low-level pollution.[16]

The interplay between industrial pollution, weather conditions, and naturally occurring allergens precipitating asthma is complex. The role of exhaust fumes from the internal combustion engine has been regarded with suspicion,[17] especially since they have replaced coal burning as a major source of atmospheric pollution. Lipsett and colleagues undertook a meta-analysis of 30 studies and demonstrated the relationship between exposure to diesel exhaust and lung cancer.[18] Between 1970 and 1992 nitrogen oxides emissions from road transport vehicles increased from approximately 630 to 1400 thousand tonnes per year, as a proportion from all sources from 27% to 51%, while black smoke (particulate $<15\ \mu m$ diameter) derived from diesel oil increased from 91 to 200 tonnes, 9% to 44% of total emissions.[19] Anderson encouraged further investigation of the specific effect of motor vehicle pollution.[20]

This study is based on data collected for the Fourth National General Practice Morbidity Survey.[21] It is primarily concerned with patients in selected occupational groups who were recognised by their GPs as suffering from asthma, ischaemic heart disease (IHD), etc, during the course of a year providing particular insight into chronic morbidity. To assist in the interpretation of the data, we also measured the frequency of consultation, which provides some indication of exacerbations and short-term post exposure effects. It is postulated that if motor exhausts have a significant impact

HOW THIS FITS IN

What do we know?
Vehicle exhaust emissions are believed by many to have caused increasing prevalence of asthma in the late 1980s. This has not been demonstrated scientifically, though bronchospasm has been induced experimentally following exposure to exhaust fumes.

What does this paper add?
Road transport workers reported no more asthma than persons in matching occupations, suggesting that increasing exhaust emissions were not responsible for the increased prevalence of asthma. It also demonstrated the use of data from general practice to study health in relation to occupation.

on the annual prevalence of asthma (and the other morbidities) or the frequency of new attacks of asthma (and other morbidities) that impact will be evident to a greater extent in workers with increased exposure to motor exhausts. The study focused on the relationship between occupation and respiratory illness, providing a methodology by which any occupation and morbidity combination can be studied in a morbidity database generated in general practice.

Method

The Fourth National Morbidity Survey included half a million people (representative by age, sex, and social class of the national population) for whom all consultations with GPs, together with the consultation/episode type were reported during a 12-month period (September 1991 to August 1992). In addition, persons registered in the practices were interviewed on a single occasion during the study year and questioned about their smoking habits ('Have you smoked a cigarette during the last week?'), employment status, occupation, marital status, and ethnic origin. Patient age, sex, and residential postcode were obtained from practice records. Morbidity was classified by the International Classification of Diseases (ICD) (ninth revision) and the occupation by the Standard Occupational Classification,[22] which groups similar occupations according to skill and educational requirements, firstly into minor group codes and then into nine major groups.

Males aged 16 to 64 years who at the time of interview were in employment or on a government scheme, and who had been in the labour market a year previously, were analysed by occupational group. We identified occupations coded at minor group level that were particularly associated with roadside and traffic-related activities and hence likely to have high exposure levels to vehicle exhaust. We did not analyse data separately for individual minor groups in which there were fewer than 200 persons but grouped together smaller exposed categories within the same major group. Together we refer to these as the 'all-exposed' (Table 1). The remaining persons included within the same major groups of occupation were identified as 'controls'. Persons in the major groups 1 to 4 (managerial, professional, and skilled non-manual occupations) who were unlikely to have high exposure were combined to form a 'non-manual' group.

The morbidities examined were: asthma (ICD 493); chronic obstructive pulmonary disease and allied conditions including asthma (COPD: ICD 490–496); acute respiratory infections (ICD 460–466); ischaemic heart disease (IHD: ICD 410–414); and all circulatory disorders (ICD Chapter VII). The data were examined by cigarette smoking (current or non-smoker), and by occupational group. Rates are expressed per 1000 person years based on person days of registration. The term 'person consulting' is applied to a person making at least one consultation for the specified morbidity during the 12-month study period. Person consulting rates for a disease provide a measure of annual disease prevalence.

