2. Studies of Cancer in Humans

2.1 Case reports

Many cases of cancer of the sinonasal cavities and paranasal sinuses (referred to below as 'sinonasal cancer') have been reported among woodworkers. The earliest reports of cases of cancer of the upper respiratory tract in association with woodworking were published in Germany (reviewed by Schroeder, 1989).

Macbeth (1965) reported 20 patients (17 men) from High Wycombe, United Kingdom, presenting with a malignant disease of the paranasal sinuses; 15 of the cases, all in men, were associated with the making of wooden chairs. Macbeth noted later that the tumours were all adenocarcinomas (Acheson, 1976). Several furniture factories are located in High Wycombe which specialize in chair-making from a variety of domestic and imported hardwoods. The cross-sectional prevalence of woodworkers in the local male population at the time of the study was 23.5%.

Following these observations, a survey was carried out in the Oxford area, including High Wycombe, of 148 cases (98 males) of nasal cancer diagnosed in 1951–65 (Acheson *et al.*, 1968; Acheson, 1976). Cases were classified according to sex and histological type of cancer. The results for men indicated a strong relationship between adenocarcinoma and present or past work in the furniture industry. Of the 33 cases of adenocarcinoma in men, 24 (73%) were in woodworkers, 22 of whom (67%) worked in furniture manufacture. Among the 65 remaining male cases of nasal tumour, the corresponding numbers were five (8%) and three (5%). For the subgroup of men who were employed at the onset of their illness, which was diagnosed in 1956 or later, a detailed occupational history was obtained and was compared with the findings of the 1961 census. The estimated rate for adenocarcinoma in cabinet- and chair makers and wood machinists in High Wycombe was similar, namely 0.7 ± 0.2 per 1000 men per annum during the decade 1956–65, which was at least 500 times the rate in adult males in southern England. The risk was extended to workers making products other than chairs. The results suggested that carpenters and joiners in High Wycombe had no increase in risk. The species of wood used by the 16 patients for whom information was available before the Second World War were oak (14/16), beech (11/16) and mahogany (13/16). Walnut was also frequently used.

Acheson *et al.* (1972) performed a survey of nasal adenocarcinoma in England excluding the Oxford area. Cases of nasal adenocarcinoma were collected from cancer registries (for the period 1961–66 for most registries) and were compared with cases of nasal cancer other than adenocarcinomas. The study comprised 107 cases of adenocarcinoma (80 male) and 110 cases of nasal cancer other than adenocarcinoma (85 male) when restricted to cases 'accepted' mainly on the basis of confirmation of the histological classification. Thirty-three men (41%) and one woman (3.7%) with nasal adenocarcinoma had at some time worked as woodworkers; of these, 24 (73%) men had worked in the furniture industry. The ratio of observed cases:expected cases was 95 for furniture workers and 5 for other woodworkers (principally, carpenters and joiners) on the basis of the distribution at the 1961 census. Among nasal cancer cases other than adenocarcinoma, a significant excess in woodworkers was also observed. The main types of

wood dusts were known for some of the woodworkers (with both adenocarcinoma and other histological types): most were exposed to more than one species. The species most often indicated in the furniture industry were oak (eight adenocarcinoma patients), mahogany (six adenocarcinoma patients) and beech, birch and walnut (four adenocarcinoma patients for each of the species). Four patients had used mainly softwoods; three of those with adenocarcinomas were joiners or joiners and carpenters, and the last had worked as a packing case maker and had a squamous-cell carcinoma.

After the results from the United Kingdom were published, cases were reported from many countries, including Belgium (Debois, 1969), the Netherlands (Delemarre & Themans, 1971), Denmark (Andersen, 1975; Andersen *et al.*, 1976, 1977), France (Trotel, 1976), Australia (Ironside & Matthews, 1975), western (Gülzow, 1975; Kleinsasser & Schroeder, 1989) and eastern Germany (Löbe & Ehrhardt, 1983; Wolf *et al.*, 1986), Sweden (Engzell *et al.*, 1978; Klintenberg *et al.*, 1984), Austria (Smetana & Horak, 1983), Norway (Voss *et al.*, 1985), Switzerland (Rüttner & Makek, 1985) and Spain (López *et al.*, 1990). Subsequently, many more case reports were published in different countries (for an extensive review, see for instance Mohtashamipur *et al.*, 1989a). A systematic analysis of these studies is not included, as many analytical studies were available.

The studies that presented data on occupational exposures to specific species of wood are summarized in Table 15.

2.2 Descriptive studies

The studies placed under this heading were mainly designed for generating hypotheses, especially by use of record linkage with routinely collected data.

A number of descriptive studies (Table 16) have dealt with cancer mortality or incidence among woodworkers, defined on the basis of occupational title and/or industrial branch reported on death certificates (Menck & Henderson, 1976; Milham, 1976; Gallagher *et al.*, 1985), in hospital files (Grufferman *et al.*, 1976; Menck & Henderson, 1976; Bross *et al.*, 1978), in cancer registries (Acheson, 1967; Nandakumar *et al.*, 1988) or in the records of pension funds (Olsen & Jensen, 1987; Olsen *et al.*, 1988), in union files (Milham, 1978) or declared at censuses (Pukkala *et al.*, 1983; Gerhardsson *et al.*, 1985; Pearce & Howard, 1986; Linet *et al.*, 1988, 1993). None of these studies provides quantitative or semi-quantitative information on exposure to wood dust.

Some studies based on occupational titles specifically address nasal cancer in woodworkers (Table 17), both in terms of mortality (Minder & Vader, 1987) and morbidity (Malker *et al.*, 1986; Vetrugno & Comba, 1987; Olsen, 1988). These studies corroborate the well-established indication of an increased risk for nasal cancer in woodworkers. The same observation applies to incidence studies of nasal cancer in which information on occupation was provided by questionnaires and/or interviews with patients (Ghezzi *et al.*, 1983; Petronio *et al.*, 1983).

Table 15. Case reports of sinonasal cancer according to occupation and type of wood

Study, year, country	Sex	Origin	Histological type	Exposed cases/ total cases	Occupations	Main types of wood
Acheson *et al.* (1968); Acheson (1976); Oxfordshire, United Kingdom	M	Registry	Adenocarcinoma	24/33	22 in the furniture industry (mainly wood machinists and furniture makers)	Oak, beech, mahogany, walnut
Acheson *et al.* (1972), United Kingdom	M	Registries	Adenocarcinoma	33/80	24 in the furniture industry (mainly cabinet- and chair makers, wood machinists and turners) 6 not in the furniture industry (mainly joiners and carpenters)	Oak, mahogany, beech, birch, walnut Softwoods in 3 cases
Leroux-Robert (1974), France	M	Hospital	Adenocarcinoma, ethmoid sinus	26/92	Not reported	All patients had used European hardwoods, some exclusively, and mainly oak (22/26), exclusively oak in one case
Luboinski & Marandas (1975), Paris, France	M	Hospital	Adenocarcinoma, ethmoid sinus	21/43	8 joiners, 4 joiners and cabinet-makers, 7 cabinet-makers, 1 cooper, 1 coffin maker	European hardwoods (oak, chestnut, wild cherry, walnut, beech, poplar); tropical species, including mahogany
Ironside & Matthews (1975), Victoria, Australia	M	Hospital	Adenocarcinoma	10/18	3 carpenters, 2 woodturners/ wood machinists, 2 builders, 1 sawmill owner, 1 timber worker, 1 joiner	Native timber

Table 15 (contd)

Study, year, country	Sex	Origin	Histological type	Exposed cases/ total cases	Occupations	Main types of wood
Andersen *et al.* (1976, 1977), Aarhus, Denmark	MF	Hospital	Adenocarcinoma	12/17	10 cabinet- and chair makers, 1 turner, 1 coach builder	Several kinds of wood used by each cabinet- and chair maker; primarily beech, oak, walnut; periodically mahogany and teak
	MF	Hospital	Squamous-cell carcinoma	5/71	1 carpenter, 1 turner, 1 sawyer, 1 forestry worker, 1 brushmaker	
Engzell *et al.* (1978), Sweden	M	Registry	Adenocarcinoma	19/36	19 joiners or cabinet-makers (at least 12 cabinet-makers)	Hardwoods such as oak, teak, mahogany and birch; never exclusively softwood
Voss *et al.* (1985), Norway	M	Hospital	Adenocarcinoma	1/2	Cabinet-maker	Birch, pine, spruce, teak, mahoghany
	M	Hospital	Squamous-cell carcinoma and undifferentiated carcinoma	8/30	3 joiners/carpenters, 3 loggers, 1 sawmill/ carpenter, 1 cabinet-maker	Pine and spruce (7 cases), pine and lime (1 case)
Kleinsasser & Schroeder (1989), Germany	M	National recruitment	Adenocarcinoma, intestinal type	77/85	55 joiners and cabinet-makers, 11 wheelwrights, 6 coopers, 5 parquet floor layers, 5 carpenters (non-exclusive categories)	Oak, beech No case patient had handled softwood or exotic wood exclusively.

Table 16. Studies of mortality and morbidity in woodworkers

Reference	Method	Results
Milham & Hesser (1967)	Analysis of occupations reported on death certificates (New York State, USA, 1940–53 and 1957–64). Comparison with all other causes of death	Hodgkin's disease: significant association with woodworking (χ^2, 14.59; p<0.001)
Acheson (1967)	Analysis of occupations of patients in the Oxford area, United Kingdom, 1956–65	Hodgkin's disease: three cases among woodworkers versus four expected
Grufferman *et al.* (1976)	Incidence by occupation in Boston, USA, 1959–73. Reference rates: whole Boston population	Hodgkin's disease: woodworkers: RR, 1.6 (95% CI, 0.9–2.6); 15 observed
Menck & Henderson (1976)	Mortality by occupation in Los Angeles County, USA, 1968–70. Reference rates: mortality in all occupations	Lung cancer: lumber, wood, furniture: SMR, 1.1 [0.7–1.8]; 20 observed
Milham (1976)	Proportionate analysis of mortality by occupation from death certificates, Washington State, USA, 1950–71	Plywood mill workers, stomach cancer: PMR, 1.5 [1.0–2.2]; 32 observed; leukaemia: PMR, 1.9 [1.2–2.9]; 23 observed Sawmill workers, cancer of the testis: PMR, 1.7 [0.9–2.7]; 15 observed Carpenters, stomach cancer: PMR, 1.3 [1.1–1.4]; 271 observed; Hodgkin's disease: PMR, 1.6 [1.1–2.2]; 38 observed
Bross *et al.* (1978)	Analysis of occupations of cancer patients attending Roswell Park Memorial Institute, USA, 1956–65. Comparison groups: noncancer patients	Oesophageal cancer: lumber workers: significantly increased risk
Milham (1978)	Analysis of mortality of woodworkers, USA, 1969–73. Reference rates from US population	Malignant neoplasm of stomach: SMR, 1.1 [1.0–1.2]; 407 observed
Pukkala *et al.* (1983)	Incidence by occupation declared at 1970 census in Finland, 1971–75. Reference rates from total economically active population	Lung cancer: woodworking: SIR, 1.3 [1.2–1.4]; 366 observed Joiners: SIR, 1.4 [1.3–1.6]; 264 observed
Gallagher *et al.* (1985)	Proportionate cancer mortality analysis of woodworkers in British Columbia, Canada, 1950–78	Loggers: nasal sinus: PCMR, 3.6 (1.2–8.5); 5 observed Woodworkers: stomach: PCMR,1.3 (1.1–1.5); 116 observed; non-Hodgkin's lymphoma, PCMR, 1.4 (1.0–1.9); 42 observed

Table 16 (contd)

Reference	Method	Results
Pearce & Howard (1986)	Analysis of cancer mortality rates by occupation in New Zealand, 1974–78. Reference: mortality rates of all employed people	Large-bowel cancer in cabinet-makers and woodworkers: RR, 2.6 (1.3–4.6); 11 observed
Olsen & Jensen (1987)	Proportionate analysis of cancer incidence by occupation in Denmark, 1970–79	Among men: woodworking: stomach cancer: SPIR, 1.8 (1.3–2.5), 41 observed; breast cancer: SPIR, 3.9 (1.2–12) Among men: manufacture of wooden furniture: cancer of nasal cavities and sinuses: SPIR, 5.9 (2.5–14), 5 observed
Nandekumar *et al.* (1988)	Incidence by occupation in Western Australia, 1960–84. Reference rates: other occupations except farming	Multiple myeloma: woodworking: RR, 1.7 (0.78–3.9); 3 cases
Linet *et al.* (1988)	Incidence by industry through record linkage between 1960 census and National Cancer Registry in Sweden, 1961–79. Reference: national incidence rates	Acute nonlymphocytic leukaemia: wood (men): SIR, 1.3 [1.0–1.7]; 67 observed
Linet *et al.* (1993)	Incidence by industry through record linkage between 1960 census and National Cancer Registry in Sweden, 1961–79. Reference: national incidence rates	Non-Hodgkin's lymphoma: furniture and furnishings (men): SIR, 1.3 [1.0–1.7]; 55 observed

CI, confidence interval; RR, relative risk; SMR, standardized mortality ratio; PMR, proportionate mortality ratio; SIR, standardized incidence ratio; PCMR, proportionate cancer mortality ratio; SPIR, standardized proportionate incidence ratio

Table 17. Mortality and morbidity studies on nasal cancer in wood workers

Reference	Method	Results
Malker *et al.* (1986)	Incidence in Swedish subjects who reported their occupation as woodworker at 1960 census. Follow-up through 1979. Comparison with population.	Woodworkers (males) - All nasal cancers: SIR, 1.3 [0.8–1.9], 24 observed - Adenocarcinomas: SIR, 2.2 [0.8–4.8], 6 observed Furniture workers (males) - All nasal cancers: SIR, 4.1 [2.7–6.1], 25 observed - Adenocarcinoma: SIR, 17 [10–26], 19 observed
Minder & Vader (1987)	Mortality of Swiss subjects who reported their occupation as woodworker at 1980 census. Follow-up through 1985. Comparison with all workers.	SMR: 6.2 (3.6–10), 16 observed
Vetrugno & Comba (1987)	Analysis of the occupations reported by 189 cases diagnosed and/or treated in 1983–85 at 61 Italian ear-nose-and-throat clinics and hospital departments.	Among males, woodworkers account for 11% of the case series and 22% of adenocarcinoma cases.
Olsen (1988)	Analysis of employment histories reported by cases diagnosed in Denmark 1970–84.	Among males: wooden furniture production: SIR, 3.6 (1.3–8.0), 5 observed
Ghezzi *et al.* (1983)	Incidence among woodworkers in Brianza (Italy), 1976–80. Comparison with incidence in other occupations.	Rate ratio: 4.4 (1.8–9.1), 7 observed
Petronio *et al.* (1983)	Incidence in woodworkers in Trieste (Italy), 1968–80. Comparison with incidence in all occupations.	Woodworkers: incidence rate: 6.4×10^{-5} All occupations: incidence rate: 0.54×10^{-5}
Gerhardsson *et al.* (1985)	Record linkage between 1960 census and 1961–79 cancer registry in Sweden for morbidity from respiratory cancers in furniture workers. Reference rates: all other employed men.	Sinonasal carcinoma: SMR, 7.1; 90% CI, 4.4–11, 15 observed Sinonasal adenocarcinoma: SMR, 44; 90% CI, 27–69, 14 observed

CI, confidence interval; SMR, standardized mortality ratio; SIR, standardized incidence ratio

2.3 Cohort studies

The only cohort study that addressed the issue of exposure to wood dust was that conducted in High Wycombe, United Kingdom (Acheson *et al.*, 1984); the others assessed exposure by occupational title.

One cohort study was conducted in Finland of 1223 sawmill workers followed-up during 1945–80 (Jäppinen *et al.*, 1989). Cancer incidence was not in excess overall, and no cases of nasal cancer were found (0.3 expected). The only cancer for which an increased incidence was seen was non-melanocytic skin cancer (excluding basal-cell carcinoma), with six cases in men (standardized incidence ratio [SIR], 3.1; 95% confidence interval [CI], 1.2–6.8) and two cases in women [SIR, 1.8; 95% CI, 0.2–6.6]; however, four of the six male patients were first employed after 1945, when chlorophenols were used.

Four cohort studies of furniture workers are available, from the United Kingdom, Denmark, Germany and the United States. In the Danish study, 40 428 members of the carpenters' and cabinet-makers' union in 1971 were followed up to 1976 (Olsen & Sabroe, 1979). The overall mortality of both active and retired workers was below that expected; the only cancer for which increased mortality was seen was that of the nose and sinuses (standardized mortality ratio [SMR], 4.7; 95%CI, 2.5–6.8; four deaths).

In the study of 5108 furniture workers in High Wycombe, United Kingdom, followed through 1982, overall mortality and mortality from all cancers were below expectation; the only cancer site for which there was increased mortality was that of the nose and sinuses ([SMR, 8.2; 95%CI, 3.7–16] nine deaths) (Rang & Acheson, 1981; Acheson *et al.*, 1984). When workers were divided into three groups according to dustiness of workplace, all nasal cancer deaths were found in the group exposed to the most dust [SMR, 16; 95% CI, 7.2–30].

In a cohort of 759 cabinet-makers or joiners studied during 1973–84 in Germany, no cases of nasal cancer were found [expected number not reported]; the only cancer for which the incidence was increased was malignant melanoma (SIR, 9.5; 95%CI, 2.4–28; two cases) (Barthel & Dietrich, 1989).

A cohort of furniture makers in the United States, which included 34 801 subjects (of whom 12 158 were employed in wooden furniture facilities), was studied between 1946 and 1983 (Miller *et al.*, 1989, 1994). Overall mortality and mortality from all cancers were below expectation for the wooden furniture workers; the only neoplasm for which mortality was increased was myeloid leukaemia (SMR, 1.9; 95%CI, 1.0–3.5; 11 deaths); seven deaths were from acute leukaemia. A significant increase in mortality from chronic nephritis was also found (SMR, 2.5; 95% CI, 1.1–5.0; eight deaths). Two cohort members died from nasal cancer (2.5 expected); one case occurred in the cohort of wooden furniture workers [expected number not reported].

A cohort of 2283 plywood workers from four mills in Washington and Oregon, United States, was studied between 1945 and 1977 (Robinson *et al.*, 1990). Overall mortality and mortality from all cancers were below expectation, and no significantly increased mortality was seen. No deaths from nasal cancer were found (0.4 expected).

A total of 10 322 American Cancer Society volunteers enrolled in a large prospective study conducted between 1959 and 1972 reported wood-related occupations, and their mortality was compared with that of over 400 000 volunteers with other occupations (Stellman & Garfinkel, 1984). Overall mortality and mortality from all cancers were close to expectation; a significant increase in mortality was found from cancers of the stomach (SMR, 1.5; 44 deaths) and urinary bladder (SMR, 1.4; 29 deaths); non-significant increases in mortality were found for lung cancer (SMR, 1.1; 135 deaths) and nasal cancer (SMR, 2.0; two deaths); the two deaths from nasal cancer occurred among carpenters and joiners (SMR, 3.3).

Cohort studies on woodworkers are summarized in Table 18.

During the last decade, several papers raised the possibility that the risk for colorectal cancer was increased among wooden pattern and model makers exposed to wood dust in the automobile industry (Swanson & Belle, 1982; Swanson *et al.*, 1985; Tilley *et al.*, 1990; Becker *et al.*, 1992; Roscoe *et al.*, 1992). These studies are summarized in Table 19. Although various study designs were used, leading to different risk estimates (SMRs, proportionate mortality ratios [PMRs] and SIRs), the first three reported excess risks for colorectal cancer. The suggested association has been the object of some debate in the scientific literature (Chovil, 1982; Davies, 1983; Kurt, 1986). [The studies that gave positive results had several methodological problems, namely short duration of observation, high proportion of loss to follow-up and inadequate assessment of exposure; the study that was of more adequate design with respect to ascertainment of exposure and control of confounding (Roscoe *et al.*, 1992) did not reach positive conclusions.]

2.4 Case–control studies

Information on exposure to wood dust or employment in wood-related occupations has been reported in studies dealing with many cancer sites. The Working Group reviewed in particular case–control studies of organs in the respiratory, the digestive and the lympho-haematopoietic systems. The case–control studies are grouped according to whether exposure to wood dust was addressed specifically or whether the results are based on job titles or industrial branch. The term 'relative risk' is used to cover all estimated risk ratios, which are usually given as odds ratios.

