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Occupational, domestic and environmental mesothelioma risks in Britain

A case-control study

Prepared by the **Institute of Cancer Research** and the **London School of Hygiene and Tropical Medicine** for the Health and Safety Executive 2009

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Research Report

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Occupational, domestic and environmental mesothelioma risks in Britain

A case-control study

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UK mesothelioma mortality is the highest worldwide, but no large case-control study with personal interviews has been conducted. We obtained lifetime occupational and residential histories from 622 mesothelioma patients (512 men, 110 women) and 1420 population controls. The lifetime risk was about 1 per 1,000 in men and women with no occupational or domestic asbestos exposure, irrespective of the type of building they lived or worked in, and 2 per 1,000 in exposed workers' relatives. The average LR per 1000 for 10 years duration before age 30 was 59 among carpenters, who constituted 4% of controls and 21% of cases among men, 20 for plumbers, electricians and painters, and 8 for other construction workers. Other high-risk occupations included lagging and shipyard work, with lower risks in various industrial sectors where asbestos was also encountered. The predicted total of ~90,000 mesotheliomas in the UK by 2050 will include about 15,000 former carpenters. The risk persisted in men beginning work after 1970 when crocidolite was no longer used. An important factor underlying the very high risk in British construction workers, particularly carpenters, is likely to be the widespread use of power tools on amosite insulation board, which continued with no effective dust control until the 1980s. Asbestos exposure was common in the workplace, with 65% of male and 23% of female controls having worked in occupations that were classified as medium or higher risk.The increase in female cases in the UK, many with no identified exposure, suggests widespread environmental contamination from industrial and construction activities.

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BACKGROUND

By 1970 Britain led the world in asbestos regulation, yet the British mesothelioma death-rate is now the highest in the world, with 1740 deaths in men (1 in 40 of all male cancer deaths below age 80) and 316 in women in 2006. According to the latest HSE projection about 1 in 170 of all British men born in the 1940s will die of mesothelioma. The increase in mesothelioma mortality in Britain over the last 40 years is the legacy of widespread use of asbestos. Substantial exposures continued until about 1970 in parts of the asbestos industry, and until the early 1980s in the much larger workforce in construction and other occupations where asbestos lagging was applied or AIB (asbestos insulation board) was sawn. Most mesotheliomas now occurring are due to exposures prior to 1980, and analyses of British mesothelioma deaths based on last recorded occupation suggest that former construction workers, particularly plumbers, electricians and carpenters, constitute the main high risk group, together with insulation workers, shipbuilders and locomotive engineers. However, until now, no representative study to quantify the relationship between mesothelioma risk and lifetime occupational and residential history has been carried out in Britain. A separate scientific publication of the results set out in this report is also available(Rake et al., 2009).

METHODS

Lifetime occupational and residential histories were obtained by telephone interview with 622 mesothelioma patients (512 men, 110 women) and 1420 population controls. Lifetime risks (LR) were estimated for British men and women born in the 1940s. Occupations other than construction were classified as high, medium or low risk, and proportions of mesotheliomas attributable to these groups, including construction, and to domestic exposures (living with an exposed worker) were also estimated.

RESULTS

Men: Relative to low-risk occupations, risks (odds ratios) for men with more than 10 years of exposure before age 30 were 50.0(95%CI 25.8-96.8; LR = 1 in 17) for carpenters, 17.1(95%CI 10.3-28.3; LR = 1 in 50) for plumbers, electricians and painters, 7.0(95%CI 3.2-15.2; LR = 1 in 125) for other construction workers, 15.3(95%CI 9.0-26.2; LR = 1 in 55) for other recognised high-risk occupations, and 5.2(95%CI 3.1-8.5; LR = 1 in 170) in other 'medium risk' industries where asbestos may be encountered. The risk in men who had worked only in industrial occupations that we classified as low-risk was no higher than in white-collar workers; only 8% (13/153) of male mesothelioma cases who had worked in 'low-risk' industrial occupations had never worked in a higher risk occupation. Among men, 46% of mesotheliomas were attributable to construction, 39% to other occupations and 1.3% to domestic exposures, with 14% of cases not attributable to any known occupational or domestic asbestos exposure. Over a fifth (21%) of male cases had worked as carpenters. Only 4 cases (<1%) had worked for 5 or more years in asbestos product manufacturing.

Women: Only 5 of the 110 women with mesothelioma had worked in high-risk occupations (odds ratio (OR) 4.8, 95%CI 1.3-17.7), and a further 32 had worked in industrial jobs classified as medium risk, often as assemblers (OR 2.4, 95%CI 1.3-4.3). Among women 22% of mesotheliomas were attributable to occupational exposures and 16% to domestic exposures, with 62% not attributable to occupational or domestic asbestos exposure.

Unexposed cases: The LR was similar in apparently unexposed men and women (less than 1 in 1000). This 'background' risk was approximately doubled in exposed workers' relatives (OR 2.0, CI 1.3-3.2). No other specific environmental hazards were identified.

CONCLUSIONS

1. Mesothelioma risk is determined largely by asbestos exposure before age 30, and ranges from a lifetime risk of 1 in 17 for ten or more years of carpentry before age 30 to less than 1 in 1,000 in apparently unexposed men and women. Our results suggest that the predicted total of 90,000 mesotheliomas in Britain between 1970 and 2050 will include approximately 15,000 carpenters.

2. The risk of lung cancer caused by asbestos is likely to be of the same order as the mesothelioma risk. This would imply that more than 1 in 10 of British carpenters born in the 1940s with more than 10 years of employment in carpentry before age 30 will die of a cancer caused by asbestos.

3. Asbestos exposure was widespread, with 65% of male and 23% of female controls having worked in occupations that were classified as medium or higher risk.

4. Britain was the largest importer of amosite (brown asbestos), and there is strong although indirect evidence that this was a major cause of the uniquely high mesothelioma rate. The US imported far less amosite than Britain but used similar amounts of chrysotile (white asbestos) and more crocidolite (blue asbestos), and US mesothelioma death-rates in middle age are now 3 to 5 times less than British rates. British carpenters frequently worked with asbestos insulation board containing amosite.

5. We found no evidence of increased risk associated with non-industrial workplaces or those that were classified as 'low risk', including motor mechanics and workers handling gaskets and mats that may have contained asbestos.

6. The only potential non-occupational exposure associated with increased risk was living with an exposed worker.

7. The increasing trend in female rates in Britain and a comparison between British and US female rates both suggest that a substantial proportion of mesotheliomas with no known occupational or domestic exposure were probably caused by environmental asbestos exposure. The sources of this presumably included construction, building maintenance and industrial activities but may also include release of asbestos from buildings due to normal occupation and weathering.

FURTHER RESEARCH

Ongoing studies include TEM measurement of asbestos lung burdens in three series of subjects who have provided occupational interviews: (1) mesothelioma patients in this study, using samples obtained at post-mortem; (2) resected lung cancer patients; using samples obtained at operation; and (3) pneumothorax patients, using the small amount of tissue that is removed when the lung is repaired. The results should clarify the contribution of different types of asbestos to mesothelioma risk, and the pneumothorax study will show whether younger construction workers are still substantially exposed from the asbestos materials that remain in many buildings.

1. INTRODUCTION

Asbestos exposure accounts for most cases of mesothelioma and a substantial number of lung cancers – probably of the same order as the number of mesotheliomas, though estimates are uncertain (Darnton et al., 2006). The mesothelioma death rate has greatly increased in Britain since the 1960s, and there are now over 2000 mesothelioma deaths per year, similar to melanoma and roughly double the number due to cervical cancer, with approximately six times as many deaths in men as in women. The total number of mesothelioma deaths in Britain from the late 1960s to 2050 is predicted to be about 90,000, most of which are still to occur (Hodgson et al., 2005), and a quarter of a million mesothelioma deaths may eventually occur throughout Western Europe (Peto et al., 1999). Proportional mortality analysis of the British mesothelioma data (McElvenny et al., 2005) shows that construction workers, particularly plumbers, electricians and carpenters, constitute the main high risk group, together with insulation workers, shipbuilders and locomotive engineers. Mesotheliomas also appear at a lower rate in other sectors of industry, but many cases have no obvious occupational origin, particularly among women. Most mesotheliomas now occurring are due to asbestos exposure prior to 1980 when asbestos use was widespread, particularly in the construction industry. It is not known whether substantial asbestos exposure is still common among building workers, or what proportion of cases with no known history of asbestos exposure are due to unrecognised exposure in other occupations, DIY activities or environmental exposure.

This is the first population-based study in Britain to quantify the relationship between mesothelioma risk and lifetime occupational history obtained at interview, and the largest worldwide. A separate scientific publication of the results set out in this report is also available(Rake et al., 2009). Previous case-control studies have used hospital-based controls or relied on next-of-kin interviews and most involved small numbers of cases(Agudo et al., 2000; Howel et al., 1997; Iwatsubo et al., 1998; Muscat & Wynder, 1991; Rodelsperger et al., 2001; Teschke et al., 1997). The occupations and work practices conferring the highest risks, particularly widespread use of asbestos materials in construction, had largely ended by the early 1980s in the UK, but our results are also relevant to countries where uncontrolled asbestos exposure is still common.

Much of the asbestos used in construction between 1960 and 1980 is still in place, and an important practical question is whether this may still be causing a substantial hazard to construction workers involved in renovation and maintenance of older buildings. There are as yet too few mesotheliomas in men born since 1960 to determine whether their risks provide evidence of a continuing hazard.

2. METHODS

2.1 STUDY DESIGN

Cases and controls

This report is based on lifetime occupational histories obtained at interview from mesothelioma patients and population controls. Recruitment was initially restricted to patients born before 1940, although the protocol was later amended to include mesothelioma patients and controls born between 1925 and 1939. This resulted in a higher proportion of younger mesothelioma cases than seen nationally.

Interviewed mesothelioma cases are followed up, and where possible lung tissue is obtained from post-mortem samples for measurement of asbestos fibres by optical and transmission electron microscopy (TEM). Representative population controls who can be interviewed and from whom lung samples can also be obtained are difficult to identify. Resected lung cancer patients were therefore also recruited to provide a comparison group for these lung burden measurements, as surgical lung samples suitable for fibre analysis are usually available from these patients. Lung cancer is also caused by asbestos exposure, but the attributable fraction is much lower than for mesothelioma. After adjustment for social class, resected lung cancers should therefore provide a reasonably unbiased comparison group for lung fibre burden analysis. Collection of lung samples from interviewed mesothelioma and lung cancer patients and analyses of lung fibre burden are ongoing, and the results will be presented in a later report. Pneumothorax patients from whom a sample of lung tissue removed at operation is available are now being recruited and interviewed in a separate study. These patients are usually much younger than mesothelioma and lung cancer patients, and their lung burdens will reflect the exposures characteristic of current occupational practices, particularly in construction.

2.2 CASE AND CONTROL ASCERTAINMENT AND DATA COLLECTION

Mesothelioma patients

Mesothelioma patients born since 1925 who were diagnosed in England, Wales and Scotland were identified through a network of collaborative chest physicians, surgeons and nurses, the National Cancer Research Network, and English and Scottish hospital admissions. A small proportion were referred from the Thames Cancer Registry, the Mesothelioma Information Service in Leeds, and various asbestos victim support groups.

Population and GP controls

Population controls were selected at random from a one in 300 sample from Health Authority registers (now Primary Care Trusts), frequency matched by 5-year age group and sex. No data were provided by any of the Health Boards in Scotland due to fears of legal liability under confidentiality and data protection law. Five Health Authorities in England and three in Wales also refused to send any data, and six sent anonymised data. Up to six randomly selected age-matched GP controls were approached for each interviewed mesothelioma case in these areas.

Interview data

Cases and controls were ineligible if they were physically or mentally ill, deaf, without access to a telephone or unable to speak English. All eligible patients were sent a pre-interview postal questionnaire (available separately online) requesting lifetime occupational and residential history. These questionnaires formed the basis for the structured telephone interview, which also included questions on smoking history, DIY activities and other possible environmental exposures. Subjects were asked about various asbestos exposures in each job, depending on the type of work. These included work with asbestos insulation board (AIB), lagging, sprayed coatings, cement, insulation, heat-protection materials, gaskets, textiles and brake linings. For each job the duration, description and occupational code were recorded, together with frequency of direct or indirect asbestos exposure. Occupational histories were obtained for 622 mesothelioma cases and 1,420 controls. Interviews were conducted between January 2001 and June 2006.

Socio-economic status

Postcodes from subjects in England and Wales were matched to 2001 census data using postcode at interview. A Townsend deprivation score (Townsend et al., 1988) and quintile is available for each census ward (small group of postcodes) in England and Wales. Less than 5% of subjects, including those from Scotland, for whom postcodes could not be linked were put into a 6th socio-economic status group for the analysis.

2.3 STATISTICAL METHODS

The main analyses focussed on mesothelioma risks for job groups categorised from subjects' job titles rather than their reported asbestos exposures, since the latter are more likely to be liable to differential response by cases. However, we also investigated the effect on mesothelioma risk of reported asbestos exposure in conjunction with job group. Odds ratios (ORs) adjusted for 5-year period of birth and socioeconomic status (SES) were estimated by unconditional logistic regression analysis using STATA(StataCorp, 2007). Region was not adjusted for because no evidence of confounding was seen when the main analysis (shown in section 3.4) was stratified by either strategic health authority or region. Occupational histories were truncated in 1992, 10 years before the median year of diagnosis. More recent exposure is unlikely to be relevant, both because asbestos exposure was rarely reported in jobs beginning in the 1990s (figure 3.2.1), and because of the long latency for mesothelioma induction.

Job categories

Staff blinded to case-control status coded job titles to the Standard Occupational Classification 1990 (SOC) (HMSO, 1991). Jobs were then allocated to six job categories primarily on the basis of SOC code, supplemented by details of the job or location. PMRs based on all mesothelioma deaths in Britain aged 16-74 years between 1991 and 2000 (McElvenny et al., 2005) provided the basis for this categorisation. The most significantly raised PMRs (>200 with a lower confidence interval of >100 and based on more than 30 deaths) are shown in table 2.3.1. The non-construction-related jobs in this table form the basis for the first job category (non-construction high risk). Asbestos manufacturing and work on board ships or in dockyards identified from job descriptions as well as SOC codes were also included.

Table 2.3.1 Highest mesothelioma proportional mortality ratios (PMRs) for males aged 16-74 in Great Britain, 1991-2000 (PMR>200 with lower confidence interval >100 and based on more than 30 deaths).

SOC Occupation Code	*Occupation description*	*Deaths*	*PMR*
541	Coach & vehicle body builders	48	528.2
534	Metal plate workers, shipwrights, riveters	138	416.6
532	Plumbers, heating & ventilating engineers & related trades	412	388.7
570	Carpenters & joiners	598	382.3
896	Construction & related operatives	154	359.2
521	Electricians, electrical maintenance fitters	323	264.1
893	Electrical, energy, boiler & related plant operatives & attendants	75	252.1
533	Sheet metal workers	80	245.7
913	Mates to metal/electrical & related fitters	50	230.9
211	Mechanical engineers	52	217.4
516	Metal working production & maintenance fitters	539	207.9

Preliminary analyses indicated that the risk was much higher for carpenters and substantially higher for plumbers, electricians and painters and decorators than for other construction workers, so these formed our next three job categories. Remaining industrial occupations (mainly defined by SOC units, i.e. 2-digit codes) were divided into two further job categories, 'medium risk industrial' and 'low risk industrial', on the basis of PMRs. The medium risk industrial job groups had average PMRs of more than 100, exceptions being railway workers, which included engine drivers (SOC 882, PMR 115), metal machining & instrument makers, which included boring & drilling setters (SOC 511, PMR 178) and precision instrument makers (SOC 517, PMR 101), and assemblers, lineworkers & routine process operatives, which included 4 minor groups with PMRs greater than 100: other assemblers (SOC 859, PMR 213), inspectors (SOC 860, PMR 129), laboratory testers (SOC 864, PMR 165) and other routine process operatives (SOC 869, PMR 121). After excluding asbestos and shipping industry workers, the remainder of the mechanical engineers and metal working production & maintenance fitters were no longer considered to be high risk, and these were also included in the medium risk industrial group. The low risk industrial group comprised occupations with average PMRs of less than 100, exceptions being draughtsmen (SOC 310) with a PMR of 150 and engineers & technologists (SOC 210-219) with an average PMR of 141. There are two SOC codes for "electrical engineers": SOC 212 (professional) with PMR of 198 and SOC 522 (non-professional) with PMR of 199. The former were classified as low risk and the latter as medium risk. Electrical engineers were coded to 212 or 522 on the basis of job title if their professional status was not known.

All jobs were thus divided into six job categories, the first five of which are likely to entail asbestos exposure: 1: non-construction high-risk, 2: carpenter, 3: plumber/electrician/painter, 4: other construction, 5: medium risk industrial, and 6: low risk industrial or non-industrial jobs where asbestos exposure was unlikely.

Table 2.3.2 Classification of job categories with average national mesothelioma PMRs

Job category and occupation	*SOC 90 codes & criteria for classification*	*PMR[1]*
Non-construction high risk occupations		***128.4***
Metal plate worker	533, 534	331.8
Coach & vehicle body builders	541	527.5
Asbestos product manufacturer	Hands-on making asbestos products in regulated industry	139.4
Laggers and electrical, energy, boiler attendants	893 plus 896, 921, 929, 990 further categorised on job title	121.8
Docker, shipbuilding or working on board ship	880, 332, 903 plus 169, 173, 174, 239, 385, 463, 620, 621, 630, 900, 930, 952, 953 further categorised on job title & anyone who spent >50% of time on board ship/in a shipyard	135.2
Navy	"Royal Navy", or equivalent, as employer	125.6
Construction		***188.9***
Carpenters	570, 920	381.0
Plumbers	532, plus 913 further categorised on job title	361.8
Electricians	521, plus 913 further categorised on job title	259.0
Painters & decorators	507	170.8
Other construction workers	111, 500-506, 509, 885, 886, 895, 896 (if not classified as lagger, above), 921, 923, 924, 929 plus 990 & 913 further categorised on job title	123.0
Medium risk industrial		***130.1***
Metal working production & maintenance fitters	516 plus 913 further categorised on job title	209.6
Railway worker	881-884, 922	74.2
Chemist or industrial scientist	200, 300-302, 309	159.0
Surveyor or inspector	110, 260, 262, 311	109.7
Metal machining & instrument makers nec.	510-515 517-519	73.0
Electrical & electronic trades nec.	520, 522-529	135.6
Welding, steel erecting & fixing	535-537	173.9
Metal working process operatives	830-844	122.3
Assemblers & routine process operatives	850-869	75.1
Plant & machine operatives nec.	887-892, 894, 897-899	104.8
Low risk industrial		***69.4***
Motor mechanic	540	47.6
Draughtsmen	310	150.3
Engineers & technologists nec.	210-219	140.6
Stores & warehousemen	440-441	72.4
Armed forces nec.	150-151, 600-601	77.5
Drivers & road transport workers	731, 870-875	49.1
Other industrial not elsewhere classified	113, 153, 171, 304, 348, 396, 531, 542-544, 553, 561, 569, 571, 590, 596, 597, 599, 611, 612, 615, 619, 631, 642, 672, 699, 733, 801, 809, 811, 820, 822, 824, 825, 829, 910, 911-913, 919, 923, 924, 931, 933, 934, 940, 941, 955, 956, 958, 990, 999 nec & anyone spent >75% of time in heavy industry (e.g. power station), factory or warehouse	69.8
Office and other low risk		***58.7***
	101, 120-127, 130-132, 139, 154, 155, 160, 169, 170, 172-179, 190, 191, 220-224, 230-235, 239-242, 250-253, 260, 261, 270, 271, 290-293, 320, 340-347, 361-363, 370, 371, 380, 381, 383-387, 390, 392, 399-401, 410-412, 420, 421, 430, 450-452, 459-462, 490, 556, 559, 560, 569, 580-582, 592, 594, 595, 598, 610, 619-622, 630, 640-644, 650-652, 659-661, 670, 671, 673, 690, 691, 699, 700-703, 710, 719-722, 730, 732, 790-792, 900-904, 950-956, 958 & nec	

[1] *Average PMR using all SOC codes contributing to job category*

Exposure to asbestos

Self-reported exposure to asbestos was classified in several ways:

Substantial exposure – either working on or disturbing AIB, sprayed coatings or lagging, including industrial workers handling raw asbestos or asbestos insulation.
Higher risk activities – sawing AIB or applying lagging or sprayed coatings.
Frequent contact – exposure at least once a week.
Direct (work done themselves) or indirect (work done by someone in the same area).