The main statistical evaluation of the occupational data was based on standardised person prevalence ratios for each morbidity — the ratio of observed to expected numbers of persons consulting, referred to subsequently as 'prevalence ratio'. The calculation of expected numbers was based on age (five-year age bands) and smoking habit. The prevalence ratio for all employed persons is 100. The prevalence ratio in each exposed occupational group was compared with the major group-matched controls. For persons who were not employed, defined by their employment status at the time of interview, separate but similar calculations and comparisons were made using their stated previous occupation in three broad occupational categories: all-exposed, controls, and non-manual. These data were examined primarily to assess possible bias arising from the presence of disease as the cause of their unemployment. We also examined the mean rate of consultations per person consulting in the broad occupational categories, seeking for evidence of excessive health care utilisation, possibly suggesting increased severity of illness.

Results

The study included 93 692 men aged 16 to 64 years in employment and providing occupation data when interviewed, who together contributed 90 687 person years at risk (Table 1). Among these, 32% reported smoking at interview. Smoking among the manual employed groups varied from 32% of persons in sales occupations to 56% in roadside workers, and in the non-manual group 25%. Fewer motor mechanics reported smoking (34%) than men in comparable occupations (36%). A total of 20 858 men (19 932 person years) were not employed at the time of enquiry; 47% were smokers. Smoking among the not-employed all-exposed group was notably higher than in their employed equivalents. Among the employed, separate examination in the age groups 16 to 34 years and 35 to 64 years showed similar proportions of smokers, whereas among those not employed, 56% of men aged 16 to 34 years smoked compared with 43% aged 35 to 64 years. The relative increase in smoking among younger not employed men was present in all three broad occupational categories.

The prevalence rates for asthma (Table 2) were similar to those for COPD (other forms of COPD were comparatively uncommon in employed persons). Examination by age (data not presented), showed generally higher rates in men aged 16 to 34 years compared with those aged 35 to 64 years for asthma and acute respiratory infections, in every occupation except bus and coach drivers. For IHD and for all circulatory disorders, rates were higher in the older age

Table 1. Person-years surveyed by occupational group (SOC codes), age, and smoking habit (SH%).

	Person years	SH%
Employed men aged 16–64 years		
SOC 1–4 Non-manual		
(managers and administrators, professionals, associate professions and technical occupations, clerical and secretarial occupations)	39 757	25
Exposed occupations and controls		
SOC 5 Craft and related occupations		
Motor mechanics, auto engineers, etc. (soc 540)	1487	34
Other vehicle trades (soc 541–544)	489	36
Remainder of craft and related occupations	21 433	36
SOC 6 Personal and protective occupations		
Ambulance personnel and railway station staff (soc 631, 642)	223	38
Remainder personal and protective occupations	4419	39
SOC 7 Sales occupations		
Street traders, roundsmen, etc. (soc 730–732)	515	40
Remainder of sales occupations	3396	32
SOC 8 Plant and machine operatives		
Drivers of road goods vehicles (soc 872)	3069	43
Bus and coach drivers (soc 870, 871, 873, 875)	604	41
Taxi cab drivers (soc 874)	710	46
Rail transport operatives (soc 881, 884)	322	34
Remainder of plant and machine operatives	8499	41
SOC 9 Other manual and unskilled occupations		
Roadside workers (soc 923–924, 957)	222	56
Remainder of other occupations	5540	43
All-exposed	7642	41
Controls (remainder occupations SOC 5–9)	43 288	38
Total	90 687	32
Not-employed men aged 16–64 years (stated occupation)		
SOC 1–4 Non-manual	5358	32
Exposed occupations and controls		
All-exposed	1937	55
Controls (remainder occupations SOC 5–9)	12 637	53
Total	19 932	47

Table 2. Annual prevalence (person consulting) rates per 1000 person years by occupational group, age, and morbidity.

