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# The burden of occupational cancer in Great Britain

## Sinonasal cancer

Prepared by the **Health and Safety Laboratory**, the **Institute of Occupational Medicine** and **Imperial College London** for the Health and Safety Executive 2012

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The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer was the attributable fraction (AF) being the proportion of cases that would not have occurred in the absence of exposure; and the AF was used to estimate the number of attributable deaths and registrations. The study involved obtaining data on the risk of the cancer due to the exposure of interest, taking into account confounding factors and overlapping exposures, as well as the proportion of the target population exposed over the relevant exposure period. Only carcinogenic agents, or exposure circumstances, classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens were considered. Here, we present estimates for sinonasal cancer that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

The estimated total (male and female) AF, deaths and registrations for sinonasal cancer related to overall occupational exposure is 32.67% (95% Confidence Interval (CI)= 21.53-55.01), which equates to 38 (95%CI= 25-63) attributable deaths and 126 (95%CI= 83-212) attributable registrations.

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## EXECUTIVE SUMMARY


The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer used in this project was the attributable fraction i.e. the proportion of cases that would not have occurred in the absence of exposure; this was then used to estimate the attributable numbers. This involved obtaining data on the risk of the disease due to the exposure of interest, taking into account confounding factors and overlapping exposures, and the proportion of the target population exposed over the period in which relevant exposure occurred. Estimation was carried out for carcinogenic agents or exposure circumstances classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens. Here, we present estimates for sinonasal cancer that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

Formaldehyde, wood dust, leather dust (work in boot and shoe manufacture), nickel, chromium VI and mineral oils have been classified by the IARC as definite human carcinogens for sinonasal cancer. Worker exposure to chromium occurs in the production of stainless steel, other alloys, and chrome-containing pigments and during chrome-plating and welding. Formaldehyde exposure occurs during production, in pathology and embalming and in the plastics, plywood and textile industries. Mineral oils exposure, particularly oil mists, occur in metalworking, print press operating, and cotton and jute spinning. Worker exposure to nickel occurs in nickel refining, mining and smelting, production of nickel alloys, stainless steel and nickel-cadmium batteries and in welding of stainless steel. The highest exposures to wood dust occur in wood furniture and cabinet manufacture, especially during machine sanding and similar operations. Exposure also occurs in plywood and particleboard mills, sawmills, in joinery shops, window and door manufacture, wooden boat manufacture, installation and refinishing of wood floors, pattern and model making, pulp and paper manufacture, construction carpentry and logging.

Due to assumptions made about cancer latency and working age range, only cancers in ages 25+ in 2005/2004 could be attributable to occupation. For Great Britain in 2005, there were 63 total deaths in men aged 25+ and 52 in women aged 25+ from sinonasal cancer; in 2004 there were 219 total registrations for sinonasal cancer in men aged 25+ and 159 women aged 25+.

The estimated total (male and female) attributable fractions, deaths and registrations for sinonasal cancer related to occupational exposure is 32.67% (95% Confidence Interval (CI)=21.53-55.01), which equates to 38 (95%CI=25-63) attributable deaths and 126 (95%CI=83-212) attributable registrations. Results for individual carcinogenic agents for which the attributable fraction was determined are as follows:

- **Chromium VI**: The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to chromium VI is 5.69% (95%CI= 2.16-15.50), which equates to 7 (95%CI=3-18) attributable deaths and 22 (95%CI=8-59) attributable registrations.

- **Formaldehyde:** The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to formaldehyde is 0.17% (95%CI=0.10-0.45) which equates to 0 (95%CI=0-1) attributable deaths and 1 (95%CI=0-2) attributable registration.
- **Leather dust**: The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupation in boot and shoe manufacture (leather dust exposure) is 8.39% (95%CI=4.17-15.19), which equates to 10 (95%CI=5-18) attributable deaths and 31 (95%CI=16-57) attributable registrations.
- **Mineral oils**: The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to mineral oils is 13.84% (95%CI=1.37-38.97), which equates to 16 (95%CI=2-45) attributable deaths and 55 (95%CI=5-154) attributable registrations.
- **Nickel**: The estimated total (male only) attributable fraction for sinonasal cancer associated with occupational exposure to nickel at the Clydach refinery is 0.00% (95%CI=0.00-0.02) for men which equates to 0 (95%CI=0-0) attributable deaths and 0 (95%CI=0-1) attributable registrations.
- **Wood dust:** The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to wood dust is 10.02% (95%CI=3.85-19.60), which equates to 12 (95%CI=4-23) attributable deaths and 39 (95%CI=15-76) attributable registrations.

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# 1 INCIDENCE AND TRENDS

Cancer of the nose and paranasal sinuses (sinonasal cancer, SNC) (ICD-10 C30/C31; ICD-9 160) is a disease with a differential racial and geographical distribution. In most parts of the world it is a rare condition but in certain ethnic groups: Southern Chinese, Eskimos and other Arctic natives, inhabitants of South-East Asia, and also the populations of North Africa and Kuwait, this low risk profile alters. In the UK about 400 cases are diagnosed each year (ONS MB1 Series[1]) (Table 1 and), and fewer than 150 people die from the condition (ONS DH2 Series[2]) (Table 3). Long-term trends in the incidence of SNC were studied on the basis of notifications of cancer cases in England and Wales over the past 10 years. On average 386 cases of SNC (222 males and 164 females) were diagnosed each year between 1995 and 2004. Annual incidences per 100,000 males/females appear to be relatively steady. This contrasts with the simultaneous increases in risk for cancers of the middle and lower respiratory tract, and indicate that cigarette smoking does not play any significant role in the aetiology of SNC. Since this tumour type has few non-occupational aetiologies, the stable time trends observed indicate that all the major risk factors have been present in work places in a relatively unchanged form for more than ten years. It should be noted however that recent disease rates may relate to quite distant past exposures due to the long latency periods possible for sinonasal cancer.

The five-year relative survival rate is about 50% (Roush, 1996), but this varies according to the stage and histological type. Patients with well-differentiated squamous cell carcinoma (SCC) had a significantly higher five-year survival rate than patients with poorly differentiated carcinomas (Jakobsen *et al*, 1997). Cancer mortality to incidence ratios for cancer of the nasal cavity and middle ear (C30) are 0.09 for men and 0.19 for women (ONS, 2006). For cancer of the accessory sinus (C31) the ratio is 0.64 for men and 0.85 for women.

About 60% of sinonasal cancers are squamous cell carcinomas, and adenocarcinomas are the next most common histology type accounting for 1-2% (Cancer Research UK[3]).

**Table 1** Number of male sinonasal cancer registrations in England, Wales and Scotland for 1995-2004.

| Year | England | | Wales | Scotland | |
|---|---|---|---|---|---|
| | C30 | C31 | C30-C31 | C30 | C31 |
| 1995 | 88 (0.4) | 97 (0.4) | 14 (1.0) | 8 (0.3) | 9 (0.4) |
| 1996 | 95 (0.4) | 93 (0.4) | 16 (1.1) | 15 (0.6) | 14 (0.5) |
| 1997 | 113 (0.5) | 81 (0.3) | 17 (1.2) | 6 (0.2) | 9 (0.4) |
| 1998 | 98 (0.4) | 92 (0.4) | 12 (0.9) | 12 (0.5) | 10 (0.3) |
| 1999 | 90 (0.4) | 91 (0.4) | 13 (0.9) | 9 (0.3) | 15 (0.5) |
| 2000 | 122 (0.5) | 77 (0.3) | 14 (1.0) | 9 (0.3) | 11 (0.4) |
| 2001 | 100 (0.4) | 90 (0.4) | 11 (0.8) | 10 (0.3) | 7 (0.3) |
| 2002 | 103 (0.4) | 76 (0.3) | 16 (1.1) | 11 (0.4) | 7 (0.3) |
| 2003 | 117 (0.5) | 74 (0.3) | 7 (0.5) | 9 (0.3) | 11 (0.4) |
| 2004 | 123 (0.5) | 72 (0.3) | 14 (1.0) | 9 (0.3) | 5 (0.2) |
| **Average** | **105 (0.4)** | **84 (0.4)** | **13 (0.9)** | **10 (0.4)** | **10 (0.4)** |

Source: ONS MB1 Series (ONS 2007a), Information Services Division (ISD 2008). Numbers in brackets are crude rates per 100,000

[1] http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=8843andPos=andColRank=1andRank=240
[2] http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=618
[3] http://www.cancerhelp.org.uk/help/default.asp?page=13799

**Table 2** Number of female sinonasal cancer registrations in England, Wales and Scotland for 1995-2004.

| Year | England | | Wales | Scotland | |
|---|---|---|---|---|---|
| | C30 | C31 | C30-C31 | C30 | C31 |
| 1995 | 58 (0.2) | 58 (0.2) | 12 (0.8) | 9 (0.3) | 11 (0.4) |
| 1996 | 72 (0.3) | 67 (0.3) | 15 (1.0) | 9 (0.3) | 7 (0.2) |
| 1997 | 81 (0.3) | 52 (0.2) | 18 (1.2) | 5 (0.2) | 3 (0.1) |
| 1998 | 80 (0.3) | 55 (0.2) | 3 (0.2) | 8 (0.2) | 6 (0.1) |
| 1999 | 93 (0.4) | 57 (0.2) | 16 (1.1) | 20 (0.5) | 6 (0.2) |
| 2000 | 93 (0.4) | 60 (0.2) | 10 (0.7) | 10 (0.3) | 4 (0.1) |
| 2001 | 88 (0.3) | 54 (0.2) | 11 (0.7) | 10 (0.3) | 7 (0.2) |
| 2002 | 72 (0.3) | 46 (0.2) | 11 (0.7) | 15 (0.4) | 4 (0.1) |
| 2003 | 102 (0.4) | 41 (0.2) | 12 (0.8) | 9 (0.2) | 4 (0.1) |
| 2004 | 91 (0.4) | 40 (0.2) | 12 (0.8) | 10 (0.3) | 7 (0.2) |
| **Average** | **83 (0.3)** | **53 (0.2)** | **12 (0.8)** | **10 (0.3)** | **6 (0.2)** |

Source: ONS MB1 Series (ONS 2007a), Information Services Division (ISD 2008). Numbers in brackets are crude rates per 100,000

**Table 3** Number of sinonasal cancer deaths in England, Wales and Scotland 1999-2005.

| Year | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|
| | England and Wales | | Scotland | | England and Wales | | Scotland | |
| | C30 | C31 | C30 | C31 | C30 | C31 | C30 | C31 |
| 1999 | 60 | | 0 | 4 (0.1) | 34 | | 0 | 5 (0.1) |
| 2000 | 74 | | 2 (0.1) | 5 (0.2) | 43 | | 6 (0.2) | 1 (0.0) |
| 2001 | 13 | 55 | 2 (0.1) | 5 (0.2) | 14 | 52 | 0 | 2 (0.1) |
| 2002 | 17 | 52 | 3 (0.1) | 6 (0.2) | 13 | 31 | 3 (0.1) | 5 (0.1) |
| 2003 | 18 | 59 | 2 (0.1) | 2 (0.1) | 27 | 30 | 0 | 3 (0.1) |
| 2004 | 12 | 51 | 3 (0.1) | 4 (0.1) | 18 | 35 | 2 (0.0) | 4 (0.1) |
| 2005 | 15 | 41 | 1 (0.0) | 7 (0.2) | 15 | 33 | 0 | 4 (0.1) |
| **Average*** | **15** | **52** | **2 (0.1)** | **5 (0.2)** | **17** | **36** | **2 (0.2)** | **3 (0.1)** |

Source: ONS DH2 Series (ONS 2007b), Welsh Cancer Intelligence and Surveillance Unit (WCISU 2008), Information Services Division (ISD 2008). Numbers in brackets are crude rates per 1,000,000 for England/Wales and per 100,000 for Scotland. * Excludes 1999 and 2000 for deaths in England and Wales

# 2 OVERVIEW OF AETIOLOGY

## 2.1 INTRODUCTION

The low absolute risk in the general population has been accompanied by high relative risks for specific chemical exposures and occupational settings, such as nickel refining and woodworking. For these reasons SNC has been designated a ‘sentinel cancer’ that may permit the identification of environmental cancer risk factors (Olsen, 1988; Rutstein *et al*, 1984).

In the data presented in the Occupational Health Decennial Supplement (Drever, 1995) the risk was in excess in the furniture and cabinet making industry, which was reflected by the elevated PRRs and PMRs in job groups related to the industry (Table 4). Dust from vegetable-tanned leather has also been shown to cause these cancers and again PRR and PMR were elevated in leather and shoe workers. Other exposures that have been shown to be associated include chromium, nickel, welding, flame cutting and soldering, and lacquers and paints (Hernberg *et al*, 1983a; Hernberg *et al*, 1983b).

**Table 4** Job codes with significantly high PRRs and PMRs for cancer of the nose and nasal cavities. Men and women aged 20-74 years, England. For males, PMRs for occupations that entail exposure to wood or leather dust are also included.

| Job Group | | Registrations | PRR | 95% CI | Deaths | PMR | 95% CI |
|---|---|---|---|---|---|---|---|
| **SIC code** | **Description** | **(1981 – 1987)** | | | **(1979 – 1980 and 1982 – 1990)** | | |
| **Men** | | | | | | | |
| 049 | Police | | | | 9 | 235 | 107-446 |
| 061 | Hospital porters and ward orderlies | | | | 8 | 256 | 111-505 |
| 068 | Leather and shoe workers | | | | 7 | 257 | 103-530 |
| 104 | Carpenters | | | | 19 | 138 | 83-216 |
| 105 | Cabinet makers | 9 | 803 | 367-1525 | 8 | 568 | 245-1119 |
| 106 | Case and box makers | | | | 2 | 554 | 67-2001 |
| 108 | Woodworking machinists | 10 | 710 | 341-1307 | 8 | 386 | 167-761 |
| 109 | Other woodworkers | 5 | 676 | 220-1580 | 2 | 330 | 40-1192 |
| 124 | Machine tool operators | | | | 34 | 146 | 101-204 |
| 164 | Packers and sorters | 6 | 312 | 115-681 | | | |
| **Women** | | | | | | | |
| 060 | Other service personnel | 29 | 153 | 103-220 | | | |

Source: Drever *et al.* (1995) Occupational Health Decennial Supplement

The recent numbers for the Occupational Health Decennial Supplement examined mortality for the period 1991-2000 in men and women aged 20-74 years in England (Table 5) (Coggon *et al,* 2009). In comparison to the previous supplement, only cabinet makers re-appear, with a higher PMR.

**Table 5** Job codes with significantly high PMRs for cancer of the nose and nasal cavities. Men and women aged 20-74 years, England and Wales 1991-2000.

| Job Group | | Deaths | Expected deaths | PMR | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|
| **SIC code** | **Description** | **1991 - 2000** | | | | |
| **Men** | | | | | | |
| 071 | Warp Preparers, Bleachers, dyers and finishers | 3 | 0.51 | 588 | 121 | 1717 |
| 105 | Cabinet Makers | 11 | 1.00 | 1096 | 547 | 1961 |
| 172 | Sewage plant attendants | 3 | 0.55 | 541 | 112 | 1582 |
| **Women** | | | | | | |
| 070 | Spinners and Winders | 3 | 0.36 | 826 | 170 | 2414 |

Source: Coggon *et al.* (2009) Occupational mortality in England and Wales, 1991-2000

IARC have assessed the carcinogenicity of a number of substances and occupational circumstances with those classified as Group 1 having sufficient evidence in humans and those classified as Group 2A having limited evidence in humans. Those classified as causing SNC or possibly causing SNC are given in Table 6. Siemiatycki *et al*, (2004) summarised the evidence used in the classification of these agents and substances as suggestive (Table 6). Other exposures and industries/occupations that are considered to be associated with an increased risk of SNC include polycyclic aromatic hydrocarbons, the textile manufacturing industry and radium dial painters. Tobacco smoking and other life-style factors seem to play a minor role, if any, in the aetiology of SNC (Roush, 1996).

**Table 6** Occupational agents, groups of agents, mixtures, and exposure circumstances classified by the IARC Monographs, Vols 1-77, into Groups 1 and 2A, which have the nasal cavity and parasinuses as the target organ.

| **Agents, Mixture, Circumstance** | **Main industry, Use** | **Evidence of carcinogenicity in humans*** | **Strength of evidence$** | **Other target organs** |
|---|---|---|---|---|
| **Group 1: Carcinogenic to Humans** | | | | |
| **Agents, groups of agents** | | | | |
| Wood dust | Logging and sawmill workers; pulp and paper and paperboard industry; woodworking trades (e.g. furniture industries, cabinetmaking, carpentry and construction); used as filler in plastic and linoleum production | Sufficient | Strong | Nasopharyngeal |
| Chromium VI | Chromate production plants' dyes and pigments; plating and engraving; chromium ferro-alloy production; stainless-steel welding; in wood preservatives; leather tanning; water treatment; inks; photography; lithography; drilling muds; synthetic perfumes; pyrotechnics; corrosion resistance | Sufficient | Suggestive | Lung |
| Nickel Compounds | Nickel refining and smelting; welding | Sufficient | Strong | Lung |
| Mineral oils | Production; used as lubricant by metal workers, machinists, engineers; printing industry (ink formulation); used in cosmetics, medicinal and pharmaceutical preparations | Sufficient | Suggestive | Skin<br>Bladder<br>Lung |
| Formaldehyde | Production; pathologists; medical laboratory technicians; plastics; textile industry | Sufficient | Suggestive | Nasopharyngeal<br>Leukaemia |
| **Exposure circumstances** | | | | |
| Boot and shoe manufacture and repair | Leather dust; benzene and other solvents | Sufficient | Strong | Bladder<br>Leukaemia<br>Lung |
| Furniture and cabinet-making | Wood dust | Sufficient | Strong | |
| Isopropanol manufacture, strong acid process | Diisopropyl sulphate; isopropyl oils; sulphuric acid | Sufficient | Strong | Larynx<br>Lung |
| **Group 2A: Probably Carcinogenic to Humans** | | | | |
| **Agents** and **groups of agents** | | | | |
| None | | | | |
| **Other exposure circumstances** | | | | |
| Textile Manufacturing Industry | Textile dust in manufacturing process; dyes and solvents in dyeing and printing operations | | | |
| Polyaromatic Hydrocarbons | Work involving combustion of organic matter; foundries; steel mills; firefighters; vehicle mechanics | | | |
| Ionising Radiation | Radiologists, technologists, nuclear workers, radium-dial painters, underground miners, plutonium workers, cleanup workers following nuclear accidents, aircraft crew | | | |

* Evidence according to the IARC monograph evaluation; $ taken from Siemiatycki *et al*. (2004)

## 2.2 EXPOSURES

### 2.2.1 Wood Dust

Occupational exposure to fine particulate wood dust is a well-known cause of SNC, and has been classified as carcinogenic to humans by the IARC (IARC, 1995). The evidence seems to be strongest for exposure to hardwood dust and adenocarcinoma of the nose and sinuses and fine particulate dust generated by sanding seems to be more carcinogenic than coarse dust generated by sawing.

The highest exposures have generally been reported in wood furniture and cabinet manufacture, especially during machine sanding and similar operations (with wood dust levels frequently above 5mg/m$^3$). IARC have classified this occupation as a Group 1 carcinogen to humans (IARC, 1987b). Exposure levels above 1mg/m$^3$ have also been measured in the finishing departments of plywood and particleboard mills, where wood is sawn and sanded, and in the workroom air of sawmills and planer mills near chippers, saws and planers. Exposure also occurs among workers in joinery shops, window and door manufacture, wooden boat manufacture, installation and refinishing of wood floors, pattern and model making, pulp and paper manufacture, construction carpentry and logging. However, the latter occupations are not classified as carcinogenic to humans. Measurements are generally available only since the 1970s, and exposures may have been higher in the past because of less efficient (or non-existent) local exhaust ventilation and other measures to control dust.

