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Occupation, economic activity and cancer mortality in Spain

Executive summary

Title:

Occupation, economic activity and cancer mortality in Spain: Executive summary

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www.insst.es

Composition:

INSST Publications and Editorial Service

Edition:

Madrid, March 2021

NIPO (on line): 118-21-017-9

Hyperlinks:

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PREFACE

Facing cancer in working population means facing one of the main challenges in the fields of Public Health and Occupational Health. Estimations by the Spanish Society of Medical Oncology (SEOM) for 2019 show that the likelihood of developing cancer increases from 2% in 30 and 35 age group to 15.7% in the 60-64 age group, which has an especial relevance in an ageing working society.

That draw two areas in which we can take actions from the working conditions management: (i) the prevention of working exposure related cancer (occupational cancer) and (ii) the return to work of persons who has developed a cancer.

Occupational cancer, according to statements by the European Commission's Commissioner for Employment, Social Affairs, Capacities and Mobility at Work, Marianne Thyssen, accounts a 53% of deaths due to occupational risks exposure at workplace.

Cancer prevention is as complex as its causality, being the environment, working exposures and life habits, risk factors which a special relevance in its occurrence. According to the NIOSH-USA Research Agenda, the three most relevant factors that contribute to cancer burden are tobacco, diet and occupation.

The HSE-UK estimates those neoplasms in which the participation of an occupational exposure in its aetiology is higher: Mesothelioma (95%), Sinus Cancer (33%), Lung Cancer (14%), Nasopharyngeal Cancer (8%), Bladder Cancer (5%) and Skin Cancer (4%).

In addition, the study of cancer incidence show a social gradient, in such a way to working exposure, other factors related to occupation are added such as economic level, access to health programs and medical care, healthy environmental and habits, etc., prove a social inequality in the risk of occupational cancer.

This research analyses cancer mortality in Spain by crossing census data with national mortality registry. Which allows estimating the risk of death from cancer in the Spanish working population by the Standardized Mortality Ratio (SMR) by gender and age, in different occupations and economic activities, showing the areas of preferential interest for the prevention of cancer in general and occupational cancer in particular.

Without a doubt, this publication is a step that provides knowledge in the field of occupational cancer, that should be followed by others in the field of carcinogenic agents elimination or substitution, applied field epidemiology, clinical research, improvement of occupational cancer surveillance and information systems, which constitute a priority commitment for the INSST, as it cannot be otherwise given the serious impact on workers' health.

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INTRODUCTION

Cancer is the 2^a leading cause of death in the developed world. The World Health Organization (WHO) and the International Agency for Research on Cancer (IARC) estimate that cancer kills 8 million people every year. Occupational cancer accounts for 19% of cancer deaths¹.

The European Commission is committed to fighting cancer as part of its plan to improve workplace health and safety². The goals of the Spanish Occupational Health and Safety Strategy 2015-2020 include improving knowledge on work-related cancer in order to identifying groups, activities and companies that are exposed to the chemical carcinogens listed in Spanish Royal Decree 1299/ 2006³. This report on cancer mortality by occupation and industry in Spain aims to meet this objective by reporting the mortality rates for all cancers listed in such law – tumours of the liver and intrahepatic bile ducts, nasal cavity, paranasal sinuses, larynx, lungs, skin, prostate, and bladder as well as mesothelioma and lymphoma – and for other cancer sites with high mortality.

The analysis focus on mortality during 2001-2011 in people who were employed on the day of the 2001 Population Census. By linking census data with data from the death register during 2001-2011, it has been possible to carry out this analysis for the first time in Spain. The results reflect the heterogeneity of the occupational inequalities of this mortality for the different cancer sites.

1. OCCUPATIONAL ACTIVITY AND CANCER

The association of different occupations and industries with mortality from specific cancer sites may result from workers' exposure to physical, chemical and biological risks in the workplace. However, different occupational categories are characterised by different lifestyles, some of which (smoking, drinking alcohol, physical inactivity, poor diet) are risk factors for developing cancer. In addition, the worker's professional category is related to other circumstances associated with the occurrence of cancer, such as educational level, income level or environment of the place of residence.

1.1. Exposure to carcinogens in the workplace

IARC classifies occupational agents and exposures according to the degree of scientific evidence on human carcinogenicity⁴ in 5 groups: 1 (carcinogenic to humans); 2A (probably carcinogenic to humans); 2B (possibly carcinogenic to humans); 3 (not classifiable as carcinogenicity to humans); and 4 (probably not carcinogenic to humans).

IARC has classified 44 mostly occupational exposures as carcinogenic: 32 agents and 12 industrial processes or occupations⁵⁻⁷. Table 1.1.1 shows Group 1 agents with the associated cancer site and the occupation and/ or industry of possible exposition. The carcinogens causing the highest n° of cancer cases are asbestos, diesel engine emissions, crystalline silica, solar radiation and second-hand tobacco smoke⁶. Some exposures occur naturally, such as solar exposure and wood dust, while others are man-made, such as vinyl chloride. Some are simple chemical molecules, such as benzene and trichloroethylene; other are molecule mixtures, such as mineral agents.

The industries and occupations included in IARC Group 1 (and the associated cancer sites) are aluminium production (lung and bladder), auramine production (bladder), coal gasification (lung), coal-tar distillation (skin), hematite mining (lung), coke production (lung), iron and steel founding (lung), isopropyl alcohol production (nasal cavity), magenta production (bladder), painters (bladder, mesothelioma, lung), and rubber manufacture (stomach, lung, bladder, leukaemia). While those included in Group 2A are: art glass and glass manufacture (lung, stomach), carbon electrode manufacture (lung), and hairdressers or barbers (bladder, lung).

Table 1.1.1. Confirmed carcinogens (IARC Group 1), by cancer site/ type and occupation or industry.

Agents or groups	Cancer type	Occupation/ industry / use
Aromatic amines	Bladder	Rubber / pigments manufacture
Chemical reagents (sulphuric acid; 1,3-butadiene; formaldehyde, vinyl chloride ^c)	Larynx Leukaemia and/ or lymphoma Liver	Rubber / plastic/ textiles manufacture
Diesel engine exhaust	Lung	Transport, mining
Polycyclic aromatic hydrocarbons (benzopyrene, soot, coal)	Lung, skin	Pigments, production of aluminium, coal industry, construction, firefighting
Metals (arsenic, beryllium, cadmium, chromium, nickel, and their compounds)	Lung Skin and bladder Nasal cavity and sinuses	Art glass, deoxidisation processes, pesticides, pigments, batteries, aerospace industry, metallurgy, alloys, catalysts
Dust and fibres (asbestos, wood and leather dust, crystalline silica)	Larynx, lung, mesothelioma, ovary Nasal cavity Lung	Construction, wood industry, shoe manufacture

Source: International Agency for Research on Cancer (IARC). World Cancer Report 2014.

Table 1.1.2. Cancers, with the agents and main activities potentially responsible for their occurrence, included in Annex 1 Spanish Social Security system occupational diseases table (Spanish Royal Decree 1299/ 2006 and subsequent amendments in Spanish Royal Decree 1150/ 2015 and Spanish Royal Decree 257/ 2018).