	Asthma		COPD		ARI		IHD		All circulatory disorders	
	16–34	35–64	16–34	35–64	16–34	35–64	16–34	35–64	16–34	35–64
Not-employed persons										
All-exposed	39	28	40	35	170	151	0.0	16	21	91
Controls (residue occupations SOC 5–9)	34	24	36	31	177	148	0.3	18	19	97
Non-manual (occupations SOC 1–4)	37	24	39	29	174	148	0.1	14	19	89
Total	35	24	37	31	175	148	0.2	16	19	93
Not-unemployed persons										
All-exposed	55	45	58	93	208	210	1.8	116	26	276
Controls (residue occupations SOC 5–9)	48	44	52	83	205	195	0.7	80	21	227
Non-manual (Occupations SOC 1–4)	34	39	37	60	201	166	0.8	67	22	227
Total	46	43	50	77	205	188	0.8	80	22	232

ARI = acute respiratory infections.

group. Rates in persons not employed were uniformly higher than in their employed equivalents; however, the difference was particularly noticeable in the rates for IHD.

Among employed males, the prevalence ratio for asthma in the all-exposed group exceeded that in the total working male population. However, the difference from occupation-matched controls was not statistically significant (Table 3). For the not employed, the prevalence ratio for asthma in the all-exposed (112) was similarly raised relative to the total not employed, though here the difference was not significant; also, prevalence ratios in both the all-exposed and controls for asthma, COPD, and all circulatory disorders exceeded those for all not employed. However, with the exception of IHD, the ratios were not significantly different in all-exposed from the matching controls. Prevalence ratios for acute respiratory infection in the not employed were generally close to 100. Among not-employed men from the non-manual occupation group, prevalence ratios were significantly below average for all conditions reported, which contrasts with their employed equivalents.

Prevalence ratios are presented for the exposed occupational groups in Table 4, together with the equivalent ratios

Table 3. Prevalence ratios standardised for age and smoking habit (PR) and 95% confidence intervals (CI) by occupational category and morbidity. (PR all occupations = 100 in each of the employed and not-employed categories.)

	Asthma		COPD		ARI		IHD		All circulatory disorders	
	PR	CI	PR	CI	PR	CI	PR	CI	PR	CI
Employed persons (All = 100)										
All-exposed	116[a]	101–130	112	99–125	100	95–106	93	72–115	99	90–108
Controls (remainder occupations SOC 5–9)	97	92–103	99	94–104	100	97–102	110	99–120	103	99–107
Non-manual (occupations SOC 1–4)	100	94–106	99	94–104	100	98–103	92	82–101	98	94–101
Total	100		100		100		100		100	
Not-employed persons (All = 100)										
All-exposed	112	89–135	120[a]	102–139	109	98–119	152[a]	128–176	123[a]	111–135
Controls (remainder occupations SOC 5–9)	106	98–114	109[a]	103–116	103[a]	100–107	112[a]	104–120	105[a]	101–109
Non-manual (occupations SOC 1–4)	85[a]	73–97	76[a]	68–85	9[a]	85–97	76[a]	67–85	90[a]	84–95
Total	100		100		100		100		100	

[a]PRs are statistically significantly different from total population ($P<0.05$). ARI = acute respiratory infections.

Table 4. Prevalence ratios by individual occupational category and morbidity, standardised for age and smoking habit (PR) and 95% confidence intervals (CI). (PR all occupations = 100.)

	Asthma		COPD		ARI		IHD		All circulatory disorders	
Employed persons (All = 100)	PR	CI	PR	CI	PR	CI	PR	CI	PR	CI
Motor mechanics, auto engineers, etc.	98	70–127	96	70–123	91	79–103	88	30–145	111	87–136
Other vehicle trades	123	68–179	116	65–167	110	88–133	78	0–185	105	61–148
Controls remainder, craft and related occupations	93	86–101	94	87–101	95[a]	91–98	104	90–119	99	93–104
Ambulance personnel and railway station staff	149	52–247	137	52–221	141[a]	102–181	72	0–173	97	49–145
Controls remainder, personal and protective occupations	83	67–98	85	70–99	114[a]	106–122	120	85–155	111	98–124
Street traders, roundsmen, etc.	146	83–208	124	71–178	103	81–125	45	0–108	62[a]	34–90
Controls remainder sales occupations	102	82–121	97	80–115	98	90–106	83	50–117	93	79–107
Drivers of road goods vehicles	97	76–119	93	74–111	94	86–103	80	50–110	85	72–97
Bus and coach drivers	127	71–183	140	87–193	114	93–136	68	8–127	116	84–148
Taxi cab drivers	143	88–198	142	93–191	111	91–131	121	50–193	114	85–142
Rail transport operatives	174	89–260	170	93–246	90	64–116	214	81–346	137	92–181
Controls remainder, plant and machine operatives	96	83–108	103	91–115	105[a]	100–111	131[a]	107–156	110[a]	102–119
Roadside workers	170	65–275	155	63–246	115	80–151	187	4–370	136	75–198
Controls remainder other occupations	124[a]	107–141	124[a]	108–139	102	95–108	103	76–130	106	95–116