2.4.1 Cancer of the nasal cavity and paranasal sinuses

(a) Exposure to wood dust

Hernberg *et al.* (1983) reported the results of a joint Danish–Finnish–Swedish case–control study of 167 patients with primary malignant tumours of the nasal cavity and paranasal sinuses diagnosed in Denmark, Finland and Sweden between July 1977 and December 1980. Ninety-five cases were epidermoid carcinoma, 18 were adenocarcinoma, 17 were anaplastic carcinoma and 37 were other histological types. Controls were 167 patients with tumours of the colon and rectum, who were matched to patients on country, sex and age at diagnosis. Cases and controls were identified through the national cancer registries of Finland and Sweden and four of the five oncological centres in Denmark. Subjects were interviewed extensively by telephone to

Table 18. Cohort studies of workers in wood-related industries

Industry	Reference	Methods	Results	Notes
Sawmill workers	Jåppinen *et al.* (1989)	1223 sawmill workers employed between 1945 and 1961; follow-up till 1980; cancer incidence in the cohort contrasted to local incidence rates. Lost to follow-up: 0.2%	SIR: All cancers: men, 1.1 (0.9–1.3), 90 observed women, 1.2 (0.9–1.6), 55 observed Skin cancer: men, 3.1 (1.2–6.8), 6 observed women, [1.8; 0.2–6.6], 2 observed No other significantly increased SIR. No case of nasal cancer, 0.3 expected. *Women* Lip, mouth, pharynx (1 observed/0.9 expected) Stomach, 1.1 (0.4–2.5), 5 observed Colon (2 observed/2.3 expected) Rectum, 2.3 (0.6–5.8), 4 observed Larynx (0 observed/0.1 expected) Lung, 3.3 (0.9–8.3), 4 observed Lymphoma (0 observed/0.9 expected) Hodgkin's disease (0 observed/0.2 expected) Leukaemia, 2.7 (0.6–8.0), 3 observed *Men* Lip, mouth, pharynx, 1.8 (0.6–3.8), 6 observed Stomach, 0.8 (0.4–1.5), 11 observed Colon, 1.7 (0.6–4.1), 5 observed Rectum, 1.3 (0.4–3.3), 4 observed Larynx (2 observed/2.1 expected) Lung, 1.0 (0.6–1.4), 24 observed Lymphoma, 2.0 (0.6–5.2), 4 observed Hodgkin's disease (2 observed/0.8 expected) Leukaemia, 2.2 (0.6–5.5), 4 observed	Sawn timber, mainly pine and spruce; dust levels in sawmills generally below 1 mg/m^3

Table 18 (contd)

Industry	Reference	Methods	Results	Notes
Furniture workers	Olsen & Sabroe (1979)	40 428 members of the Danish carpenters'/cabinet-makers' trade union active or retired in 1971; follow-up through 1976; mortality in the cohort contrasted with national mortality rates	SMR: All causes: Active workers, 0.82 (0.76–0.88), 692 observed Retired workers, 0.70 (0.67–0.74), 1483 observed Nasal cancer: All workers, 4.7 (2.5–6.8), 4 observed (3 cases in cabinet-makers, 1 in a carpenter); no other significantly increased SMR *Active* Intestine, 0.75 (0.29–1.2) Stomach, 1.1 (0.53–1.6) Lung, 0.96 (0.68–1.1) Leukaemia, 1.3 (0.55–2.0) *Retired* Intestine, 0.94 (0.65–1.2) Stomach, 0.84 (0.59–1.1) Lung, 1.1 (0.92–1.3) Leukaemia, 0.71 (0.29–1.1)	Type of wood not reported
Furniture workers	Rang & Acheson (1981); Acheson *et al.* (1984)	5108 workers born before 1940 and active before 1969 in at least one of nine furniture workshops in High Wycombe (United Kingdom) Categorization of exposures: - class I (less dusty): office workers, upholsterers and yardmen - class II (dusty): polishers, veneerers and maintenance men - class III (very dusty): cabinet- and chair makers, sanders and wood machinists Mortality studied for 1941–82; rates for England and Wales used as reference. Lost to follow-up: 1.2%	SMR: All causes: 0.68 (0.62–0.76), 1638 observed All cancers: 0.88 (0.80–0.97), 435 observed Nasal cancer: 8.1 (3.7–16), 9 observed; all cases in people with very dusty occupations (0.57 expected). No other significantly increased SMR or trend with level of exposure. Mouth, pharynx, 1.2 (0.45–2.7) Stomach, 1.2 (0.92–1.5) Colon, 0.68 (0.42–1.0) Rectum, 1.1 (0.7–1.7) Larynx, 0.58 (0.12–1.7) Lung, 0.80 (0.68–0.93) All lymphatic/haematopoietic, 0.92 (0.61–1.3)	Chairs traditionally made from beech; wide range of imported hardwood used in furniture (Acheson *et al.*, 1968)

Table 18 (contd)

Industry	Reference	Methods	Results	Notes
Furniture workers	Barthel & Dietrich (1989)	759 cabinet-makers or joiners from 170 enterprises located in Neubrandenburg district (Germany), followed from 1973 to 1984; cancer incidence in the cohort compared with incidence rates of the population of the district	SIR: All tumours, 1.1, 40 observed Malignant melanoma, 9.5 (2.4–28), 2 observed No other significantly increased SIR; no case of nasal cancer Stomach, 1.3, 7 observed Appendix, colon, sigmoid, 1.5, 3 observed Rectum, 2.1, 6 observed Lung, 0.68, 9 observed Lymphoma, 3.9, 1 observed Myeloma, 5.2, 1 observed	Species of wood most frequently worked with: pine, beech and oak
Furniture workers	Miller *et al.* (1989, 1994)	12 158 members of the United Furniture Workers of America first employed between 1946 and 1962 at factories producing wooden furniture. Mortality studied from 1946 to 1983; US rates used as reference. SMRs computed for subcohort followed for at least 20 years (10 497 subjects).	SMR: All causes, 0.9 (0.8–0.9), 1427 observed All malignant neoplasms, 0.9 (0.8–1.0), 342 observed Buccal cavity and pharynx, 0.7 (0.3–1.4), 7 observed Stomach, 1.0 (0.5–1.6), 14 observed Colon and rectum, 0.8 (0.6–1.1), 36 observed Nose, 1 observed Larynx, 0.6 (0.1–1.8), 3 observed Lung, 1.0 (0.8–1.1), 116 observed Hodgkin's disease, 2.2 (0.6–5.5), 4 observed Non-Hodgkin's lymphoma, 1.0 (0.5–1.9), 11 observed Multiple myeloma,1.6 (0.7–3.1), 9 observed Leukaemia, 1.4 (0.8–2.2), 17 observed	

Table 18 (contd)

Industry	Reference	Methods	Results	Notes
Plywood workers	Robinson *et al.* (1990)	2283 white males who worked for at least one year between 1945 and 1955 in any of four mills located in Washington and Oregon (USA); mortality studied through March 1977; US rates used as reference; 2% lost to follow-up	SMR: All causes, 0.7 [0.7–0.8], 570 observed All malignant neoplasms, 0.7 [0.6–0.9], 100 observed Lymphatic/haematopoietic, 1.6 [0.8–2.7], 12 observed Lymphosarcoma and reticulosarcoma, 1.0 [0.3–2.6], 4 observed Hodgkin's disease, 1.1 [0.1–4.0], 2 observed Multiple myeloma, 3.3 [0.7–9.7], 3 observed Other lymphatic, 2.7 [0.6–8.0], 3 observed Leukaemia, 0.9 [0.3–2.0], 5 observed Buccal cavity and pharynx, 0.6 [0.1–1.9], 3 observed Stomach, 0.4 [0.1–1.1], 4 observed Intestine, 0.6 [0.3–1.2], 8 observed Nose, 0 observed, 0.4 expected Larynx, 0.5 [0.01–2.5], 1 observed Lung, 0.8 [0.5–1.1], 33 observed	Plywood manufactured from softwood (mainly Douglas fir, but also cedar, pine, spruce, hemlock, larch, true firs and redwood)
Woodworkers	Stellman & Garfinkel (1984)	10 322 volunteers enrolled in the American Cancer Society prospective study, whose occupation was in a wood-related industry, followed 1959–72; mortality compared with that of over 400 000 non-woodworkers in the study	SMR: All causes, 0.98, 2503 observed All cancers, 1.0, 513 observed Stomach, 1.5, $p < 0.01$, 44 observed Urinary bladder, 1.4, $p < 0.05$, 29 observed Lung, 1.1, $p > 0.05$, 135 observed Nasal cavity, 2.0, $p > 0.05$, 2 observed Colon and rectum, 0.75, $p < 0.05$, 57 observed Larynx, 0.68, $p > 0.05$, 3 observed Leukaemia, 1.3, $p > 0.05$, 32 observed Hodgkin's disease, 0.67, $p > 0.05$, 3 observed Other lymphatic, 0.70, $p > 0.05$, 17 observed	Stomach: among carpenters and joiners, SMR 1.7, $p < 0.01$, 36 observed Lung: among carpenters and joiners, SMR 1.2, $p < 0.05$, 101 observed Nasal cavity: both cases occurred among carpenters and joiners (SMR, 3.3)

SIR, standardized incidence ratio; CI, confidence interval; SMR, standardized mortality ratio

Table 19. Cohort studies of wooden pattern and model makers

Reference	Methods	Results	Notes
Swanson & Belle (1982)	1070 wooden model and pattern makers active in 1970 in seven automobile manufacturing plants located in Detroit (USA); cancer incidence in the cohort studied 1970–78 and compared with that of the population of metropolitan Detroit. 24.1% lost to follow-up	SIR: All cancers, 1.5 [1.1–2.0], 40 observed Colon and rectum, 2.9 [1.4–5.1], 11 observed Salivary glands, 21 [2.4–72], 2 observed No other significantly increased SIR	
Swanson *et al.* (1985)	316 wooden model or pattern makers employed by one US automobile manufacturing company in 1976 and followed through 1982. Colon cancer incidence in the cohort compared with that of the population of metropolitan Detroit. 36.4% lost to follow-up	SIR: Colon cancer, 4.9 [1.3–13], 4 observed	
Tilley *et al.* (1990)	7062 white male pattern and model makers active or retired in 1980 in the USA and Canada followed through 1985 in order to study cause-specific mortality and incidence of colorectal cancer; expected figures derived from incidence rates of Detroit SEER registry and from US death rates; 6% lost to follow-up by 1984	SMR: All causes, 0.7 (0.6–0.8), 335 observed All malignant neoplasms, 0.9 (0.7–1.1), 108 observed Large intestine, 2.0 (1.3-3.0), 22 observed No other significantly increased SMR SIR: Colorectal cancer, 1.1 (0.8–1.5), 39 observed	Incidence study limited to subcohort involved in screening programme
Becker *et al.* (1992)	528 model and pattern makers employed by a German automobile company between 1960 and 1985, followed through 1985; mortality compared with that of a cohort of tool makers in the same company. 2% of model makers and 6% of tool makers lost to follow-up	RR: All causes, 1.1 (0.5–2.2), 28 observed All malignant neoplasms, 1.8 (1.3–2.7), 11 observed Stomach, 6.9 (1.4–32), 3 observed Genitourinary organs, 5.7 (1.4–23), 3 observed Brain, 9.8 (1.4–70), 2 observed	

Table 19 (contd)

Reference	Methods	Results	Notes
Roscoe *et al.* (1992)	2294 white male wooden model makers employed for any time between 1940 and 1980 by three US automobile companies in metropolitan Detroit; vital status ascertained through 1984. US mortality rates used as reference.. 1% lost to follow-up	SMR: All causes, 0.8 (0.7–0.8), 706 observed All cancers, 1.0 (0.8–1.2), 173 observed No significantly increased SMRs; no association between colon or stomach cancer and exposure to wood in nested case–control study	Automotive model makers in the USA worked with mahogany, maple, birch, cherry and South American hardwoods; since the mid-1950s, mainly South American hardwoods, such as cativo, for dies

SIR, standardized incidence ratio; SMR, standardized mortality ratio; RR, rate ratio

establish occupational and exposure histories. Excess risks were observed for exposure to hardwood dust alone (odds ratio, 2.0; 95% CI, 0.2–21), softwood dust alone (3.3; 1.1–9.4) and mixed hard and softwood dusts (12; 2.4–59) on the basis of a matched analysis. Both of the subjects who had been exposed to hardwood dust alone, and none of the 13 subjects exposed to softwood dust alone, had adenocarcinomas. Subjects who had been exposed to mixed hardwood/softwood dusts had cancers of mixed histological types.

Olsen *et al.* (1984) studied the relationship between occupational factors and sinonasal and nasopharyngeal cancer in Denmark. A total of 488 cases of sinonasal carcinoma (excluding sarcomas) were diagnosed in Denmark between 1970 and 1982 and identified by the Danish Cancer Registry. The 2465 controls were patients with cancers of the colon, rectum, prostate or breast, diagnosed during the same period. Employment histories (industry only) back to 1964 were collected through linkage with national pension fund records, and current occupation was established through linkage with the Central Population Registry. A group of industrial hygienists reviewed the employment histories and assigned an exposure category (unexposed, probably exposed, certainly exposed, insufficient information) to a list of predetermined compounds, which included wood dust (relative risk, 2.5; 95% CI, 1.7–3.7 for men).

Olsen and Asnaes (1986) further evaluated this data set by histologically confirmed sub-groups (squamous-cell and adenocarcinoma). The odds ratio for adenocarcinoma among men with definite exposure to wood dust was 16 (5.2–51), which increased to 30 (8.9–104) when only exposures 10 or more years before diagnosis were considered. The odds ratio for squamous-cell carcinoma associated with definite exposure to wood dust was 1.3 (0.6–2.8) and did not change when only exposure 10 or more years before diagnosis was considered.

Hayes *et al.* (1986a) conducted a case–control study of sinonasal cancer in the Netherlands. Cases were histologically confirmed primary epithelial sinonasal cancers newly diagnosed in men aged 35–79 years between 1978 and 1981 who were identified by the six major institutions in the Netherlands which treat head and neck tumours. The controls were a random sample of living and dead males in the Netherlands in 1980, who were selected from municipal resident registries and the records of the Central Bureau of Genealogy, respectively. A total of 91 case patients or their survivors and 195 controls or their survivors were interviewed. Detailed occupational and exposure histories were collected. An excess risk for all sinonasal cancers (odds ratio, 2.5 [95% CI, 1.2–5.1]), especially adenocarcinoma (18 [5.5–57]), was observed for employment in wood-related occupations, after adjustment for age. Exposure to wood dust was assessed by an industrial hygienist who was unaware of the case or control status of the person. The risk of adenocarcinoma was higher when only high-exposure jobs were considered (26 [7.0–99]), but no excess of squamous-cell carcinoma was observed (0.5 [0.1–2.9]) among men in the highest exposure category. The excess of adenocarcinoma was seen among workers first employed before 1942. The authors stated that the woodworkers had been exposed to both hard- and softwood dusts.

Merler *et al.* (1986) conducted a case–control study of nasal cancer in Vigevano, Italy, with the primary goal of examining the risk in the leather industry. Cases were malignancies of the sinonasal cavity newly diagnosed in residents of Vigevano between 1968 and 1982 and identified through the otolaryngology departments of local hospitals, the cancer registry of the

National Cancer Institute of Milan and the mortality records of the city. Two controls per case, matched on age, sex, vital status and, if dead, on year of death, were chosen from electoral rolls (living controls) and mortality records (dead controls). Interviews, which included occupational histories, were conducted with 21 case patients and 39 controls. No case patient and two controls had been exposed to wood dust.

Bolm-Audorff *et al.* (1989, 1990) conducted a case–control study of histologically confirmed cases of nasal and nasopharyngeal cancer diagnosed in hospitals in Hesse, Germany, between 1 January 1983 and 31 December 1985. Fifty-four of the 66 cases were sinonasal cancers. A single control was matched to each case on age, sex and residence and was chosen from among patients with non-occupational bone fractures. Information on exposure was collected through interviews. The relative risk for all cases (sinonasal and nasopharyngeal cancer) was 3.8 (95% CI, 0.8–17), which increased to 7.8 (1.3–48) for an exposure of five years or more. Six of the seven exposed case patients had sinonasal cancer. The two exposed cases of sinonasal adenocarcinoma were both associated with exposure to hardwood (beech and oak), while the two other carcinomas were associated with exposure to softwoods; the two remaining exposed cases, a lymphoma and a neuroblastoma, were associated with exposure to mixed woods and hardwoods, respectively. Two controls had been exposed to wood dust. [The Working Group noted that the tree species were not identified for controls.]

Vaughan (1989) performed a case–control study of squamous-cell cancers of the sinonasal cavity in western Washington State, United States. Living patients in whom the cancers were diagnosed between 1979 and 1983 were identified from a population-based tumour registry, and 27 people with sinonasal cancer were interviewed. Random-digit dialling was used to obtain 552 controls who were similar in age and sex to the cases. Interviews were used to collect life-time work histories. The analyses were adjusted for age, sex, smoking and alcohol consumption. Excesses of squamous-cell cancers of the sinonasal cavity were reported for forestry and logging workers (odds ratio, 1.8; 95% CI, 0.4–7.2) and woodworking machine operators (7.5; 1.5–37). Vaughan and Davis (1991) later categorized these cases according to exposure to wood dust. The odds ratio for employment in any wood-related occupation was 2.4 (0.8–6.7), which increased to 7.3 (1.4–34) when only exposure for 10 or more years after an induction period of 15 years was considered. The authors stated that the cases were associated with exposure predominantly to dust from softwood. Information on exposure was obtained from surrogates for half of the cases but none of the controls; however, exclusion of cases for which information was obtained from surrogates did not greatly affect the risk estimates.

Luce *et al.* (1991, 1992, 1993) conducted a case–control study of patients with sinonasal cancer diagnosed between January 1986 and February 1988 in 27 participating hospitals in France. A total of 207 patients out of 303 were alive at the time of interview and agreed to participate in the study; 57 died before being interviewed, and 39 could not be located. Controls of similar age and sex to the patients were recruited from two sources: patients with a cancer diagnosed at another site and at the same or a nearby hospital; and neighbourhood controls selected from lists provided by the patients. Of these, 323 hospital and 86 neighbourhood controls were eligible and agreed to participate in the study. Detailed occupational and exposure histories were collected by personal interviews. The degree of occupational exposure to wood

dust was assessed by an industrial hygienist who was unaware of the case or control status of the person. Among men, an elevated risk for sinonasal adenocarcinoma (odds ratio, 289; 95% CI, 136–615, based on 77 exposed cases and 29 exposed controls) was associated with probable or definite, medium–high exposure to wood dust, but no relationship was observed for squamous-cell carcinoma (1.0; 0.4–2.6). The results for specific occupational groups are presented in Tables 21 and 22.

Lerclerc *et al.* (1994) reported the results of further analyses of this study in respect of species of wood. Eighty of the 82 male patients with adenocarcinoma had been exposed to hardwood dusts, but only seven of these to hardwood alone. The odds ratio for adenocarcinoma among men exposed to hardwood or mixed wood dust was 168 (95% CI, 78–362). Positive trends were observed for duration and intensity of exposure. The relative risk was higher among men exposed before 1946 (254) than those first exposed afterwards (137). [The odds ratio for adenocarcinoma among men exposed exclusively to hardwood was 57.] Seventeen of the 59 male squamous-cell cases were associated with exposure to wood dust—three to hardwood only, three to softwood only and the remainder to a mixture of woods. The authors stated that because few subjects were exposed to one wood type alone, the relative risks for squamous-cell carcinoma could not be calculated for exposure to each type of wood alone. The odds ratios for squamous-cell carcinoma associated with exposure to hardwood (or hardwood plus other woods) and softwood (or softwood plus other woods) were 1.4 and 1.7 (not significant), respectively. Duration and intensity of exposure to either hard- or softwoods were not clearly associated with the risk for squamous-cell carcinoma, although some evidence for an excess risk was observed for subjects exposed before 1946. [The Working Group was concerned that the procedures for selecting non-hospital controls may have artificially biased the proportion of woodworking controls downward. For non-hospital controls, cases were asked to provide 'the names of several persons (colleagues excluded)' to serve as referents. The proportion of non-hospital controls exposed to hardwoods (18.8%) and softwoods (20.3%), however, was similar to the proportion among hospital controls (18.3% and 16.3%, respectively), indicating that bias was unlikely.]

Zheng *et al.* (1992a) conducted a case–control study of nasal cancer in Shanghai, China. Patients with newly diagnosed sinonasal cancer between January 1988 and February 1990 were identified in the population-based cancer registry of Shanghai. Controls were randomly selected in the general population from the records of the Shanghai Resident Registry. Personal interviews were conducted with 60 cases and 414 controls, and information was collected on occupational history and exposures. Of the cases, 25 were squamous-cell carcinomas, six were adenocarcinomas, 22 were tumours of other histological types and the remainder were not evaluated histologically. The relative risks for all sinonasal cancers combined were calculated for self-reported exposure to wood dust (odds ratio, 1.9; 95% CI, 0.7–5.0) and employment in wood-related occupations (1.7; 0.5–6.3).

(b) Occupational group

Brinton *et al.* (1977) conducted a case–control study among people who died in North Carolina (United States) counties in which at least 1% of the population was employed in furniture manufacture according to the 1963 census. Death certificates were used to identify 37

cases of cancer of the nasal cavity and sinuses between 1956 and 1974. Two controls for each case ($n = 73$) were randomly selected from among people who had died and were of the same sex, race, county of death, age at death and year of death. Information on occupation and industry was also obtained from the death certificates, and a matched analysis was performed. Elevated risks were observed for people employed in the furniture industry (odds ratio, 4.4; 95% CI, 1.3–15) and in other woodworking occupations (sawmill workers and carpenters) (1.5; 0.4–4.3).

Cecchi *et al.* (1980) performed a case–control study of sinonasal adenocarcinoma in Florence, Italy. Cases diagnosed between 1963 and 1977 were identified from the records of the otorhinolaryngology clinic or the radiology institute of the University of Florence. Eleven of 13 patients or their survivors [numbers of patients and survivors not given] were interviewed in order to obtain information on occupation and smoking habits. Two controls per case, matched on sex, age, place of residence, smoking and year of admission to hospital, were selected from among non-cancer internal medicine patients and received the same interview. Three case patients and two controls had been employed as woodworkers. Of the exposed patients, two had worked in small woodworking shops, and the third had worked with both wood and leather.