Cancers	Agents	Activities
Malignant neoplasm of liver and intrahepatic bile ducts	Vinyl chloride monomer	Vinyl chloride production and polymerisation
Hepatic angiosarcoma	Arsenic and its compounds	Preparation, use and handling of arsenic and its compounds
	Vinyl chloride monomer	Vinyl chloride production and polymerisation
Malignant neoplasm of nasal cavity	Chromium (VI) compounds	Preparation, use and handling of hexavalent chromium compounds; manufacture of catalysts, dyes, pigments, chemical products for tanning, and wood treatment products
	Nickel compounds	Nickel smelting and refining, stainless steel production, battery manufacture
	Wood dust	Wood occupations
Primary cancer of the ethmoid and paranasal sinuses	Nickel compounds	Nickel smelting and refining, stainless steel production, battery manufacture
Malignant neoplasm of larynx	Asbestos	Industries that use asbestos, manufacture of brake and clutch linings, manufacture of fibre cement products, motor vehicle repair, dismantling and demolition of facilities containing asbestos
Malignant neoplasm of bronchus and lung	Arsenic	Preparation, use and handling of arsenic and its compounds
	Beryllium	Extraction and metallurgy of beryllium, aerospace industry, nuclear industry
	Bis(chloromethyl) ether	Plastic synthesis, ion-exchange resin synthesis, vulcanised rubber treatment
	Cadmium	Industrial preparation and use of cadmium; manufacture of cadmium pigments for paint, varnish, plastic materials, paper, rubber, fireworks
	Chromium (VI) compounds	Preparation, use and handling of hexavalent chromium compounds; manufacture of catalysts, dyes, pigments, chemical products for tanning, and wood treatment products
	Radon	Underground mining, processes with precursors of radon-222 in the uranium-238 decay chain
	Silica	Work in mines, tunnels, quarries, galleries; demoulding, deburring and desanding in foundries; sandblasting and grinding; iron and steel, ceramic and paper industries.

In Spain, several types of occupational cancer are classified as occupational diseases. Table 1.1.2 shows the cancers included in the Spanish Social Security system occupational diseases table, together with the agents and activities potentially responsible for their occurrence.

1.2. Behaviours related to occupation that increase cancer risk

Almost one third of cancer deaths in developed countries results from tobacco use. Smoking is a major cause of lung, laryngeal, pharyngeal, oesophageal, bladder, kidney and pancreatic cancer. It is also a cause of cancer of the paranasal sinuses, oral cavity, trachea, stomach, liver, colon-rectum and cervix, and of myeloid leukaemia⁶. Alcohol-related cancer deaths, meanwhile,

are thought to represent 4% of all cancer deaths in the developed world. Alcohol use increases the risk of mouth, pharyngeal, laryngeal, oesophageal, colon, breast, and primary liver cancer. The risk of all these cancer types, with the exception of primary liver cancer, is increased by alcohol-tobacco combination. Studies performed in the USA and Europe found the highest prevalence of tobacco and alcohol use in workers in hospitality, construction and farming, while education and health sector workers showed a lower prevalence⁸⁻¹². In Spain, the 2001 National Health Survey and other surveys show similar results, especially in men¹³.

Physical inactivity combined with excess body weight is estimated to account for 20%-30% of some of the most common cancers, and 5% of all cancer deaths are thought to result from physical inactivity alone. In people aged ≥ 50 , 15%-20% of cancer deaths could be caused by obesity. The evidence of obesity-cancer association is convincing in oesophageal adenocarcinoma and in pancreatic, colorectal and kidney cancer. In women, the association is clearer in endometrial cancer and postmenopausal breast cancer⁶. The 2001 Spanish National Health Survey showed a higher prevalence of physical inactivity (insufficient free-time physical activity) in construction workers, farmers and livestock workers, hospitality staff, and food industry workers, and the lowest one in workers in the education, health, finance-assimilated and public administration sectors. A similar pattern emerged for obesity prevalence. We find the same tendencies in Europe and the USA, where workers in manual and service-sector occupations have higher rates of obesity than nonmanual workers¹⁴⁻¹⁶. Studies show the same pattern by age and/ or industry in insufficient intake of fruit and vegetables (lack of daily consumption). It has recently been suggested that the role of nutritional factors in cancer risk is less relevant than previously thought⁶; however, other studies continue to show the probable protective effect of fruit and vegetables on cancer risk, something that has been found, though not established, in cancers of oral cavity, pharynx, larynx, oesophagus and stomach⁶.

1.3. Socioeconomic circumstances associated with occupation

People's occupation usually reflects their educational level. Higher professional qualifications normally lead to jobs with better working conditions (greater autonomy at work, less exposure to occupational risks), and a higher salary. Higher educational level is also associated with healthier lifestyle choices. This may be because a better income can guarantee the material conditions needed to satisfy basic life necessities. A study on men workers in Spain found that the higher rates of cancer mortality in less vs. more qualified workers were due more to differences in education than income¹⁷. Studies have also shown lower cancer survival in people of low socioeconomic status even in countries that provide universal health care¹⁸⁻²⁰.

In other cases, the opposite is true. For example, high educational level is associated with higher breast cancer incidence and mortality in women²¹⁻²³. Having few children, older age at first childbirth and using hormone replacement therapy for menopause increases breast cancer risk. These factors are more common in women with higher professional qualifications. There is also evidence to suggest that higher breast and prostate cancer occurrence and/ or mortality in people with high income and/ or living in affluent areas may be due to greater access to medical exams and population screening programmes, resulting in overdiagnosis of these cancers²⁴.

2. METHODS

2.1. Data

Data came from the national longitudinal cohort study of people residing in Spain in 2001. All people included in the Spanish National Statistics Institute (INE) population census of 1 November 2001 were followed up until 31 December 2011. For all people who died in that decade, the cause of death was recorded. This analysis included people in the cohort who, on census date, were employed and aged 20-64: 9 579 759 men and 5 919 413 women. Each person contributed to the death risk with a specific n° of person-years of follow-up, either until 31-12-2011 (end of follow-up) or until the date of death from any cause. Almost 155 million person-years (95.4 million in men and 59.5 million in women) were analysed. There were 338 907 deaths during follow-up (276 863 in men and 62 044 in women).

The INE checked the vital status of each person during the follow-up by consulting the death register, which shows the date and cause of death recorded on the medical death certificate. Such cause was coded according to the International Classification of Diseases, 10th Revision (ICD-10). The causes of death analysed (ICD-10 code) correspond to cancer sites in Spanish Royal Decree 1299/ 2006, including mesothelioma (C45), lymphoma (C81-C85), squamous cell carcinoma of the skin (C44), and malignant neoplasms of lung (C33-C34), bladder (C67), liver (C22), nasal cavity and middle ear (C30), accessory sinuses (C31), larynx (C32) and prostate (C61). We also analysed death from cancer sites, namely leukaemia (C91-C95), multiple myeloma (C88 y C90), and malignant neoplasms of oral cavity and pharynx (C00-C14), oesophagus (C15), stomach (C16), colon and rectum (C18-C20), pancreas (C25), testis (C62), ovary (C56), corpus uteri (C54), cervix uteri (C53), breast (C50), kidney (C64), brain (C71), thyroid gland (C73), and bone (C40-C41). During 2001-2011 there were 147 847 deaths from these cancer sites in participants, of which 21.9% (32 367) in women and 78.1% (115 480) in men.

The 2001 Census collected many demographic characteristics, including sex, age, employment status, and the occupation and industry of employees. Occupations and industries were coded according to the 1994 Spanish National Classification of Occupations and the 1993 Spanish National Classification of Industries, respectively. For this analysis, occupations and industries were grouped into 55 and 53 categories, respectively.

2.2. Statistical analysis

For each cancer site, the age-specific mortality rate and the age-standardised mortality rate (ASDR), in men and women, were calculated using the age distribution of the whole study population as the standard population. However, to compare the magnitude of mortality in the different occupations and industries, the age-standardised mortality ratio (SMR) was used. This measure was chosen because the n° of deaths from some cancers is very low in some occupations and industries, generating very unstable death rates. For each cancer the age- and sex-SMR in each occupation or industry was calculated by dividing the n° of recorded or observed deaths by the n° of expected deaths. The n° of expected deaths for each cancer site in each occupation or industry, is the n° of deaths from this cancer that would occur if the workers in this category had the same age- and sex-specific mortality rate as that observed in the whole study population.

Specifically, the SMR in both sexes for the cancer site *c* in the category of occupation or industry *k* was calculated using the following formula:

$$\text{SMR}_{ck} \text{ in both sexes} = \frac{(\sum dM_{ick} + \sum dW_{ick})}{(\sum DM_{ic} / PYM_i \times pyM_{ik} + \sum DW_{ic} / PYW_i \times pyW_{ik})}$$

where dM_{ick} and dW_{ick} are the n° of deaths recorded in men and women in age group i from cancer site c in category of occupation or industry k ; DM_{ic} and DW_{ic} are the n° of deaths in all men and in all women in age i from cancer site c ; PYM_i and PYW_i are the n° of person-years in all men and in all women in age i ; and pyM_{ik} and pyW_{ik} are the n° of person-years in men and in women in age group i and in category of occupation or industry k .