[a] PRs are statistically significantly different from total population ($P<0.05$). ARI = acute respiratory infections.

for the residual occupations in the same chapter of the code. Ratios for asthma and COPD were high in rail transport operatives and roadside workers. The ratio for persons grouped with roadside workers exceeded that for all employed males. Men in personal and protective service occupations, including ambulance personnel and railway station staff, had the highest prevalence ratio for acute respiratory infections. For IHD and all circulatory disorders, prevalence ratios were significantly greater than 100 in the residue of plant and machine operatives: comparatively (though not significantly), high prevalence ratios were observed in rail transport operatives and roadside workers. Particularly low prevalence ratios for IHD and circulatory disorders were reported in street traders. Ratios in motor mechanics did not differ significantly from the employed population in each of the morbidities examined.

The mean rates of consultation per person consulting in employed persons were similar (with minor exceptions) in the all-exposed and in the controls (Table 5). Rates were generally higher in the not-employed than in the employed equivalents and generally higher in the younger age group (data not presented).

Discussion

The main objective of this study was to examine the prevalence of respiratory and circulatory diseases in relation to occupations exposed to motor vehicle exhausts. After standardisation for age and smoking habit, we identified an increased proportion of men consulting for asthma in the all-exposed compared with the total employed population, though not when compared with men in occupation-matched controls. No significant differences were observed in the other morbidities examined. In some of the occupational groups, numbers were relatively small but the large group of motor mechanics, who might be particularly likely to experience high exposure, did not show an increased prevalence relative to controls for any of the conditions examined. Roadside workers and rail transport operatives had the highest ratios for asthma and for COPD. Ratios in ambulance personnel, railway station staff, street traders,

Table 5. Consultations rates per person consulting in one year for consolidated occupational groups, by employment status, age and morbidity.

	Asthma	COPD	ARI	IHD	All circulatory disorders
Employed persons					
All-exposed	2.3	2.1	1.4	3.3	2.7
Controls (remainder occupations SOC 5–9)	2.1	2.1	1.5	2.9	2.8
Non-manual (occupations SOC 1–4)	1.9	1.9	1.4	2.9	2.5
Total	2.0	2.0	1.4	2.9	2.6
Not-employed persons					
All-exposed	3.0	3.0	1.5	3.2	3.6
Controls (remainder occupations SOC 5–9)	2.9	3.1	1.6	3.0	3.4
Non-manual (occupations SOC 1–4)	2.6	2.9	1.6	3.3	3.1
Total	2.8	3.0	1.6	3.1	3.3

ARI = acute respiratory infections.

roundsmen, bus drivers, and taxi drivers were generally higher than others in their matching occupational groups. Drivers of roads goods vehicles reported average ratios. There was less variation in the ratios for acute respiratory infections but the comparatively low prevalence ratios in rail transport operatives are worth noting. Prevalence ratios for IHD were generally different from those for asthma though rail transport operatives and roadside workers again reported high values; those for street traders and bus drivers were less than those for their peers. In some occupations prevalence ratios for all circulatory diseases, which includes IHD and hypertension, differed from those for IHD exclusively.

Morbidity surveys are based on persons consulting doctors and clearly some sick people do not consult. However, when considering diseases for which medical treatment is usually required, the loss to a study designed to capture data from every contact over a full 12-month period is small and unlikely to be biased in respect of the occupation of the sufferer. We examined data separately for the unemployed, recognising that consulting patterns vary with employment status. For asthma episodes concordance of diagnostic practice between sentinel practices (many included in the present study) and hospital episode data has been shown.[23]

The occupation grouping we have used to identify risk in relation to exposure to vehicle exhaust is similar to that used by other researchers.[18,24] The effects of increasing dose are important,[25] though an exposure gradient of increasing dose by occupation is difficult to define. We identified some occupational subgroups with increased levels of respiratory morbidity, possibly relating to differing exposure levels. Motor vehicle mechanics, whose working environment needs to be mechanically ventilated because of the high levels of exhaust gases, were not among the most severely affected by asthma.