Roush *et al.* (1980) conducted a case–control study of sinonasal cancer in Connecticut (United States) based on the tumour register. Cases were sinonasal cancers in 216 men 35 years of age or older who had died between 1935 and 1975. The 691 controls were a random sample of men aged 35 years or older who had died in Connecticut between 1935 and 1975. Occupational information was collected from death certificates and city directories, in which information is based on interviews conducted during door-to-door surveys. Job titles were classified for exposure to wood dust on the basis of a review of the literature. The odds ratio associated with wood-related occupations was 4.0 (95% CI, 1.5–11) when information from both sources was considered. The odds ratio was somewhat lower (2.8) when only information from death certificates was considered and somewhat higher (5.9) when only information from city directories was considered.

Tola *et al.* (1980) performed a case–control study of patients with malignant tumours of the nose and paranasal sinuses reported to the Finnish Cancer Registry between 1970 and 1973. For each case a single control of similar age and sex was chosen from among cancer patients (other than respiratory) from the same geographical area. Questionnaires on occupational history and exposures were completed by 45 case subjects and 45 controls. Of the cases, 20 were squamous-cell carcinomas, 10 were transitional-cell carcinomas and two were malignancies classified as adenocarcinoma. One patient with an adenocarcinoma had been employed as a joiner and had been exposed mainly to oak dust. One control had been employed as a carpenter. No other results related to exposure to wood were reported.

Elwood (1981) reported the results of a case–control study of 121 men with primary epithelial tumours of the sinonasal cavity seen at the main cancer treatment centre in British Columbia, Canada, between 1939 and 1977. Of the cases, 61 were squamous-cell carcinomas, 20 were anaplastic carcinomas, 16 were transitional-cell carcinomas, 11 were adenocarcinomas, six were sarcomas, and seven were of unknown histological type. A control group of 120 patients with cancer that was considered to be unrelated to smoking or outdoor work, matched

on age and year of diagnosis, was chosen. Information on occupation and smoking was retrieved from medical records, and relative risks were calculated using conditional logistic regression after adjustment for smoking and ethnicity. An elevated risk was observed for employment in wood-related occupations (odds ratio, 2.5; $p < 0.03$). Of the 28 exposed patients, 10 were loggers, seven were carpenters, four were forestry workers, four were construction workers, two were log scalers and one was a cabinet-maker. The authors reported that the predominant exposure of all but the cabinet-maker would have been to native softwoods.

Hardell *et al.* (1982) conducted a case–control study of nasal and nasopharyngeal cancers in northern Sweden to examine their relationship with exposure to phenoxy acids or chlorophenol, which included 44 male patients with sinonasal cancer who had been reported to the Swedish Cancer Registry between 1970 and 1979. Thirty-one of the cases were squamous-cell carcinomas, four were anaplastic carcinomas and three were adenocarcinomas; six were tumours of other histological types. The 541 controls had initially been identified and interviewed for a study of soft-tissue sarcoma and lymphoma. Information on exposure and employment history were collected using postal questionnaires and supplemental telephone interviews. A crude relative risk of 2.0 [95% CI, 1.1–3.6] was observed for previous employment as a carpenter, cabinet-maker or sawmill worker (19 exposed cases, 151 exposed controls). The authors noted that little hardwood is used for furniture making in northern Sweden.

Battista *et al.* (1983) performed a case–control study of sinonasal cancer in the province of Siena, Italy, where 4–7% of the active male population is employed in wood-related industries. They studied 36 male patients in whom sinonasal cancers were diagnosed at the Ear, Nose and Throat Clinic or the Radiotherapy Unit in Siena between 1963 and 1981. Seventeen (47%) of the cases were squamous-cell carcinomas and five (14%) were adenocarcinomas. For each case, five referents were selected from among men of the same age (within one year) who were admitted to the medical clinic of Siena for other diseases at the same time. All case patients and 164 of the 180 referents or their next-of-kin completed a postal questionnaire, and occupational histories were collected. Exposure to wood dust was defined as employment as a woodworker or cabinet-maker. An elevated risk for all sinonasal cancers was reported for exposed men (odds ratio, 4.7; 95% CI, 1.7–13), and the risk was especially increased for adenocarcinoma (90; 20–407). The seven case patients with exposure to wood dust had used a wide variety of species, the commonest being chestnut (four cases), oak (four cases), poplar (three cases) and fir (two cases).

Brinton *et al.* (1984) conducted a case–control study of patients with sinonasal cancer admitted to four hospitals in North Carolina and Virginia, United States, between 1970 and 1980. Two controls for each living case patient, matched on year of admission, age, sex, race and area of residence, were selected from living hospital patients. For deceased cases, similar matching criteria were used, but one hospital patient (not required to be living) and one patient with a death certificate were chosen. Potential controls were excluded if an upper aerodigestive cancer, oesophageal cancer, benign respiratory neoplasm, mental disorder or chronic sinonasal disease had been diagnosed. Telephone interviews were conducted with 160 case patients and 290 controls or their survivors. An elevated relative risk for sinonasal adenocarcinoma was associated with previous employment in any wood-related job (odds ratio, 3.7; $p < 0.05$), but no excess of squamous-cell carcinoma was observed (odds ratio, 0.8).

Ng (1986) conducted a case–control study of cancer of the nasal cavity and sinuses among Chinese people in Hong Kong. Two series of controls were used: people with nasopharyngeal cancer and people with other malignancies, all of which were diagnosed between 1974 and 1981 at the Institute of Radiology and Oncology in Hong Kong. There were 225 cases of nasal cancer (119 squamous-cell, 50 anaplastic, four adenocarcinomas, 37 of other histological types and 15 of unknown histological type), 224 cases of nasopharyngeal cancer (112 squamous-cell, 102 anaplastic and 10 of unknown histological type) and 226 controls with other malignancies. Occupational histories were collected from medical records. Two wood-related occupational categories were considered: furniture makers and woodworkers (comprising two cancers of the nasal cavity and sinuses, five nasopharyngeal cancers and one other malignancy) and construction carpenters (comprising two cancers of the nasal cavity and sinuses and three nasopharyngeal carcinomas). None of the four nasal cavity and sinus adenocarcinomas were in wood-related workers. No odds ratios or other estimates of relative risk were presented for wood-related occupations.

Fukuda *et al.* (1987) and Fukuda and Shibata (1988, 1990) reported the results of a case–control study on Hokkaido Island in Japan of cases of squamous-cell carcinoma of the maxillary sinus, newly diagnosed in 1982–86 in people between 40 and 79 years of age, at the two university and the two medical college hospitals on Hokkaido Island. Two controls per case, matched on sex, age and residence, were chosen from among a pool of potential controls selected from telephone directories. A questionnaire was posted to all potential cases and controls, who were later telephoned to obtain their permission to participate in the study and to confirm the responses to the questions. The matched analysis in the latest published results included 169 eligible cases and 338 eligible controls. The exposure category of woodworkers consisted of people employed as carpenters, joiners, furniture makers and other woodworkers. Excess risks for squamous-cell carcinoma of the maxillary sinus were observed among both men (relative risk, 2.9; 95% CI, 1.5–5.6) and women (2.0; 0.3–14). A significant trend ($p < 0.05$) of increasing risk with increasing duration of employment was also seen.

Takasaka *et al.* (1987) performed a case–control study of male patients with nasal or paranasal cancer who were admitted to Tohoku University Hospital, Japan, between 1971 and 1982. Three to five controls of the same sex, age and date of admission were selected from among patients with other otorhinolaryngological diseases admitted to the same hospital. Mailed questionnaires requesting occupational history and information on exposures were completed by 107 case patients and 413 controls. Eighty-five of the 98 cases for which histological information was available were squamous-cell carcinomas and six were adenocarcinomas. Excess risks were associated with longest-held occupation as a forester (odds ratio, 2.0; 95% CI, 0.5–7.3), woodworker (1.6; 0.4–7.1) or carpenter (2.1; 0.8–5.8).

Bimbi *et al.* (1988) conducted a hospital-based case–control study in Milan, Italy, of 53 patients with malignant epithelial cancers admitted between 1982 and 1985 to the Head and Neck Oncology Department of the National Institute for the Study and Treatment of Cancer. Controls were 217 patients admitted to the same department during the same years, mainly for cancers of the nasopharynx, thyroid and salivary gland. Information on occupational history was collected from medical records. Three cases and no control had been employed as woodworkers.

Finkelstein (1989) reported the results of a study based on information from death certificates of 124 men, 35 years of age or older, who had died of cancer of the nasal cavity or paranasal cavity in Ontario, Canada, between 1973 and 1983. One control per case, matched on age and year of death, was chosen from among people who had died of other causes. Information on usual job and industry was collected from death certificates. Nine cases and six controls had been employed in wood-related occupations (odds ratio, 1.9 [95% CI, 0.6–6.4]). Workers who had been employed in nickel refining (10 cases and no control) were excluded from the unmatched analyses.

Kawachi *et al.* (1989) reported the results of an exploratory study to examine the risk for cancer among woodworkers. Case patients and controls were men in the New Zealand Cancer Registry in whom cancer had been diagnosed between 1980 and 1984 and whose occupation was noted in Registry records. The case patients were 46 registrants in whom cancer of the nasal cavity and sinuses had been diagnosed, while the controls were 19 858 registrants with cancers at all other sites. The only information available on exposure was the current or most recent occupation. No excess risk was observed (odds ratio, 1.0; 95% CI, 0.2–4.0; based on two exposed cases) after adjustment for age.

Loi *et al.* (1989) conducted a case–control study of nasal cancer in the Pisa area of Italy, a region where there are many factories manufacturing wooden products, especially furniture. Case patients were 38 male nasal cancer patients admitted to Pisa University Hospital between October 1972 and October 1983; five controls per case, matched on sex, age, province of usual residence and admission date, were chosen from among patients admitted to the same hospital for diseases other than respiratory cancer or lymphoma. A postal questionnaire was used to obtain information on occupational history and smoking habits. Workers who had been employed in wood-related occupations for six or more months at least five years before diagnosis were considered to have been exposed. Subjects who had been employed in leather-related occupations, their matched controls and other controls who had been employed in leather-related occupations were excluded from the analyses of wood-related risks. A relative risk of 9.7 (95% CI, 3.2–29) was observed for employment in wood industries. The relative risk for adenocarcinoma alone tended to infinity, as all case subjects had been exposed. Individual information on exposure to different wood species was not available, but the authors stated that chestnut, walnut and fir were the most commonly used in the region. [The Working Group noted that some of the study subjects might have died before the study was conducted, and, consequently, next-of-kin may have been interviewed.]

Shimizu *et al.* (1989) conducted a case–control study of 45 men and 21 women with newly diagnosed squamous-cell carcinoma of the maxillary sinus at six university hospitals in north-eastern Japan, between October 1983 and October 1985. Two controls, matched on age and sex, were selected from a random sample of residents in the same area from telephone directories. Each patient was asked to complete a questionnaire during initial hospitalization, which requested information about previous occupations and other potential risk factors; controls completed the same questionnaire by post. A matched analysis was performed. The relative risk among men for woodworking or joinery was 2.1 (95% CI, 0.8–5.3); the risk was 7.5 (1.5–39) when only jobs involving sanding or turning were considered.

Viren and Imbus (1989) conducted a study based on information on death certificates of 536 people in the United States who had died of nasal cancer in the states of Washington and Oregon between 1963 and 1977, Mississippi between 1962 and 1977 and North Carolina between 1964 and 1977. Two controls per case ($n = 1072$) were chosen from among people in the same states who had died from causes other than cancer, non-malignant respiratory disease or accidents; they were matched to the case patient on sex, age, race and year of death. Usual occupation and industry were obtained from death certificates. A matched analysis was performed only for men (332 cases, 664 controls). Relative risks of 3.3 ($p < 0.01$) for forestry and logging workers, 1.3 for woodworkers and woodworking machine operators and 1.6 for carpenters were observed. [The Working Group noted that the subjects from North Carolina may also have been included by Brinton *et al.*, 1977.]

Haguenoer *et al.* (1990) conducted a case–control study to investigate occupational risk factors for cancers of the upper respiratory and digestive tracts (nose, lips, buccal cavity, pharynx and larynx) in northern France. An occupational history, which included only jobs held for at least 15 years, was established by interview; people who did not have at least one job that met this criterion (one-half the subjects) were excluded from the study. There were 14 histologically confirmed sinonasal cancers among men treated in the first semester of 1983. Two controls per case, matched for sex, age, ethnic group, area of residence and histories of smoking and alcohol drinking, were chosen from among non-cancer hospitals patients in the same region. Four patients with sinonasal cancer and no matched control reported previous employment as a woodworker.

Comba *et al.* (1992a) reported the results of a collaborative case–control study in north-eastern and central Italy of cases of sinonasal cancer diagnosed between 1982 and 1987 at hospitals providing services to the provinces of Verona, Vicenza and Siena. Four controls per case were selected from among patients admitted for diseases other than chronic rhino-sinonasal diseases or nasal bleeding to the same hospital at the same time, who were similar to the case patient with regard to sex, age and area of residence. Personal interviews were conducted by telephone or post with 78 of 96 case patients and 254 of 378 controls or their next-of-kin, to collect information on occupational history and exposures. An elevated relative risk associated with woodworking was observed for both men (odds ratio, 5.8 [95% CI, 1.8–18]) and women (3.2 [0.2–50]). The relative risks for sinonasal adenocarcinoma (14 [2.3–83]) and squamous-cell carcinoma (1.7 [0.3–9.2]) were presented for men only. The authors noted that the types of wood used by the case patients were both hard- and softwoods of many species, including birch, fir, poplar, beech, maple, cherry, oak, mahogany, walnut and chestnut.

Comba *et al.* (1992b) conducted another case–control study among the residents of Brescia Province in north-eastern Italy, with the primary aim of examining the relative risk for sinonasal cancer associated with employment in the metal industry. Cases were malignant epithelial sinonasal tumours treated at the ear, nose and throat department or the radiotherapy unit of Brescia Hospital between 1980 and 1989. Four controls per case were chosen from among patients treated at the same centres for benign and malignant tumours of the head and neck, excluding epidermoid carcinomas of the tongue, oral cavity, oro- and hypopharynx and larynx, who were of the same sex and age. A total of 34 case patients (23 men) and 102 controls

(70 men) or their survivors [numbers of cases and survivors not given] were interviewed, and detailed occupational histories were obtained. The age-adjusted odds ratio for male woodworkers was 11 [95% CI, 0.5–229).

Zheng *et al.* (1993) conducted a case–control study of 147 white men, 45 years of age or older, who had died from sinonasal cancer in 1985 and were identified in a national survey of mortality in the United States in 1986. Controls were 449 white men who had died during the same period from causes not related to smoking or alcohol consumption. The next-of-kin of cases and controls received a structured questionnaire by post requesting information on demographic factors, histories of smoking and alcohol consumption, occupational history and dietary habits. After adjustment for age and cigarette smoking, a relative risk of 1.7 (95% CI, 0.6–4.3) was observed for previous employment as a carpenter or other wood-related worker, relative to professional, managerial, technical and sales workers.

Magnani *et al.* (1993) conducted a case–control study of sinonasal cancer in the district of Biella in north-western Italy with the primary goal of examining risks in the woollen textile industry. Cases were epithelial or histologically unspecified sinonasal cancers diagnosed among residents of the local health areas of Biella and Cossato between 1976 and 1988. Four controls per case were chosen from among patients of the same sex and age, who were admitted to the same hospital in the same year with diagnoses other than respiratory cancer. Mailed questionnaires or telephone interviews, which included an occupational history, were completed by 26 cases and 111 controls or their relatives. An elevated risk for sinonasal cancer was associated with employment as a wood or furniture worker (odds ratio, 4.4; 95% CI, 1.4–13); the risk was much higher when only adenocarcinomas were considered (22; 4.4–124).

The studies on sinonasal cancer are summarized in Tables 20, 21 and 22.

Demers *et al.* (1995) performed a pooled analysis of case–control studies of sinonasal cancer and exposure to wood dust, in which the following criteria had been met: the histological types of the cases were identified; occupational histories had been collected from patients (or their survivors) and controls by interview or questionnaire; and data on age, sex and tobacco smoking were available. The authors of the 15 studies that met these criteria were asked to participate in the pooled analysis; 12 were both able and willing to do so. The studies were those conducted in Shanghai, China (Zheng *et al.*, 1992a); France (Luce *et al.*, 1991, 1992, 1993); Hessia, Germany (Bolm-Audorff *et al.*, 1989, 1990); Siena, Verona and Vicenza, Italy (Comba *et al.*, 1992a); Brescia, Italy (Comba *et al.*, 1992b); Biella, Italy (Magnani *et al.*, 1989, 1993); Vigevano, Italy (Merler *et al.*, 1986); the Netherlands (Hayes *et al.*, 1986a,b, 1987); northern Sweden (Hardell *et al.*, 1982); North Carolina and Virginia, United States (Brinton *et al.*, 1984); Los Angeles, United States (Mack & Preston-Martin, unpublished data); and Seattle, United States (Vaughan, 1989; Vaughan & Davis, 1991). The aggregated data consisted of 680 male cases (169 adenocarcinomas, 329 squamous-cell cancers, 157 of other histology and 25 of unknown histology), 2349 male controls, 250 female cases (26 adenocarcinomas, 101 squamous-cell cancers, 105 of other histology and 18 of unknown histology) and 787 female controls. Seven categories of jobs with potential exposure to wood dust were defined by combining occupation and industry title: forestry workers, loggers, pulp and paper workers, sawmill

Table 20. Results of community-based case–control studies of sinonasal cancer: all histological types and unspecified

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Exposure to wood dust								
Hernberg *et al.* (1983)	Denmark/ Finland/ Sweden	MF	167/167	Interviews	Hardwood only	2.0	0.2–21	
					Softwood only; primarily pine and spruce, also birch and aspen	3.3	1.1–9.4	
					Mixed hard- and softwood	12	2.4–59	
Olsen *et al.* (1984)	Denmark	MF	488/2465	Linkage with national pension fund records	Exposure to wood dust (men only)			Exposure based on expert assessment of work history
					Probable exposure	1.2	0.7–2.1	
					Definite exposure	2.5	1.7–3.7	
					≥ 10 years since first exposure	2.9	1.8–4.7	
Merler *et al.* (1986)	Italy	MF	21/39	Interview	Exposure to wood dust			0/2 exposed case/controls
Bolm-Audorff *et al.* (1989, 1990)	Germany	MF	66/66	Interviews	Exposure to wood dust; oak, beech and softwood	3.8	0.8–17	Cases include 12 naso-pharyngeal cancers. Six of seven exposed cases had nasal cancer. Controls matched on sex, age and residence
					Duration ≥ 5 years	7.8	1.3–48	
Zheng *et al.* (1992a)	China	MF	60/414	Interviews	Exposure to wood dust	1.9	0.7–5.0	Self-reported exposure; adjusted for age
					Wood-related occupations	1.7	0.5–6.3	
Occupational group								
Brinton *et al.* (1977)	USA	M	37/73	Death certificates	Furniture industry	4.4	1.3–15	Controls matched on sex, race, age, county and year of death
					Sawmill workers, carpenters and other woodworking occupations	1.5	0.4–4.3	
Roush *et al.* (1980)	USA	M	216/691	Death certificates and city directories	Wood-related occupation			
					Death certificate only	2.8		
					City directories only	5.9		
					Either source of information	4.0	1.5–11	

Table 20 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or p	Comments
Occupational group (contd)								
Tola *et al.* (1980)	Finland	MF	45/45	Questionnaires	Wood-related occupations			1/1 exposed case/control
Elwood (1981)	Canada	M	121/120	Medical records	Wood-related occupations; primarily softwood	2.5	$p < 0.03$	Matched on age and year of diagnosis and adjusted for smoking and ethnicity
Hardell *et al.* (1982)	Sweden	M	44/541	Questionnaires	Carpenter, cabinet-maker or sawmill worker	2.0	[1.1–3.6]	Crude relative risk; 19/151 exposed cases/controls
Battista *et al.* (1983)	Italy	M	36/164	Questionnaries	Woodworker or cabinet-maker; exposure to chestnut, oak, poplar, fir, alder, walnut, beech and acacia	4.7	1.7–13	Cases of carcinoma only; matched on age
Brinton *et al.* (1984)	USA	MF	160/290	Interviews	Furniture industry Lumber industry Carpentry	0.8 1.4 1.5	0.3–2.0 0.7–2.6 0.6–3.4	Adjusted for year of admission, age, sex, race and area of residence
Hayes *et al.* (1986a)	Netherlands	M	91/195	Interviews	Wood-related occupations Furniture and cabinet-making Factory joinery/carpentry House carpentry Other wood-related occupations	2.5 13 2.1 0.6 1.1	[1.2-5.1] [2.7-59] [0.4-11] [0.1-4.3] [0.3-4.8]	Adjusted for age Adjusted for age
Ng (1986)	Hong Kong	MF	225/226	Medical records	Furniture makers, woodworkers Construction carpenters			2/1 exposed cases/control 2/0 exposed cases/control
Takasaka *et al.* (1987)	Japan	M	107/337	Questionnaires	Longest-held occupation Foresters Woodworkers Carpenters	 2.0 1.6 2.1	 0.5–7.3 0.4–7.1 0.8–5.8	