In the industry an occupational exposure limit (OEL) of 5mg/m$^3$ for total inhalable hardwood dust came into effect in April 1988, which was replaced by a maximum exposure limit (MEL) of the same value when COSHH Regulations came into force in October 1989. A MEL of the same value was introduced in January 1997 for softwood.

A recent study, using data stored in National Exposure Database (NEDB), investigating trends in inhalation exposure of wood dust showed that levels had declined by 8.1% per year, after taking into account the effect of the data source (inspection visit or representation survey) (Creely *et al*, 2006). The trend was fairly constant across industry sectors (manufacture of furniture and manufacture of wood products, not furniture) and occupations (carpenters, wood machinists, sanders/polishers). These reductions were said to have been brought about by significant changes in equipment and production methods, lower production rates and modification/upgrading capabilities of dust control and extraction equipment. Although this analysis showed a decrease in levels a survey carried out in 2000 by the HSE noted that wood dust exposure in nearly 30% of 47 small businesses surveyed was in excess of the 5mg/m$^3$ MEL, and a written COSHH assessment was available at only 34% of sites visited (Dilworth, 2000). Circular sawing and sanding were identified as processes giving rise to particularly high exposures. About 5% of samples exceeded the MEL by five times, but no site- or process-specific factors could be identified that could have led to these levels of exposure. Comparison with a similar survey in 1988/9 (HSE, 1990) showed the number of samples exceeding the MEL had been reduced significantly from 40.5% to 27.2%. Similarly, in 1988/9 only 12.2% of sites controlled all exposures to wood dust to below the MEL, whereas in 1999/2000 this figure had increased almost threefold to 34.0%. Nevertheless, the number of premises with at least one exposure in excess of 50mg/m$^3$ was similar.

Within the industries above exposure may also occur to solvents and formaldehyde in glues and surface coatings, phenol, wood preservatives, engine exhausts and fungal spores. According to Acheson *et al.* (1982b), the fact that woodworking machinists (who saw timber) and cabinet- and chain makers (who shape, finish, sand and assemble furniture) experience similar risks makes it unlikely that the tumours are due to a chemical agent applied to the wood at a particular stage of the process, but that they are more probably due to a substance in wood itself.

SNC has been associated with woodworking in many countries, including England (Acheson, 1976; Acheson *et al*, 1972; Acheson *et al*, 1981; Acheson *et al*, 1982b; Rang and Acheson, 1981), France (Luce *et al*, 1992), Denmark (Hernberg *et al*, 1983b; Olsen, 1988), Sweden (Hardell *et al*, 1982; Hernberg *et al*, 1983b), Finland (Hernberg *et al*, 1983b), the Netherlands (Hayes *et al*, 1986), Italy (Comba *et al*, 1992a; Comba *et al*, 1992b; Merler *et al*, 1986), the USA (Brinton *et al*, 1984; Robinson *et al*, 1996; Vaughan and Davis, 1991; Vaughan *et al*, 2000), Canada (Elwood, 1981) and Australia (Ironside and Matthews, 1975). Some of these studies are described below. The mean latent period (time of first exposure to time of cancer incidence) has been estimated to be 43 years (range 27-69) (Roush, 1996), and following termination of exposure the risk of SNC may persist for many years.

Elwood (1981) investigated the association between wood exposure and smoking with cancer of the nasal cavity and paranasal sinuses in British Columbia. Overall, 121 men were seen for SNC between 1939 and 1977. For each case three cancer controls were chosen who were of a similar age and had been diagnosed with an unrelated tumour at a similar time. The three controls were split into distinct groups; group one had tumours not related to outdoor exposure or smoking, group two had tumours known to be related to smoking and group three had tumours related to outdoor exposure. Patient medical records provided information on occupation, smoking, ethnicity and tumour. A list of occupations that involved exposure to wood (or other dusts) included outdoors work and other occupations and was produced independently. For control group 1 there was an increased risk for patients exposed to wood (RR=2.3, p=0.02), and after adjustment for smoking and ethnicity the risk remained elevated (RR=2.5, p<0.03). Investigation of exposure in the control group 1 compared to the general British Columbia population indicated it was a valid comparison group. The results were also found to indicate that the association with wood exposure were independent of smoking and outdoor work. The author noted that due to limitations in the data the true risks are likely to be higher than those reported, and that risk may not be restricted to those in furniture manufacture but also include individuals who handle wood in primary industries.

A follow-up study of 5,138 men who had worked in at least one of nine furniture factories in Buckinghamshire up to 1968 was conducted (Rang and Acheson, 1981). Details of employees born before 1940 were obtained from nine firms, information obtained included job held in the factory and date of termination of employment or death. The Furniture Manufacturers Association provided classification with respect to dust exposure (less dusty, dusty or very dusty). The general population of Oxford were used for reference. In total there were eight cases of nasal cancer in furniture workers over the period 1954-68 (SRR=727, 95%CI=314-1433) all of which were adenocarcinomas (SRR=13333, 95%CI=5757-26273). No cases occurred within the lowest exposure category, one occurred in relation to dusty exposure (All: SRR=500, 95%CI=13-2786, Adenocarcinoma: SRR=10000, 95%CI=253-55716) and seven in very dusty employment (All: SRR=1167, 95%CI=469-2404, Adenocarcinoma: SRR=2333, 95%CI=9381-48077). The trend of nasal cancer (all types) and of nasal adenocarcinoma with increasing occupational dustiness was found to be significant (p<0.05).

Acheson *et al*. (1981) conducted an occupational survey of nasal cancer in England and Wales. Incidence of nasal cancer was obtained for the period 1963-1967 from the Office of Population Censuses and Surveys. From this, hospitals, general practitioners and patients (or next of kin) were contacted to obtain details on occupation and smoking habits. There was a statistically significant increased risk found among male woodworkers (SIR=284, p<0.01, n=59), in particular, cabinet and chair makers (SIR=966, p<0.01) and machinists and other woodworkers (SIR=616 and SIR=293 respectively, p<0.05) and carpenters and joiners (SIR=149, p>0.05). With relation to type of tumour, a significant excess of adenocarcinoma was found among woodworkers (29 observed, 6.4 expected).

Hardell *et al*. (1982) reported results of an epidemiological study of nasal and nasopharyngeal cancer and exposure to several agents, one of which was woodwork. The study consisted of all male patients aged between 25-85 years who were residents of the three most northern counties of Sweden, whose cancer had been reported to the Swedish Cancer Registry over the period 1970-1979. Referents were taken from previous studies conducted in the Umeå region. Overall, there were 44 cases of nasal cancer included in the study, of which 19 reported working as a carpenter, cabinet maker or in a sawmill (Crude rate ratio = 2.0).

A study to investigate the connection between nasal and sinonasal cancer and occupational exposures in Denmark, Finland and Sweden was published in 1983 (Hernberg *et al*. 1983b). New cases of nasal and sinonasal cancer for the period July 1977 to December 1980 were collected from the national cancer registries for Finland and Sweden and from hospital records for Denmark. All cases were matched to a control for age and gender and country; controls were patients from the same sources with colonic or rectal cancer diagnosed in the same period. Detailed occupational histories were taken for each occupation held for more than one year, however, the last ten years of employment were not included to allow for a latency period. Exposures of interest were classified in relation to intensity (none, moderate, heavy), duration and calendar period. For the purpose of analysis those occupations classified as moderate or heavy exposure were deemed to be exposed. It is worth noting that in this study the occupation of lumberjack was categorised as unexposed. Exposure to hardwood dust alone was associated with a non-significant excess risk (OR=2.0, 95%CI=0.2-21.0, n=2), whereas exposure to softwood dust alone and exposure to a mixture of hardwood and softwood dust were associated with a significantly increased risk (Softwood: OR=3.3, 95%CI=1.1-9.4, n=13, Mixed: OR=12.0, 95%CI=2.4-59.2, n=12). It was also found that smokers had higher risks than non smokers. However, the authors note that due to the small numbers in the analysis no definite conclusions can be drawn. Investigation of the exposure histories for the cases revealed that hardwood dust exposure was associated with adenocarcinoma and softwood dust exposure only was associated with epidermoid and anaplastic carcinomas.

Brinton *et al*. (1984) conducted a case-control study focussing on cancer of the nasal cavity and paranasal sinuses, with particular relation to occupational exposures. Each occupational exposure investigated will be described in the relevant section of this report. The study included 193 patients, aged 18 years and over, diagnosed with a primary malignancy at four hospitals in North Carolina and Virginia between 1970 and 1980, and 232 hospital controls matched by hospital, year of admission, age, gender, race and state economic area of usual residence. Patients with particular conditions were excluded from being controls. Telephone interviews were conducted with study subjects or next of kin to determine various factors including occupational exposures. No excess of nasal cancer was found with relation to employment in furniture manufacturing (Male: RR=0.74, n=5, Female: RR=0.91, n=3, All: RR=0.79, 95%CI=0.3 -2.0) and other wood industries (Male: RR=0.65, n=3, All: RR=0.57, 95%CI=0.1-2.3). Non-significant increases in risk were found for lumbering (Male: RR=1.45, n=26, All: RR=1.39, 95%CI=0.7-2.6) and Carpentry (Male: RR=1.60, n=13, All: RR=1.48, 95%CI=0.6-3.4). However, any exposure to wood dust significantly increased the risk of adenocarcinoma (RR=3.68, n=10, $p<0.05$) particularly among the furniture industry (RR=5.68, n=4, $p<0.05$). Excess risks were also observed among all histological types of sinonasal cancer for those employed in lumber/carpentry industry, excess risk was also observed for sinonasal adenocarcinoma and work in the construction industry; other for other types of wood exposure and risk of squamous cell carcinoma. The authors note that this study indicated that the occupational hazard of wood dust exposure and nasal cancer is not limited to furniture makers.

A case-control study was conducted in the Netherlands to examine the relationship between woodworking and sinonasal cancer (Hayes *et al*. 1986). In total, 116 male patients aged 35-79 years were identified with sinonasal cancer between 1978 and 1981. Living/deceased controls were identified from the municipal/national death registries respectively. Job histories were obtained from individuals or close relatives and classified for occupational exposure to wood dust. Where required, estimates were adjusted for age and smoking. The risk of nasal adenocarcinoma was elevated in the wood and paper industry (OR=11.9, 90%CI=4.9-31.2) as was all nasal cancer (OR=1.7, 90%CI=1.0-2.9). High risks for nasal cancer were found for employment in furniture and cabinet making (OR=12.5, 90%CI=3.9-52.6, n=15; adenocarcinoma: OR=139.8, 90%CI=31.6-999.4, n=14), factory and carpentry work (OR=2.1, 90%CI=0.5-7.9, n=4; adenocarcinoma: OR=16.3, 90%CI=2.8-85.3, n=3) and employment in any wood related occupations (OR=2.5, 90%CI=1.4-4.6, n=25; adenocarcinoma: OR=17.6, 90%CI=6.9-49.2, n=17). When level of exposure was investigated, squamous cell carcinoma was related to any exposure and low-level exposure (Any: OR=1.3, 90%CI=0.7-2.4, n=17; Low: OR=2.5, 90%CI=1.1-5.2, n=12; Moderate: OR=0.7, 90%CI=0.2-2.4, n=3; High: OR=0.5, 90%CI=0.1-1.9, n=2). In contrast adenocarcinoma was related to any exposure and high-level exposure (Any: OR=8.5, 90%CI=3.4-25.4, n=18; Moderate: OR=1.6, 90%CI=0.1-12.3, n=1; High: OR=26.3, 90%CI=9.3-85.5, n=17). The authors found that the association between high wood dust exposure and adenocarcinoma was strongest for workers employed over the period 1930-1941; no cases were observed in men whose first exposure was after 1941. However, any high exposure over the three time periods (before 1930, 1930-1941 and after 1941) and length of employment (under 10 years, more than 10 years and more than 30 years) was associated with significantly elevated risks.

Olsen, (1988) investigated associations between occupation and sinonasal cancer in Denmark. All 382 cases of nasal cancer diagnosed between 1970 and 1984 from the linked Danish Cancer Registry-Supplementary Pension Fund data were analysed. The occupation held longest by the individual was chosen to be the most appropriate. The general population of Denmark was used for comparison. Estimates were adjusted for age and calendar period. Excess risks were found for men and women employed in the manufacture of wooden furniture (Male: SPIR=360, 95%CI=132-792, n=5; Female: SPIR=523, n=1). No risks were significantly elevated for wood workers employed outside the furniture manufacturing industry.

The relationship between wood dust exposure and squamous cell cancer of the upper respiratory tract was investigated using data from two population based case-control studies in Washington State over the period 1979-1987 (Vaughan and Davis, 1991). The Cancer Surveillance System of the Fred Hutchinson Cancer Research Center identified Cancer cases. At least two controls for each case were selected by random digit dialling and were chosen to have a similar age and gender distribution. Lifetime occupational histories were obtained by interviews. Nasal cancer was strongly associated with employment in wood-related occupations (OR=2.4, 95%CI=0.8-6.7) increasing to an OR of 3.1 (95%CI=1.0-9.0) after a 15-year induction period was considered. When exposure was defined as long term employment (more than 10 years) at least 15 years before diagnosis the risk increased further (OR=7.3, 95%CI=1.4-34.2). Estimates were adjusted for age, gender, smoking, alcohol consumption and race. The authors conclude that the finding suggest that exposure to softwood dust increases the risk of sinonasal squamous cell cancer.

Luce *et al*. (1992) conducted a case-control study in France to examine occupational risk factors for sinonasal cancer. In total, 207 cases diagnosed between January 1986 and February 1988 and 409 controls were analysed. Two sources of controls were combined, the first were hospital controls that had a different cancer diagnosed in the same time period, the second were individuals provided by the cases as someone who could be contacted on their behalf, all were matched for age and gender. Due to the similarities in socio-demographic and occupational factors the two groups were combined for the analysis. Detailed information was collected on occupational history and other potential risk factors. Among males, the risk of nasal cancer was significantly elevated for cabinetmakers (adenocarcinoma: OR=35.4, 95%CI=18.1-69.3, n=37; other: OR=11.2, 95%CI=2.7-45.9, n=3), carpenters and joiners (adenocarcinoma: OR=25.2, 95%CI=14.6-43.6, n=48; other: OR=5.8, 95%CI=1.8-18.6, n=4) and wood working machine operators (adenocarcinoma: OR=7.4, 95%CI=3.4-15.8, n=15). Squamous cell cancer was only found to be significantly elevated in male workers employed for at least 15 years in the wood manufacturing industry as a carpenter or joiner (OR=8.1, 95%CI=1.3-50.3). For adenocarcinoma, the risks did not alter after a fifteen-year induction period was taken into account. No elevated risks were observed for females employed in wood related occupations. The authors note that adjustment for smoking did not change the risk estimates. They also note the risk estimates may be underestimated as the reference group for each occupational group includes all individuals who had never worked in that occupation but could have been employed in another occupation associated with an increased risk.

A case-control study conducted in the province of Brescia investigated the association between nasal cancer and work in the metal industry (Comba *et al*. 1992a). In total, thirty-five cases of nasal cancer in Brescian residents were diagnosed or treated at the Brescia Hospital over the period 1980-1989. Controls (n=102) were residents of Brescia and patients at the hospital with benign and malignant neoplasms of the head and neck matched to cases by age and gender. Through telephone interviews with the patient or next of kin, detailed information on occupational history was collected, including details about employment in wood working industries, as this was regarded as a potential confounder. An excess risk for woodworkers was observed, after adjustment for age (OR=11, 90%CI=0.85-139, n=3). The authors note that the high risk of nasal cancer in wood workers is consistent with earlier findings.

Comba *et al*. (1992b) conducted a case-control study in the provinces of Verona and Vicenza and Siena. Cases of nasal cancer diagnosed in the years 1982-1987 and controls admitted to the same hospitals were included in the analysis. Controls were matched to cases by age, gender, residency and date of admission. Patients or their next of kin were interviewed to obtain information on occupational history. Individuals were deemed to be unexposed for creation of the reference category if they had never been exposed to work involving wood, leather, metal, textile, mining and construction, farming or other occupations involving exposure to dusts and fumes. For males, a significant increase was associated with work in the wood industry (OR=5.8, 90%CI=2.2-16, n=14); work as a furniture maker, joiner or carpenter had an increased risk of 6.5 (90%CI=2.1-20), whilst work as a lumberjack had a lower risk of 4.1 (90%CI=1.1-15). In females an elevated risk was observed for work in the wood industry but this was non-significant and based only on one case and one control (OR=3.2, 90%CI=0.32-32). Estimates were adjusted for age and gender.

A pooled reanalysis of data from five cohort studies- British furniture workers, members of the union representing furniture workers in the US, plywood workers and wood model makers - was undertaken to provide information of the risk of cancer associated with wood dust (Demers *et al*. 1995a). Appropriate general mortality rates were used for comparison. A significant excess of nasal cancer was observed (SMR=3.1, 95%CI=1.6-5.6, n=11). This excess was subsequently discovered to be among furniture workers (SMR=4.3, 95%CI=2.2-7.8, n=11) and amongst those with definite exposure (Possible: SMR=0.8, 95%CI=0.0-4.6, n=1; Probable: SMR=1.2, 95%CI=0.0-6.5, n=1; Definite: SMR=8.4, 95%CI=3.9-16.0, n=9). The risk for sinonasal cancer was greatest among workers first employed before 1940 (before 1940: SMR=12.5, 95%CI=5.7-23.7, n=9; 1940-1949: SMR=1.2, 95%CI=0.1-6.6, n=1; 1950-1959: SMR=0.7, 95%CI=0.0-3.8, n=1) and workers with at least 30 years since first employment (20-29years: SMR=2.6, 95%CI=0.5-7.6, n=3; over 30 years: SMR=7.6, 95%CI=3.3-185.0, n=8). Further investigation revealed a significant excess of nasal cancer among furniture workers employed in the highest wood dust category prior to 1940 (SMR=18.6, 95%CI=8.0-36.6, n=8). The authors conclude that the risk of nasal cancer appeared to be associated with exposure to wood dust but was primarily based on cases from the British furniture worker cohort.

Demers *et al*. (1995b) published a pooled reanalysis of twelve case-control studies investigating the association between wood dust and sinonasal cancer from seven countries. A job exposure matrix based on occupation and industry titles was used to determine the risk associated with wood-related jobs and exposure to wood dust. The combined dataset consisted to 680 male and 250 female cases and 2,349 male and 787 female controls. Estimates were adjusted for age and study. An increased risk of nasal cancer was observed for employment in all wood related occupations for males (OR=2.0, 95%CI=1.6-2.5, n=220) and females (OR=1.6, 95%CI=0.9-2.8, n=18). For males this was evident among sawmill, furniture, carpentry and other wood production workers. The highest risk for both males and females was found to be for adenocarcinoma (Males: OR=13.5, 95%CI=9.0-20.0, n=120; Females: OR=2.8, 95%CI=0.8-10.3, n=3). Women in jobs exposed to wood dust also had an excess of squamous cell carcinoma (OR=2.1, 95%CI=0.8-5.5). The risk of nasal cancer and adenocarcinoma among men was found to increase with exposure and evidence was found to be particularly strong for workers with high exposure (Nasal: OR=5.8, 95%CI=4.2-8.0, n=126; Adenocarcinoma: OR=45.5, 95%CI=28.3-72.9, n=104). A similar trend was not observed for women, although this could be due to small numbers. The risks of all nasal cancer and adenocarcinoma were significantly increased in males and non-significantly in females with duration of exposure. This appeared to be greatest in workers employed in moderate or high wood dust occupations. Introduction of a latency period of 5, 10 or 20 years further strengthened the association between duration of employment and adenocarcinoma. The authors conclude that the findings strongly support the association between exposure to wood dust in many occupations and sinonasal adenocarcinoma; however, the evidence for squamous cell carcinoma is ambiguous.

