Occupational Cancer Risks in Commercial Painters

A review prepared for the Industrial Injuries Advisory Council (IIAC)

Professor Tom Sorahan

Dr Hilary Cross

Dr Steven Sadhra

Professor Jon Ayres

Institute of Occupational and Environmental Medicine

University of Birmingham

Edgbaston

B'ham B15 2TT

1st April, 2010

Summary

There is an extensive epidemiological literature on cancer risks in commercial painters. Unfortunately, it is dominated by case-control studies. There is a well understood potential for bias in such studies, but this potential does not appear to have dampened the enthusiasm of their advocates, neither researchers nor sponsors. Nevertheless, taken at face value the case-control literature suggests that elevated cancer risks are shown in painters for bladder cancer and lung cancer. Convincing evidence of effects in humans usually requires the demonstration in cohort studies of cancer risks varying, at least approximately with exposure (or a surrogate of exposure). Unfortunately, the data assembled for the cohort studies has been so limited that such analyses have not, in the main, been attempted. The overall cohort findings suggest, however, that painters do not suffer from discernible excess risks for leukaemia but that they may well suffer from occupational cancer risks for lung cancer and bladder cancer. It is not possible to identify a group, either by type of painting or by duration of painting that suffers a doubling of risk.

CONTENTS

Tables

Glossary

SMR	standardised registration ratio
SIR	standardised incidence ratio
Obs	observed
Exp	expected
95% CI	95% confidence interval
RR	relative risk or rate ratio
OR	odds ratio

1. Introduction

There are many specialities within the overall occupational category of commercial painters. House painters and painters of commercial premises would tend to use the sort of products (e.g. oil-based gloss paints, water-based emulsions, primers, stabilising solutions, turpentine, white spirits, wallpaper pastes, methylene chloride and other paint strippers) used by the general population for do-it-yourself work. Over the last fifty years, the main solvents used to formulate paints have included toluene, xylene, ketones, alcohols, esters and glycol ethers. Titanium oxide, chromium compounds, iron compounds and carbon black are still used a pigments; lead pigments were withdrawn some years ago. The burning of old paint surfaces could, however, still lead to fumes containing lead compounds and other chemicals no longer found in commercial paints. Overall exposures for house painters, in terms of total airborne particulates or total vapour, is considered to be low compared to many other occupations. The painting of commercial premises, however, may well involve the application of specialised spray paints (polyurethane paints containing di-isocyanates) not commonly used by the general public, as would the painting of vehicles. It is quite possible, therefore, that risks identified in one group of commercial painters will not be present in another.

This review considers the epidemiological literature relating to cohorts (and accompanying nested case-control studies), linkage studies, and population-based case-control studies. The latter are well-known to be fraught with problems relating to bias, and lesser weight is given to then, though they are included for the sake of completeness. We intend to follow the advice of Doll (1984) in establishing occupational carcinogenicity, namely:-

A positive association between exposure and disease in groups of individuals with known exposures that

a) is not explicable by bias in recording or detection, confounding, or chance,

b) varies approximately with dose and time after exposure, and

c) is observed repeatedly in different circumstances.

Population-based case-control studies do not fit into the above scheme because they are concerned with opinions or recollections about exposures and not with "known exposures". These recollections and opinions can be easily contaminated by case/control status, such that cases tend to report more exposures than controls either by cases over-reporting exposures or by controls under-reporting exposures. Furthermore, these types of studies rely on the participation of volunteers, so that typically we have a large percentage of cases and controls with unknown exposures.

Record linkage studies involve the combining of occupational data from one source with follow-up data from another source. The source of occupational data might involve the identification of a cross-sectional census cohort from a National Census; follow-up data is then obtained by linkage with mortality or cancer registers. The arrangements for the collection of follow-up data may be little different from the traditional cohort study, and we will consider these studies alongside the more traditional cohort studies. The limitations of the record linkage study are related to the typical lack of information on work and exposure history, and a reliance on self-reported occupational titles.

Studies of routinely collected data include analyses of occupation as recorded in sets of death certificates or sets of cancer registrations. The studies typically suffer from a large number of problems: a large percentage of deaths or cancers may have no occupation recorded, a single occupation only is available and the selection of a single job for a person who has had many jobs may be arbitrary, the occupation is selected after the cancer has been diagnosed, and for studies of death certificates the occupation is selected by a family member. Population based-control studies and studies of routinely collected data are useful for identifying important hypotheses. These hypotheses should then be tested and refined in cohort studies.

The ideal, yet still practical, study is a large entry cohort of all subjects first employed in a given industry in a specified time period, with full work histories for employment in that industry, with a long period of follow-up, and with reliable exposures estimates. We will be giving most weight to the studies that get closest to this design, i.e. studies that have some prospect of satisfying the Doll criteria described above. We will also be giving particular attention in these cohort studies to any sub-groups of painters, specified by type of industry, by type of work, or by cumulative exposure, for whom it would be reasonable to posit there is a doubling of risk or more.

This review has been conducted at the request of the Industrial Injuries Advisory Council (IIAC) in order to assist IIAC in advising the government on the prescription of industrial diseases. The review will aim to address the following issues:

(i) Do published epidemiological data indicate a significantly increased risk of any specific form of cancer in commercial painters?

(ii) If so, is the risk of the cancer more than doubled compared to the general population?

(iii) Can any such doubling of risk be connected to an exposure specifically associated with employment as a painter, any defined exposure duration or level, and any defined timeframe?

(iv) If risks appear to be increased, are the associations independent of confounding factors?

(v) How would such exposures compare with those occurring among British commercial painters?

(vi) Consideration of biological plausibility of any association between a type of cancer and a specific exposure.

Matched case-control studies here refer to studies in which each case is individually matched to one or more controls. For such studies matched analyses should have been carried out that maintain the individual matching (eg conditional logistic regression). Unmatched case-control studies here refer to frequency matched case control studies in which a group of cases (typically specified by age and sex) are matched with a group of controls (specified in the same way) or to studies in which a control group is selected without regard to any distribution of cases. Both types of unmatched study should have been analyses by unconditional methods, in which potential confounding effects are adjusted by stratification or modelling. Some fairly arbitrary practical decisions had to be taken to select specific findings for any meta-analyses. Standardised mortality ratios (SMRs) and standardised incidence ratios

(SIRs) were combined to provide overall estimates of risk, and were shown to a baseline of unity rather than to a baseline of 100. For studies that provided both measures, the SIR was selected. For case-control studies that provided a number of relative risks (odds ratios) with different adjustments, those with the most adjustment were selected. All attempts were made to make sure that no data were entered twice into any meta-analysis, either from multiple publications or from sub-group analysis. In addition, for those studies that quoted a lower 95% confidence interval of 0.0, a more appropriate recalculation was made using the following formula:

LCL= RR*RR/UCL

where LCL is the revised lower confidence interval,

UCL is the original upper confidence interval, and

RR is the relative risk.

For those studies that only quoted 90% confidence intervals, 95% confidence intervals were calculated using the following formula:

95% CI = exp[ln(RR) +/- ((ln(UCL90)-ln(RR)) * 1.960 /1.645)]

where UCL90is the upper 90% confidence interval, and

RR is the relative risk.

1.1 Literature search

Literature searches were conducted through the University of Birmingham e-library facilities using the EBSCO host interface with advanced search screen. MEDLINE and CINAHL were selected as the most appropriate databases. The following search terms were used: paint* [TX] *and* occupational cancer [TX] *or* paint* [TX] *and* bladder cancer [TX] *or* paint* [TX] *and* lung cancer [TX] *or* occupation [TX] *and* bladder cancer [TX] *or* occupation [TX] *and* lung cancer [TX]. Titles and abstracts of all articles appearing in search results were examined for relevance to the review. Articles reporting epidemiology studies (cohort, record linkage or case-control) which presented findings for commercial painters and/or paint manufacturers were obtained in full for detailed examination. Reference lists of all selected papers were also reviewed, as were those of relevant IARC monographs and other reviews.

2. Epidemiological studies of cancer risks in painters and paint manufacturers

2.1 Cohort studies and nested case-control studies

2.1.1Painters

Englund, 1980; Engholm and Englund, 1982

Englund (1980) and Engholm and Englund (1982) identified a cohort of 30,580 male members of the Swedish painters' union in 1966 and analysed mortality for the period 1966-74 and cancer incidence for the period 1966-71. Deaths and cancer registrations were obtained by matching with national registers; the loss to follow-up was only 1%. All causes mortality was close to expectation among painters (Obs 2740, SMR 1.02, 95% CI 98 to 106), as was overall cancer incidence (Obs 647, SIR 1.09, 95% CI 101 to 118). Excess cancer morbidity risks were shown for cancer of the oesophagus (Obs 17, SIR 2.15, 95% CI 1.24 to 3.40), cancer of the liver and bile ducts (Obs 12, SIR 2.00, 95% CI 1.03 to 3.49), lung cancer (Obs 81, SIR 1.28, 95%

CI 1.03 to 1.59), cancer of the larynx (Obs 14, SIR 1.77, 95% CI 0.97 to 2.97), and for lymphatic leukaemia (Obs 13, SIR 1.73, 95% CI 0.92 to 2.96). Information on smoking habits was not available. In a sister study based on population-based registries, about 38,000 painters in the 1960 census were linked to the national cancer registry, 1960-73. A significant excess was shown for cancer of the oesophagus (Obs 38, SIR 1.48, 95% CI 108 to 203). There was also a two-fold excess of pleural tumours based on six cases.

Whorton et al, 1983

Whorton et al. (1983) followed up a cohort of 6,424 union members (including 2,197 painters) residing in the San Francisco/Oakland Standard Metropolitan Statistical Area. Six occupations were represented: asbestos workers, bakers, painters, plasterers, plumbers and roofers. The cohort was identified from union membership records in 1976 and 1977. The vital status of about 15% of the cohort was unknown at the end of follow-up; these workers were assumed to be alive. Incident cases of cancer were identified by computer linkage to the California Tumour Registry, and the registry's age-, sex- and year-specific incidence rates were used to calculate expected numbers of cancer cases. A significantly increased incidence of lung cancer was found in painters (Obs 15, SIR 1.99, 95% CI 1.12 to 3.30). Non-significant excesses were shown for leukaemia (Obs 3, SIR 2.15, 95% CI 0.26 to 7.76) and for cancer of the bladder (Obs 3, SIR 1.31, 95% CI 0.27 to 3.81). Information on smoking habits was not available.

Gubéran et al, 1989

Mortality and cancer incidence in painters was investigated in Switzerland in a record-linkage study by Gubéran et al (1989). A cohort of 1916 painters was identified from the 1970 census conducted in Geneva, Switzerland and followed up from 1971 to 1984. The cohort comprised building painters (1338), plaster painters (196), car painters (195), other spray painters (68), and sign and other painters (119). A total of 230 foreign nationals (12% of the cohort) were lost to follow-up. Expected numbers of deaths and incident cancers were based on regional rates. The cohort of painters had significantly increased mortality for all causes (Obs 254, SMR 1.16, 95% CI 1.03 to 1.31), all malignant neoplasms (Obs 96, SMR 1.27; 95% CI 1.04 to 1.55), and lung cancer (Obs 40, SMR 1.74, 95% CI 1.31 to 2.26). The excess for bladder cancer failed to reach formal levels of statistical significance (Obs 7, SMR 2.06, 95% CI 0.83 to 4.24). There was a marked contrast between bladder cancer findings for building painters (Obs 6, SMR 2.50, 95% CI 92 to 546) and all other painters combined (Obs 1, SMR 0.71, 95% CI 2 to 395). Information on smoking habits was not available.

Significant excesses in cancer incidence were observed for all malignant neoplasms (Obs 159, SIR 1.20; 95% CI 1.03 to 1.41), lung cancer (Obs 40, SIR 1.47, 95% CI 1.08 to 1.99), bladder cancer (Obs 13, SIR 1.71, 95% CI 0.91 to 2.92), and testicular cancer (Obs 5, SIR 3.13, 95% CI 1.01 to 7.33). The study provided no information on cancer risks in relation to decade of first employment, cumulative exposure or duration of employment. Comparisons were also made, however, with a cohort of electricians, obtained from the Census. These comparisons supported the hypothesis that occupational lung and bladder cancers may have been present in the painter cohort.

Alexander et al, 1996

Lung cancer risks in a cohort study of 2,426 chromate-exposed aerospace workers were investigated by Alexander et al (1996). Cohort subjects were primarily employed in aircraft manufacturing and included spray painters, decorative painters, maintenance painters, paint mixers and attendants, sanders, polishers and chrome-platers. All subjects were exposed to chromates. The cohort comprised workers with ≥6 months employment in a "chromate-exposed" job during 1974-1994. Expected numbers of lung cancer cases rates were based on incidence rates in the local population. There was no overall excess of lung cancer (Obs 15, SIR 0.77; 95% CI 0.4 to 1.3). Individual estimates of cumulative chromate exposure were based on work histories and exposure measurements taken during 1974-1994. Estimates of solvent exposure were not available. Lung cancer risks were found to be inversely related to cumulative chromate exposure. Similarly, duration of employment in painting jobs was found to be inversely related to lung cancer risks in this study. The study had no information on smoking habits. The study provided no evidence that aerospace workers using chromate-based paints were subject to discernible levels of excess lung cancer risks. The study had no information on smoking habits.

Van Loon et al, 1997

Van Loon et al (1997) organised a prospective cohort study in the Netherlands on lung cancer risks in relation to diet, lifestyle and job history. In 1986, 340,439 men and women aged 55-69 years were selected from the general population and invited to complete a self-administered questionnaire. The response rate was very poor at 36%. Subjects who had already been diagnosed with cancer were excluded from the cohort, and the final cohort of 58,279 males with questionnaire data were followed-up for a short period only (1986-1990). A total of 677 cases of lung cancer were identified of which 524 cases had complete job histories. The exposures of the cases were not compared with the exposures of the rest of the cohort but rather with a sample of 1630 study subjects (so-called case-cohort method). An industrial hygienist reviewed the self-reported work histories attaching numerical weights to concepts such as ‘possible exposure’, ‘probable exposure’ and ‘nearly certain exposure’. These weights were then multiplied by durations of employment to produce what the authors call a “cumulative probability of exposure”. A significant trend was shown between lung cancer risk and ‘lifetime exposure index’ to paint dust (no exposure: n = 487, RR = 1.0; low exposure: n = 4, RR = 1.46, 95% CI 0.43 to 4.97; high exposure: n= 14, RR = 3.60, 95% CI 1.48 to 8.74). Exposure to solvents was not considered. We attach little importance to these findings given the poor response rate, the use of self-reported data, and the somewhat limited exposure assessments.

Steenland and Palu, 1999; Stockwell & Matanoski, 1985

Steenland and Palu (1999) reported on mortality for the period 1975-1994 in a cohort of 42,170 painters and 14,316 other workers (non-painters). The cohort had been first identified by Matanoski et al (1986); the latter authors reported on mortality for the first four years of follow-up, 1975-79. This earlier report also includes more information on cohort enumeration. Study subjects (painters and non-painters) were, or had been, members of the International Brotherhood of Painters and Allied Trades

(IBPAT), and identifying particulars and limited work history details had been abstracted from union records. All study subjects were males, had been born prior to 1940, had at least one year of union membership, and had been members of the union (active or retired) sometime in the period 1975-79 in four US states (California, Missouri, New York, Texas). Even though many sources were used for tracing deaths in the cohort (Internal Revenue Service, the Health Care Finance Administration, the Post Office, the Social Security Administration Death Tapes, the National Death Index) there was a relative large percentage of subjects with unknown vital status (6.6% of painters, 7.4% non-painters). It seems possible that the relatively incomplete tracing was due to the absence of full forenames in the Union records. Furthermore, cause of death was unknown (i.e the death certificate could not be located) for 5.1% of the identified deaths. The study included active and retired union members; the range of year of birth for the painters under study was said to be 1865-1941. The lower limit here does not seem plausible given that a painter born in 1865 would be 110 years old at the start of follow-up in 1975. In a similar vein, the range for year of union entry in painters was 1900-1979; the lower limit was 75 years before the start of follow-up. It seems clear, however, that the cohort includes many painters from the early decades of the twentieth century. Expected numbers of deaths for the period 1975-1994 were based on mortality rates in white US males. Information on smoking habits was not available.