Table 20 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Occupational group (contd)								
Bimbi *et al.* (1988)	Italy	MF	53/217	Medical records	Wood industry			3/0 exposed cases/control
Finkelstein (1989)	Canada	M	124/124	Death certificates	Wood-related occupations	1.9	[0.6–6.4]	
Kawachi *et al.* (1989)	New Zealand	M	46/19 858	Tumour registry records	Woodworkers	1.0	0.2–4.0	Adjusted for age
Loi *et al.* (1989)	Italy	M	38/153	Questionnaires	Wood industries. Individual exposure by wood species not known, but walnut, chestnut and fir commonly used in region	9.7	3.2–29	Calculated after excluding cases and controls who were leather workers
Viren & Imbus (1989)	USA	M	332/664	Death certificates	Forestry and logging	3.3	$p < 0.01$	Matched on sex, age, race, state and year of death
					Woodworking and woodworking machine operators	1.3		5/8 exposed cases/ controls
					Carpenters	1.6		14/18 exposed cases/ controls
Haguenoer *et al.* (1990)	France	M	14/28	Interviews	Woodworkers			Only jobs held for at least 15 years were evaluated; 4/0 exposed cases/control
Comba *et al.* (1992a)	Italy	MF	78/254	Interviews and questionnaires	Woodworkers (men)	5.8	[1.8–18]	Results for men adjusted for age. Exposure to both hard- and softwoods
					Furniture makers, joiners or carpenters	6.5	[1.7–25]	
					Lumberjack	4.1	[0.9–19]	
					Woodworkers (women)	3.2	[0.2–50]	
Comba *et al.* (1992b)	Italy	M	23/70	Interviews	Woodworkers	11	[0.5–229]	Adjusted for age

Table 20 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Occupational group (contd)								
Zheng *et al.* (1993)	USA	M	147/449	Questionnaire	Carpenters and other woodworkers	1.7	0.6–4.3	Adjusted for age and smoking
Magnani *et al.* (1993)	Italy	MF	26/111	Questionnaires	Wood and furniture workers	4.4	1.3–13	
					Duration, 1–9 years	3.5	0.6–19	
					Duration, ≥ 20 years	5.8	1.4–24	

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female

Table 21. Results of community based case–control studies of sinonasal cancer: adenocarcinoma

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Exposure to wood dust								
Hayes *et al.* (1986a)	Netherlands	M	23/195	Interviews	Wood-related occupations	18	[5.5–57]	Adjusted for age
					Furniture and cabinet-making	140	[18–1094]	Adjusted for age
					Factory joinery/carpentry	16	[2.1–125]	
					Housing carpentry and other wood-related occupations	0.0		0/9 exposed case/controls
					Exposure to wood dust	8.5	[2.6–28]	Exposure based on expert assessment of work history
					High exposure	26	[7.0–99]	
Olsen & Asnaes (1986)	Denmark	M	39/2465	Linkage with national pension fund records	Definite wood dust exposure	16	5.2–51	Exposure based on expert assessment of work history records; adjusted for exposure to formaldehyde
					≥ 10 years since first exposure	30	8.9–104	
Luce *et al.* (1991, 1992, 1993); Leclerc *et al.* (1994)	France	M	82/320	Interviews	Loggers	0.6	0.1–4.6	All results adjusted for age
					duration >15 years	0.0		
					Cabinet-makers	35	18–69	
					duration >15 years	33	14–76	
					Woodworking machine operators	7.4	3.5–16	
					duration >15 years	48	8.8–260	
					Carpenters, joiners	25	15–44	
					duration >15 years	45	22–50	
					Exposure to wood dust			Exposure based on expert assessment of work history
					Probable or definite, medium–high exposure	289	136–615	
					Hardwood dust (incl. mixed)	168	78–362	80 of 82 cases exposed to hardwood or mixed dusts
					> 35 years of exposure	303	64–1427	
					Highest level of exposure	530	104–2696	
					First exposed before 1946	254	55–1185	

Table 21 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Occupational group								
Cecchi *et al.* (1980)	Italy	MF	11/22	Interviews	Wood-related occupation	[3.7]	[0.5-27]	Crude odds ratio; 3/2 exposed cases/controls
Battista *et al.* (1983)	Italy	M	5/NR	Questionnaires	Woodworker or cabinet-maker Chesnut, oak, poplar, alder, walnut and acacia	90	20–407	
Brinton *et al.* (1984)	USA	M	13/183	Interviews	Furniture industry	5.7	1.7-19	
					Lumber industry	1.6		4 exposed cases
					Carpentry	2.9		3 exposed cases
					Any wood-related job	3.7	$p < 0.05$	10 exposed cases;
Comba *et al.* (1992)	Italy	M	13/184	Interviews and questionnaires	Wood workers (men)	14	[2.3–83]	
Magnani *et al.* (1993)	Italy	MF	14/111	Questionnaires	Wood and furniture workers	22	4.4–124	

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female; NR, not reported

Table 22. Results of community-based case–control studies of sinonasal cancer: squamous-cell carcinoma

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or *p*	Comments
Exposure to wood dust								
Hayes *et al.* (1986a)	Netherlands	M	50/195	Interviews	Exposure to wood dust	1.3*	[0.6–2.7]	*Adjusted for age; exposure based on expert assessment of work history
					High exposure	0.5	[0.1–2.9]	
Olsen & Asnaes (1986)	Denmark	M	215/2465	Linkage with national pension fund records	Definite exposure to wood dust	1.3	0.6–2.8	Exposure based on expert assessment of work history; adjusted for exposure to formaldehyde
					≥ 10 years since first exposure	1.3	0.5–3.6	
Vaughan (1989); Vaughan & Davis (1991)	USA	MF	27/552	Interviews	Forestry/logging	1.8	0.4–7.2	Primary exposure to softwood; all results adjusted for age, sex, smoking and alcohol intake
					Duration ≥ 10 years	11		
					Woodworking machine operator	7.5	1.5–37	
					Duration ≥ 10 years	29		
					Any wood-related occupation	2.4	0.8–6.7	
					Exposures lagged by 15 years	3.1	1.0–9.0	
					Duration ≥ 10 years after lagging by 15 years	7.3	1.4–34	
Luce *et* al. (1991, 1992,1993); Leclerc *et al.* (1994)	France	M	59/320	Interviews	Loggers	2.9	0.8–10	All results age-adjusted
					Duration >15 years	3.9	0.3–56	
					Cabinet-makers	1.6	0.3–8.9	
					Duration >15 years	3.4	0.5–22	
					Woodworking machine operators	1.2	0.2–6.6	
					Duration >15 years	0.0		
					Carpenters, joiners	1.6	0.5–5.1	
					Duration >15 years	1.9	0.4–9.0	
					Carpenter, joiner employed in wood manufacture	2.3	0.6–9.0	
					Duration >15 years	8.1	1.3–50	
					Exposure to wood dust			Exposure based on expert assessment of work history
					Probable or definite low exposure	1.4	0.6–3.0	
					Probable or definite medium–high exposure	1.0	0.4–2.6	

Table 22 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/ RR	95% CI or p	Comments
	France (contd)				Hardwood dust (incl. mixed)	1.4		14/58 exposed cases/controls
					First exposed < 1946	2.2	1.0–4.8	No trend with duration/intensity
					Softwood dust (incl. mixed)	1.7		13/54 exposed cases/controls
					First exposed < 1946	2.5	1.1–6.0	No trend with duration/intensity
Occupational group								
Brinton *et al.* (1984)	USA	M	53/183	Interviews	Furniture industry	0.3		1 exposed case
					Lumber industry	1.1		12 exposed cases
					Carpentry	1.0		5 exposed cases
					Any wood-related job	0.8		22 exposed cases
Fukuda *et al.* (1987); Fukuda & Shibata (1988, 1990)	Japan	MF	169/338	Questionnaires	Woodworkers (men)	2.9	1.5–5.6	Cases were maxillary sinus only;
					Woodworkers (women)	2.0	0.3-14	matched on age, sex and residence
					Duration of woodworking (men)			Significant trend ($p < 0.05$):
					2–11 years	1.1		8/16 exposed cases/controls
					12–29 years	2.5		10/9 exposed cases/controls
					29–55 years	4.2		11/6 exposed cases/controls
Shimizu *et al.* (1989)	Japan	M	45/90	Questionnaires	Woodworking or joinery	2.1	0.8–5.3	Matched on age and sex
					Sanding or lathing	7.5	1.5–39	
Comba *et al.* (1992a)	Italy	M	25/184	Interviews and questionnaires	Woodworkers (men)	1.7	[0.3–9.2]	
Magnani *et al.* (1993)	Italy	MF	11/111	Questionnaires	Wood and furniture workers	0.9	0.4–8.3	

OR, odds ratio; RR, relative risk; C I, confidence interval; M, male; F, female

workers, furniture makers, other wood product workers and carpenters. The jobs were classified with regard to the level of exposure to wood dust on the basis of an ad-hoc job–exposure matrix. Logistic regression was applied, with control for age and study. No association was seen between tobacco smoking and exposure to wood dust. A high risk for adenocarcinoma in men was associated with employment in wood-related occupations (odds ratio, 14; 95% CI, 9.0–20); no excess risk was found for squamous-cell carcinoma in men (0.8; 0.6–1.1). The corresponding odds ratios for women were 2.8 (0.8–10) and 1.2 (0.5–3.1). When subjects were categorized according to exposure to wood dust, a clear exposure–response relationship was found for adenocarcinoma in men, but not for squamous-cell carcinoma in men or for either histological type in women (Table 23). Similarly, an association with duration of employment in wood-related jobs or duration of moderate or high exposure to wood dust was found only with adenocarcinoma in men. The overall relative risks for adenocarcinoma showed some heterogeneity among the studies included in the re-analysis, with particularly high risks for adenocarcinoma in European countries other than Sweden (Table 24). [This finding may suggest variability in the type or intensity of exposure in different countries. The Working Group noted that elevated risks were found for highly exposed individuals in Sweden and the United States, however, although these were based on small numbers.]

Table 23. Results of pooled analysis of studies on exposure to wood dust: cases of adeno- and squamous-cell carcinoma

Sex	Exposure to wood dust	No. of exposed controls	Adenocarcinoma		Squamous-cell carcinoma	
			No. of exposed cases	Odds ratio	No. of exposed cases	Odds ratio
Men	Low	83	1	0.6	6	0.5
	Moderate	402	14	3.1*	42	1.0
	High	82	104	46*	11	0.8
Women	Low	11	2	7.7*	2	1.5
	Moderate	10	0	0	2	4.5
	High	6	0	0	2	1.6

From Demers *et al.* (1995)

*$p < 0.05$

Table 24. Odds ratios for adenocarcinoma by individual study included in a pooled re-analysis of studies of exposure to wood dust

Reference	Any exposure		High exposure	
	No. of exposed cases/controls	Odds ratio	No. of exposed cases/controls	Odds ratio
Zheng *et al.* (1992)	0/12	0.0	0/1	0.0
Luce *et al.* (1991, 1992, 1993)	79/45	161	69/15	516
Bolm-Audorff *et al.* (1989, 1990)	2/1	64	1/0	∞
Comba *et al.* (1992a)	8/23	12	7/11	23
Comba *et al.* (1992b)	2/2	32	2/1	50
Magnani *et al.* (1989, 1993)	5/8	15	5/2	55
Merler *et al.* (1986)	1/4	0.5	1/0	∞
Hayes et al. (1986a,b, 1987)	17/35	13	16/13	36
Hardell *et al.* (1982)	1/277	0.5	1/22	6.1
Brinton *et al.* (1984)	4/58	0.9	2/9	3.0
Mack & Preston-Martin (1995)	0/12	0.0	0/2	0.0
Vaughan (1989); Vaughan & Davis (1991)	0/98	0.0	0/6	0.0

From Demers et al. (1995); odds ratios adjusted for age and study

2.4.2 Cancers of other parts of the respiratory system

(a) Nasopharyngeal cancer

(i) Exposure to wood dust

Armstrong *et al.* (1983) conducted a study of 100 Chinese patients (65 men and 35 women) diagnosed with nasopharyngeal cancer between 1973 and 1980 and treated at the Institute for Radiotherapy at the General Hospital of Kuala Lampur (the only hospital offering this treatment for nasopharyngeal cancer in Malaysia). A matched neighbourhood control of the same sex and of similar age was selected for each case. Both cases and controls had lived in the study region for at least five years. Interviews were used to collect information on occupational and other exposure. A matched analysis was performed. The relative risk reported for exposure to wood and sawdust was 2.2 ($p < 0.08$, one-sided).

In the study of Olsen *et al.* (1984) described on p. 109, there were 266 cases of nasopharyngeal carcinoma (excluding sarcomas). A relative risk of 0.4 (95% CI, 0.2–1.0) was observed among men with definite exposure to wood dust. Olsen and Asnaes (1986) further evaluated this data set by histologically confirmed sub-group; results were not presented for nasopharyngeal cancer, but the authors stated that there was no association with exposure to wood dust.

In the study of Vaughan (1989), described on p. 110, 21 people with nasopharyngeal cancer were interviewed. An excess risk for nasopharyngeal cancer was reported for carpenters (odds ratio, 3.3; 95% CI, 0.8–13) in any employment; the risk increased to 4.5 (1.1–19) after exclusion of the last 15 years. Vaughan and Davis (1991) later categorized these cases according to exposure to wood dust. The odds ratio for nasopharyngeal cancer associated with employment in any wood-related occupation was 1.2 (0.2–4.6) and increased to 4.2 (0.4–27) when only exposure for 10 or more years after an induction period of 15 years was considered. The authors stated that the case patients were predominantly exposed to softwood dust.

In the study of Bolm-Audorff *et al.* (1989, 1990), described on p. 110, 12 of the 66 cases were nasopharyngeal cancers. One case of undifferentiated carcinoma of the nasopharynx was associated with exposure to wood dust (oak and beech) for 24 years, while two controls had been exposed to wood dust (species not identified), one of them for fewer than five years.

The etiology of nasopharyngeal carcinoma was studied in the Philippines, in investigations addressing both viral (Hildesheim *et al.*, 1992) and non-viral (West *et al.*, 1993) risk factors. There were 104 people with histologically confirmed nasopharyngeal carcinoma in the Philippines General Hospital and 104 hospital controls (matched on sex, age and private versus public ward) and 101 community controls (matched on sex, age and neighbourhood). The occupational history of each subject was collected by personal interview. The occupations of carpenter, lumberman, raftsman, woodchopper, farm manager and farmer were considered to entail exposure to wood dust on the basis of an assessment by an industrial hygienist who was unaware of the case or control status of the subject. A matched analysis was conducted. The relative risk for exposure fewer than 35 years before diagnosis was 1.3, and that for exposure 35 or more years before first diagnosis was 2.1. [The Working Group noted that the authors did not control for the presence of Epstein–Barr virus antibodies, which showed a strong association with nasopharyngeal cancer (odds ratio, 21) in the study of Hildesheim *et al.* (1992).]

(ii) Occupational group

In the study of Hardell *et al.* (1982) described on p. 113, there were 27 male patients with nasopharyngeal cancer; five were squamous-cell carcinoma, 20 were anaplastic carcinoma and two were adenoid cystic carcinoma. A crude relative risk of 1.3 [95% CI, 0.6–2.9] was reported for employment as a carpenter, cabinet-maker or sawmill worker, with nine exposed cases and 151 exposed controls. [The comparability of the ages of cases and controls was unknown.]. The authors noted that little hardwood is used for furniture making in northern Sweden.

In the study of Ng (1986), described on p. 114, there were 224 cases of nasopharyngeal cancer: 112 squamous-cell, 102 anaplastic and 10 of unknown histology; 226 controls had other malignancies. Among people in the two wood-related occupational categories, furniture makers and woodworkers had five nasopharyngeal cancers and one other malignancy, and construction carpenters had three nasopharyngeal cancers and no other malignancies. No odds ratios or other estimates of relative risk were presented.

In the study of Kawachi *et al.* (1989), described on p. 115, excess risks were observed for nasopharyngeal cancer among woodworkers (odds ratio, 2.5; 95% CI, 0.9–6.6), forestry and

logging workers (6.0; 1.0–28) and carpenters (2.5; 0.6–8.5), after adjustment for age. No cases were observed among sawmill workers, pulp and paper workers or cabinet-makers.

Sriamporn *et al.* (1992) performed a case–control study in North-east Thailand of 120 patients with histologically confirmed nasopharyngeal cancer diagnosed between 1987 and 1990, who were undergoing radiation therapy at the only hospital offering such therapy in the area. Sixty-nine (57.5%) of the cases were squamous-cell carcinoma, and the remaining 51 were undifferentiated carcinomas. The 120 controls were patients admitted to the same hospital for diseases other than cancer and respiratory disease, who were matched to the cases on sex and age. Occupational histories were collected by questionnaire. The results were adjusted for age, sex, smoking, consumption of alcohol and salted fish, education and area of residence. Excess risks were reported for wood cutting, excluding agriculture (odds ratio, 4.1; 95% CI, 0.8–22) and for wood cutting and farming combined (8.0; 2.3–28).

Studies on nasopharyngeal cancer are summarized in Table 25.

(b) Pharyngeal cancer other than cancer of the nasopharynx

Elwood *et al.* (1984) reported the results of a case–control study of 374 patients with primary epithelial cancers of the oral cavity, pharynx (excluding nasopharynx) and larynx in British Columbia, Canada. The study included 44 oropharyngeal cancers, 38 hypopharyngeal cancers and five pharyngeal cancers at 'other' subsites. Controls were 374 patients with selected other cancers, who were matched to the cases on age and sex. Lifetime occupational histories were collected by interview in 1977–80. No quantitative results for wood-related exposures were reported, but the authors stated that 'exposure to wood dust was assessed and analysed in more detail, examining nature, intensity, and duration of exposure, but no regular or significant trends were seen'.

In the study of Vaughan (1989), described on p. 110, 183 people with cancer of the oro- or hypopharynx and 552 controls were interviewed. Excess risks were reported for carpenters, construction carpenters and machine operators in the wood industry after exclusion of exposure during the previous 15 years. Vaughan and Davis (1991) later categorized these cases according to exposure to wood dust. The odds ratio for pharyngeal cancer associated with employment in any wood-related occupation was 0.5 (95% CI, 0.2–1.2); it was 1.5 (0.4–5.5) when only exposure for 10 or more years after an induction period of 15 years was considered.

In the study of Haguenoer *et al.* (1990), described on p. 116, there were 114 histologically confirmed cases of oro- and hypopharyngeal cancers (no nasopharyngeal cancers were included) among men treated during the first semester of 1983. A matched analysis was conducted. A history of employment in woodworking occupations was associated with an increased risk for all cancers of the upper respiratory tract combined (odds ratio, 3.5; 95% CI, 1.2–10). Four case patients with oro- and hypopharyngeal cancers and one matched control had been employed as woodworkers, but no odds ratio was presented.

Maier *et al.* (1991) conducted a case–control study in the Heidelberg and Giessen areas of Germany of 200 male patients with squamous-cell carcinomas of the mouth, oropharynx, hypopharynx and larynx that had been diagnosed or treated at an eye, nose and throat clinic during 1987 and 1988. For each case, four age-matched male controls were selected from among

Table 25. Community-based case-control studies on cancer of the nasopharynx

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Exposure to wood dust								
Armstrong *et al.* (1983)	Malaysia	MF	100/100	Interviews	Exposed to wood/saw dust	2.2	*p* (one-sided) = 0.08	Self-reported exposure; matched on age and sex; ethnic Chinese
Olsen *et al.* (1984)	Denmark	MF	266/2465	Linkage with national pension fund records	Definite exposure to wood dust (men)	0.4	0.2–1.0	Exposure based on expert assessment of work history
Vaughan (1989); Vaughan & Davis (1991)	USA	MF	21/552	Interviews	Carpenters Construction carpenters Any wood-related occupation Duration ≥ 10 years	4.5 6.8 1.5 4.2	1.1–19 1.6–28 0.2–6.1 0.4-27	Only squamous-cell cancers; exposure primarily to softwood. Exposures lagged by 15 years. Results adjusted for age, sex, smoking and alcohol intake
Bolm-Audorff *et al.* (1990)	Germany	MF	12/66	Interviews	Exposed to wood dust			1/2 exposed case/controls
West *et al.* (1993)	Philippines	MF	104/205	Interviews	Wood dust-exposed occupation < 35 years since first employment ≥ 35 years since first employment	 1.3 2.1		Exposed occupations were carpenters, farm managers, farmers, lumbermen, raftsmen and wood-choppers. Matched on sex and age
Occupational group								
Hardell *et al.* (1982)	Sweden	M	27/541	Questionnaires	Carpenter, cabinet-maker or sawmill worker	1.3	[0.6-2.9]	9/151 exposed cases/controls
Ng *et al.* (1986)	Hong Kong	MF	224/226	Medical records	Furniture makers, woodworkers Construction carpenters	[5.0]		5/1 exposed cases/control 3/0 exposed cases/control

Table 25 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Occupational group (contd)								
Kawachi *et al.* (1989)	New Zealand	M	NR/ ~19 000	Tumour registry records	Woodworkers	2.5	0.9–6.6	Adjusted for age
					Foresters, loggers	6.0	1.0–28	
					Sawmill, pulp and paper workers			0/108 exposed case/controls
					Cabinet-makers			0/91 exposed case/controls
					Carpenters	2.5	0.6–8.5	
Sriamporn *et al.* (1992)	Thailand	MF	120/120	Interview	Wood cutting, not agriculture	4.1	0.8–22	Adjusted for age, sex, smoking, consumption of alcohol and salted fish, education and area of residence
					Wood cutting and agriculture	8.0	2.3–28	

NR, not reported; OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female

non-cancer patients attending the same clinic and a university clinic. Information on occupational and other exposures was collected from questionnaires. An elevated relative risk associated with self-reported exposure to wood dust was found for cancers at all upper aerodigestive tract sites combined (2.2; 95% CI, 1.0–4.9), but no site-specific results were reported.