The results we report are logically consistent. Moreover, because the population is widely dispersed across England and Wales, they are unlikely to be confounded by factors such as local environment and ethnicity. High prevalence ratios of acute respiratory infection could be expected in persons with high levels of personal contact. The generally low prevalence of IHD among transport workers could be expected in occupational groups involving drivers who have regular medical examinations. Prevalence ratios in exposed persons not in employment were similar to those in employed persons for chronic respiratory conditions, though not for IHD, emphasising the importance of IHD in relation to employment. Studies of employed persons are always potentially biased by the exclusion of disease-affected persons leaving their occupation ('healthy worker effect'),[26] though at least for asthma and COPD no such bias was found.

The proportion of smokers, at 32%, is similar to that reported in the General Household Study for 1991 (31% in employed males).[27] The increased proportion of smokers among persons not in employment is a cause for sadness: the elements of disadvantage in life ride together. In general, smoking was common among drivers. The need for standardisation by smoking habit in occupational data is well recognised and clearly illustrated in this report.

The study is potentially limited by its cross-sectional character, with its single enquiry of occupation and smoking information and the morbidity experienced from only one year. Though people change employment, they are likely to continue working in similar industrial settings. Because of the large population under surveillance, occupation-related health problems of importance are likely to show up in the detailed analyses undertaken here. Any cross-sectional study is limited by the problem of survivor bias. However, if mortality were increased one would also observe increased morbidity.

The findings of this study provide an important piece of evidence supporting the conclusions of the expert committee of the Department of Health[28,29] and Anderson's reflection that motor vehicle pollution is unlikely to be the main cause of increasing asthma.[20] They give objectivity in a debate that is commonly joined on the basis of opinion rather than evidence. Our conclusion is based on the results in the all-exposed, coupled with the low ratio in motor mechanics. The high levels of morbidity among roadside workers and rail transport operatives suggest that other occupation-related factors might be important determinants of airways disease. A study of Copenhagen street cleaners (who were compared with cemetery workers), showed an increased risk of COPD after standardising for age and smoking habit.[30]

This secondary analysis of morbidity survey data also demonstrates the added value of augmenting consultation data with individual occupation and smoking data. We found two other studies of asthma in which a similar approach has been used.[31,32] Both these studies reported increased risks for persons in some occupations but the data were not standardised for smoking habit. Both emphasised the benefits of linking occupation and health care utilisation for surveillance of occupation-related diseases.