In painters, mortality from all causes of death was close to expectation (Obs 18,259, SMR 1.04). Elevated SMRs were shown for a number of cancers including stomach cancer (Obs 197, SMR 1.39, 95% CI 1.20 to 1.59), lung cancer (Obs 1,746, SMR 1.23, 95% CI 1.17 to 1.29), and bladder cancer (Obs 166, SMR 1.23, 95% CI 1.05 to

1.43). Mortality was somewhat lower in the non-painters for all these causes other than for cancer of the stomach (all causes: Obs 4,427, SMR 0.99; stomach cancer: Obs 56, SMR 1.51; lung cancer: Obs 422, SMR 1.02; bladder cancer: Obs 22, SMR 0.74). There was no information on individual smoking histories, but other studies indicated that US painters had above-average smoking habits. The authors estimated that about half of the lung cancer excess might be attributed to this higher prevalence of smoking, as would a much smaller proportion of the bladder cancer excess. No analyses were reported for decade of joining the union or for duration of active membership, and confident interpretation of this study would be assisted by such analyses. It is difficult to believe that the latter analysis was not possible given that retired members would pay lower annual fees than active members.

Analyses were carried out by period from joining the Union. The authors note that findings for those painters with ≥20 years of follow-up from joining the Union had results that differed little from the overall results, "as 70% of cancer deaths occurred ≥20 years after entering the Union". This comment misses the point. What matters is whether the earlier period of follow-up differs from the later period. This has now been examined in Table 1. There is, in fact, no important difference in lung cancer risks between earlier and later periods of follow-up, whereas for bladder cancer there is a suggestion that risks are higher in later periods of follow-up.

The study was also analysed using Poisson regression, using the non-painters sub-cohort as an internal reference group. After adjusting for age and calendar year, significant rate ratios (RRs) were shown in painters for lung cancer mortality (RR 1.23, 95% CI 1.11 to 1.35) and bladder cancer (RR1.77, 95% CI 1.13 to 2.77).

Currently, this study is largest cohort study of cancer risks in painters. It suffers from problems in tracing study subjects and in obtaining all relevant death certificates. Analyses that should have been carried have not been attempted and there are many analyses with only two category comparisons (eg painters/non-painters). Nevertheless, the study indicates that occupational bladder cancer risks may well have been present in this cohort of US painters. Occupational lung cancers may also be present.

A nested case-control study from the above Steenland and Palu study had previously been conducted of lung cancers (1975-79 only) in the sub-cohort of New York union members (Stockwell & Matanoski, 1985). The 124 male lung cancer cases were identified through the New York State Cancer Registry, and 371 controls without cancer were selected randomly from the union membership and stratified by birth date and geographical location of the local unions. Responses to questionnaires on work history, work environment and life-style factors were received from 69 (66%) of the cases and 182 (59%) of the controls; of these, 65 (94%) and 55 (33%) were completed by a proxy for cases and controls, respectively. Painting as the reported usual trade was associated with a high risk of lung cancer (RR 2.8, 95% CI 1.5 to 5.2); high risks were also seen for work in allied trades: painter as a union speciality (RR 3.2, 95% CI 1.4 to 7.1) and ever having worked as a painter (RR 2.6, 95% CI 1.3 to 4.9). In the 57 cases for which the information was available, 53 men were reported to have used 'spackling' compounds (probably wall repair pastes that once contained asbestos), compared with 112 of 161 controls (RR 5.2, 95% CI 1.9 to 14.5). The authors attempted to adjust for several variables, including asbestos exposure (on the basis of use of ‘spackling’ compounds). The risk for lung cancer among painters who never wore a respirator remained high (RR 5.4, 95% CI 1.0 to 29.3). This set of elevated risks are not consistent with the overall cohort findings and it seems likely that these risks reflect bias introduced by poor response rates and unreliable reporting from proxies; we do not attach any weight to them.

Chen et al, 1999

Chen et al (1999) identified a cohort of 1,292 male painters from a dockyard in Scotland. These employees worked in the dockyard paintshop for at least one year between 1950 and 1992. Observed mortality was compared with expected numbers based on mortality rates for Scottish males, specified by age and calendar year. Information on smoking habits was not available. For reasons that are entirely unclear the analysis was restricted to mortality for the period 1975-94 in those 309 employees born in the period 1900-29. Mortality was close to expectation for all causes (Obs 123, SMR 0.98, 95% CI 0.82 to 1.17) and for lung cancer (Obs 16, SMR 1.12, 95% 0.64 to 1.82). There was a non-significant excess of bladder cancers based on four deaths only (Obs 4, SMR 3.05, 95% CI 0.83 to 7.82). A further 82 deaths were identified in the rest of the cohort (1,292 – 309 = 983); there were no deaths from bladder cancer in this latter sub-cohort.

Boice et al, 1999

Mortality among 77,965 aircraft manufacturing workers at factories in California, USA was investigated in a retrospective cohort study by Boice et al, 1999. The study cohort comprised workers employed for at least one year on or after 1st January, 1960.

Mortality was analysed for the period 1960-96 and details of deaths were obtained from the National Death Index and a variety of other sources. Only 0.7% of the total cohort was lost to follow-up. Expected numbers of deaths in white employees were based on mortality rates for white residents in the State of California, specified by sex, age and calendar year. Expected numbers of deaths in non-white workers were based on similar national mortality rates for non-whites. Detailed work histories had been abstracted and the study included a sub-cohort of 1,216 workers who had ever been employed as a painter (1,139 males, 77 females), with exposure to chromate-based paints and primers. Mortality in painters was below expectation for all causes (Obs 435, SMR 0.89, 95% CI 0.81 to 0.98) and for all cancers (Obs 101, SMR 0.87, 95% CI 0.71 to 1.06). Lung cancer mortality showed a slight but non-significant increase (Obs 41, SMR 1.11, 95% CI 0.80 to 1.51). Analyses were not presented for cancer risks by period of hire, by duration of employment as a painter, or by period from hire. Information on smoking habits was not available.

Brown et al, 2002

Brown et al (2002) studied cancer incidence in painters and workers from the paint and varnish manufacturing industry in Sweden in a record-linkage study using data from two national censuses combined with data from cancer incidence and mortality registers. Cohorts were identified from national censuses conducted in 1960 and 1970, and included subjects who were alive and free from cancer at the beginning of 1971 and who, at either census, were employed in a relevant painting trade. The cohorts included painters (42,433 males, 239 females), workers engaged in the manufacture of paints and varnishes (5,741 males, 1,897 females), lacquerers (12,331 males, 974 females), 6,662 artists (artistic painters) (6,662 males, 2,136 females), and

882 females glazers. Subjects were followed up from 1971 to 1989. Expected numbers of cancers were based on national incidence rates (specified by gender, age group and calendar year).

For male painters, the incidence of all cancers showed no excess (Obs 4475, SIR 1.0, 95% CI 1.0 to 1.0). Lung cancer incidence was, however, significantly increased (Obs 548, SIR 1.2, 95% CI 1.1 to 1.3) and increases of borderline significance were shown for rectal cancer (Obs 267, SIR 1.2, 95% CI 1.0 to 1.3) and cancer of the extrahepatic bile ducts (Obs 22, SIR 1.5, 95% CI 1.0 to 2.3). Bladder cancer incidence was only slightly increased in this sub-cohort (Obs 344, SIR 1.1, 95% CI 1.0 to 1.2).

For male lacquerers, the incidence of all cancers also showed no excess (Obs 933, SIR 1.0, 95% CI 1.0 to 1.1). Lung cancer incidence was, however, significantly increased (Obs 128, SIR 1.3, 95% CI 1.1 to 1.6). Bladder cancer incidence was non-significantly increased in this sub-cohort (Obs 78, SIR 1.2, 95% CI 0.9 to 1.4).

Among men working in the paint and varnish plants, the incidence of all cancers was close to expectation (Obs 618, SIR 1.1, 95% CI 1.0 to 1.2). Risks, however, were significantly increased for lung cancer (Obs 87, SIR 1.5, 95% CI 1.2 to 1.9), pancreatic cancer (Obs 30, SIR 1.7, 95% CI 1.1 to 2.4), and non-lymphatic leukaemia (Obs 13, SIR 2.1, 95% CI 1.1 to 3.6). Increases of borderline significance were reported for cancer of the small intestine (Obs 7, SIR 2.6, 95% CI 1.0 to 5.4) and colon cancer (Obs 52, SIR 1.3, 95% CI 1.0 to 1.7). Bladder cancer was only slightly increased in this cohort (Obs 48, SIR 1.2, 95% CI 0.8 to 1.5).

For male artists, overall cancer risks were close to expectation (Obs 664, SIR 1.0, 95% CI 1.0 to 1.1), as were those for lung cancer (Obs 69, SIR 1.0, 95% CI 0.8 to 1.3). There was, however, a significant excess of bladder cancer (Obs 71, SIR 1.5, 95% CI 1.2 to 1.9).

Findings for female sub-cohorts were based on small numbers though a non-significant excess of lung cancer was shown for lacquerers (Obs 5, SIR 1.5, 95% CI 0.5 to 3.6). No information was available for smoking habits. In addition the survey data did not permit analyses of cancer risks by decade of first employment, duration of employment or period from first employment.

Pukkala et al, 2009

Cancer incidence in specific occupational groups was investigated in five Nordic countries in a large record-linkage cohort study involving nearly 15 million people (Pukkala et al, 2009). Cohorts included subjects participating in national population censuses conducted in Denmark, Finland, Iceland, Norway and Sweden during 1960-1990, who were aged 30-64 years and still alive and living in the country at the start of the year following the census. Cohort subjects, amounting to 14.9 million people, were assigned to one of 53 occupational categories based on self-reported census data. The ‘painters and wallpaper hangers’ category comprised 98,743 males and 3,215 females. Follow-up was from the beginning of the year after the first available census until 2003 (Denmark, Norway), 2004 (Iceland) or 2005 (Finland, Sweden). Observed numbers of cancer cases for each occupational category were compared with expected numbers based on national incidence rates. SIRs were calculated for each country separately and for the five countries combined. Information on smoking habits was not available. Combined cancer incidence data for male painters showed significant increases for all cancers (Obs 20,127, SIR 1.05, 95% CI 1.04 to 1.06), lung cancer (Obs 3,418, SIR 1.23, 95% CI 1.19 to 1.28), mesothelioma (Obs 144, SIR 1.77, 95% CI 1.51 to 2.09), and bladder cancer (Obs 1,642, SIR 1.08, 95% CI 1.03 to 1.14). An elevated incidence was also shown for cancer of the tongue (Obs 93, SIR 1.27, 95% CI 1.03 to 1.56), cancer of the oral cavity (Obs 160, SIR 1.49, 95% CI 1.28 to 1.74), cancer of the pharynx (Obs 176, SIR 1.24, 95% CI 1.07 to 1.44), cancer of the oesophagus (Obs 306, SIR 1.14, 95% CI 1.02 to 1.28), rectal cancer (Obs 1131, SIR 1.11, 95% CI 1.05 to 1.18), cancer of the larynx (Obs 303, SIR 1.22, 95% CI 1.09 to 1.36), and cancer of the renal pelvis (Obs 111, SIR 1.23, 95% CI 1.02 to 1.48). It is most unlikely that painting could be a risk factor for so many different sites of cancer; it seems possible that non-occupational factors related to the occupation of painting are involved in the pattern of results. Combined cancer incidence data for female painters showed a significant increase for lung cancer only (Obs 47, SIR 1.90, 95% CI 1.40 to 2.53).

Pronk et al, 2009

In 1996-2000, Pronk et al (2009) interviewed 71,067 non-smoking women aged 40-70 years from Shanghai, China, and obtained information on family history of cancer, employment histories and residential histories. Information on cancer incidence for the period 1996-2005 was obtained from the local cancer registry and from later contact with the study subjects. Attempts were made to relate the work histories with a list of IARC Group I carcinogens (‘definite’ human carcinogens). When “less specific criteria" were applied to the interpretation of the work histories, there were only 14 cases of lung cancer in women who were judged to have been exposed to known carcinogens (Obs 14, relative risk (RR) 0.9, 95% CI 0.5 to 1.6). When "more specific criteria" were applied to the same data there were no cases of lung cancer in women who were judged to have been exposed to known carcinogens. Given the considerable contrast between these two numbers (14 and zero) it is difficult to attach too much importance to the finding of an elevated relative risk for painters (Obs 6, RR 2.0, 95% CI 0.9 to 4.5).

2.1.2Paint manufacturers

Bertazzi et al, 1981

Bertazzi et al (1981) followed a small cohort of 427 workers employed in paint manufacturing in Italy. The main exposures was said to be to chromate-based paints, although there was also some exposure to asbestos. The workers had been employed for at least six months in the period 1946-77 and mortality was analysed for the period 1954-78. Follow-up was 98% complete. There was a significant excess mortality from all cancers (Obs 18, SMR 1.84; 95% CI 1.12 to 2.85) based on national mortality rates. Lung cancer mortality was significantly elevated based on either national rates (Obs 8, SMR 3.34, 95% CI 1.44 to 6.58) or local rates (Obs 8, SMR 2.27, 95% CI 1.00 to 6.58). There was a positive non-significant trend (P=0.07) between lung cancer SMRs and duration of employment.

Morgan et al, 1981

Findings from a large cohort of 16,243 US male workers in the paint and coating manufacturing industry were reported by Morgan et al (1981). These men had been employed for at least twelve months with some employment after 1st January, 1946, at one of 12 large or 20 medium to small companies. Vital status was established for 94% of the cohort; death certificates could not be obtained for 8% of decedents. Mortality was analysed for the period 1946-76, and expected numbers of deaths were based on rates for US white males. Overall mortality was below expectation (Obs 2633, SMR 0.86, 95% CI 83 to 89). Mortality from cancer of the colon was significantly in excess (Obs 65, SMR 1.38, 95% CI 1.07 to 1.76). There was also a suggestion of elevated mortality for cancer of the rectum (Obs 26, SMR 1.39, 95% CI 0.91 to 2.04). Lung cancer mortality was not elevated (Obs 150, SMR 0.98, 95% CI 0.84 to 1.15); information on smoking habits was not available. In addition, there was no overall excess for bladder cancer (Obs 16, SMR 0.98, 95% CI 0.56 to 1.59) or leukaemia (Obs 20, SMR 0.92, 95% CI 0.56 to 1.42).

The cohort was also divided into sub-cohorts based, in the main, on likely exposure to pigments, solvents, or lacquers. Findings were unexceptional except that an excess of leukaemia was found in workers with at least one year of exposure to lacquer (Obs 8, SMR 2.12, 95% CI 0.92 to 4.18). A further report on this study (Morgan et al, 1985) provided little additional information.

Lundberg and Milatou-Smith, 1998

A cohort of 416 men who had worked for five years or more in one of nine Swedish paint manufacturing companies during the period 1955-75 was assembled by

Lundberg (Lundberg, 1986). Some 43% of the cohort had been first employed before 1955. In the 1930s ands early 1940s, heavy naphthas, toluene and benzene had been used as solvents. All employees had worked in a solvent-exposed environment . Mortality was analysed for the period 1961-81, and national mortality rates were used to calculate expected numbers. Overall mortality was low (Obs 96, SMR 0.88, 95% CI 0.70 to 1.06), as was mortality from all cancers (Obs 22, SMR 0.84, 95% CI 0.52 to 1.27) and from lung cancer (Obs 3, SMR 0.63, 95% CI 0.12 to 1.84). Mortality was elevated for multiple myeloma (Obs 3, SMR 5.49, 95% CI 1.13 to 16.06). There was only a single death from leukaemia (Obs 1, SMR 1.07, 95% CI 0.02 to 5.95).

An updated analysis was published in 1998 (Lundberg and Milatou-Smith, 1998). Five immigrant workers had left Sweden and the cohort now comprised 411 workers. Mortality was analysed for the period 1961-94 and cancer incidence for the period 1961-92. Overall mortality was close to expectation (Obs 207, SMR 0.95, 95% CI 0.83 to 1.09), and there was no excess mortality from all cancers (Obs 50, SMR 1.00, 95% CI 0.76 to 1.32). Lung cancer mortality was close to expectation (Obs 11, SMR 1.11, 95% CI 0.53 to 2.04) as was mortality from leukaemia (Obs 2, SMR1.18, 95% CI 0.14 to 4.25). Overall cancer incidence was also close to expectation (Obs 83, SIR1.04, 95% CI 0.84 to 1.29), and there was no excess incidence for lung cancer (Obs 6, SIR 0.71, 95% CI 0.26 to 1.54). A non-significant excess of leukaemia was based on small numbers (Obs 3, SIR 1.43, 95% CI 0.29 to 4.18). There was, however, an elevated mortality (Obs 6, SMR 2.00, 95% CI 0.73 to 4.33) and an elevated cancer incidence (Obs 9, SIR 2.30, 95% CI 1.04 to 4.33) from all lymphatic and haematopoietic neoplasms in workers first employed before 1957. It seems unlikely that early benzene exposure was not the sole cause of this excess as there was only a single case of acute myeloid leukaemia. There was no excess of bladder cancer in the cohort although detailed findings were not presented for this disease.