Merletti *et al.* (1991) reported the results of a case–control study on occupation and cancer of the oral cavity and oropharynx in Turin, Italy. The cases were cancers of the oropharynx ($n = 12$) and oral cavity ($n = 74$) diagnosed among male residents of Turin between 1982 and 1984. The 385 controls were selected from a random sample of city residents interviewed as part of a study on laryngeal cancer. Occupational histories were collected by interview. Results were presented only for all cases combined (oropharynx and oral cavity). The odds ratios were adjusted for age, education, area of birth, tobacco smoking and alcohol drinking. The odds ratio for previous employment as a cabinet-maker or related woodworker was 1.2 (95% CI, 0.4–3.9); that for employment in any wood industry was 0.9 (0.3–3.0), and that for employment in the wood furniture industry was 1.4 (0.4–5.5).

Huebner *et al.* (1992) performed a case–control study of oral and pharyngeal (excluding nasopharyngeal) cancer among residents of four areas of the United States: Los Angeles, metropolitan Atlanta, two counties south of San Francisco, and New Jersey. Cases were identified from population-based tumour registries, to give 1114 cases diagnosed between 1 January 1984 and 31 March 1985. Controls (1268) were obtained through random-digit dialling (aged 18–64 years) and Health Care Financing Administration files (aged 65–79 years) and were frequency matched to controls on sex, race, age and study area. Information on occupation and exposure was collected at interviews. The results were adjusted for age, race, smoking, alcohol consumption and study location. The relative risks for pharyngeal cancers in men were 2.2 (95% CI, 1.0–4.7) for previous employment in the furniture/fixture industry and 2.3 (0.7–7.4) for work with woodworking machines.

Studies on oropharyngeal and hypopharyngeal cancers are summarized in Table 26.

(c) Laryngeal cancer

(i) Exposure to wood dust

Maier *et al.* (1992) reported on a case–control study of laryngeal cancer in Germany. The cases were histologically confirmed squamous-cell carcinomas of the larynx in 164 male patients who had attended the department of Otorhinolaryngology–Head and Neck Surgery, University of Heidelberg, for treatment or follow-up examinations during 1988–89. Controls were 656 males with no known cancer, who were selected randomly from two out-patient clinics in Heidelberg and matched to the cases 4:1 by age and residential area. All subjects were interviewed on life style, education and occupational history and exposures. The percentages of cases and controls, respectively, who were exposed at least once in a week during 10 years or more to different wood dusts were as follows: wood dust in general, 12.6% and 8.3% ($p < 0.08$); beech, oak, 5.8% and 6.1% ($p < 0.7$); pine, 12.6% and 7.5% ($p < 0.06$); 'precious wood', 0.8% and 3.5% ($p < 0.3$); and exotic wood, 0% and 2.1% ($p < 0.3$). For exposure to pinewood dust, the relative risks, p values and undefined CIs, adjusted for alcohol consumption and tobacco

Table 26. Community-based case-control studies on cancer of the oro- and hypopharynx in occupational groups

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Elwood *et al.* (1984)	Canada	MF	87/374	Interviews	Unspecified exposure to wood			'No regular or significant trends'
Vaughan (1989), Vaughan & Davis (1991)	USA	MF	183/552	Interviews	All carpenters	1.3	0.5–3.4	Only squamous-cell cancers; all exposures lagged by 15 years
					Construction carpenters	1.8	0.7–4.8	
					Wood machine operator	2.8	0.3–2.4	
					Any wood-related occupation	0.5	0.2–1.2	
					Duration ≥ 10 years	1.5	0.4–5.5	
Haguenoer *et al.* (1990)	France	M	114/228	Interviews	Woodworkers			4/1 exposed cases/control. Only jobs held for at least 15 years evaluated; matched on sex, age, ethnic group, area of residence, smoking and alcohol drinking
Huebner *et al.* (1992)	USA	MF	1114/1268	Interviews	Furniture/fixture industry	2.2	1.0–4.7	For subset of male cases of pharyngeal cancer only
					Woodworking machines	2.8	0.7–7.4	

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female

smoking, were as follows: all laryngeal cancers, 1.9 ($p = 0.05$; CI, 0.9–3.7); glottal cancers, 3.2 ($p = 0.03$; CI, 1.1–9.0); supraglottal cancers, 1.3 ($p = 0.6$; CI, 0.4–3.5). The mean time between the beginning of exposure to pinewood dust and the expression of laryngeal cancer was 39.7 years. [The Working Group noted the incomplete documentation of the composition of the control group, statistical methods and results.]

Zheng *et al.* (1992b) reported on a population-based case–control study of laryngeal cancer in Shanghai, China. A total of 263 residents of urban Shanghai, aged 20–75, in whom laryngeal cancer was newly diagnosed in 1988–90, were identified from a population-based cancer registry in Shanghai; 201 (76.4%) were interviewed. Controls were randomly selected from the urban Shanghai population and frequency matched by sex and age to all cases of oral, pharyngeal, laryngeal and nasal cancers reported to the Shanghai Cancer Registry during 1985–86. Of the 414 controls interviewed, 12% were second controls. The interview covered demographic data, tobacco smoking, alcohol drinking, dietary habits and occupational history and exposures. Adjusted odds ratios were calculated by stratification and unconditional logistic regression. Self-reported occupational exposure to wood dust among males was associated with an odds ratio of 1.4 (95% CI, 0.6–3.2), adjusted for age and smoking.

(ii) Occupational group

A case–control study of laryngeal cancer was reported by Wynder *et al.* (1976) in the United States which included 258 men and 56 women with a histologically confirmed laryngeal cancer (ICD 161.0,1), who had been admitted to hospitals in New York City, Los Angeles, Houston, Birmingham, Miami and New Orleans during 1970–73. Controls were 516 hospitalized men and 168 women (without a current diagnosis of tobacco- or alcohol-related disease and with no history of cirrhosis, stroke, gastric ulcers or myocardial infarct), who were individually matched to the cases by year of interview, hospital status and age at diagnosis. Occupational exposure to wood dust was reported for 22% of the male cases and 1.2% of controls ($p < 0.05$). Of the current smokers, equal proportions of cases and controls had been exposed to wood dust.

Occupational risks for laryngeal cancer were examined in the Third National Cancer Survey data (Flanders & Rothman, 1982). Cancer cases occurring during 1969–71 were identified in records from seven cities and two states in the United States, and a 10% probability sample of the subjects was interviewed. Ninety men with laryngeal cancer represented the cases, and 933 men with cancers at other sites, excluding oesophagus, stomach, small intestine, colon, pancreas, liver, bladder, kidney, lung, bronchus, oral cavity and pharynx, constituted the control group. Information on age, alcohol use, tobacco use and industrial and occupational categories (longest and second-longest held job) was obtained at interview and used in the analysis. The relative risks, adjusted for age, alcohol use, tobacco smoking and race, were 3.5 [95% CI, 0.6–19] for work in the lumber industry and 1.3 [0.3–6.6] for carpenters.

A hospital-based case–control study in New Haven, Connecticut (United States) (Zagraniski *et al.*, 1986), addressed occupational risk factors for laryngeal cancer. The cases were histologically confirmed primary squamous-cell carcinomas of the larynx (ICD 8 US adapted: 161) diagnosed in 1975–80 among white male residents of Connecticut alive in 1980–

81 and treated in one of two New Haven hospitals. Controls were white male general surgery patients with no prior diagnosis of cancer or respiratory disease, who were individually matched to the cases by hospital, calendar year of admission, decade of birth, county of residence, smoking status and type of tobacco used. The interview covered occupational history, including specific exposures, medical history, tobacco and alcohol use and demographic and home environmental data. A total of 148 cases were identified; 22 were not invited for interview because of death, move out of the state, loss to follow-up and other reasons. No proxy data were sought. Of the remaining 126 cases, 14.3% refused to be interviewed. Thus, 12.7% completed a telephone interview and 73.0% completed a personal interview. Of the 317 controls, 57.1% were interviewed personally. Any employment as a woodworker was associated with an odds ratio of 2.5 (95% CI, 0.5–13); the odds ratio for carpenters was 1.1 (0.6–2.0). These figures were adjusted for lifetime exposure to tobacco and alcohol and were based on a conditional logistic model with 87 cases and 153 controls. [The Working Group noted the low response rate among the controls.]

Morris Brown *et al.* (1988) reported on a case–control study of laryngeal cancer conducted in six counties of the Gulf Coast of Texas, United States. Cases were primary laryngeal cancers (ICD9: 161.X, 231.0) diagnosed in white males aged 30–79, identified through tumour registers and the records of 56 hospitals. During 1975–80, 220 living and 83 dead case patients were identified. Controls were a sample of white males resident in the six-county area, who were frequency matched to the cases by age, vital status, ethnic group and county of residence; they were identified from Texas Department of Health mortality tapes, drivers' licence records and Medicare records. Interviews including job histories were completed for 153 living case patients (69.5%) and close relatives of 56 dead case patients (67.5%). Exclusions on histological grounds resulted in 183 case patients (136 living, 47 dead). There were 250 controls (179 alive, 71 dead); the response rates were 62.8% for the dead controls, 60.9% for those identified from drivers' licence lists and 85.7% for those identified from Medicare records. The odds ratio for any employment as a woodworker or furniture maker, adjusted for tobacco smoking and alcohol drinking in the logistic model, was 8.1 (95% CI, 0.95–69; 7 exposed cases); that for employment as a carpenter was 1.7 (0.8–3.5; 19 exposed cases).

Bravo *et al.* (1990) reported on a case–control study of laryngeal cancer conducted in Spain. The cases were histologically confirmed epidermoid carcinomas of the larynx diagnosed in 85 patients (83 men) at La Paz Hospital, Madrid, during 1985–87. Twenty-six eligible case subjects were not included in the study because of death, having moved out of the country, refusal or loss. Controls were a random sample of 170 patients from the same hospital, excluding those with respiratory diseases or alcoholic cirrhosis; they were 'stratified' with respect to the cases according to sex, age and admission month. Personal interviews were conducted with all subjects, except for 15 case patients for whom a relative was interviewed. Occupational exposure to wood dust was associated with a crude odds ratio of 0.70. The mean duration of exposure to wood dust was 25 years for the exposed cases and 26 years for the exposed controls. [The Working Group noted the incomplete description of the exposure assessment and the crude statistical analysis].

In their study of exposure to wood dust and cancer of the upper respiratory tract, described on p. 110, Vaughan and Davis (1991) compared 234 cases of squamous-cell cancer of the larynx with 547 controls. They observed no excess risk for ever having been employed in a wood-exposed occupation (odds ratio, 1.0; 95% CI, 0.5–1.9), after adjustment for potential confounders. An elevated risk was observed for employment for 10 or more years, when allowing for a 15-year induction period (2.5; 0.6–10).

In a hospital-based case–control study in the United States (Muscat & Wynder, 1992), the associations between laryngeal cancer and exposure to tobacco, alcohol and occupational factors were examined in 194 white men with histologically confirmed primary laryngeal cancer selected from the records of the Memorial Sloan-Kettering Cancer Center and seven other hospitals in New York, Illinois, Michigan and Pennsylvania and interviewed in 1985–90. Controls were 184 men matched by hospital, age and year of interview, who included patients with gastrointestinal cancers, prostate cancers or lymphomas and bone, spinal and other 'non-neoplastic conditions'. Eighty-nine percent of the eligible case patients and controls agreed to be interviewed; no proxies were used. Self-reported occupational or recreational exposure to wood dust for at least 8 h per week for at least one year was associated with an odds ratio of 1.7 (95% CI, 0.7–4.6), adjusted for age, education, tobacco smoking, alcohol drinking and relative body weight.

A population-based case–control study in western Washington State (United States) (Wortley *et al.*, 1992) addressed occupational risk factors for laryngeal cancer. Cases were laryngeal cancers (ICD0: 161.0–161.9) diagnosed in 1983–87 in 291 patients who were identified through the cancer surveillance system (population-based cancer registry covering 13 counties in western Washington) of the Fred Hutchinson Cancer Research Center, Seattle; 235 (80.8%) were successfully interviewed. The closest next-of-kin was interviewed if the case was dead (17 surrogate interviews). Controls were men identified by random-digit dialling, who were frequency matched to the cases in categories of age and sex; 547 (80%) of the eligible controls were successfully interviewed. Lifetime occupational histories were coded according to the 1980 United States census codes for occupation and industry. Odds ratios were derived from a multiple logistic regression model and adjusted for smoking, alcohol drinking, age and education. The odds ratio for any employment as a woodworking machine operator, lagged by 10 years, was 0.4 (95% CI, 0.1–1.3); for fewer than 10 years, the odds ratio was 0.4, and for at least 10 years, it was 2.3 (CIs not given; trend $p = 0.36$). Five cases and 18 controls had been employed as woodworking machine operators. [The Working Group noted that although the number of controls in this study (547) was similar to that in the study of Vaughan and Davis (1991), they used separate control series.]

The studies on laryngeal cancer are summarized in Table 27.

(d) Lung cancer

(i) Exposure to wood dust

Blot *et al.* (1982) reported on occupational determinants of lung cancer in an area of northern Florida (United States) with exceptionally high rates of lung cancer. Interviews were conducted with 181 patients with lung cancer, 342 hospital controls (1978–79), 217 next-of-kin

Table 27. Community-based case-control studies on cancer of the larynx

Reference	Country	Sex	Cases/	Source of controls on exposure	Exposure to which relative information	OR/RR risk applies	95% CI or p	Comments
Exposure to wood dust								
Maier *et al.* (1992)	Germany	M	164/656	Interview	Wood dust		$p < 0.08$	12.6% of cases, 8.3% of controls; incomplete documentation
					Pinewood dust	1.9	$p = 0.05$	
					Pinewood dust, glottal cancers only	3.2	$p = 0.03$	
Zheng *et al.* (1992b)	China	M	177/269	Interview	Wood dust (self-reported)	1.4	0.6–3.2	Adjusted for age, smoking
Occupational group								
Wynder *et al.* (1976)	USA	M	258/516	Interview	Wood dust		$p < 0.05$	Crude analysis; 22% of cases, 1.2% of controls
Flanders & Rothman (1982)	USA	M	90/933	Interview	Lumber industry as major employer	3.5	[0.6-19]	Adjusted for age, race, smoking, alcohol consumption
					Carpenter	1.3	[0.3–6.6]	
Zagraniski *et al.* (1986)	USA	M	87/153	Interview	Woodworker (ever)	2.5	0.5-13	Adjusted for smoking, alcohol consumption; low response in controls
					Carpenter (ever)	1.1	0.6–2.0	
Morris Brown *et al.* (1988)	USA	M	183/250	Interview	Woodworker or furniture maker (ever)	8.1	1.0-69	Adjusted for smoking, alcohol consumption
					Carpenter	1.7	0.8–3.5	
Bravo *et al.* (1990)	Spain	MF	85/170	Interview	Wood dust	0.7		Incomplete documentation

Table 27 (contd)

Reference	Country	Sex	Cases/	Source of controls on exposure	Exposure to which relative information	OR/RR risk applies	95% CI or *p*	Comments
Occupational group (contd)								
Vaughan & Davis (1991)	USA	MF	234/547	Interview	Any wood dust >10 years with 15-year induction	1.0 2.5	0.5-1.9 0.6-10	Squamous-cell only; exposure predominantly to softwood
Muscat & Wynder (1992)	USA	M	194/184	Interview	Wood dust	1.7	0.7-4.6	Adjusted for age, education, smoking, alcohol consumption, relative body weight
Wortley *et al.* (1992)	USA	MF	235/547	Interview	Woodworking machine operator > 10 years	2.3	*p* (trend) = 0.36	Adjusted for age, education, smoking, alcohol consumption

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female

of dead lung cancer patients and 217 dead control subjects. The controls were selected from among hospital patients with diagnoses of or deaths from diseases other than lung cancer or chronic respiratory disease. The response rates were 86% for cases and 83% for controls. The final study group consisted of 321 cases and 434 controls. An excess relative risk for lung cancer (1.7; 95% CI, 1.0–2.7) was reported among people ever employed in the lumber or wood industries, after adjustment for tobacco smoking. A gradient was suggested with duration of employment in the lumber or wood industry: the relative risk was 1.3 among those employed 1–9 years and 1.6 among those employed for more than 10 years; both relative risks were calculated in comparison with those for people never employed in the wood industry. The excess was concentrated among those exposed to wood dust mainly in sawmills (1.9); the excess associated with exposure to wood dust was higher (3.4; 10 exposed cases) for small-cell carcinoma than for other cell types.

A hospital-based case–control study was conducted in an area of Louisiana (United States) with a high rate of lung cancer (Correa *et al.*, 1984). 'Current' primary lung cancers were identified from admission and pathology records of all the major hospitals in southern Louisiana, in one central Louisiana parish and two northern Louisiana parishes, except for the city of New Orleans, where the study was limited to four large hospitals. [The period of case ascertainment was not given.] A control subject was selected for each case from the same hospital and individually matched by race, sex and age. Patients whose main diagnosis was emphysema, chronic bronchitis, chronic obstructive pulmonary disease or cancer of the larynx, oral cavity, oesophagus or urinary bladder were excluded. Acceptable personal interviews were conducted with 1338 (76%) cases and 1393 (89%) controls. The questions covered occupation, residence, diet, smoking and drinking habits, health, water supply and other related items. The odds ratios (unconditional) were adjusted for smoking. For all occupations, only white male workers who had ever been employed in the 'forestry' category (most of them sawmill workers) had a significantly elevated odds ratio (1.7). Exposure to wood dust was associated with an odds ratio for lung cancer of 1.4 ($p < 0.05$); of 45 other suspected occupational exposures, only mineral oil mist was also significantly associated with lung cancer.

A nested case–control study of lung cancer in 19 608 male employees of a chemical plant in Texas (United States) (Bond *et al.*, 1986),was designed to examine the associations between lung cancer and a number of occupational exposures. A total of 308 lung cancer deaths were recorded during 1944–80 on death certificates as cancer of the bronchus, lung or site unspecified within the respiratory system as the underlying cause, as a contributing cause or as 'other significant conditions'. Two control groups, one a dead and the other a living series, were individually matched to the lung cancer patients. Work histories were grouped into 50 work areas of homogeneous exposures. Chemical and physical exposure profiles were developed by an industrial hygienist for each case and each control. In comparison with pooled controls, the odds ratio for any (as opposed to no) exposure to wood dust was 1.1 (95% CI, 0.72–1.8). With a 15-year lag, it was 1.3 (0.78–2.2); for low exposure to wood dust, 3.9 (1.1–14); for moderate exposure, 0.91 (0.39–2.1); and for high exposure, 0.99 (0.56–1.8). [The Working Group noted that this was a study of a multi-product chemical plant where there were numerous exposures

and where exposure to wood dust would be minimal in comparison with that in wood-related industries.]

Kjuus *et al.* (1986) used data from interviews with 176 men admitted to two hospitals in Telemark and Vestfold, Norway, for lung cancer during 1979–83 and with 176 age-matched control subjects admitted during the same period to the same hospitals. Patients with conditions that would have precluded employment in heavy industry, poor general health, obvious mental conditions or chronic obstructive lung disease were excluded as controls. One case and two potential controls refused the interview. Woodwork as the main lifetime occupation was associated with an odds ratio of 0.7 (95% CI, 0.2–2.3), adjusted for cigarette smoking. The odds ratio for exposure to wood dust, adjusted for a number of confounders, was 0.5, representing a significant deficit.

A population-based multi-site case–control study of cancer addressed associations between occupational factors and cancer (Siemiatycki *et al.*, 1986; Siemiatycki, 1991). A total of 3730 histologically confirmed cases of cancer at 19 sites, newly diagnosed among male residents, aged 35–70, of Montréal, Canada, in 19 major hospitals during 1979–85 were identified, and the patients were interviewed for detailed lifetime job histories and potential confounders. The response rate was 81.5%. A team of chemists and hygienists examined the questionnaires and translated each job into a list of potential exposures with the help of a checklist of some 300 occupational exposures. Odds ratios for each cancer site were calculated in comparison with other cancers and adjusted for smoking and other factors, including other occupational exposures, and were presented for any exposure and for substantial exposure (at least 10 years' duration after the first five years). There were 1082 patients with lung cancer, and 857 (79%) responded. The odds ratio for any exposure to wood dust was 1.2 [95% CI, 1.0–1.5]; for substantial exposure, it was 1.3 [0.9–1.8]. When the analysis was restricted to French-Canadian subjects, the odds ratios for oat-cell lung cancer were 1.3 [0.9–2.0] for any exposure and 1.6 [0.9–2.8] for substantial exposure.

A population-based case–control study was conducted in New Mexico, United States (Lerchen *et al.*, 1987) of 506 white residents of New Mexico (333 males and 173 females), aged 25–84 years, with primary lung cancer other than bronchioalveolar carcinoma, which was diagnosed in 1980–82 and registered by the New Mexico Tumor Registry. A total of 771 controls (499 males and 272 females) were identified through randomly selected residential telephone numbers and, for people aged 65 or older, from a roster of Medicare participants. The controls were frequency matched to cases for sex, ethnic group and 10-year age category. The case subjects and controls or their next-of-kin were interviewed about smoking and occupational history, and a self-reported history of exposures to 18 specific agents was obtained. The interview rate was 89% for cases and 83% for controls. The odds ratio for ever having been employed for at least one year as a woodworker was 0.8 (95% CI, 0.3–1.7), after adjustment for age and ethnic group. [The Working Group noted that the numbers of case subjects and controls exposed to wood dust were exactly the same as those of people employed one or more years as a woodworker and assumed that these were the same individuals.]