Occupational exposure analyses

ORs for each job category for men with more than 5 years of employment in relevant jobs are shown in table 3.2.2a. The reference group comprises 25 cases and 278 controls who worked only in low risk jobs with less than 5 years of low risk industrial work. Men who worked for up to 5 years in a medium or higher risk category are thus excluded from the table. In the left-hand column the job categories are not mutually exclusive, as a man could work in several jobs for at least 5 years. The right-hand part of table 3.2.2 shows ORs for the mutually exclusive classification based on each man's highest job category. Results for women are shown in Table 3.2.2b. These analyses are repeated in appendix tables 3.2.2c, d and e for occupations before age 30 in men (separately for those born before and after 1940) and for all women.

Table 3.2.3 shows male ORs for age at first exposure and duration of employment in any high or medium risk work and in carpentry, and table 3.2.4 shows duration in these job categories before and after age 30. The reference group for these ORs comprises the 38 male mesotheliomas and 413 controls with no employment in non-construction high risk, construction or medium risk industrial jobs.

Cumulative exposure index

Duration of exposure in each job was weighted by a rounded factor reflecting the ratios of male ORs for more than 10 years employment before age 30 in each job category (see Table 3.2.6; 10 for carpentry, 3 for plumbing, electrical, painting and non-construction high risk jobs, and 1 for other construction or medium risk industrial work). Contributions for each job were summed to give a cumulative index of overall exposure before and after age 30. Table 3.2.5 shows male ORs by cumulative exposure index before and after age 30 relative to men with none of these exposures. Table 3.2.6 shows male ORs for duration and type of reported exposure within each job category.

Other analyses included the proportion of jobs in each category in which various asbestos exposures were reported by cases and controls (tables 3.2.7 and 3.2.8), ORs based on the last job prior to interview (Table 3.2.9) and a tabulation of main occupation before age 30 against last job category (Table 3.2.10).

Low exposure analysis

Subjects who reported only low exposure jobs and no substantial asbestos exposure were analysed separately (Tables 3.3.2 – 3.3.6). Non-occupational exposures before age 30 that were investigated in this low exposure subgroup included living with an asbestos worker, living near a potential hazard (e.g. asbestos factory or disposal site, power plant, shipyard), type of residence (e.g. council property, prefab, high rise block), work with other asbestos products, including heat protection materials, gaskets and brake linings, DIY involving asbestos, and amount and duration of smoking. Average daily cigarette consumption in current and ex-smokers was calculated as cumulative lifetime pack-years divided by total duration of smoking.

Attribution to occupational and other exposures

To estimate the number of mesothelioma cases attributed to occupational and non-occupational asbestos exposures, men and women were classified in table 3.4.2 into eight mutually exclusive exposure groups ranked as 1: high-risk (including lagging and shipbuilding but excluding construction), 2: carpenter, 3: plumber, electrician, painter, 4: other construction, 5: medium risk industrial, 6: other substantial occupational asbestos exposure, 7: living with an occupationally exposed relative, and 8: the reference group, comprising cases (18 men, 34 women) and controls (289 men, 150 women) with none of these exposures. Subjects were assigned to the highest category in which they were ever exposed, regardless of duration. Numbers of mesothelioma cases attributed to occupational and non-occupational asbestos exposures were also calculated in the same way for men (30 cases, 83 controls) who were born since 1950 and began work in 1970 or later when crocidolite use had virtually ceased in the UK (table 3.4.3).

Lifetime risk estimation

The overall average OR for all British men relative to this unexposed reference group was 7.4 (weighted average among controls: table 3.4.2, last row). A recent analysis of national mesothelioma mortality trends (Hodgson et al., 2005) predicts a lifetime risk for British men born 1943-47 of 0.59%. Lifetime risks for men born in the 1940s were therefore estimated by multiplying the ORs in table 3.4.2 by 0.080% (i.e. 0.59%/7.4), which is the estimated lifetime risk of men in the unexposed reference group. The corresponding multiplying factor to derive lifetime risks from ORs in tables 3.2.3, 3.2.4 and 3.2.6, where the reference group (comprising 38 male cases and 413 controls) includes men with domestic exposure or reported substantial occupational exposure in low-risk jobs, is 0.12% (0.59%/5.0 – see table 3.2.6 footnote).

3. RESULTS

3.1 RECRUITMENT

Numbers of potential subjects who were ineligible or could not be contacted are shown in the upper part of table 3.1.1. Of the 541 mesothelioma patients who were not invited, three quarters were already deceased or too ill to be contacted. The main reasons for population controls not to be invited were refusal by the GP to give permission and loss to follow-up (i.e. address changed and not updated on Health Authority system). The lower part of the table shows response rates among those who were invited. The proportion of those invited who were eventually interviewed, sometimes after several reminders, was 73% of mesothelioma patients and 60% of controls.

Table 3.1.2 shows notification sources of the mesothelioma patients. The treating physician or lung cancer nurse referred the majority of those interviewed. A small number contacted the study office themselves after hearing about the study, and 7 of these were interviewed.

Response rates by socio-economic status are shown in table 3.1.3. As expected, response rates were highest in the more affluent groups. Sixty nine percent of population controls in the top two quintiles of SES took part compared with 46% in the lowest quintile.

Comparison of current occupation against the 2001 census showed no evidence that construction workers were under-ascertained, with 8.3% of controls classified as working in "skilled construction and building trades" and 1.8% as carpenters, compared to census proportions of 6.5% and 1.7% respectively.

Ninety-two percent of mesothelioma cases were histologically diagnosed (table 3.1.4). Histological confirmation is being sought for the remaining patients, usually at post-mortem. Median age at interview was similar for mesothelioma cases and controls (table 3.1.5). Over 90% of the interviewed mesothelioma patients were resident in England, 4% in Scotland and 5% in Wales. (Table 3.1.6. Further breakdown by strategic health authority is shown in appendix table 3.1.)

Table 3.1.1 Study recruitment

	Born since 1940			*Born 1925-39*	
	Mesothelioma cases	***Health Authority controls***	***GP selected controls***	***Mesothelioma cases***	***Health Authority controls[1]***
Ineligible/ not contacted					
Deceased	166	42		105	65
Wrong diagnosis	15			2	
Permission refused by consultant/GP	51	109		36	60
Lost to follow up	1	109	2	0	36
Too ill	71	36		81	26
Other reason[2]	4	30	1	9	13
Total	308	326	3	233	200
Invited to take part					
Interview obtained	406 (72.6%)	887 (62.1%)	127 (57.5%)	216 (73.0%)	406 (56.5%)
Postal questionnaire only[3]	11 (2.0%)	16 (1.1%)	5 (2.3%)	10 (3.4%)	5 (0.7%)
Declined	53 (9.5%)	238 (16.7%)	34 (15.4%)	35 (11.8%)	207 (28.8%)
No response	89 (16.0%)	287 (20.1%)	55 (24.9%)	35 (11.8%)	101 (14.1%)
Total invited	559	1428	221	296	719

[1]*This category includes 29 GP controls born between 1935 and 1939, 22 of whom were interviewed.*
[2]*No telephone, deaf, non-English speaking, learning difficulties, emigrated*
[3]*Towards the end of the study, a further 85 mesothelioma cases were invited to complete a postal questionnaire but not a telephone interview, of whom 93% (79) returned the questionnaire. These are not presented in this table.*

Table 3.1.2 Source of mesothelioma and lung cancer case notification

Source	*All notifications*		*Interviewed cases*	
	Mesothelioma cases born since 1940	*Mesothelioma cases born 1925-1939*	*Mesothelioma cases born since 1940*	*Mesothelioma cases born 1925-1939*
Treating physician	362 (41.8%)	281 (53.1%)	192 (47.3%)	131 (60.7%)
Lung cancer nurse	214 (25.0%)	178 (33.7%)	102 (25.1%)	65 (30.1%)
NCRN or other research/trial nurses	82 (9.5%)	18 (3.4%)	38 (9.4%)	4 (1.9%)
Treating physician via HES[1]	113 (13.0%)	-	35 (8.6%)	-
Treating physician via cancer registry	31 (3.6%)	5 (1.0%)	6 (1.5%)	2 (0.9%)
Asbestos group	46 (5.3%)	15 (2.8%)	24 (5.9%)	2 (0.9%)
Self-referral	8 (0.9%)	18 (3.4%)	7 (1.7%)	12 (5.6%)
Other or NK	11 (1.3%)	14 (2.7%)	2 (0.5%)	0
Total	867 (100%)	529 (100%)	406 (100%)	216 (100%)

[1] *HES = Hospital Episode Statistics*

Table 3.1.3 Response rates by deprivation

Socio-economic status		*Mesothelioma cases*	*Health Authority Controls*	*GP Controls*
Most Affluent	1	115 (83.3%)	261 (68.3%)	19 (70.4%)
	2	138 (80.2%)	283 (69.7%)	16 (66.7%)
	3	107 (67.7%)	278 (62.5%)	16 (64.0%)
	4	112 (70.9%)	243 (57.6%)	20 (47.6%)
Most Deprived	5	116 (65.9%)	218 (45.9%)	17 (41.5%)
	NK	34 (64.2%)	10 (58.8%)	39 (62.9%)
Total		622 (72.8%)	1293 (60.2%)	127 (57.5%)

Table 3.1.4 Grounds of diagnosis amongst interviewed mesothelioma cases

Grounds of diagnosis	*Mesothelioma cases*
Histological	572 (92.0%)
Cytology	7 (1.1%)
Clinical only	10 (1.6%)
Grounds not known	33 (5.3%)
Total	622 (100%)

Table 3.1.5 Median (and range) age at interview

	Mesothelioma cases	*Population controls*
Males		
Born 1925-1939	66 (61, 76)	68 (62, 79)
Born since 1940	57 (30, 64)	58 (37, 65)
Females		
Born 1925-1939	66 (62, 75)	67 (63, 78)
Born since 1940	57 (33, 63)	59 (40, 65)

Table 3.1.6 Residential region at interview

Region	*Mesothelioma Cases*		*Population Controls*	
	n	**%**	**n**	**%**
England				
East Anglia	33	5.3	73	5.1
East Midlands	36	5.8	136	9.6
North	30	4.8	91	6.4
North West	65	10.5	170	12.0
South East	240	38.6	448	31.6
South West	67	10.8	170	12.0
West Midlands	51	8.2	141	9.9
Yorkshire & Humberside	44	7.1	102	7.2
All England	**566**	**91.0**	**1331**	**93.7**
Scotland	**27**	**4.3**	**43**	**3.0**
Wales	**28**	**4.5**	**45**	**3.2**
Other[1]	1	0.2	1	0.1
Total	**622**	**100.0**	**1420**	**100.0**

[1] *Other included Eire (1 mesothelioma) and France (1 control)*

3.2 OCCUPATIONAL EXPOSURE

All interviewed subjects (622 mesotheliomas and 1420 controls) are shown in table 3.2.1 by sex, period of birth and asbestos exposure (ever/never worked in job categories 1-5). Numbers of mesotheliomas and controls who had worked before 1992 for at least five years in each job category are shown in tables 3.2.2a (men) and 3.2.2b (women). The reference group for the calculation of ORs comprised those who worked only in low-risk jobs with less than 5 years in low risk industrial occupations. The categories in the left-hand part of the table are not mutually exclusive, but in the right-hand part subjects are excluded if they had ever worked in a higher job category.

Carpentry was the job category with the highest male OR (Table 3.2.2a: OR 36.0, 95%CI 19.2-67.3), followed by all non-construction high-risk jobs (OR 16.8, 95%CI 9.6-29.3), plumbers, electricians and painters (OR 14.6, 95%CI 8.8-24.4) and other construction workers (OR 7.9, 95%CI 4.7-13.3). Very few women had worked in high risk or construction occupations for more than 5 years (table 3.2.2b: 1 case and 4 controls). The overall OR for medium risk industrial work (mechanical and electrical process and assembly workers, welders, railway workers, surveyors, inspectors and industrial scientists) was 5.2 (95%CI 3.3-8.2) in men and 1.7 (95%CI 0.9-3.5) in women. The OR remains high when those with higher risk occupations are excluded (male OR 5.2 overall, 3.2 excluding high-risk and construction workers). In contrast, the male OR for the remaining 'low risk' industrial occupations, including draughtsmen, warehousemen, drivers, plant and machine operators and armed forces, falls from 4.1 (95%CI 2.6-6.4) overall to 1.1 (95%CI 0.5-2.2) when those who had also worked in medium or higher risk jobs are excluded. The effect of excluding other more hazardous work for various non-industrial occupations is also shown. Among teachers, for example, 7 of the 11 male mesotheliomas and 7 of the 18 female cases had also worked in higher risk jobs.

Similar analyses based on exposure before age 30 and split by year of birth are shown in appendix tables 3.2.2c, d and e. Most ORs are substantially higher in men born 1925-39 than in those born since 1940, but the confidence intervals are wide due to the small number of older male cases (4/175 cases and 70/284 controls) employed only in low risk jobs who form the reference group in Table 3.2.2d. Thus, for example, after excluding men with higher exposures their ORs for all low risk industrial jobs (OR 4.9, 95% CI 1.4-17.8) and for motor mechanics (unadjusted OR 26.3, 95% CI 2.1-359.9) were high but only marginally significant. Appendix 3.2.2f shows an analysis of low risk non-industrial jobs using those who only worked in offices as the reference category.

Table 3.2.3 shows ORs for men ever employed as carpenters (lower part) or in at least one high or medium risk job (upper part) by age starting the first such job and duration of relevant employment. The risks were highest in men with long exposure in high or medium risk occupations beginning before age 20. The OR for 20 or more years of employment in men first exposed before age 20 is 13.4 (95%CI 9.2-19.6) for high or medium risk work, and 99.7 (95%CI 43.7-227.5) for carpentry. The odds ratio for first exposure in any high or medium risk job after age 30 is much lower and not statistically significant (OR 1.7, 95%CI 0.7-3.9).

Table 3.2.4 shows male ORs by duration of exposure in high or medium risk occupations before and after age 30, again showing the marked effects of early exposure and long duration. Ten or more years of high or medium risk work beginning after age 30 caused an OR of only 1.1 (95%CI 0.3-3.8), but the same exposure in men who had already worked for more than 10 years before age

30 increased their OR from 6.8 to 13.1, a factor of 2.1 (95%CI 1.1-4.0). This analysis is shown separately for men born before and after 1940 in appendix tables 3.2.4a and b.

Table 3.2.5 shows ORs by cumulative exposure before and after age 30 (weighted duration in medium or high risk jobs – see footnote and Methods). As expected there is an increasing trend in risk with increasing exposure before age 30. A trend after age 30 is apparent in those who were heavily exposed (weighted duration > 30 years) before age 30.

In table 3.2.6 men are assigned to the 5 occupational groups on the basis of the highest category in which they ever worked (see Methods). As in tables 3.2.3 and 3.2.4, ORs are relative to men employed only in low risk industrial or non-industrial jobs (38 cases and 413 controls). The OR and corresponding lifetime risk (LR) for 10 or more years of relevant work before age 30 were highest for carpenters (OR 50.0, LR 5.9%), about one third as high for electricians, plumbers and painters (OR 17.1, LR 2.0%) and for non-construction high-risk jobs (OR 15.3, LR 1.8%), and lower for other construction workers (OR 7.0, LR 0.8%) and for all medium risk industrial jobs (OR 5.2, LR 0.6%). ORs for all men in each category are also shown, ranging from 23.3 for carpenters to 2.8 for medium risk industrial workers.

The nature and frequency of reported substantial asbestos exposure were also predictive (table 3.2.6), with higher risks within in each job category in men reporting frequent direct exposure, but the OR was still significantly increased within each job category among men who did not report direct or indirect substantial asbestos exposure in any job before age 30. These 'unexposed' ORs were 9.8 (95%CI 4.1-23.5) for carpenters, 5.5 (95%CI 3.1-9.7) for non-construction high risk, 4.4 (95%CI 2.2-8.7) for plumbers, electricians and painters, 2.7 (95%CI 1.5-4.8) for other construction and 1.9 (95%CI 1.1-3.1) for medium risk industrial. The proportion of controls reporting direct exposure before age 30 was 67% (28/42) among carpenters, 55% (63/114) among plumbers, electricians and painters, 26% (37/142) among other construction workers, 12% (32/263) among medium risk industrial workers and 3% (12/413) among low risk workers. Appendix tables 3.2.6a and b show these analyses for subjects born since 1940 and for older cases (born 1925-1939). Patterns of risk by duration of employment in high and medium risk jobs (upper part of tables) and by nature and frequency of reported exposure (lower part) are similar to the overall results.