2.1.3 Summaries of findings from cohort and nested case-control studies

A summary of the cohort descriptions for key occupational cohorts of painters is shown in Table 2. A summary of the overall findings for lung cancer in the key occupational cohort studies of painters is shown in Table 3. A simple summation of observed and expected numbers provides an overall risk estimate (SMR/SIR) of 1.23 (95% CI 1.20 to 1.26). A corresponding meta-analysis using a fixed effects model provides almost identical results (SMR/SIR 1.23, 95% CI 1.20 to 1.27). A corresponding meta-analysis using a random effects model produced a marginally higher point estimate of risk with a wider confidence interval (SMR/SIR 1.25, 95% CI 1.18 to 1.32). Heterogeneity in the set of risk estimates approached formal levels of statistical significance (P = 0.06).

A summary of the overall findings for bladder cancer in the key occupational cohort studies of painters is shown in Table 4. A simple summation of observed and expected numbers provides an overall risk estimate (SMR/SIR) of 1.10 (95% CI 1.05 to 1.14). A corresponding meta-analysis using a fixed effects model provides almost identical results (SMR/SIR 1.10, 95% CI 1.06 to 1.15). A corresponding meta-analysis using a random effects model produces a marginally higher point estimate of risk with a wider confidence interval (SMR/SIR 1.14, 95% CI 1.05 to 1.24). There was no significant heterogeneity in the set of risk estimates (P = 0.16).

A summary of the overall findings for leukaemia in the key occupational cohort studies of painters is shown in Table 5. A simple summation of observed and expected numbers provides an overall risk estimate (SMR/SIR) of 0.95 (95% CI 0.89 to 1.02). A corresponding meta-analysis using a fixed effects model provides almost identical results (SMR/SIR 0.94, 95% CI 0.88 to 1.02). A corresponding meta-analysis using a random effects model produces a marginally lower point estimate of risk with a wider confidence interval (SMR/SIR 0.92, 95% CI 0.79 to 1.07). Heterogeneity in the set of risk estimates approached formal levels of statistical significance (P = 0.06).

A summary of the cohort descriptions for key occupational cohorts of paint manufacturers is shown in Table 6. A summary of the overall findings for lung cancer in the key occupational cohort studies of paint manufacturers is shown in Table 7. A simple summation of observed and expected numbers provides an overall risk estimate (SMR) of 1.01 (95% CI 0.87 to 1.18). A summary of the overall findings for bladder cancer in the key occupational cohort studies of paint manufacturers is shown in Table 8. Only a single study is available. A summary of the overall findings for leukaemia in the key occupational cohort studies of paint manufacturers is shown in Table 9. A simple summation of observed and expected numbers provides an overall risk estimate (SMR/SIR) of 0.97 (95% CI 0.61 to 1.45). Only two studies were available

2.2 Studies of routinely collected data

There have been many analyses of routinely collected data (most notably the UK decennial supplements on occupation and mortality) that suggest there are occupational cancer risks in painters (Office of Population Censuses and Surveys (OPCS), 1972; OPCS, 1979; OPCS 1986). The UK decennial supplements typically analyse sets of national death certificates over a three year period centred on the census year and include comparisons of the numbers of deaths from specified causes and in specified occupations with expected numbers based on the proportions of deaths found for that occupation for all causes of death combined. Regarding the occupation of painter, the strongest evidence has been supplied for excess risks of lung cancer. Similar findings have been produced from similar studies in other parts of the world (IARC, 1989; IARC in press).

2.3 Case-control studies

2.3.1 Cancer of the lung

Breslow et al, 1954

Breslow et al (1954) identified 518 cases of lung cancer in 11 Californian hospitals during the period 1949-52. Controls were selected from patients admitted to the same hospital for a condition other than cancer or a chest disease, and matched for age, sex and race. Detailed occupational and smoking histories were obtained by interview. The authors reported that 22 cases had been employed as construction or maintenance painters for at least five years, as had 12 controls (RR 1.9, 95% CI 0.93 to 3.8). Smoking was not controlled for, although smoking histories had been recorded.

Menck and Henderson, 1976

Menck and Henderson (1976) identified deaths from lung cancer for the years 1968-70 (2161 cases) and incident cases of lung cancer for the years 1972-73 (1777 cases) from the Los Angeles County Cancer Surveillance Program. All subjects were classified by occupation and industry on the basis of either death certificate data or information in hospital records. Of the 3938 subjects, 689 had no reported occupation and 1222 no reported industry of employment. Employment details for the general population aged 20-64 years were estimated from a sample of the population in the 1970 census, and the risk of lung cancer for each occupation was compared to the risk in the total population. The relative risk for lung cancer in painters was significantly elevated (Obs 45, RR 1.58, 95% CI 1.14 to 2.04).

Viadana et al, 1976; Decouflé et al, 1977; Houten et al, 1977

Cancer cases recorded at a cancer centre in New York State, USA, in 1956-65 were compared with all patients with non-neoplastic lesions in regard to occupations related to inhalation of combustion products or chemicals and to personal characteristics (Viadana et al, 1976; Decouflé et al, 1977; Houten et al, 1977). The information was obtained through an interview at the time of admission for all patients. Each of the 11,591 white male subjects was included for analysis for each occupation held; specific occupations were compared with those of an unexposed clerical group. Painters were analysed as a subgroup of people with chemical exposures and as a subgroup of those with metal-related occupations. An elevated risk of lung cancer was found for painters (Obs 42, RR 1.7, p=0.02).

Coggon et al, 1986a

Coggon et al (1986a) identified all 2,942 cases of cancer first diagnosed in one of three English counties in the period 1975-80 among males aged 18-54 years. Occupational and smoking histories were obtained either by mailed questionnaires or from information in hospital records or on death certificates. Cancer risks at 15 specific sites were calculated for various occupations using registrations at other sites as controls, adjusting for age, region, source of occupational data and smoking history. Lung cancer was associated with the occupation of painter or decorator (Obs 20, RR 1.3).

Kjuus et al, 1986

A study of 176 male incident lung cancer cases under 80 years of age and admitted in 1979-83 to one of two hospitals in neighbouring counties in Norway was conducted by Kjuus et al (1986). Controls were matched on age through admission lists or from the same department records; persons with physical or mental handicaps, general poor health or an admission diagnosis of chronic obstructive pulmonary disease were excluded from the control group. Occupational histories were determined by interview and work site records then coded by job title and separated into three groups according to potential exposure to lung carcinogens, which included painting and paints. Only jobs held for at least three years were considered, and the selected occupation was the longest job held; employments after 1970 were not reviewed. The RR for painting and paperhanging was 1.7 (Obs 5, 95% CI 0.4 to 7.3), adjusted for smoking. The RR for lung cancer associated with exposure to paints, glues and lacquer was 1.2 (Obs 17, 95% CI 0.6 to 2.6), adjusted for smoking.

Lerchen et al, 1987

Occupational histories obtained by interview were compared in a case-control study of 506 lung cancer patients (333 men and 173 women) diagnosed in 1980-82, and registered with the New Mexico Tumour Registry. A total of 771 controls were selected through random telephone numbers or from rosters of elderly (Lerchen et al, 1987). Next-of-kin provided the information for half of the cases and 2% of controls. Jobs held by individuals from age 12 years were classified according to an a-priori list of potentially hazardous occupations. Employments held for less than twelve months were not considered. Lung cancer risks were elevated in men associated with employment as a construction painter (Obs 9, RR 2.7, 95% CI 0.8 to 8.9), with adjustment for age, ethnicity and smoking.

Levin et al, 1988

In a cancer registry-based case-control study, Levin et al (1988) identified 833 male lung cancer cases diagnosed between February 1984 and February 1985 in Shanghai, China, and 760 randomly selected male controls from the general urban Shanghai population, frequency matched within five-year age strata. Personal interviews to obtain occupational and smoking histories were obtained for 733 cases and 760 controls. More than 60 industries and occupations were examined; ever having worked as a painter was associated with a RR of 1.4, adjusted for age and smoking (Obs 15, 95% CI 0.5 to 3.5). Relative risks were also supplied by duration of employment as a painter (< 10years: Obs 7, RR 1.9; 10-19 years: Obs 2, RR 2.8; 20-29 years: Obs 5, RR 2.2; ≥ 30 years: Obs 1, RR 0.3).

Ronco et al, 1988

Ronco et al (1988) reported a population-based case-control study from two areas in northern Italy which included 164 male lung cancer cases identified from death records during 1976-80 and 492 controls who had died of conditions other than chronic lung disease or smoking-related cancers. Information on smoking and occupation was obtained through interviews of next-of-kin. Many exposures suspected of increasing the risk for lung cancer were evaluated, and individuals who had not held any job in any industry that was associated with exposure to a known or suspected lung carcinogen were classified as nonexposed. Risks were somewhat elevated in painters, after adjustment for age, smoking and employment in other studied exposures (Obs 5, RR 1.3, 95% CI to 0.43 to 4.1).

Bethwaite et al, 1990

Bethwaite et al (1990) conducted an unmatched case-control study to investigate the association between specific cancer sites and work as a painter in New Zealand. The study involved male patients registered with the New Zealand Cancer Registry during the period 1980-1984, aged 20 years or more at registration. Information on occupation, defined as the subjects' current or most recent occupation at the time of registration, was available for 19,904 subjects. The number of cases was determined for each cancer site; the registrants for the other cancer sites formed the control group. Age-adjusted RRs were calculated for painters and for each cancer site. There were 4,224 cases of lung cancer. The relative risk for painters was 1.12 (Obs 88, 95% CI

0.93 to 1.52). The findings of this registry-based study are limited by the absence of detailed information on occupational history, smoking habits and other potential confounders.

Burns and Swanson, 1991

Results of an unmatched case-control investigation of lung cancer and occupation carried out in the Detroit metropolitan area, USA, were reported by Burns and Swanson (1991). Cases comprised lung and bronchus cancer patients identified through the regional Cancer Surveillance System and involved 5,935 black and white subjects (3918 males, 2017 females). No dates were supplied regarding years of diagnosis. Unmatched controls comprised 3,956 patients (1981 males, 1975 females) diagnosed with cancer of the colon or rectum, similarly identified through the Cancer Surveillance System. Telephone interviews were carried out with subjects or surrogates to obtain complete lifetime occupational and smoking histories, medical history, and information on demographics and residence. 'Usual occupation' was established for each subject, and was defined as the occupation and industry worked in the longest. Lung cancer risk was associated with occupation as painter (Obs 97, RR 1.96, 95% CI 1.23 to 3.13), adjusted for smoking, gender, race and age at diagnosis. When data were analysed according to specific job, lung cancer risks were reported to be concentrated among painting machine operators (Obs 37, RR 4.50, 95% CI 1.71 to 11.82) rather than house painters (results not presented in report).

Notani et al, 1993

The association between occupation and lung cancer risk in men was investigated in an unmatched case-control study in Bombay, India during the period 1986-1990 by Notani et al (1993). Cases consisted of 246 hospital patients with lung cancer who resided in the State of Maharashtra. With most of the cases, diagnosis had been confirmed histiologically or cytologically; a small number had been confirmed by radiology or clinically. Controls consisted of 212 male hospital patients, diagnosed with cancer of the mouth or pharynx or non-cancerous oral disease, and with a similar community distribution to the cases. Information on lifetime occupational history, demographics, tobacco use, alcohol consumption and past medical history was obtained by interview. Detailed information was recorded for each job held. Lung cancer risk was determined for men ever employed as a painter (≥1 year) *versus* never employed as a painter, adjusted for age only or age and smoking. With adjustment for age only, the RR was 1.33 (Obs 6, 95% CI 0.4 to 4.7). Adjustment for age and smoking gave a RR of 1.62 (95% CI 0.4 to 7.0).

De Stefani et al, 1996

The association between lung cancer and occupation was investigated as part of a large unmatched case-control study of cancer and occupation in Uruguay, carried out during the period January 1993 to December 1994 (De Stefani et al, 1996). The study population comprised male cancer patients aged between 30 and 75 years admitted to one of five hospitals. Information on socio-demographics, smoking habits and alcohol consumption was obtained by interview conducted shortly after admission. A complete occupational history was obtained for each patient with specific information on exposures and exposure durations for jobs held for twelve months or more. There were 270 lung cancer cases. Controls comprised remaining cancer patients, excluding cancers with likely shared aetiology or anatomical proximity (e.g. pharynx, oral cavity, bladder). Lung cancer risk was determined for ever employed as a painter, adjusted for age, residence, smoking, education and alcohol consumption. For painters the RR was 1.2 (Obs 18, 95% CI 0.6 to 2.4). Relative risks were also calculated by duration of employment (1-20y: RR 0.9, 95% CI 0.2 to 3.0; ≥21 y: RR 1.4, 95% CI 0.6 to 3.1).

Muscat et al, 1998

Muscat et al (1998) investigated lung cancer risk and occupation among black men and women in the USA in an unmatched hospital based case-control study conducted during 1978-1996. Cases consisted of newly diagnosed, histologically confirmed lung cancer (365 men, 185 women). Controls comprised hospital admissions with conditions unrelated to tobacco use, frequency matched by age group, gender, race (where possible) and month of diagnosis (252 men, 135 women). Information on demographics, smoking and medical history, and occupational history was obtained by interview. Subjects provided details of exposures in their usual adult occupation. RRs were calculated for specific occupational exposure categories and job categories, with adjustment for age, education and smoking. Lung cancer risks in men with occupational exposure to paint had a RR of 0.7 (Obs 3, 95% CI 0.3 to 1.1). For women the RR was 1.8 (Obs 5, 95% CI 0.3 to 12.3).

Wünsch-Filho et al, 1998

The association between occupation and lung cancer was investigated in an unmatched case-control study in Brazil (Wünsch-Filho et al, 1998). Cases and controls were identified from 14 hospitals during the period 1989-1991. Cases consisted of 398 patients (307 men, 91 women) with newly diagnosed lung cancer that had been confirmed by histology or cytology. Controls comprised 860 patients (546 men, 314 women), matched by age, gender and hospital, and excluding those with chronic respiratory disease or smoking-related cancers. Information on smoking history, passive smoking, medical history and familial cancer was obtained by questionnaire either from the patient (84% of subjects) or, when the patient was too ill, from next-of-kin. Detailed work history was also obtained for each subject for jobs held for six months or more. There was no elevated lung cancer risk for men ever employed as a painter, with adjustment for age, smoking, familial cancer, migratory history and socioeconomic status (Obs 128, RR 0.77, 95% CI 0.56 to 1.08). For men employed as a painter for ≥10 years, the RR was 1.29 (Obs 82, 95% CI 0.79 to 2.11). Analysis of data for women was limited by small numbers in each occupational category.

Pezzotto and Poletto, 1999

Pezzotto and Poletto (1999) investigated the relationship between occupational exposure and lung cancer in Argentina. The study involved 367 male cases of histologically-confirmed primary lung cancer, admitted to one of three hospitals during the period 1992-1998. Controls comprised 586 male patients admitted for diseases unrelated to smoking and frequency matched by age-group. Lifetime occupational history was obtained for each subject by interview, with specific information recorded for jobs held for more than one year, together with detailed information on smoking habits. RRs adjusted for age, smoking habit and lifelong cigarette consumption were calculated for specific occupations. With regard to painters, findings were reported for ‘house painters’ only (Obs 4, RR 2.4, 95% CI 0.4 to 19.4).

Jahn et al, 1999; Brüske-Hohlfeld et al, 2000

The association between occupation and lung cancer was investigated by pooling data from two German case-control studies, one conducted during 1988-1993 and the other during 1990-1996. Pooled data for women were separately analysed and reported in a study by Jahn et al (1999). Corresponding data for men were reported by Brüske-Hohlfeld et al (2000). In both of the original studies, cases were limited to lung cancer which had been confirmed cytologically or histologically, and diagnosis had taken place <3 months before study interviews. Cases involving metastases secondary to other cancers were excluded. In both of the original studies, information on demographics, diet, smoking, and medical history was obtained by face-to-face interview, together with detailed occupational history for jobs held for six months or more. Population controls in one of the original studies were individually matched to cases by age, gender and region; in the other study population controls were frequency matched to cases by age, gender and region. In the pooled studies, risks were calculated for ever employed in a specific industry/occupation *versus* never employed in that industry/occupation, and presented with no adjustment, adjustment for smoking or adjustment for smoking and asbestos exposure. Analysis of pooled data for women involved 686 cases and 712 population controls (Jahn et al, 1999).