The results in tables 4.1 to 4.4, show age- and sex-SMRs, except for sex-specific cancer sites, for which age-SMRs in either men or women are shown.

The statistical significance of the SMRs in each occupation or industry has been assessed using the chi-square test with one degree of freedom. Under the null hypothesis, the n° of recorded deaths would follow a Poisson distribution with the same mean and variance as the n° of expected deaths. Tables show the chi-square p-value for each calculated RME. Values of $p < 0.05$, $p < 0.01$ or $p < 0.001$, indicate that the RME is different from 1.00 at confidence levels of 95%, 99% or 99.9%, respectively.

3. STRENGTHS AND LIMITATIONS

The participants are not a population sample, but all people included in the 2001 Spanish Census who, on November 1, 2001, were aged 20-64 and employed. Therefore there is no problem of representativeness. However, a classification bias in employment or industry cannot be ruled out, since the one they had at the time of the mortality analysis could be different from the census. Furthermore, the results may also reflect pre-census occupational exposures. However, it can be assumed that it is a non-differential bias with respect to the result, since the mortality risk from cancer does not determine a change in occupation.

Furthermore, it is important to ensure that the primary cause of death recorded in the medical death certificate is accurate. In this study, causes of death were considered to be very accurate for two reasons: Firstly, the cancer types were very probably diagnosed by a pathologist based on pathognomonic signs; and secondly, the participants were relatively young and most people who died probably only had the condition that resulted in their death. In older people the primary cause of death is less clear, since they tend to suffer multiple diseases.

The magnitude of mortality for a specific cancer site in each occupation or industry may be related to variety of factors. This study is limited to assess the possible effect on such mortality of the chemical and physical factors related to occupations and/ or industries. It is difficult to identify occupational factors associated with some cancer sites, as some lifestyle choices could be more frequent in certain occupations or industries and act as confounders. This is true for tobacco use and lung cancer mortality, for example. However, the methodological approach of this study is highly relevant where a given cancer site is very infrequent and is strongly associated with an occupation or industry, as is the case for nasal cancer and occupations or activities related to the wood. Lastly, the varying magnitude of mortality for some cancers by occupation may be related to occupational differences in survival rates, reflecting differences in socioeconomic position. This is unlikely, however, since Spain has universal health care.

4. RESULTS AND COMMENTS

A. Occupational cancer sites included in Spanish Royal Decree 1299/ 2006

4.1. Lung cancer

There were 47 825 deaths, with an ASDR of 41.0/ 100 000 person-years in men and 9.8/ 100 000 in women. People aged 55-64 had the highest lung cancer mortality risk, and the sexual difference in risk declined with age. By occupation, significantly elevated SMRs were found in unskilled construction workers (1.42), fishers/ sailors (1.37), miners and similar (1.30), waiting staff (1.27), skilled construction workers (1.26), painters and similar (1.21), unloaders and similar (1.18), janitors/ security guards (1.16), cooks (1.15), industrial moving machinery operators (1.13), metal workers (1.11), other catering workers (1.09) and cleaners (1.09). There were significantly low SMRs in several occupations, including highly qualified professionals and domestic workers (Table 4.1).

The industries with significantly elevated SMRs were fishing (1.38), drinking establishments (1.31), extractive/ mining industry (1.26), waste disposal/ sanitation and similar activities (1.25), building/ structural construction (1.20), other business services (1.20), restaurants (1.19), cleaning services (1.12), metallurgy (1.11), tools/ metal products manufacture (1.09), associative and recreational activities (1.08) and central public services (1.04). We found low SMRs with statistical significance in several industries, particularly in education (Table 4.3).

The highest-risk occupations and industries for men were similar to those for both sexes. For women, however, liberal and technical professions had the highest cancer mortality risk.

IARC has classified the following agents found in occupational settings as Group 1 carcinogens for lung cancer: arsenic and its inorganic compounds; beryllium and its compounds; cadmium and its compounds; chromium (VI) compounds; nickel compounds; sulphur mustard; asbestos (all forms); crystalline silica dust; ionising radiation and radioactive elements; soot; coal-tar pitch, diesel engine exhaust, bis(chloromethyl)ether, chloromethyl methyl ether, welding fumes, and unspecified agents produced in coal gasification, rubber, aluminium and coke production, iron and steel founding, Acheson process, hematite mining (underground), and painting. Agents with limited evidence in humans are strong inorganic acid mists; benzene; creosotes; tetrachlorodibenzo-para-dioxin; hydrazine; diazinon; alpha-chlorinated toluenes and benzoyl chloride; cobalt metal with tungsten carbide; oxidised bitumens and their emissions during roofing; hard bitumens and their emissions during mastic asphalt work; fibrous silicon carbide; and unspecified agents present in art glass manufacture, glass containers manufacture, pressed ware manufacture, carbon electrode manufacture, emissions from high-temperature frying, printing processes, and nonarsenical insecticide application.

IARC Group 1 nonoccupational carcinogenic hazards include tobacco smoking, second-hand tobacco smoke, particulate matter in outdoor air pollution, indoor emissions from household combustion of coal or biomass fuel (primarily wood), and MOPP (vincristine-prednisone-nitrogen mustard-procarbazine mixture)²⁵⁻²⁷.

Several of the high-risk occupations and industries identified in this study may expose workers to IARC Group 1 human carcinogens²⁸⁻³⁰, although most of them are also associated with a high prevalence of tobacco use, which is the leading cause of lung cancer³¹. The fact that the highest-risk occupations for women are certain liberal and technical professions is probably due to its higher prevalence of tobacco use. The SMR in fishers/ sailors seems particularly high, although previous studies have found a similar risk level in this group³². The high risk for waiting staff could be explained in part by exposure to second-hand tobacco smoke, since the law banning smoking in catering establishments was not implemented in Spain until 2011³³. It is true, however, that prevalence of tobacco use tends to be high in this group of workers³⁴.

4.2. Mesothelioma

There were 741 deaths, with an ASDR of 0.6/ 100 000 person-years in men and 0.2/ 100 000 in women. The occupations with significantly elevated SMRs were plastic/ rubber workers (2.91), plumbers (2.85), hairdressers/ barbers and similar (2.79), unloaders and similar (2.55), other chemical industry workers (1.87), metal workers (1.83) and electricians (1.78). High SMRs almost reaching statistical significance were observed in construction managers and cleaners. There were significantly low SMRs in farmers and other professional workers, and low SMRs bordering on statistical significance in waiting staff (Table 4.1).

The industries with significantly elevated SMRs were metallurgy (2.61), building/ structural installations (2.18), vehicle/ transport equipment manufacture (2.14), glass/ ceramic/ nonmetallic minerals industry (2.00), plastic/ rubber industry (1.88), and tools/ metal products manufacture (1.49). Personal services had a high SMR almost reaching statistical significance. A significantly low SMR was observed in farming/ forestry, and low SMRs bordering on statistical significance in tax/ accounting advisory services and building/ structural construction (Table 4.3).

IARC Group 1 carcinogens for mesothelioma found in occupational settings include asbestos (all forms), erionite, fluoro-edenite and painting²⁵⁻²⁷. The activities most associated with handling asbestos are insulation, construction and renovation of structures. Asbestos-related disease has been linked not only to occupational exposure, but also environmental exposure, in people who live near textile or isolation material factories or erionite outcrops. Tobacco is not a risk factor, but ionising radiation and simian vacuolating virus 40 may be³⁵. In Spain, large-scale use of asbestos began in the 1940s and peaked in the 1970s, and it was totally banned in 2001. Given that the individual risk of mesothelioma increases 3-4 four decades after the beginning of exposure, the death rate is likely to continue increasing, particularly in older people, as is occurring in the USA³⁶.