The proportion of jobs in each job category in which direct and indirect asbestos exposures were reported by cases and controls are shown in table 3.2.7. In most cases the proportion of jobs where exposure was reported increased with job duration. Cases reported more direct exposures than controls, but there was little difference in reported frequency of indirect (bystander) exposure. Proportions of cases and controls with direct exposure to AIB and lagging before age 30 in the high risk and construction categories are given in Table 3.2.8. Working with AIB was reported by 74% of cases and 71% of controls in carpentry, most of whom sawed and drilled it. Sixteen percent of cases and 13% of controls in carpentry also reported direct exposure to lagging, mainly when removing it in the course of their work. Plumbers, electricians and painters came in direct contact with both AIB (39% cases and 32% controls) and lagging (49% cases and 38% controls). They mainly reported removing or damaging lagging, though 10% reported applying lagging materials. Similar numbers of cases and controls in other construction jobs (25% cases and 23% controls) reported direct exposure to AIB, but many more cases (24%) than controls (9%) reported direct contact with lagging. Eighteen percent of the cases in these jobs reported removing asbestos lagging in the course of their work compared to 5% of controls. The difference is less marked among men in medium risk jobs, with 11% of cases and 5% of controls reporting removing lagging.

Figure 3.2.1 shows the proportions of male cases and controls beginning a new job in each period since 1940 who reported asbestos exposure in that job. Jobs of more than 5 years duration are excluded to ensure that reported exposure is representative of the period when the job started. The frequency of exposure fell sharply during the 1970s, and the heaviest exposures (sawing AIB or applying lagging or sprayed coatings) had virtually ceased by 1982.

Table 3.2.9 shows risk by last job at interview or at retirement split by year of birth for comparison against published PMRs, which are based on the last full-time occupation recorded on death certificates (McElvenny et al., 2005). There are 140 cases and 524 controls in the low risk reference group in comparison to 25 cases and 278 controls in table 3.2.2, so the ORs are much lower. The OR for those still in carpentry jobs at interview was 10.5 (95%CI 6.1-18.1). Table 3.2.10 shows the correlation between main job before age 30 and job at interview or retirement. Among high risk jobs the strongest correlation between main occupation before age 30 and last job before interview or retirement in cases was for carpenters (56% still working as carpenters and only 21% in low risk jobs).

Table 3.2.1 Interviewed mesothelioma cases and controls by job category, year of birth and sex

Year of birth	*Central age*[1]	*Mesothelioma cases*				*Population controls*				*National Mesothelioma Registrations 2000-04*	
		Ever worked in high or medium risk jobs[2]	*Never worked in high or medium risk jobs*[3]	*Total*	*%*	*Ever worked in high or medium risk jobs*[1]	*Never worked in high or medium risk jobs*[2]	*Total*	*%*	*n*	*%*
Males											
≥ 1965	35	1	1	2	0.4	1	3	3	0.3	3	0.1
1960-64	40	4	0	4	0.8	5	7	13	1.2	14	0.2
1955-59	45	11	2	13	2.5	20	16	36	3.2	48	0.8
1950-54	50	42	2	44	8.6	66	45	111	10.0	166	2.9
1945-49	55	105	14	119	23.2	162	123	285	25.6	524	9.0
1940-44	60	145	10	155	30.3	252	128	380	34.2	893	15.3
1935-39	65	82	7	89	17.4	97	46	143	12.9	1223	21.0
1930-34	70	48	1	49	9.6	52	27	79	7.1	1420	24.4
1925-30	75	36	1	37	7.2	44	18	62	5.6	1529	26.3
Total		**474**	**38**	**512**	**100.0**	**699**	**413**	**1112**	**100.0**	**5820**	**100.0**
Females											
≥ 1965	35	0	2	2	1.8	0	0	0		5	0.6
1960-64	40	0	1	1	0.9	2	4	6	1.9	5	0.6
1955-59	45	1	7	8	7.3	1	13	14	4.5	23	2.6
1950-54	50	2	5	7	6.4	7	13	20	6.5	31	3.4
1945-49	55	6	11	17	15.5	9	45	54	17.5	86	9.5
1940-44	60	13	21	34	30.9	17	75	92	29.9	162	18.0
1935-39	65	8	17	25	22.7	22	55	77	25.0	181	20.1
1930-34	70	5	7	12	10.9	9	21	30	9.7	178	19.8
1925-30	75	2	2	4	3.6	4	11	15	4.9	230	25.5
Total		**37**	**73**	**110**	**100.0**	**71**	**237**	**308**	**100.0**	**901**	**100.0**

[1] *97% (601/622) of cases were diagnosed between 2000 and 2004*
[2] *Ever worked in job categories 1-5: high risk, carpenters, plumber/electrician/painter, other construction and medium risk industrial jobs.*
[3] *Worked only in low risk industrial or non-industrial jobs.*

Table 3.2.2 Numbers of mesothelioma cases and controls who worked for at least 5 years (before 1992) in various occupations. Subjects with any exposure in preceding occupational categories are excluded in the right-hand part of the table.

Table 3.2.2a All men

Job category and occupation	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk						
Metal plate worker	17	12	43.3 (13.5, 138.6)			
Coach & vehicle body builders	4	2	25.1 (3.5, 177.1)			
Asbestos product manufacturer	4	5	9.3 (2.0, 43.8)			
Laggers & electrical, energy, boiler attendants	9	6	24.1 (6.3, 92.3)			
Docker, shipbuilding or working on board ship	48	36	16.1 (8.3, 31.3)			
Navy	26	16	20.7 (8.9, 47.6)			
All non-construction high risk jobs	**102**	**78**	**16.8 (9.6, 29.3)**			
Construction				**Construction (no other high risk jobs)**		
Carpenter	**93**	**36**	**36.0 (19.2, 67.3)**	**81**	**30**	**39.3 (20.2, 76.5)**
Plumber	44	30	18.8 (9.7, 36.3)	39	27	18.9 (9.5, 37.7)
Electrician	44	41	14.7 (7.7, 28.0)	38	35	14.6 (7.5, 28.4)
Painters & decorators	30	27	17.5 (8.0, 38.0)	25	22	20.0 (8.5, 47.0)
Plumbers, electricians & painters & decorators	**115**	**96**	**14.6 (8.8, 24.4)**	**99**	**82**	**14.8 (8.7, 25.1)**
Other construction	**81**	**120**	**7.9 (4.7, 13.3)**	**59**	**101**	**6.8 (4.0, 11.7)**
Medium risk industrial				**Medium risk industrial (no high risk or construction)**		
Metal working production & maintenance fitters	41	55	9.6 (5.0, 18.2)	18	35	8.6 (3.7, 19.6)
Railway worker	5	9	6.7 (1.8, 24.6)	2	4	5.6 (0.7, 44.8)
Chemist or industrial scientist	12	27	6.4 (2.6, 15.8)	7	17	6.2 (2.1, 18.5)
Surveyor or inspector	36	57	7.8 (4.2, 14.6)	12	41	3.7 (1.6, 8.4)
Metal machining & instrument makers nec.	11	33	4.9 (2.0, 11.6)	8	23	5.7 (2.1, 15.8)
Electrical & electronic trades nec.	15	60	3.4 (1.6, 7.3)	7	38	2.4 (0.9, 6.2)
Welding, steel erecting & fixing	15	20	7.4 (3.2, 17.3)	2	5	3.6 (0.6, 23.5)
Metal working process operatives	5	22	3.0 (1.0, 9.1)	2	13	2.3 (0.4, 12.2)
Assemblers & routine process operatives	22	59	4.3 (2.2, 8.5)	10	35	3.8 (1.6, 9.0)
Plant & machine operatives nec.	18	33	6.7 (3.2, 14.3)	7	22	4.0 (1.5, 10.8)
All medium risk industrial jobs	**157**	**331**	**5.2 (3.3, 8.2)**	**57**	**201**	**3.2 (1.9, 5.3)**

Low risk industrial				**Low risk industrial (no high risk, construction or med risk industrial)**		
Motor mechanic	18	54	3.8 (1.9, 7.8)	2	23	0.7 (0.2, 3.5)
Draughtsmen	12	20	8.3 (3.3, 20.6)	0	7	
Engineers & technologists nec.	17	54	3.6 (1.8, 7.3)	3	15	1.8 (0.5, 7.2)
Stores & warehousemen	8	30	3.4 (1.4, 8.6)	0	12	
Armed forces nec.	6	14	5.1 (1.7, 15.9)	1	4	4.6 (0.4, 54.1)
Drivers & road transport workers	39	103	4.3 (2.4, 7.7)	3	30	1.2 (0.3, 4.4)
Other industrial not elsewhere classified	74	197	4.0 (2.4, 6.7)	8	67	1.4 (0.6, 3.4)
All low risk industrial jobs	**153**	**406**	**4.1 (2.6, 6.4)**	**13**	**135**	**1.1 (0.5, 2.2)**
< 5 years low risk industrial or non-industrial[1]				**< 5 years low risk industrial or non-industrial only (no medium or higher risk)**		
Cleaners	3	4	-	0	1	-
Retail workers	13	96	-	3	38	-
Doctors, nurses & hospital workers	3	24	-	1	13	-
Teachers & school workers	11	79	-	4	42	-
Kitchen workers	8	17	-	0	9	-
Office workers	46	204	-	11	119	-
Other	87	337	-	19	138	-
All low risk non-industrial jobs	**143**	**612**		**25**	**277**	
Reference group[2]	**25**	**278**	**1.0 (ref.)**	**25**	**278**	**1.0 (ref.)**
All males	512	1112		512	1112	

[1] *No comparisons can be made as some of these constitute the reference group*

[2] *ORs reference = subjects working only in non-industrial jobs, or in low risk industrial jobs for less than 5 years.*

nec = not elsewhere classified

Table 3.2.2b All women

Job category and occupation	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk						
Metal plate worker	0	1	-	0	1	-
Docker, shipbuilding or working on board ship	1	1	3.3 (0.2, 58.9)	1	1	3.3 (0.2, 58.9)
All non-construction high risk jobs	**1**	**2**	**1.7 (0.1, 19.9)**	**1**	**2**	**1.7 (0.1, 19.9)**
Construction				**Construction (no other high risk jobs)**		
Electrician	0	1	-	0	1	-
Painters & decorators	0	2	-	0	1	-
Medium risk industrial				**Medium risk industrial (no high risk or construction)**		
Metal working production & maintenance fitters	1	0	-	1	0	-
Chemist or industrial scientist	1	1	4.1 (0.2, 70.1)	1	1	4.1 (0.2, 70.1)
Surveyor or inspector	1	0	-	1	0	-
Metal machining & instrument makers nec.	0	2	-	0	2	-
Welding, steel erecting & fixing	1	0	-	1	0	-
Metal working process operatives	1	1	2.8 (0.1, 54.1)	1	1	2.7 (0.1, 51.9)
Assemblers & routine process operatives	11	24	1.6 (0.7, 3.5)	11	23	1.6 (0.7, 3.6)
Plant & machine operatives nec.	0	1	-	0	1	-
All medium risk industrial jobs	**15**	**29**	**1.7 (0.9, 3.5)**	**15**	**28**	**1.8 (0.9, 3.6)**
Low risk industrial				**Low risk industrial (no high risk, construction or med risk industrial)**		
Draughtsmen	0	1	-	0	1	-
Stores & warehousemen	0	5	-	0	3	-
Drivers & road transport workers	2	2	3.1 (0.4, 23.5)	0	2	-
Other industrial not elsewhere classified	8	39	0.6 (0.3, 1.5)	5	26	0.6 (0.2, 1.7)
All low risk industrial jobs	**11**	**49**	**0.7 (0.3, 1.4)**	**5**	**33**	**0.5 (0.2, 1.3)**
< 5 years low risk industrial or non-industrial[1]				**< 5 years low risk industrial or non-industrial only (no medium or higher risk)**		
Cleaners	6	9	-	2	3	-
Retail workers	19	69	-	13	44	-
Doctors, nurses & hospital workers	16	43	-	9	32	-
Teachers & school workers	18	38	-	11	35	-
Kitchen workers	7	6	-	6	1	-

Office workers	44	118	-	36	96	-
Other	20	73	-	13	58	-
All low risk non-industrial jobs	**100**	**275**	**-**	**66**	**198**	**-**
Reference group[2]	**68**	**204**	**1.0 (ref.)**	**68**	**204**	**1.0 (ref.)**
All females	110	308		110	308	

[1] *No comparisons can be made as some of these constitute the reference group*

[2] *ORs reference = subjects working only in non-industrial low risk jobs or low risk industrial jobs for less than 5 years. nec = not elsewhere classified*

Table 3.2.3 – Odds ratios for males by age started work and total duration in high or medium risk occupations and in carpentry. All Odds Ratios are relative to the 38 cases and 413 controls with no high risk, construction or medium risk industrial jobs.

	Total duration of exposure									
	<5 years		*5-9 years*		*10-19 years*		*≥20 years*		*Total*	
	cases/ controls	*OR (CI)*	*cases/ controls*	*OR (CI)*	*cases/ controls*	*OR (CI)*	*cases/ controls*	*OR (CI)*	*cases/ controls*	*OR (CI)*
Age at first high risk job[1]				*Total duration in all high risk jobs*						
<20	27/75	4.0 (2.3, 6.9)	36/77	5.2 (3.1, 8.7)	51/93	5.9 (3.6, 9.6)	311/265	13.4 (9.2, 19.6)	425/510	9.2 (6.4, 13.1)
20-29	7/41	1.8 (0.8, 4.4)	3/16	2.0 (0.6, 7.3)	7/37	2.1 (0.9, 5.0)	24/46	5.5 (3.0, 10.1)	41/140	3.1 (1.9, 5.0)
≥30	5/15	3.6 (1.2, 10.4)	0/6		2/23	1.0 (0.2, 4.3)	1/5	1.8 (0.2, 16.3)	8/49	1.7 (0.7, 3.9)
Total	39/131	3.2 (2.0, 5.3)	39/99	4.3 (2.6, 7.2)	60/153	4.2 (2.7, 6.6)	336/316	12.1 (8.3, 17.6)	474/699	7.3 (5.1, 10.4)
Age at first carpentry job				*Total duration in carpentry jobs*						
<20	7/9	9.0 (3.0, 26.4)	6/7	10.0 (3.0, 33.1)	14/5	38.9 (12.4,122.1)	63/10	99.7(43.7,227.5)	90/31	38.0 (21.3, 67.5)
≥20	5/4	21.3 (4.8, 93.4)	2/3	9.3 (1.4, 61.9)	3/6	5.5 (1.3, 24.5)	5/5	11.0 (2.9, 41.1)	15/18	10.0 (4.6, 21.9)
Total	12/13	11.0 (4.5, 27.0)	8/10	9.2 (3.3, 25.9)	17/11	18.5 (7.8, 44.1)	68/15	62.5(30.9,126.5)	105/49	26.5 (15.9, 44.2)

[1] *All high risk exposure = high risk, all construction jobs and medium risk industrial jobs*

Table 3.2.4 – Odds ratios for males by duration of employment in high or medium risk occupations and in carpentry before and after age 30. All Odds Ratios are relative to the 38 cases and 413 controls with no high risk, construction or medium risk industrial jobs.

	Duration of exposure after age 30							
	none		*<10 years*		*≥10 years*		*Total*	
	cases/ controls	*OR (CI)*	*cases/ controls*	*OR (CI)*	*cases/ controls*	*OR (CI)*	*cases/ controls*	*OR (CI)*
Duration in all high risk jobs before age 30[1]				*Duration in all high risk jobs after age 30*				
none			5/21	2.5 (0.9, 6.8)	3/28	1.1 (0.3, 3.8)	8/49	1.7 (0.7, 3.9)
<10 yrs	59/163	3.9 (2.5, 6.1)	27/76	3.9 (2.2, 6.8)	47/104	4.7 (2.9, 7.7)	133/343	4.1 (2.8, 6.1)
≥10 yrs	19/31	6.8 (3.5, 13.3)	54/53	11.5 (6.9, 19.1)	260/223	13.1 (8.9, 19.3)	333/307	12.1 (8.4, 17.6)
Total	78/194	4.4 (2.8, 6.7)	86/150	6.2 (4.1, 9.6)	310/355	9.6 (6.6, 14.0)	474/699	7.3 (5.1, 10.4)
Duration in carpentry jobs before age 30				*Duration in carpentry jobs after age 30*				
none			3/7	6.5 (1.5, 28.0)	2/4	7.0 (1.2, 42.2)	5/11	6.6 (2.1, 21.0)
<10 yrs	16/16	11.4 (5.1, 25.6)	6/1	58.3 (6.4, 532.1)	8/6	15.1 (4.8, 47.2)	30/23	14.6 (7.6, 28.3)
≥10 yrs	7/3	26.3(6.3,109.7)	12/2	93.1 (18.9, 458.3)	51/10	73.8 (32.3, 168.9)	70/15	66.3 (32.5, 135.5)
Total	23/19	13.4 (6.5, 27.6)	21/10	28.1(11.6, 67.8)	61/20	40.9 (21.3, 78.8)	105/49	26.5 (15.9, 44.2)

[1] *All high risk exposure = high risk, all construction jobs and medium risk industrial jobs*

Table 3.2.5 – Odds ratios for males by weighted duration in high or medium risk occupations before and after age 30

		Weighted duration after age 30[1]					
		None	***<10 years***	***10-19 years***	***20-29 years***	***≥30 years***	***Total***[2]
Weighted duration before age 30[1]							
None	cases/controls	38/413	4/20	2/18	1/5	1/6	8/49
	OR (CI)	1.0 (ref)	2.1 (0.7, 6.5)	1.2 (0.3, 5.3)	1.9 (0.2, 16.8)	1.8 (0.2, 15.9)	1.7 (0.7, 3.8)
<10 years	cases/controls	38/136	16/65	7/43	12/26	5/16	78/286
	OR (CI)	3.0 (1.9, 5.0)	2.7 (1.4, 5.1)	1.8 (0.7, 4.3)	4.6 (2.1, 9.9)	3.3 (1.1, 9.6)	2.9 (1.9, 4.4)
10-19 years	cases/controls	15/32	19/32	32/64	30/56	8/18	104/202
	OR (CI)	5.1 (2.5, 10.3)	6.8 (3.5, 13.3)	5.8 (3.4, 10.1)	6.0 (3.4, 10.7)	4.7 (1.9, 11.7)	5.7 (3.8, 6.7)
20-29 years	cases/controls	11/12	6/4	8/3	8/4	13/10	46/33
	OR (CI)	11.1 (4.5, 27.2)	16.6 (4.4, 62.5)	26.2 (6.6, 103.6)	21.4 (6.0, 76.0)	14.3 (5.8, 35.1)	15.3 (8.7, 26.9)
≥30 years	cases/controls	14/14	8/8	17/16	33/15	166/76	238/129
	OR (CI)	10.8 (4.7, 24.7)	10.7 (3.7, 30.9)	11.6 (5.4, 25.1)	24.4 (12.1, 49.3)	25.1 (16.2, 38.9)	20.7 (13.8, 30.9)
Total[2]	cases/controls	78/194	53/129	66/144	84/106	193/126	474/699
	OR (CI)	4.4 (2.9, 6.8)	4.5 (2.8, 7.1)	5.1 (3.3, 7.9)	9.0 (5.7, 14.2)	17.5 (11.7, 26.4)	7.3 (5.1, 10.4)

[1] *Based on relative risks from table 3.2.6 (>10 years row) – weightings applied: 1 for medium risk and other construction, 3 for non-construction high risk, plumbers, electricians and painters and 10 for carpenters.*
[2] *Excluding ref group*

Table 3.2.6 Job category and reported asbestos exposure in all men before age 30. Subjects who ever worked in each job category are excluded in subsequent columns.