Unadjusted RR estimates indicated significantly increased lung cancer risk for women ever employed as painters (Obs 13, RR 4.1, 95% CI 1.15 to 14.72). With adjustment for smoking, the increased risk lost significance (RR 3.0, 95% CI 0.73 to 12.33). Analysis of pooled data for men involved 3,498 cases and 3,541 population controls (Brüske-Hohlfeld et al, 2000). For men ever employed as a 'painter and lacquerer', the unadjusted RR was 1.6, the relative risk with adjustment for smoking was 1.39, and the relative risk with additional adjustment for asbestos exposure was 1.42 (Obs 147, 95%CI 1.05 to 1.92).

Matos et al, 2000

An Argentinian matched case-control study of lung cancer and occupation was reported by Matos et al (2000). The cases involved male lung cancer patients admitted for treatment at one of four hospitals in Buenos Aires during 1994-1996 (199 cases). Controls involved subjects admitted to hospital during the same period as cases, with conditions unrelated to tobacco use and who were residents in the same area as cases. Two male controls were matched to each case by age-group and hospital. Interviews were conducted to obtain information on demographics, complete occupational history, smoking history, eating habits and residence. Detailed information was requested concerning jobs held for one year or more. Lung cancer risks were estimated for ever employed in a specific industry/occupation *versus* never employed in that industry/occupation, with adjustment for hospital, age, smoking and employment associated with increased lung cancer risk. Lung cancer risks were determined for two painting categories: painters (general) and painters (blowtorch). Painters (general) had a RR of 1.2 (Obs 16, 95% CI 0.5 to 2.4); painters (blowtorch) had a RR of 1.4 (Obs 8, 95% CI 0.5 to 4.4).

Pohlabeln et al, 2000

Pohlabeln et al (2000) reported the first of three European multi-centre case-control studies examining the relationship between lung cancer and occupation among non-smokers. The investigation was based in seven European countries (France, Germany, Italy, Portugal, Spain, Sweden and the UK) and was carried out during 1988-1994. Cases and controls were restricted to "non-smokers", defined as lifetime smoking of <400 cigarettes. Controls were either population-based (six centres), hospital-based (five centres; involving diseases not related to smoking), or combined population- and hospital- based (one centre). The study involved 650 cases (509 females; 141 males) and 1,542 controls (1,011 females; 531 males). Information on demographics, lifetime smoking habits and occupational history was obtained by face-to-face interview. Relative risks were calculated for ever-employed for six months or more in specific occupations. For males employed as painters in the construction industry the RR was 1.84 (Obs 6, 95% CI 0.59 to 5.74). Risk estimates were not presented for female painters due to small numbers.

Richiardi et al, 2004

The association between occupation and lung cancer was investigated in an unmatched case-control study in Italy by Richiardi et al (2004). Primary lung cancer cases were identified through local hospitals and involved cases that had been confirmed either histologically or cytologically. The study included 1,132 cases (956 males, 176 females) and 1,553 population controls, frequency-matched to cases by gender and age-group (1,253 males, 300 females). Information on demographics, smoking habits and occupational history was obtained by interview. Lung cancer risks were calculated with adjustment for age, smoking, study area and number of job periods. For men ever employed as painters in the construction, automotive and other industries, the RR was 2.0 (Obs 61, 95% CI 1.4 to 3.3). With additional adjustment for education, the RR was 1.7 (95% CI 1.0 to 3.0). When analysis was limited to men ever employed as construction painters, the corresponding RRs were 2.0 (95% CI 1.2 to 3.6) and 1.7 (95% CI 1.0 to 3.0), based on 42 cases. For ever employed painters not classified elsewhere, the corresponding RRs were 2.0 (95% CI 0.9 to 4.2) and 1.7 (95% CI 0.8 to 3.7), based on 20 cases. No data were presented for female painters.

De Stefani et al, 2005

De Stefani et al (2005) investigated occupational risks associated with adenocarcinoma of the lung in Uruguay during the period 1994-2000. Cases were identified from four hospitals and involved 338 males with histologically confirmed adenocarcinoma of the lung. Controls comprised 1014 male patients from the same hospitals, admitted for conditions unrelated to tobacco smoking, and frequency-matched to cases by age, residence and urban/rural status. Face-to-face interviews were conducted on cases and controls to obtain information on demographics, complete history of smoking and alcohol consumption, and detailed occupational history. Lung cancer risks were determined for employment in specific occupations, with adjustments which included age, residence, education and smoking status. For men ever-employed as a painter the RR was 1.8 (Obs 26, 95% CI 1.0 to 3.1). Analysis of data according to duration of employment showed no evidence of a trend (≤20 years: RR 9.6, 95% CI 2.6 to 36.0; >20 years: RR 1.2, 95% CI 0.6 to 2.2).

Zeka et al, 2006

A multi-centre unmatched study involved sixteen centres in seven European countries (Czech Republic, Hungary, Poland, Romania, Russia, Slovakia and the UK) and took place during 1998-2002 (Zeka et al, 2006). In this study, 'never-smokers' were defined as subjects with a lifetime smoking of <100 cigarettes. The study involved 223 lung cancer cases (48 males, 175 females), diagnosed at one of the participating centres and confirmed either clinically, histologically or cytologically. Controls comprised 1039 subjects (534 males, 505 females), frequency matched to cases by gender and age. In fourteen centres, the controls were hospital patients, excluding those with malignant cancers, respiratory disease or other conditions related to smoking. In the remaining two centres, population-based controls were used. Information on smoking habits, alcohol consumption, education, exposure to second-hand smoke, medical history and other possible confounders was obtained by face-to-face interview conducted within three months of diagnosis (cases) or within three months of case interviews (controls). Specific questionnaires were used to record information about jobs held for one year or more, including detailed information about tasks and activities so that exposures could be estimated. Lung cancer risk was determined for employment in one of two occupational groups (known high-risk occupations or suspected high risk occupations). No male cases and nine male controls had ever been employed as painters (construction, automotive industry and other users). For females ever-employed as painters the RR was 1.8 (Obs 6, 95% CI 0.53 to 6.0).

Bardin-Mikolajczak et al, 2007

A further multi-centred European case-control study investigated the association between lung cancer and occupation (Bardin-Mikolajczak et al, 2007). The study involved 2,632 lung cancer cases and 2,871 controls and was carried out during 1998-2001. A similar methodology was used as for that described above (Zeka et al, 2006). RRs were calculated for subjects ever-employed in specific occupations for one year or more. Only those results showing significant associations were presented. No relative risks were presented for painters.

2.3.1.1 Summary of case-control studies into lung cancer

A summary of the overall findings for occupation as a painter in case-control studies carried out into the aetiology of lung cancer is shown in Table 10. A meta-analysis using a fixed effects model provides a significantly elevated relative risk (RR 1.28 95% CI 1.13 to 1.45). A corresponding meta-analysis using a random effects model also produced a significantly elevated relative risk (RR 1.34, 95% CI 1.14 to 1.57). There was no significant heterogeneity in the set of risk estimates (P = 0.18). Other meta-analyses have produced very similar meta-estimates. Guha et al (2010a) present a summary relative risk (random effects) estimate of 1.35 (95% CI 1.22 to 1.51) for case-control studies, whilst Bachand et al (2010) present a summary relative risk (random effects) estimate of 1.29 (95% CI 1.10 to 1.51). Chance thus provides no realistic explanation for the elevated risks shown for painters in the available case-control studies. Adjustment for smoking was carried out in most of these studies, and whilst the adjustment can never be perfect, confounding by smoking is also unlikely to explain the positive findings. Bias, the perennial scourge of case-control studies that rely on self-reported data supplied by non-random samples of volunteers, is more difficult to exclude.

2.3.2 Cancer of the bladder

Wynder et al, 1963

Wynder et al. (1963) examined occupational and other risk factors associated with bladder cancer in 300 male patients diagnosed in the period 1057-61 at one of seven New York hospitals. Controls consisted of an equal number of male hospital patients who did not have myocardial infarction or cancers of the respiratory system or upper alimentary tract and were matched by age and time of admission. Interviews were conducted directly with the patients. The investigators reported 18 painters among cases and 12 among controls. A RR has been estimated for the group that had ever worked as a painter (RR 2.2, 95% CI 1.0 to 4.5). No adjustment was possible for cigarette smoking.

Cole et al, 1972

Cole et al (1972) conducted a case-control study of transitional- or squamous-cell carcinoma of the lower urinary tract in eastern Massachusetts using newly diagnosed cases aged 20-89 during an 18-month period, 1st January 1967 to 30th June 1968. Out of 668 cases ascertained, a random sample of 510 was selected for interview; a usable occupational history was obtained for 461. Controls were selected from the general population of the same area and matched on age and sex. Certain occupations (including painting) were classified as 'suspect'. The RR for lower urinary tract cancer in male painters, adjusted for age and smoking was 1.2 (28 cases, 95% CI 0.71 to 1.9).

Viadana et al, 1976; Decouflé et al, 1977; Houten et al, 1977

Cancer cases recorded at a cancer centre in New York State, USA, in 1956-65 were compared with all patients with non-neoplastic lesions in regard to occupations related to inhalation of combustion products or chemicals and to personal characteristics (Viadana et al, 1976; Decouflé et al, 1977; Houten et al, 1977). The information was obtained through an interview at the time of admission for all patients. Each of the 11,591 white male subjects was included for analysis for each occupation held; specific occupations were compared with those of an unexposed clerical group. Painters were analysed as a subgroup of people with chemical exposures and as a subgroup of those with metal-related occupations. An elevated risk of bladder cancer was found for painters (Obs 16, RR 1.6).

Howe et al, 1980

Howe et al (1980) conducted a case-control study of bladder cancer in three areas of Canada; they identified 821 cases through provincial cancer registries in 1974-76 and matched them by age, sex and neighbourhood to 821 controls. Personal interviews were obtained for 632 cases (480 men and 152 women; 77%) and an equal number of controls. Among men, working as a painter was not associated with elevated risk. The RR for commercial painting was 1.0 (24 cases in discordant pairs, 95% CI 0.6 to 2.3), whilst that for spray painting was 1.8 (16 cases in discordant pairs, 95% CI 0.7

to 4.6). The relative risk for spray painting was reduced to 1.0 after correction for exposure in other suspect 'high-risk' industries.

Silverman et al, 1983

As part of the US National Bladder Cancer Study, Silverman et al (1983) conducted a population-based case-control study of bladder cancer in the Detroit area, USA. They identified 420 male cases diagnosed in the period 1977-78 with transitional- or squamous-cell carcinoma of the lower urinary tract, and aged 21-84 years. Interview data was obtained for 339 (81%) subjects, but the analysis was restricted to 303 white males. Controls were 296 white males stratified for age who were selected from a random digit-dialling survey for those under age 65 and from a random sample of the Health Care Financing Administration lists for those over 65. Employment was measured as 'ever' or 'usual' occupation or industry; 'usually unexposed' were those not employed in the industry of interest. The findings suggested no increased risk for bladder cancer for painters in general (15 cases, RR 1.0, 95% CI 0.5 to 2.2), for painters in the automobile industry (three cases, RR 0.5, 95% CI 0.1 to 2.1) or for paint manufacturers (one case, RR 0.2, 95% CI 0 to 2.2).

Schoenberg et al, 1984

A case-control study of incident bladder cancer in 658 white males aged 21-84 during 1978-79 and of 1258 population controls was conducted in New Jersey, USA, by Schoenberg et al (1984). Controls were selected in the manner described by Silverman et al (1983). The RR for bladder cancer in men ever employed as a painter, adjusted for age, was 1.4 (34 cases, 95% CI 0.85 to 2.3). When occupations were classified by materials used, paint exposure was associated with a significantly elevated risk of bladder cancer (111 cases, RR 1.6, 95% CI 1.2 to 2.1). The risk was higher for those first exposed under age 41 and did not increase with duration of exposure.

Vineis and Magnani, 1985

A case-control study of bladder cancer in Italy (Vineis & Magnani, 1985) involved 512 male cases aged under 75 between 1978-83 and 596 hospital controls. The controls were matched by age and were subjects with benign urological conditions or surgical conditions. Occupational and smoking histories were obtained by interview. No increased risk was seen for painters in the building industry (Obs 12, RR 1.0, 95% CI 0.40 to 2.2), painters in carpentry (Obs 1, RR 0.6, 956% CI 0.04 to 8.4) or spray painters (Obs 2, RR 1.2, 95% CI 0.20 to 5.8), but the RR for car painters was 2.1 (95% CI 0.60 to 7.0) based on seven cases.

Morrison et al, 1985

Morrison et al. (1985) examined 15 occupations in relation to risks for lower urinary tract cancer in Nagoya, Japan (1976-78), Manchester, UK (1976-78), and Boston, USA (1976-77), using incident male cases aged 21-89 and unmatched population-based controls. They identified 741 cases in Boston, 577 in Manchester and 348 in Nagoya. Interviews were obtained for 81% of the cases in Boston, 96% in Manchester and 84% in Nagoya; the corresponding figures for the controls were 80%, 90% and 80%. The analysis was limited to 430 cases and 397 controls in Boston, 399 cases and 493 controls in Manchester and 226 cases and 443 controls in Nagoya, for whom smoking histories were known. Occupational exposure to paint or paint manufacture was associated with a risk of bladder cancer only in the Boston population (Obs 35, RR 1.5, 95% CI 0.9 to 2.6), and not in the Manchester population (Obs 23, RR 0.7, 95% CI 0.4 to 1.3) or Nagoya population (Obs 5, RR 0.7, 95% CI 0.2 to 2.0). These relative risks were adjusted for age and smoking history.

Coggan et al, 1986b

Coggon et al (1986b) identified all 2,942 cases of cancer first diagnosed in one of three English counties in the period 1975-80 among males aged 18-54 years. Occupational and smoking histories were obtained either by mailed questionnaires or from information in hospital records or on death certificates. Cancer risks at 15 specific sites were calculated for various occupations using registrations at other sites as controls, adjusting for age, region, source of occupational data and smoking history. Bladder cancer was not associated with employment as a painter or decorator (Obs 10, RR 0.7, 95% CI .27 to 1.81).

Claude et al, 1986; Claude et al, 1988

Claude et al (1986) reported a hospital-based case-control study of tumours of the lower urinary tract, carried out in the Federal Republic of Germany. A total of 340 men and 91 women with such cancer between 1977 and 1982 were matched by age and sex to either hospital patients primarily from urology wards or, for those over 65, to people in homes for the elderly. Subjects were interviewed about occupations, specific exposures and life-style factors. There was no reported excess risk for the occupational category of painting, but the RRs associated with specific exposures suggested a risk of painting in men. Spray painting was associated with an increased risk for cancer of the lower urinary tract (RR 4.7, 95% CI 2.1 to 10.4; 28 cases in discordant pairs), as was exposure to lacquer (RR 1.6, 95% CI 0.98 to 2.5, 45 cases in discordant pairs). In order to examine occupational risks more extensively, an additional 191 male cases were included, to make a total of 531 cases (Claude et al., 1988). Painting as an occupation was associated with an increased risk for bladder cancer (Obs 15, RR 1.3, 95% CI 0.59 to 2.7). An examination of specific exposures indicated significant excess risks for cancer of the lower urinary tract for any exposure to spray paints (Obs 52, RR 2.9, 95% CI 1.7 to 4.9), to lacquer and paints (Obs 78, RR 1.5, 95% CI to 1.1 to 2.2) or to chromium/chromate (RR 2.2, 95% CI 1.4 to 3.5). After correction for smoking, a significant positive trend of increased risk with increasing duration of exposure for individuals exposed to spray paints and chromium/chromate could be seen.

Jensen et al, 1987

Jensen et al (1987) carried out an unmatched case-control study of bladder cancer in Denmark and interviewed 371 patients (280 men, 91 women) with invasive and non-invasive lesions diagnosed during 1979-81. The occupations of cases were compared with those of 771 controls (577 men, 194 women) selected from residents in the same area. Detailed occupational histories were taken, which included industry, type and place of work, and duration of work; the information was coded according to industry. Significantly more cases than controls were ever painters (employed in furniture lacquering and painting, industrial painting, sign-post painting, painting firms or car painting) (Obs 13, RR 2.54, 95% CI 1.12 to 5.73). There was a significant positive trend ($P = 0.02$) with duration of employment as a painter (1-19y: Obs 5, RR 1.6, 95% CI 0.5 to 5.5; ≥20y: Obs 8, RR 4.1, 95% CI 1.2 to 13.9).

Iscovich et al, 1987

Iscovich et al (1987) performed a matched case-control study of 117 bladder cancer cases diagnosed in Argentina in 1983-85 and individually matched on age and sex to 117 neighbourhood controls and 117 hospital controls. Hospital controls were selected from the same hospital as the case; about 12% of patients had diseases known to be associated with tobacco smoking. Neighbourhood controls were selected from persons living in the same street block as the cases. A detailed questionnaire, containing information on smoking, demographic, socioeconomic and medical variables and occupational history for the three occupations of longest duration as well as the most recent occupation was administered. No increased risk for bladder cancer was observed among painters (Obs 3, RR 0.55, 95% CI 0.12 to 2.5).