Most of occupations and industries with high SMRs for mesothelioma in this study involve exposure to asbestos. Previous studies have associated this cancer with many of these occupations/ industries, including plumbers, chemical industry workers, electricians, metal workers, building/ structural installations (construction) and the glass/ ceramic/ nonmetallic minerals industry³⁶⁻³⁷. Our analysis showed an SMR of 1.59 for painters, though this finding did not reach statistical significance.

4.3. Laryngeal cancer

There were 3435 deaths, with an ASDR of 3.23/ 100 000 person-years in men and 0.18/ 100 000 in women. The occupations with significantly high SMRs were miners and similar (1.90), unskilled construction workers (1.90), other unskilled workers (1.86), cleaners (1.84), fishers/ sailors (1.57), skilled construction workers and similar (1.53), waiting staff (1.49), police officers and similar (1.26) and farmers (1.21). There were significantly low SMRs in several occupations, especially in qualified professions (Table 4.1).

By industry, the results showed significantly high SMRs in waste disposal/ sanitation and similar activities (2.52), drinking establishments (1.53), fishing (1.49), metallurgy (1.43), building/ structural construction (1.37) and restaurants (1.35); and significantly low SMRs in several industries, particularly in technical services and education (Table 4.3).

IARC Group 1 carcinogens for laryngeal cancer with potential workplace exposure include strong inorganic acid mists and asbestos (all forms). The carcinogenic hazards with limited evidence in humans are sulphur mustard, rubber production and second-hand tobacco smoke. Non occupational risk factors with sufficient evidence in humans include tobacco smoking and alcohol consumption; and with limited evidence, human papillomavirus (HPV) type 16²⁵⁻²⁷.

There is a lot of evidence that tobacco and alcohol are the main risk factors for laryngeal cancer: tobacco accounts for more than 50% of cases, and alcohol for 25-50% of them^{28,38-39}. In addition, in occupational settings, workers can be exposed to confirmed or suspected carcinogens such as strong inorganic acid mists; asbestos; polycyclic aromatic hydrocarbons; engine exhaust gases; coal-burning gases; chlorinated solvents; formaldehyde; mineral oil; and dust from silica, wood, cement, metals, coal or textiles^{28,40-41}. Alcohol and tobacco use and asbestos exposure can also act in synergy.

In this study, increased laryngeal cancer mortality was found in occupations that had been previously classified as high risk, including miners, skilled construction workers, metal workers, catering workers, cleaners and fishers/ sailors⁴²⁻⁴³, but not in others, such as painters, plumbers, hairdresser/ barbers, electricians, butchers, vehicle mechanics, chemical and textile industry workers, transport workers and workers exposed to engine exhaust gases^{37,40,42-43}. Nor did a significantly high SMR in wood workers was found, something found in other studies⁴⁰⁻⁴¹.

It can be assumed that occupational differences in mortality from laryngeal cancer are primarily due to differences in alcohol and tobacco use⁴². In fact, the occupational distribution of these magnitudes shows substantial similarities¹³, with higher prevalence of alcohol and tobacco use in catering/ hospitality, construction, primary sector activities (farming, fishing and the extractive industry) and cleaning services¹²⁻¹³. Second-hand tobacco smoke may account for part of the excess risk in catering workers, since the law banning smoking in catering establishments was not implemented in Spain until 2011.

4.4. Bladder cancer

There were 5183 deaths, with an ASDR of 4.6/ 100 000 person-years in men and 0.6/ 100 000 in women. By occupation, significantly high SMRs were found in waiting staff (1.71), other unskilled workers (1.40), cooks (1.32), metal workers (1.14) and skilled construction workers and similar (1.13). There were high SMRs just short of statistical significance in painters and similar, other catering workers, food industry workers, janitors/ security guards and sales assistants. There were significantly low SMRs in engineers, livestock workers, secondary/ tertiary teachers, and executives; and low SMRs bordering on statistical significance in medical doctors and similar, engineering technicians and similar, primary school teachers and similar, non-public-facing administrative assistants and other business owners (except farmers and restaurant owners) (Table 4.1).

The industries with significantly high SMRs were drinking establishments (1.75), other business services (1.33) and restaurants (1.24). High SMRs almost reaching statistical significance were recorded in tools/ metal products manufacture, building/ structural finishing, retail food trade, and hotels and similar. There were significantly low SMRs in computer services, financial intermediation, livestock/ hunting, primary and secondary/ tertiary education; and low SMRs approaching statistical significance in mechanical machinery manufacture, waste disposal/ sanitation and similar activities, and farming/ forestry (Table 4.3).

The IARC Group 1 carcinogens for bladder cancer in occupational settings include ionising radiation; arsenic and its inorganic compounds; aromatic amines (benzidine, *ortho*-toluidine, 4-amino-biphenyl, 2-naphthylamine); production of aluminium, rubber, and colourants (auramine and magenta); and painting. Carcinogenic agents with limited evidence in humans include soot; coal-tar pitch; tetrachloroethylene; 2-mercaptobenzothiazole; diesel engine exhaust; 4-chloro-*ortho*-toluidine; and unspecified agents from dry cleaning, hairdressing, printing and textile manufacture.

Nonoccupational Group 1 carcinogens include tobacco smoking, *Schistosoma haematobium*, and medicines like chlornaphazine and cyclophosphamide; while pioglitazone is a nonoccupational carcinogen with limited evidence in humans²⁵⁻²⁷.

Tobacco smoking is considered the most significant risk factor for bladder cancer, accounting for around half of cases³¹. Bladder cancer incidence appears to be higher in workers exposed to aro-

matic amines, and bladder cancer mortality appears to be higher in those exposed to polycyclic aromatic hydrocarbons and heavy metals⁴⁴⁻⁴⁵.

The results of this study are consistent with previous studies that have found a high risk in metal workers and textile industry workers⁴⁶⁻⁴⁷, although the excess risk is modest. By contrast, there is little prior evidence of a high risk in catering workers. The occupational disparity in the risk may primarily reflect differences in tobacco smoking, although exposure to occupational carcinogens could play a part in some groups. For example, exposure to 2-naphthylamine in foundries or during pyrolysis of waste cooking oils could account for some of the excess risk in metal and catering workers, although exposure to second-hand tobacco smoke is also a risk factor in the latter. The use of stains and solvents could explain some of the excess risk in painters, construction workers and shoe/ leather workers, especially when combined with tobacco smoking³¹.

4.5. Squamous cell carcinoma of the skin

There were 302 deaths, with an ASDR of 0.24/ 100 000 person-years in men and 0.11/ 100 000 in women. The occupations with significantly high SMRs were livestock workers (2.21), medical doctors and similar (1.98), sales assistants (1.63) and farmers (1.55). There were high SMRs just short of statistical significance in cleaners (1.55), and a significantly low SMR in secondary/ tertiary teachers (Table 4.1).

By industry, significantly high SMRs were found in social services (2.42), livestock/ hunting (1.97) and farming/ forestry (1.52); and a high SMR bordering on statistical significance in other retail trade (1.47). Secondary/ tertiary education showed a significantly low SMR (Table 4.3).

IARC Group 1 carcinogenic agents for skin cancer other than melanoma with possible occupational exposure include solar and ionising radiation, arsenic and its inorganic compounds, untreated/ mildly treated mineral oils, shale oils, coal-tar pitch, and coal-tar distillation. The Group 2A carcinogens are creosotes and petroleum refining. Nonoccupational risk factors with sufficient evidence include methoxsalen plus ultraviolet A (UVA) radiation and some medicines; and with limited evidence, HIV type 1 (HIV-1), some human papillomavirus (HPV), and medicines²⁵⁻²⁷.

The leading risk factor is sun exposure⁴⁸, although artificial UV radiation could play a part⁴⁹. There is also evidence associating this squamous cell skin carcinoma with exposure to aromatic hydrocarbons, polychlorinated biphenyls (PCBs), trichloroethylene, heavy metals, pesticides, insecticides, herbicides, some paints and varnishes, hydrazine, sulphur, and radon^{31,49,50}.