		High risk excluding construction	***Carpenters***	***Construction Plumbers, electricians, painters***	***Other construction***	***All other jobs Medium risk industrial***	***Low risk (ref)***
Duration in job category before age 30							
None	cases/controls	4/15	3/10	6/12	7/24	4/26	
	OR (CI)	2.8 (0.9, 8.9)	3.1 (0.8, 11.8)	5.2 (1.8, 14.9)	3.2 (1.3, 8.1)	1.5 (0.5, 4.6)	
<5 years	cases/controls	52/59	9/12	13/34	20/66	15/79	
	OR (CI)	9.8 (5.9, 16.2)	8.2 (3.2, 20.9)	4.0 (1.9, 8.3)	3.3 (1.8, 6.0)	2.1 (1.1, 4.0)	
5-9 years	cases/controls	42/25	11/5	24/22	12/30	8/68	
	OR (CI)	18.3 (10.0, 33.7)	24.4 (8.0, 74.9)	12.3 (6.3, 24.2)	4.3 (2.0, 9.0)	1.2 (0.6, 2.8)	
≥10 years	cases/controls	55/39	66/15	69/46	13/22	41/90	
	OR (CI)	15.3 (9.0, 26.2)	50.0 (25.8, 96.8)	17.1 (10.3, 28.3)	7.0 (3.2, 15.2)	5.2 (3.1, 8.5)	
Lifetime risk for ≥10 years in job category[1]		1.8%	5.9%	2.0%	0.8%	0.6%	0.12%
Type and duration of asbestos exposure before age 30[2]							
None	cases/controls	29/56	12/12	16/38	23/91	35/202	33/393
	OR (CI)	5.5 (3.1, 9.7)	9.8 (4.1, 23.5)	4.4 (2.2, 8.7)	2.7 (1.5, 4.8)	1.9 (1.1, 3.1)	
Indirect[3]							
<5 years	cases/controls	5/14	2/1	2/4	4/6	4/16	1/1
	OR (CI)	4.0 (1.3, 11.7)	16.8 (1.4, 196.0)	5.0 (0.9, 28.9)	7.6 (2.0, 28.5)	2.5 (0.8, 7.9)	
≥5 years	cases/controls	23/11	1/1	15/9	4/8	6/13	1/7
	OR (CI)	21.7 (9.7, 48.5)	10.2 (0.6, 171.2)	18.3 (7.4, 44.9)	6.1 (1.7, 21.4)	4.7 (1.7, 13.2)	
Direct infreq[4]							
<5 years	cases/controls	10/6	11/11	5/19	2/7	1/8	0/4
	OR (CI)	18.0 (6.1, 53.2)	12.1 (4.9, 30.0)	2.9 (1.0, 8.2)	3.0 (0.6, 15.1)	1.2 (0.1, 9.8)	
≥5 years	cases/controls	20/16	32/8	39/25	8/17	11/18	1/7
	OR (CI)	13.5 (6.4, 28.5)	49.6(21.1,116.4)	17.4 (9.5, 32.0)	5.5 (2.2, 13.6)	6.9 (3.0, 15.8)	
Direct freq[5]							
<5 years	cases/controls	26/13	12/4	6/7	4/7	2/1	1/1
	OR (CI)	22.3 (10.5, 47.4)	32.0 (9.7,105.5)	9.5 (3.0, 29.9)	6.4 (1.8, 23.0)	22.4 (1.9, 261.3)	
≥5 years	cases/controls	40/22	19/5	29/12	7/6	9/5	1/0
	OR (CI)	19.2 (10.2, 36.1)	38.4(13.5,109.6)	27.5 (12.9, 58.6)	11.0 (3.4, 34.9)	20.7 (6.5, 65.5)	

Ever worked in job category						
cases/controls	153/138	89/42	112/114	52/142	68/263	**38/413**
OR (CI)	11.9 (7.9, 18.0)	23.3 (14.1, 38.5)	10.8 (7.1, 16.5)	4.0 (2.5, 6.4)	2.8 (1.8, 4.3)	**1.0 (ref)**

[1] Projected lifetime risk to age 90 for all British men born 1943-47 = 0.59%. Projected risk in each subgroup = OR x 0.59%/5.0. The OR for all British men (5.0) = average of ORs from bottom row of table weighted by number of controls in each group.

[2] Type and duration of asbestos exposure may occur in any job category. Groups are mutually exclusive i.e. if several exposures occur, these are coded hierarchically,

[3] Work done by someone in the same area,

[4] Work done themselves less than once per week,

[5] Work done themselves > once per week

Table 3.2.7 Reported contact with AIB, lagging and/or sprayed coatings before age 30 by job category and job duration. Men may contribute information to several job and duration categories. For a given job category and duration, men are classified into direct contact, indirect contact only or none.

Table 3.2.7a Non-construction high risk jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	38.2	23.8	2.9	0.0	41.1	23.8	34	21
1-4 years	43.0	22.9	14.0	21.4	57.0	44.3	86	70
≥5 years	49.4	40.0	22.2	18.2	71.6	58.2	81	55
Total	**51.0**	**30.1**	**16.1**	**17.9**	**67.1**	**48.0**	**149**	**123**

Table 3.2.7b Carpentry jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	23.8	0.0	4.8	0.0	28.5	0.0	21	3
1-4 years	57.1	58.8	6.5	5.9	63.6	64.6	77	34
≥5 years	79.1	87.5	3.0	0.0	82.1	87.5	67	16
Total	**78.0**	**73.7**	**2.0**	**5.3**	**80.0**	**79.0**	**100**	**38**

Table 3.2.7c Plumber, electrician & painter jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	16.0	10.0	12.0	15.0	28.0	25.0	25	20
1-4 years	46.6	44.9	12.5	7.7	59.1	52.6	88	78
≥5 years	65.2	54.9	18.0	21.1	83.2	76.0	89	71
Total	**65.9**	**50.8**	**13.6**	**12.5**	**79.5**	**63.3**	**132**	**128**

Table 3.2.7d Other construction jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	18.2	8.6	0.0	2.9	18.2	11.5	22	35
1-4 years	35.8	22.9	13.4	13.3	49.2	36.2	67	105
≥5 years	40.0	36.2	14.3	8.6	54.3	44.8	35	58
Total	**35.1**	**25.8**	**12.4**	**10.4**	**47.5**	**36.2**	**97**	**163**

Table 3.2.7e Medium risk jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	2.8	8.9	11.1	1.8	13.9	10.7	36	56
1-4 years	12.5	6.9	9.2	4.8	21.7	11.7	152	292
≥5 years	33.3	16.2	9.3	6.6	42.6	22.8	75	197
Total	**20.5**	**12.2**	**8.3**	**6.2**	**28.8**	**18.4**	**205**	**418**

Table 3.2.7f Low risk industrial risk jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	0.0	2.4	4.0	2.4	4.0	4.8	50	82
1-4 years	1.2	2.7	5.8	2.7	7.0	5.2	174	409
≥5 years	11.3	4.0	2.8	5.6	14.1	9.6	71	251
Total	**4.0**	**3.6**	**6.1**	**4.2**	**10.1**	**7.8**	**228**	**553**

Table 3.2.7g Low risk jobs

Job duration	*% direct contact*		*% indirect contact only*		*% any contact*		*n*	
	cases	*controls*	*cases*	*controls*	*cases*	*controls*	*cases*	*controls*
<1 year	0.0	1.0	0.0	0.0	0.0	1.0	36	97
1-4 years	1.5	0.8	1.5	1.8	3.0	2.6	131	514
≥5 years	0.0	2.1	2.0	0.9	2.0	3.0	50	336
Total	**1.2**	**1.7**	**1.8**	**1.8**	**3.0**	**3.5**	**171**	**664**

Table 3.2.8 Type of reported direct (self) contact with AIB, lagging and/or sprayed coatings before age 30 by job category.

% reporting direct exposure	*Non-construction high risk jobs*		*Carpentry jobs*		*Plumber, electrician & painter jobs*	
	Cases	*Controls*	*Cases*	*Controls*	*Cases*	*Controls*
AIB						
Saw	8.7	7.3	68.0	68.4	20.5	12.5
Remove	12.8	7.3	23.0	23.7	12.9	9.4
Drill	9.4	6.5	64.0	52.6	22.7	18.0
Other	1.3	0.8	6.0	2.6	13.6	9.4
Any contact with AIB	**18.8**	**13.8**	**74.0**	**71.1**	**39.4**	**32.0**
Lagging						
Remove	30.9	13.8	9.0	10.5	27.3	16.4
Damage	19.5	10.6	5.0	5.3	33.3	19.5
Apply	20.1	5.7	4.0	7.8	9.9	9.4
Other	9.4	5.7	3.0	0.0	4.6	7.8
Any contact with lagging	**45.0**	**26.0**	**16.0**	**13.2**	**48.5**	**37.5**
Any contact with sprayed coatings	**9.4**	**4.9**	**4.0**	**2.6**	**9.1**	**2.3**
n	149	123	100	38	132	128

% reporting direct exposure	*Other construction jobs*		*Medium risk jobs*		*Low risk jobs*	
	Cases	*Controls*	*Cases*	*Controls*	*Cases*	*Controls*
AIB						
Saw	15.5	17.2	4.9	2.9	0.5	0.6
Remove	14.4	9.8	4.4	1.9	0.0	0.5
Drill	13.4	11.7	4.9	3.1	0.5	0.5
Other	3.1	1.8	1.5	1.7	0.3	0.4
Any contact with AIB	**24.7**	**22.7**	**8.8**	**6.7**	**0.8**	**1.2**
Lagging						
Remove	17.5	4.9	11.2	5.0	0.8	0.9
Damage	5.2	4.9	8.3	4.1	0.8	0.6
Apply	5.2	1.2	7.8	3.6	0.3	0.6
Other	1.0	0.0	2.4	0.0	1.0	0.4
Any contact with lagging	**23.7**	**8.6**	**17.1**	**8.1**	**2.3**	**1.6**
Any contact with sprayed coatings	**8.3**	**1.2**	**1.0**	**0.2**	**0.0**	**0.0**
n	97	163	205	418	399	1217

Figure 3.2.1 Proportion of all men reporting asbestos exposure by year started job

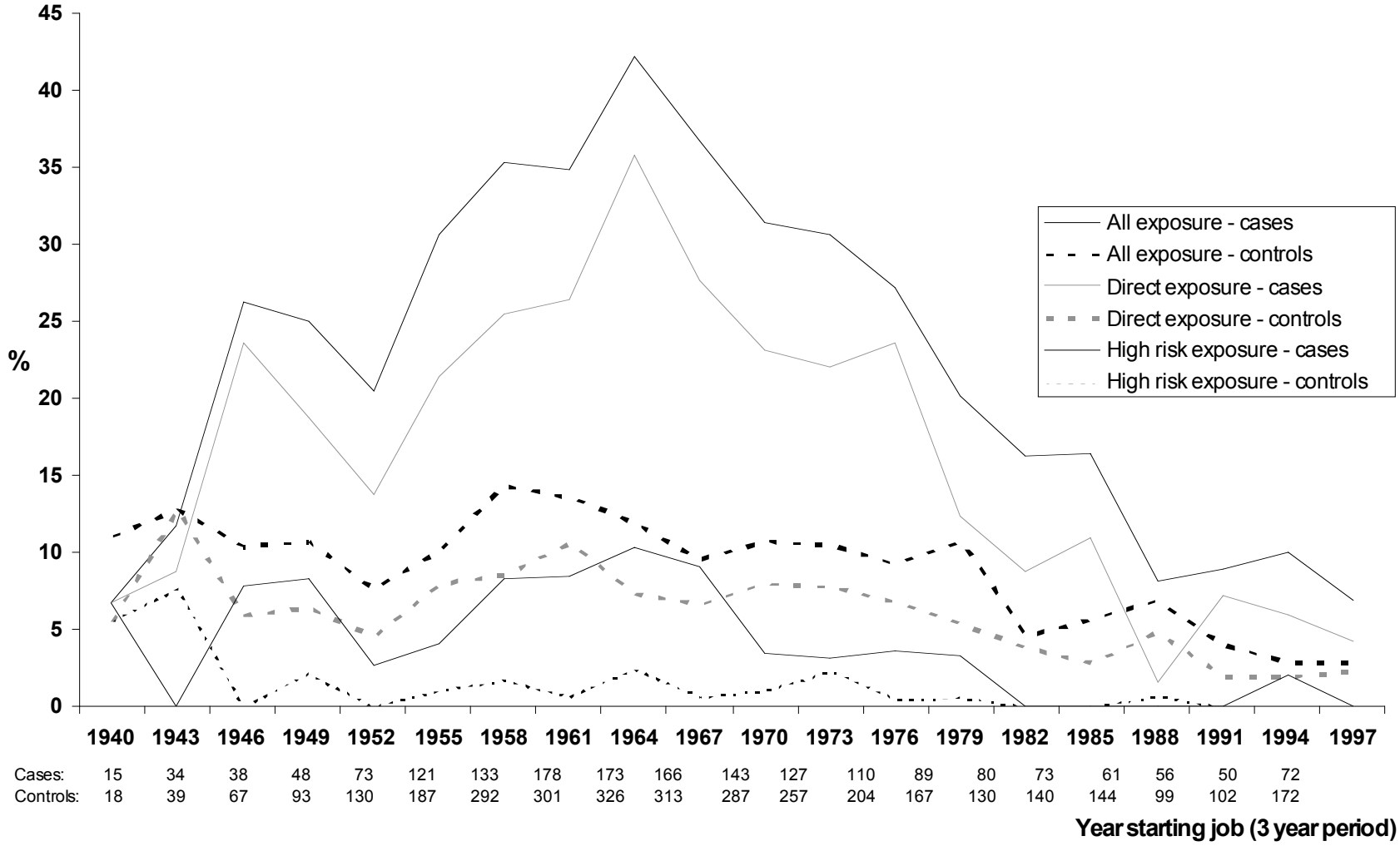

Table 3.2.9 Numbers of male mesothelioma cases and controls by last job before interview and year of birth

Job category and occupation	*Born 1925-1939*			*Born since 1940*			*All men*		
	Cases	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk									
Metal plate worker	3	2	4.2 (0.7, 27.1)	3	3	4.2 (0.8, 21.5)	6	5	4.1 (1.2, 14.1)
Asbestos product manufacturer	1	0	-	0	0	-	1	0	-
Laggers & electrical, energy, boiler attendants	1	0	-	3	1	12.1 (1.2, 119.2)	4	1	15.6(1.7 (142.8)
Docker, shipbuilding or working on board ship	7	3	5.2 (1.2, 21.7)	9	10	3.5 (1.4, 9.0)	16	13	4.1 (1.9, 8.8)
Navy	2	0	-	0	0	-	2	0	-
All non-construction high risk jobs	**14**	**5**	**7.3 (2.4, 21.8)**	**15**	**14**	**4.3 (2.0, 9.3)**	**29**	**19**	**5.2 (2.8, 9.6)**
Construction									
Carpenter	**16**	**6**	**7.2 (2.6, 19.9)**	**41**	**15**	**11.6 (6.1, 21.9)**	**57**	**21**	**10.5 (6.1, 18.1)**
Plumber	2	3	2.3 (0.4, 14.7)	17	15	4.8 (2.3, 10.1)	19	18	4.3 (2.2, 8.4)
Electrician	7	5	3.8 (1.1, 13.0)	16	18	3.8 (1.9, 7.7)	23	23	3.9 (2.1, 7.2)
Painters & decorators	3	2	4.1 (0.7, 26.4)	14	14	4.2 (1.9, 9.1)	17	16	4.3 (2.1, 8.7)
Plumbers, electricians & painters & decorators	**12**	**10**	**3.5 (1.4, 8.7)**	**47**	**47**	**4.2 (2.7, 6.8)**	**59**	**57**	**4.1 (2.7, 6.2)**
Other construction	**16**	**17**	**2.6 (1.2, 5.7)**	**38**	**56**	**2.9 (1.8, 4.6)**	**54**	**73**	**2.8 (1.9, 4.2)**
Medium risk industrial									
Metal working production & maintenance fitters	5	4	2.0 (0.5, 8.1)	9	14	2.6 (1.1, 6.2)	13	19	2.5 (1.2, 5.2)
Railway worker	1	2	2.0 (0.2,23.7)	0	4	-	1	6	0.7 (0.1, 5.6)
Chemist or industrial scientist	2	4	1.6 (0.3, 9.4)	2	7	1.2 (0.2, 5.9)	4	11	1.3 (0.4, 4.2)
Surveyor or inspector	5	8	1.5 (0.5, 5.1)	9	31	1.2 (0.6, 2.7)	14	39	1.3 (0.7, 2.6)
Metal machining & instrument makers nec.	3	0	-	3	13	0.9 (0.3, 3.4)	6	13	1.8 (0.7, 5.0)
Electrical & electronic trades nec.	3	12	0.7 (0.2, 2.6)	5	9	2.4 (0.8, 7.5)	8	21	1.3 (0.6, 3.0)
Welding, steel erecting & fixing	1	4	0.6 (0.1, 5.2)	4	6	2.7 (0.7,9.9)	5	10	1.7 (0.6, 5.2)
Metal working process operatives	0	4	-	0	12	-	0	16	-
Assemblers & routine process operatives	6	10	1.6 (0.6, 4.9)	3	15	0.9 (0.2, 3.1)	9	25	1.2 (0.6, 2.7)
Plant & machine operatives nec.	6	7	2.5 (0.8, 8.0)	3	13	1.0 (0.3, 3.5)	9	20	1.6 (0.7, 3.6)
All medium risk industrial jobs	**31**	**56**	**1.5 (0.8, 2.6)**	**38**	**124**	**1.3 (0.8, 2.0)**	**69**	**180**	**1.4 (1.0, 1.9)**
Low risk industrial									
Motor mechanic	4	1	10.8 (1.1, 101.2)	3	11		7	12	2.2 (0.9, 5.9)