### 2.2.2 Formaldehyde

Formaldehyde is used mainly in the production of phenolic, urea, melamine and polyacetal resins. These have wide uses as adhesives and binders for the wood products, pulp and paper, and synthetic vitreous fibre industries and in the production of plastics and coatings and in textile finishing. It is also used extensively as an intermediate in the manufacture of industrial chemicals, and directly in aqueous solution (formalin) as a disinfectant and preservative in many applications. Occupational exposure occurs in a wide range of occupations and industries, the highest being observed during the varnishing of furniture and wooden floors, in the finishing of textiles, the garment industry, the treatment of fur and in certain jobs within manufactured board mills and foundries. Short-term high exposures have been reported for embalmers, pathologists and paper workers.

Sinonasal cancers occur in rats exposed to formaldehyde vapour (Albert *et al*, 1982). The widespread ambient exposures (e.g. via particleboard, MDF and insulation) have led to substantial interest in assessing the risks related to exposure to formaldehyde (Acheson, 1985). Studies have suggested associations most commonly with nasopharyngeal cancer rather than SNC (Blair *et al*, 1987; Blair *et al*, 1986; Vaughan *et al*, 1986a; Vaughan *et al*, 1986b). The most recent IARC monograph concerned with formaldehyde (IARC 2006) stated that there is sufficient evidence of carcinogenicity in humans and hence re-classified formaldehyde from Group 2A (IARC 1995) to Group 1.

Exposure to formaldehyde appears to be an independent risk factor for adenocarcinoma of the nasal cavity and sinuses (Luce *et al*, 1993). A pooled analysis (Luce *et al*, 2002) showed an increased risk in men and women (thought never to have been exposed to wood dust or leather dust), with an exposure-response trend for an index of cumulative exposure. Two other studies have shown an increased risk (Hansen and Olsen, 1995; Olsen and Asnaes, 1986), whilst larger studies have shown no excesses (Coggon *et al*, 2003; Hauptmann *et al*, 2004; Pinkerton *et al*, 2004).

As described previously Brinton *et al*. (1984) conducted a case-control study on nasal cancer. They found a non-significant deficit in risk associated with reported exposure to formaldehyde (Males: RR=0.28, n=1, Females: RR=0.48, n=1, Total: RR=0.35, 95%CI=0.1-1.8). The authors note that this finding could be due to the small numbers reporting exposure to formaldehyde.

Using a data system that links cancer incidence from the Danish Cancer Registry to occupational information, 488 cases of nasal carcinoma and 2465 cancer controls (colon, rectum, prostate/breast) were identified between 1970 and 1982 (Olsen *et al*, 1984). The level of risk for both males and females was found to be the same (RR=2.8); however the increased risk was only significant for males (Males: 95%CI=1.8-4.3, n=33, Females: 95%CI=0.5-14.3). When a 10-year latency period was taken into account, the risk of nasal carcinoma in males increased to 3.1; which was still found to be significant (95%CI=1.8-5.3, n=23). The authors noted that wood dust exposure was a confounding factor for nasal cancer; but after adjustment for exposure to wood dust and age, the risk for males reduced to 1.6; which was no longer significant.

Olsen and Asnaes (1986) conducted a case-control study on 287 nasal and 179 paranasal sinuses cancer cases diagnosed in Denmark between 1970 and 1982 to investigate the relationship with occupational exposure to formaldehyde. Cases and controls were selected from the files of the Danish Cancer Registry. Approximately three controls for each case were selected from patients with cancer of the colon, rectum, prostate and breast diagnosed in the same period. Information on job history was obtained from national data systems; subsequently industrial hygienists assessed exposure to formaldehyde. After adjustment for wood dust exposure, there were excesses found for both squamous cell carcinoma (RR=2.3, 95%CI=0.9-5.8, n=13) and adenocarcinoma (RR=2.2, 95%CI=0.7-7.2, n=17) among men who had ever been exposed to formaldehyde. A 10-year latency period was considered but this did not greatly affect the risk estimates (Squamous Cell Carcinoma: RR=2.4, 95%CI=0.8-7.4, n=8, Adenocarcinoma: RR=1.8, 95%CI=0.5-6.0, n=12). In the sub-population not exposed to wood dust an excess risk was observed after exposure to formaldehyde (Squamous Cell Carcinoma: RR=2.0, 95%CI=0.7-5.9, n=4, Adenocarcinoma: RR=7.0, 95%CI=1.1-43.9, n=1). Again, adding a 10-year latency period did not affect the results (Squamous Cell Carcinoma: RR=1.4, 95%CI=0.3-6.4, n=2, Adenocarcinoma: RR=9.5, 95%CI=1.6-57.8, n=1). No results are presented for women as the exposure rates were found to be too low to allow estimation. The authors noted that due to the strong relationship between adenocarcinoma and wood dust it may be difficult to obtain an unbiased estimate of the influence of formaldehyde.

A case-control study was conducted in France to determine whether occupational exposure to formaldehyde was associated with an increased risk of sinonasal cancer (Luce *et al*. 1993). Overall 207 cases and 409 controls were interviewed to obtain detailed job history information. No significant association was found between formaldehyde exposure and squamous cell carcinoma of the nasal cavities. As mentioned by Olsen and Asnaes (1986), Luce and colleagues also found that it was not possible to assess the independent effect of formaldehyde and nasal adenocarcinoma due to the strong association with wood dust. However, the authors concluded that exposure to formaldehyde may increase the risk of nasal adenocarcinomas, by comparison with the risk due to wood dust versus wood dust and formaldehyde.

Hansen and Olsen (1995) investigated mortality in Denmark during the period 1970-1984. Male cancer cases were identified who had been employed since 1964 in one of 265 companies in which there was exposure to formaldehyde and had worked at least 10 years prior to diagnosis. Exposure was determined using job titles: white-collar workers (low) and blue-collar workers (above baseline). National cancer rates of Denmark were used as reference. Estimates were adjusted for age and calendar time. A significantly elevated risk was observed for cancer of the sinonasal cavities (SPIR=2.3, 95%CI=1.3-4.0, n=13). Elevated risks were found among workers exposed to both wood dust and formaldehyde (SPIR=5.0, 95%CI=0.5-13.4) and among workers moderately exposed to formaldehyde but with no probable exposure to wood dust (SPIR=3.0, 95%CI=1.4-5.7). The risk of cancer of the nasal passages only was 2.9 (95%CI=1.3-5.3, n=9). The authors conclude that their study provides further evidence that occupational exposure to formaldehyde increases the risk of sinonasal cancer.

An analysis of European case-control studies on sinonasal cancer was conducted to examine the risk of occupation by gender and histological type (Mannetje *et al*. 1999). The pooled data consisted of 104 female and 451 male sinonasal cancer cases and 241 female and 1,464 male controls. Detailed information on lifetime occupational history was collected in all studies. Exposure to wood dust, leather dust and formaldehyde was determined via a job exposure matrix. Estimates were adjusted for age, gender, study and other occupational exposures. In women, there was no excess of SNC observed due to formaldehyde (OR=0.83, 95%CI=0.41-1.69, n=15). However, there was a significantly increased risk found in men (OR=1.66, 95%CI=1.27-2.17, n=229). Exposure to formaldehyde was particularly associated with adenocarcinomas rather than squamous cell carcinomas (Adenocarcinoma: OR=3.30, 95%CI=1.98-5.49, n=124, Squamous Cell Carcinoma: OR=1.27, 95%CI=0.92-1.74, n=80).

Luce *et al*. (2002) conducted a pooled analysis on data from 12 case-control studies to examine the associations between sinonasal cancer and occupational exposures. The pooled data set consisted of 195 adenocarcinomas, 432 squamous cell carcinomas and 3,136 controls. Occupational exposures were determined by job exposure matrix. Estimates were adjusted for age, study and other occupational exposures, including wood and leather dust. An increased risk for adenocarcinoma was found for exposure to formaldehyde in both males (Low: OR=0.7, 95%CI=0.3-1.9, n=6, Medium: OR=2.4, 95%CI=1.3-4.5, n=31, High: OR=3.0, 95%CI=1.5-5.7, n=91) and females (Low: OR=0.9, 95%CI=0.2-4.1, n=2, High: OR=6.2, 95%CI=2.0-19.7, n=5). Among subjects never exposed to wood or leather dust, increased risks for adenocarcinomas were still present (Male: Low: OR=0.3, 95%CI=0.0-2.3, n=1, Medium: OR=1.4, 95%CI=0.5-4.3, n=4, High: OR=1.9, 95%CI=0.5-6.7, n=3, Female: Low: OR=0.5, 95%CI=0.1-3.9, n=1, High: OR=11.1, 95%CI=3.2-38.0, n=5). Excesses were also found for squamous cell carcinoma in both males (Low: OR=1.2, 95%CI=0.8-1.8, n=43, Medium: OR=1.1, 95%CI=0.8-1.6, n=40, High: OR=1.2, 95%CI=0.8-1.8, n=30) and females (Low: OR=0.6, 95%CI=0.2-1.4, n=6, Medium: OR=1.3, 95%CI=0.6-3.2, n=7, High: OR=1.5, 95%CI=0.6-3.8, n=6). For men, the risk was also increased for 30 or more years of exposure to formaldehyde (OR=1.4, 95%CI=0.9-2.3). The authors concluded that the results of the pooled analysis supported the hypothesis that occupational exposure to formaldehyde increases the risk of sinonasal cancer, particularly adenocarcinomas.

In 2003, an extended study of a cohort of British chemical workers from six factories where formaldehyde was produced or used was published (Coggon *et al*. 2003). The cohort consisted of 14,014 men employed after 1937 (identified from employment records). From the records jobs were categorised for exposure to formaldehyde (background, low, moderate, high and unknown). The cohort was followed for mortality and cancer incidence from January 1941 to December 2000 via the National Health Service Central Register. National mortality rates for England and Wales were used as a comparison population. Overall, there were two deaths from sinonasal cancer recorded (SMR=0.87, 95%CI=0.11-3.14). Neither man had been exposed to high levels of formaldehyde (>2ppm), but one death had occurred in the extended follow-up period from 1990-2000 (SMR=1.68, 95%CI=0.04-9.34).

Two other cases of sino-nasal cancer were registered in men whose deaths were assigned to other causes. The authors concluded that a small effect of risk of sinonasal cancer from exposure to formaldehyde cannot be ruled out.

Hauptmann *et al*. (2004) carried out an extended follow-up of a large cohort of exposed workers in the USA. In total 25,619 workers employed in ten US facilities that produce or use formaldehyde were examined for mortality to 1994. Various resources were used to determine vital status. Exposure to formaldehyde was estimated based on job titles and visits to the plants. Standardised mortality ratios were estimated using the US population as reference and relative risks were adjusted for calendar year, age, gender, race and pay category. A 15-year lag period for exposure was also included. An excess for cancer of the nose and nasal cavity among exposed workers was observed (SMR=1.19, 95%CI=0.38-3.68, n=3). A non-significant increase in risk was found for the highest average exposure observed among nasal cancer deaths (exposure range (0-0.5ppm): RR=1.00, n=2 and 0.5-1.0ppm: RR=1.48, n=1), peak exposure (exposure range (0-2.0ppm): RR=1.00, n=1; 2.0-4.0ppm: RR=1.55, n=1 and >4.0ppm: RR=1.47, n=1) and cumulative exposure (exposure range (0-1.5ppm): RR=1.00, n=2 and 1.5-5.5ppm: RR=1.32, n=1). The authors note that although the analysis is consistent with an effect between cancer of the nasal cavity and formaldehyde, the number of deaths was too low to enable a firm conclusion to be reached.

### 2.2.3 Boot and Shoe Manufacture and Repair

In 1980, and again in 1987, IARC concluded that there is an excess risk of cancer among people employed in the boot and shoe manufacturing and repair industry (IARC, 1981; IARC, 1987b). The strongest evidence cited was for excess risks for sinonasal cancer and leukaemia. Some of the exposures found in these industries (e.g. formaldehyde and tannin) may overlap with those found in woodworking, and it is interesting that adenocarcinomas appear to be more strongly related to this type of exposure.

Relative risks well in excess of ten-fold have been reported from studies in England and Italy (Acheson *et al*, 1982a; Merler *et al*, 1986). People who worked in the dustiest operations were found to be at the greatest risk suggesting a role for exposure to leather dust. A further study of over 500 men in three UK towns showed a significant risk to those in the dustiest operations within the industry (Pippard and Acheson, 1985). However, other PMR and cohort studies have shown no excess of nasal cancer (Decoufle and Walrath, 1983; Garabrant and Wegman, 1984; Paci *et al*, 1989; Walker *et al*, 1993; Walrath *et al*, 1987).

Acheson *et al*. (1970a; 1970b) conducted an analysis of nasal cancer in the Northamptonshire boot and shoe industry. Over the period 1953-1967 there were 46 cases of sinonasal cancer (29 male and 17 female) recorded on the Oxford Cancer Register. Occupational histories were obtained by questionnaire or interview with the individual or a relative where possible. Other sources of information included hospital records, death certificates and trade union records. Male cancer rates in the Southern Register area of Northamptonshire were used as reference. Only results of male boot and shoe workers are published. Of the 29 male cases of sinonasal cancer there were 17 cases in employees from the boot and shoe trade (7 adenocarcinomas, 7 squamous carcinomas and 3 other types). Overall the risk for SNC was constant across the two age groups studied (15-64yrs: SIR=8, n=9; >65yrs: SIR=8, n=8; All: SIR=8, n=17). The risk of squamous carcinoma was also constant across age groups with an SIR of 4 (15-64yrs: n=4; >65yrs: n=3; All: n=7). In contrast the risk for adenocarcinoma increased with age (15-64yrs: SIR=20, n=2; >65yrs: SIR=50, n=5; All: SIR=35, n=7). From further inspection of incidence rates and occupational histories, the authors concluded that there is evidence that the increased risk of cancer in the boot and shoe industry is concentrated among workers exposed to various dusts.

In an extended follow-up from 1950 through 1979 an increased risk of sinonasal cancer was observed within the footwear manufacturing industry (Acheson *et al*, 1982a). As found previously, the excess was found to be limited to the workers who were exposed to the dust of leather soles and heels. The authors note that despite the reduction of workers involved in these processes there is no evidence of a decline in incidence of sinonasal cancer.

As described previously, Brinton *et al*. (1984) conducted a case-control study on nasal cancer. They found no significantly elevated risk associated with reported work in the leather or shoe industry (Males: RR=2.01, n=2, Total: RR=1.26, 95%CI=0.1-9.4). This finding could be due to the small numbers reporting employment in this industry.

Pippard and Acheson (1985) conducted a mortality study of 5,017 men employed in the boot and shoe manufacturing industry in the towns of Great Britain. Follow-up was through 1982. The mortality ratios of the counties of the three towns were used for reference. There was an excess of death from nasal cancer observed (Observed=10, Expected=1.87) which was found to be significant among workers in the finishing room.

A case-control study was conducted on cancer incidence of nasal tumours occurring between 1968 and 1982 among Vigevano residents (Merler *et al,* 1986). Occupational histories were taken via interview and exposure to leather dust (and other shoe making substances) was assigned as "none", "light/uncertain" or "heavy" by occupational physicians. Two controls per case were matched by vital status, age, sex and residence. The overall odds ratio for exposure to leather dust was 47.1 for men (95%CI=8.7-255.1) and 3.5 for women (95%CI=0.2-59.0). For "heavy" exposure the OR was 121.0 (95%CI=17.3-844.3, n=11 - all male) and for "light/uncertain" exposure the OR was 7.5 (95%CI=1.8-31.7, n=8), which resulted in a significant trend for the level of exposure to leather dust (p-value<0.001). The odds ratio was higher for adenocarcinoma (Overall: OR=41.4, 95%CI=7.6-226.8, n=13; "heavy": OR=88.0, 95%CI=12.1-642.0, n=8; "light": OR=20.4, 95%CI=2.7-152.0, n=5) compared to other tumours (Overall: OR=6.9, 95%CI=1.4-34.4, n=5) and among workers exposed to the worst conditions (OR=12.9, 95%CI=1.6-104.4, n=18), after controlling for exposure to solvents. The authors note that smoking habits and exposure to other solvents are unlikely to confound the relationship found between exposure to leather dust and sinonasal cancer.

Battista *et al*. (1995) investigated nasal cancer in leather workers in the provinces of Tuscany and Venetia. Cases were defined as a diagnosis of nose and paranasal sinus neoplasm diagnosed between 1982 and 1987. Four controls were matched to each case via sex, age, residence and time of hospital admission. Work histories were taken via interview and questionnaire. In total, 96 cases and 378 controls were enrolled in the study. There was a significant association with employment in the leather industry (OR=6.8, 95%CI=1.9-25, n=26) in particular in the shoe-making industry (OR=8.3, 95%CI=1.9-36, n=16) and non-significantly in the leather tanning industry (OR=5.0, 95%CI=0.92-28, n=2).

Data from two historical cohorts from England and Italy were extended and analysed for cancer risk in shoe manufacturing workers (Fu *et al*, 1996). The English cohort consisted of 4,215 male shoe and boot manufacturing workers (previously analysed by Pippard and Acheson, 1985), the follow-up was extended by 9 years, from 1939 to 1991. The Italian cohort consisted of 2,008 male and female workers who had ever been employed after 1939 and worked between 1950 and 1984 at a large shoe manufacturing plant in Florence, the follow-up was extended by 6 years, from 1950 to 1990. Exposure categorisation (high/probable dust and high/probable solvents) was determined via available work histories and job titles. National mortality rates were used for reference. An increased risk of nasal cancer was found in both cohorts (England: SMR=7.41, 95%CI=3.83-12.94 n=12, Italy: SMR=9.09, 95%CI=0.23-50.65, n=1). Of the workers directly involved in shoe production, these excesses remained (England: SMR=8.05, 95%CI=4.16-14.10, n=12, Italy: SMR=12.50, 95%CI=0.31-69.70, n=1). The risk in the English cohort appeared to be associated with exposure to leather dust (probable: SMR=11.70, 95%CI=5.34-22.20, n=9, high: SMR=25.00, 95%CI=0.63-139.00, n=1). In the Italian cohort the elevated risk was associated with probable exposure to solvents. The majority of the English cases occurred among workers employed in the manufacture of welted boots (SMR=9.26, 95%CI=4.44-17.00, n=10), a sector of the industry thought to have the highest exposure to leather dust. However, excesses among production of women's shoes (SMR=3.33, 95%CI=0.08-16.80, n=1) and women's and children's shoes (SMR=4.17, 95%CI=0.10-23.20, n=1) were also found in England. The authors concluded that their findings confirm the associations between exposure to leather dust and nasal cancer in the shoe manufacturing industry.

### 2.2.4 Nickel

Nickel has many uses in industry because of its unique properties. The majority of all nickel is used in alloys, because it imparts such properties as corrosion resistance, heat resistance, hardness, and strength. The main uses are in the production of stainless steel, copper-nickel alloys, and other corrosion-resistant alloys. Pure nickel is used in electroplating, as a chemical catalyst, and in the manufacture of alkaline batteries, coins, welding products, magnets, electrical contacts and electrodes, spark plugs, machinery parts, and surgical and dental prostheses. Exposure to nickels occurs by inhalation, ingestion and skin contact of airborne fumes, dusts and mists in nickel and nickel alloy production plants as well as in welding, electroplating, grinding and cutting operations.

The maximum exposure limit for soluble nickel salts is 0.1mg/m$^3$ (as Ni; 8-hr TWA); for insoluble salts the limit was 3mg/m$^3$ (as Ni; 8-hr TWA), which was reduced to 0.5mg/m$^3$ (as Ni; 8-hr TWA) in 1992. For metallic nickel a limit of 1mg/m$^3$ (as Ni; 8-hr TWA) was set in 1984, which was subsequently reduced to 0.5mg/m$^3$ (as Ni; 8-hr TWA) in 1992.