Generally, the results of this study are consistent with those already published, that have found a high risk of skin cancer in outdoor workers, farmers, livestock workers, foresters and gardeners, as a result of high sun exposure⁵¹⁻⁵². Some studies have also found a high risk in middle- or upper-class indoor workers, including health workers⁵¹, possibly in connection with occupational exposure to ionising radiation or voluntary exposure to UV radiation. The high SMRs found in our study in livestock workers and farmers could be due to their high exposure to solar radiation, through pesticides could account for some of the risk. The high risk in medical doctors could result from exposure to ionising radiation at work²⁹⁻³⁰. On the other hand, there is no simple explanation for the high risk found in other occupations, such as sales assistants and social services employees.

4.6. Lymphoma

There were 4212 deaths, with an ASDR of 3.2/ 100 000 person-years in men and 1.7/ 100 000 in women. There were no significantly high SMRs in any occupation, though high SMRs almost reaching statistical significance were found in artists/ models/ athletes (1.28) and cleaners (1.17). There were significantly low SMRs in other semiprofessional workers, medical doctors and sim-

ilar, secondary/ tertiary teachers, unskilled construction workers, and engineering technicians and similar. Low SMRs approaching statistical significance were found in livestock workers and engineers (Table 4.1).

There were no significantly high SMRs in any industry, but high SMRs almost reaching statistical significance were found in building/ structural installations (1.23), restaurants (1.14) and central public services (1.08) (Table 4.3).

Analysing only the women, significantly high SMRs were found in janitors and security guards (2.13) and sales/ financial agents (1.57), as well as in workers in the wood/ paper industry (2.66), plastic/ rubber industry (2.36), and vehicles/ transport equipment manufacture (1.86).

There are two main types of lymphoma, which were not distinguished in this study: Hodgkin's lymphoma (HL) and non-Hodgkin's lymphoma (NHL). There are no firmly established occupational risk factors for HL, although some studies have mentioned the wood industry⁵³, which would be consistent with our results in women. For NHL, however, there are confirmed and suspected occupational agents³¹, and different occupations and industries have been related to this cancer. Specifically, IARC has classified as Group 1 carcinogens for NHL ionising radiation, 1,3-butadiene, trichloroethylene and pentachlorophenol²⁵⁻²⁸.

Exposure to trichloroethylene solvent could explain the significantly high risk in this study in women working in wood/ paper or plastic/ rubber industries, and in vehicle/ transport equipment manufacture²⁹⁻³⁰. Furthermore, exposure to 1,3-butadiene from engine exhaust gases and plastic/ rubber manufacturing, could account for the high risk in women working in plastic/ rubber industries or as industrial moving machinery operators⁵⁴. Lastly, exposure to pentachlorophenol, used as a wood preservative, could help to explain the excess risk in women working in the wood/ paper industry.

4.7. Myeloma

There were 1652 deaths, with an ASDR of 1.2/ 100 000 person-years in men and 0.8/ 100 000 in women. The only occupation with a significantly high SMR was police officers/ similar (1.61). There were no significantly low SMRs in any occupation (Table 4.1). By industry, significantly high SMRs were found in other business services (1.72), computer services (1.69) and central public services (1.21); and a high SMR approaching statistical significance in social services. Vehicle/ transport equipment manufacture had a significantly low SMR, and low SMRs bordering on statistical significance were observed in maintenance/ repair of motor vehicles and metallurgy (Table 4.3). When only women were analysed, there were significantly high SMRs in rubber/ plastic workers (4.44), rubber/ plastic industries (3.10), drinking establishments (2.09) and personal services (1.75).

No carcinogens have been linked to myeloma with sufficient evidence in humans, including benzene and ionising radiation²⁵⁻²⁸. Risk factors include farm work and exposure to pesticides^{42,55-56}. In this study, there was no excess risk observed in farming/ forestry or in livestock/ hunting, although the oldest participants were 74 years old at the end of the study, meaning it cannot rule out an association in older people. Regarding other occupations or industries, previous evidence is less consistent. There is evidence indicating increased risk in cleaners, hairdressers and barbers, firefighters, metal workers, several manufacturing occupations and industries, and food and drink industries⁵⁵⁻⁵⁶. This study revealed no statistically significant excess risk in these categories, except in women working in drinking establishments.

4.8. Prostate cancer

There were 3450 deaths, with an ASDR of 3.22/ 100 000 person-years in men. The only occupation with a significantly high SMR was industrial moving machinery operators (1.55). There were

high SMRs just short of statistical significance in electricians, unskilled and skilled construction workers and similar, carpenters and wood/ paper workers, farmers and sales/ financial agents. There was a significantly low SMR in secondary/ tertiary teachers and low SMRs almost reaching statistical significance in engineering technicians and similar, businesspeople/ business managers and non-public facing administrative assistants (Table 4.1).

The only industry with a significantly high SMR was the meat industry (1.48), although a high SMR approaching statistical significance were found in farming/ forestry. A significantly low SMR was observed in vehicle/ transport equipment manufacture, and low SMRs bordering on statistical significance in the chemical industry, households with employees, and provision of public services to the community (Table 4.3).

Carcinogens of possible occupational origin linked to prostate cancer with limited evidence in humans are as follows according IARC: arsenic and its inorganic compounds; cadmium and its compounds; malathion; ionising radiation; thorium-232; and unspecified agents related to firefighting, rubber production and night shift work. Nonoccupational risk factors with limited evidence include androgenic steroids and consumption of red meat²⁵⁻²⁷.

The lack of a clear risk distribution pattern by occupation and industry is consistent with previous studies⁵⁷. The small variations could be due to differing access to diagnosis and early treatment according to social class^{42,58}, although this study do not clearly support this hypothesis. Some studies have pointed to asbestos, which could explain in part the high risk in industrial moving machinery operators and unskilled construction workers in this study. Unlike other studies⁵⁹, this study found no significantly high risk in farming or in police officers and similar, a group including firefighters. Previous studies have identified the latter as high risk, although the results are inconsistent⁶⁰⁻⁶¹. Nor a significantly elevated risk was found in the plastic/ rubber industry, specifically in rubber workers, who have been identified as having the highest risk of prostate cancer⁵⁷.

4.9. Liver cancer

There were 6752 deaths, with an ASDR of 5.8/ 100 000 person-years in men and 1.5/ 100 000 in women. By occupation, significantly high SMRs in graphic artists (1.51), waiting staff (1.45), glass/ ceramic/ nonmetallic mineral workers (1.45), cooks (1.38), other catering workers (1.36), janitors/ security guards (1.34), unskilled construction workers (1.28), plumbers (1.28), painters and similar (1.25) and cleaners (1.22). Occupations with significantly low SMRs were engineers and similar, engineering technicians and similar, secondary/ tertiary teachers, medical doctors and similar, executives, other mechanics, and farmers (Table 4.1).

By industry, significantly high SMRs were found in waste disposal/ sanitation and similar activities (1.58), restaurants (1.57), drinking establishments (1.48), other business services (1.40), households with employees (1.37), editing/ graphic arts (1.31), hotels and similar (1.22) and central public services (1.11). There were significantly low SMRs in technical services, computer services, wood/ paper industry, plastic/ rubber industry, furniture/ similar products manufacture, financial intermediation, secondary/ tertiary education, primary education and farming/ fishing (Table 4.3).

IARC Group 1 liver cancer carcinogens with potential workplace exposure are 1,2-dichloropropane, vinyl chloride, and some radioactive elements. Agents with limited evidence are ionising radiation, arsenic and its inorganic compounds, dichlorodiphenyltrichloroethane (DDT), dichloromethane (methylene chloride), and trichloroethylene. IARC nonoccupational hazards with sufficient evidence in humans include alcohol use, hepatitis B and C virus, tobacco smoking, oestrogen/ progestogen contraceptives, aflatoxins and some trematode infestations. Risk factors with limited evidence are HIV type 1, androgenic steroids, betel quid without tobacco, and *Schistosoma japonicum*²⁵⁻²⁷.