Twenty-five major industrial titles were evaluated as risk factors for lung cancer in a population-based case–control study conducted in Shanghai, China (Levin *et al.*, 1988). The

case series consisted of all lung cancers newly diagnosed during 1984–85 among men aged 35–64 who resided in the urban areas of Shanghai. Population controls were randomly selected from the same areas from specified age categories in sampling fractions that produced similar age distributions for the cases and controls. Personal interviews were conducted with 733 surviving case subjects (88% of the total incident cases and 99% of survivors) and 760 controls. The interview concerned lifetime occupational history, smoking and other information; detailed data were obtained on every job the subject had held for at least one year since the age of 16. The employment data were classified by the industrial and occupational headings defined for the 1982 Chinese population census. Any employment in furniture manufacture was associated with an odds ratio of 1.3 (95% CI, 0.5–3.4), adjusted for smoking and age. The adjusted odds ratio for any employment in timber processing or as a wood, bamboo, hemp, rattan, palm or straw products maker was 1.2 (0.7–2.2). Self-reported exposure to wood dust was associated with a significantly increased odds ratio of 1.7 (1.0–2.7), in contrast to people who reported no exposure to dust, smoke or fumes in the workplace. Most of the subjects who reported exposure to wood dust worked in furniture manufacture or timber production. A total of 672 female case subjects and 735 female controls were also interviewed, but the small numbers in many industrial and occupational categories precluded a detailed analysis. An increased risk, similar to that observed among men, was associated with self-reported exposure to wood dust [no odds ratio given]. The authors found only slight differences in risk by cell type for most occupational or industrial categories but did not document this statement.

(ii) Occupational group

Harrington *et al.* (1978) analysed data from death certificates on the occupations of 858 white men who died of lung cancer in coastal Georgia, United States, during 1961–74, and of 858 controls who died of conditions other than lung cancer, chronic respiratory disease or bladder cancer during the same period. The controls were individually matched to the cases by age at death, year of death, sex, race and county of usual residence, and matched-pairs analyses were conducted. The usual occupations were coded into major occupational and industrial categories. The relative risk for work in the wood and paper industry was 1.3 ($p > 0.05$). A significant excess relative risk for work in the wood and paper industry (3.3; $p < 0.01$) was found in small rural counties but not in the largest counties. The excess was greater among sawmill, lumber and forestry workers than among pulp and paper workers and carpenters, but no relative risks were presented. No data were available on tobacco smoking and possible industrial confounders.

In a pilot study, Esping and Axelson (1980) used data from death certificates on the occupations associated with 25 deaths from respiratory cancer (ICD [1965]: 160–163) and those of 370 controls who had died from diseases other than respiratory and digestive cancers in the small town of Mjölby, Sweden, where there was a comparatively large woodworking industry. The deaths had occurred among men 50 years of age or older during the period 1963–77. The age-adjusted rate ratio for 'exposure to woodwork' was 4.1 (95% CI, 1.6–11). The crude relative risks were 6.0 for furniture makers and 2.3 for other woodworkers. The smoking habits were not known.

A case–control study in Alameda County, California, United States (Milne *et al.*, 1983), covered 925 deaths from lung cancer (747 men) and 6420 deaths from other cancers (3130 men) that occurred among county residents over 18 years of age between 1958 and 1962. The study examined associations between lung cancer and usual occupation and industry, as recorded on the death certificate and coded by the US Bureau of Census Industrial and Occupational Classification System. The odds ratio were 0.8 for men employed in sawmills, 4.2 ($p < 0.01$) for men in furniture manufacture, 1.0 for male cabinet-makers and furniture finishers and 1.2 for carpenters.

In a hospital-based case–control study in metropolitan Florence, Italy (Buiatti *et al.*, 1985), frequency matching on smoking status was used to compare 376 people with histologically confirmed primary lung cancer (340 men) with 892 control subjects with discharge diagnoses other than lung cancer and attempted suicide (817 men). The case patients and controls had been admitted in the period 1981–83. Occupational histories were collected for all cases and controls in person, and the response rate was 100%. The odds ratio for men ever employed in woodwork, adjusted for age, smoking and place of birth, was 0.6 (95% CI, 0.3–1.1).

Coggon *et al.* (1986) reported on a case–control study of cancer of the bronchus among middle-aged men in Cleveland, Humberside and Cheshire, United Kingdom, diagnosed during 1975–80. Controls were patients with other cancers. Occupational and smoking histories were obtained from a postal questionnaire, addressed either to the patients or their next-of-kin. The overall response rate was 52% (738 cases, 2204 controls). For patients who reported ever having been employed as a woodworker, the relative risk was 1.7 (95% CI, 1.0–3.0), adjusted for age, residence, source of occupational history and smoking. The risk ratio for ever having been employed in the industrial order of timber and furniture was 1.6 ($n = 17$). The authors compared the distribution of occupations among respondents and nonrespondents, using information from hospital records, and found no evidence of bias in reporting by response category.

In a population-based case–control study in northern Sweden (Damber & Larsson, 1987), data on 589 dead male cases and two series of matched control subjects drawn from population registries (582 deceased, 453 living) were used to examine associations between the risk for lung cancer and occupation. The cases represented deaths during 1972–79 among people in whom lung cancer was diagnosed. The occupations were ascertained from a postal questionnaire addressed to living controls or to close relatives of the cases and dead controls. The response rates were 98% for cases, 96% for dead controls and 97% for living controls. At least one year of employment as a carpenter was associated with an odds ratio of 0.8 (95% CI, 0.5–1.3), adjusted for lifetime tobacco consumption, when compared with dead controls, and with an odds ratio of 0.7 (0.5–1.2) when live controls were used.

The association between occupation and the risk for lung cancer was examined in a case–control study conducted in six areas of New Jersey, United States (Schoenberg *et al.*, 1987). The cases were histologically confirmed primary cancers of the trachea, bronchus and lung diagnosed in 763 white males in 1980–81. Nine hundred white male population controls were selected from files of drivers' licences and death certificates. Interviews were completed with 429 case patients and 564 controls or their next-of-kin (334 and 336, respectively), in order to obtain demographic data and information on personal and environmental risk factors, including

smoking, diet and occupation. The response rate was 70% for the case patients and 64% for the controls. Information on industry and job title was coded by the index system used in the 1970 United States census. The risk for lung cancer was analysed for 42 job title categories and 34 job titles in specified industries, after adjustment for smoking. The risk among men who had ever been employed as furniture or fixture workers was 1.5 (95% CI, 0.76–3.0). Smoking-adjusted odds ratios for carpenters (46 cases, 55 controls) and lumber and wood products workers (16 cases, 17 controls) were 0.90–0.99.

A population-based case–control study of lung cancer and occupation was conducted in two industrialized areas of northern Italy (Ronco *et al.*, 1988) involving 126 men who had died from lung cancer between 1976 and 1980. Controls were a random sample of 384 men who had died from other causes (except chronic lung conditions and smoking-related cancers) during the same period and who were individually matched to the cases by year of death and 10-year age class. Next-of-kin were interviewed at home or by telephone with regard to the lifelong tobacco consumption and occupational histories of the cases and controls. The response rate was 77% for cases and 78% for controls. Job titles were coded by the ILO classification, and industrial activities according to the United Nations international classification of industries. While no excess risk was associated with carpentry or joinery (6 cases, 28 controls), increased odds ratios were observed for woodworkers employed in furniture and cabinet-making, with an aggregated odds ratio of 2.8 (0.93–8.4), adjusted for age, smoking and having been engaged in an occupation known or suspected to be associated with increased lung cancer risk.

Hoar Zahm *et al.* (1989) examined the associations between different histological types of lung cancer and occupations in 4431 white Missouri (United States) residents with histologically confirmed lung cancer diagnosed in 1980–85 and reported to the Missouri Cancer Registry. The 11 326 controls were all white Missouri residents with a diagnosis of any cancer except those of the lip, oral cavity, oesophagus, lung, bladder, ill-defined sites and unknown sites, during the same period. The occupation at the time of diagnosis of cancer was abstracted from the Registry files, which obtained this information from medical records. Occupation was coded according to the index system of the United States Bureau of Census, and codable information was available for 52% of the cases and 45% of the controls. The smoking history was unknown for 15% of the cases with known occupation and for 37% of the controls. Odds ratios were calculated for a number of occupations, with adjustment for age and smoking. For all lung cancers, the odds ratio associated with cabinet- and furniture making was 1.3 (95% CI, 0.5–3.3), and that for carpenters was 1.3 (1.0–1.7). Cabinet- and furniture makers had increased risks for adenocarcinoma of the lung (2.0; 0.4–8.1), small-cell carcinoma (1.6; 0.2–7.9) and tumours of 'other' or mixed-cell types (1.9; 0.4–7.4), but not for squamous-cell carcinoma (0.7; 0.1–3.5). In carpenters, the odds ratio for adenocarcinoma was 1.6 (1.0–2.5); that for small-cell carcinoma, 1.1 (0.6–2.0); that for squamous-cell carcinoma, 1.2 (0.8–1.8); and that for other or mixed type, 1.3 (0.8–2.2).

The studies of cancer risk in wood-related occupations, using the New Zealand Cancer Registry (Kawachi *et al.*, 1989), described on p. 115, showed age-adjusted odds ratios of 1.3 (95% CI, 1.2–1.6) for all woodworkers, 1.3 (0.85–1.9) for foresters and loggers, 1.8 (1.2–2.5) for sawmill workers, 1.2 (0.77–1.8) for cabinet-makers 1.3 (1.1–1.5) for carpenters. Although

52% of the pulp and paper mill and sawmill workers were regular smokers at the time of the 1981 census, compared with a 38% smoking prevalence in the total labour force of New Zealand, sawmill workers did not have an excess risk of other cancers (those of the larynx, oesophagus and bladder) associated with tobacco smoking. In carpenters, the prevalence of smoking was 36%.

A case–control study was conducted in France to examine the relationship between bronchial adenocarcinoma and exposure to wood dust (Schraub *et al.*, 1989). All histologically confirmed male cases of adenocarcinoma of the lung reported to the cancer registry of the Doubs region during 1978–85 formed the case series: 22 living and 40 dead cases were identified; nine case patients could not be located, and the remaining case patients or their next-of-kin were interviewed. A population sample (three controls randomly selected from among males within five years of the ages of the cases at the time of diagnosis) of 160 men formed the control group, representing an 86% participation rate. The controls were on average five years older than the cases. Occupational exposures and consumption of tobacco and alcoholic beverages were documented by interviews with live case patients and 160 controls and with families or physicians of the dead case patients. The crude odds ratio for exposure to wood dust was 1.1 (95% CI, 0.38–2.7). Adjustments for cigarette smoking, age and urban–rural residence resulted in 'only trivial, nonsignificant increases' in the odds ratio associated with exposure to wood dust. The mean duration of exposure was 6.8 years for the cases and 17.3 years for the controls. [The Working Group noted that, although the controls were older than the cases, the authors did not indicate whether the work histories of the controls were truncated to match the time-frame of those of the cases.]

A community-based case–referent study of occupational risk factors for lung cancer was conducted in the Detroit metropolitan area, United States (Burns & Swanson, 1991). Histories of occupation and tobacco use were obtained by telephone interview for 5935 incident lung cancer case patients and 3956 controls with colorectal cancer. The cases and controls were identified through the metropolitan Detroit cancer surveillance system, in which patients are enrolled within two to six weeks after diagnosis; the overall response rate was about 93%. The odds ratio for woodworkers was 1.1 (95% CI, 0.70–1.8), after adjustment for age at diagnosis, cigarette smoking history, race and sex. For workers in wood manufacture, which included many fewer subjects than the occupational category 'woodworkers', the odds ratio was 2.3 (0.81–6.4).

In a hospital-based case–control study conducted in five German cities (Jöckel *et al.*, 1992), 194 patients with primary lung cancer, 194 hospital controls with an admission diagnosis unrelated to tobacco smoking and 194 population controls identified from residential registries were interviewed about smoking, occupational and residential histories. Controls were individually matched to the cases by sex and age. The response rate of the population controls was 40.7%. The smoking-adjusted odds ratio was 0.9 (95% CI, 0.46–2.0) for males in the paper, wood and printing industries, 0.7 (0.28–1.9) for wood processing workers and 0.8 (0.36–1.6) for carpenters and brick masons. [The Working Group noted the low participation rate in the controls.]

In a hospital-based case–control study in nine metropolitan areas of the United States (Morabia *et al.*, 1992), 1793 male lung cancer cases were matched by race, age, hospital, year of

interview and cigarette smoking with 2230 cancer and 998 non-cancer hospital controls, some of whom had tobacco-related diagnoses. Usual occupation, exposure to potential carcinogens and cigarette smoking were addressed during interviews conducted in 1980–89. Carpenters and cabinet-makers had a nonsignificant excess risk (odds ratio, 1.4), adjusted for age and tobacco smoking.

An updating (Kauppinen *et al.*, 1993) of a Finnish case–control study nested in a cohort of male woodworkers (Kauppinen *et al.*, 1986) was based on a cohort of 7307 workers from 35 industrial facilities (sawmills and furniture, construction carpentry, plywood and particle-board factories). A total of 136 incident respiratory cancers (cancers of the lung, trachea, larynx, epiglottis, tongue, pharynx, mouth, nose and nasal sinuses) was identified in the cohort during 1957–82. Three control subjects in the cohort who had not contracted respiratory cancer were matched to each case by year of birth. Plant- and time-specific job exposure matrices were constructed for 12 major agents in the wood industry. Job histories were based on plant records and complemented by responses to questionnaires from the case patients and controls or their next-of-kin; the questionnaires also provided data on tobacco smoking. The smoking-adjusted odds ratio for lung cancer and exposure to wood dust was 1.3 [95% CI, 0.8–2.3] with no exposure lagging; the ratio dropped to 0.44 [0.2–1.3] after lagging by 10 years. No trend by level or cumulative exposure was observed.

Associations with occupation were examined in a case–control study conducted in India (Notani *et al.*, 1993) of 246 male residents of Mahrashtra State with a diagnosis of lung cancer. A total of 212 sex- and age-matched hospital controls (patients with cancers of the mouth and pharynx or non-neoplastic oral diseases) were selected, such that the community distribution was similar to that of the cases. Interviews were conducted with the case patients and controls to obtain lifetime occupational history, self-reported history of specific exposures, demographic variables, tobacco use, alcohol consumption and medical history. Each job was coded according to the International Standard Classification of Occupations. The odds ratios for ever having been employed as a woodworker were 3.0 (95% CI, 1.0–9.3; adjusted for age) and 3.2 (0.9–12; adjusted for age and smoking). [The Working Group noted that the participation rates of the case patients and controls were not documented and that the inclusion of controls with cancer of the pharynx biased the odds ratio towards the null.]

The associations between lung cancer and occupation were examined in a case–control study of 965 women aged 29–70 in whom primary lung cancer was diangosed in the cities of Shenyang and Harbin, China, and notified to the cancer registries of these cities during 1985–87 (Wu-Williams *et al.*, 1993). They represented 92% of the eligible cases. Controls were women randomly selected from the populations of the same cities and frequency matched to the cases by age. Personal interviews were conducted with the cases and controls to obtain demographic data and information on lifetime smoking habits, sources of pollution, histories of occupation and specific exposures, and medical and dietary histories. The employment data were classified by industry and occupation according to the classification of the 1982 Chinese population census. The odds ratio for workers in the manufacture of wooden products, adjusted for smoking, study area, age and education, was 0.9 (95% CI, 0.5–1.7). For nonsmokers, the odds ratio, adjusted for study area, age and education, was 1.5 ($p > 0.05$). Timber processing was associated with an

odds ratio of 1.1 (0.6–2.0), adjusted for smoking, study area, age and education. For nonsmokers, the odds ratio, adjusted for study area, age and education, was 1.5 ($p > 0.05$). Self-reported exposure to wood dust was associated with an odds ratio of 1.1 (0.8–1.7; adjusted for smoking, study area, age and education). The odds ratio was 1.3 ($p > 0.05$) among nonsmokers, after adjustment for study area, age and education.

Studies on lung cancer are summarized in Table 28.

2.4.3 Cancers of the lymphatic and haematopoietic system

(a) Non-Hodgkin's lymphoma

(i) Exposure to wood dust

In the study of Siemiatycki (1991), described on p. 140, the total number of eligible cases of non-Hodgkin's lymphoma was 258; 215 responded, for a response rate of 83%. The odds ratio for any exposure to wood dust was 0.8 [95% CI, 0.6–1.2]; for substantial exposure, it was 1.0 [0.6–1.6]).

Partanen *et al.* (1993) reported on a small industry-based case–control study of malignant lymphoma and exposures in the wood industry. In a retrospective cohort of male woodworkers, eight cases of non-Hodgkin's lymphoma were notified to the Finnish Cancer Registry in 1957–82. Fifty-two controls from the cohort were individually matched to the cases by year of birth and survival in 1983. Individual employment histories in woodworking facilities were abstracted from factory records, and a number of exposures were reconstructed with an ad-hoc plant- and period-specific job–exposure matrix. For the cases, this information was completed by interview of selected people at the factories and from questionnaires sent to the case subjects or their next-of-kin. [The Working Group noted that the data on exposure were more detailed for cases than for controls and that this may have induced a positive bias in the results.] The unadjusted odds ratios associated with exposure to wood dust were 2.1 (95% CI, 0.43–11) for all lymphomas and 2.1 (0.23–20) for non-Hodgkin's lymphoma.

(ii) Occupational group

Cartwright *et al.* (1988) reported on risk factors for non-Hodgkin's lymphoma in a case–control study in the United Kingdom. Case patients were identified in 1979–84 in hospitals, the cancer registry and the lymphoma panel in Yorkshire; additional cases during the period were sought in the area. Only cases confirmed histologically were accepted. The controls were in-patients with a variety of nonmalignant conditions. Attempts were made to match two hospital controls to each case by residential health district, sex and age. Case patients and control patients were interviewed with regard to past medical history, drug use, family medical history, hobbies, occupation, smoking and alcohol consumption. Of a total of 1407 patients with non-Hodgkin's lymphoma who had been notified, 437 (244 with low-grade tumours, 177 with high-grade tumours and 36 with unspecified subtypes) were interviewed; the commonest reasons for failure to be interviewed were insufficient information on the patient's age, sex or address, lack of histopathological confirmation or death before interview. An interview was completed with 724 controls. For woodworkers, a 'nonsignificant risk ratio under 2.0' was reported, with 28 exposed cases and 35 exposed controls. Occupational or private (more than three months) exposure to

Table 28. Case–control studies of lung cancer

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative	OR/RR risk applies	95% CI or p	Comments
Exposure to wood dust								
Blot *et al.* (1982)	USA	M	321/434	Interview	Wood dust Wood dust	1.9 3.4		All lung cancer Small-cell lung cancer
Correa *et al.* (1984)	USA	MF	1338/1393	Interview	Wood dust	1.4	$p < 0.05$	Adjusted for smoking; white men
Bond *et al.* (1986)	USA	M	308/588	Company records	Any wood dust (15-year lag) High exposure	1.3 1.0	0.8–2.2 0.6–1.8	Nested study
Kjuus *et al.* (1986)	Norway	M	176/176	Interview	Woodworking Wood dust	0.7 0.5	0.2–2.3 $p < 0.05$	Matching by age; adjusted for cigarette smoking
Siemiatycki *et al.* (1986), Siemiatycki (1991)	Canada	M	857/1360	Interview	Wood dust, any exposure Wood dust, substantial exposure	1.2 1.3	[1.0-1.5] [0.9–1.8]	Adjusted for a number of confounders
Lerchen *et al.* (1987)	USA	M	333/499	Interview	Wood dust (ever)	0.8	0.3–1.7	Adjusted for age, ethnic group, smoking
Levin *et al.* (1988)	China	M	733/760	Interview	Wood dust (self-reported)	1.7	1.0–2.7	Category matching by age; adjusted for smoking and age
Occupational group								
Harrington *et al.* (1978)	USA	M	858/858	Death certificate	Wood and paper industry (usual job)	1.3	$p > 0.05$	Matching by age, year of death, race and residence
Esping & Axelson (1980)	Sweden	M	25/370	Death register	Woodworking Furniture maker Other woodworker	4.1 6.0 (crude) 2.3 (crude)	1.6–11	Rough adjustment for age

Table 28 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative	OR/RR risk applies	95% CI or *p*	Comments
Occupational group (contd)								
Milne *et al.* (1983)	USA	M	747/3130	Death certificate	Sawmills Furniture manufacture Cabinet-maker, furniture finisher (usual job)	0.8 4.2 1.0	$p > 0.05$ $p < 0.01$ $p > 0.05$	
Buiatti *et al.* (1985)	Italy	M	340/817	Interview	Woodworking (ever)	0.6	0.3–1.1	Adjusted for age, smoking, place of birth
Coggon *et al.* (1986)	United Kingdom	M	738/2204	Postal questionnaire	Woodworking (ever)	1.7	1.0–3.0	Adjusted for age, residence, source of history (patient or relative), smoking
Damber & Larsson (1987)	Sweden	M	589/1035	Postal questionnaire	Carpenter (at least 1 year)	0.8 (dead controls) 0.7 (living controls)	0.5–1.3 0.5–1.2	Matching by sex, birth year. residence; adjusted for smoking
Schoenberg *et al.* (1987)	USA	M	763/900	Interview	Furniture and fixture worker (ever)	1.5	0.8–3.0	Adjusted for smoking
Ronco *et al.* (1988)	Italy	M	126/384	Interview	Furniture or cabinet-maker (ever)	2.8	0.9–8.4	Adjusted for age, smoking, other occupations
Hoar Zahm *et al.* (1989)	USA	M	4431/11 326	Cancer register (medical record)	Cabinet- and furniture makers (at time of diagnosis)	1.3 (all lung cancer) 2.0 (adenocarcinoma)	0.5–3.3 0.4–8.1	Adjusted for age, cigarette smoking
Kawachi *et al.* (1989)	New Zealand	M	4224/15 680	Cancer registry	Any woodworking Sawmill worker Cabinet-maker	1.3 1.8 1.2	1.2–1.6 1.2–2.5 0.8–1.8	Adjusted for age

Table 28 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative	OR/RR risk applies	95% CI or p	Comments
Occupational group (contd)								
Schraub *et al.* (1989)	France	M	53/160	Interview	Wood dust	1.1	0.4–2.7	
Burns & Swanson (1991)	USA	MF	5935/3956	Interview	Woodworker Wood manufacture	1.1 2.3 (usual job)	0.7–1.8 0.8–6.4	Adjusted for age, race, sex, tobacco smoking
Jöckel *et al.* (1992)	Germany	M	146/292	Interview	Wood processing worker (ever)	0.7	0.3–1.9	Matching by sex and age; adjusted for tobacco smoking
Morabia *et al.* (1992)	USA	M	1793/3228	Interview	Carpenter and cabinet-maker (usual job)	1.4	$p > 0.05$	Adjusted for age and smoking
Kauppinen *et al.* (1993)	Finland	M	136/408	Company records	Wood dust	0.4	[0.2–1.3]	Adjusted for smoking; 10-year lagging of exposures
Notani *et al.* (1993)	India	M	246/212	Interview	Woodworker (ever)	3.2	0.9–12	Adjusted for age and smoking
Wu-Williams *et al.* (1993)	China	F	965/959	Interview	Timber processing (> 1 year) Wood dust (self-reported)	1.5 1.1	$p > 0.05$ 0.8–1.7	In nonsmokers Adjusted for smoking, study area, age, education

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female

wood dust was associated with a significantly increased risk ratio of 1.5 (95% CI, 1.0–2.1). Exposure to wood dust was associated more strongly with the low-grade subtype of non-Hodgkin's lymphoma (odds ratio, 2.0; $p < 0.05$) than with the high-grade type (odds ratio, 1.1). [The Working Group noted that the controls were insufficiently described; it is not clear whether the 'risk ratios' reported are crude or adjusted for sex and age; a source of possible bias is the fact that a large proportion of cases could not be interviewed.]