Draughtsmen	2	4	1.1 (0.2, 6.3)	2	3		4	7	1.7 (0.5, 6.1)
Engineers & technologists nec.	5	5	2.5 (0.7, 9.3)	8	18		13	23	2.2 (1.1, 4.4)
Stores & warehousemen	1	4	0.7 (0.1, 6.6)	3	20		4	24	0.7 (0.2, 1.9)
Armed forces nec.	0	1	-	0	0		0	1	-
Drivers & road transport workers	10	17	1.4 (0.6, 3.4)	20	46		30	63	1.7 (1.1, 2.8)
Other industrial not elsewhere classified	19	34	1.6 (0.8, 3.1)	27	74	1.5 (0.9, 2.5)	46	108	1.6 (1.0, 2.3)
All low risk industrial jobs	**41**	**66**	**1.6 (1.0, 2.8)**	**63**	**172**	**1.5 (1.1, 2.2)**	**104**	**238**	**1.6 (1.2, 2.2)**
Other low risk jobs (reference group)	45	124	1.0	95	400	1.0	140	524	1.0

	Born 1925-1939			***Born since 1940***			***All men***		
Job category	***Cases***	***Controls***	***OR (95% CIs)***	***Cases***	***Controls***	***OR (95% CIs)***	***Cases***	***Controls***	***OR (95% CIs)***
All non-construction high risk jobs	14	5	7.3 (2.4, 21.8)	15	14	4.3 (2.0, 9.3)	29	19	5.2 (2.8, 9.6)
Carpenter	16	6	7.2 (2.6, 19.9)	41	15	11.6 (6.1, 21.9)	57	21	10.5 (6.1, 18.1)
Plumbers, electricians & painters & decorators	12	10	3.5 (1.4, 8.7)	47	47	4.2 (2.7, 6.8)	59	57	4.1 (2.7, 6.2)
Other construction	16	17	2.6 (1.2, 5.7)	38	56	2.9 (1.8, 4.6)	54	73	2.8 (1.9, 4.2)
All medium risk industrial jobs	31	56	1.5 (0.8, 2.6)	38	124	1.3 (0.8, 2.0)	69	180	1.4 (1.0, 1.9)
All low risk industrial jobs	41	66	1.6 (1.0, 2.8)	63	172	1.5 (1.1, 2.2)	104	238	1.6 (1.2, 2.2)
Other low risk jobs (reference group)	45	124	1.0	95	400	1.0	140	524	1.0

Table 3.2.10 Main occupation while aged under 30 by last job before interview - all men

	Last job before interview/retirement						
Main occupation aged under 30	***Non-construction high risk***	***Carpenter***	***Plumber, electrician & painter***	***Other construction***	***Medium risk***	***Low risk***	***Total (100%)***
Mesothelioma cases							
Non-construction high risk	**26 (17.5%)**	7 (4.7%)	5 (3.4%)	10 (6.7%)	16 (10.7%)	85 (57.1%)	149
Carpenter		**48 (55.8%)**	1 (1.2%)	16 (18.6%)	3 (3.5%)	18 (20.9%)	86
Plumber, electrician & painter	2 (1.8%)		**49 (45.0%)**	9 (8.3%)	9 (8.3%)	40 (36.7%)	109
Other construction		1 (2.0%)	1 (2.0%)	**13 (26.5%)**	7 (14.3%)	27 (55.1%)	49
Medium risk	1 (1.4%)	1 (1.4%)	3 (4.1%)	5 (6.9%)	**31 (42.5%)**	32 (43.8%)	73
Low risk				1 (2.2%)	3 (6.5%)	**42 (91.3%)**	46
Population controls							
Non-construction high risk	**16 (13.0%)**	2 (1.6%)	12 (9.8%)	10 (8.1%)	27 (22.0%)	56 (45.5%)	123
Carpenter		**11 (32.4%)**	1 (2.9%)	5 (14.7%)	5 (14.7%)	12 (35.3%)	34
Plumber, electrician & painter			**37 (35.9%)**	7 (6.8%)	18 (17.5%)	41 (39.8%)	103
Other construction		1 (0.8%)	1 (0.8%)	**33 (26.0%)**	20 (15.8%)	72 (56.7%)	127
Medium risk	1 (0.4%)	3 (1.1%)	5 (1.9%)	5 (1.9%)	**94 (35.7%)**	155 (58.9%)	263
Low risk	2 (0.4%)	4 (0.9%)	1 (0.2%)	13 (2.8%)	16 (3.5%)	**1426 (92.2%)**	462

3.3 LOW EXPOSURE ANALYSES

Potential workplace exposures

The 102 cases (31 male, 71 female) and 623 controls (387 male, 236 female) included in the low exposure analyses are shown in bold in Table 3.3.1. Subjects reporting any high risk, construction or medium risk job or any substantial asbestos exposure (AIB, lagging and sprayed coatings) are excluded. Other potential asbestos exposures at work included contact with brakes or gaskets while doing occupational vehicle maintenance, non-substantial exposure (handling gaskets, mats, other heat protective materials and engine parts in other workplaces), and working near construction activities or where asbestos was present. ORs within the low exposure group for these potential exposures are shown in table 3.3.2. ORs for work before age 30 in any low risk industrial job beginning before and after 1960 are also shown. There were no significant associations between mesothelioma risk and any of these exposures, although the OR was 2.9 (95%CI 0.9-9.0) for low risk industrial work before 1960.

Non-occupational exposures

The OR for any type of DIY activity (table 3.3.3) was 0.7 (95%CI 0.4-1.2), and no subgroup of DIY activity by frequency or possible asbestos exposure suggested any excess. ORs were statistically significantly elevated for living with a potentially exposed worker both before age 15 (OR 1.6, 95%CI 1.0-2.6) and before age 30 (OR 1.9, 95%CI 1.2-3.0) (table 3.3.4). Domestic exposure beginning after age 30 did not show an excess (OR 0.4, 95%CI 0.1-1.8), and there was no trend with duration of domestic exposure. Among men, exposures were from parents and siblings, whereas the main exposures in women came from their husbands. Residential exposures are shown in table 3.3.5. The OR for living within a mile of a potential source before age 30 (asbestos factory or disposal site, shipyard or power plant) was 0.6 (95%CI 0.2-2.0). No type of housing was significantly associated with risk (prefab, Council or former Council, high-rise, any asbestos in the building).

The OR for current smokers compared with non-smokers was 1.5 (95%CI=0.8-2.7) in this unexposed subgroup, and 1.2 (95%CI 0.9-1.6) overall (table 3.3.6).

Table 3.3.1 Low risk occupational groups and reported asbestos exposure at work

	Males		Females	
	cases	**controls**	**cases**	**controls**
High or medium risk jobs	474	699	37	71
Only low risk jobs				
Reported substantial asbestos exposure before age 30	5	20	1	1
Reported substantial asbestos exposure after age 30	2	6	1	0
Low exposure subgroup (no substantial exposure)	**31**	**387**	**71**	**236**
All subjects	**512**	**1112**	**100**	**308**

Table 3.3.2 Univariate analysis of other reported occupational asbestos exposures before age 30 among men and women in low risk jobs.

Exposure	*Males*			*Females*			*Both sexes*
	Cases	*Controls*	*OR (95% CI)*	*Cases*	*Controls*	*OR (95% CI)*	*OR (95% CI)*
Potential occupational exposure before age 30							
Non-substantial exposure at work*	3	39	1.1 (0.3, 3.9)	5	7	2.6 (0.8, 8.7)	1.6 (0.7, 3.6)
Contact with brakes, gaskets etc while doing occupational vehicle maintenance	2	54	0.4 (0.1, 1.7)	0	0	-	0.4 (0.1, 1.7)
Asbestos in place of work	6	102	0.6 (0.2, 1.6)	11	32	1.1 (0.5, 2.5)	0.8 (0.5, 1.5)
Construction work at place of work	8	94	1.2 (0.5, 2.9)	22	56	1.5 (0.8, 2.9)	1.4 (0.8, 2.3)
Working in or near a shipyard or construction site	1	12	0.9 (0.1, 7.4)	1	2	1.7 (0.1, 20.1)	1.3 (0.3, 6.1)
Industrial work before age 30							
None	16	219	1.0	60	171	1.0	1.0
Started before 1960	9	64	2.9 (0.9, 9.0)	5	35	0.5 (0.2, 1.3)	1.0 (0.5, 2.0)
Started after 1960	6	104	0.7 (0.3, 1.9)	6	30	0.4 (0.1, 1.1)	0.5 (0.2, 1.0)
All subjects	**31**	**387**		**71**	**236**		

**Handling gaskets, mats, other heat protective materials and engine parts, excluding vehicle maintenance*

Table 3.3.3 Univariate analysis of DIY exposures among men and women in low risk jobs.

Exposure	*Males*			*Females*			*Both sexes*
	Cases	*Controls*	*OR (95% CI)*	*Cases*	*Controls*	*OR (95% CI)*	*OR (95% CI)*
Any DIY	14	208	0.7 (0.3, 1.5)	5	24	0.6 (0.2, 1.6)	0.7 (0.4, 1.2)
All subjects	**31**	**387**		**71**	**236**		

Table 3.3.4 Univariate analysis of reported domestic exposures among men and women in low risk jobs.

Exposure	*Males*			*Females*			*Both sexes*
	Cases	*Controls*	*OR (95% CI)*	*Cases*	*Controls*	*OR (95% CI)*	*OR (95% CI)*
Domestic exposure							
Domestic exposure before age 15	10	77	2.0 (0.9, 4.5)	19	50	1.3 (0.7, 2.4)	1.6 (1.0, 2.6)
Domestic exposure before age 30	13	98	2.1 (1.0, 4.6)	37	86	1.9 (1.1, 3.3)	1.9 (1.2, 3.0)
Age first domestic exposure							
Never	18	274	1.0	32	134	1.0	1.0
<15 years	10	77	2.0 (0.9, 4.8)	19	50	1.5 (0.7, 2.9)	1.7 (1.0, 3.0)
15-29 years	3	21	1.9 (0.5, 7.7)	18	36	2.2 (1.1, 4.5)	2.0 (1.1, 3.8)
≥30 years	0	15	-	2	16	0.5 (0.1, 2.2)	0.4 (0.1, 1.8)
Total duration of domestic exposure							
Never	18	274	1.0	32	134	1.0	1.0
<5 years	4	40	1.6 (0.5, 5.2)	7	16	1.7 (0.6, 4.8)	1.7 (0.8, 3.5)
5-19 years	8	53	2.3 (0.9, 5.7)	16	43	1.5 (0.7, 3.0)	1.7 (1.0, 3.1)
≥20 years	1	20	0.8 (0.1, 6.7)	15	43	1.5 (0.7, 3.1)	1.4 (0.7, 2.7)
Domestic exposure: type of relative							
Parent	8	64	1.8 (0.7, 4.4)	19	42	1.5 (0.8, 2.9)	1.6 (1.0, 2.8)
Spouse	0	1	-	21	45	1.8 (1.0, 3.4)	1.6 (0.9, 3.0)
Sibling	5	34	2.0 (0.7, 5.9)	8	24	1.0 (0.4, 2.4)	1.3 (0.6, 2.6)
Other	0	14	-	3	5	2.0 (0.4, 9.4)	0.9 (0.2, 3.4)
Son	0	12	-	4	17	0.8 (0.2, 2.5)	0.7 (0.2, 2.0)
Summary variables							
Any domestic exposure before age 15	10	77	2.0 (0.9, 4.5)	19	50	1.4 (0.7, 2.7)	1.7 (1.0, 2.8)
Exposure from spouse before age 30	0	0	-	11	26	1.7 (0.8, 3.8)	1.6 (0.7, 3.6)
Exposure from spouse after age 30	0	1	-	2	9	0.8 (0.2, 4.1)	0.8 (0.2, 3.8)
None of the above	21	309	1.0 (ref)	39	151	1.0 (ref)	1.0 (ref)
All subjects	**31**	**387**		**71**	**236**		

Table 3.3.5 Univariate analysis of residential exposures among men and women in low risk jobs.

Exposure	*Males*			*Females*			*Both sexes*
	Cases	*Controls*	*OR (95% CI)*	*Cases*	*Controls*	*OR (95% CI)*	*OR (95% CI)*
Lived within 1 mile of the following before age 30							
Construction material site	0	6	-	3	7	1.6 (0.4, 6.6)	1.0 (0.3, 3.8)
Cement plant	0	6	-	0	3	-	-
Asbestos plant or disposal site	0	5	-	0	0	-	-
Foundry	2	17	1.3 (0.3, 6.1)	3	12	0.8 (0.2, 3.2)	0.9 (0.3, 2.6)
Ship building or repair	1	8	1.7 (0.2, 15.9)	1	7	0.4 (0.0, 3.7)	0.8 (0.2, 2.6)
Power plant	0	10	-	2	6	1.1 (0.2, 5.9)	0.7 (0.2, 3.3)
Petrochemical/large chemical plant	1	11	1.0 (0.1, 8.8)	3	9	1.3 (0.3, 5.2)	1.1 (0.4, 3.5)
Lived within 1 mile of an asbestos factory, shipyard or power plant	1	20	0.7 (0.1, 5.5)	2	12	0.5 (0.1, 2.4)	0.6 (0.2, 2.0)
Residential exposure before age 30							
Any asbestos in property	13	170	1.0 (0.4, 2.1)	31	95	1.1 (0.6, 1.9)	1.0 (0.7, 1.6)
Council or ex-council houses	8	141	0.6 (0.3, 1.5)	30	100	1.0 (0.5, 1.7)	0.8 (0.5, 1.3)
Prefab houses	1	16	0.9 (0.1, 7.6)	3	8	1.6 (0.4, 6.6)	1.2 (0.4, 3.7)
High-rise flats	2	11	2.8 (0.5, 14.4)	2	4	1.2 (0.2, 7.1)	1.9 (0.6, 6.4)
Duration in high-rise flats before age 30							
None or <1 year	29	375	1.0	69	232	1.0	1.0
1-4 years	1	9	1.9 (0.2, 17.4)	2	3	1.7 (0.3, 11.4)	1.6 (0.4, 6.6)
≥5 years	1	2	5.1 (0.4, 64.7)	0	1	-	3.1 (0.3, 33.7)
All subjects	**31**	**386**		**71**	**236**		

Table 3.3.6 Univariate analysis of smoking among men and women in low risk jobs and in all subjects.

Exposure	*Males in low risk jobs*			*Females in low risk jobs*		
	Cases	*Controls*	*OR[1] (95% CI)*	*Cases*	*Controls*	*OR[1] (95% CI)*
Smoking						
Non-smokers	12	147	1.0	34	137	1.0
Ex-smokers[4]	12	166	0.8 (0.3, 2.0)	24	65	1.5 (0.8, 2.7)
Current smokers	7	74	1.0 (0.4, 2.9)	13	34	1.7 (0.8, 3.6)
Current smokers: average daily amount						
< 10 cigs	1	19	0.6 (0.1, 5.3)	2	9	0.9 (0.2, 4.6)
10-19 cigs	4	38	1.1 (0.3, 3.9)	8	19	1.8 (0.7, 4.6)
20-29 cigs	1	12	0.9 (0.1, 7.7)	3	6	2.6 (0.6, 11.8)
30+ cigs	1	5	3.0 (0.3, 31.7)	0	0	
Total	**31**	**387**		**71**	**236**	

Exposure	*Subjects in low risk jobs only*			*All subjects*		
	Cases	*Controls*	*OR[2] (95% CI)*	*Cases*	*Controls*	*OR[3] (95% CI)*
Smoking						
Non-smokers	46	284	1.0	204	532	1.0
Ex-smokers[4]	36	231	1.3 (0.8, 2.1)	275	595	1.1 (0.9, 1.4)
Current smokers	20	108	1.5 (0.8, 2.7)	143	293	1.2 (0.9, 1.6)
Current smokers: average daily amount						
< 10 cigs	3	28	0.8 (0.2, 2.9)	33	58	1.7 (1.0, 2.9)
10-19 cigs	12	57	1.6 (0.8, 3.4)	72	154	1.2 (0.8, 1.7)
20-29 cigs	4	18	1.7 (0.5, 5.5)	33	63	1.1 (0.7, 1.8)
30+ cigs	1	5	3.5 (0.4,33.0)	5	18	0.8 (0.3, 2.3)
Total	**102**	**623**		**622**	**1420**	

[1] *Adjusted for year of birth, SES and duration in low risk industrial jobs before age 30*
[2] *Adjusted for year of birth, SES, sex and duration in low risk industrial jobs before age 30*
[3] *Adjusted for year of birth, SES, sex and duration in 6 occupational groups before age 30*
[4] *At diagnosis for mesothelioma cases and at 1 year prior to interview for population controls*

3.4 SUMMARY ANALYSES OF ALL SUBJECTS

Domestic exposure

Analyses of the effect of domestic exposure for all subjects are shown in table 3.4.1. These analyses were adjusted for main job category and duration within that job category before age 30. A number of significant associations were seen in females: ORs were significantly elevated for those with domestic exposure before age 30 (OR 2.3, 95% CI 1.5, 3.8), those with 20 or more years of domestic exposure before age 30 (OR 2.6, 95% CI 1.4, 4.7), and those exposed via their spouse (rather than other relatives) (OR 2.2, 95% CI 1.3, 3.8). No increased risks were seen in males for domestic exposures. However, some of the combined results for males and females were statistically significant or of borderline significance: a combined OR of 1.2 (95%CI 0.9-1.6) was seen for living with a high risk parent or sibling and an estimate of 2.1 (1.3-3.5) for living with a high risk spouse. The latter was based largely on women, as only 2 male cases and 1 male control reported living with a high-risk spouse. Twenty percent of controls reported living with a high risk parent and 12% with a high risk sibling, and 20% of female controls had lived with a high-risk spouse. Subjects were not explicitly asked about family members suffering from mesothelioma, but 3 male and 4 female cases mentioned a first-degree relative with mesothelioma during the interview.

Attributable fractions for all exposures

All men and women were classified into eight non-overlapping exposure categories in the analysis in table 3.4.2. Five of the 110 female cases reported high risk work (OR 4.8, 95%CI 1.3-17.7). A further 32 female cases had done medium risk industrial work (OR 2.4, 95%CI 1.3-4.3), the majority (88%) as assemblers or routine process operatives. The risk was also increased in those who worked only in low-risk jobs but reported substantial asbestos exposure (7 male and 2 female cases: combined OR 3.8, 95%CI 1.7-8.8). The ORs for domestic exposure before age 30 in table 3.4.2 (2.1 for men, 1.9 for women; combined OR estimate 2.0, 95%CI 1.3-3.2) are based on subjects with no occupational exposure.

Table 3.4.2 shows the number of cases in each exposure category attributable to that exposure, ranging from 97% (86.4/89) among male carpenters to 59% (24.3/50) in men and women who lived with an exposed worker before age 30. Subjects are shown in the row corresponding to their highest exposure, so the groups are mutually exclusive. The reference group for this analysis comprises the 52 cases (18 men, 34 women) and 439 controls (289 men, 150 women) with none of these exposures. 85% (435.6/512) of male and 22% (24.5/110) of female cases are attributed to occupational exposure, and a further 1.3% (6.8/512) of male and 16% (17.5/110) of female cases had no occupational exposure but were attributed to living with a high-risk worker. The total number of unattributed cases is 69.6 (14% of all cases) in men and 68.0 (62% of all cases) in women.