Early studies of industrial cohorts suggested that the risk of sinonasal cancer associated with nickel exposure arose in the course of the nickel refining process (Brinton *et al*, 1984; Hernberg *et al*, 1983b; Roush *et al*, 1980). This has been attributed to exposure to a mixture of oxides and sulphides of nickel, although increased risk has also been found with exposure to oxides of nickel in the absence of sulphides. Most of the observations of elevated risk appear to be in workers exposed to high levels of soluble nickel compounds through processes that have not been used in GB for many years.

Roush *et al*. (1980) report findings from a case-control study of sinonasal cancer among individuals who died in Connecticut over the period 1935-1975. Cases of sinonasal cancer were determined via the Connecticut Tumour Registry and limited to males aged over 35 years at death. Controls were obtained from the Connecticut Division of Health Statistics. Occupations were taken from death certificates and city directories. These occupations were compared to job titles in published literature to determine likely exposure circumstances. Actual exposures to substances were not obtained. Work entailing nickel exposure was found to have a non-significant deficit for the risk of sinonasal cancer (OR=0.7, 95%CI=0.4-1.5).

As described previously, Brinton *et al*. (1984) conducted a case-control study on nasal cancer. They found no significantly elevated risk associated with reported exposure to nickel (Males: RR=1.98, n=1, Total: RR=1.78, 95%CI=0.1-27.6). This finding could be due to the small numbers reporting exposure to nickel.

A cohort of male employees of the Falconbridge nickel refinery during 1916-1983 was followed for cancer incidence (Andersen *et al*. 1996). Two sets of employees were identified consisting of those who had started work between 1916 and 1940 with three or more years employment (379 workers) and employees with more than one year exposure who had started work between 1946 and 1983 (4,385 workers). Employees were followed from the beginning of 1953 to the end of 1993; each individual ‘follow-up’ commenced after three years of employment (for those starting in the period 1916-1940) and after one year (for those starting after 1946). The Cancer Registry in Norway was used to ascertain cancer status. The Norwegian male population were used as reference. Estimates of exposure were based on published literature, measurements made at the refinery in 1973 and expert estimation. The workers were found to have an increased risk for sinonasal cancer (SIR=18, 95%CI=12-25, n=32). Nickel oxide is the most frequently encountered form of nickel in the refinery and it was discovered that 13 of the sinonasal cancer cases had a very high cumulative exposure to nickel oxide. A positive dose-response was found between sinonasal cancer and exposure to both nickel oxide and soluble nickel. However, the authors note that the risk may be diminishing as all 32 cases were among workers who were first employed prior to 1956.

Anttila *et al*. (1998) assessed cancer risk among workers exposed to nickel in Finland. Cancer incidence to December 1995 was obtained from the Finnish Cancer Registry for 1,388 workers (1,339 males and 49 females) employed for at least 3 months at a copper/nickel smelter and nickel refinery in Harjavalta. In total there were 1,155 workers exposed to nickel over the period 1960-1985 (smelter-

566, repair shop-239 and refinery-418). Region-specific (south-western Finland) population rates of cancer were used as reference. Estimates were adjusted for age, gender and calendar period. Exposure to nickel was determined via available records from hygienic measurements made from 1966 onwards. There was a significantly increased risk of nasal cancer among workers ever exposed to nickel (SIR=8.79, 95%CI=1.06-31.7, n=2), this persisted after a 20-year latency was taken into account (SIR=15.9, 95%CI=1.92-57.3, n=2). Both cases of nasal cancer occurred in nickel refinery workers. In this sub-cohort there continued to be an increased risk of nasal cancer among workers exposed to nickel sulphate below 0.5mg/m$^3$ and low concentrations of other nickel compounds (SIR=41.1, 95%CI=4.97-148, n=2). This increased risk persisted after a 20-year latency was taken into account (SIR=67.1, 95%CI=8.12-242, n=2) and in workers with a duration of employment greater than 5 years (SIR=75.2, 95%CI=9.10-271, n=2). The risk of nasal cancer was found to increase with the duration of employment (results not provided). Since elevated nasal cancer risks were limited to the refinery, where the primary exposure was nickel sulphate, the authors concluded that it is likely that this substance is responsible for the elevated risk. The authors also note that the risk reported in the study is likely to be an underestimate, as soon after the follow-up of the cohort came to an end another nasal cancer was diagnosed, and, a further case of cancer on the nose with unknown origin (coded as nasopharyngeal) may also be nasal cancer.

Mortality and cancer incidence among Swedish battery workers exposed to nickel hydroxide and cadmium oxide was investigated (Järup *et al*, 1998). Overall 869 workers, employed for at least a year between 1940 and 1980 were followed until 1992. Vital status and cause of death were obtained from the Swedish cause of death registry and cancer cases were obtained from the Swedish cancer registry. Regional rates were used for reference. Exposure was determined via employment records and previous measurement reports. No results for mortality from sinonasal cancer are provided. A significantly increased risk for cancer of the nose and nasal sinuses in men was found (SIR=832, 95%CI=172-2430, n=3). After a 10-year latency period was considered and an exposure for nickel of ≥2000$\mu$g/m3 the SIR increased to 1080 (95%CI=131-3900, n=2). However, these two cases were also exposed to cadmium, thus the authors note that the increased risk of sinonasal cancer may be associated with exposure to nickel, cadmium or a combination of both exposures.

Sorahan and Williams (2005) conducted a mortality study of 812 workers from a nickel carbonyl refinery in Clydach. All male workers first employed at the refinery in the period 1953-1992 with at least 5 years employment were included in the study. National male mortality rates from England and Wales were used for reference. Exposure was determined via company records. Follow-up was from 1958 through 2000. Individual vital status was established from company records, electoral register lists and the National Health Service Central Register. Causes of death were obtained from death certificates. Overall only one death was recorded for SNC (SMR=9.95, Exp=0.1). The authors note that this result is in contrast to other studies conducted on this cohort for workers employed before 1930.

Further to the above study, the risk of nasal cancer among workers at the Clydach nickel refinery since 1930 was evaluated (Grimstrud and Peto, 2006). The study combined data from the two most recently published papers for the cohort (Sorohan and Williams, 2005 and Easton *et al*. 1992). Workers who were employed for a minimum of five years and employed for the first time between 1902 and 1992 were included. A persisting excess risk of nasal cancer was found for workers employed over the study period. For first employment between 1902-1919 and 1920-1929, risks of sinonasal cancer were significantly elevated (1902-1919: SMR=37.67, 95%CI=284.61-493.18, n=55 and 1920-1929: SMR=72.55, 95%CI=37.51-126.96, n=12). First employment between 1930-1939 and 1953-1992 were non-significantly elevated (1930-1939: SMR=14.34, 95%CI=0.36-79.87, n=1 and 1953-1992: SMR=9.95, 95%CI=0.25-55.42, n=1). The combined estimate (employment for the period 1930-1992) was found to be statistically significant (SMR=8.70, 95%CI=1.05-31.41, n=2). The evidence for an excess risk is weak in refiners first employed after 1950, when the refinery process was modified improving work conditions and reducing occupational dust exposures.

### 2.2.5 Chromium

Chromium VI (CrVI) has been widespread in commercial use for over 100 years because of its property as a corrosion inhibitor. Early uses included chrome pigments and tanning liquors. More recently is has been widely used in chromium alloys and chrome plating. The steel industry is the major consumer of chromium. Of the occupational situations in which exposure to chromium occurs, highest exposures to chromium VI may occur during chromate production, welding, chrome pigment manufacture, chrome plating and spray painting; highest exposures to other forms of chromium occur during mining, ferrochromium and steel production, welding and cutting and grinding of chromium alloys. A MEL for all chromium VI compounds of 0.05mg/m$^3$ (8-hr TWA) was established in 1992. IARC classified chromium VI compounds as a Group 1 carcinogen in 1990 (IARC, 1990a). Only inhalation is considered a concern for occupational exposure, thus the lung is the major site of concern.

Sinonasal cancer has been associated with hexavalent chromate in primary studies of chromate production workers in Japan, the UK and the USA, of chromate pigment production workers in Norway and of chromium platers in the UK, although in the latter study the observed excess was not considered to be due to chromium exposure.

As described previously, Brinton *et al.* (1984) conducted a case-control study on nasal cancer. They found no significantly elevated risk associated with reported exposure to chromium (Males: RR=5.09, n=5, Total: RR=1.49, 95%CI=0.4-5.6). The authors note that this finding is consistent with other surveys conducted on workers involved in manufacturing of chromate pigments. The study found that the risk appeared to be associated with the use of chromate products in the building industry and painting rather than manufacture.

Davies *et al.* (1991) reported findings of an update of mortality from respiratory cancer in UK chromate production workers. Three factories were included in the analysis, and all workers who were engaged in major plant and process work. In total 2,298 workers who were employed between 1950 and 1976 with at least one year employment were observed for cancer mortality to 1988. Three main groups of workers were created; those employed before 1945 (early), those employed prior to major process changes (pre-change) and those employed after the major process changes (post-change). Information on vital status was available from factories, the National Health Service Central Register and the Scottish General Register Office. National death rates were used for reference. Estimates were adjusted for social class and area of residence. In total there were four deaths from nasal cancer, occurring in two of the factories (Rutherglen and Eaglescliffe). In Rutherglen these deaths were among "early" workers (SMR=30.42, p<0.01) and in Eaglescliffe were among "prechange" workers (SMR=18.24, p<0.01). This resulted in a combined significant excess of death from nasal cancer (SMR=15.38, n=4). All four men had more than 20 years of employment and exposure to chromates. Latency was found to vary from 29 years to 53 years.

A mortality study of chromium smelter workers in New Jersey was conducted (Rosenman and Stanbury, 1996). Individuals were identified in 1990-1991 from the Social Security records of four former chromate producing facilities; two of which (A and B) were owned by the same company. Various record sources were used to determine vital status, and cause of death was obtained from death certificates. The general population of the USA were used as reference. Both proportionate mortality and proportionate cancer mortality ratios were calculated. Estimates were adjusted for age and time period. In white men there was a significantly elevated risk nasal cavity/sinus cancer (PMR= 6.85, 95%CI=3.14-14.94; PCMR=5.18, 95%CI=2.37-11.30, n=6). Increases in risk were also seen for

- Duration of work: 1-10yrs: PMR= 6.87 (95%CI=1.88-25.06) and PCMR= 4.88 (95%CI=1.34-17.79) n=2; 10-20yrs PMR=23.62 (95%CI=8.03-69.50) and PCMR= 14.29 (95%CI=4.86-42.01) n=3; >20yrs: PMR= 15.38 (95%CI= 2.71-87.16) and PCMR= 9.26 (95%CI=1.63-52.45) n=1,
- Latency from time since first employed: 0-10yrs: PMR= 28.99 (95%CI=7.95-105.70) and PCMR= 15.5 (95%CI= 4.25-56.54) n=2; 10-20yrs: PMR=5.32 (95%CI=0.94-30.13) and PCMR=

3.75 (95%CI= 0.66-21.22) n=1; >20yrs PMR=4.85 (95%CI= 1.65-14.25) and PCMR= 3.93 (95%CI= 1.34-11.56) n=3;

- Latency from time since last employed: 0-10yrs PMR= 24.27 (95%CI= 10.37-56.82) and PCMR= 12.79 (95%CI=5.46-29.94) n=5; 10-20yrs PMR= 5.24 (95%CI=0.92-29.60) and PCMR= 4.55 (95%CI=0.80-25.75) n=1).

The six sinonasal cancer deaths were distributed across all four factories and factory specific rates were found to be elevated for:

- Sites A and B: PMR= 11.63 (95%CI= 3.19-42.40) and PCMR= 8.00 (95%CI= 2.19-29.17) n=2;
- Site C: PMR=11.86 (95%CI= 4.03-34.87) and PCMR= 9.01 (95%CI= 3.06-26.49) n=3
- Site D: PMR=2.15 (95%CI= 0.38-12.16) and PCMR= 1.67 (95%CI= 0.29-9.47) n=1.

No deaths from sinonasal cancer occurred among black men or women. The authors note that the trends with duration and latency are supportive of a causal relationship between work in chromium smelter facilities and sinonasal cancer.

Sorahan and Harrington (2000) conducted a mortality study focussing on lung cancer in Yorkshire chrome platers; however, other cancers were considered. Overall 1,087 (920 men and 167 women) from 54 plants were followed-up over the period 1972-1997. All workers were employed as chrome platers for at least 3 months. Exposure information on 916 of the exposed individuals was available from a previous survey conducted in 1969-1972. The Office of National Statistics provided vital status up to the close of the study and cause of death. Mortality rates for the general population of England and Wales were used for reference. Estimates were adjusted for age and calendar period. Over the study period there was one male death from cancer of the nose and sinuses (SMR=6.87, 95%CI=0.17-38.30) and no female deaths.

### 2.2.6 Mineral Oils

Mineral oils are primarily used as lubricant base oils to produce further refined oil products, including engine oils, machine oils and metalworking oils. These oils are used in manufacturing, mining, construction and other industries (such as the automotive and the printing industry). Exposure to mineral oils primarily occurs via inhalation, ingestion or dermal contact.

As described previously, Roush *et al*. (1980) reported findings from a case-control study of sinonasal cancer among individuals who died in Connecticut. Work entailing cutting oil exposure was found to be significantly associated with sinonasal cancer (OR=2.8, 95%CI=1.4-5.7, n=19). The association was found to be higher in workers who died over the age of 68 and earlier in the study from 1935 to 1958 (under 68 early: OR=2.6, under 68 late: OR=1.2, over 68 early: OR=25.5 and over 68 late: OR=2.1). No differences were found with respect to histologic type and anatomic subsite. Actual exposures to substances were not obtained, but the authors note that the results were consistent with previous literature.

As described previously, Brinton *et al*. (1984) conducted a case-control study on nasal cancer. They found no significantly elevated risk associated with reported exposure to mineral oils (Males: RR=1.36, n=6, Females: RR=1.49, n=1, Total: RR=1.37, 95%CI=0.5-4.1). The authors note that this finding could be due to the small numbers reporting exposure to mineral oils.

Despite an association being reported, subsequent reviews of occupational exposure to metalworking fluids did not consider sinonasal cancer (Calvert *et al*, 1998; Mirer, 2003; NIOSH, 1998).

### 2.2.7 Other Exposures

**Textile Dust**

The textiles and clothing industries employ around 189,000 in the UK across 10,700 businesses. Increasingly these are small businesses. Textile workers are exposed to textile-related dusts throughout the manufacturing process. During spinning, weaving and knitting operations, exposure to chemicals is generally limited. In dyeing and printing operations workers are frequently exposed to dyes, optical brighteners, organic solvents and fixatives. Workers in finishing operations are exposed to crease-resistance agents (many of which release formaldehyde), flame-retardants and antimicrobial agents. In dyeing, printing and finishing processes, workers typically have multiple exposures that can vary with time and process.

Several studies have shown an association between textile work and sinonasal cancer (Acheson *et al*, 1972; Acheson *et al*, 1981; Bimbi *et al*, 1988; Brinton *et al*, 1985; Comba *et al*, 1992a; Comba *et al*, 1992b; Malker *et al*, 1986; Ng, 1986; Olsen, 1988). Exposure to textile dust was considered a plausible agent, although a possible association with cotton dust was suggested (Acheson *et al*, 1972; Brinton *et al*, 1985). IARC (IARC, 1990b) concluded there is limited evidence that working in the textile manufacturing industry entails a carcinogenic risk, and that any risk is due to exposure to dusts from fibres and yarns. Exposure to textile dust is not considered any further as it is a group 2B carcinogen.

**Polycyclic Aromatic Hydrocarbons**

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are manufactured, and these pure compounds usually exist as colourless, white, or pale yellow-green solids. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides.

Workers are exposed by inhalation, ingestion and skin contact, the main route of exposure being inhalation. PAHs are produced in a number of occupational settings including coal gasification, coke production, coal-tar distillation, chimney sweeping (soots), coal tar and pitches, creosotes (a mixture of over 150 compounds), and others, most of which have been classified by IARC as Group 1 carcinogenic situations (creosote is Group 2A) (IARC, 1984; IARC, 1985). Exposure to PAHs is common in four occupational processes associated with sinonasal cancer; namely petroleum production (Blot *et al*, 1977), furnace oven workers and coke production (Acheson *et al*, 1981; Bruusgaard, 1959) and mineral oil in metal-cutting operations (Roush *et al*, 1982; Roush *et al*, 1980). However, risks do appear to have been reduced (Roush *et al*, 1980).

Exposure to PAHs is not considered any further as IARC do not consider the nasal cavity and parasinuses to be a target organ for these substances.

**Radiation**

Radiation exposure has been associated with sinonasal cancer in radium dial painters (Aub *et al*, 1952; Brues and Kirsh, 1977; Polednak *et al*, 1978; Rowland, 1975). However, this occupation does not exist anymore and therefore poses no problem; thus this exposure is not considered any further.

# 3 ATTRIBUTABLE FRACTION ESTIMATION

## 3.1 GENERAL CONSIDERATIONS

### Substances and Occupations

The substances considered in the estimation of the attributable fraction (AF) for sinonasal cancer are those outlined in

**Table 7** Substances considered in the estimation of the attributable fraction for sinonasal cancer

| Agents, Mixture, Circumstance | AF calculation | Strength of evidence | Comments |
|---|---|---|---|
| **Group 1: Carcinogenic to Humans** | | | |
| **Agents, groups of agents** | | | |
| Wood dust | Y | Strong | |
| Chromium VI | Y | Suggestive | Processed changed in the UK in 1958-60, so included for pre-1960 exposures only |
| Nickel Compounds | Y | Strong | Estimation for Clydach workers only as few other workers exposed in GB. |
| Mineral Oils | Y | Suggestive | |
| **Exposure circumstances** | | | |
| Boot & shoe manufacture & repair | Y | Strong | Considered as leather dust |
| Furniture & Cabinet-making | Y | Strong | Considered as wood dust |
| Isopropanol manufacture | N | Strong | No data |
| **Group 2A: Probably Carcinogenic to Humans** | | | |
| **Agents & groups of agents** | | | |
| Formaldehyde | Y | Suggestive | |
| **Exposure circumstances** | | | |
| None | | | |

### Data Relevant to the Calculation of AF

The two data elements required are an estimate of relative risk (RR), and either (1) an estimate of the proportion of the population exposed (Pr(E)) from independent data for Great Britain, or (2) an estimate of the proportion of cases exposed (Pr(E|D)) from population based study data.

The RR chosen from a 'best study' source is described for each exposure, with justification of its suitability. Information on the 'best study' and independent data sources for the proportion of the population exposed are also summarised for each exposure in the appropriate section below. In the absence of more precise knowledge of cancer latency, for solid tumours a latency of up to 50 years and at least 10 years has been assumed for all types of the cancer. Therefore it is assumed that exposure at any time between 1956 and 1995 (the Risk Exposure Period, REP) can result in a cancer being recorded in 2004 as a registration or in 2005 as an underlying cause of death. Although strictly speaking the REP for cancer registrations recorded in 2004, the year for which estimation has been carried out, would be 1955-1994, for simplification the years 1956 to 1995 have also been used, as for deaths, as the proportion exposed will not be affected. For an independent estimate of the proportion of the population exposed, numbers of workers ever exposed during this period are estimated by extrapolating from a point estimate of exposed workers taken from the period. If this is from CAREX relating to 1990-93, an adjustment is made to take account of gross changes in employment levels which have occurred particularly in manufacturing industry and the service sector across the REP. Otherwise a point estimate that represents numbers employed as close as possible to about 35 years before the target year of 2005 is used, as this is thought to represent a 'peak' latency for the solid tumours, and is also close to the mid-point of the REP for estimating numbers ever exposed across the period (for which a linear change in employment levels is implicitly assumed). Where the Census of Employment is used, the point estimate data are for 1971. Where the LFS is used, the first year available and therefore used is 1979. A turnover factor is applied to estimate numbers ever exposed during the REP, determined mainly by the estimate of staff turnover per year during the period. For each exposure therefore, if an AF has been based on independent estimates of numbers exposed, the table of results includes the point estimate of numbers employed, the adjustment factor for CAREX if applicable, the staff turnover estimate, and the resulting estimate of numbers ever exposed during the REP. Other estimates used in the calculations that remain constant across exposures (unless otherwise stated) are given below:

- Number of years in REP = 40

- Proportion in the workplace ever exposed is set to one, i.e. all are assumed to be exposed, in the absence of more detailed information. Where sources other than CAREX are used for the point estimate of numbers exposed, such as the LFS or Census of Employment, a precise as possible definition of workers exposed is sought.