A case–control study of non-Hodgkin's lymphoma and occupation based on information from death certificates was reported by Schumacher and Delzell (1988), involving 501 male residents of North Carolina (United States), who died at 35–75 years of age from non-Hodgkin's lymphoma (ICD 8,9 200.0–200.9, 202.0–202.9) during 1968–70, 1975–77 and 1980–82. The controls were 569 male residents of North Carolina who died from causes other than cancer in the same periods and who were frequency matched to the cases by age, year of death and race. The usual occupation and industry were abstracted from death certificates and coded according to a system that combined industry and occupation. Work in paper and wood industries was associated with odds ratios of 0.79 [95% CI, 0.5–1.3] in whites and 1.3 [0.3–4.8] in blacks. For work in the furniture industry, which was a subcategory of paper and wood, the odds ratios were 0.74 [0.4–1.4] for whites and 1.9 [0.1–30] for blacks.

Franceschi *et al.* (1989) reported on a hospital-based case–control study of non-Hodgkin's lymphoma conducted in the province of Pordenone, north-eastern Italy. The cases were histologically confirmed non-Hodgkin's lymphomas diagnosed in 1984–88 in men and women under the age of 80, who had been admitted as in-patients or referred for follow-up at the out-patient clinics at Aviano Cancer Centre and general hospitals in the province. Of the 232 eligible case patients with lymphosarcoma and reticulosarcoma (ICD: 200) and other non-Hodgkin's lymphoma (ICD: 202), 18 died before they could be interviewed and there was no histological confirmation for six. None of the living case patients refused interview. The case series thus comprised 208 non-Hodgkin's lymphoma patients—110 men and 98 women. Controls were 401 interviewed in-patients at the same hospitals (215 men, 186 women), who were under the age of 80. Patients with admission diagnoses of malignant disorders, conditions related to alcohol and tobacco consumption, haematological, allergic and autoimmune conditions, and diseases that might have resulted in diet modifications, such as diseases of the respiratory and digestive tracts, cardiovascular disease and diabetes, were excluded from the control series. The interview covered sociodemographic characteristics, smoking, consumption of alcohol and coffee, intake of selected food items, medical history, vaccinations, tonsillectomy, medical radiation exposure, occupational history and self-reported exposure to 20 potentially carcinogenic agents, including wood dust. The job category 'wood and furniture workers', not further specified, was associated with an odds ratio of 0.66 (95% CI, 0.37–1.2), adjusted for age and sex. The number of subjects exposed to wood dust was too small for analysis.

Persson *et al.* (1989) examined associations between occupational exposures and Hodgkin's disease and non-Hodgkin's lymphoma in Sweden. The 106 non-Hodgkin's lymphoma cases (66 in men) were identified at the register of the Department of Oncology, Örebro Medical Centre Hospital in people who were alive in 1986 and whose cancers were diagnosed when they were 20–80 years of age, during 1984–86. Six eligible case patients were either unwilling to parti-

cipate or could not be contacted. Population controls representing the catchment area of the hospital comprised 275 people aged 20–80, after replacement of 17% who were unable or unwilling to participate. 'Exposure' was defined as that occurring 5–45 years before diagnosis of a non-Hodgkin's lymphoma and lasting at least one year. An elevated risk was suggested in carpenters and cabinet-makers (crude odds ratio, 3.1). The odds ratio for exposure to fresh wood, as defined by employment as a sawmill worker, lumberjack or paper pulp worker, was 1.3. The odds ratio for work as a carpenter or cabinet-maker, adjusted for age at diagnosis, sex and farming, was 2.8 [95% CI, 0.9–8.5]; that for exposure to fresh wood was 1.0 [0.3–3.5].

A subsequent study (Persson *et al.*, 1993) was conducted with similar methods in an adjacent region of Sweden (Östergötland, Jönköping, Kalmar). The cases were non-Hodgkin's lymphomas (ICD8: 200.0–2) diagnosed in 1975–84 among men who were alive in 1986, who were aged 20 years or more, who were living in the catchment area and were identified at the cancer registry covering the region. After 14 refusals and lack of diagnostic confirmation, 93 cases of non-Hodgkin's lymphoma remained. The 204 controls had also been used in other case–control studies (Flodin *et al.*, 1986, 1987, 1988) and resided in the catchment area from which the cases were drawn. A postal questionnaire requested information about occupational exposures, medical care and leisure exposures. 'Exposure' was defined as occupation 5–45 years before the diagnosis of a non-Hodgkin's lymphoma and lasting at least one year. The crude odds ratio for non-Hodgkin's lymphoma in subjects exposed to fresh wood (sawmill workers, lumberjacks and paper pulp workers) was 2.6. The odds ratio for carpenters and cabinet-makers was 0.9 [95% CI, 0.3–2.4], adjusted for age at diagnosis and occupational confounders. Among the workers exposed to fresh wood, the subcategory 'lumberjacks' was associated with an adjusted odds ratio of 6.0 [95% CI, 0.8–44].

Reif *et al.* (1989) conducted a series of case–control studies on a number of cancer sites in New Zealand to assess associations between forestry work and cancer. All cancer cases in men aged 20 years and over were identified in 1980–84 at the New Zealand Cancer Registry. Occupation was recorded for 19 904 men (80%); 535 eligible cases of non-Hodgkin's lymphoma (ICD: 200,202) were available. Cases of other cancers formed the control group. The age-adjusted odds ratio for non-Hodgkin's lymphoma among foresters and loggers was 1.8 (95% CI, 0.85–4.0); the odds ratio for sawmill workers was 1.2 (0.43–3.2; four exposed cases).

Whittemore *et al.* (1989) conducted a case–control study on mycosis fungoides, a cutaneous T-cell lymphoma. They interviewed 174 people over 20 years of age in northern California, Los Angeles County and the Seattle–Puget Sound area (United States) in whom mycosis fungoides had been diagnosed in 1981–86 and identified at tumour registries and hospitals. The controls were 294 people selected by random-digit dialling who were also interviewed about potential risk factors for mycosis fungoides, and a lifetime employment history was taken. The response rate among the case subjects was 60% (23% were dead), and that among controls was 76%. Relatively fewer case subjects than controls reported previous employment in the paper and wood industry (relative risk, 0.5; $p = 0.02$). The risk was also reduced among people exposed to chromium and its salts, mercury and its salts, halogenated and aromatic hydrocarbons and uncured plastic. [The Working Group noted that employment in the wood and paper industry

was insufficiently focused to provide a reasonable proxy for exposure to wood dust; in addition, the response rate for the cases was low.]

Scherr *et al.* (1992) conducted a hospital-based case–control study on occupational exposures and risk for non-Hodgkin's lymphoma. Interviews were conducted with 303 residents of the Boston, Massachusetts (United States), metropolitan area (80% participation rate) with confirmed non-Hodgkin's lymphoma diagnosed in 1980–82, or with their next-of-kin, and with 303 population controls (72% participation rate) matched by age, sex, town and precinct of residence. The case patients were identified at nine hospitals and the controls from town resident lists. Interviews were completed with 202 patients, 101 proxies of patients and 303 controls, and job histories were obtained. The odds ratio for non-Hodgkin's lymphoma associated with exposure to particles (dust, sawdust and fibres) was 1.4 (95% CI, 0.9–1.8); that for employment in the paper and wood industry was 1.7 (0.7–4.2). [The Working Group noted that the categories 'particles' and 'paper and wood industry' were remote proxies for exposure to wood dust; furthermore, a high proportion of next-of-kin of patients were interviewed]

A population-based case–control study of 622 white men with non-Hodgkin's lymphoma diagnosed in 1980–83 and 1245 white male population controls without haematopoietic or lymphatic malignancies in Iowa and Minnesota, United States, was conducted to examine associations between occupation and risk for non-Hodgkin's lymphoma (Blair *et al.*, 1993). Case patients and controls who resided in the cities of St Paul, Duluth, Minneapolis and Rochester were excluded because agricultural exposures were the primary focus of the study. Case coverage was almost complete; interviews were conducted with 87% of the case subjects or their next-of-kin and with 77% of the controls. The interview covered sociodemographic characteristics, agricultural activities and exposures, exposures to chemicals in hobbies, residential history, medical history, familial history of cancer and occupational history. A job–exposure matrix was developed for job title–industry combinations and a number of exposures. Exposure to wood dust was associated with an odds ratio of 0.9 (95% CI, 0.7–1.2), adjusted for age, state, smoking, family history of malignant lymphoproliferative disease, agricultural exposure to pesticides, use of hair dyes and direct or surrogate responder. In a category of lower intensity of exposure to wood dust, the odds ratio was 0.9 (0.7–1.2). In the category of higher intensity, there were no cases and two controls.

(b) Hodgkin's disease

(i) Exposure to wood dust

In the study of Partanen *et al.* (1993), described on p. 146, four cases of Hodgkin's disease were notified. In comparison with 21 controls from the cohort individually matched to the cases, the unadjusted odds ratio for Hodgkin's lymphoma and exposure to wood dust, based on three exposed cases, was 2.1 (95% CI, 0.21–22).

(ii) Occupational group

Milham and Hesser (1967) reported an association between occupational exposure to wood and Hodgkin's disease in upstate New York, United States. They analysed the occupations of 1549 white men, aged 25 years or more, who had died of Hodgkin's disease during 1940–53 and 1957–64, and 1549 dead controls individually matched to the cases by age, sex, race (white

only), residence and date of death. 'Exposure to wood' was defined as notification of a wood-related occupation (the commonest were carpenter and cabinet-maker) on the death certificate. The analysis revealed 69 pairs in which the case was exposed and the control unexposed, and 30 pairs in which the case was unexposed and the control exposed, yielding an odds ratio of [2.3] ($p < 0.001$). No other occupational group showed a significant excess.

Petersen and Milham (1974) evaluated the risk for Hodgkin's disease in occupations related to woodworking in Washington State, United States. The study had three phases: (i) a case–control study of deaths from Hodgkin's disease in 1950–71, with controls consisting of all residual, nonaccidental and nonviolent deaths, individually matched to each case by year of death, age at death and county of residence (707 matched pairs), in which wood-related occupations were ascertained from death certificates; (ii) a study of dead cases of Hodgkin's disease and dead controls during 1965–70 (158 matched pairs), in which occupational histories were obtained from interviews with relatives; and (iii) a proportionate mortality study of deaths from Hodgkin's disease in 1950–71. In the case–control study based on death certificates, there were 56 discordant pairs in which the case was in a woodworker and 32 discordant pairs in which the control was a woodworker, yielding an odds ratio of [1.8] ($p < 0.05$). In the study based on interviews, the frequencies of discordant pairs were 23 and 10, respectively ([odds ratio, 2.3] $p < 0.05$). The proportionate mortality ratio in woodworkers was 1.6 (56 deaths from Hodgkin's disease observed; $p < 0.001$).

Abramson *et al.* (1978) conducted a case–control study of Hodgkin's disease in Israel. All cases histologically diagnosed among Jewish residents of Israel in 1960–72 were eligible, giving 527 patients (454 definite, 37 probable and 36 possible). Jewish controls were drawn from the national population register, individually matched to the cases by sex, birth year, country of birth, father's region of birth (for subjects born in Israel) and year of immigration. Interviews were conducted with patients or proxies; proxy information was obtained for 68% of cases and 28% of controls. The response rate was 96%, and suitable controls were interviewed for 473 cases. The interview yielded information on occupation. Separate comparisons were made for the main histological subtypes, nodular sclerosis and mixed cellularity. Work with wood or trees (predominantly carpentry) was associated with a relative risk of 1.1 ($p > 0.05$). The risk for nodular sclerosis subtype was 0.6, but that for mixed cellularity was 5.2 ($p = 0.0005$).

Greene *et al.* (1978) identified 167 deaths from Hodgkin's disease among white men in North Carolina, United States, in 1956–74, and two controls for each case, matched by sex, race, county of death and age and year of death. A risk ratio of 1.4 (95% CI, 0.8–2.3) was associated with occupational exposure to wood and paper and a risk of 4.2 (1.4–13) with carpentry and lumbering.

Fonte *et al.* (1982) reported on a case–control study in Italy on Hodgkin's disease diagnosed in 207 men and 180 women admitted to the university hospital of Pavia during 1972–79. The controls were 441 men and 330 women admitted to an internal medical unit in Pavia in 1977–79. The occupations appearing in medical records were classified. Nine case patients worked in the wood industry, resulting in a relative risk of 7.2 (95% CI, 2.3–22). [The Working Group noted that the methods used were not well described.]

Bernard *et al.* (1987) reported on risk factors for Hodgkin's disease in a case–control study in the United Kingdom. All cases identified between October 1979 and December 1984 in hospitals in Yorkshire were eligible for inclusion; only those histopathologically confirmed were accepted. The controls represented in-patients with a variety of nonmalignant conditions and were matched to the cases by health district, sex and age in a ratio of 2:1. Case patients and controls were interviewed about past medical history, drug use, family medical history, hobbies, occupation, smoking and alcohol consumption. The study comprised 297 interviewed patients, who represented 70% of all histologically confirmed cases. For both woodworkers and contact with wood dust, a nonsignificant risk ratio 'under 2.0' was reported (woodworkers: 16 cases, 35 controls; wood dust: 24 cases, 46 controls). [The Working Group noted that a large proportion of case patients could not be interviewed and the results for woodworkers and exposure to wood dust were stated only as 'under 2.0'.]

Brownson and Reif (1988) evaluated occupational risks for Hodgkin's disease, mainly in farming, by identifying cases and controls through the cancer registry in Missouri (United States). Hodgkin's disease (ICD 9: 201) was diagnosed in 475 white male Missouri residents over 20 years of age in 1984 and 1985. The 1425 controls represented other cancers, excluding those of the oral cavity, pharynx, oesophagus, larynx, lung, bladder and prostate, and were individually matched 3:1 to the cases by age. Usual occupation and industry, as obtained from the routine records of the registry, were coded by the codes of the 1980 United States census. The registry also provided data on the smoking habits of the subjects. Carpenters had an increased risk for Hodgkin's disease: odds ratio, 3.1; 95% CI, 1.0–9.8, adjusted for age and smoking. [The Working Group noted that the control group included certain cancers that are potentially etiologically related to exposure to wood dust, which would have biased the odds ratio towards the null.]

In the study of Persson *et al.* (1989), described on p. 150, 54 cases of Hodgkin's disease were identified. No excess risk for Hodgkin's disease was associated with carpentry or cabinet-making; the odds ratio, adjusted for age at diagnosis, sex and farming, was 0.2 [95% CI, 0.01–2.8]. The adjusted ratio for exposure to fresh wood, as defined by employment as sawmill worker, lumberjack or paper pulp worker, was 0.4 [0.1–1.5].

In the study of Persson *et al.* (1993), reported on p. 151, 31 cases of Hodgkin's disease were identified. The odds ratio for Hodgkin's disease associated with the job title 'carpenters and cabinet-makers' was 0.2 (one exposed case, 25 exposed controls). The odds ratio for Hodgkin's disease in subjects exposed to fresh wood, adjusted for age at diagnosis and occupational confounders, was 3.8 [95% CI, 0.9–17].

(c) Multiple myeloma

(i) Exposure to wood dust

A hospital-based case–control study of multiple myeloma was reported in the United Kingdom (Cuzik & De Stavola, 1988). The cases were identified at major referral centres in six areas of England and Wales between 1978 and 1984. Two controls were sought for each case and matched by age and sex: one from the same hospital as the case and one from the list of the general practitioner of the case patient. Interviews were conducted with 409 case subjects, 399

hospital controls and 260 general practitioner controls to obtain occupational histories and information on exposures to chemicals and radiation, diseases, immunizations, family history, chronic infections and defects in immune regulation. The results were given as percentages of employed or exposed cases and controls: 1.5% of the case patients and 2.5% of the hospital controls had been employed in the production of furniture or upholstery [crude odds ratio, 0.6; 95% CI, 0.2–1.7]; 2.8% of the case patients and 1.3% in the controls had been exposed to wood dust for 1–10 years [crude odds ratio, 2.2; 0.8–6.5]; and 3.0% of the cases and 4.3% of the controls had been exposed for more than 10 years [crude odds ratio, 0.7; 0.3–1.5].

In 1982, more than 77 000 American Cancer Society members enrolled over 1.2 million friends, neighbours and relatives in a prospective mortality study, which included the completion of an initial questionnaire on medical, occupational and lifestyle factors and exposure history. In a case–control study of multiple myeloma based on these data (Boffetta *et al.*, 1989), 282 people who had died during the first four years and for whom multiple myeloma was reported on the death certificate as the underlying or contributing cause of death were identified, after successful tracing of 98.5% of subjects and 84% coverage of death certificates. Four randomly selected controls were matched to the cases by sex, American Cancer Society division, year of birth and ethnic group, for a total of 1128. A further subdivision was made between incident cases ($n = 128$) and prevalent cases ($n = 154$) during the case ascertainment period, since a cancer detected before this period might have affected habits and occupations and the reporting of them. Self-reported exposure to wood dust was associated with an odds ratio of 1.2 (95% CI, 0.5–3.2; logistic model, with adjustment for age, sex, ethnic group, division of the American Cancer Society, education, history of diabetes, X-ray treatment, pesticide and herbicide exposure and farming) for incident cases.

A population-based case–control study (Heineman *et al.*, 1992) was carried out of the occupational exposures of 1098 Danish men in whom multiple myeloma was diagnosed in 1970–84 and recorded at the Danish Cancer Registry, and of 4169 male population controls matched on birth year who were alive at the time of diagnosis of the case. Histological confirmation was available for 92% of the cases. Job histories from 1964 on were abstracted from the records of the nationwide Supplementary Pension Fund. A job–exposure matrix was constructed for 47 substances. The age-adjusted odds ratios related to exposure to wood dust were 1.2 (95% CI, 0.7–2.1) for furniture maker as the most recent occupation, 1.1 (0.4–2.5) for sawmill and other woodwork, 1.0 (0.6–1.4) for wood and wood products, 0.7 (0.3–1.3) for lumber and 1.6 (0.7–4.0) for miscellaneous wood products. Employment for fewer than five years in the wood and wood product industry was associated with an age-adjusted odds ratio of 1.1 (0.6–1.9); in those employed for five years or more, it was 0.9 (0.4–1.8). The results for women were reported in another article (Pottern *et al.*, 1992). There were 1010 cases and 4040 matched controls. The industrial category 'wood/products' was associated with an age-adjusted odds ratio of 1.1 (95% CI, 0.3–3.4); the odds ratio for probable exposure to wood dust was 1.9 (0.4–8.1).