Siemiatycki et al, 1987

In the unmatched case-control study of Siemiatycki et al (1987), an increased risk for bladder cancer was seen among people exposed to white spirits, 21% of whom worked in construction trades, mostly comprising painting. Findings, however, were not shown for the category of painting and this study is not shown in our later summary tables.

Schifflers et al, 1987

A pilot case-control study of bladder cancer in Belgium (Schifflers et al, 1987) included 74 cases first diagnosed in the period 1984-85 and 203 population controls selected from electoral rolls and matched for age and sex. While cases were interviewed by the investigators, most of the controls were interviewed by others. A group of 16 jobs, including painting, were defined as hazardous and associated with a high risk for bladder cancer, but exposure to painting as a specific job did not show a significant excess.

Jensen et al, 1988

A matched case-control study from Denmark (Jensen et al, 1988) concentrated on cancers of the renal pelvis and urethra. The 96 cases, aged below 80, were identified from 27 hospitals in 1979-82; three hospital controls were matched to each case on hospital, age and sex. Patients with urinary tract and smoking-related diseases were not eligible as controls. Questionnaire data on smoking and on occupation and occupational exposures were obtained. An elevated risk for upper urinary tract cancer was associated with occupational exposure as painter or paint manufacturer, after adjustment for sex and lifetime tobacco consumption (Obs 10, RR 1.8, 95% CI 0.7 to 4.6).

Risch et al, 1988

A case-control study of bladder cancer was carried out during the period 1979-82 in Alberta and in Toronto, Ontario (Risch et al, 1988). Cases aged 35-79 were identified through a cancer institute, from a province-wide tumour registry in Alberta, and through review of hospital records in Ontario. Interviews were carried out with 835 (67%) of the cases (826 histologically verified) and 792 (53%) of the controls about jobs in 26 industries that had previously been examined in studies of bladder cancer, and on occupational exposures to fumes, dust, smoke and chemicals. The analysis was carried out on the 781 matched sets for which adequate information was available. Occupational exposure to paints in a full-time job for at least six months, eight to 28 years before diagnosis was not associated with an increased risk for bladder cancer in men (Obs 204, RR 1.1, 95% CI 0.77 to 1.6) but it was for women (Obs 14, RR 3.9, 95% CI 0.9 to 26.7). Little difference in risk was seen between commercial painters and spray painters.

González et al, 1989

González et al (1989) conducted a matched case-control study during 1985-1986 based on bladder cancer cases from 12 hospitals in five Spanish provinces. Cases consisted of 497 patients (438 males, 59 females) with pathologically confirmed bladder cancer. Two controls were selected for each case, matched by gender and age group, one hospital control (excluding patients diagnosed with chronic respiratory, cardiac or urinary tract conditions, or haematuria) and one population control. Interviews were conducted with all cases and controls to establish occupational history, including details of all jobs lasting more than six months, socioeconomic status, education level and smoking habits. RRs were calculated for each occupational group, adjusted for potential confounders (smoking and exposure to other high risk occupations). For male painters, the RR was 1.16 (Obs 17, 95% CI 0.7 to 2.0). No RR values were presented for women painters.

Silverman et al, 1989a

The association between occupation and bladder cancer risk was investigated among white males as part of the National Bladder Cancer Study, a population-based unmatched case-control study involving 10 geographic areas of the USA (Silverman et al, 1989a). The study involved all 2,100 cases of histologically confirmed bladder cancer diagnosed in white males during a one-year period during 1977-1978. Controls (approximately two for each case) were selected from the same areas by random-digit dialling or from Health Care Finance Administration lists. Controls were frequency matched to cases for age and geographic area (3874 white males). Information on occupational history, including details of jobs held for ≥6 months, was obtained by interview. Interviews of the cases were conducted within 3 months of diagnosis. Bladder cancer risks associated with ever employed in each occupation *versus* never employed were determined for each occupation with adjustment for smoking. For all painters combined (including artistic painters), the RR was 1.5 (Obs 116, 95% CI 1.2 to 2.0). Risks were calculated for different sub-groups of painters. For construction and maintenance painters, the RR was 1.5 (Obs 76, 95% CI 1.1 to 2.2); painters of manufactured articles had a RR of 1.8 (Obs 25, 95% CI 0.8 to 2.3); artistic painters had a RR of 1.8 (Obs 13, 95% CI 0.8 to 4.3) and sign painters had a RR of 1.1 (Obs 95% CI 0.3 to 3.7). Analysis of bladder cancer risk according to duration of employment showed a significant positive trend (P<0.001) for all painters combined; RRs were 1.7, 0.9, 1.6 and 1.9 for employment durations of <5, 5-9, 10-24 and ≥25 years respectively, based on 50, 14, 26 and 22 cases. This trend, however, is clearly reliant on the difference in risk between non-painters and painters, rather than on differences in the painting duration groups.

Silverman et al, 1989b

As part of the same National Bladder Cancer Study, a similar investigation of occupation and bladder cancer was conducted among non-white males using the same methodology reported in the previous study (Silverman et al, 1989b). This study involved 126 cases and 383 controls. The smoking adjusted RR for all painters combined was 1.2 (Obs 5, 95% CI 0.4 to 3.7). For construction and maintenance painters, the RR was 1.4 (Obs 4, 95% CI 0.4 to 5.4).

Bethwaite et al, 1990

Bethwaite et al (1990) conducted an umatched case-control study in New Zealand to investigate associations between specific cancer sites and work as a painter. The study involved male patients registered with the New Zealand Cancer Registry during the period 1980-1984, aged 20 years or more at registration. Information on occupation, defined as the subjects' current or most recent occupation at the time of registration, was available for 19,904 subjects. The number of cases was determined for each cancer site; the registrants for the other cancer sites formed the control group. Age-adjusted RRs were calculated for each cancer site for painters. With regard to bladder cancer, there were 912 cases; the remaining 18,992 cancer registrants formed the control group. The RR for bladder cancer in painters was 1.52 (Obs 24, 95% CI 1.00 to 2.31). RRs for bladder cancer in painters by age group were 2.27 (Obs 9, 95% CI 1.15 to 4.48) and 1.27 (Obs 15, 95% CI 0.75 to 2.15) for age-groups 20-59 years and ≥60 years, respectively.

La Vecchia et al, 1990

An unmatched case-control study of bladder cancer aetiology was conducted in northern Italy involving 263 cases of bladder cancer (219 males, 44 females) identified through local hospitals (La Vecchia et al, 1990). Controls consisted of 287 hospital patients (210 males, 77 females) admitted for non-cancer or non-urinary tract conditions. Information on demographics, smoking, alcohol consumption, diet and employment history was established by interview. Subjects were asked about employment in any of 19 specified industries/occupations and occupational exposure to any of 14 agents. For those ever employed in painting (including spray painting), the RR was 1.9 with adjustment for smoking (Obs 15, 95% CI 0.8 to 4.2).

Myslak et al, 1991

An unmatched case-control study of bladder cancer was conducted in the East Ruhr area of Germany by Myslak et al (1991). A total of 403 male cases bladder cancer cases were identified from three hospitals during 1984-1987. Controls comprised 426 patients with benign urological disease from the same hospital departments. Information about work history and smoking habits was obtained by postal questionnaire. Response rates were 82% and 84% for cases and controls, respectively. Subjects were assigned to the 'painter' occupational category if they had ever been employed as a painter for six months or more and had no previous employment in another occupation causally associated with bladder cancer. The RR for past employment as a painter was 2.76 (Obs 21, 95% CI 1.21 to 6.28).

Cordier et al, 1993

Occupational risks of bladder cancer were investigated in a hospital-based matched case control study conducted in France during the period 1984-1987 (Cordier et al, 1993). Cases comprised patients (658 males, 107 females) with histologically confirmed bladder cancer attending one of seven hospitals, either for first diagnosis or for treatment following earlier diagnosis. Controls consisted of an equal number of patients from the same hospitals (excluding patients with other cancer, patients with respiratory disease and patients with symptoms suggestive of bladder cancer. Controls were matched to each case by gender, age, ethnic origin and place of residence. Information on socio-demographics, smoking habits, beverage consumption and lifetime work history was obtained by interview. Details of jobs held for six months or more were recorded. RRs were calculated according to industry and occupation, with adjustment for hospital, age, place of residence and smoking. Bladder cancer risk for men ever employed as a painter *versus* never employed as a painter showed no increase (Obs 19, RR 0.97, 95% CI 0.50 to 1.88). There was, however, an elevated risk for the sub-category of spray painter (Obs 8, RR 6.41, 95% CI 0.79 to 51.85). Relative risks were not presented for female painters.

Barbone et al, 1994

An unmatched case-control study was conducted in the Province of Pordenone by Barbone et al (1994). The study involved 273 cases (236 males, 37 females) identified through clinical centres in the area between 1986 and 1990. Controls (573) were identified from hospital admissions, but excluded patients admitted with cancer or urinary tract disease. Information on employment, smoking, alcohol consumption, diet and demographics was determined by interview, conducted within 12 months of diagnosis for cases and within a few days of hospital admission for controls. Subjects were asked about employment in any of 18 specified industries/occupations and occupational exposure to any of 13 agents. Results were presented for males and females separately. For males ever employed in painting occupations the RR was 3.1, (Obs 6, 95% CI 0.7 to 13). No cases of bladder cancer were reported for female painters. Risks associated with exposure to certain agents were presented for 'dyes/paints' combined, providing no useful data for paints only.

Siemiatycki et al, 1994; Ramanakumar et al, 2008

An unmatched case-control study of bladder cancer, part of a large case-control study of cancer and occupation conducted in Canada during 1979-1986, was reported by Siemiatycki et al (1994). Cases of bladder cancer occurring amongst male residents of the Montreal area, aged 35-70 years were identified from all large hospitals in the area. The 484 cases were all newly diagnosed, histologically confirmed bladder cancers. A pooled control group was used in the study, comprising 533 population controls selected from electoral lists or by random digit-dialling plus 1879 cancer controls consisting of other cancer patients involved in the larger case-control study. Information on potential confounders and details of lifetime occupational history was obtained by interview. Face-to-face interviews were conducted for most cases; information was provided by proxies for a small number of cases. Bladder cancer risks were determined for each occupation according to duration of employment (<10 years; ≥10 years), with adjustments that included smoking, age, ethnicity and socioeconomic status. Results were reported separately for 'construction painters' and for 'other painters'. For construction painters, the RRs for the two employment durations were 1.2 (<10y: Obs 5, 95% CI 0.4 to 3.2) and 1.5 (≥10y: Obs 8, 95% CI 0.7 to 3.4). For other painters, bladder cancer risks were somewhat lower; RRs for the two employment duration categories were 1.1 (Obs 5, 95% CI 0.4 to 3.0) and 0.9 (Obs 4, 95% CI 0.3 to 2.7), respectively.

Ramanakumar et al (2008) investigated cancer risk in painting-related occupations with an analysis of (essentially) the same study materials. Cancer cases were identified from 18 hospitals during 1979-1986 and were limited to male Canadian citizens aged 35-70 years. The study involved 3,730 cancer cases and included 478 cases of bladder cancer. Examination of detailed occupational history enabled potential exposure to specific substances to be assessed for each subject. The substances included three paint-related agents: metal coatings, wood varnishes and stains, and wood and gypsum paints. Relative risks were adjusted for age, smoking and other possible confounders. For bladder cancer, there was no increased risk for those who had 'ever worked as a painter' (Obs 17, RR 1.0; 95% CI 0.3 to 2.7). Relative risks were also calculated for any association between bladder cancer risks and exposure to one of the three paint-related agents. The RR for 'substantial exposure' to metal coatings was 2.7 (Obs13, 95% CI 0.7 to 4.4). The RR for 'substantial exposure' to wood varnishes and stains was 1.7 (Obs 18, 95% CI 0.9 to 3.6), for wood and gypsum paints 1.0 (Obs 23, 95% CI 0.3 to 1.6), and any paint product 1.3 (Obs 37, 95% CI 0.7 to 2.2).

Porru et al, 1996

An unmatched hospital-based case-control study of bladder cancer was conducted in Brescia Province in northern Italy (Porru et al, 1996). Cases were identified from patients admitted to hospital for diagnosis of bladder cancer, treatment or follow-up during 1992-1993 and consisted of 355 subjects (275 males, 80 females). Controls were identified from the same hospital or from two additional hospitals from patients admitted for urological diseases other than cancer (579 subjects: 397 males, 182 females). Interviews were carried out to establish work history, smoking habits, alcohol and coffee consumption and socio-demographic characteristics. RRs were calculated for males and females separately, with adjustment for age, smoking, alcohol and coffee consumption, and other factors. Calculation of RRs according to job title showed a non-significant increased risk for male painters (Obs 12, RR 1.4; 95% CI 0.6 to 3.5). Findings were not shown for female painters.

Teschke et al, 1997

An unmatched case-control study of bladder cancer and nasal cancer was carried out in British Columbia (BC), Canada by Teschke et al (1997). With regard to bladder cancer, the study involved 105 cases registered with the BC Cancer Agency during the period September 1990 to May 1991, plus 139 population-based controls, frequency matched by age and gender. Information on occupational and medical history, smoking habits and other exposures was obtained by interview. RR estimates were adjusted for age, gender and smoking. For those ever employed as painters, the RR was 2.8 (Obs 4, 95% CI 0.4 to 21.3). When RRs were calculated with the most recent 20 years of employment removed, the RR for painters was 2.0 (Obs 2, 95% CI 0.1 to 33.0).

Pesch et al, 2000

Pesch et al (2000) conducted a multicentre, unmatched case-control study to examine urothelial cancer risk associated with occupational exposure to specific substances. This population-based study involved five regions of Germany and included 1035 incident cases of histologically confirmed urothelial cancer (704 males, 331 females) recruited during 1991-1995. Bladder cancer represented 90% of the male cases and

84% of the female cases. The remaining urothelial cancers affected the ureter or renal pelvis. Population controls were randomly selected from local residency registries and were frequency-matched to cases by region, gender and age. Controls included 2650 males and 1648 females. Information on lifestyle and occupational exposure was obtained by interview. Cases were interviewed within 6 months of first diagnosis. RRs adjusted for age, study centre and smoking were calculated for specific occupations or job tasks by duration of exposure. For male painters, RRs were 1.3 (Obs 12, 95% CI 0.6 to 2.6), 0.7 (Obs 6, 95% CI 0.3 to 1.6) and 1.6 (Obs 5, 95% CI 0.5 to 4.7) for medium, long and very long exposure durations, respectively. Exposure duration categories were defined by 30th, 60th and 90th percentiles of the distribution of exposure duration in exposed controls.

Zeegers et al, 2001

The association between bladder cancer and occupational exposure to specific agents, including paint components, was investigated in the Netherlands in a case-cohort study (Zeegers et al, 2001). A prospective cohort study of 58,279 men, resident in the Netherlands in 1986 was conducted. Follow-up for the sub-cohort was from 1986-1992; during this period cancer incidence was established by record linkage to cancer registries and a national database of pathology reports. The study involved 532 incident cases of bladder cancer and a sub-cohort of 1630 men without bladder cancer. Information on work history and other potential confounders was established by self-administered questionnaire completed at the beginning of the follow-up period. Based on this information, probability of exposure to each of four agents (paint components, PAHs, diesel exhausts, and aromatic amines) was determined by experts in the field. Four lifetime exposure categories were used, based on a probability weighting and duration of exposure: no exposure, low, medium and high exposure. It was not made clear what sort of occupations involved exposure to paint components nut not to paint. RRs were calculated for bladder cancer for low, medium and high exposure categories, adjusted for age, smoking and other occupational exposures. For paint components, the respective RRs were 0.75 (95% CI 0.22 to 1.72), 1.78 (95% CI 0.94 to 3.37) and 1.31 (95% CI 0.72 to 2.40), based on 8, 20 and 19 observed cases, respectively. The trend was not statistically significant (P = 0.09), and does not involve an analysis of known exposures.