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References

1. Ninan KN, Russell G. Respiratory symptoms and atopy in Aberdeen schoolchildren: evidence from two surveys 25 years apart. *BMJ* 1992; **304:** 873-875.
2. Burr ML, Butland BK, King S, *et al*. Change in asthma prevalence: two surveys 15 years apart. *Arch Dis Child* 1989; **64:** 1452-1456.
3. Peat JK, van den Berg RH, Green WF, *et al*. Changing prevalence of asthma in Australian children. *BMJ* 1994; **308:** 1591-1596.
4. Anderson HR, Butland BK, Strachan DP. Trends in prevalence and severity of childhood asthma. *BMJ* 1994; **308:** 1600-1604.
5. Fleming DM, Crombie DL. Prevalence of asthma and hay fever in England and Wales. *BMJ* 1987; **294:** 279-283.
6. Ayres JG, Noah ND, Fleming DM. Incidence of episodes of acute asthma and acute bronchitis in general practice 1976-1987. *BMJ* 1993; **43:** 361-364.
7. Speight ANP, Lee DA, Hey EN. Underdiagnosis and undertreatment of asthma in childhood. *BMJ* 1983; **286:** 1253-1256.
8. Green M. Air pollution and health. [Editorial.] *BMJ* **311:** 401-402 1995.
9. Schwartz J, Dockery DW. Increased mortality in Philadelphia associated with daily air pollution concentrations. *Am Rev Respir Dis* 1992; **145:** 600-604.
10. Dockery DW, Pope IIIA, Xiping XU, *et al*. An association between air pollution and mortality in six US cities. *N Engl J Med* 1993; **329:** 1735-1739.
11. Ware JH, Thibodeau LA, Speizer FE, *et al*. Assessment of the health effects on atmospheric sulphur oxides and particulate matter: evidence from observational studies*. Environ Health Perspect* 1981, **41:** 255-276.
12. Anderson HR, Limb ES, Bland JM, *et al*. Health effects of an episode of nitrogen dioxide air pollution in London, December 1991. *Thorax* 1994; **49:** 1053.
13. Ministry of Health. *Mortality and morbidity during London fog of December 1952*. London: HMSO, 1954.
14. Anonymous. Asthma and the weather. [Editorial.] *Lancet* 1985; **i(8437):** 1079-1080.
15. Newson R, Strachan D, Archibald E, *et al*. Effects of thunderstorms and airborne grass pollen on the incidence of acute asthma in England, 1990-1994. *Thorax* 1997; **52(8):** 669-670.
16. Ware JH, Ferris BG Jr, Dockery DW, *et al*. Effects of sulfur oxides and suspended particulates on respiratory health of preadolescent children. *Am Rev Respir Dis* 1986; **133:** 834-842.
17. Read RC, Green M. Internal combustion and health. *BMJ* 1990; **300:** 761-762.
18. Lipsett M, Campleman S. Occupational exposure to diesel exhaust and lung cancer: a meta-analysis. *Am J Public Health* 1999; **89:** 1009-1017.
19. Department of Environment. *Digest of Environmental Protection and Water Statistics 1994.* London: HMSO, 1994.
20. Anderson HR. *Air pollution and trends in asthma*. Ciba Foundation Symposium, 1997, **206:** 290-303.
21. McCormick A, Fleming DM, Charlton J. *Morbidity statistics from general practice - Fourth national study 1991-1992. A study carried out by the RCGP, OPCS and DOH*. Office of Population Censuses and Surveys Government Statistical Service. London: HMSO, 1995.
22. OPCS. *Standard Occupational Classification*. Vol 1. London: HMSO, 1990.
23. Fleming DM, Cross KW, Sunderland R, Ross AM. Comparison of the seasonal patterns of asthma identified in general practitioner episodes, hospital admissions, and deaths. *Thorax* 2000; **55(8):** 662-665.
24. Fear NT, Roman E, Pannett B. Fathers' occupation and childhood mortality: analysis of routinely collected data. *Health Stat Q* 1999; **2:** 7-15.
25. Barker RD, van Tongeren MJA, Harris JM, *et al*. Risk factors for sensitisation and respiratory symptoms among workers exposed to acid anhydrides: a cohort study. *Occup Environ Med* 1998; **55:** 684-691.
26. Venables KM, Dally MB, Nunn AJ, *et al*. Smoking and occupational allergy in workers in a platinum refinery. *BMJ* 1989; **299:** 939-942.
27. Thomas M, Goddard E, Hickman M, Hunter P (eds). Office of Population Censuses and Surveys. *General Household Survey for 1992*. [OPCS Social Survey Division 1994; Series GHS no 23]: London: HMSO, 1994.
28. Department of Health Committee on the Medical Effects of Air Pollutants*. Asthma and Outdoor Air Pollutants*. London: HMSO, 1995.
29. Department of Health Committee on the Medical Effects of Air Pollutants*. Non-Biological Particles and Health* London: HMSO, 1995.
30. Raasschou-Nielsen O, Nielsen ML, Gehl J. Traffic-related air pollution: exposure and health effects in Copenhagen street cleaners and cemetery workers. *Arch Environ Health* 1995 **50(3):** 207-213.
31. Kraut A, Wall R, Mustard C. Prevalence of physician-diagnosed asthma by occupational groupings in Manitoba, Canada. *Am J Ind Med* 1997; **32(3):** 275-282.
32. Van der Velden J. Abrahamse HPhH, de Bakker DH. Arbeid en gezondheid gezien vanuit de huisartspraktijk. (Occupation and health in general practice in the Netherlands). *Tijdschr Soc Gezondheidsz* 1995; **73:** 300-307.