- Numbers ever of working age during the target REP = 19.4 million men, 21.0 million women. This is the denominator for the proportion of the population exposed, and is based on population estimates by age cohort in the target year.

- Total deaths from sinonasal cancer in GB in 2005 = 63 for men aged 25+ (55 England and Wales and 8 Scotland), 48 for women aged 25+ (52 England and Wales and 4 Scotland).

- Total registrations from sinonasal cancer in GB in 2004 = 219 for men aged 25+ (192 England, 13 Wales and 14 Scotland), 159 for women aged 25+ (131 England, 11 Wales and 17 Scotland).

Attributable numbers are estimated by multiplying the AF by the total number of cancers in GB. Only cancers which could have been initiated during the risk exposure period are counted, taking normal retirement age into account. Therefore for solid tumour cancers, total deaths or registrations recorded at all adult ages (25+) are used to estimate attributable numbers, and for short latency cancers, deaths and registrations for ages 15-84 for men and 15-79 for women are used.

For each agent where data on worker numbers are only available for men and women combined (CAREX data), the assumed percentage of men is given in addition to the numbers exposed. The allocation to high and low, and occasionally negligible, exposure level categories, or division into separate exposure scenarios, is also included in these tables. Where no separate estimate of relative risk is available for the low exposure level category, an estimate is based on an average of the high/low ratios for cancer-exposure pairs for which data were available.

Full details of the derivation of the above factors and the methods of calculating AF are published separately (Estimation of the Burden of Cancer in Great Britain due to Occupation Technical Report: Methodology). Unless otherwise stated, Levin's method is used for estimates using independent estimates of numbers exposed, and Miettinen's method is used for study based estimates. A summary of the methodology is given in the Statistical Appendix.

## 3.2 CHROMIUM

**(a) Risk Estimate:**

A study at three UK chromate producing factories observed a significant excess of deaths from nasal cancer (4 obs, 0.26 exp; SMR – 15.4; 95%CI= 4.2-39.4), up to 1988 (Davies *et al*, 1991). However, all of these deaths occurred in men starting work before major plant and process changes were completed during 1958-1960. A study of 1,087 Yorkshire chrome platers employed between 1972 and 1997 also observed an (albeit non-significant) excess risk (SMR 6.87; 95%CI=0.17-38.3) (Sorahan and Harrington, 2000). However, this was based on only one case, and it is not stated when the subject had first been exposed. A review of epidemiological studies of chrome and cancer mortality was unable to conduct a meta-analysis relating to sinonasal cancer (Cole and Rodu, 2005). The authors found that the relevant literature consisted almost entirely of case reports.

Another study of a cohort of workers known to have been employed between 1937 and 1971 in four former chromate producing facilities in the US (Rosenman and Stanbury, 1996), found a PMR of 5.18 (95% CI=2.37-11.30). For the present study this estimate has been used for the high exposed group. Due to the absence of sufficient dose-response data specific to chromium and sinonasal cancer a RR = 3.34 (95% CI=0.4-10.5) has been estimated for the low exposure level category. This was based on a harmonic mean of the high/low ratios across all other cancer-exposures pairs in the overall project for which data were available

**(b) Numbers Exposed:**

Table 8 gives the numbers of workers exposed to chromium by industry according to CAREX for 1990-1993. For the male/female split all are assumed to be “blue collar” workers in SOC major groups 5, 8 and 9.

**Table 8** Numbers of workers exposed to chromium according to CAREX in 1990-1993

| **Industry** | **CAREX Data 1990-1993** | | **Exposure Level** |
|---|---|---|---|
| | **Number Exposed** | **Number in Industry** | |
| Forestry and logging | | | |
| Crude petroleum and natural gas production | 1198 | 53300 | L |
| Food manufacturing | 2049 | 414150 | L |
| Beverage industries | 264 | 88100 | L |
| Manufacture of textiles | 3286 | 182000 | L |
| Manufacture of wearing apparel, except footwear | 1012 | 189500 | L |
| Manufacture of leather and products of leather | 554 | 16825 | L |
| Manufacture of footwear | 108 | 38500 | L |
| Manufacture of wood, wood and cork products | 3020 | 132975 | L |
| Manufacture of furniture and fixtures | 138 | 144325 | L |
| Manufacture of paper and paper products | 1802 | 119050 | L |
| Printing, publishing and allied industries | 3634 | 354750 | L |
| Manufacture of industrial chemicals | 3020 | 130000 | H |
| Manufacture of other chemical products | 1626 | 175175 | H |
| Petroleum refineries | 874 | 18075 | L |
| Manufacture of rubber products | 928 | 53025 | L |
| Manufacture of plastic products, nec | 3408 | 136900 | L |
| Manufacture of pottery, china and earthenware | 250 | 54450 | L |
| Manufacture of glass and glass products | 609 | 43275 | L |
| Manufacture of other non-metallic mineral products | 169 | 70875 | L |
| Iron and steel basic industries | 680 | 48425 | H |
| Non-ferrous metal basic industries | 2368 | 79325 | H |
| Manufacture of fabricated metal products | 21038 | 292200 | H |
| Manufacture of machinery, except electrical | 22792 | 692275 | H |
| Manufacture of electrical machinery, apparatus, appliances | 5443 | 473750 | L |
| Manufacture of transport equipment | 14482 | 456900 | H |
| Manufacture of instruments, photographic and optical | 1651 | 86225 | L |
| Other manufacturing industries | 620 | 59375 | H |
| Electricity, gas and steam | 660 | 140975 | L |
| Construction | 4264 | 1753450 | L |
| Land transport | 1528 | 671050 | L |
| Water transport | 1026 | 68175 | L |
| Air transport | 4328 | 95700 | L |
| Services allied to transport | 74 | 180725 | L |
| Sanitary and similar services | 448 | 274225 | L |
| Personal and household services | 20687 | 686750 | L |
| **Total** | **130038** | **847477** | |
| | | | |
| **Main Industry Sector** | | % Male | |

| | | | | |
|---|---|---|---|---|
| Agriculture, hunting and forestry; fishing | High<br>Low | 0<br>0 | | |
| Mining/quarrying, electricity/gas/steam, manufacturing industry | High<br>Low | 66626<br>31057 | 76%<br>76% | |
| Construction | Low | 4264 | 99% | |
| Service industries | Low | 28091 | 65% | |

**(c) AF Calculation:**

The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to chromium VI is 5.69% (95% CI=2.16-15.50), which equates to 7 (95%CI= 3-18) attributable deaths and 22 (95%CI=8-59) attributable registrations. The estimated AF or men is 7.23% (95%CI=2.75-19.38) resulting in 5 (95%CI=2-12) attributable deaths and 16 (95%CI=6-42) attributable registrations; and for women the AF is 3.80% (95%CI=1.43-10.73) resulting in 2 (95%CI=1-6) attributable deaths and 6 (95%CI=2-17) attributable registrations (Table 9).

**Table 9** Results for Nasal Cancer and Exposure to Chromium VI

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Risk Estimate Reference** | **Exposure** | **Main Industry Sector[1]** | **RR[2]** | **Ne[3]** | **Carex adj[4]** | **TO[5]** | **NeREP[6]** | **PrE[7]** | **AF** | **LL** | **UL** | **AN** | **LL** | **UL** | **AR** | **LL** | **UL** |
| **Men** | (Rosenman and Stanbury, 1996) | H | C-E | 5.18 | 50636 | 1.4 | 0.09 | 244928 | 0.0126 | 0.0490 | 0.0162 | 0.1119 | 3 | 1 | 7 | 11 | 4 | 25 |
| | | H | All | | 50636 | | | 244928 | 0.0126 | 0.0490 | 0.0162 | 0.1119 | 3 | 1 | 7 | 11 | 4 | 25 |
| | | L | C-E | 3.42 | 23603 | 1.4 | 0.09 | 114171 | 0.0059 | 0.0132 | 0.0000 | 0.0773 | 1 | 0 | 5 | 3 | 0 | 17 |
| | | L | F | 3.42 | 4221 | 1 | 0.12 | 19162 | 0.0010 | 0.0022 | 0.0000 | 0.0130 | 0 | 0 | 1 | 0 | 0 | 3 |
| | | L | G-Q | 3.42 | 18259 | 0.9 | 0.11 | 68656 | 0.0035 | 0.0079 | 0.0000 | 0.0465 | 1 | 0 | 3 | 2 | 0 | 10 |
| | | L | All | | 46084 | | | 201989 | 0.0104 | 0.0234 | 0.0000 | 0.1368 | 1 | 0 | 9 | 5 | 0 | 30 |
| | | All | All | | 96720 | | | 446917 | 0.0230 | 0.0723 | 0.0275 | 0.1938 | 5 | 2 | 12 | 16 | 6 | 42 |
| **Women** | (Rosenman and Stanbury, 1996) | H | C-E | 5.18 | 15990 | 1.5 | 0.14 | 134520 | 0.0064 | 0.0258 | 0.0087 | 0.0612 | 1 | 0 | 3 | 4 | 1 | 10 |
| | | H | All | | 15990 | | | 134520 | 0.0064 | 0.0258 | 0.0087 | 0.0612 | 1 | 0 | 3 | 4 | 1 | 10 |
| | | L | C-E | 3.42 | 7454 | 1.5 | 0.14 | 62705 | 0.0030 | 0.0070 | 0.0000 | 0.0429 | 0 | 0 | 2 | 1 | 0 | 7 |
| | | L | F | 3.42 | 43 | 0.67 | 0.15 | 171 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | L | G-Q | 3.42 | 9832 | 0.8 | 0.15 | 47079 | 0.0022 | 0.0052 | 0.0000 | 0.0322 | 0 | 0 | 2 | 1 | 0 | 5 |
| | | L | All | | 17328 | | | 109955 | 0.0052 | 0.0122 | 0.0000 | 0.0752 | 1 | 0 | 4 | 2 | 0 | 12 |
| | | All | All | | 33318 | | | 244475 | 0.0116 | 0.0380 | 0.0143 | 0.1073 | 2 | 1 | 6 | 6 | 2 | 17 |

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

## 3.3 FORMALDEHYDE

### (a) Risk Estimate

A cohort of British chemical workers exposed to formaldehyde was established in the early 1980s (Coggon *et al*, 2003). Five of the six companies involved produced their own formaldehyde on site and either used it to manufacture resins and adhesives, or exported the product as formalin, paraformaldehyde or alcoforms. The last company imported formalin to produce resins. The cohort comprised 14,014 men who were followed up to 2000. Between 1941 and 2000 the SMR was 0.87 (95%CI=0.11-3.14), with only two cases observed. In a pooled analysis, by IARC, of 12 case-control studies a non-significant elevated risk, increasing with level of exposure to formaldehyde, was observed among individuals with no or low exposure to wood dust (Luce *et al*, 2002). Higher and significant ORs were observed among those with moderate and high levels of exposure to wood dust. Luce *et al* only estimated ORs for adenocarcinomas and for squamous cell carcinomas separately. Mannetje *et al*. (1999) obtained ORs from a subset of eight European studies of Luce's original twelve, for sinonasal cancer as a whole, which were adjusted for the effect of other occupational exposures. The ORs were 1.66 (95%CI=1.27–2.17) for men and 0.83 (95%CI=0.41-1.69) for women for occupational exposure to formaldehyde. These results are supported by a study in Denmark by Olsen *et al* (1984), in which a RR for formaldehyde of 2.8 was found, which after controlling for wood dust exposure reduced to 1.6. As the Mannetje pooled analysis includes studies from the use of formaldehyde and not just production and also adjusted for other exposures such as wood dust the ORs from this paper are used for the current AF estimate. This is 1.66 (95%CI=1.27-2.17) for the high level exposure group for men and a risk estimate of 1.0 for women. The RR estimate for the low and background groups have been set to 1 based on the result from Coggon *et al.* (2003).

### (b) Numbers Exposed:

The number of workers exposed to formaldehyde in 1990-1993 according to CAREX is given in Table 10. Embalmers and related professions are considered to be included in the 'personal and household services' category based on the SOC 'personal service occupations' (SOC major group 6 and minor group 629). According to the British Institute of Embalmers (BIOE), there are currently 1400 registered embalmers in the UK and Ireland, 100 of whom work overseas (BIOE, Pers. Comm.). However, not all registered embalmers will be working at one time, with many retired or employed elsewhere. As the occupation is unregulated, there is no requirement for workers to qualify and hence register, and there may be many more employed in the embalming services than current estimates allow (BIOE, Pers. Comm.). It is also uncertain how many embalmers were employed in the past although it is thought that numbers are increasing. In the AF estimate the CAREX figure for personal and household services has thus been used.

In order to split the CAREX exposed numbers between men and women, it is assumed that all the exposed occupations in manufacturing and in construction were in skilled trades, shop floor and transport operatives (SOC major groups 5, 8 and 9), and that the exposed occupations in the service sector were in professional, associated professional and technical and personal and protective service occupations (SOC groups 2, 3 and 6), except workers employed in personal and household services. For this industry, it assumes that workers are mainly embalmers and according to BIOE, 78% are male. These data were used to estimate Pr(E) for Levin's calculation of AF, as an alternative to the European population based studies.

**Table 10** Number of workers exposed to formaldehyde according to CAREX in 1990-1993

| Industry | | CAREX Data 1990-1993 | | |
|---|---|---|---|---|
| | | **Number Exposed** | **Number in Industry** | **Exposure Level** |
| Crude petroleum and natural gas production | | 656 | 53300 | B |
| Beverage industries | | 881 | 88100 | B |
| Manufacture of textiles | | 4730 | 182000 | H |
| Manufacture of wearing apparel, except footwear | | 17992 | 189500 | H |
| Manufacture of wood and wood and cork products, except furniture | | 12430 | 132975 | L |
| Manufacture of furniture and fixture, except primary of metal | | 39772 | 144325 | L |
| Manufacture of paper and paper products | | 722 | 119050 | B |
| Manufacture of industrial chemicals | | 1006 | 130000 | L |
| Manufacture of other chemical products | | 360 | 175175 | L |
| Manufacture of plastic products nec | | 2021 | 136900 | L |
| Manufacture of glass and glass products | | 278 | 43275 | H |
| Manufacture of other non-metallic mineral products | | 585 | 70875 | L |
| Iron and steel basic industries | | 1870 | 48425 | L |
| Non-ferrous metal basic industries | | 1254 | 79325 | L |
| Manufacture of fabricated metal products, except machinery and equipment | | 535 | 292200 | L |
| Manufacture of machinery except electrical | | 760 | 692275 | L |
| Construction | | 4511 | 1753450 | L |
| Education services | | 122 | 1455875 | H |
| Research and scientific institutes | | 176 | 91100 | H |
| Medical, dental, other health and veterinary services | | 2796 | 1435675 | H |
| Recreational and cultural services | | 74 | 534600 | B |
| Personal and household services | | 276 | 686750 | H |
| **Total** | | **93807** | **8535150** | |
| | | | | |
| **Main Industry Sector** | | | % Male | |
| Agriculture, hunting and forestry; fishing | High<br>Low | 0<br>0 | | |
| Mining/quarrying, electricity/gas/steam, manufacturing industry | High<br>Low<br>Background | 23000<br>60593<br>2259 | 76%<br>76%<br>76% | |
| Construction | Low | 4511 | 99% | |
| Service industries | High<br>Background | 3370<br>74 | 45%<br>45% | |

Clothing retail workers may also be exposed to formaldehyde. This category is not included in the CAREX estimates of exposed workers, and clothing retail was not noted as a high risk occupation in the pooled Mannetje study (1999), for which full occupational histories were collected and exposure to formaldehyde was examined using a job-exposure matrix. However the high proportion of study controls recorded as exposed to formaldehyde in this study may include these workers.

### (c) AF Calculation:

The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to formaldehyde is 0.17% (95%CI=0.10-0.45) which equates to 0 (95%CI=0-1) attributable deaths and 1 (95%CI=0-2) attributable registration. For sinonasal cancer associated with exposure to formaldehyde the estimated AF for men is 0.31% (95%CI=0.19-0.81) resulting in 0 (95%CI=0-1) attributable deaths and 1 (95%CI=0-2) attributable registrations; and for women the AF is 0% resulting in 0 attributable deaths or registrations (Table 11).

**Table 11** Results for Nasal Cancer and Exposure to Formaldehyde

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Risk Estimate Reference | Exposure | Main Industry Sector[1] | RR[2] | Ne[3] | Care x adj[4] | TO[5] | NeREP[6] | PrE[7] | AF | LL | UL | AN | LL | UL | AR | LL | UL |
| Men | Mannetje *et al*. (1999) | H | C-E | 1.66 | 17480 | 1.4 | 0.09 | 84552 | 0.0055 | 0.0029 | 0.0018 | 0.0078 | 0 | 0 | 0 | 1 | 0 | 2 |
| | | H | G-Q | 1.66 | 1608 | 0.9 | 0.11 | 6045 | 0.0003 | 0.0002 | 0.0001 | 0.0004 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | H | All | | 19088 | | | 90596 | 0.0058 | 0.0031 | 0.0019 | 0.0081 | 0 | 0 | 1 | 1 | 0 | 2 |
| | Coggon *et al.* (2003) | L | C-E | 1 | 46051 | 1.4 | 0.09 | 222750 | 0.0103 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | L | F | 1 | 4466 | 1 | 0.12 | 20272 | 0.0010 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | L | All | | 50517 | | | 243022 | 0.0114 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Coggon *et al.* (2003) | B | C-E | 1 | 1717 | 1.4 | 0.09 | 8304 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | G-Q | 1 | 33 | 0.9 | 0.11 | 125 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | All | | 1750 | | | 8430 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | All | All | | 71354 | | | 342048 | 0.0176 | 0.0031 | 0.0019 | 0.0081 | 0 | 0 | 1 | 1 | 0 | 2 |
| Women | Mannetje *et al*. (1999) | H | C-E | 1 | 5520 | 1.5 | 0.14 | 46438 | 0.0022 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | H | G-Q | 1 | 1762 | 0.8 | 0.15 | 8439 | 0.0004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | H | All | | 7282 | | | 54877 | 0.0026 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Coggon *et al.* (2003) | L | C-E | 1 | 14542 | 1.5 | 0.14 | 122339 | 0.0058 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | L | F | 1 | 45 | 0.67 | 0.15 | 181 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | L | All | | 14587 | | | 122520 | 0.0058 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Coggon *et al.* (2003) | B | C-E | 1 | 542 | 1.5 | 0.14 | 4756 | 0.0002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | G-Q | 1 | 41 | 0.8 | 0.15 | 194 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | All | | 583 | | | 4755 | 0.0002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | All | All | | 22453 | | | 182153 | 0.0087 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

### 3.4 LEATHER DUST (BOOT AND SHOE MANUFACTURE AND REPAIR)

**(a) Risk Estimate**

An increase risk of nasal cancer in the boot and shoe industry was noted over 30 years ago in Northamptonshire (Acheson *et al*, 1970a; Acheson *et al*, 1970b). An Italian study observed an OR of 6.8 (90%CI=1.9-2.5) in those employed in the whole leather industry (Battista *et al*, 1995); an OR of 8.3 (95%CI=1.9-36.0) was associated with shoemaking, while leather tanners had an OR of 5.0 (95%CI= 0.92-28.0). In two cohorts of shoe manufacturers (one in Italy and one in England), an SMR 7.41 (95%CI=3.83-12.94) was observed among the English cohort (Fu *et al*, 1996). The SMR for those probably exposed to leather dust was 8.05 (95%CI 4.16-14.10), and in those with a high exposure was 11.7 (95%CI=5.34-22.2). In the present study the overall RR estimate of 7.41 (95%CI=3.83-12.94) for the English cohort from Fu *et al* is used in the calculation of AF.