Pelucchi et al, 2002

Pelucchi et al (2002) conducted an unmatched case-control study into the aetiology of bladder cancer in Italy. Cases comprised 110 females diagnosed in the period 1985-92 with histologically confirmed bladder cancer identified from hospitals in north-eastern Italy. Controls comprised 298 female patients from the same hospitals. Interviews were conducted to obtain information on sociodemographics, smoking, consumption of beverages, medical history, and occupational history. RRs were reported after adjustments for age, smoking, tea/coffee consumption, education, and study centre. A non-significantly elevated RR was obtained for ever employed in dyestuff and painting industries (Obs 3, RR 1.44, 95% CI 0.3 to 6.84). Findings were not presented separately for painters

Zheng et al, 2002

An unmatched case-control study carried out in Iowa, USA during 1986 to 1989 involved 1452 histologically confirmed cases of bladder cancer (1135 men, 317 women) identified through the State Registry (Zheng et al, 2002). A total of 2434 population controls (1601 men, 833 women) were frequency-matched by gender and age; subjects with a previous cancer diagnosis were excluded. Information on demographics, residence, smoking, medical and occupational history was obtained by postal questionnaire for most subjects; telephone interviews were carried out for remaining subjects. Detailed occupational histories were recorded for jobs held for five years or more. Relative risks were calculated for separately for occupations and industries, with adjustment for age, smoking and having a first-degree relative with bladder cancer. Bladder cancer risk was significantly increased for two groups of male painters. For the occupation 'construction and maintenance painters' the RR was 2.7 (Obs 11, 95% CI 1.0 to 7.7), with a RR of 1.4 for ≥10 years employment (Obs 6, 95% CI 0.4 to 4.7) For men employed in the painting and paperhanging industry the RR was 2.9 (Obs 9, 95% CI 0.9 to 9.1); with ≥10 years employment the RR was 1.9 (Obs 6, 95% CI 0.5 to 6.5). No results were presented for women painters.

Colt et al, 2004

Colt et al (2004) reported on a population-based case-control study of occupation and bladder cancer conducted in New Hampshire, USA. Bladder cancer cases diagnosed from 1994 to 1998 were identified from the State Cancer Registry. A total of 424 cases were included in the study, together with 645 population controls. Interviews were conducted to determine socio-demographic information, smoking habits, previous medical history and detailed occupational histories. Bladder cancer risk was calculated for each occupation for men and women separately. RRs were not specifically shown for painters, but were reported as being <1.3 for men employed as a 'painter' (Obs 12) or as a 'painter, construction and maintenance' (Obs 7). Fewer than 10 women were employed in either occupation, and results were not presented for female painters.

Gaertner et al, 2004

The association between bladder cancer and specific occupations was investigated in seven Canadian provinces in an unmatched population-based case-control study (Gaertner et al 2004). Incident cases of histologically confirmed bladder cancer were identified from provincial cancer registries during the period 1994-97. Population controls, frequency matched to cases by age and gender, were recruited by random digit-dialling or from health insurance databases. Postal questionnaires, together with follow-up by telephone if required, were used to obtain information on socio-demographics, occupational and smoking history, dietary habits and specific exposures. Data were analysed for 887 cases (535 men, 352 women) and 2847 controls. RRs were calculated for ever *versus* never employed in each occupation, with adjustment for province, ethnic origin, age, smoking and consumption of coffee and specific foods. Bladder cancer risk associated with employment as a painter showed no significant increase in either men or women. The RR in men was 0.74 (Obs 12, 95% CI 0.36 to 1.53) and in women was 1.08 (Obs 3, 95% CI 0.27 to 4.37).

Band et al, 2005

Band et al (2005) conducted an unmatched case-control study of cancer in Canada involving 1129 cases of bladder cancer in males aged ≥20 years identified during the period 1983 to 1990. Controls were 8,492 individuals with cancer of all other sites (excluding lung cancer and those with unknown primary site), frequency matched by age and year of diagnosis. Occupational history and information on smoking, alcohol consumption, education and ethnicity was obtained by self-administered questionnaire. For the occupation ever employed as 'painter, paperhanger and related' the RR was 1.53 (Obs 22, 95% CI 0.95 to 2.46). For usual occupation as 'painter, paperhanger and related' the RR was 1.37 (Obs 10, 95% CI 0.68 to 2.77).

Reulen et al, 2007

Reulen et al (2007) reported on a Belgian unmatched case-control study involving cases registered with a Regional Cancer Registry during 1996-2004. The study included 202 cases of histologically confirmed transitional carcinoma of the bladder (174 males, 28 females) and 390 population controls (231 males, 159 females), and excluded study subjects with a previously diagnosed bladder cancer. The response rate for controls was only 26%. Information on socio-demographic factors, lifetime smoking history and lifetime occupational history for jobs held for six months or more was obtained by interview. Relative risks adjusted for age, gender, smoking and educational level were calculated for each occupation. For those employed as painters and varnishers (males and females combined), there was a non-significant excess of bladder cancer (Obs 10, RR 2.2, 95% CI 0.7 to 7.2).

Dryson et al, 2008

A nationwide unmatched case-control study of bladder cancer was conducted in New Zealand by Dryson et al (2008). The study involved bladder cases reported to the national Cancer Registry during 2003-2004 and controls selected from the electoral roll. The final numbers of cases and controls were 213 and 471, respectively; the study had low response rates (64% for cases and 48% for controls). Information on demographics, smoking, ethnicity and occupational history was obtained by interview. Relative risks were calculated for specific occupations and/or industries with adjustment for age, gender, smoking and ethnicity. There was a non-significantly elevated risk for occupation as a painter and paperhanger (Obs 11, RR 1.42, 95% CI 0.56 to 3.60).

Samanic et al, 2008

Bladder cancer risk was investigated in a hospital-based matched case-control study in Spain by Samanic et al (2008). The study was conducted during the period 1998-2000 and involved 18 hospitals from five regions of Spain. Cases included 1159 patients aged 21-80 years newly diagnosed with bladder cancer (1013 men, 146 women). Controls were individually matched to each case by age, gender, race/ethnicity and hospital and were selected from hospital admissions with conditions unrelated to exposures linked to bladder cancer (1231 controls; 1066 men and 165 women). All participants were interviewed to establish information on occupational history, smoking habits, medical conditions, family history of cancer, diet and residential history. Details of each job held for six months or more were recorded. Bladder cancer risks were calculated for each industry or occupation for men and women separately, with adjustment for age, hospital region and smoking. For men ever employed as a painter, paperhanger or plaster, the RR was 1.60 (Obs 37, 95% CI 0.93 to 2.78). When risks for this occupational category were calculated according to duration of employment as a painter, the RR was 2.47 (Obs 20, 95% CI 1.08 to 5.64) for <10 years employment and 1.11 (Obs 17, 95% CI 0.53 to 2.32) for ≥10 years employment. Risks were not presented for women employed as painters, presumably due to small numbers.

Kobrosly et al, 2009

A unmatched case-control study of bladder cancer in Michigan, USA involving 418 cases aged between 21-80 years and diagnosed during 2000-2004 was carried out by Kobrosly et al (2009). Population controls (n=571) were frequency matched by age, gender and race. Occupational histories were obtained by interview, together with demographic information and data on life-time smoking habits. For ever painters in the automotive industry (manual painters and those operating painting machinery) the RR was 5.41 (Obs 6, 95% CI 0.63 to 46.44). For those workers 'usually employed' as a painter in the automotive industry the RR was 3.05 (Obs 3, 95% CI 0.30 to 30.78).

2.3.2.1 Summary of case-control studies into bladder cancer

A summary of the overall findings for occupation as a painter in case-control studies carried out into the aetiology of bladder cancer in shown in Table 11. A meta-analysis using a fixed effects model provides a significantly elevated relative risk (RR 1.37, 95% CI 1.23 to 1.52). A corresponding meta-analysis using a random effects model produced the same summary (RR 1.37, 95% CI 1.23 to 1.52). There was no significant heterogeneity in the set of risk estimates (P = 0.75). Other meta-analyses have produced slightly lower meta-estimates. Guha et al (2010b) present a summary relative risk (random effects) estimate of 1.29 (95% CI 1.17 to 1.42) for case-control studies, whilst Bachand et al (2010) present a summary relative risk (random effects) estimate of 1.28 (95% CI 1.17 to 1.41). Chance thus provides no realistic explanation for the elevated risks shown for painters in the available case-control studies. Adjustment for smoking was carried out in most of these studies, and whilst the adjustment can never be perfect, confounding by smoking is also unlikely to explain the positive findings. Bias, the perennial scourge of case-control studies that rely on self-reported data supplied by non-random samples of volunteers, is more difficult to exclude.

2.3.3 Leukaemia

A summary of findings for case-control studies relating to leukaemia is shown in Table 12, for the sake of completeness. Given the absence of any discernible excesses for this disease in cohort studies we attach little importance to these findings.

2.3.4 Cancer sites other than bladder cancer, lung cancer or leukaemia

A summary of findings for case-control studies relating to sites of cancer other than lung cancer, bladder cancer or leukaemia is shown in Table 13, for the sake of completeness. Confident interpretation is not possible.

3.0 Discussion and conclusions

There is an extensive epidemiological literature on cancer risks in commercial painters. Unfortunately, it is dominated by case-control studies. There is a well understood potential for bias in such studies, but this potential does not appear to have dampened the enthusiasm of their advocates, neither researchers nor sponsors. Nevertheless, taken at face value the case-control literature suggests that elevated cancer risks are shown in painters for bladder cancer and lung cancer. Chance and confounding from smoking can be excluded as explanations for these elevated risks. Unfortunately even for case-control studies that appear to have been well carried out and have 'good' response rates, it is never possible to conclude that any particular study variable has attracted unbiased information, unless the case-control data is checked with other sources. Convincing evidence of effects in humans usually requires the demonstration in cohort studies of cancer risks varying, at least approximately with exposure (or a surrogate of exposure). Unfortunately, the data assembled for the cohort studies has been so limited that such analyses have not, in the main, been attempted. The overall cohort findings suggest, however, that painters do not suffer from discernible excess risks for leukaemia but that they may well suffer from occupational cancer risks for lung cancer and possibly also from bladder cancer. It is not possible to identify a group, either by type of painting or by duration of painting that suffers a doubling of risk.

It is possible to be fairly confident that discernible cancer risks have not been present for paint manufacturers. By extrapolation, it seems reasonable to conclude that exposures shared by paint manufacturers and painters (both chemicals and levels of exposure) can not be responsible for any excess risks in painters.

To conclude in the style of the original questions put before us by IIAC, the published epidemiological data indicate a significantly increased risk of lung cancer and bladder cancer in commercial painters but not in paint manufacturers, compared with rates in the general population. However, the elevated risks in painters for these two sites of cancer are not doubled compared to background risks. The elevated risk of lung cancer in painters may be due, at least in part, to confounding from smoking. It is common, of course, for occupational cohorts not to include information on smoking and this is why it is particularly important to have contrasts (eg dose-response effects) within a dataset because it will often be safe to assume that smoking habits will not have influenced these contrasts.

Table 1. Findings for lung cancer and bladder cancer from Steenland and Palu, 1999, by period from joining the Union.

Period from joining Union (y)	Obs	Exp	SMR	(95% CI)
Lung cancer				
1-19	386	322.7	1.20	
≥20	1360	1096.8	1.24	(1.18 to 1.31)
Total	1746	1419.5	1.23	(1.17 to 1.29)
Bladder cancer				
1-19	20	18.2	1.10	
≥20	146	116.8	1.25	(1.06 to 1.47)
Total	166	135.0	1.23	(1.05 to 1.43)

Table 2. Definition of occupational cohorts for painters.

Author	Country	Cohort		Type	Definition	Follow-up period
		Size	Source			
Englund 1980; Engholm and Englund, 1982	Sweden	30,580	Union records	Census	Members in 1966	1966-74
Whorton et al, 1983	USA	2,197	Union records	Census	Members in 1976/77	1976-80
Gubéran et al 1989	Switzerland	1,916	Census records (1970)	Census		1971-84
Alexander et al, 1996	USA	2,429	Company records	Entry and census	Employment ≥6mnths	1974-94
Van Loon et al, 1997	Netherlands	58,279	General population	Census	Males aged 55-69yr	1986-90
Boice et al, 1999	USA	1,216	Company records	Entry and census	Employed ≥1yr since 1960	1960-96
Chen et al, 1999	Scotland	1,292 (PMR)	Single workplace	Entry and census	Employed ≥1yr 1950-92 Born 1900-29	1960-94
		309 (SMR)				1975-94
Steenland and Palu, 1999	USA	42,170	Union records	Active and retired	Born before 1940; alive end of 1974	1975-94
Brown et al, 2002	Sweden	42,433	Census records (1960 and/or 1970)	Census	Employed in 1960 or 1970	1971-89
Pronk et al, 2009	China	71,067 (201/970 painters)	Resident offices	Census	Never-smoking females with employment experience	1996-2005
Pukkala et al, 2009	Nordic countries	14.9 million	Census records (1960, 1970, 1980/81 and/or 1990)	Census	Aged 30-64 yr economically active on entry	Census date to 2005/6

Table 3. Findings for lung cancer in key occupational cohort studies of painters.

Study	Obs	Exp	SMR/SIR	(95% CI)
Englund 1980; Engholm and Englund, 1982	81	63.3	1.28[b]	(1.03 to 1.59)
Whorton et al, 1983	15	7.5	1.99[b]	(1.12 to 3.30)
Gubéran et al, 1989	40	27.3	1.47[b]	(1.08 to 1.99)
Alexander et al, 1996	15	19.5	0.77[b]	(0.43 to 1.27)
Boice et al, 1999	41	36.9	1.11[a]	(0.80 to 1.51)
Chen et al, 1999	16	14.3	1.12[a]	(0.64 to 1.82)
Steenland and Palu, 1999	1,746	1,419.5	1.23[a]	(1.17 to 1.29)
Brown et al, 2002	548	456.7	1.20[b]	(1.10 to 1.30)
Pukkala et al, 2009	3,418 (m) 47 (f)	2,778.9 24.7	1.23[b] 1.90[b]	(1.19 to 1.28) (1.40 to 2.53)
Total	5,967	4,848.5	1.23	(1.20 to 1.26)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 4. Findings for bladder cancer in occupational cohort studies of painters.

Study	Obs	Exp	SMR/SIR	(95% CI)
Whorton et al, 1983	3	2.3	1.31[b]	(0.27 to 3.81)
Gubéran et al, 1989	13	7.6	1.71[b]	(0.91 to 2.92)
Chen et al, 1999	4	1.3	3.05[a]	(0.83 to 7.82)
Steenland and Palu, 1999	166	135.0	1.23[a]	(1.05 to 1.43)
Brown et al, 2002	344	312.7	1.10[b]	(1.00 to 1.22)
Pukkala et al, 2009	1,642 (m)	1,520.4	1.08[b]	(1.03 to 1.14)
	15 (f)	9.9	1.52[b]	(0.85 to 2.51)
Total	2,172	1,979.3	1.10	(1.05 to 1.14)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 5. Findings for leukaemia in occupational cohort studies of painters.

Study	Obs	Exp	SMR/SIR	(95% CI)
Englund 1980; Engholm and Englund, 1982	13	7.5	1.73[b]	(0.92 to 2.96)
Whorton et al, 1983	2	0.9	2.15[b]	(0.26 to 7.76)
Gubéran et al, 1989	1	2.3	0.43[b]	(0.91 to 2.92)
Boice et al, 1999	3	4.1	0.74[a]	(0.15 to 2.16)
Steenland and Palu, 1999	138	150.0	0.92[a]	(0.78 to 1.11)
Brown et al, 2002	115	127.8	0.90[b]	(0.75 to 1.08)
Pukkala et al, 2009	475(m)	489.7	0.97[b]	(0.88 to 1.06)
	6(f)	9.0	0.67[b]	(0.25 to 1.46)
Total	753	791.3	0.95	(0.89 to 1.02)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 6. Definition of occupational cohorts for paint manufacturers.

Author	Country	Cohort Size	Cohort Source	Type	Definition	Follow-up period
Bertazzi et al, 1981	Italy	427	Factory records	Entry + census	Employed 1946-77	1954-78
Morgan et al, 1981	USA	16,243	Factory records	Entry + census	Employed 1946-76	1946-76
Lundberg and Milatou-Smith, 1998	Sweden	411	Factory records	Entry + census	Employed 1955-75	1961-94

Table 7. Findings for lung cancer in key occupational cohort studies of paint manufacturers.

Study	Obs	Exp	SMR/SIR	(95% CI)
Bertazzi et al, 1981	8	3.5	3.34[a]	(1.44 to 6.58)
Morgan et al, 1981	150	153.1	0.98[a]	(0.84 to 1.15)
Lundberg and Milatou-Smith, 1998	10	9.0	1.11[a]	(0.53 to 2.04)
Total	168	165.6	1.01	(0.87 to 1.18)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 8. Findings for bladder cancer in occupational cohort studies of paint manufacturers.

Study	Obs	Exp	SMR/SIR	(95% CI)
Morgan et al, 1981	16	16.3	0.98[a]	(0.56 to 1.59)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 9. Findings for leukaemia in occupational cohort studies of paint manufacturers.