In high-income countries, the main risk factors for liver cancer are nonoccupational, and include alcoholic cirrhosis and hepatitis B and C infections, although there is evidence pointing to other

factors, such as aflatoxins, obesity, diabetes, tobacco use, non-alcoholic fatty liver disease, ochratoxin A, polychlorinated biphenyls (PCBs) and genetic factors⁶²⁻⁶⁴. Eating vegetables and drinking coffee would appear to have a protective effect⁶²⁻⁶³. Regarding occupational risks, some studies have demonstrated a higher risk after exposure to trichloroethylene and vinyl chloride⁶⁴⁻⁶⁵, while others have found associations with organic solvents, chlorinated pesticides, arsenic, cadmium and asbestos⁶⁶⁻⁶⁷.

In this study, liver cancer mortality was lower in women and skilled workers. The highest risks were concentrated in catering and hospitality industries, domestic and cleaning services, and some groups of manual workers. These results suggest that lifestyle choices, especially alcohol use, play a major part in the risk distribution. These results are consistent with previous studies that found an increased risk in catering and hospitality industries, graphic arts, construction – including plumbers and painters – and domestic and personal services^{42,66,68}. On the other hand, previous studies have found an increased risk in categories not identified as high risk in this study, such as farming, food industry, paper production, vehicle mechanics, chemical industry, iron founding, maritime and shipyard professions^{42,66,69}. Occupational exposure to carcinogenic agents could be partly responsible for the occurrence of liver cancer in people working in glass/ ceramics, construction, graphic arts, cleaning, and waste disposal/ sanitation and similar activities^{29,30,67}.

4.10. Cancer of the paranasal sinuses

There were 148 deaths, with an ASDR of 0.1/ 100 000 person-years in men and 0.0/ 100 000 in women. The occupations with significantly high SMRs were caregivers/ personal assistants (3.33) and carpenters and wood/ paper workers (2.39). Farmers had a high SMR just short of statistical significance. There were no significantly low SMRs in any occupation (Table 4.1).

No significantly high SMRs were found in any industry, but high SMRs almost reaching statistical significance were observed in the glass/ ceramic industry (2.50) and furniture/ similar products manufacture (2.25). There were no significantly low SMRs in any industry (Table 4.3).

The IARC Group 1 carcinogens found in occupational settings and linked to nasal cavity and paranasal sinus cancer are: wood and leather dusts, nickel compounds, isopropyl alcohol manufacture using strong acids, and radium isotopes. The agents with limited evidence are formaldehyde, chromium-VI compounds, and unspecified agents from carpentry and joinery and textile manufacturing. IARC also identified tobacco smoking as a nonoccupational risk factors with sufficient evidence in humans²⁵⁻²⁷. Occupational exposure to wood dust, particularly from hard woods like beech and oak, is the main known risk factor for this cancer⁷⁰. There is also less consistent evidence attributing increased risk to exposure to diisopropyl sulphate, dichloroethyl sulphide, organic solvents, glues, pesticides, welding fumes, textile manufacture, flour in baking and flour milling industries, and infection by some human papillomavirus (HPV)^{31,70-72}.

The results of this study show a high risk in some occupations and industries that could expose workers to known human carcinogens, particularly wood dust, nickel, chromium and formaldehyde. Many studies have assessed the association between occupation/ industry and this cancer⁷⁰⁻⁷³.

4.11. Cancer of the nasal cavity and middle ear

There were 53 deaths, with an ASDR of 0.0/ 100 000 person-years. By occupation, significantly high SMRs were in street hawkers (5.53), other chemical industry workers (5.29) and medical doctors and similar (4.32); and a high SMR almost reaching statistical significance in carpenters and wood/ paper workers (2.89). There were no significantly low SMRs in any occupation (Table 4.1).

The industries with significantly high SMRs were metallurgy (4.72), furniture/ similar products manufacture (3.76), and mechanical machinery manufacture (3.20). There were no significantly low SMRs in any industry (Table 4.3).

Cancer of the nasal cavity and middle ear has been associated with many of the same risk factors as paranasal sinus cancer. These risk factors are tobacco use²⁵⁻²⁷; alcohol use; radiotherapy; infections by some human papillomavirus (HPV); and occupations with exposure to wood or leather dust, chromium VI, nickel, formaldehyde, cotton fibres, linen fibres, rayon fibres, and trichlorophenoxyacetic acid in pesticides^{31,72-74}. There is also evidence associating these cancers with local irritation caused by infections or other agents⁷³.

Although it is necessary be very cautious when interpreting these results, based as they are on only 57 deaths, they suggest a high risk in some occupations and industries with possible exposure to known human carcinogens, particularly wood dust, nickel, chromium and formaldehyde. Some of our results are consistent with previous studies, particularly regarding excess risk in workers exposed to wood dust⁷⁵, and in the metallurgy industry, where nickel and chromium could be the responsible agents⁷⁴. Exposure to these metals may also account for the increased risk in street hawkers, as they are usually present in engine exhaust gases⁷⁶.

B. Other cancer sites

4.12. Cancer of the oral cavity and pharynx

There were 5585 deaths, with an ASDR of 5.0/ 100 000 person-years in men and 0.9/ 100 000 in women. By occupation, significantly high SMRs were found in unskilled construction workers (1.94), painters and similar (1.72), janitors/ security guards (1.60), fishers/ sailors (1.59), domestic workers (1.56), skilled construction workers and similar (1.52), unloaders and similar (1.52), waiting staff (1.42), other unskilled workers (1.41), food industry workers (1.36), cleaners (1.32), plumbers (1.28) and farmers (1.25). There were significantly low SMRs, ranging from 0.40 to 0.78, in primary school teachers and similar, engineers and similar, executives, secondary/ tertiary teachers, medical doctors and similar, other business owners (except farmers and restaurant owners), engineering technicians and similar, nurses/ health technicians, lawyers and similar, other professional workers, businesspeople/ business managers and sales/ financial agents (Table 4.2).

The industries with significantly high SMRs were households with employees (1.54), fishing (1.49), building/ structural finishing (1.42), building/ structural construction (1.39), metallurgy (1.38), restaurants (1.36), cleaning services (1.36), drinking establishments (1.32), building/ structural installations (1.25) and central public services (1.13). There were significantly low SMRs, ranging from 0.48 to 0.86, in secondary/ tertiary education, technical services, textile industry, primary education, personal services, healthcare services, tax/ accounting advisory services, sales of motor vehicles/ components, financial intermediation, maintenance/ repair of motor vehicles, vehicles/ transport equipment manufacture, other wholesale trade, and other retail trade (Table 4.4).

IARC Group 1 carcinogens with possible workplace exposure linked to cavity and pharyngeal cancer are ionising radiation, formaldehyde, and wood dust. The carcinogens with limited evidence are second-hand tobacco smoke, asbestos (all forms), printing processes, solar radiation, and radioiodines. Nonoccupational risk factors with sufficient evidence include alcohol use, tobacco smoking, smokeless tobacco, betel quid with and without tobacco, Chinese-style salted fish, human papillomavirus (HPV) type 16, and Epstein-Barr virus. Hydrochlorothiazide and HPV type 18 are nonoccupational carcinogenic hazards with limited evidence^{25-27,31}. The most significant risk factors for these cancers are alcohol and tobacco use, which sometimes act in synergy²⁵.

The results of this study clearly show an inverse association between the risk of these cancers and qualification level, with the highest risk among unskilled workers. Since the prevalence of alcohol and tobacco use is also higher in this group, the occupational differences in risk are almost certainly related to differences in use of these substances. Most previous studies have low statistical power and do not provide conclusive evidence regarding occupations with specific exposures⁷⁷. Increased risk has been observed in a wide range of occupations, including lawyers, journalists, artists, painters, hairdressers and barbers, waiting staff, hotel porters, dentists, sailors, textile and shoe workers, outdoor workers (lip cancer), secretaries, flight attendants, stewards, and people exposed to polycyclic hydrocarbons and engine exhaust gases⁷⁸⁻⁸⁰.