**(b) Numbers Exposed:**

Only those exposed to vegetable-tanned leather dust are believed to be at risk (Coggon, 2007, personal communication). No CAREX data exist for leather dust, but the LFS estimate that about 10,500 people work in leather and related trades, and 19,000 in the manufacture of leather goods (average numbers in employment for 2002 to 2004).

Data from the Census of Employment indicate that about 63,000 men and 68,000 women were employed in the leather and footwear industries in 1971, the point in the relevant exposure period for nasal cancer thought to be responsible for the highest number of these cancers occurring in 2004. These estimates are used for the calculation of AF based on independent data. There are no more detailed data available on type of leather dust to which workers are exposed, so this must be considered an upper limit estimate.

**Table 12** Number of workers possibly exposed to leather dust and/or working in the boot and shoe manufacturing industry, according to Census of Employment in 1971

| SIC code | Description | Male | Female | Total |
|---|---|---|---|---|
| 431 | Leather (tanning and dressing) | 16,449 | 4,364 | 20,813 |
| 432 | Leather goods | 6,956 | 12,390 | 19,346 |
| 450 | Footwear | 39,348 | 51,738 | 91,086 |
| | Total | 62,753 | 68,492 | 131,245 |

**(c) AF Calculation:**

The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupation in boot and shoe manufacture (leather dust exposure) is 8.39% (95%CI=4.17-15.19), which equates to 10 (95%CI=5-18) attributable deaths and 31 (95%CI=16-57) attributable registrations. The estimated AF from for men is 6.68% (95%CI=3.28-12.31) resulting in 4 (95%CI=2-8) attributable deaths and 15 (95%CI=7-27) attributable registrations; and for women the AF is 10.49% (95% CI=5.26-18.74) resulting in 5 (95%CI=3-10) attributable deaths and 17 (95%CI=8-30) attributable registrations (Table 13).

**Table 13** Results for Nasal Cancer and Leather Dust Exposure

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Risk Estimate Reference** | **Exposure** | **Main Industry Sector[1]** | **RR[2]** | **Ne[3]** | **Care x adj[4]** | **TO[5]** | **NeREP[6]** | **PrE[7]** | **AF** | **LL** | **UL** | **AN** | **LL** | **UL** | **AR** | **LL** | **UL** |
| Men | Fu *et al*, (1996) | | C-E | 7.41 | 62753 | 1.4 | 0.09 | 216814 | 0.0112 | 0.0668 | 0.0328 | 0.1231 | 4 | 2 | 8 | 15 | 7 | 27 |
| | | | All | | 62753 | | | 216814 | 0.0112 | 0.0668 | 0.0328 | 0.1231 | 4 | 2 | 8 | 15 | 7 | 27 |
| | | | All | | 62753 | | | 216814 | 0.0112 | 0.0668 | 0.0328 | 0.1231 | 4 | 2 | 8 | 15 | 7 | 27 |
| Women | Fu *et al*, (1996) | | C-E | 7.41 | 68492 | 1.5 | 0.14 | 384132 | 0.0183 | 0.1049 | 0.0526 | 0.1874 | 5 | 3 | 10 | 17 | 8 | 30 |
| | | | All | | 68492 | | | 384132 | 0.0183 | 0.1049 | 0.0526 | 0.1874 | 5 | 3 | 10 | 17 | 8 | 30 |
| | | | All | | 68492 | | | 384132 | 0.0183 | 0.1049 | 0.0526 | 0.1874 | 5 | 3 | 10 | 17 | 8 | 30 |

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

### 3.5 MINERAL OILS

**(a) Risk Estimate:**

Tolbert (1997) reviews the relationship between mineral oil and cancer, covering metal machining, print press operating, and cotton and jute spinning. He suggested that as sinonasal cancer is a rare cancer, case-control studies rather than cohort studies are more useful for estimating RR. He reported a single case-control study using the Connecticut Tumour Registry (Roush *et al*, 1980) which supported an association of sinonasal cancer with work entailing exposure to machining fluid, with an OR of 2.8 (95%CI=1.4-5.7). For the present study this estimate has been used for the high exposure group. An RR = 1.85 (95%CI=0.2-5.3) has been estimated for the low exposure level categories. An RR of 1.00 has been used for the background level. This was based on a harmonic mean of the high/low ratios across all other cancer-exposures pairs in the overall project for which data were available.

**(b) Numbers Exposed:**

No data exist in CAREX on the number of workers exposed to mineral oils, The numbers of metal machinists potentially exposed to mineral oils (metal working fluids) in Great Britain are shown in Table 14, taken from LFS data for 1979. ‘Low’ (L) exposure levels are indicated as such. Exposure level (H) indicates jobs with known exposure to soluble MWF as a fine mist spray. Increases in printing workers due to mineral oils have also been identified in several studies (Tolbert 1997). However, Tolbert suggested that the primary constituent that distinguishes newspaper printing ink from metalworking fluids is carbon black, which is known to be contaminated with benzo(a)pyrene and other polycyclic aromatic hydrocarbons. Printing workers have thus been excluded from any estimation. In addition, industry sectors where most of the exposure to MWF is thought to be dermal have also been excluded (motor mechanic (auto engines), maintenance fitters (aircraft engines) and office machinery mechanics and their foremen).

**Table 14** Numbers of workers exposed to mineral oils according to LFS 1979

| SIC code | Description | Male | Female | Total | Exposure Level |
|---|---|---|---|---|---|
| **LFS 1979** | | | | | |
| 111.1 | Foremen of Press and Machine Tool Setters | 2164 | - | 2164 | L |
| 111.2 | Foremen of other Centre Lathe Turners | 736 | - | 736 | L |
| 111.3 | Foremen of Machine Tool Setter Operators | 581 | - | 581 | L |
| 111.4 | Foremen of Machine Tool Operators | 8947 | 252 | 9199 | L |
| 111.5 | Foremen of Press Stamping and Automatic Machine Operators | 1498 | - | 1498 | L |
| 111.6 | Foremen of Metal Polishers | 265 | - | 265 | B |
| 111.7 | Foremen of Fettlers Dressers | - | - | - | B |
| 111.8 | Foremen of Shot Blasters | - | - | - | B |
| 112.1 | Press and Machine Tool Setters | 64157 | 740 | 64897 | H |
| 112.2 | Other Centre Lathe Turners | 49774 | - | 49774 | H |
| 112.3 | Machine Tool Setter Operators | 10818 | 232 | 11050 | H |
| 112.4 | Machine Tool Operators | 335097 | 50424 | 385521 | H |
| 113.1 | Press Stamping and Automatic Machine Operators | 34002 | 18281 | 52283 | H |
| 113.2 | Metal Polishers | 11112 | 1425 | 12537 | B |
| 113.3 | Fettlers Dressers | 12391 | 1619 | 14010 | B |
| 114.1 | Foremen of Toolmakers Tool Fitters Markers-Out | 4319 | - | 4319 | L |
| 114.2 | Foremen of Precision Instrument Makers and Repairers | 969 | - | 969 | L |
| 114.3 | Foremen of Watch and Chronometer Makers and Repairers | - | - | - | L |
| 114.4 | Foremen of Metal Working Production Fitters and Fitter/Machinists | 27544 | - | 27544 | L |
| 115.0 | Toolmakers Tool Fitters Markers-Out | 92886 | 510 | 93396 | H |
| 116.1 | Precision Instrument Makers and Repairers | 28071 | 1667 | 29738 | L |
| 116.2 | Watch and Chronometer Makers and Repairers | 6527 | 225 | 6752 | L |
| 117.0 | Metal Working Production Fitters and Fitter/Machinists | 546544 | 6933 | 553477 | L |
| 131.8 | Shot Blasters | 6049 | - | 6049 | B |
| 160.5 | Labourers and Other Unskilled Workers in Foundries in Engineering | 15469 | 567 | 16036 | L |
| 160.6 | Labourers and Other Unskilled Workers in Engineering and Allied Trades | 21276 | 259 | 21535 | L |
| TOTAL | (excluding those dermally exposed only) | **1281196** | **83134** | **1364330** | |

**(c) AF Calculation:**

The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to mineral oils is 13.84% (95% CI=1.37-38.97), which equates to 16 (95%CI= 2-45) attributable deaths and 55 (95%CI=5-154) attributable registrations. The estimated AF for men is 22.40% (95%CI=1.67-62.53) resulting in 14 (95%CI=1-39) attributable deaths and 49 (95%CI=4-137) attributable registrations; and for women the AF is 3.47% (95%CI=1.00-10.43) resulting in 2 (95%CI=1-5) attributable deaths and 6 (95%CI=2-17) attributable registrations (Table 15).

**Table 15** Results for Nasal Cancer and exposure to Mineral Oils

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Risk Estimate Reference | Exposure | Main Industry Sector[1] | RR[2] | Ne[3] | Carex adj[4] | TO[5] | NeREP[6] | PrE[7] | AF | LL | UL | AN | LL | UL | AR | LL | UL |
| Men | Tolbert (1997) | H | C-E | 2.8 | 586734 | 1.4 | 0.09 | 2027188 | 0.1045 | 0.1460 | 0.0287 | 0.3037 | 9 | 2 | 19 | 32 | 6 | 67 |
| | | H | All | | 586734 | | | 2027188 | 0.1045 | 0.1460 | 0.0287 | 0.3037 | 9 | 2 | 19 | 32 | 6 | 67 |
| | | L | C-E | 1.85 | 664645 | 1.4 | 0.09 | 2296374 | 0.1184 | 0.0780 | 0.0000 | 0.5465 | 5 | 0 | 34 | 17 | 0 | 120 |
| | | L | All | | 664645 | | | 2296374 | 0.1184 | 0.0780 | 0.0000 | 0.5465 | 5 | 0 | 34 | 17 | 0 | 120 |
| | | B | C-E | 1 | 29817 | 1.4 | 0.09 | 103019 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | All | | 29817 | | | 103019 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| Women | Tolbert (1997) | H | C-E | 2.8 | 70187 | 1.5 | 0.14 | 393639 | 0.0187 | 0.0324 | 0.0070 | 0.0793 | 2 | 0 | 4 | 5 | 1 | 13 |
| | | H | All | | 70187 | | | 393639 | 0.0187 | 0.0324 | 0.0070 | 0.0793 | 2 | 0 | 4 | 5 | 1 | 13 |
| | | L | C-E | 1.85 | 9903 | 1.5 | 0.14 | 55540 | 0.0026 | 0.0022 | 0.0000 | 0.0555 | 0 | 0 | 3 | 0 | 0 | 9 |
| | | L | All | | 9903 | | | 55540 | 0.0026 | 0.0022 | 0.0000 | 0.0555 | 0 | 0 | 3 | 0 | 0 | 9 |
| | | B | C-E | 1 | 3044 | 1.5 | 0.14 | 17072 | 0.0008 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | All | | 3044 | | | 17072 | 0.0008 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | All | All | | 83134 | | | 466252 | 0.0222 | 0.0347 | 0.0100 | 0.1043 | 2 | 1 | 5 | 6 | 2 | 17 |

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

### 3.6 NICKEL

**(a) Risk Estimate:**

Significant excesses of nasal cancer have been observed in studies of nickel-exposed workers in refining (Andersen *et al*, 1996; Anttila *et al*, 1998; Grimsrud and Peto, 2006; Jarup *et al*, 1998; Sorahan and Williams, 2005). However, the only group of workers with any significant exposure to nickel in the UK are those that have been employed at the Clydach nickel carbonyl refinery in South Wales (n=812) (Sorahan and Williams, 2005). The most recent study of this cohort found an SMR of 8.7 (95% CI=1.05-31.4), which was based on only two cases, one of whom started work after 1930 but before the refining process changed in the early 1950s, and the other after 1950. This is the estimate that will be used in the calculation of AF for the Clydach cohort. Few estimates of risk from sinonasal cancer are available for nickel exposure in industries other than refining and no excess risk was observed for nickel exposure in nickel/copper smelting (Antilla 1998). Estimation of the AF for nickel has thus been restricted to refining at Clydach.

**(b) Numbers Exposed:**

The number of workers first employed in the period 1953-1992 with at least five years of employment at Clydach was 812, all men (Sorahan and Williams, 2005)

**(c) AF Calculation:**

The estimated total (males only) attributable fraction for sinonasal cancer associated with occupational exposure to nickel at the Clydach refinery (for exposures which have occurred since 1955) the AF is 0.01% (95%CI= 00-0.04), which equates to 0 (95%CI= 0-0) attributable deaths and 0 (95%CI= 0-0) attributable registrations (Table 16).

**Table 16** Results for Nasal Cancer and Exposure to Nickel

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Risk Estimate Reference | Exposure | Main Industry Sector[1] | RR[2] | Ne[3] | Carex adj[4] | TO[5] | NeREP[6] | PrE[7] | AF | LL | UL | AN | LL | UL | AR | LL | UL |
| Nickel | (Sorahan & Williams, 2005) | H | C-E | 8.7 | 812 | 1.4 | 0.09 | 164 | 0.0000 | 0.0001 | 0.0000 | 0.0004 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nickel | | H | All | | 812 | | | 164 | 0.0000 | 0.0001 | 0.0000 | 0.0004 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nickel | | All | All | | 812 | | | 164 | 0.0000 | 0.0001 | 0.0000 | 0.0004 | 0 | 0 | 0 | 0 | 0 | 0 |

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

## 3.7 WOOD DUST

**(a) Risk Estimate:**

An excess nasal cancer risk was demonstrated over 30 years ago amongst woodworkers in the furniture industry in England and other countries (Acheson, 1976; Acheson *et al*, 1968; Acheson *et al*, 1972; Macbeth, 1965). A study of furniture workers between 1954-1968 observed SRRs in excess of 1000 (Rang and Acheson, 1981). Since then a number of other studies of wood-related industries have been undertaken and in 1995 two pooled analyses were published by IARC. The first was of five cohorts, results of which were published between 1984 and 1994 (Demers *et al*, 1995a). This analysis obtained an overall summary SMR of 3.1 (95%CI 1.6-5.6) for SNC, for woodworkers in all industries. For the present study, the overall summary RR estimated by Demers *et al* (1995a) has been used for the higher exposure groups and an RR = 2.0 (95%CI 0.3-5.2) has been estimated for the low exposure level category. This was based on a harmonic mean of the high/low ratios across all other cancer-exposures pairs in the overall project for which data were available.

**(b) Numbers Exposed:**

The number of workers exposed to wood in various industries according to CAREX for 1990-93 are given in Table 17. Exposure in construction has been allocated to the ‘higher’ category, as it has been assumed that these were all carpenters/joiners. In order to split the CAREX exposed numbers between men and women, it is assumed that all occupations are in skilled trades, shop floor and transport operatives (SOC major groups 5, 8 and 9). These data are used to estimate Pr(E) for Levin’s calculation of AF.

**Table 17** Numbers of workers exposed to wood dust according to CAREX in 1990-1993

| Industry | CAREX Data 1990-1993 | | |
|---|---|---|---|
| | Number Exposed | Number in Industry | Exposure Level |
| Forestry and logging | 10887 | 14500 | H |
| Crude petroleum and natural gas production | 68 | 53300 | L |
| Food manufacturing | 412 | 414150 | L |
| Beverage industries | 9 | 88100 | L |
| Tobacco manufacture | 7 | 9950 | L |
| Manufacture of textiles | 58 | 182000 | L |
| Manufacture of wearing apparel, except footwear | 50 | 189500 | L |
| Manufacture of leather and products of leather or of its substitutes | 32 | 16825 | L |
| Manufacture of footwear | 11 | 38500 | L |
| Manufacture of wood and wood and cork products, except furniture | 55930 | 132975 | H |
| Manufacture of furniture and fixture, except primary of metal | 94196 | 144325 | H |
| Manufacture of paper and paper products | 4308 | 119050 | L |
| Printing, publishing and allied industries | 2126 | 354750 | L |
| Manufacture of industrial chemicals | 620 | 130000 | L |
| Manufacture of other chemical products | 1151 | 175175 | L |
| Petroleum refineries | 24 | 18075 | L |
| Manufacture of rubber products | 25 | 53025 | L |
| Manufacture of plastic products nec | 415 | 136900 | L |
| Manufacture of glass and glass products | 206 | 43275 | L |
| Manufacture of other non-metallic mineral products | 1498 | 70875 | L |
| Iron and steel basic industries | 188 | 48425 | L |
| Non-ferrous metal basic industries | 260 | 79325 | L |
| Manufacture of fabricated metal products, except machinery and equipment | 2104 | 292200 | L |
| Manufacture of machinery except electrical | 4939 | 692275 | L |
| Manufacture of electrical machinery, apparatus, appliances and supplies | 684 | 473750 | L |
| Manufacture of transport equipment | 7272 | 456900 | L |
| Manufacture of instruments, photographic and optical goods | 132 | 86225 | L |
| Other manufacturing industries | 1953 | 59375 | L |
| Electricity, gas and steam | 24 | 140975 | L |
| Construction | 228115 | 1753450 | H |
| Land transport | 5114 | 671050 | L |
| Water transport | 58 | 68175 | L |
| Air transport | 558 | 95700 | L |
| Services allied to transport | 3805 | 180725 | L |
| Communication | 7 | 459425 | L |
| Sanitary and similar services | 4150 | 274225 | L |
| Education services | 2438 | 1455875 | L |
| **Total** | **433834** | **9673325** | |
| | | | |
| **Main Industry Sector** | | Male % | |

| Industry | | CAREX Data 1990-1993 | | |
|---|---|---|---|---|
| | | Number Exposed | Number in Industry | Exposure Level |
| Agriculture, hunting and forestry; fishing | Moderate | 10887 | 78% | |
| Mining/quarrying, electricity/gas/steam, manufacturing industry | High<br>Low | 150126<br>28576 | 76%<br>76% | |
| Construction | High | 228115 | 99% | |
| Service industries | Low | 16130 | 65% | |

### (c) AF Calculation:

The estimated total (male and female) attributable fraction for sinonasal cancer associated with occupational exposure to wood dust is 10.02% (95%CI=3.85-19.60), which equates to 12 (95%CI=4-23) attributable deaths and 39 (95%CI=15-76) attributable registrations. The estimated AF for men is 15.33% (95% CI=5.94-29.12) resulting in 10 (95%CI=4-18) attributable deaths and 34 (95%CI=13-64) attributable registrations; and for women the AF is 3.49% (95%CI=1.29-7.89) resulting in 2 (95%CI=1-4) attributable deaths and 6 (95%CI=2-13) attributable registrations (Table 18).