Study	Obs	Exp	SMR/SIR	(95% CI)
Morgan et al, 1981	20	21.7	0.92[a]	(0.56 to 1.42)
Lundberg and Milatou-Smith, 1998	3	2.1	1.43[b]	(0.29 to 4.18)
Total	23	23.8	0.97	(0.61 to 1.45)

a. SMR for mortality data.
b. SIR for cancer incidence data.

Table 10. Case-control studies of lung cancer with findings for paint manufacture and painting.

Reference[a]	Location, time	Controls Type	Source	Exposure	No. of cases	Exposed cases (n)	RR	(95% CI)
Breslow (1954)	USA, 1949-52	Hospital	Interview	Construction and maintenance painter	518 m+f	22	1.9	(0.9 to 3.8)
Viadana (1976); Decouflé (1977); Houten (1977)	USA, 1956-65	Non-cancer admissions	Interview at admission	Painter		42	1.7	NG
Coggon (1986a)	UK, 1975-80	Other cancers	Interview	Painter	738 m	20	1.3	NG
Kjuus (1986)	Norway, 1979-83	Hospital	Interview and worksite records	Painting and paperhanging	176 m	5	1.7	(0.4 to 7.3)
Lerchen (1987)	USA, 1980-82	Population and rosters of elderly	Interview	Construction painter	333 m	9	2.7	(0.8 to 8.9)
Levin (1988)	China, 1984-85	Population	Interview	Painter	733 m	15	1.4	(0.5 to 3.5)
Ronco (1988)	Italy, 1976-80	Deaths without smoking-related diseases	Interview	Painter	164 m	5	1.3	(0.4 to 4.1)
Bethwaite (1990)	New Zealand, 1980-1984	Other cancers	Cancer Registry	Painter	4224 m	88	1.12	(0.93 to 1.52)
Burns (1991)	USA (no date provided)	Colon or rectum cancers	Interview	Painter	5935 m+f	97	1.96	(1.23 to 3.13)
Notani (1993)	India, 1986-1990	Hospital admissions	Interview	Painter	246 m	6	1.62	(0.4 to 7.0)
De Stefani (1996)	Uraguay, 1993-1994	Other cancers	Interview	Painter	270 m	18	1.2	(0.6 to 2.4)
Muscat (1998)	USA, 1978-1996	Hospital admissions	Interview	Occupational exposure to paint	365 m 185 f	3 5	0.7 1.8	(0.3 to 1.1) (0.3 to 12.3)
Wünsch-Filho (1998)	Brazil, 1990-1991	Hospital admissions	Interview	Painter	307 m	128	0.77	(0.56 to 1.08)
Jahn (1999)	Germany, 1988-	Population	Interview	Painter	686 f	13	3.0	(0.73 to 12.33)

Reference[a]	Location, time	Controls		Exposure	No. of cases	Exposed cases (n)	RR	(95% CI)
		Type	Source					
	1993 and 1990-1996							
Brüske-Hohlfeld (2000)	Germany, 1988-1996	Population	Interview	Painter	3,498 m	147	1.42	(1.05 to 1.92)
Pezzotto (1999)	Argentina, 1992-1998	Hospital admissions	Interview	House painter	367 m	4	2.4	(0.4 to 19.4)
Matos (2000)	Argentina, 1994-1996	Hospital admissions	Interview	Painter (general)	199 m	16	1.2	(0.5 to 2.4)
				Painter (blowtorch)		8	1.4	(0.5 to 4.4)
Pohlabeln (2000)	Europe, 1988-1994	Population and/or hospital	Interview	Construction painter (non-smokers)	141 m	6	1.84	(0.59 to 5.74)
					509 f	2	NG	NG
Richiardi (2004)	Italy, 1990-1992	Population	Interview	Painter (construction, automotive + other)	956 m	61	1.7	(1.1 to 2.8)
De Stefani (2005)	Uraguay, 1994-2000	Hospital admissions	Interview	Painter	338 m	26	1.8	(1.0 to 3.1)
Zeka (2006)	Europe, 1998-2002	Hospital admissions or population	Interview	Painter (non-smokers)	48 m	0	-	-
					175 f	6	1.8	(0.53 to 6.0)

RR, relative risk; CI, confidence interval; NG, not given.
a. first author only.

Table 11. Case-control studies of bladder cancer with findings for paint manufacture and painting.

Reference[a]	Location, time	Controls: Type	Controls: Source	Exposure	No. of cases	Exposed cases (n)	RR	(95% CI)
Wynder (1963)	USA, 1957-61	Hospital, without smoking-related disease	Interview	Painter	300 m	18	2.2	(1.0 to 4.5)
Cole (1972)	USA, 1967-68	General population	Interview	Painter	461 m	28	1.2	(0.7 to 1.9)
Viadana (1976); Decouflé (1977); Houten (1977)	USA, 1956-65	Non-cancer admissions	Interview at admission	Painter	_	16	1.6	NG
Howe (1980)	Canada, 1974-76	Neighbourhood	Interview	Commercial painting	480 m	-	1.0	(0.6 to 2.3)
				Spray painting		-	1.8	(0.7 to 4.6)
Silverman (1983)	USA, 1977-78	Population	Interview	Painter	303 m	15	1.0	(0.5 to 2.2)
				Car painter		3	0.5	(0.1 to 2.1)
				Paint manufacture		1	0.2	(0.02 to 2.2)
Schoenberg (1984)	USA, 1978-79	Population	Interview	Painter	658 m	34	1.4	(0.85 to 2.3)
Morrison (1985)	USA, UK, Japan, 1976-78	Population	Interview	Paint or paint manufacture	USA, 430 m	35	1.5	(0.9 to 2.6)
					UK, 399 m	23	0.7	(0.4 to 1.3)
					Japan, 226 m	5	0.7	(0.2 to 2.0)
Vineis (1985)	Italy, 1978-83	Hospital; other urological and surgical	Interview	Painter (building industry)	512 m	12	1.0	(0.40 to 2.2)
				Car painter		7	2.0	(0.6 to 7.0)
				Carpentry painter		1	0.6	(0.04 to 8.4)
				Spray painter in different industries		2	1.2	(0.2 to 5.8)
Coggon (1986b)	UK, 1975-80	Other cancers	Interview	Painter	179 m	10	0.7	NG

Jensen (1987)	Denmark, 1979-81	Population	Interview	Painter	371 m+f	13	2.5	(1.1 to 5.7)
Iscovich (1987)	Argentina, 1983-85	Neighbourhood and hospital	Interview	Painter	117 m+f	3	0.55	(0.12 to 2.5)
Claude (1988)	FRG, NG	Hospital urological and homes for elderly	Interview	Painter	531 m	15	1.3	(0.6 to 2.7)
Risch (1988)	Canada, 1979-82	Population	Interview	Painter	781 m+f	204 m	1.1	(0.9 to 26.7)
						14 w	3.9	(0.9 to 26.7)
González (1989)	Spain, 1985-86	Hospital admissions and population	Interview	Painter	438 m	17	1.16	(0.7 to 2.0)
Silverman (1989a)	USA,1977-78	Population	Interview	Painter	2100 m (white)	116	1.5	(1.2 to 2.0)
Silverman (1989b)	USA, 1977-78	Population	Interview	Painter	126 m (non-white)	5	1.2	(0.4 to 3.7)
Bethwaite (1990)	New Zealand, 1980-84	Other cancers	Cancer Registry	Painter	912 m	24	1.52	(1.00 to 2.31)
La Vecchia (1990)	Italy, 1985-88	Hospital admissions (non-cancer or URT disease)	Interview	Painter	263 m+f	15	1.8	(0.8 to 4.2)
Myslak (1991)	Germany, 1984-87	Hospital admissions (benign urological disease)	Postal questionnaire	Painter	403 m	21	2.76	(1.21 to 6.28)
Cordier (1993)	France, 1984-87	Hospital admissions	Interview	Painter	658 m	19	0.97	(0.50 to 1.88)
Barbone (1994)	Italy, 1986-90	Hospital admissions (non-cancer or urinary tract disease)	Interview	Painter	236 m	6	3.1	(0.7 to 13.0)
					37 f	0	0.0	-
Porru (1996)	Italy, 1992-93	Hospital admissions (urological, non-cancer disease)	Interview	Painter	275 m	12	1.4	(0.6 to 3.5)
Teschke (1997)	Canada, 1990-91	Population	Interview	Painter	105 m+f	4	2.8	(0.4 to 21.3)
Pesch (2000)	Germany, 1991-95	Population	Interview	Painter – medium duration	704 m (in total)	12	1.3	(0.6 to 2.6)

				- long duration		6	0.7	(0.3 to 1.6)
				- very long duration		5	1.6	(0.5 to 4.7)
Zeegers (2001)	Netherlands, 1986-92	Sub-cohort	Self-administered questionnaire	Paint components – low cum. Exposure	532m (in total)	8	0.75	(0.33 to 1.72)
				- medium cum. exposure		20	1.78	(0.94 to 3.37)
				- high cum. Exposure		19	1.31	(0.72 to 2.40)
Zheng (2002)	USA, 1986-89	Population	Postal questionnaire	Painter (construction & maintenance)	1135 m	11	2.7	(1.0 to 7.7)
Gaertner (2004)	Canada, 1994-97	Population	Postal questionnaire	Painter	535 m	12	0.74	(0.36 to 1.53)
					352 f	3	1.08	(0.27 to 4.37)
Band (2005)	Canada, 1983-90	Other cancers	Self-administered questionnaire	Ever employed as painter, paperhanger and related	1125m	22	1.53	(0.95 to 2.46)
Reulen (2007)	Belgium, 1996-2000	Population	Interview	Painter and varnisher	202 m+f	10	2.2	(0.7 to 7.2)
Dryson (2008)	New Zealand, 2003-04	Population	Interview	Painter and paperhanger	213 m+f	11	1.42	(0.56 to 3.60)
Ramankumar (2008)	Canada, 1979-86	Pooled population + other cancers	Interview	Painter	478 m	17	1.0	(0.3 to 2.7)
Samanic (2008)	Spain, 1998-2000	Hospital admissions	Interview	Painter, paperhanger or plaster	1013 m	37	1.60	(0.93 to 2.78)
Kobrosly (2009)	USA, 2000-04	Population	Interview	Painter (automotive industry)	418 m+f	6	5.41	(0.63 to 46.4)

RR, relative risk; CI, confidence interval; NG, not given.
a. first author only.

Table 12. Case-control studies of leukaemia with findings for paint manufacture and painting.

Reference[a]	Location, time	Controls Type	Controls Source	Exposure	No. of cases	Exposed cases (n)	RR	(95% CI)
Viadana (1972)	USA, 1959-62	Population	Interview	Painter	845 m	31	2.8	(1.4 to 6.0)
Timonen (1978)	Finland, 1973-1977	Hospital	Interview	Paint containing benzene derivatives and lead	45 m+f	4	1.0	–
Flodin (1986)	Sweden, 1977-82	Population	Interview	Painter	59 m+f			
Lindquist (1987)	Sweden, 1980-83	Population	Interview	Painter	125 m+f	13	13	(2.0 to 554)
Costantini (2001)	Italy, 1991-93	Population	Interview	Painter	383 m	10	1.7	(0.8 to 3.8)
McLean (2009)	New Zealand, 2003-04	Population	Interview	Painter and paperhanger	225 m+f	4	0.61	(0.18 to 2.07)

RR, relative risk; CI, confidence interval; NG, not given.
a. first author only.

Table 13. Case-control studies for sites of cancer other than bladder, lung or leukaemia with findings for paint manufacture and painting.

Reference[a]	Location, time	Cancer site	Exposure	No. of cases	Exposed cases (n)	RR	(95% CI)
Bethwaite (1990)	New Zealand, 1980-1984	Kidney	Painter	542 m	14	1.45	0.85-2.50
		Multiple myeloma	Painter	295 m	10	1.95	1.05-3.65
Huebner (1992)	USA, 1984-1985	Oral cavity and pharynx	Painter	762 m	22	1.18	0.58-2.39
				352 f	7	1.12	0.37-3.36
Wortley (1992)	USA, 1983-1987	Larynx	Painter	235 m+f	14	2.8	1.1-6.9
Teschke (1997)	Canada, 1990-1992	Nasal cavity	Painter	48 m+f	2	2.2	0.2-17.9
Kaerlev (2002)	Europe, 1995-1997	Small bowel	Construction painter	84 m+f	3	3.3	0.9-12.0
Boffetta (2003)	Europe, 1980-1983	Larynx/hypopharynx	Construction painter	1,010 m	18	1.36	0.67-2.74
Rajaraman (2004)	USA, 1994-1998	Brain	Auto body painter	197 m+f	2	6.4	1.0-40.2
			Painter		2	0.5	0.1-2.2

RR, relative risk; CI, confidence interval; NG, not given.
a. first author only.

References

Alexander, B H, Checkoway, H, Wechsler, L, Heyer, N J, Muhm, J M and O'Keeffe, T.P. Lung cancer in chromate-exposed aerospace workers. *J.Occup.Environ.Med.* 1996;38:1253-1258.

Bachand, A, Mundt, K A, Mundt, D J and Carlton, L E. Meta-analyses of occupational exposure as a painter and lung and bladder cancer morbidity and mortality 1950-2008. *Crit.Rev.Toxicol.* 2010;40:101-125.

Band, P R, Le, N D, MacArthur, A C, Fang, R and Gallagher, R P. Identification of occupational cancer risks in British Columbia: A population-based case-control study of 1129 cases of bladder cancer. *J.Occup.Environ.Med.* 2005;47:854-858.

Barbone, F, Franceschi, S, Talamini, R, Bidoli, E and La Vecchia, C. Occupation and bladder cancer in Pordenone (north-east Italy): A case-control study. *Int.J.Epidemiol.* 1994;23:58-65.

Bardin-Mikolajczak, A, Lissowska, J, Zaridze, D, et al. Occupation and risk of lung cancer in Central and Eastern Europe: The IARC multi-center case-control study. *Cancer Causes Control.* 2007;18:645-654.

Bertazzi, P A, Zocchetti, C, Terzaghi, G F, Riboldi, L, Guercilena, S and Beretta, F. [Cancerogenic risk in the production of paints and varnishes. Mortality study]. *Med.Lav.* 1981;72:465-472.

Bethwaite, P B, Pearce, N and Fraser, J. Cancer risks in painters: Study based on the New Zealand cancer registry. *Br.J.Ind.Med.* 1990;47:742-746.

Boffetta, P, Richiardi, L, Berrino, F, et al. Occupation and larynx and hypopharynx cancer: An international case-control study in France, Italy, Spain, and Switzerland. *Cancer Causes Control.* 2003;14:203-212.

Boice, J D, J., Marano, D E, Fryzek, J P, Sadler, C J and McLaughlin, J K. Mortality among aircraft manufacturing workers. *Occup.Environ.Med.* 1999;56:581-597.

Breslow, L, Hoaglin, L, Rasmussen, G and Abrams, H K. Occupations and cigarette smoking as factors in lung cancer. *Am.J.Public Health Nations Health.* 1954;44:171-181.

Brown, L M, Moradi, T, Gridley, G, Plato, N, Dosemeci, M and Fraumeni,Joseph F.,,Jr. Exposures in the painting trades and paint manufacturing industry and risk of cancer among men and women in Sweden. *J.Occup.Environ.Med.* 2002;44:258-264.

Brüske-Hohlfeld, I, Möhner, M, Pohlabeln, H, et al. Occupational lung cancer risk for men in Germany: Results from a pooled case-control study. *Am.J.Epidemiol.* 2000;151:384-395.

Burns, P B and Swanson, G M. The occupational cancer incidence surveillance study (OCISS): Risk of lung cancer by usual occupation and industry in the Detroit metropolitan area. *Am.J.Ind.Med.* 1991;19:655-671.

Chen, R, Dick, F and Seaton, A. Health effects of solvent exposure among dockyard painters: Mortality and neuropsychological symptoms. *Occup.Environ.Med.* 1999;56:383-387.

Claude, J, Kunze, E, Frentzel-Beyme, R, Paczkowski, K, Schneider, J and Schubert, H. Life-style and occupational risk factors in cancer of the lower urinary tract. *Am.J.Epidemiol.* 1986;124:578-589.

Claude, J C, Frentzel-Beyme, R R and Kunze, E. Occupation and risk of cancer of the lower urinary tract among men. A case-control study. *Int.J.Cancer.* 1988;41:371-379.

Coggon, D, Pannett, B, Osmond, C and Acheson, E D. A survey of cancer and occupation in young and middle aged men. I. Cancers of the respiratory tract. *Br.J.Ind.Med.* 1986a;43:332-338.

Coggon, D, Pannett, B, Osmond, C and Acheson, E D. A survey of cancer and occupation in young and middle aged men. II. Non-respiratory cancers. *Br.J.Ind.Med.* 1986b;43:381-386.