4.13. Oesophageal cancer

There were 4740 deaths, with an ASDR of 4.4/ 100 000 person-years in men and 0.5/ 100 000 in women. The occupations with significantly high SMRs were unskilled construction workers (1.88), fishers/ sailors (1.67), unloaders and similar (1.60), waiting staff (1.41), cleaners (1.41), skilled construction workers and similar (1.36), cooks (1.30), painters and similar (1.30), janitors and security guards (1.25) and metal workers (1.16). There were significantly decreased SMRs, ranging 0.54-0.81, in lawyers and similar, executives, engineers and similar, primary school teachers and similar, medical doctors and similar, secondary/ tertiary teachers, other business owners (except farmers and restaurant owners) and sales/ financial agents (Table 4.2).

By industry, significantly high SMRs were found in drinking establishments (1.57), fishing (1.45), building/ structural finishing (1.36), households with employees (1.34), building/ structural construction (1.33), energy and water production/ distribution (1.32) and hotels and similar (1.28). There were significantly low SMRs, ranging 0.59-0.86, in primary education, personal services, shoe/ leather industry, chemical industry, technical services, secondary/ tertiary education, tax/ financial advisory services, financial intermediation, healthcare services, other wholesale trade, and farming/ forestry (Table 4.4).

IARC identifies ionising radiation as a Group 1 carcinogen for oesophageal cancer with possible workplace exposure. Carcinogens with limited evidence in humans are unspecified agents from dry cleaning and rubber production. The nonoccupational risk factors with sufficient evidence in humans are alcohol use and acetaldehyde associated with alcohol use, tobacco smoking, smokeless tobacco, and betel quid with and without tobacco. Carcinogenic hazards with limited evidence include very hot beverages and traditional Asian pickled vegetables²⁵⁻²⁷. The leading risk factors are Barrett's oesophagus and tobacco and alcohol use. Studies have also associated this cancer with exposure to asbestos, silica dust and sulphuric acid⁸¹⁻⁸².

As with oral cavity and pharyngeal cancer, the results of this study show a clear inverse association between risk of oesophageal cancer and educational level, with a higher risk in unskilled occupations. The higher prevalence of alcohol and tobacco use in unskilled workers almost certainly accounts for some of the increased risk of this cancer in such occupations, since the results are not adjusted for those risk factors. The results are fairly consistent with a previous cohort study that found an increased risk in waiting staff, cooks, sailors, wood and construction workers and builders; and a low risk in medical doctors, technical workers, teachers and gardeners⁸³. Another cohort study found higher risk levels in workers exposed to silica and construction dust – particularly cleaners and cladding and roofing installers – and lower risk levels in textile industry workers and people working in religious organisations⁸¹. Case-control studies have found an increased oesophageal cancer risk in a wide range of occupations, including farmers; livestock workers; workers in direct contact with animals; gardeners; workers exposed to certain airborne dusts, asbestos or ionising radiation; miners; stone workers; wood workers; construction workers; loader/ unloaders; firefighters; assembly workers; administrative assistants; healthcare workers; and waiting staff⁸⁴⁻⁸⁵.

4.14. Stomach cancer

There were 9264 deaths, with an ASDR of 7.3/ 100 000 person-years in men and 3.2/ 100 000 in women. The results showed significantly high SMRs in the following occupations: fishers/ sailors (1.44), unskilled construction workers (1.39), painters and similar (1.26), industrial moving machinery operators (1.26), skilled construction workers and similar (1.24), electricians (1.23), livestock workers (1.23), cooks (1.19), cleaners (1.17), waiting staff (1.15), drivers (1.12) and farmers (1.11). There were significantly low SMRs, ranging from 0.50 to 0.86, in engineers and similar, medical doctors and similar, secondary/ tertiary teachers, lawyers and similar, other semiprofessional workers, primary school teachers and similar, executives, engineering technicians and similar, sales/ financial agents, other business owners (except farmers and restaurant owners) and non-public-facing administrative assistants (Table 4.2).

By industry, significantly high SMRs were found in building/ structural finishing (1.38), fishing (1.37), waste disposal/ sanitation and other activities (1.32), cleaning services (1.30), livestock/ hunting (1.24), building/ structural construction (1.19) and farming/ fishing (1.12). There were significantly low SMRs, ranging 0.61-0.89, in technical services, tax and accounting advisory services, secondary/ tertiary education, sea/ air transport, editing/ graphic arts, post/ telecommunications, financial intermediation, healthcare services, primary education, and central public services.

IARC Group 1 carcinogens for stomach cancer with potential occupational exposure are ionising radiation and unspecified agents present in rubber production. Agents with limited evidence are asbestos (all forms) and inorganic lead compounds. Nonoccupational risk factors with sufficient evidence include *Helicobacter pylori* and tobacco smoking; and with limited evidence, ingested nitrate or nitrite under conditions that result in endogenous nitrosation, consumption of processed meat, traditional-Asian pickled vegetables, Chinese-style salted fish, and Epstein-Barr virus²⁵⁻²⁷. There is also evidence of a relationship between stomach cancer and exposure to crystalline silica, hexavalent chromium, pesticides and wood dust⁸⁶⁻⁸⁷.

This study showed an increased risk in several occupations, generally low-skilled ones, such as fishers/ sailors and construction workers, while highly qualified occupations had low risk levels. The latter finding has appeared in previous studies⁸⁸. There is no clear occupational pattern suggesting an association with specific exposures, so occupational factors probably contribute little to the incidence of this cancer. The high risk found in fishers/ sailors could be due to the higher prevalence of tobacco smoking or consumption of processed food in these occupations, although sea salt intake could also play a part⁸⁹. Significantly increased risk was found in occupations that had been identified as high risk previously, such as cooks, farm and livestock workers (probably exposed to pesticides), and drivers^{84,87}, but not in others, such as miners (coal, tin), metal processing workers – particularly iron and steel founding – and rubber, leather, chemical and wood industry workers⁸⁷⁻⁸⁸.

4.15. Colorectal cancer

There were 17 471 deaths, with an ASDR of 13.0/ 100 000 person-years in men and 7.6/ 100 000 in women. The occupations with significantly high SMRs were street hawkers (1.24), other semiprofessional workers (1.21), electricians (1.17), sales/ financial agents (1.12) and non-public-facing administrative assistants (1.10). There were significantly low SMRs, ranging 0.74-0.93, in medical doctors and similar, primary school teachers and similar, and farmers (Table 4.2). By industry, we found significantly high SMRs in associative and recreational activities (1.23), metallurgy (1.18), building/ structural finishing (1.13) and restaurants (1.11); and significantly low SMRs in healthcare services (0.88) and farming/ forestry (0.93). (Table 4.4). If we examine occupation and industry together, we find an SMR range of 0.74-1.24.

Ionising radiation is an IARC Group 1 carcinogen for this cancer with potential workplace exposure. Hazards with limited evidence in humans are asbestos (all forms) and night shift work. Nonoccupational risk factors with sufficient evidence include consumption of alcohol, tobacco

and processed meat; and with limited evidence, red meat consumption and *Schistosoma japonicum*²⁵⁻²⁷. Other possible risk factors are heavy metals, asbestos, mineral fibres, wood dust, ammonia, diesel motor fumes, dyes, organic solvents, dioxins, and products of rubber industries⁹⁰⁻⁹³. Some studies have also associated physical inactivity with this cancer^{92,94}.

The small SMR range by occupation and industry and the lack of a clear risk distribution pattern suggests that occupational exposure does not account for colorectal cancer occurrence to any relevant degree. Previous studies have estimated that 11%-15% of cases could be caused by occupational exposure to carcinogens⁹⁵. Most of the studies fails to identify specific occupations with a higher risk of this cancer. There is evidence to suggest a higher risk in industries that use chemical products, such as the leather industry, basic metals manufacture, plastic and rubber manufacture, and repair and installation of machinery (that exposes workers to asbestos)⁹⁵. The increased risk in metallurgy is the only finding in our study that coincides with these previous results.