**Table 18** Results for Nasal Cancer and Wood Dust Exposure

| | | | | Data | | Calculations | | | | Attributable Fraction (Levins[8]) and Monte Carlo Confidence Interval | | | Attributable Deaths | | | Attributable Registrations | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Risk Estimate Reference** | **Exposure** | **Main Industry Sector[1]** | **RR[2]** | **Ne[3]** | **Carex adj[4]** | **TO[5]** | **NeREP[6]** | **PrE[7]** | **AF** | **LL** | **UL** | **AN** | **LL** | **UL** | **AR** | **LL** | **UL** |
| Men | Demers *et al*, (1995a) | H | A-B | 3.1 | 8492 | 1 | 0.07 | 23201 | 0.0012 | 0.0021 | 0.0007 | 0.0041 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | H | C-E | 3.1 | 114096 | 1.4 | 0.09 | 551887 | 0.0284 | 0.0506 | 0.0176 | 0.0971 | 3 | 1 | 6 | 11 | 4 | 21 |
| | | H | F | 3.1 | 225834 | 1 | 0.12 | 1025129 | 0.0528 | 0.0940 | 0.0327 | 0.1804 | 6 | 2 | 11 | 21 | 7 | 40 |
| | | H | All | | 348421 | | | 1600217 | 0.0825 | 0.1467 | 0.0511 | 0.2817 | 9 | 3 | 18 | 32 | 11 | 62 |
| | | L | C-E | 2.05 | 21718 | 1.4 | 0.09 | 105050 | 0.0054 | 0.0048 | 0.0000 | 0.0340 | 0 | 0 | 2 | 1 | 0 | 7 |
| | | L | G-Q | 2.05 | 10485 | 0.9 | 0.11 | 39423 | 0.0020 | 0.0018 | 0.0000 | 0.0127 | 0 | 0 | 1 | 0 | 0 | 3 |
| | | L | All | | 32202 | | | 144473 | 0.0074 | 0.0066 | 0.0000 | 0.0467 | 0 | 0 | 3 | 1 | 0 | 10 |
| | | All | All | | 380624 | | | 1744690 | 0.0899 | 0.1533 | 0.0594 | 0.2912 | 10 | 4 | 18 | 34 | 13 | 64 |
| Women | Demers *et al*, (1995a) | H | A-B | 3.1 | 2395 | 0.75 | 0.1 | 7365 | 0.0004 | 0.0007 | 0.0002 | 0.0016 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | H | C-E | 3.1 | 36030 | 1.5 | 0.14 | 303110 | 0.0144 | 0.0293 | 0.0094 | 0.0640 | 2 | 0 | 3 | 5 | 1 | 10 |
| | | H | F | 3.1 | 2281 | 0.67 | 0.15 | 9148 | 0.0004 | 0.0009 | 0.0003 | 0.0019 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | H | All | | 40707 | | | 319623 | 0.0152 | 0.0308 | 0.0099 | 0.0674 | 2 | 1 | 4 | 5 | 2 | 11 |
| | | L | C-E | 2.05 | 6858 | 1.5 | 0.14 | 57696 | 0.0027 | 0.0028 | 0.0000 | 0.0203 | 0 | 0 | 1 | 0 | 0 | 3 |
| | | L | G-Q | 2.05 | 5646 | 0.8 | 0.15 | 27033 | 0.0013 | 0.0013 | 0.0000 | 0.0095 | 0 | 0 | 0 | 0 | 0 | 2 |
| | | L | All | | 12504 | | | 84729 | 0.0040 | 0.0041 | 0.0000 | 0.0297 | 0 | 0 | 2 | 1 | 0 | 5 |
| | | All | All | | 53210 | | | 404352 | 0.0193 | 0.0349 | 0.0129 | 0.0789 | 2 | 1 | 4 | 6 | 2 | 13 |

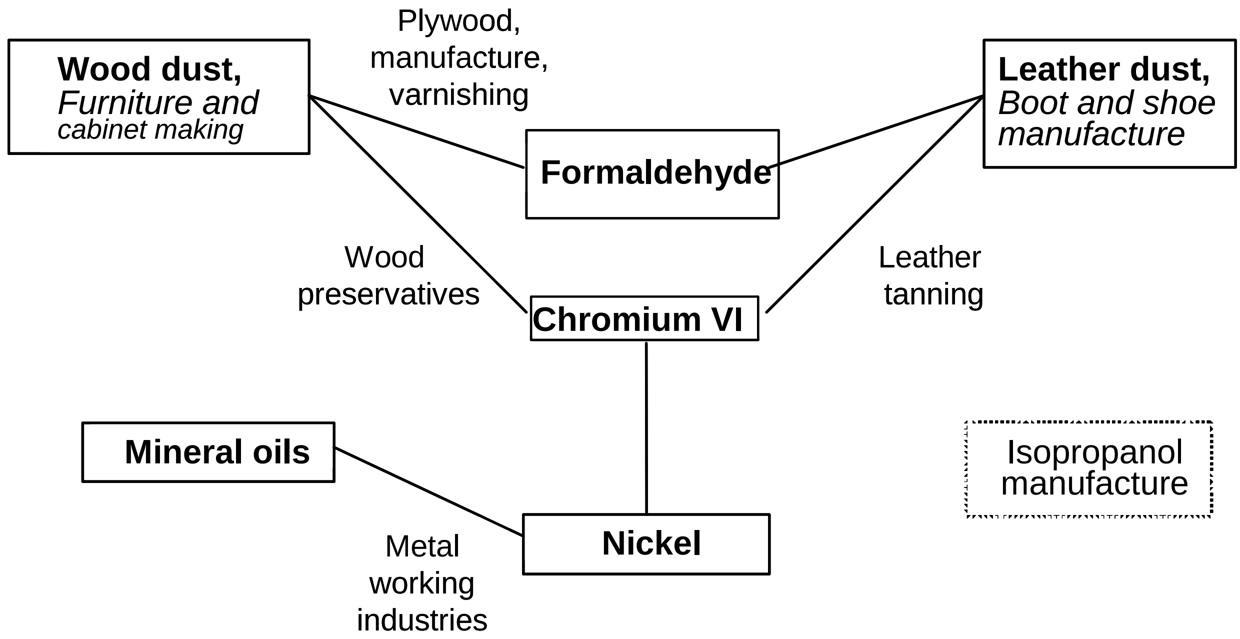
1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the best study
3. Numbers exposed, allocated to men/women
4. CAREX adjustment factor to mid-REP (Table A1)
5. Staff turnover (TO, Table A1)
6. Number ever exposed during the REP (Statistical Appendix equation 3)
7. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
8. Statistical Appendix equation 1

# 4 OVERALL ATTRIBUTABLE FRACTION

## 4.1 EXPOSURE MAP

The exposure map (Figure 1) gives an indication of how exposures overlap in the working population. It illustrates the potential for double counting of the exposed population to occur when an overall AF is calculated, and facilitates strategies to avoid this. For a given cancer, the map entries consist of either an agent (or group of agents such as PAHs), or an exposure scenario (i.e. an industry or occupation in which such exposure occurs). Agents are in plain type, exposure scenarios in italics, from Table 6. Lines joining boxes then indicate where overlap would occur were all the entries in the map simply considered separately (these exposure scenarios are indicated in the smaller print, again based on information in Table 6). For substances and occupations shown not in bold and those in dotted boxes a separate AF has not been estimated, as these exposure scenarios are included with another exposure to avoid double counting (see Table 7)

**Figure 1** Nasal Cancer Exposure Map



## 4.2 SUMMARY OF RESULTS

The results are summarised in Tables 19 and 20.

**Table 19** Summary of RR used to calculate AF

| Agent | Exposure | RR | LL | UL |
|---|---|---|---|---|
| Chromium VI | L | 3.42 | 0.42 | 10.52 |
| Chromium VI | H | 5.18 | 2.37 | 11.3 |
| Formaldehyde (men and women) | B | 1 | 1 | 1 |
| Formaldehyde (men and women) | L | 1 | 1 | 1 |
| Formaldehyde (men) | H | 1.66 | 1.27 | 2.17 |
| Formaldehyde (women) | H | 1 | 1 | 1 |
| Leather Dust | H | 7.41 | 3.83 | 12.94 |
| Mineral oils | B | 1 | 1 | 1 |
| Mineral oils | L | 1.85 | 0.25 | 5.31 |
| Mineral oils | H | 2.8 | 1.4 | 5.7 |
| Nickel | H | 8.7 | 1.05 | 31.4 |
| Wood dust | L | 2.05 | 0.28 | 5.21 |
| Wood dust | H | 3.1 | 1.6 | 5.6 |

**Key:** H= high; L= low; B= Background

**Table 20** Results

| Agent | Numbers of Men Ever Exposed | Numbers of Women Ever Exposed | Proportion of Men Ever Exposed | Proportion of Women Ever Exposed | AF Men | MCLL Men | MCUL Men | AF Women | MCLL Women | MCUL Women | Attributable Deaths (Men) | Attributable Deaths (Women) | Attributable Registrations (Men) | Attributable Registrations (Women) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chromium VI | 446917 | 244475 | 0.0230 | 0.0116 | 0.0723 | 0.0275 | 0.1938 | 0.0380 | 0.0143 | 0.1073 | 5 | 2 | 16 | 6 |
| Formaldehyde | 342048 | 182153 | 0.0176 | 0.0087 | 0.0031 | 0.0019 | 0.0081 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 1 | 0 |
| Leather Dust | 216814 | 384133 | 0.0112 | 0.0183 | 0.0668 | 0.0328 | 0.1231 | 0.1049 | 0.0526 | 0.1874 | 4 | 5 | 15 | 17 |
| Mineral oils | 4426581 | 466252 | 0.2282 | 0.0222 | 0.2240 | 0.0167 | 0.6253 | 0.0347 | 0.0100 | 0.1043 | 14 | 2 | 49 | 6 |
| Nickel | 164 | 0 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0 | 0 | 0 | 0 |
| Wood dust | 1744690 | 404352 | 0.0899 | 0.0193 | 0.1533 | 0.0594 | 0.2912 | 0.0349 | 0.0129 | 0.0789 | 10 | 2 | 34 | 6 |
| **Totals*** | | | | | **0.4330** | **0.2732** | **0.7404** | **0.1979** | **0.1444** | **0.3160** | **27** | **10** | **95** | **31** |

*Totals are the product sums and are not therefore equal to the sums of the separate estimates of attributable fraction, deaths and registrations for each agent. The difference is especially notable where the constituent AFs are large.

## 4.3 EXPOSURES BY INDUSTRY/JOB

Table 21 shows for industry categories from CAREX and job categories from LFS, attributable registrations in 2004 and attributable deaths in 2005 by agent

**Table 21** Industry/occupation codes by agent

| Agent | Industry | Number Ever Exposed over REP (Men) | Number Ever Exposed over REP (Women) | Attributable Registrations (Men) (2004) | Attributable Deaths (Men) (2005) | Attributable Registrations (Women) (2004) | Attributable Deaths (Women) (2005) | Attributable Registrations (Total) (2004) | Attributable Deaths (Total) (2005) |
|---|---|---|---|---|---|---|---|---|---|
| Chromium VI | Manufacture of electrical machinery, apparatus, appliances and supplies | 20,009 | 10,990 | 1 | 0 | 0 | 0 | 1 | 0 |
| Chromium VI | Manufacture of fabricated metal products, except machinery and equipment | 77,339 | 42,476 | 3 | 1 | 1 | 0 | 5 | 1 |
| Chromium VI | Manufacture of industrial chemicals | 11,102 | 6,097 | 0 | 0 | 0 | 0 | 1 | 0 |
| Chromium VI | Manufacture of machinery except electrical | 83,787 | 46,018 | 4 | 1 | 1 | 0 | 5 | 2 |
| Chromium VI | Manufacture of transport equipment | 53,238 | 29,240 | 2 | 1 | 1 | 0 | 3 | 1 |
| Chromium VI | Non-ferrous metal basic industries | 8,705 | 4,781 | 0 | 0 | 0 | 0 | 1 | 0 |
| Chromium VI | Personal and household services | 50,560 | 34,670 | 1 | 0 | 1 | 0 | 2 | 1 |
| **Chromium VI** | **Total** | **446,917** | **244,475** | **16** | **5** | **6** | **2** | **22** | **7** |
| **Formaldehyde** | **Total** | **342048** | **182153.** | **1** | **0** | **0** | **0** | **1** | **0** |
| Leather Dust | Footwear | 135,949 | 290,169 | 9 | 3 | 13 | 4 | 22 | 7 |
| Leather Dust | Leather (tanning and dressing) | 56,832 | 24,475 | 4 | 1 | 1 | 0 | 5 | 1 |
| Leather Dust | Leather goods | 24,033 | 69,489 | 2 | 0 | 3 | 1 | 5 | 1 |
| **Leather Dust** | **Total** | **216,814** | **384,133** | **15** | **4** | **17** | **5** | **31** | **10** |
| Mineral oils | Press and machine tool setters | 221,665 | 4,150 | 3 | 1 | 0 | 0 | 4 | 1 |
| Mineral oils | Other centre lathe turners | 171,971 | 0 | 3 | 1 | 0 | 0 | 3 | 1 |
| Mineral oils | Machine tool setter operators | 37,377 | 1,301 | 1 | 0 | 0 | 0 | 1 | 0 |
| Mineral oils | Machine tool operators | 1,157,773 | 282,800 | 18 | 5 | 4 | 1 | 22 | 6 |
| Mineral oils | Press stamping and automatic machine operators | 117,478 | 102,528 | 2 | 1 | 1 | 0 | 3 | 1 |
| Mineral oils | Foremen of metal working production fitters and fitter/machinists | 95,166 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |

| Agent | Industry | Number Ever Exposed over REP (Men) | Number Ever Exposed over REP (Women) | Attributable Registrations (Men) (2004) | Attributable Deaths (Men) (2005) | Attributable Registrations (Women) (2004) | Attributable Deaths (Women) (2005) | Attributable Registrations (Total) (2004) | Attributable Deaths (Total) (2005) |
|---|---|---|---|---|---|---|---|---|---|
| Mineral oils | Toolmakers tool fitters markers-out | 320,925 | 2,860 | 5 | 1 | 0 | 0 | 5 | 1 |
| Mineral oils | Precision instrument makers and repairers | 96,986 | 9,349 | 1 | 0 | 0 | 0 | 1 | 0 |
| Mineral oils | Metal working production fitters and fitter/machinists | 1,888,330 | 38,883 | 14 | 4 | 0 | 0 | 14 | 4 |
| Mineral oils | Labourers and other unskilled workers in engineering and allied trades | 73,509 | 1,453 | 1 | 0 | 0 | 0 | 1 | 0 |
| **Mineral oils** | **Total** | **4426581** | **466252** | **49** | **14** | **6** | **2** | **55** | **16** |
| Mineral oils | Metal Workers | 3,811,384 | 432,528 | 43 | 12 | 5 | 2 | 48 | 14 |
| Mineral oils | Motor mechanics, watch makers (Personal and household services) | 22,551 | 1,262 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mineral oils | Precision instrument and tool makers (Manufacture of instruments, photographic and optical goods) | 436,181 | 12,210 | 6 | 2 | 0 | 0 | 6 | 2 |
| **Nickel** | **Total** | **164** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Wood dust | Construction | 1,025,129 | 9,148 | 21 | 6 | 0 | 0 | 21 | 6 |
| Wood dust | Forestry and logging | 23,201 | 7,365 | 0 | 0 | 0 | 0 | 1 | 0 |
| Wood dust | Manufacture of furniture and fixture, except primary of metal | 346,280 | 190,185 | 7 | 2 | 3 | 1 | 10 | 3 |
| Wood dust | Manufacture of wood and wood and cork products, except furniture | 205,608 | 112,925 | 4 | 1 | 2 | 1 | 6 | 2 |
| **Wood dust** | **Total** | **1,744,690** | **404,352** | **34** | **10** | **6** | **2** | **39** | **11** |

# 5 BIBLIOGRAPHY


Acheson, E.D. (1976). Nasal cancer in furniture and boot and shoe manufacturing industries. *Preventive Medicine*, **5,** 295-315.

Acheson, E.D. (1985). Formaldehyde: epidemiological evidence. *IARC Scientific Publication*, **65,** 91-95.

Acheson, E.D., Cowdell, R.H., Hadfield, E. and Macbeth, R.G. (1968). Nasal cancer in woodworkers in the furniture industry. *British Medical Journal*, **2**.

Acheson, E.D., Cowdell, R.H. and Jolles, B. (1970a). Nasal cancer in the Nortamptonshire boot and shoe industry. *British Medical Journal*, **1,** 385-393.

Acheson, E.D., Cowdell, R.H. and Jolles, B. (1970b). Nasal cancer in the shoe industry. *British Medical Journal*, **1,** 791.

Acheson, E.D., Cowdell, R.H. and Rang, E.H. (1972). Adenocarcinoma of the nasal cavity and sinuses in England and Wales. *British Journal of Industrial Medicine*, **29,** 21-30.

Acheson, E.D., Cowdell, R.H. and Rang, E.H. (1981). Nasal cancer in England and Wales - an occupational survey. *British Journal of Industrial Medicine*, **38,** 218-224.

Acheson, E.D., Pippard, E.C. and Winter, P. (1982a). Nasal cancer in the Northamptonshire boot and shoe industry - is it declining? *British Journal of Cancer*, **46,** 940-946.

Acheson, E.D., Winter, P., Hadfield, E. and Macbeth, R.G. (1982b). Is nasal adenocarcinoma in the Buckinghamshire furniture industry declining. *Nature*, **299,** 263-265.

Albert, R.E., Sellakumar, A.R., S., L. and al., e. (1982). Gaseous formaldehyde and hydrogen chloride induction of nasal cancer in the rat. *Journal of the National Cancer Institute*, **68,** 597-603.

Andersen, A., Berge, S.R., Engeland, A. and Norseth, T. (1996). Exposure to nickel compounds and smoking in relation to incidence of lung and nasal cancer among nickel refinery workers. *Occupational and Environmental Medicine*, **53,** 708-713.

Anttila, A., Pukkala, E., Aitio, A., Rantanen, T. and Karjalainen, S. (1998). Update of cancer incidence among workers at a copper/nickel smelter and nickel refinery. *International Archives of Occupational and Environmental Health*, **71,** 245-250.

Aub, J.C., Evans, R.D., Hemplemann, L.H. and *et al*. (1952). The late effects of internally deposited radioactive materials in man. *Medicine*, **31,** 221-329.

Battista, G., Comba, P., Orsi, D., Norpoth, K. and Maier, A. (1995). Nasal cancer in leather workers: an occupational disease. *Journal of Cancer Research and Clinical Oncology*, **121,** 1-6.

Blair, A., Stewart, P.A., Hoover, R.N. and al., e. (1987). Letter to the Editor: Cancers of the nasopharynx and oropharynx and exposure to formaldehyde. *Journal of the National Cancer Institute*, **78,** 191-193.

Blair, A., Stewart, P.A., O'Berg, M. and al., e. (1986). Mortality among industrial workers exposed to formaldehyde. *Journal of the National Cancer Institute*, **76,** 1071-1084.

Blot, W.J., Brinton, L.A. and Fraumeni Jr, J.F. (1977). Cancer mortality in US counties with petroleum industries. *Science*, **198**.

Brinton, L.A., Blot, W.J., Becker, J.A., Winn, D.M., Browder, J.P., Farmer Jr, J.C. and Fraumeni Jr, J.F. (1984). A case-control study of cancers of the nasal cavity and paranasal sinuses. *American Journal of Epidemiology*, **119,** 896-906.

Brinton, L.A., Blot, W.J. and Fraumeni Jr, J.F. (1985). Nasal cancer in the textile and clothing industries. *British Journal of Industrial Medicine*, **42,** 469-474.

Brues, A.M. and Kirsh, I.E. (1977). The fate of individuals containing radium. *Transactions of the American Clinical Climatology Association*, **88,** 211-218.

Bruusgaard, A. (1959). Occurrence of certain forms of cancer in gas workers. *Tidsskr Nor Largeioren*, **79,** 755-756.

Calvert, G.M., Ward, E., Schnorr, T.M. and Fine, L.J. (1998). Cancer risks among workers exposed to metalworking fluids: a systematic review. *Am J Ind Med*, **33,** 282-92.

Coggon, D., Harris, E.C., Poole, J. and Palmer, K.T. (2003). Extended follow-up of a cohort of British chemical workers exposed to formaldehyde. *Journal of the National Cancer Institute*, **95,** 1608-1615.