Cole, P, Hoover, R and Friedell, G H. Occupation and cancer of the lower urinary tract. *Cancer.* 1972;29:1250-1260.

Colt, J S, Baris, D, Stewart, P, et al. Occupation and bladder cancer risk in a population-based case-control study in New Hampshire. *Cancer Causes Control.* 2004;15:759-769.

Cordier, S, Clavel, J, Limasset, J C, et al. Occupational risks of bladder cancer in France: A multicentre case-control study. *Int.J.Epidemiol.* 1993;22:403-411.

Costantini, A S, Miligi, L, Kriebel, D, et al. A multicenter case-control study in Italy on hematolymphopoietic neoplasms and occupation. *Epidemiology.* 2001;12:78-87.

Decouflé, P, Stanislawczyk, K, Houten, L, Bross, I D J and Viadana, E. *A retrospective survey of cancer in relation to occupation* (DHEW (NIOSH) Publ. No. 77-178), 1977, Cincinnati, OH, NIOSH.

De Stefani, E, Kogevinas, M, Boffetta, P, Ronco, A and Mendilaharsu, M. Occupation and the risk of lung cancer in Uruguay. *Scand.J.Work Environ.Health.* 1996;22:346-352.

De Stefani, E, Boffetta, P, Brennan, P, Deneo-Pellegrini, H, Ronco, A and Gutiérrez, L P. Occupational exposures and risk of adenocarcinoma of the lung in Uruguay. *Cancer Causes Control.* 2005;16:851-856.

Doll R. Occupational cancer: problems in interpreting human evidence. *Ann.Occup.Hyg.* 1984;28:291-305.

Dryson, E, 't Mannetje, A, Walls, C, et al. Case-control study of high risk occupations for bladder cancer in New Zealand. *Int.J.Cancer.* 2008;122:1340-1346.

Englund, A. Cancer incidence among painters and some allied trades. *J.Toxicol.Environ.Health.* 1980;6:1267-1273.

Engholm, G and Englund, A. Cancer incidence and mortality among Swedish painters. In: Englund,A, Ringen, K and Mehlman, M A, eds, *Advances in Modern Environmental Toxicology, Vol. II, Occupational Health Hazards of Solvents,* Princeton Scientific Publishers, 1982, 173-185.

Flodin, U, Fredriksson, M, Persson, B, Hardell, L and Axelson, O. Background radiation, electrical work, and some other exposures associated with acute myeloid leukemia in a case-referent study. *Arch.Environ.Health.* 1986;41:77-84.

Gaertner, R R W, Trpeski, L and Johnson, K C. A case-control study of occupational risk factors for bladder cancer in Canada. *Cancer Causes Control.* 2004;15:1007-1019.

González, ,C.A., López-Abente, G, Errezola, M, et al. Occupation and bladder cancer in Spain: A multi-centre case-control study. *Int.J.Epidemiol.* 1989;18:569-577.

Gubéran, E, Usel, M, Raymond, L, Tissot, R and Sweetnam, P M. Disability, mortality, and incidence of cancer among Geneva painters and electricians: A historical prospective study. *Br.J.Ind.Med.* 1989;46:16-23.

Guha, N, Merletti, F, Steenland, N K, Altieri, A, Cogliano, V and Straif, K. Lung cancer risk in painters: A meta-analysis. *Environ.Health Persp*ect.2010a;118:303-312.

Guha, N, Steenland, N K, Merletti, F, Altieri, A, Cogliano, V and Straif, K. Bladder cancer risk in painters: A meta-analysis. 2010b in press

Houten, L, Bross, I D, Viadana, E and Sonnesso, G. Occupational cancer in men exposed to metals. *Adv.Exp.Med.Biol.* 1977;91:93-102.

Howe, G R, Burch, J D, Miller, A B, et al. Tobacco use, occupation, coffee, various nutrients, and bladder cancer. *J.Natl.Cancer Inst.* 1980;64:701-713.

Huebner, W W, Schoenberg, J B, Kelsey, J L, et al. Oral and pharyngeal cancer and occupation: A case-control study. *Epidemiology.* 1992;3:300-309.

IARC Monographs on the evaluation of carcinogenic risks to humans. Vol 47. Occupational exposures in paint manufacturing and painting. International Agency for Research on Cancer, Lyon, 1989.

IARC Monographs on the evaluation of carcinogenic risks to humans. Shift work, painting and firefighting. International Agency for Research on Cancer, Lyon, in press.

Iscovich, J, Castelletto, R, Estève, J, et al. Tobacco smoking, occupational exposure and bladder cancer in Argentina. *Int.J.Cancer.* 1987;40:734-740.

Jahn, I, Ahrens, W, Brüske-Hohlfeld, I, et al. Occupational risk factors for lung cancer in women: Results of a case-control study in Germany. *Am.J.Ind.Med.* 1999;36:90-100.

Jensen, O M, Wahrendorf, J, Knudsen, J B and Sørensen, ,B.L. The Copenhagen case-referent study on bladder cancer. risks among drivers, painters and certain other occupations. *Scand.J.Work Environ.Health.* 1987;13:129-134.

Jensen, O M, Knudsen, J B, McLaughlin, J K and Sørensen, B L. The Copenhagen case-control study of renal pelvis and ureter cancer: Role of smoking and occupational exposures. *Int.J.Cancer.* 1988;41:557-561.

Kaerlev, L, Teglbjaerg, P S, Sabroe, S, et al. Occupational risk factors for small bowel carcinoid tumor: A European population-based case-control study. *J.Occup.Environ.Med.* 2002;44:516-522

Kjuus, H, Skjaerven, R, Langård, S, Lien, J T and Aamodt, T. A case-referent study of lung cancer, occupational exposures and smoking. I. Comparison of title-based and exposure-based occupational information. *Scand.J.Work Environ.Health.* 1986;12:193-202.

Kobrosly, R W, Meliker, J R and Nriagu, J O. Automobile industry occupations and bladder cancer: A population-based case-control study in Southeastern Michigan, USA. *Occup.Environ.Med.* 2009;66:650-656.

la Vecchia, C, Negri, E, D'Avanzo, B and Franceschi, S. Occupation and the risk of bladder cancer. *Int.J.Epidemiol.* 1990;19:264-268.

Lerchen, M L, Wiggins, C L and Samet, J M. Lung cancer and occupation in New Mexico. *J.Natl.Cancer Inst.* 1987;79:639-645.

Levin, L I, Zheng, W, Blot, W J, Gao, Y T and Fraumeni, J F, J. Occupation and lung cancer in Shanghai: A case-control study. *Br.J.Ind.Med.* 1988;45:450-458.

Lindquist, R, Nilsson, B, Eklund, G and Gahrton, G. Increased risk of developing acute leukemia after employment as a painter. *Cancer.* 1987;60:1378-1384.

Lundberg, I. Mortality and cancer incidence among Swedish paint industry workers with long-term exposure to organic solvents. *Scand.J.Work Environ.Health.* 1986;12:108-113.

Lundberg, I and Milatou-Smith, R. Mortality and cancer incidence among Swedish paint industry workers with long-term exposure to organic solvents. *Scand.J.Work Environ.Health.* 1998;24:270-275.

Matanoski, G M, Stockwell, H G, Diamond, E L, et al. A cohort mortality study of painters and allied tradesmen. *Scand.J.Work Environ.Health.* 1986;12:16-21.

Matos, E L, Vilensky, M, Mirabelli, D and Boffetta, P. Occupational exposures and lung cancer in Buenos Aires, Argentina. *J.Occup.Environ.Med.* 2000;42:653-659.

McLean, D, Mannetje, A ', Dryson, E, et al. Leukaemia and occupation: A New Zealand cancer registry-based case-control study. *Int.J.Epidemiol*. 2009;38:594-606.

Menck, H R and Henderson, B E. Occupational differences in rates of lung cancer. *J.Occup.Med.* 1976;18:797-801.

Morgan, R W, Claxton, K W, Kaplan, S D, Parsons, J M and Wong, O. Mortality of paint and coatings industry workers. A follow-up study. *J.Occup.Med.* 1985;27:377-378.

Morgan, R W, Kaplan, S D and Gaffey, W R. A general mortality study of production workers in the paint and coatings manufacturing industry. A preliminary report. *J.Occup.Med.* 1981;23:13-21.

Morrison, A S, Ahlbom, A, Verhoek, W G, et al. Occupation and bladder cancer in Boston, USA, Manchester, UK, and Nagoya, Japan. *J.Epidemiol.Community Health.* 1985;39:294-300.

Muscat, J E, Stellman, S D, Richie, J P, J. and Wynder, E L. Lung cancer risk and workplace exposures in black men and women. *Environ.Res.* 1998;76:78-84.

Myslak, Z W, Bolt, H M and Brockmann, W. Tumors of the urinary bladder in painters: A case-control study. *Am.J.Ind.Med.* 1991;19:705-713.

Notani, P N, Shah, P, Jayant, K and Balakrishnan, V. Occupation and cancers of the lung and bladder: A case-control study in Bombay. *Int.J.Epidemiol.* 1993;22:185-191.

Office of Population Censuses and Surveys. *The Registrar General's Decennial Supplement, England and Wales 1961, Occupational Mortality Tables,* 1972, London, HMSO.

Office of Population Censuses and Surveys. *Occupational Mortality 1970-1972, England and Wales, Decennial Supplement,* 1979, London, HMSO.

Office of Population Censuses and Surveys. *Occupational Mortality, 1979-80, 1982-83, Great Britain, Decennnial Supplement,* 1986, London, HMSO.

Pelucchi, C, La Vecchia, C, Negri, E, Dal Maso, L and Franceschi, S. Smoking and other risk factors for bladder cancer in women. *Prev.Med.* 2002;35:114-120.

Pesch, B, Haerting, J, Ranft, U, Klimpel, A, Oelschlägel, B and Schill, W. Occupational risk factors for urothelial carcinoma: Agent-specific results from a case-control study in Germany. *Int.J.Epidemiol.* 2000;29:238-247.

Pezzotto, S M and Poletto, L. Occupation and histopathology of lung cancer: A case-control study in Rosario, Argentina. *Am.J.Ind.Med.* 1999;36:437-443.

Pohlabeln, H, Boffetta, P, Ahrens, W, et al. Occupational risks for lung cancer among nonsmokers. *Epidemiology.* 2000;11:532-538.

Porru, S, Aulenti, V, Donato, F, et al. Bladder cancer and occupation: A case-control study in northern Italy. *Occup.Environ.Med.* 1996;53:6-10.

Pronk, A, Coble, J, Ji, B T, et al. Occupational risk of lung cancer among lifetime non-smoking women in Shanghai, China. *Occup.Environ.Med.* 2009;66:672-678.

Pukkala, E, Martinsen, J I, Lynge, E, et al. Occupation and cancer -- follow-up of 15 million people in five Nordic countries. *Acta Oncol.* 2009;48:646-790.

Rajaraman, P, De Roos, A,J., Stewart, P A, et al. Occupation and risk of meningioma and acoustic neuroma in the United States. *Am.J.Ind.Med.* 2004;45:395-407.

Ramanakumar, A V, Nadon, L and Siemiatycki, J. Exposures in painting related occupations and risk of selected cancers: Results from a case-control study in Montreal. *Am.J.Ind.Med.* 2008;51:419-427.

Reulen, R C, Kellen, E, Buntinx, F and Zeegers, M P. Bladder cancer and occupation: A report from the Belgian case-control study on bladder cancer risk. *Am.J.Ind.Med.* 2007;50:449-454.

Richiardi, L, Boffetta, P, Simonato, L, et al. Occupational risk factors for lung cancer in men and women: A population-based case-control study in Italy. *Cancer Causes Control.* 2004;15:285-294.

Risch, H A, Burch, J D, Miller, A B, Hill, G B, Steele, R and Howe, G R. Occupational factors and the incidence of cancer of the bladder in Canada. *Br.J.Ind.Med.* 1988;45:361-367.

Ronco, G, Ciccone, G, Mirabelli, D, Troia, B and Vineis, P. Occupation and lung cancer in two industrialized areas of northern Italy. *Int.J.Cancer.* 1988;41:354-358.

Samanic, C M, Kogevinas, M, Silverman, D T, et al. Occupation and bladder cancer in a hospital-based case-control study in Spain. *Occup.Environ.Med.* 2008;65:347-353.

Schifflers, E, Jamart, J and Renard, V. Tobacco and occupation as risk factors in bladder cancer: A case-control study in southern Belgium. *Int.J.Cancer.* 1987;39:287-292.

Schoenberg, J B, Stemhagen, A, Mogielnicki, A P, Altman, R, Abe, T and Mason, T J. Case-control study of bladder cancer in New Jersey. I. Occupational exposures in white males. *J.Natl.Cancer Inst.* 1984;72:973-981.

Siemiatycki, J, Dewar, R, Nadon, L and Gérin, M. Occupational risk factors for bladder cancer: Results from a case-control study in Montreal, Quebec, Canada. *Am.J.Epidemiol.* 1994;140:1061-1080.

Siemiatycki, J, Dewar, R, Nadon, L, Gérin, M, Richardson, L and Wacholder, S. Associations between several sites of cancer and twelve petroleum-derived liquids. results from a case-referent study in Montreal. *Scand.J.Work Environ.Health.* 1987;13:493-504.

Silverman, D T, Hoover, R N, Albert, S and Graff, K M. Occupation and cancer of the lower urinary tract in Detroit. *J.Natl.Cancer Inst.* 1983;70:237-245.

Silverman, D T, Levin, L I, Hoover, R N and Hartge, P. Occupational risks of bladder cancer in the United States: I. White men. *J.Natl.Cancer Inst.* 1989a;81:1472-1480.

Silverman, D T, Levin, L I and Hoover, R N. Occupational risks of bladder cancer in the United States: II Nonwhite men. *J.Natl.Cancer Inst.* 1989b;81:1480-1483.

Steenland, K and Palu, S. Cohort mortality study of 57,000 painters and other union members: A 15 year update. *Occup.Environ.Med.* 1999;56:315-321.

Stockwell, H G and Matanoski, G M. A case-control study of lung cancer in painters. *J.Occup.Med.* 1985;27:125-126.

Teschke, K, Morgan, M S, Checkoway, H, et al. Surveillance of nasal and bladder cancer to locate sources of exposure to occupational carcinogens. *Occup.Environ.Med.* 1997;54:443-451.

Timonen, T T and Ilvonen, M. Contact with hospital, drugs, and chemicals as aetiological factors in leukaemia. *Lancet.* 1978;1:350-352.

van Loon, ,A.J., Kant, I J, Swaen, G M, Goldbohm, R A, Kremer, A M and van den Brandt, ,P.A. Occupational exposure to carcinogens and risk of lung cancer: Results from the Netherlands cohort study. *Occup.Environ.Med.* 1997;54:817-824.

Viadana, E and Bross, I D. Leukemia and occupations. *Prev.Med.* 1972;1:513-521.

Viadana, E, Bross, I D and Houten, L. Cancer experience of men exposed to inhalation of chemicals or to combustion products. *J.Occup.Med.* 1976;18:787-792.

Vineis, P and Magnani, C. Occupation and bladder cancer in males: A case-control study. *Int.J.Cancer.* 1985;35:599-606.

Whorton, M D, Schulman, J, Larson, S R, Stubbs, H A and Austin, D. Feasibility of identifying high-risk occupations through tumor registries. *J.Occup.Med.* 1983;25:657-660.

Wortley, P, Vaughan, T L, Davis, S, Morgan, M S and Thomas, D B. A case-control study of occupational risk factors for laryngeal cancer. *Br.J.Ind.Med.* 1992;49:837-844.

Wünsch-Filho, V, Moncau, J E, Mirabelli, D and Boffetta, P. Occupational risk factors of lung cancer in São Paulo, Brazil. *Scand.J.Work Environ.Health.* 1998;24:118-124.

Wynder, E L, Onderdonk, J and Mantel, N. An epidemiological investigation of cancer of the bladder. *Cancer.* 1963;16:1388-1407.

Zeegers, M, Swaen, G, Kant, I, Goldbohm, R A and PA. Occupational risk factors for male bladder cancer: Results from a population based case cohort study in the Netherlands. *Occup.Environ.Med.* 2001;58:590-596.

Zeka, A, Mannetje, A, Zaridze, D, et al. Lung cancer and occupation in nonsmokers: A multicenter case-control study in Europe. *Epidemiology.* 2006;17:615-623.

Zheng, T, Cantor, K P, Zhang, Y and Lynch, C F. Occupation and bladder cancer: A population-based, case-control study in Iowa. *J.Occup.Environ.Med.* 2002;44:685-691.