Table 3.4.3 shows the same analysis for men who were born in 1950 or later and began work in 1970 or later, all of whom were diagnosed at age 55 or younger (30 cases, 83 controls). One third (10/30) of these mesothelioma cases were carpenters compared to 1/83 of the controls (OR=177, 95% CI: 13-2391). The number of unattributed cases is 7.9 (26%).

Table 3.4.1 Univariate analysis of reported domestic exposures among all subjects. All analyses are adjusted for duration and main job category before age 30

Exposure	*Males*			*Females*			*Both sexes*
	Cases	*Controls*	*OR (95% CI)*	*Cases*	*Controls*	*OR (95% CI)*	*OR (95% CI)*
Domestic exposure							
Domestic exposure before age 15 by main job category							
High risk	124	106	0.9 (0.6, 1.2)	2	3	-	0.9 (0.6, 1.2)
Other construction	18	32	1.8 (0.8, 4.0)	0	1	-	1.8 (0.8, 4.0)
Medium risk	17	64	1.1 (0.6, 2.2)	13	17	3.1 (1.0, 9.5)	1.3 (0.7, 2.1)
Low risk	11	83	1.5 (0.7, 3.2)	19	50	1.3 (0.7, 2.6)	1.4 (0.9, 2.4)
All subjects	170	285	1.1 (0.9, 1.5)	34	71	1.5 (0.9, 2.6)	1.2 (0.9, 1.5)
Domestic exposure before age 30 by main job category							
High risk	151	130	0.9 (0.6, 1.3)	4	5	-	0.9 (0.6, 1.2)
Other construction	21	41	1.7 (0.8, 3.6)	0	1	-	1.7 (0.8, 3.6)
Medium risk	22	79	1.1 (0.6, 2.0))	22	26	5.0 (1.6, 15.5)	1.5 (0.9, 2.5)
Low risk	14	104	1.6 (0.8, 3.3)	38	87	2.2 (1.2, 3.8)	1.8 (1.2, 2.8)
All subjects	208	354	1.1 (0.9, 1.4)	64	119	2.3 (1.5, 3.8)	1.3 (1.0, 1.6)
Age first domestic exposure							
Never	269	712	1.0	40	165	1.0	1.0
<15 years	170	285	1.2 (0.9, 1.5)	34	71	2.0 (1.1, 3.6)	1.3 (0.9, 1.8)
15-29 years	38	69	1.1 (0.7, 1.7)	30	48	2.7 (1.5, 5.1)	1.5 (1.0, 2.1)
≥30 years	35	46	1.5 (0.9, 2.6)	6	24	1.0 (0.3, 2.7)	1.4 (0.9, 2.2)
Total duration of domestic exposure							
Never	269	712	1.0	40	165	1.0	1.0
<5 years	51	115	1.1 (0.7, 1.7)	11	24	2.1 (0.9, 4.9)	1.3 (0.9, 1.8)
5-19 years	116	190	1.2 (0.9, 1.6)	26	65	1.6 (0.9, 3.0)	1.2 (0.9, 1.6)
≥20 years	76	95	1.2 (0.8, 1.8)	32	54	2.6 (1.4, 4.7)	1.5 (1.1, 2.1)
Type of relative exposure (ever) was from							
Parent	135	228	1.1 (0.8, 1.4)	32	60	1.6 (0.9, 2.8)	1.2 (0.9, 1.5)
Spouse	2	1	4.7 (0.3, 78.2)	40	61	2.2 (1.3, 3.8)	2.1 (1.3, 3.5)
Sibling	89	130	1.2 (0.9, 1.7)	13	34	1.2 (0.6, 2.6)	1.2 (0.9, 1.6)
Other	20	47	0.8 (0.4, 1.5)	5	6	2.8 (0.7, 10.4)	1.0 (0.6, 1.7)
Son	47	49	1.5 (0.9, 2.4)	7	30	0.5 (0.2, 1.3)	1.1 (0.8, 1.7)

Summary variable							
Any domestic exposure before age 15	170	285	1.1 (0.9, 1.5)	34	71	1.9 (1.1, 3.3)	1.2 (1.0, 1.5)
Exposure from spouse before age 30	0	0	-	24	34	2.9 (1.5, 5.7)	2.3 (1.2, 4.2)
Exposure from spouse after age 30	0	1	-	2	12	0.5 (0.1, 2.6)	0.5 (0.1, 2.3)
None of the above	342	826	1.0	50	191	1.0	1.0
Total	**512**	**1112**		**110**	**308**		

Table 3.4.2 Mesothelioma cases in men and women attributed to asbestos exposure in each exposure category. Subjects in each row are excluded in subsequent rows.

Highest exposure category	***Males***					***Females***					***All subjects***
	Cases			***Controls***	***OR (95% CI)***	***Cases***			***Controls***	***OR (95% CI)***	***OR (95% CI)***
	Attributed to this exposure					***Attributed to this exposure***					
	Yes	***No[1]***	***Total***			***Yes***	***No[1]***	***Total***			
Occupational exposure											
Non-construction high risk	144.3	8.7	153	138	17.5 (10.3,29.8)	4.0	1.0	5	5	4.8 (1.3, 17.7)	13.7 (9.1, 20.7)
Carpenters	86.4	2.6	89	42	34.2 (18.7,62.6)	-	-	0	0	-	27.4 (16.6, 45.4)
Plumbers, electricians & painters	105.0	7.0	112	114	15.9 (9.2, 27.3)	-	-	0	2	-	12.4 (8.1, 19.0)
Other construction	43.2	8.8	52	142	5.9 (3.3, 10.5)	-	-	0	1	-	4.7 (2.9, 7.4)
Medium risk industrial	51.4	16.6	68	263	4.1 (2.4, 7.2)	18.7	13.3	32	63	2.4 (1.3, 4.3)	3.1 (2.1, 4.6)
Other substantial exposure	5.3	1.7	7	26	4.2 (1.6, 10.9)	1.8	0.2	2	1	9.6(0.8,112.3)	3.8 (1.7, 8.8)
Non-occupational exposure											
Domestic exposure < age 30	6.8	6.2	13	98	2.1 (1.0, 4.5)	17.5	19.5	37	86	1.9 (1.1, 3.2)	2.0 (1.3, 3.2)
None of the above (ref)	**-**	**18.0**	**18**	**289**	**1.0**	**-**	**34.0**	34	**150**	**1.0**	**1.0**
TOTAL	**442.4**	**69.6**	**512**	**1112**	**7.4[2]**	**42.0**	**68.0**	**110**	**308**	**1.6[2]**	

[1] *Number not attributed to exposure = total cases / OR*
[2] *Average of ORs weighted by number of controls in each row*

Table 3.4.3 Male cases and controls born in 1950 or later who began work in 1970 or later, and numbers of cases attributed to asbestos exposure in each exposure category. Subjects in each row are excluded in subsequent rows.

Highest exposure category	*Males born 1950 or later who started work in 1970 or later*				
	Cases			*Controls*	*OR (95% CI)*
	Attributed to this exposure				
	Yes	*No*[1]	*Total*		
Occupational exposure					
Non-construction high risk	3.8	0.2	4	2	16.3 (1.8, 150.3)
Carpenters	9.9	0.1	10	1	177.3 (13.1, 2391.3)
Plumbers, electricians & painters	1.3	0.7	2	9	2.7 (0.3, 25.3)
Other construction	5.2	0.8	6	11	7.8 (1.4, 43.1)
Medium risk industrial	1.9	2.1	4	17	1.9 (0.4, 10.2)
Other substantial exposure			-	-	
Non-occupational exposure					
Domestic exposure < age 30	0.0	1.0	1	15	1.0 (0.8, 11.9)
None of the above (ref)	**0.0**	**3.0**	**3**	**28**	**1.0**
TOTAL	**22.1**	**7.9**	**30**	**83**	

[1] *Number not attributed to exposure = total cases / OR*
[2] *Average of ORs weighted by number of controls in each row*

4. DISCUSSION

4.1 OCCUPATIONAL EXPOSURE

Occupational PMRs for mesothelioma based on last full-time occupation as recorded on death certificates provide the only detailed data on mesothelioma risks in Britain(McElvenny et al., 2005). The risk depends mainly on asbestos exposure below age 30 however (tables 3.2.3 and 3.2.4), and our study provides the first overview of the distribution of risk in the British population, the extraordinary risks suffered by men who did the most dangerous jobs when they were young, and the contribution of environmental exposure, particularly to the families of exposed workers. Recall bias was minimised by structured questions about specific exposures, and our main analyses were based on job title, which should be less liable to differential response by cases than reported asbestos exposure. The value of lifetime job histories is illustrated by the data in table 3.2.2 on men who had worked for at least 5 years in low risk industrial occupations. Their OR fell from 4.1 (95%CI: 2.6-6.4) to only 1.1 (95% CI: 0.5-2.2) when those who had also done more hazardous work were excluded. Among motor mechanics, for example, only 2 of 18 cases compared with 23 of 54 controls had never worked in other more hazardous occupations.

Ninety four percent (481/512) of male mesotheliomas and 65% (725/1112) of male controls had worked in a hazardous occupation, implying an attributable fraction of 85% (table 3.4.2). The predicted lifetime mesothelioma risk for British men born in the 1940s who did more than 10 years of relevant work before age 30 is 5.9% for carpenters, 2.0% for plumbers, electricians and painters, and 0.8% for other construction workers (table 3.2.6). The lifetime risk is 1.8% for all high risk non-construction occupations, but this is a broad category that includes dockyard workers, cabin staff on cruise liners and marine engineers. This is the largest published study of mesothelioma risk in relation to lifetime occupational history, but much larger numbers would be needed to provide reliable estimates for individual occupations.

Men who had worked in carpentry accounted for 21% of all male mesotheliomas and 4% of controls (table 3.2.3: 49/1112 controls, 105/512 cases), and 33% (table 3.4.3: 10/30) of mesotheliomas in men born since 1950 who started work in 1970 or later. The predicted eventual total of 90,000 mesothelioma deaths in both sexes in Britain by 2050 (Hodgson et al., 2005) will thus include about 15,000 former carpenters. The excess lung cancer risk in heavily exposed workers is likely to be of the same order as the mesothelioma risk (Darnton et al., 2006), so more than one in ten of all British carpenters born in the 1940s may die of a cancer caused by asbestos. A substantial proportion of these deaths will be among those who installed AIB as fireproofing required under building regulations(HMSO, 1965) and these will far exceed any possible benefit to the public. Stringent working practices must now be maintained to ensure that the lower but potentially substantial risk to those now removing these same materials will not outweigh the reduction in risk to occupants and maintenance workers from asbestos in buildings.

The ORs within each occupational exposure category were lower but still substantially increased even in men who recalled no substantial asbestos exposure, suggesting that many were exposed indirectly or could not identify the asbestos materials they handled. Most people report their own and their parents' occupations correctly many years later(Berney & Blane, 1997), but recall of past asbestos exposure shows poor reproducibility at re-interview(Holmes & Garshick, 1991). A recent study of plumbers showed that many do not recognise the friable asbestos materials that they still

sometimes encounter(Bard & Burdett, 2006). The increased risk for medium risk industrial work reflects widespread and often unrecognised contact with asbestos in metal working, electrical trades and assembly line work. A large proportion of the British population worked in these sectors (24% of male and 20% of female controls). There were too few occupationally exposed female mesotheliomas to estimate risks reliably, but table 3.4.2 suggests that workplace exposure caused about 22% (24.5/110) of all female cases. The occupational hazard in women was concentrated in medium risk industrial settings, particularly assembly line work.

4.2 LOW-RISK OCCUPATIONS

The preliminary analyses in table 3.2.2 confirmed the validity of the medium and low risk industrial job categories. The risk for those who had worked in the low risk industrial group was not elevated once those who had also worked in medium and higher risk jobs were excluded (OR 1.1 in men, 0.5 in women), and the only evidence of an occupational risk outside high or medium risk and construction job categories was the 7 men and 2 women who reported substantial personal or bystander asbestos exposure in other occupations (table 3.4.2: combined OR 3.8, 95%CI 1.7-8.8). There was little or no evidence of increased risk in non-industrial workplaces such as schools or hospitals after excluding those who also worked in higher risk jobs (appendix table 3.2.2f). The raised OR for female kitchen workers (OR 23.7 based on 6 cases and 1 control; 95%CI 1.3-432.2) seems likely to be a chance finding. These cases did not report asbestos exposure, and no risk was seen in male kitchen workers (no cases and 9 controls).

4.3 NON-OCCUPATIONAL EXPOSURE

The only substantial risk factor in those with no direct occupational exposure was living with a high-risk worker before age 30, which approximately doubled the risk in both sexes (combined OR 1.9, 95%CI 1.2-3.0). The excess risk, which was confined to those who lived with an exposed worker before age 30, corresponds to an increase in lifetime risk of about 1 per 1,000. The risk due to such domestic exposure has been recognised for many years(Bourdes et al., 2000; Joubert et al., 1991; Magnani et al., 2001; Newhouse & Thompson, 1965; Vianna & Polan, 1978). There was no overall risk in men and women who reported living within a mile of a potential environmental hazard (asbestos factory or disposal site, shipyard or power plant) before age 30, although the risk was non-significantly increased in those who lived near one of these potential sources for 20 or more years (OR 3.3, 95% CI 0.7-14.8, based on 3 cases and 6 controls). We had no means of identifying sites that produced substantial local exposure. There was certainly some hazard to residents around a few factories in the past(Magnani et al., 2001; Newhouse & Thompson, 1965), but no risk was seen around others(Hammond et al., 1979a), and many apparently environmental cases are related to occupational exposures(Arblaster et al., 1995). There was no significant difference between current smokers and lifelong non-smokers either in this apparently unexposed subgroup (OR 1.5, 95%CI 0.8-2.7) or overall (OR 1.2, 95%CI 0.9, 1.6).

4.4 BACKGROUND INCIDENCE RATE

The unattributed cases in each row of table 3.4.2 are presumably due to ambient or unreported asbestos exposure or to other or natural causes. This unexplained lifetime risk is similar for non-industrial (including retail, office, educational, health care and agricultural) and low-risk industrial work, and corresponds to a predicted lifetime risk of 0.08% in men. The analysis of attributable risk in table 3.4.2 indicates that these background cases accounted for 69.6 (14%) of the 512 male and 68.0 (62%) of the 110 female mesothelioma cases. The same analysis restricted to subjects born in

1940-49 also gave similar male and female estimates for the number of unattributed cases (31.9/274 in men and 36.7/51 in women). Table 3.2.1 shows that the male:female ratio of interviewed cases born 1940-49 (5.4:1) was close to that of all British mesothelioma deaths in 2000-2004 among those born 1940-49 (5.7:1). The annual number of unexplained mesotheliomas is thus similar in men and women, and corresponds to a lifetime risk of the order of 1 per 1,000 among Britons of both sexes born in the 1940s.

This unexplained rate accounts for almost two-thirds of our female cases, so the threefold increase since 1970 in the overall British female death-rate below age 65 implies at least a doubling in this 'background' female rate. Most of this increase has occurred in the last 10 years, so it seems likely to be due to an increase in ambient asbestos exposure that coincided with the widespread occupational exposures of the 1960s and 1970s rather than to an increase in diagnostic awareness. The inference that the majority of female cases in the UK are due to asbestos exposure is also suggested by the much lower rates seen in both sexes in the US than in the UK (Rake et al., in press 2009). These observations suggest that at most a third,of all mesotheliomas currently occurring in British women are genuinely 'spontaneous' cases unrelated to asbestos exposure, far lower than the 62% that are unexplained in our study. This implies that of the order of 100 female cases per year, and a similar number in men, are caused either by environmental asbestos exposure, or by unsuspected occasional or ambient exposure in occupational settings that we have classified as "low risk". Our use of broad job categories as a proxy for asbestos exposure implies averaging a spectrum of risks within each category, but the similarity of the overall background rate in men and women, and in 'low-risk' industrial and non-industrial workers, suggests that few of these cases were due to unreported occupational exposure.

4.5 LATENCY, PERIOD OF EXPOSURE AND FUTURE TRENDS

The upper part of table 3.2.4 shows that high or medium risk exposure beginning after age 30 did not cause a statistically detectable increase in risk (OR 1.7, 95%CI 0.7-3.9). Among men already exposed for 10 or more years before age 30, however, a further 10 or more years of exposure after age 30 increased the OR from 6.8 to 13.1 for all high-risk work. The estimated factor is 2.1 (95%CI 1.1-4.0) in an analysis restricted to these two subgroups, suggesting that the mesothelioma risk caused by asbestos exposure before age 30 is approximately doubled by a similar exposure after age 30. These analyses are however confounded by the limited recruitment period, as age at diagnosis and year of birth are almost completely correlated. There was no effect of exposure beginning after age 30 in men born since 1940 (appendix table 3.2.4a: OR 1.1, 95%CI 0.3-3.7), but the risk was almost statistically significant in those born in 1925-39 (appendix table 3.2.4b: OR 3.0, 95%CI 0.9-10.3). However, men born in 1940-55 were 35 in 1975-90, when asbestos use was decreasing and less than 30 years before diagnosis. Exposure at age 35 in those born in 1925-39 occurred in 1960-1974, when asbestos was widely used and up to 45 years before diagnosis.

If this apparently synergistic interaction between early and later exposure is real, the conventional additive model proposed almost 30 years ago(Peto, 1978) on which most risk assessments(HEI, 1991) and recent predictions of future mesothelioma incidence(Hodgson et al., 2005) were based should be modified. Under this additive model most cases are caused by exposure at younger ages, and the additional effect of later exposure is much less. Lifetime risk estimates are based on the prediction that 0.59% of men born around 1945 will die of mesothelioma, which was derived by fitting an additive model of asbestos carcinogenesis (Hodgson et al., 2005). The death-rate in men born around 1945 is higher up to age 55 than in any earlier or later birth cohort, but few had substantial asbestos exposure after age 35, and we still do not know how rapidly their mortality will

increase at older ages. The suggestion that many apparently unexposed cases are due to an increase in ambient asbestos exposure in the 1960s and 1970s is also relevant to future projections. If those born after 1980 are at much lower risk from ambient as well as domestic exposure than those born before 1960 the national rate below age 40 may fall substantially by 2020 in both sexes. The future burden of mesothelioma is thus still uncertain.