Coggon D, Harris EC, Brown T, Rice T, Palmer KT (2009) Occupational mortality in England and Wales, 1991-2000. Office of Public Sector Information, London

Comba, P., Barbieri, P.G., Battista, G., Belli, S., Ponterio, F., Zanetti, D. and Axelson, O. (1992a). Cancer of the nose and paranasal sinuses in the metal industry - a case-control study. *British Journal of Industrial Medicine*, **49,** 193-196.

Comba, P., Battista, G., Belli, S., de Capua, B., Merler, E., Orsi, D., Rodella, S., Vindigni, C. and Axelson, O. (1992b). A case-control study of cancer of the nose and paranasal sinuses and occupational exposures. *American Journal of Industrial Medicine*, **22,** 511-520.

Creely, K.S., van Tongeren, M., While, D., Soutar, A.J., Tickner, J., Agostini, M., de Vocht, F., Kromhout, H., Graham, M., Bolton, A., Cowie, H. and Cherrie, J.W. (2006). Trends in Inhalation Exposure: Mid-1980s till Present. Institute of Occupational Medicine.

Davies, J.M., Easton, D.F. and Bidstrup, P.L. (1991). Mortality from respiratory cancer and other causes in United Kingdom chromate production workers. *British Journal of Industrial Medicine*, **48,** 299-313.

Decoufle, P. and Walrath, J. (1983). proportionate mortality among US shoeworkers. *American Journal of Industrial Medicine*, **4,** 523-532.

Demers, P.A., Boffetta, P., Kogevinas, M., Blair, A., Miller, B.A., Robinson, C.F., Roscoe, R.J., Winter, P., Colin, D., Matos, E. and Vainio, H. (1995a). Pooled reanalysis of cancer mortality among 5 cohorts of workers in wood-related industries. *Scandinavian Journal of Work and Environmental Health*, **21,** 179-190.

Demers, P.A., Kogevinas, M., Boffetta, P., Leclerc, A., Luce, D., Gerin, M., Battista, G., Belli, S., Bolm-Audorf, U., Brinton, L.A., Colin, D., Comba, P., Hardell, L., Hayes, R.B., Magnani, C., Merler, E., Morcet, J.-F., Preston-Martin, S., Matos, E., Rodella, S., Vaughan, T.L., Zheng, W. and Vainio, H. (1995b). Wood dust and sino-nasal cancer: pooled reanalysis of twelve case-control studies. *American Journal of Industrial Medicine*, **28,** 151-166.

Dilworth, M. (2000). Wood Dust Survey 1999/2000. Health and Safety Laboratory: Buxton.

Drever, F. (1995). *Occupational Health Decennial Supplement*. Series DS no. 10: The Registrar General's Decennial Supplement for England and Wales. HMSO: London.

Elwood, J.M. (1981). Wood exposure and smoking: Association with cancer of the nasal cavity and paranasal sinuses in British Columbia. *Canadian Medical Association Journal*, **124,** 1573-1577.

Fu, H., Demers, P.A., Costantini, A.S., Winter, P., Colin, D., Kogevinas, M. and Boffetta, P. (1996). Cancer mortality among shoe manufacturing workers: an analysis of two cohorts. *Occupational and Environmental Medicine*, **53,** 394-398.

Garabrant, D.H. and Wegman, D.H. (1984). Cancer mortality among shoe and leather workers in Massachusetts. *American Journal of Industrial Medicine*, **5,** 303-314.

Grimsrud, T.K. and Peto, J. (2006). Persisting risk of nickel related lung cancer and nasal canceramong Clydach refiners. *Occupational and Environmental Medicine*, **63,** 365-366.

Hansen, J. and Olsen, J.H. (1995). Formaldehyde and cancer morbidity among male employees in Denmark. *Cancer Causes and Control*, **6,** 354-360.

Hardell, L., Johansson, B. and Axelson, O. (1982). Epidemiologic study of nasal and nasopharyngeal cancer and their relation to phenoxy acid or chlorophenol exposure. *American Journal of Industrial Medicine*, **3,** 247-257.

Hauptmann, M., Lubin, J.H., Stewart, P.A., Hayes, R.B. and Blair, A. (2004). Mortality from solid cancers among workers in formaldehyde industries. *American Journal of Epidemiology*, **159,** 1117-1130.

Hayes, R.B., Gerin, M., Raatgever, J.W. and de Bruyn, A. (1986). Wood-related occupations, wood dust exposure, and sinonasal cancer. *American Journal of Epidemiology*, **124,** 569-577.

Hernberg, S., Collan, Y., Degerth, R., Englund, A., Engzell, U., Kuosma, E., Mutanen, P., Nordlinder, H., Hansen, H.S., Schultz-Larsen, K. and al., e. (1983a). Nasal cancer and occupational exposures. Preliminary report of a joint Nordic case-referent study. *Scandinavian Journal of Work and Environmental Health*, **9,** 208-213.

Hernberg, S., Westerholm, P., Schultzlarsen, K., Degerth, R., Kuosma, E., Englund, A., Engzell, U., Hansen, H.S. and Mutanen, P. (1983b). Nasal and sinonasal cancer - connection with occupational exposures in Denmark, Finland and Sweden. *Scandinavian Journal of Work and Environmental Health*, **9,** 315-326.

HSE. (1990). HSE Internal Report: Exposure to hardwood dust. In *Technical Development Survey Report*. Health and Safety executive: Bootle.

IARC. (1981). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons, Wood, Leather and Some Associated Industries*. Volume 25. International Agency for Research on Cancer, Lyon

IARC (1984) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons, Part 2: Carbon Blacks, Mineral Oils (Lubricant Base Oils and Derived Products) and Some Nitroarenes.* Volume 33 International Agency for Research on Cancer, Lyon

IARC (1985) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons, Part 4: Bitumens, Coal-Tars and Derived Products, Shale-Oils and Soots.* Volume 35 International Agency for Research on Cancer, Lyon

IARC. (1987b). Overall Evaluations of Carcinogenicity: an updating of IARC monographs Vols 1 to 42. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. International Agency for Research on Cancer: Lyon.

IARC. (1990a). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons, Chromium and Chromium Compounds*. Volume 49. International Agency for Research on Cancer, Lyon

IARC. (1990b). *IARC Monographs on the evaluation of the carcinogenic risk of chemicals to humans. Some flame retardants and textile chemicals and exposures in the textile manufacturing industry.* Volume 48 International Agency for Research on Cancer, Lyon

IARC. (1995). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons,Wood Dust and Formaldehyde.* International Agency for Research on Cancer, Lyon

IARC. (2005). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polynuclear Aromatic Hydrocarbons, Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxy-2-propanol.* Volume 88. International Agency for Research on Cancer, Lyon

IARC (2006) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Formaldehyde, 2-Butoxyethanol and 1-tert-Butoxypropan-2-ol.* International Agency for Research on Cancer, Lyon

Ironside, P. and Matthews, J. (1975). Carcinoma of the nose and paranasal sinuses in woodworkers in the state of Victoria, Australia. *Cancer*, **36,** 1115-1121.

Jakobsen, M.H., Larsen, S.K., Kirkegaard, J. and Hansen, H.S. (1997). Cancer of the nasal cavity and paranasal sinuses. Prognosis and outcome of treatment. *Acta Oncologica*, **36,** 27-31.

Jarup, L., Bellander, T., Hogstedt, C. and Spang, G. (1998). Mortality and cancer incidence in Swedish battery workers exposed to cadmium and nickel. *Occupational and Environmental Medicine*, **55,** 755-759.

Luce, D., Gerin, M., Leclerc, A., Morcet, J.-F., Brugere, J. and Goldberg, M. (1993). Sinonasal cancer and occupational exposure to formaldehyde and other substances. *International Journal of Cancer*, **53,** 224-231.

Luce, D., Gerin, M., Morcet, J.-F. and Leclerc, A. (1997). Sinonasal cancer and occupational exposure to textile dust. *American Journal of Industrial Medicine*, **32,** 205-210.

Luce, D., Leclerc, A., Begin, D., Demers, P.A., Gerin, M., Orlowski, E., Kogevinas, M., Belli, S., Bugel, I., Bolm-Audorf, U., Brinton, L.A., Comba, P., Hardell, L., Hayes, R.B., Magnani, C., Merler, E., Preston-Martin, S., Vaughan, T.L., Zheng, W. and Boffetta, P. (2002). Sinonasal cancer and occupational exposures: a pooled analysis of 12 case-control studies. *Cancer Causes and Control*, **13,** 147-157.

Luce, D., Leclerc, A., Morcet, J.-F., Casallareo, A., Gerin, M., Brugere, J., Haguenoer, M. and Goldberg, M. (1992). Occupational risk factors for sinonasal cancer **-** a case-control study in France. *American Journal of Industrial Medicine*, **21,** 163-175.

Macbeth, R.G. (1965). Carcinoma of the nasal cavity and accessory sinuses in woodworkers. *Journal of Laryngology*, **79,** 592-612.

Malker, H.S.R., Mclaughlin, J.K., Blot, W.J., Weiner, J.A., Malker, B.K., Ericcson, J.L.E. and Stone, B.J. (1986). Nasal cancer and occupation in Sweden, 1961-1979. *American Journal of Industrial Medicine*, **9,** 477-485.

Mannetje, A., Kogevinas, M., Luce, D., Demers, P.A., Begin, D., Bolm-Audorf, U., Comba, P., Gerin, M., Hardell, L., Hayes, R.B., Leclerc, A., Magnani, C., Merler, E., Tobias, A. and Boffetta, P. (1999). Sinonasal cancer, occupation, and tobacco smoking in European women and men. *American Journal of Industrial Medicine*, **36,** 101-107.

Mastrangelo, G., Fedeli, U., Fadda, E., Milan, G. and Lange, J.H. (2002). Epidemiologic evidence of cancer risk in textile industry workers: a review and update. *Toxicology and Industrial Health*, **18,** 171-181.

Merler, E., Baldasseroni, A., Laria, R., Faravelli, P., Agostini, R., Pisa, R. and Berrino, F. (1986). On the causal association between exposure to leather dust and nasal cancer: further evidence from a case-control study. *British Journal of Industrial Medicine*, **43,** 91-95.

Mirer, F. (2003). Updated epidemiology of workers exposed to metalworking fluids provides sufficient evidence for carcinogenicity. *Appl Occup Environ Hyg*, **18,** 902-12.

Ng, T.P. (1986). A case-referent study of cancer of the nasal cavity and sinuses in Hong Kong. *International Journal of Epidemiology*, **15,** 171-175.

NIOSH. (1998). Occupational Exposure to Metalworking Fluids. In *Criteria for a Recommended Standard*. National Institute for Occupational Safety and Health: Cincinnati, Ohio.

Olsen, J.H. (1988). Occupational risks of sinonasal cancer in Denmark. *British Journal of Industrial Medicine*, **45,** 329-335.

Olsen, J.H. and Asnaes, S. (1986). Formaldehyde and the risk of squamous-cell carcinoma of the sinonasal cavities. *British Journal of Industrial Medicine*, **43,** 769-774.

Olsen, J.H., Jensen, S.P., Hink, M., Faurbo, K., Breum, N.O., Jensen, O.M. (1984). Occupational formaldehyde exposure and increased nasal risk in man. *International Journal of Cancer*, **34**, 639-644.

ONS. (2006). *Cancer Statistics, Registrations. Registrations of Cancer Diagnosed in 2004, England.* Vol. No. 35. Series MB1. Office for National Statistics: London.

Paci, E., Buiatti, E., Costantini, A.S., Miligi, L., Pucci, N., Scarpelli, A., Petrioli, G., Simonato, L., Winkelmann, R. and Kaldor, J. (1989). Aplastic anemia, leukemia and other cancer mortality in a cohort of shoe workers exposed to benzene. *Scandinavian Journal of Work and Environmental Health*, **15,** 313-318.

Pinkerton, L.E., Hein, M.J. and Stayner, L.T. (2004). Mortality among a cohort of garment workers exposed to formaldehyde: an update. *Occupational and Environmental Medicine*, **61,** 193-200.

Pippard, E.C. and Acheson, E.D. (1985). The mortality of boot and shoe makers, with special reference to cancer. *Scandinavian Journal of Work and Environmental Health*, **11,** 249-255.

Polednak, A.P., Stehney, F. and Rowland, R.E. (1978). Mortality among women first employed before 1930 in the US radium dial-painting industry: A group ascertained from employment lists. *American Journal of Epidemiology*, **107,** 179-195.

Rang, E.H. and Acheson, E.D. (1981). Cancer in furniture workers. *International Journal of Epidemiology*, **10,** 253-261.

Robinson, C.F., Petersen, M., Sieber, W.K., Palu, S. and Halperin, W.E. (1996). Mortality of Carpenters' Union members employed in the U.S. construction or wood products industries, 1987-1990. *American Journal of Industrial Medicine*, **30,** 674-694.

Rosenman, K.D. and Stanbury, M. (1996). Risk of lung cancer among former chromium smelter workers. *American Journal of Industrial Medicine*, **29,** 491-500.

Roush, G.C. (1996). Cancer of the Nasal Cavity and Paranasal Sinuses. In *Cancer Epidemiology and Prevention* pp. 587-602. Oxford University Press: Oxford.

Roush, G.C., Kelly, J.A., Meigs, J.A. and Flannery, J.T. (1982). Scrotal carcinoma in Conecticut metal-workers; sequel to a study of sinonasal cancer. *American Journal of Epidemiology*, **116,** 76-85.

Roush, G.C., Meigs, J.A., Kelly, J.A., Flannery, J.T. and Burdo, H. (1980). Sinonasal cancer and occupation: a case-control study. *American Journal of Epidemiology*, **111,** 183-193.

Rowland, R.E. (1975). The risk of malignancy from internally deposited radioisotopes. In *Radiation Research: Biomedical, Chemical and Physical Perspectives.*, Nygaard, O.F., Adler, H.I. and Sinclair, W.K. (eds) pp. 146-155. Academic Press: New York.

Rutstein, D.D., Mullan, R.J., Frazier, T.M., Halperin, W.E., Melius, J.M. and Sestito, J.P. (1984). Sentinel health events (occupational) - a basis for physician recognition and public health surveillance. *Archives of Environmental Health*, **39,** 159-168.

Sorahan, T. and Harrington, J.M. (2000). Lung cancer in Yorkshire chrome platers, 1972-97. *Occupational and Environmental Medicine*, **57,** 385-389.

Sorahan, T. and Williams, S.P. (2005). Mortality of workers at a nickel carbonyl refinery, 1958-2000. *Occupational and Environmental Medicine*, **62,** 80-85.

Tolbert PE (1997) Oils and cancer. *Cancer Causes Control* **8**: 386-405

Vaughan, T.L. and Davis, S. (1991). Wood dust exposure and squamous cell cancers of the upper respiratory tract. *American Journal of Epidemiology*, **133,** 560-564.

Vaughan, T.L., Stewart, P.A., Teschke, K., Lynch, C.F., Swanson, G.M., Lyon, J.L. and Berwick, M. (2000). Occupational exposure to formaldehyde and wood dust and nasopharyngeal carcinoma. *Occupational and Environmental Medicine*, **57,** 376-384.

Vaughan, T.L., Strader, C., Davis, S. and Daling, J.R. (1986a). Formaldehyde and cancers of the pharunx, sinus and nasal cavity: I Occupational exposures. *International Journal of Cancer*, **38,** 677-683.

Vaughan, T.L., Strader, C., Davis, S. and Daling, J.R. (1986b). Formaldehyde and cancers of the pharynx, sinus and nasal cavity: II. Residential exposures. *International Journal of Cancer*, **38,** 685-688.

Walker, J.T., Bloom, T.F., Stern, F.B., Okun, A.H., Fingerhut, M.A. and Halperin, W.E. (1993). Mortality of workers employed in shoe manufacturing. *Scandinavian Journal of Work and Environmental Health*, **19,** 89-95.

Walrath, J., Decoufle, P. and Thomas, T.L. (1987). Mortality among workers in a shoe manufacturing company. *Am J Ind Med*, **12,** 615-23.

# 6 STATISTICAL APPENDIX

**Formulae used in the estimation of AF**

Levin's equation

$AF = Pr(E)*(RR-1)/\{1+Pr(E)*(RR-1)\}$ (1)

where RR = relative risk, Pr(E) = proportion of the population exposed

A common denominator is used across exposure levels and industries for each exposure

Miettinen's equation

$AF = Pr(E|D)*(RR-1)/RR$ (2)

where Pr(E|D) = proportion of cases exposed (E = exposed, D = case)

Turnover equation to estimate numbers ever employed during the REP

$$N_{e(REP)} = \sum_{i=a}^{i=b} l_{(adj15)i} * n_0/(R-15)\} + \sum_{k=0}^{k=(age(u)-age(1))} \sum_{j=c+k}^{j=d+k} \{l_{(adj15)j} * n_0 * TO/(age(u)-age(l)+1)\} \quad (3)$$

where $N_{e(REP)}$ = numbers ever employed in the REP

$n_0$ = numbers employed in the exposed job/industry at a mid-point in the REP

TO = staff turnover per year

R = retirement age (65 for men, 60 for women)

$l_{(adj15)i}$ = the proportion of survivors to age i of those alive at age 15 (from GB life tables)

a to b = age range achieved by the original cohort members by the target year (2004) (e.g. 65 to 100 for the solid tumour REP)

c to d = age range achieved by the turnover recruited cohort members by the target year (25 to 64 for the solid tumour REP)

age(u) and age(l) = upper and lower recruitment age limits (24 and 15)

The derivation and assumptions underlying this formula are described in the methodology technical report, available on the HSE website. The equation can be represented as a single factor acting as a multiplier for $n_0$, calculated by setting $n_0$ to 1 in the above equation, so that the factor varies only with TO see Table A1 below.

Equation to estimate the proportion of the population exposed

$Pr(E) = N_{e(REP)} / N_{p(REP)}$ (4)

where $N_{p(REP)}$ = numbers ever of working age during the REP from population estimates for the relevant age cohorts in the target year

Equation for combining AFs where exposed populations overlap but are independent and risk estimates are assumed to be multiplicative:

$AF_{overall} = 1- \Pi_k(1-AF_k)$ for the k exposures in the set (5)

**Table A1** Employment level adjustment and turnover factors used in the calculation of AF

| | | **Main Industry Sector** | **Adjustment factor for change in employment levels*** | **Turnover per year** |
|---|---|---|---|---|
| Men | A-B | Agriculture, hunting and forestry; fishing | 1 | 7% |
| | C-E | Mining and quarrying, electricity, gas and water; manufacturing industry | 1.4 | 9% |
| | F | Construction | 1 | 12% |
| | G-Q | Service industries | 0.9 | 11% |
| | | Total | 1 | 10% |
| Women | A-B | Agriculture, hunting and forestry; fishing | 0.75 | 10% |
| | C-E | Mining and quarrying, electricity, gas and water; manufacturing industry | 1.5 | 14% |
| | F | Construction | 0.67 | 15% |
| | G-Q | Service industries | 0.8 | 15% |
| | | Total | 0.9 | 14% |

* Applied to CAREX data for the solid tumour REP only. Exposed numbers are obtained for a mid-point year in the REP where national employment data sources have been used (the LFS or CoE).

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# The burden of occupational cancer in Great Britain

## Sinonasal cancer

The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer was the attributable fraction (AF) being the proportion of cases that would not have occurred in the absence of exposure; and the AF was used to estimate the number of attributable deaths and registrations. The study involved obtaining data on the risk of the cancer due to the exposure of interest, taking into account confounding factors and overlapping exposures, as well as the proportion of the target population exposed over the relevant exposure period. Only carcinogenic agents, or exposure circumstances, classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens were considered. Here, we present estimates for sinonasal cancer that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

The estimated total (male and female) AF, deaths and registrations for sinonasal cancer related to overall occupational exposure is 32.67% (95% Confidence Interval (CI)= 21.53-55.01), which equates to 38 (95%CI= 25-63) attributable deaths and 126 (95%CI= 83-212) attributable registrations.

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