(ii) Occupational group

The risk for multiple myeloma among furniture workers was evaluated in a population-based case–control study in 20 counties of North Carolina, United States (Tollerud *et al.*, 1985).

Listings of deaths during 1956–80 showed that 301 men were recorded with multiple myeloma or another immunoproliferative neoplasm (ICD9: 203.0,1,8; 238.6). These men were matched with one to three male controls by race, county of usual residence, age at death and year of death, to give 858 controls. The principal industry of employment, as recorded in the death certificate, was analysed: furniture manufacture was associated with an odds ratio of 1.3 (p = 0.25) and other woodworking with an odds ratio of 1.1 (p = 0.69). For furniture workers born before 1905 and who died before the age of 65, the odds ratio was 5.4 (p = 0.05). The odds ratios were lower for other combinations of birth year, age at death and race; none reached statistical significance. The authors noted that no information was available on time or duration of employment or specific occupational activities or exposures, including potential confounders. Underreporting of occupation in older individuals was a further concern.

Potential risk factors for multiple myeloma (ICD1965: 203.99) were evaluated in a case–control study of 131 patients and 431 referents, all of whom were alive (Flodin *et al.*, 1987). The cases were identified from the registers of the cytological departments of three hospitals and the medical clinics of three further hospitals, all in central and south-eastern Sweden. They were diagnosed in 1973–83 and included patients who survived until 1981–83. About one-third of all incident cases in the catchment area were estimated to have been identified. Referents were a random sample from the population registers of the catchment area. A postal questionnaire sought information on potential risk factors; the response rate was 96% for cases and 80% for controls. At least one year of exposure to fresh wood (i.e. lumberjacks, paper pulp workers and sawmill workers), lagged by five years from the diagnosis of multiple myeloma, was associated with a crude rate ratio of 3.9 (95% CI 1.9–7.6; 17 cases). Another crude rate ratio was, however, presented for the same association: 2.6 [no CI given]. The rate ratio for exposure to fresh wood, adjusted for age, was 3.2 (1.5–6.5); after adjustment for age, exposure to exhaust fumes, creosote, concrete and brickwork, sulfonylurea, γ-radiation, ex-smoking and farming, the rate ratio (men only) was 2.6 (1.1–5.7). Working with dried timber was not associated with a significant excess risk.

In the study of Reif *et al.* (1989), in New Zealand, described on p. 151, the number of eligible cases of multiple myeloma (ICD: 203) was 295. The age-adjusted odds ratio associated with forestry and logging was 0.53 (95% CI, 0.08–3.7).

(d) Leukaemia

(i) Exposure to wood dust

In the study of Partanen *et al.* (1993) reported on p. 150, 12 cases of leukaemia were diagnosed, and 79 controls from the cohort were individually matched to the cases. Exposure to wood dust was not associated with an increased risk (crude odds ratio, 0.56; 95% CI, 0.2–2.2).

(ii) Occupational group

In a short communication, Burkart (1982) reported an excess risk for leukaemia among long-term workers in sawmills. Male cases (ICD9 clinically modified: 204–208) and noncancer controls were identified in four hospitals in Oregon, United States, during 1980 and administered an occupational questionnaire. With a 90% response rate, 26 leukaemia cases and 836 controls were evaluated for exposure in sawmills. The age-adjusted summary relative risk was

1.1 for < 10 years of exposure and 3.2 for > 10 years of exposure, 'with a Mantel–Haenszel summary χ^2 for dose–response significant at $p = 0.017$.' Industrial hygiene surveys in the plants indicated use of chlorophenols.

Oleske *et al.* (1985) reported on a case–control study of hairy-cell leukaemia, a rare, usually chronic form of leukaemia. In 1975–81, 53 patients with this cancer who were residents of Illinois and northern Indiana, United States, were identified at the Hairy Cell Tumor Registry and Treatment Center at the University of Chicago and through inquiries to 1100 haematologists, pathologists and medical oncologists. Interview responses were obtained from 36 patients and nine proxies. Three neighbourhood controls were matched to each case by age, sex and race. In the process of identifying eligible controls, 19% of those eligible refused interviews, so that 134 controls were interviewed. Working for a minimum of 20 h per week during at least six months in woodwork was associated in men with an odds ratio of 4.0 (95% CI, 0.90–18), after control for age, sex and race.

Pearce *et al.* (1986) reported on leukaemia among New Zealand agricultural workers. The cases were those classified as ICD: 204-208 and registered at the New Zealand Cancer Registry in 1979–83 among 546 men who were aged 20 years or more at registration. Four controls were matched to each case by age and year of registration; those with malignant lymphoma, multiple myeloma or soft-tissue sarcoma were excluded. The occupation of carpenter, as recorded on the cancer registration form (current or most recent job title), was associated with an odds ratio of 1.5 (95% CI, 1.0–2.3).

Potential risk factors for chronic lymphatic leukaemia were evaluated in a case–control study of 111 cases (ICD[1965]: 204.15) and 431 controls, all of whom were alive (Flodin *et al.*, 1988). Cases were identified from the registers of the cytological departments of three hospitals and the medical clinics of two further hospitals, all in central and south-eastern Sweden. Most of the cases were diagnosed in 1975–84, but some as early as 1964, and included those in which the patient survived until 1981–83. Controls were a random sample from the population registers of the catchment area. A postal questionnaire sought information on potential risk factors, with a response rate of 91% for case patients and 85% for controls (non-responders were replaced by other controls). At least one year of exposure to fresh wood (i.e. lumberjacks, paper pulp workers and sawmill workers), lagged by five years from the diagnosis of chronic lymphatic leukaemia, was associated with a crude rate ratio of 3.2 (95% CI, 1.5–6.6; 13 exposed cases). The risk ratio for exposure to fresh wood (men only), adjusted for age, solvents, farming, exhausts and contact with horses, was 2.4 (1.0–5.0). Working with dried timber was not associated with a significant excess risk.

In the study of Reif *et al.* (1989), reported on p. 151, there were 534 eligible cases of leukaemia (ICD: 204–208). The age-adjusted odds ratio for all leukaemias associated with forestry and logging was 0.96 (95% CI, 0.36–2.6; four exposed cases); that for sawmill workers was 0.52 (0.13–2.1; two exposed cases).

Loomis and Savitz (1991) reported on a case–control study of occupation and leukaemia (ICD9: 204–208) among 5147 men in 16 states of the United States on the basis of information from death certificates. The controls were 51 470 men who had died of other causes, excluding brain cancer, during 1985–87. The results were given for usual occupation or industry, as

abstracted from the death certificates. Woodworking was associated with an age- and race-adjusted odds ratio of 0.9 (95% CI, 0.7–1.0). The odds ratio for occupations in wood products industries was 0.7 (0.5–0.9) and that for carpenters was 0.9 (0.7–1.1).

Fincham *et al.* (1993) reported on a case–control study of cancers at several sites, using data from the Alberta Cancer Registry, Canada. On the basis of undocumented numbers of cases of leukaemia and controls with all other cancers, a crude odds ratio of 1.8 (95% CI, 1.2–2.8; 23 exposed cases) was reported for exposure to wood dust. [The Working Group noted the lack of detail in the description of the study and the crudeness of the statistical analysis.]

Studies on lymphohaematopoietic cancers are summarized in Table 29.

2.4.4 Cancers of the digestive tract

(a) Exposure to wood dust

Spiegelman and Wegman (1985) examined the relationship between occupational risk factorsand colon and rectal cancer in a case–control study based on the Third National Cancer Survey, in which data were collected on all incident cancers occurring in 1969–71 in seven metropolitan areas and two states of the United States (a region containing 10.3% of the national population). A 10% random sample was interviewed to collect information on primary and secondary occupation and industry and duration of time in these jobs. The cases were colon or rectal cancers in 343 men and 208 women. The controls were 626 men and 1235 women with other cancers classified by the authors as not commonly associated with occupational exposures (cancers of the soft tissue, eye, brain, endocrine glands, breast, male and female reproductive tracts and lymphomas). Occupational exposure to wood was estimated from a job–exposure matrix based on the National Occupational Hazards Survey. For colon and rectal cancer combined, the odds ratios, adjusted for age, race, marital status, income, weight and nutritional scores, were 1.1 ($p = 0.69$) for men and 1.5 ($p = 0.04$) for women. For colon cancer alone, the odds ratios were 1.3 ($p = 0.24$) for men and 1.5 ($p = 0.07$) for women.

In the study of Siemiatycki (1991), described on p. 140, 251 cases of stomach cancer were identified. The odds ratios were 1.4 [95% CI, 1.0–1.9] for any exposure and 1.1 [0.7–1.7] for substantial exposure. For the 497 cases of colon cancer, the odds ratios were 1.0 [0.8–1.3] for any exposure and 0.9 [0.7–1.2] for substantial exposure; for the 257 cases of rectal cancer, the odds ratios were 1.0 [0.7–1.4] for any exposure and 1.3 [0.8–2.0] for substantial exposure.

Peters *et al.* (1989) performed a case–control study of colorectal cancer among 147 white men in Los Angeles county (United States) in whom colorectal adenocarcinoma was first diagnosed in 1974–82 when they were 25–44 years of age. A matched series of 147 neighbourhood controls of the same sex, race, date of birth and neighbourhood of residence were selected. Occupational and exposure histories were collected by interview. The odds ratio for exposure to wood dust was 3.6 (95% CI, 1.2–11) after adjustment for age and education. The results by sub-site were 2.1 (0.5–8.5) for the right side of the colon, 1.5 (0.3–6.6) for the transverse and descending colon, 3.6 (0.6–21) for the sigmoid colon and 9.4 (2.0–45) for the rectum.

Table 29. Case–control studies on lymphatic and haematopoietic cancers

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Non-Hodgkin's lymphoma								
(i) Exposure to wood dust								
Siemiatycki *et al.* (1986); Siemiatycki (1991)	Canada	M	117/1563	Interview	Wood dust, substantial, >15 years' exposure	0.5	0.2–0.9	Adjusted for a number of confounders
			215/2357		Wood dust, substantial (update)	1.0	[0.7–1.5]	
Partanen *et al.* (1993)	Finland	M	8/52	Company records	Wood dust	2.1	0.2–20	Nested study; matched by age and survival; low power
(ii) Occupational group								
Cartwright *et al.* (1988)	United Kingdom	MF	437/724	Interview	Wood dust > 3 months	1.5	1.0-2.1	Incomplete documentation. Selection and information biases possible
Schumacher & Delzell (1988)	USA	M	501/569	Death certificate	Furniture industry (usual job):			
					Whites	0.7	0.4–1.4	
					Blacks	1.9	0.1–30	
Franceschi *et al.* (1989)	Italy	MF	208/401	Interview	Wood and furniture worker	0.7	0.4–1.2	
Persson *et al.* (1989)	Sweden	MF	106/275	Postal questionnaire	Carpenter, cabinet-maker > 1 year; 5–45 years' latency	2.8	[0.9–8.5]	Adjusted for age, sex, farming
					Fresh wood	1.0	[0.3–3.5]	
Reif *et al.* (1989)	New Zealand	M	535/19 369	Cancer register	Sawmill worker	1.2	0.4–3.2	Four exposed cases
Whittemore *et al.* (1989)	USA	MF (Cases: mycosis fungoides)	174/294	Interview	Employment in paper and wood industry	0.5	$p = 0.02$	Paper and wood a remote proxy for exposure to wood dust. Low response in cases

Table 29 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Non-Hodgkin's lymphoma (contd)								
Occupational group (contd)								
Scherr *et al.* (1992)	USA	MF	303/303	Interview	Employment in paper and wood industry	1.7	0.7–4.2	Paper and wood a remote proxy for wood dust
Blair *et al.* (1993)	USA	M	622/1245	Interview	Wood dust	0.9	0.7–1.2	Adjusted for age, state, smoking, family cancers, pesticides, hair dyes, responder
Persson *et al.* (1993)	Sweden	M	93/204	Postal questionnaire	Fresh wood: lumberjack	6.0	[0.8–44]	Adjusted for age, occupational confounders
Hodgkin's disease								
(i) Exposure to wood dust								
Partanen *et al.* (1993)	Finland	M	4/21	Company records	Wood dust	2.1	0.2–22	Nested study; matched by age and survival; low power
(ii) Occupational group								
Milham & Hesser (1967)	USA	M	1549/1549	Death certificate	Exposure to wood		$p < 0.001$	Discordant pairs 69/30
Petersen & Milham (1974)	USA	M	707/707	Death certificate	Woodworker	[1.8]	$p < 0.05$	Discordant pairs 56/32
Petersen & Milham (1974)	USA	M	158/158	Interview	Woodworker	[2.3]	$p < 0.05$	Discordant pairs 23/10
Abramson *et al.* (1978)	Israel	MF	506/473	Interview	Work with wood/trees	1.1 5.2	$p > 0.05$ $p < 0.0005$	All Hodgkin's disease Mixed cellularity subtype
Greene *et al.* (1978)	USA	M	167/334	Death certificate	Carpentry and lumbering	4.2	1.4–13	Matched by sex , race, county, age and year of death

Table 29 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or p	Comments
Hodgkin's disease (contd)								
Occupational group (contd)								
Fonte *et al.* (1982)	Italy	MF	387/771	Clinic charts	Wood industry	7.2	2.3–22	Methods not well described
Bernard *et al.* (1987)	United Kingdom	MF	297/489	Interview	Wood dust	'Under 2.0'	$p < 0.05$	Large non-response of cases; incomplete documentation of results for wood dust
Brownson & Reif (1988)	USA	M	475/1425	Cancer register	Carpenter	3.1	1.0–9.8	Adjusted for age and smoking
Persson *et al.* (1989)	Sweden	MF	54/275	Postal questionnaire	Fresh wood	0.4	[0.1–1.5]	Adjusted for age, sex and farming
Persson *et al.* (1993)	Sweden	M	31/204	Postal questionnaire	Fresh wood	3.8	[0.9–17]	Adjusted for age, occupational confounders
Multiple myeloma								
(i) Exposure to wood dust								
Cuzik & De Stavola (1988)	United Kingdom	MF	399/399	Interview	Wood dust > 10 years	[0.7]	[0.3–1.5]	Crude analysis
Boffetta *et al.* (1989)	USA	MF	128/512	Questionnaire	Wood dust (self-reported)	1.2	0.5–3.2	Adjusted for age, sex, ethnic group, residence and farming
Heineman *et al.* (1992)	Denmark	M	1098/4169	Pension fund records	Probable exposure to wood dust	0.8	0.6–1.2	
Pottern *et al.* (1992)	Denmark	F	1010/4040	Pension fund records	Probable exposure to wood dust	1.9	0.4–8.1	

Table 29 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Multiple myeloma (contd)								
(ii) Occupational group								
Tollerud *et al.* (1985)	USA	M	301/858	Death certificate	Furniture manufacture Furniture manufacture, born < 1905 and died < 65 years of age	1.3 5.4	$p = 0.25$ $p = 0.05$	
Flodin *et al.* (1987)	Sweden	MF	131/431	Questionnaire	Fresh wood > 1 year; lagged by 5 years (men only)	2.6	1.1–5.7	Adjusted for a number of potential confounders. Possible selection of cases
Reif *et al.* (1989)	New Zealand	M	295/19 609	Cancer register	Forestry worker and logger	0.5	0.1–3.7	One exposed case
Leukaemia								
(i) Exposure to wood dust								
Partanen *et al.* (1993)	Finland	M	12/79	Company records	Wood dust	0.6 (crude)	0.2–2.2	Nested study; matched by age and survival; low power
(ii) Occupational group								
Burkart (1982)	USA	M	26/836	Questionnaire	Sawmill exposure > 10 years	3.2	$p = 0.017$ for dose–response	Adjusted for age
Oleske *et al.* (1985)	USA	M	35/104	Interview	Woodworking > 20 h/week, > 6 months	4.0	0.9–18	Hairy-cell leukaemia
Pearce *et al.* (1986)	New Zealand	M	546/2184	Cancer register	Carpenter	1.5	1.0–2.3	

Table 29 (contd)

Reference	Country	Sex	Cases/ controls	Source of information on exposure	Exposure to which relative risk applies	OR/RR	95% CI or *p*	Comments
Leukaemia (contd)								
Occupational group (contd)								
Flodin *et al.* (1988)	Sweden	M	71/200	Postal questionnaire	Fresh wood	2.4	1.0–5.0	Adjusted for age, exposure to solvents, horses, farming, exhausts. Possible selection of cases
Reif *et al.* (1989)	New Zealand	M	534/19 370	Cancer register	Sawmill worker	0.5	0.1–2.1	Two exposed cases
Loomis & Savitz (1991)	USA	M	5147/51 470	Death certificates	Woodworker	0.9	0.7–1.0	Adjusted for age and race
Fincham *et al.* (1993)	Canada	NR	NR	Cancer register	Wood dust	1.8 (crude)	1.2–2.8	Incomplete documentation

OR, odds ratio; RR, relative risk; CI, confidence interval; M, male; F, female; NR, not reported

(b) Occupational group

Brownson *et al.* (1989) conducted a cancer registry-based case–control study of colon cancer involving white males with histologically confirmed colon cancer diagnosed between 1984 and 1987 who were reported to the Missouri Cancer Registry in the United States. Five controls for each case were randomly selected from among other white male cancer patients reported to the Registry. Data on occupation and industry from registry records (originally abstracted from medical records) were available for 1993 cases and 9965 controls. The odds ratio for carpenters was 0.9 (95% CI, 0.6–1.4) after adjustment for age. No other results related to exposure to wood were presented.

Fredriksson *et al.* (1989) reported the results of a case–control study of all people living in the region of Umeå aged 30–75 in whom adenocarcinoma of the colon had been diagnosed between 1980 and 1983 and reported to the Swedish Cancer Registry, who were alive at the time of data collection. For each case, two controls of similar age, sex and residence were identified from the National Population Register. A postal questionnaire, which included an occupational history, was completed by 312 case patients (156 men) and 623 controls (306 men). Decreased risks were observed for men who were previously employed as lumberers (odds ratio, 0.7; 95% CI, 0.4–1.0), pulp workers (0.7; 0.3–1.6) and sawmill workers (0.5; 0.3–0.9) after adjustment for age and physical activity.

In the study of Kawachi *et al.* (1989), reported on p. 115, 1014 cases of stomach cancer, 2043 of colon cancer, 1376 of rectal cancer, 184 of liver cancer, 120 of gall-bladder cancer and 571 of pancreatic cancer were available for analysis. The odds ratios for employment as a woodworker were 1.2 (95% CI, 0.9–1.6) for stomach cancer, 0.7 (0.5–0.9) for colon cancer and 1.1 (0.8–1.4) for rectal cancer.

In a further analysis, Dockerty *et al.* (1991) examined the risk for stomach cancer in a cancer registry-based case–control study in New Zealand. The study base and methods were the same as those described by Kawachi *et al.* (1989). There were 1016 men with stomach cancer available for analysis. The 19 042 controls consisted of registrants with cancer at all other sites. The only information available on exposure was the current or most recent occupation in the register. After adjustment for age, socioeconomic level, ethnic group and smoking, excess risks were observed for foresters and loggers (odds ratio, 1.8; 95% CI, 1.0–3.3) and cabinet-makers (1.4; 0.7–2.8), while decreased risks were observed for wood preparation and pulp and paper workers (0.8; 0.4–1.7) and carpenters (0.8; 0.5–1.2).

González *et al.* (1991) examined the association between occupation and gastric cancer in Spain. The cases were gastric adenocarcinomas diagnosed between 1987 and 1989 at 15 hospitals in Barcelona province, Zaragoza city, Soria province, Lugo province and the north of La Coruña province. Controls, matched on age, sex and area of residence, were selected from among patients at the same hospitals, excluding those with respiratory or gastric cancer, chronic respiratory disease, diabetes or chronic diseases that require a special therapeutic diet. Occupational histories were collected for 354 cases (235 men) and 354 controls by interviewers who were unaware of the case or control status of the patients. Odds ratios were calculated by logistic regression in order to adjust for socioeconomic status and diet. Relative risks were

calculated for people ever employed in forestry (odds ratio, 1.0; 95% CI, 0.3–3.6), wood and paper production (0.5; 0.2–1.7) and furniture and wood manufacture (1.8; 0.5–6.9). The odds ratio for employment in any job with exposure to wood dust was 1.0 (0.4–2.3).

Arbman *et al.* (1993) performed a case–control study of colon and rectal cancer in Sweden, among patients under the age of 75 with histologically confirmed adenocarcinoma of the colon or rectum, who were identified in hospitals in the county of Östergötland in south-eastern Sweden. Two control groups were selected: hospital patients with hernias and anal disorders and a random sample of the general population. A questionnaire, which included information on occupational history, was completed by 98 patients (51 men) with colon cancer, 79 (48 men) with rectal cancer, 371 (309 men) hospital controls and 430 (203 men) general population controls. The odds ratios for men employed as carpenters were 0.5 [95% CI, 0.1–2.7] for colon cancer and 0.9 [0.3–3.2] for rectal cancer. The odds ratios for men employed as forestry workers were 0.9 [0.4–2.0] for colon cancer and 0.5 [0.2–1.5] for rectal cancer. The odds ratios for men employed as sawmill workers were 1.2 [0.4–3.3] for colon cancer and 0.4 [0.1–1.9] for rectal cancer. The prevalence of exposure was very low among women.

Studies on cancers of the digestive tract are summarized in Table 30.