4.6 RISKS TO CARPENTERS IN THE UK AND ELSEWHERE

The risk to carpenters is particularly high in Britain, and also in Australia (Yeung et al., 1999). Other mesothelioma case-control studies (Agudo et al., 2000; Iwatsubo et al., 1998; Muscat & Wynder, 1991; Rodelsperger et al., 2001; Teschke et al., 1997) have not highlighted carpenters as being at particularly high risk. A study in British Columbia(Teschke et al., 1997) found inflated odds ratios for plumbers (OR=8.3, 95%CI 1.5-86.3), painters (OR=4.5, 95%CI=1.0, 23.7) and electricians (OR=3.0, 95%CI=0.8, 11.6) as well as sheet metal workers and shipyard workers, though numbers were small. A German study(Rodelsperger et al., 2001) found significantly raised odds ratios for electricians (OR=3.0) and "mechanicians, fitters and plumbers" (OR=2.8) as well as "metal production & process workers" (OR=2.1) and "stationary engine & heavy equipment operators" (OR=3.4). A population-based case-control study has recently been conducted in France. Preliminary results report increased risks of mesothelioma in plumbers, pipe-fitters, sheet metal workers and boilermakers, but no mention is made of an increased risk in carpenters(Goldberg et al., 2006). A large non-interview case-control study in California obtained limited information on main occupation for over 2,000 mesothelioma cases and pancreatic cancer controls. The highest risk was in shipyard and construction industries, and increased odds ratios were seen for plumbers (OR=4.9, 95%CI=2.8-8.3), electricians (OR=3.8, 95% CI=2.0, 7.1) and painters (OR=2.6, 95% CI=1.3-5.3) but not for carpenters (OR=1.2, 95% CI=0.8-2.0)(Pan et al., 2005). Two large cohorts of carpenters belonging to unions in the United States followed their members for cancer incidence(Dement et al., 2003) and mortality(Robinson et al., 1996). Death certificates for over 27,000 members of the US Carpenter's Union who died in 1987-1990 were analysed. The PMR for cancer of the pleura (ICD 163) was 301 (95%CI=198-437) based on 27 deaths. A further 94 mesothelioma cases were found after manual review of death certificates(Robinson et al., 1996). In a cohort of over 13,000 currently employed union carpenters in New Jersey who were followed for cancer incidence between 1979-2000 the SIR for cancer of other parts of the respiratory system (ICD 163-165) was 420 (95%CI 240-690) based on 15 cases(Dement et al., 2003).

4.7 CONTRIBUTION OF AMOSITE TO UK MESOTHELIOMA INCIDENCE

Only 4 male mesotheliomas (<1%) reported working for more than 5 years in asbestos product manufacturing, so we could not distinguish the effects of different types of asbestos in this study, but it seems likely that a major cause of the extraordinary risk to British carpenters was cutting amosite board with power tools, which was widespread in the UK construction industry through the 1970s and continued into the 1980s. By 1960 the UK was importing 38% of total world amosite production, and extensive use of amosite AIB continued through the 1970s. The UK imported 24,000 tons of amosite in 1960, almost 40% of total world production, and extensive use continued until the mid 1970s. Cutting amosite AIB with power tools typically produced dust levels exceeding 20 f/ml(MRC, 1997), ten-fold higher than the control limit of 2 f/ml in manufacturing. In the UK up to 80% of amosite was used in AIB, which was used extensively by carpenters and was installed in over 20% of the ceiling area of new public buildings from 1967-1973(MRC, 1997). The mesothelioma risk caused by amosite is two orders of magnitude greater than for chrysotile (white asbestos)(Hodgson & Darnton, 2000), and 9 of 10 lung samples from carpenters who began work in

the 1960s and died of mesothelioma contained more than 1 amosite fibre per µg. Five contained some crocidolite (blue asbestos), but only one exceeded 1 f/µg(McDonald et al., 2001b), and crocidolite was not used in Britain after 1970.

A comparison of current mesothelioma death rates and imports to the US (Virta, 2006) and UK (MRC, 1997) of white, brown and blue (crocidolite) asbestos also suggests that the much higher mesothelioma death-rate in the UK was caused by its much greater use of amosite, which constituted 14% of all asbestos imports into the UK in 1960, compared with only 3% in the US(MRC, 1997; Selikoff et al., 1972). The mesothelioma death-rate in men aged 45-49 is now more than three times higher in the UK than in the US (US: 0.26 per 100,000 in 2000-2004, based on 139 deaths; UK: 0.87 per 100,000 in 2001-2004, based on 66 deaths). These men were born between 1950 and 1959, and few would have had much asbestos exposure before 1970. The UK used slightly less chrysotile during the 1970s (2.4 kg per head in 1970, 1.7 in 1980) than the US (3.1 kg per head in 1970, 1.5 in 1980), and the UK had virtually ceased using crocidolite by 1970, while US crocidolite imports increased from 8,900 tonnes in 1970 to a peak of 16,900 tonnes (0.08 kg per head) in 1978 and remained above 5,000 tonnes per year until 1984. However, the UK imported far more amosite per head than the US in the 1970s. UK amosite imports were 21,600 tonnes (0.4 kg per head) in 1970 and did not decline until after 1976, while US amosite imports fell from 12,900 tonnes (0.07 kg per head) in 1970 to 1,400 tonnes in 1976 (Virta, 2006) (MRC, 1997). Australia's mesothelioma death-rates are similar to Britain's, and so were its patterns of amosite and crocidolite use (Leigh & Driscoll, 2003).

The mesothelioma risk caused by crocidolite was recognised by 1960(Wagner et al., 1960), and most uses had already ceased when it was effectively banned in the UK following the introduction of the 0.2 f/ml control limit in 1969(MRC, 1997). Amosite is also considerably more dangerous than chrysotile, but this was not generally accepted for a further 20 years, and the UK control limit remained the same for amosite as for chrysotile until 1983(BOHS, 1973) when it was reduced from 2 to 1 f/ml for chrysotile and from 2 to 0.5 f/ml for amosite. The 2 f/ml control limit was observed in most asbestos factories during the 1970s, but substantial asbestos exposure was common in the much larger workforce in construction , and uncontrolled cutting of amosite board with power tools continued in the UK until the 1980s. Among men born since 1950 who started work in 1970 or later, few if any of whom are likely to have used crocidolite products, 33% (10/30) of mesothelioma cases had been carpenters.

4.8 SPECULATIONS ON THE CONTRIBUTION OF CHRYSOTILE

Most of the asbestos used in Britain was chrysotile, but amphibole exposure was also common, and we could not identify men who worked with chrysotile and were not also exposed to amosite or crocidolite. An interaction between chrysotile and amphibole asbestos has previously been suggested(Acheson & Gardner, 1979), and the effects of protracted exposure shown in table 3.2.4 suggest that asbestos acts both early and late in mesothelioma induction. A late-stage 'promoting' effect of asbestos is also suggested by its synergistic interaction with smoking in causing lung cancer(Berry & Liddell, 2004)(Hammond et al., 1979b). The effect on mesothelioma risk of stopping asbestos exposure is much less marked than that of stopping smoking on lung cancer risk (Peto et al., 2000), perhaps because amphibole fibres persist in the lung for many decades after exposure has ceased, so even brief exposure produces a lifelong carcinogenic stimulus. Most chrysotile fibres disappear from the lung within a year, and a limited period of chrysotile exposure causes very few mesotheliomas in workers with no other exposure. These observations suggest that chrysotile exposure could increase the lifelong mesothelioma risk in those whose lungs contain

persistent amosite or crocidolite, just as it causes a much larger increase in the lung cancer risk in lifelong smokers than in non-smokers(Hammond et al., 1979b). Most exposed men also inhaled amphibole fibres, which were found in the lungs of 91% of British mesothelioma patients born since 1943 and in 51% of control lungs(McDonald et al., 2001a). It is widely believed that chrysotile causes few mesotheliomas(McDonald et al., 2001b), but an interaction between persisting lung burdens of amosite or crocidolite and the much larger amounts of chrysotile that were inhaled by many British workers could increase its effect.

4.9 CURRENT ASBESTOS HAZARDS

A large amount of asbestos remains in many buildings, and an important practical question is whether this is still a substantial hazard to construction workers involved in renovation and maintenance of older buildings. The lung burdens of our cases should clarify this. Interviewed mesothelioma cases are followed up, and where possible lung tissue is obtained from post-mortem samples for measurement of asbestos fibres by optical and transmission electron microscopy. We are also obtaining occupational histories and lung samples from resected lung cancer patients, and from younger men and women treated surgically for pneumothorax. The aim of these studies is to relate lung burden to mesothelioma risk, to determine the amount and type of asbestos in the lungs of young building workers, and hence to estimate their continuing risk. They will also provide direct evidence on the contribution of the expansion of amosite use after crocidolite had been effectively phased out to the 50,000 or more mesotheliomas expected in the UK over the next 40 years.

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6. APPENDIX TABLES

Appendix tables are numbered according to the section to which they refer or the table for which they provide further break-down.

Appendix table 3.1 Strategic Health Authority at interview (English subjects only)

Strategic Health Authority	*Mesothelioma Cases*		*Lung cancer cases*		*Population Controls*	
	n	**%**	**n**	**%**	**n**	**%**
Avon, Gloucestershire & Wiltshire	21	3.7	12	3.1	60	4.5
Bedfordshire and Hertfordshire	23	4.1	12	3.1	33	2.5
Birmingham and the Black Country	26	4.6	15	3.9	50	3.8
Cheshire & Merseyside	30	5.3	35	9.2	79	6.0
County Durham and Tees Valley	16	2.9	15	3.9	43	3.2
Cumbria and Lancashire	13	2.3	4	1.1	54	4.1
Dorset and Somerset	12	2.1	7	1.8	46	3.5
Essex	33	5.9	15	3.9	53	4.0
Greater Manchester	24	4.3	17	4.5	57	4.3
Hampshire and Isle of Wight	35	6.2	31	8.1	75	5.7
Kent and Medway	37	6.6	10	2.6	63	4.7
Leicestershire, Northamptonshire & Rutland	14	2.5	12	3.1	43	3.2
Norfolk, Suffolk and Cambridgeshire	33	5.9	24	6.3	73	5.5
North and East Yorkshire & Northern Lincolnshire	11	2.0	16	4.2	24	1.8
North Central London	11	2.0	2	0.5	15	1.1
North East London	14	2.5	5	1.3	23	1.7
North West London	7	1.3	12	3.1	17	1.3
Northumberland, Tyne & Wear	12	2.1	13	3.4	28	2.1
Shropshire and Staffordshire	20	3.6	14	3.7	51	3.8
South East London	17	3.0	12	3.1	20	1.5
South West London	12	2.1	4	1.1	16	1.2
South West Peninsula	34	6.1	24	6.3	64	4.8
South Yorkshire	16	2.9	3	0.8	27	2.0
Surrey and Sussex	26	4.6	18	4.7	88	6.6
Thames Valley	25	4.5	7	1.8	45	3.4
Trent	22	3.9	16	4.2	93	7.0
West Midlands South	5	0.9	13	3.4	40	3.0

West Yorkshire	17	3.0	19	4.9	51	3.8
Total	**566**	**100.0**	**387**	**100.0**	**1331**	**100.0**

Appendix tables 3.2.2c, d and e Men born after 1940 and 1925-39, and all women. Numbers of mesothelioma cases and controls who worked for at least 5 years before age 30 in various occupations. Subjects with any exposure before age 30 in preceding occupational categories are excluded in the right-hand part of the table.

Appendix table 3.2.2c Men born since 1940 – exposure before age 30

Job category and occupation	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk						
Metal plate worker	9	6	37.8 (9.1, 157.5)			
Coach & vehicle body builders	4	1	34.3 (3.4, 347.5)			
Asbestos product manufacturer	2	4	3.8 (0.6, 25.2)			
Laggers & electrical, energy, boiler attendants	3	2	23.7 (2.1, 266.9)			
Docker, shipbuilding or working on board ship	23	19	14.1 (6.3, 31.7)			
Navy	13	10	14.1 (5.2, 38.3)			
All non-construction high risk jobs	**53**	**42**	**14.2 (7.6, 26.5)**			
Construction				**Construction (no other high risk jobs)**		
Carpenter	**63**	**17**	**50.2 (23.2, 108.6)**	**57**	**15**	**53.8 (23.8, 121.6)**
Plumber	30	21	15.0 (7.2, 31.2)	28	19	15.4 (7.2, 32.9)
Electrician	28	25	12.6 (6.1, 25.9)	25	24	11.7 (5.6, 24.5)
Painters & decorators	20	13	23.2 (8.7, 61.7)	18	11	23.3 (8.5, 64.0)
Plumbers, electricians & painters & decorators	**77**	**58**	**14.0 (8.0, 24.4)**	**70**	**53**	**13.8 (7.9, 24.4)**
Other construction	**34**	**55**	**6.2 (3.3, 11.5)**	**27**	**49**	**5.4 (2.8, 10.3)**
Medium risk industrial				**Medium risk industrial (no high risk or construction jobs)**		
Metal working production & maintenance fitters	15	22	9.0 (3.8, 21.5)	10	17	8.4 (3.1, 23.0)
Railway worker	1	6	2.8 (0.3, 27.5)	0	3	0.0 (0.0, 13.0)[1]
Chemist or industrial scientist	3	10	3.5 (0.8, 14.6)	2	9	2.7 (0.5, 14.1)
Surveyor or inspector	3	13	2.6 (0.6, 10.5)	3	12	3.1 (0.7, 13.3)
Metal machining & instrument makers nec.	5	22	3.1 (1.0, 9.6)	4	18	3.0 (0.8, 10.4)
Electrical & electronic trades nec.	5	29	1.8 (0.6, 5.3)	4	24	1.8 (0.5, 5.9)
Welding, steel erecting & fixing	4	9	3.2 (0.9, 12.3)	1	4	1.7 (0.2, 19.1)
Metal working process operatives	2	11	2.0 (0.4, 10.6)	2	8	2.3 (0.4, 13.2)
Assemblers & routine process operatives	9	23	4.5 (1.8, 11.1)	7	11	7.2 (2.5, 21.2)
Plant & machine operatives nec.	6	21	2.9 (1.1, 8.1)	3	15	2.0 (0.5, 7.5)

All medium risk industrial jobs	**53**	**164**	**3.3 (2.0, 5.6)**	**33**	**119**	**2.9 (1.6, 5.1)**
Low risk industrial				**Low risk industrial (no high risk, construction or med risk industrial jobs)**		
Motor mechanic	7	41	1.6 (0.6, 4.1)	1	23	0.3 (0.0, 2.5)
Draughtsmen	6	11	6.6 (2.0, 21.4)	0	7	0.0 (0.0, 5.5)[1]
Engineers & technologists nec.	5	33	1.5 (0.5, 4.4)	2	15	1.3 (0.3, 6.4)
Stores & warehousemen	4	6	7.4 (1.8, 30.2)	0	6	0.0 (0.0, 6.5[1]
Armed forces nec.	0	10	-	0	1	-
Drivers & road transport workers	12	45	3.3 (1.4, 7.3)	2	21	1.2 (0.2, 5.8)
Other industrial not elsewhere classified	22	93	2.4 (1.3, 4.5)	3	47	0.7 (0.2, 2.3)
All low risk industrial jobs	**56**	**232**	**2.5 (1.5, 4.1)**	**7**	**111**	**0.6 (0.3, 1.5)**
Reference group[1]	25	243	1.0 (ref)	25	243	1.0 (ref)

[1]*ORs reference = subjects working only in non-industrial low risk jobs or low risk industrial jobs for less than 5 years. nec = not elsewhere classified*

Appendix table 3.2.2d Men born 1925-1939 – exposure before age 30

Job category and occupation	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk						
Metal plate worker	6	3	35.0 (4.8, 276.6)[1]			
Coach & vehicle body builders	0	0				
Asbestos product manufacturer	1	1	17.5 (0.2, 1391.5)[1]			
Laggers & electrical, energy, boiler attendants	3	1	52.5 (3.0, 2789.9)[1]			
Docker, shipbuilding or working on board ship	22	9	46.2 (11.8, 180.4)			
Navy	13	6	70.5 (12.5, 397.5)			
All non-construction high risk jobs	**44**	**22**	**41.2 (12.7, 134.3)**			
Construction				**Construction (no other high risk jobs)**		
Carpenter	**23**	**7**	**74.4 (15.5, 356.6)**	**20**	**7**	**69.0 (14.4, 332.1)**
Plumber	9	5	86.6 (8.6, 869.6)	8	5	82.6 (7.9, 864.6)
Electrician	14	9	43.3 (8.6, 218.8)	12	7	40.7 (8.0, 206.9)
Painters & decorators	8	5	65.7 (8.6, 504.4)	7	5	54.4 (6.9, 426.2)
Plumbers, electricians & painters & decorators	**31**	**20**	**38.8 (11.0, 137.0)**	**27**	**17**	**40.9 (11.0, 151.7)**
Other construction	**13**	**15**	**11.6 (2.9, 45.8)**	**10**	**13**	**13.3 (3.1, 57.2)**

Medium risk industrial				**Medium risk industrial (no high risk or construction jobs)**		
Metal working production & maintenance fitters	13	20	12.4 (3.5, 43.6)	7	18	7.8 (1.9, 32.9)
Railway worker	1	2	8.8 (0.1, 192.7)[1]	1	2	8.8 (0.1, 192.7)[1]
Chemist or industrial scientist	3	5	8.1 (1.2, 53.0)	3	3	22.9 (2.2, 235.5)
Surveyor or inspector	2	4	24.9 (1.4, 442.0)	2	3	55.2 (1.7, 1759.9)
Metal machining & instrument makers nec.	3	6	14.5 (1.6, 133.2)	1	4	8.2 (0.3, 229.2)
Electrical & electronic trades nec.	3	12	4.4 (0.8, 23.0)	2	7	4.7 (0.6, 36.5)
Welding, steel erecting & fixing	1	4	1.9 (0.1, 34.1)	1	2	2.6 (0.1, 51.9)
Metal working process operatives	1	2	9.2 (0.4, 202.1)	0	1	-
Assemblers & routine process operatives	4	10	8.1 (1.5, 43.2)	1	8	4.1 (0.2, 70.9)
Plant & machine operatives nec.	3	5	41.3 (3.8, 447.9)	2	3	160.8 (4.9, 5322.0)
All medium risk industrial jobs	**40**	**70**	**10.3 (3.5, 30.7)**	**21**	**50**	**8.0 (2.6, 25.2)**
Low risk industrial				**Low risk industrial (no high risk, construction or med risk industrial jobs)**		
Motor mechanic	6	7	22.6 (3.9, 130.3)	3	2	26.3 (2.1, 359.9)[1]
Draughtsmen	2	5	3.1 (0.2, 54.1)	0	1	-
Engineers & technologists nec.	1	3	6.5 (0.4, 104.0)	0	3	0.0 (0.0, 27.8)[1]
Stores & warehousemen	0	5	0.0 (0.0, 15.9)[1]	0	1	-
Armed forces nec.	6	3	47.0 (6.7, 331.9)	1	2	32.5 (1.0, 1092.4)
Drivers & road transport workers	7	18	8.6 (2.0, 36.2)	3	10	5.0 (0.8, 30.0)
Other industrial not elsewhere classified	14	43	6.4 (1.9, 21.4)	4	20	3.5 (0.7, 16.3)
All low risk industrial jobs	**40**	**84**	**8.4 (2.8, 25.2)**	**10**	**38**	**4.9 (1.4, 17.8)**
Reference group[2]	4	70	1.0 (ref)	4	70	1.0 (ref)

[1] *Exact unadjusted Cornfield estimates and confidence intervals*

[2] *ORs reference = subjects working only in non-industrial low risk jobs or low risk industrial jobs for less than 5 years. nec = not elsewhere classified*

Appendix table 3.2.2e All women – exposure before age 30

Job Description	*Cases*	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Non-construction high risk						
Docker, shipbuilding or working on board ship	1	1	3.7 (0.2, 65.1)	1	1	3.7 (0.2, 65.1)
All non-construction high risk jobs	**1**	**1**	**3.4 (0.2, 9.4)**	**1**	**1**	**3.4 (0.2, 60.2)**
Construction				**Construction (no other high risk jobs)**		
Painters & decorators	0	1		0	1	
Medium risk industrial				**Medium risk industrial (no high risk or construction jobs)**		
Metal working production & maintenance fitters	1	0		1	0	
Chemist or industrial scientist	1	1	4.6 (0.3, 78.3)	1	1	4.6 (0.3, 78.3)
Metal machining & instrument makers nec.	0	2		0	2	
Welding, steel erecting & fixing	1	0		1	0	
Metal working process operatives	0	1		0	1	
Assemblers & routine process operatives	7	14	1.7 (0.7, 4.6)	7	13	1.9 (0.7, 5.1)
Plant & machine operatives nec.	0	1		0	1	
All medium risk industrial jobs	**11**	**19**	**1.9 (0.9, 4.4)**	**11**	**18**	**2.1 (0.9, 4.7)**
Low risk industrial				**Low risk industrial (no high risk, construction or med risk industrial jobs)**		
Draughtsmen	0	1		0	1	-
Stores & warehousemen	0	1				
Other industrial not elsewhere classified	6	36	0.5 (0.2, 65.1)	5	30	0.5 (0.2, 65.1)
All low risk industrial jobs	**7**	**40**	**0.5 (0.2, 1.3)**	**5**	**33**	**0.5 (0.2, 1.3)**
Reference group[1]	75	221	1.0 (ref)	75	221	1.0 (ref)

[1] *ORs reference = subjects working only in non-industrial low risk jobs or low risk industrial jobs for less than 5 years. nec = not elsewhere classified*

Appendix table 3.2.2f Subdivision of lower section of tables 3.2.2a & 3.2.2b. Reference group is those who only worked in an office environment.

Low risk non-industrial	*Worked in these jobs for >5 years before 1992*			*Excluding those with higher risk or low risk industrial jobs for >5 years*		
	Cases	*Controls*	*OR (95% CIs)*	*Cases*	*Controls*	*OR (95% CIs)*
Males						
Cleaners	3	4	1.4 (0.0, 43.5)	0	1	-
Retail workers	13	96	2.3 (0.5, 10.3)	3	38	1.5 (0.2, 12.7)
Doctors, nurses & hospital workers	3	24	2.7 (0.3, 22.3)	1	13	-
Teachers & school workers	11	79	1.9 (0.4, 8.2)	4	42	1.2 (0.2, 8.1)
Kitchen workers	8	17	8.9 (1.3, 60.0)	0	9	-
Other	87	337	3.9 (1.0, 11.8)	19	138	2.0 (0.5, 7.7)
Office workers only (reference group)	3	41	1.0 (ref)	3	41	1.0 (ref)
Females						
Cleaners	6	9	0.8 (0.1, 3.9)	2	3	0.3 (0.0, 5.3)
Retail workers	19	69	0.4 (0.2, 1.1)	13	44	0.4 (0.1, 1.1)
Doctors, nurses & hospital workers	16	43	0.7 (0.3, 1.9)	9	32	0.5 (0.2, 1.7)
Teachers & school workers	18	38	1.0 (0.4, 2.6)	11	35	0.6 (0.2, 1.7)
Kitchen workers	7	6	1.8 (0.3, 9.7)	6	1	23.7 (1.3, 432.2)
Other	20	73	0.5 (0.2, 1.4)	13	58	0.3 (0.1, 1.1)
Office workers only (reference group)	12	25	1.0 (ref)	12	25	1.0 (ref)

Appendix tables 3.2.4a and b Odds ratios for males born since 1940 and born 1925-39, by duration of employment in high or medium risk occupations and in carpentry before and after age 30.

Appendix table 3.2.4a Men born since 1940 (reference group: 29 cases & 322 controls with no medium or higher risk industrial jobs)

	Duration of exposure after age 30							
	none		***<10 years***		***≥10 years***		***Total***	
	cases/ controls	***OR (CI)***	***cases/ controls***	***OR (CI)***	***cases/ controls***	***OR (CI)***	***cases/ controls***	***OR (CI)***
Duration in all high risk jobs before age 30[1]			*Duration in all high risk jobs after age 30*					
none			3/15	2.1 (0.6, 8.0)	0/17	-	3/32	1.1 (0.3, 3.7)
<10 yrs	40/121	3.7 (2.2, 6.3)	17/63	3.0 (1.5, 5.8)	19/64	3.6 (1.9, 6.8)	76/248	3.5 (2.2, 5.1)
≥10 yrs	15/23	7.5 (3.5, 16.0)	36/46	8.6 (4.8, 15.6)	178/157	13.5 (8.6, 21.1)	229/226	11.7 (7.6, 18.0)
Total	55/144	4.3 (2.6, 7.1)	56/124	4.9 (3.0, 8.1)	197/238	9.8 (6.4, 15.1)	308/506	6.8 (4.5, 10.3)
Duration in carpentry jobs before age 30			*Duration in carpentry jobs after age 30*					
none			2/4	8.0 (1.3, 49.5)	1/2	7.3 (0.6. 92.5)	3/6	7.6 (1.7, 34.0)
<10 yrs	14/9	17.8 (6.8, 46.7)	6/1	60.2 (6.6, 551.7)	7/5	15.3 (4.4, 53.0)	27/15	20.0 (9.4, 42.7)
≥10 yrs	6/3	24.5 (5.6, 107.5)	11/2	91.6 (17.8, 471.3)	32/7	68.2 (25.6, 182.1)	49/12	59.8 (26.5, 134.9)
Total	20/12	18.8 (8.1, 43.8)	19/7	37.9 (13.7, 104.9)	40/14	38.6 (17.9, 83.4)	79/33	30.4 (16.7, 55.3)

[1] *All high risk exposure = high risk, all construction jobs and medium risk industrial jobs*

Appendix table 3.2.4b Men born 1925-1939 (reference group: 9 cases & 91 controls with no medium or higher risk industrial jobs)

	Duration of exposure after age 30							
	none		***<10 years***		***≥10 years***		***Total***	
	cases/ controls	***OR (CI)***	***cases/ controls***	***OR (CI)***	***cases/ controls***	***OR (CI)***	***cases/ controls***	***OR (CI)***
Duration in all high risk jobs before age 30[1]			*Duration in all high risk jobs after age 30*					
none			2/6	4.0 (0.7, 23.7)	3/11	2.6 (0.6, 11.2)	5/17	3.0 (0.9, 10.3)
<10 yrs	19/42	4.7 (1.9, 11.3)	10/13	7.8 (2.6, 23.0)	28/40	6.9 (2.9, 16.0)	57/95	6.0 (2.8, 13.0)
≥10 yrs	4/8	4.5 (1.1, 18.3)	18/7	28.9 (9.3, 89.6)	82/66	12.8 (5.9, 27.5)	104/81	13.3 (6.2, 28.2)
Total	23/50	4.6 (1.9, 10.8)	30/26	12.4 (5.1, 29.7)	113/117	9.7 (4.6, 20.3)	166/193	8.7 (4.2, 18.0)
Duration in carpentry jobs before age 30			*Duration in carpentry jobs after age 30*					
none			1/3	4.6 (0.4, 56.1)	1/2	5.8 (0.4, 81.7)	2/5	5.1 (0.8, 32.7)
<10 yrs	2/7	2.6 (0.4, 17.8)	0/0	-	1/1	9.2 (0.5, 178.3)	3/8	3.7 (0.7, 19.3)
≥10 yrs	1/0	-	1/0	-	19/3	63.6 (13.9, 290.4)	21/3	72.8 (16.2, 362.3)
Total	3/7	4.0 (0.8, 21.0)	2/3	9.2 (1.2, 70.2)	21/6	37.2 (10.4, 132.9)	26/16	17.0 (6.2, 47.2)

[1] *All high risk exposure = high risk, all construction jobs and medium risk industrial jobs*

Appendix table 3.2.6a Job category and reported asbestos exposure before age 30 in men born after 1940. Subjects who ever worked in each job category are excluded in subsequent columns.

		High risk	***Construction***			***All other jobs***	
		excluding construction	***Carpenters***	***Plumbers, electricians, painters***	***Other construction***	***Medium risk industrial***	***Low risk (ref)***
Duration in job category before age 30							
None	cases/controls	2/8	2/5	3/9	2/17	1/16	
	OR (CI)	3.1 (0.6, 15.5)	4.6 (0.8, 25.0)	3.8 (1.0, 15.0)	1.4 (0.3, 6.3)	0.7 (0.1, 5.3)	
<5 years	cases/controls	35/42	8/8	9/24	13/54	7/64	
	OR (CI)	9.7 (5.4, 17.7)	10.6 (3.7, 30.7)	4.2 (1.8, 9.9)	2.6 (1.3, 5.4)	1.3 (0.5, 3.0)	
5-9 years	cases/controls	22/15	10/2	17/16	7/23	2/46	
	OR (CI)	17.4 (8.0, 37.8)	55.7 (11.6, 268.6)	12.3 (5.6, 27.2)	3.5 (1.4, 8.8)	0.5 (0.1, 2.1)	
≥10 years	cases/controls	31/27	47/12	51/35	10/18	29/65	
	OR (CI)	13.4 (7.0, 25.7)	45.1 (21.3, 95.3)	16.9 (9.5, 30.2)	6.6 (2.7, 15.7)	5.3 (2.9, 9.5)	
Type and duration of asbestos exposure before age 30[1]							
None	cases/controls	16/34	6/6	10/29	10/71	20/149	25/309
	OR (CI)	5.3 (2.6, 10.9)	10.7 (3.2, 35.8)	3.8 (1.7, 8.5)	1.5 (0.7, 3.3)	1.5 (0.8, 2.7)	
Indirect[2]							
<5 years	cases/controls	3/11	1/0	1/2	3/6	2/9	1/1
	OR (CI)	3.1 (0.8, 11.9)		5.7 (0.5, 65.5)	5.5 (1.3, 23.3)	2.4 (0.5, 11.9)	
≥5 years	cases/controls	12/6	1/0	8/7	4/7	1/10	1/6
	OR (CI)	23.0 (7.9, 66.5)		13.3 (4.5, 39.6)	6.7 (1.8, 24.2)	1.1 (0.1, 9.2)	
Direct infreq[3]							
<5 years	cases/controls	6/5	11/9	3/13	2/4	0/4	0/3
	OR (CI)	13.6 (3.9, 47.9)	13.5 (5.1, 35.4)	2.6 (0.7, 9.9)	5.8 (1.0, 32.9)		
≥5 years	cases/controls	14/11	30/7	30/20	7/16	8/14	1/2
	OR (CI)	14.8 (6.1, 35.7)	49.0 (19.6, 122.2)	17.2 (8.6, 34.1)	4.8 (1.8, 12.7)	6.4 (2.5, 16.6)	
Direct freq[4]							
<5 years	cases/controls	20/9	8/3	4/6	3/5	1/1	0/1
	OR (CI)	25.5 (10.6, 61.7)	30.3 (7.5, 121.6)	7.1 (1.9, 27.0)	6.6 (1.5, 29.6)	11.3 (0.7, 188.1)	
≥5 years	cases/controls	19/16	10/2	24/7	3/3	7/4	1/0
	OR (CI)	13.5 (6.2, 29.4)	56.9 (11.8, 273.9)	39.2 (15.5, 99.0)	11.1 (2.1, 58.3)	20.1 (5.5, 73.2)	
Ever worked in job category							
	cases/controls	90/92	67/27	80/84	32/112	39/191	**29/322**
	OR (CI)	11.1 (6.8, 18.1)	27.7 (15.3, 50.2)	10.8 (6.6, 17.6)	3.2 (1.9, 5.6)	2.3 (1.4, 3.9)	**1.0 (ref)**

[1] in any job category, [2] work done by someone in the same area, [3] work done themselves less than once per week, [4] work done themselves > once per week

Appendix table 3.2.6b Job category and reported asbestos exposure before age 30 in men born 1925-39. Subjects who ever worked in each job category are excluded in subsequent columns.

		High risk	***Construction***			***All other jobs***	
		excluding construction	***Carpenters***	***Plumbers, electricians, painters***	***Other construction***	***Medium risk industrial***	***Low risk (ref)***
Duration in job category before age 30							
None	cases/controls	2/7	1/5	3/3	5/7	3/10	
	OR (CI)	2.5 (0.4, 14.2)	2.2 (0.2, 21.1)	9.1 (1.6, 52.1)	7.7 (2.0, 29.7)	3.0 (0.7, 13.1)	
<5 years	cases/controls	17/17	1/4	4/10	7/12	8/15	
	OR (CI)	8.9 (3.3, 24.1)	3.4 (0.3, 34.7)	3.6 (0.9, 14.1)	6.8 (2.1, 22.2)	5.6 (1.8, 17.1)	
5-9 years	cases/controls	20/10	1/3	7/6	5/7	6/22	
	OR (CI)	22.9 (8.1, 65.3)	3.4 (0.3, 36.9)	12.3 (3.3, 45.4)	5.5 (1.4, 21.7)	3.0 (1.0, 9.6)	
≥10 years	cases/controls	24/12	19/3	18/11	3/4	12/25	
	OR (CI)	22.1 (7.5, 53.8)	62.7 (15.3, 257.0)	18.8 (6.6, 53.0)	7.4 (1.4, 10.7)	4.6 (1.7, 12.4)	
Type and duration of asbestos exposure before age 30[1]							
None	cases/controls	13/22	6/6	6/9	13/20	15/53	8/84
	OR (CI)	5.9 (2.2, 15.9)	10.4 (2.7, 39.9)	6.5 (1.9, 23.0)	6.9 (2.6, 18.7)	2.9 (1.2, 7.2)	
Indirect[2]							
<5 years	cases/controls	2/3	1/1	1/2	1/0	2/7	
	OR (CI)	7.7 (1.1, 54.0)	9.7 (0.5, 177.7)	3.9 (0.3, 48.8)		2.6 (0.4, 15.9)	
≥5 years	cases/controls	11/5	0/1	7/2	0/1	5/3	0/1
	OR (CI)	23.9 (6.6, 86.5)		40.4 (7.1, 228.6)		17.3 (3.4, 87.1)	
Direct infreq[3]							
<5 years	cases/controls	4/1	0/2	2/6	0/3	1/4	0/1
	OR (CI)	25.5 (2.4, 271.1)		3.2 (0.6, 18.3)		2.5 (0.2, 25.5)	
≥5 years	cases/controls	6/5	2/1	9/5	1/1	3/4	0/5
	OR (CI)	9.7 (2.3, 41.2)	23.1 (1.8, 289.3)	18.5 (5.0, 68.6)	10.7 (0.6, 190.2)	8.9 (1.6, 48.0)	
Direct freq[4]							
<5 years	cases/controls	6/4	4/1	2/1	1/2	1/0	1/0
	OR (CI)	15.7 (3.6, 68.4)	32.9 (3.2, 335.1)	28.3 (2.2, 361.8)	6.1 (0.5, 76.1)		
≥5 years	cases/controls	21/6	9/3	5/5	4/3	2/1	
	OR (CI)	34.8 (11.0, 110.4)	31.2 (7.0, 139.0)	11.8 (2.8, 50.2)	11.1 (2.0, 61.0)	21.4 (1.7, 276.6)	
Ever worked in job category							
	cases/controls	63/46	22/15	30/30	20/30	29/72	**9/91**
	OR (CI)	13.6 (6.2, 30.1)	15.2 (5.8, 39.8)	11.1 (4.7, 26.1)	6.7 (2.7, 16.6)	4.1 (1.8, 9.4)	**1.0 (ref)**

[1] in any job category, [2] work done by someone in the same area, [3] work done themselves less than once per week, [4] work done themselves > once per week

Appendix table 3.4.4 Year in which the youngest cases (born 1950-1971) started work, by highest job category

Highest job category	*Males - year started work*					*All males*	*All females*
	1965-69	*1970-74*	*1975-79*	*1980-84*	*≥1985*		
Occupational exposure							
Non-construction high risk	4	2	2	0	0	8	0
Carpenters	10	8	1	0	1	20	0
Plumbers, electricians & painters	7	2	0	0	0	9	0
Other construction	3	3	1	2	0	9	0
Medium risk industrial	8	3	1	0	0	12	5
Non-occupational exposure							
Domestic exposure < age 30	0	0	0	1	0	1	3
None of the above	1	0	1	1	1	4	10
TOTAL	33	18	6	4	2	63	18

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Occupational, domestic and environmental mesothelioma risks in Britain

A case-control study

UK mesothelioma mortality is the highest worldwide, but no large case-control study with personal interviews has been conducted. We obtained lifetime occupational and residential histories from 622 mesothelioma patients (512 men, 110 women) and 1420 population controls. The lifetime risk was about 1 per 1,000 in men and women with no occupational or domestic asbestos exposure, irrespective of the type of building they lived or worked in, and 2 per 1,000 in exposed workers' relatives. The average LR per 1000 for 10 years duration before age 30 was 59 among carpenters, who constituted 4% of controls and 21% of cases among men, 20 for plumbers, electricians and painters, and 8 for other construction workers. Other high-risk occupations included lagging and shipyard work, with lower risks in various industrial sectors where asbestos was also encountered. The predicted total of ~90,000 mesotheliomas in the UK by 2050 will include about 15,000 former carpenters. The risk persisted in men beginning work after 1970 when crocidolite was no longer used. An important factor underlying the very high risk in British construction workers, particularly carpenters, is likely to be the widespread use of power tools on amosite insulation board, which continued with no effective dust control until the 1980s. Asbestos exposure was common in the workplace, with 65% of male and 23% of female controls having worked in occupations that were classified as medium or higher risk.The increase in female cases in the UK, many with no identified exposure, suggests widespread environmental contamination from industrial and construction activities.

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