It should be noted that there may be many unmeasured confounders that may have biased our results. For example, some studies suggest that night shift work is a risk factor for colorectal cancer⁹⁶; however, night shift work may also involve greater exposure to chemical products.

Lastly, this cancer, like breast cancer, is controlled through public screening programmes. Differing participation in these programmes between occupational categories could also affect levels of diagnosis and mortality. People who do night shift work, for example, may be less likely to participate⁹⁷. Similarly, street hawkers, identified as high risk in our study, may participate less in these programmes, while healthcare workers, identified as low risk, may be more likely to take part.

4.16. Pancreatic cancer

There were 9132 deaths, with an ASDR of 6.9/ 100 000 person-years in men and 3.8/ 100 000 in women. The occupations with significantly high SMRs were lawyers and similar (1.31) and caregivers/ personal assistants (1.26). SMRs were significantly lower in other unskilled workers (0.65), livestock workers (0.78), farmers (0.87) and executives (0.87) (Table 4.2).

By industry, SMRs were significantly higher in sea/ air transport (1.30), tax/ accounting advisory services (1.27), and building/ structural installations (1.20). SMRs were significantly lower in livestock/ hunting (0.81), farming/ forestry (0.85) and secondary/ tertiary education (0.87) (Table 4.4).

IARC does not include any carcinogen with potential occupational exposure with sufficient evidence in humans for pancreatic cancer, but it does include some substances with limited evidence, including ionising radiations and thorium-232. Moreover, it includes nonoccupational risk factors with sufficient evidence, like smoking and smokeless tobacco, and with limited evidence, like consumption of alcohol and red meat²⁵⁻²⁷. In addition to alcohol and tobacco use, other non-occupational risk factors have been identified for this cancer, including obesity; genetic factors; diabetes; pancreatitis; and infection with *Helicobacter pylori*, HBV, HCV, and HIV. A protective effect was observed for fruit and vegetable intake, physical activity and high parity^{31,98-99}. Among the occupational risk factors, the strongest evidence involve exposure to chlorinated and polycyclic aromatic hydrocarbons. Other substances include benzo[a]pyrene, heavy metals (chrome, lead), ionising radiation, pesticides, electromagnetic fields, and sedentary work⁹⁹⁻¹⁰¹.

Our results do not show much occupational inequality in pancreatic cancer mortality (SMR range: 0.65-1.31), nor a clear pattern of risk distribution according to occupational skills level. This suggests that the most relevant risk factors for this cancer are not occupational. Behaviours like alcohol and tobacco use, unhealthy diet, obesity, and sedentarism likely play an important role. However, occupational exposures could play some role in a few categories that show higher risk, including sea/ air transport, building/ structural installations or graphic arts²⁹⁻³⁰. Prior studies have found a high risk of this cancer in diverse occupations like skilled professionals, librarians and archivists, technical assistants, butlers, flight attendants, travel agents, printers/ lithographers, electrical workers, waiting staff, drivers and other transport workers, dockworkers, and miners¹⁰²⁻¹⁰³.

4.17. Bone cancer

There were 534 deaths, with an ASDR of 0.4/ 100 000 person-years in men and 0.2/ 100 000 in women. The occupations with significantly high SMRs were hairdressers and barbers (2.61), businesspeople/ business managers (1.98), food industry workers (1.73) and public-facing administrative assistants (1.60). SMRs were significantly lower in painters and similar, while they were slightly (but not significantly) lower in carpenters and wood/ paper workers.

By industry, SMRs were significantly higher in personal services (2.03), households with employees (1.75), retail food trade (1.72), and land transport (1.46). An high SMR approaching statistical significance was found in other food industries. A significantly lower SMR was seen in furniture/ similar products manufacture.

IARC carcinogens with possible workplace exposure and sufficient evidence in humans for bone cancer are ionising radiation and some radioactive agents (plutonium and radium isotopes); there is limited evidence for radioiodines²⁵⁻²⁷. Apart from these factors no specific agents have been identified as increasing risk¹⁰⁴. The most-studied factors include male sex, age, prior radiotherapy in a bony area, and chronic bone pathologies like Paget's disease or genetic susceptibility³¹.

The results of this study are based on few deaths. Some occupations and industries were identified as having a significantly higher risk, but not an occupational aggregation of risk with a clear profile. Previous studies on occupational risk factors for this cancer are scant and inconsistent, and they have important limitations^{42,104}. A higher risk has been described in iron workers and tool manufacturers; brick layers; carpenters; manufacturers of wood, hay and cork; other healthcare personnel (including radiology professionals), military personnel, sailors and drivers^{42,104}. However, these categories do not correspond to the high-risk occupations/ industries identified in this study.

4.18. Breast cancer

There were 8409 deaths, with an ASDR of 15.40/ 100 000 person-years in women. The occupations with significantly high SMRs were plumbers (1.90), electricians (1.49), police officers and similar (1.43), other professional workers (1.33), executives (1.24), primary (1.14) and secondary/ tertiary teachers (1.22), administrative technicians (1.14), and non-public facing administrative assistants (1.13). SMRs were significantly low for assembly workers/ other manufacturing industry workers, livestock workers, domestic workers, food industry workers, cleaners, farmers and cooks, with SMRs ranging 0.67-0.85 (Table 4.2).

By industry, significantly high SMRs were seen in energy and water production/ distribution (1.51), sea/ air transport (1.48), sales of motor vehicles/ components (1.43), financial intermediation (1.24), associative and recreational activities (1.24), secondary/ tertiary education (1.22), provision of public services to the community (1.20), central public services (1.16) and primary education (1.09). SMRs were significantly lower in livestock/ hunting, households with employees, farming/ forestry, cleaning services, hotels/ similar and restaurants, with SMRs ranging from 0.69 to 0.86 (Table 4.4).

IARC identifies ionising radiation as a Group 1 carcinogen with possible workplace exposure for this cancer. Limited evidence also supports a role for dieldrin, ethylene oxide, polychlorinated biphenyls and night shift work. Moreover, there are nonoccupational risk factors with sufficient evidence as alcohol use, diethylstilbestrol, oestrogen/ progestogen contraceptives and oestrogen/ progestogen menopausal therapy; and a few with limited evidence: tobacco smoking, oestrogen menopausal therapy and digoxin²⁵⁻²⁷. Substances with an oestrogenic effect and oestrogen/ progestogen combinations are also recognised as risk factors. In this line, a possible role for exposure to endocrine disruptors (ethylene oxide, polycyclic aromatic hydrocarbons, biocides, and solvents) has been suggested¹⁰⁵. Night shift work is probably carcinogenic if it involves alterations in circadian rhythms. There is some evidence of a protective role for exercise, especially

in postmenopausal women¹⁰⁶, and for parity, which would be higher in women with lower socio-economic status⁴².

The results of this study show that the highest mortality risks for this cancer are distributed across a diverse range of activities, mainly within the service sector, and in highly qualified professionals. Unlike many cancers, the risk tends to be lower in occupations requiring fewer skills. These findings are consistent with previous studies, which have found generally lower risks in jobs involving more physical exertion⁴². In this study, these include workers in manufacturing and food industries, livestock workers, domestic workers, cleaners, farmers and cooks. The high risk identified in sea/ air transport workers is consistent with results in other studies and could be attributable to shift work and exposure to cosmic radiation¹⁰⁷⁻¹⁰⁸. Furthermore, our results differ from previous reports in that they did not identify high risk in nurses or other healthcare professions, which could be associated with shift work and exposure to ionizing radiation¹⁰⁷⁻¹⁰⁸. Finally, an increased risk of breast cancer has also been associated with exposure to endocrine disruptors in laboratories, farming/ forestry, automotive and plastic industries, canning, furniture manufacturing, metallurgy, and vehicle mechanics¹⁰⁸, but in general these categories have not been identified as high risk in this study.

4.19. Cancer of the cervix uteri

There were 1061 deaths, with an ASDR of 1.9/ 100 000 person-years in women. By occupation, significantly high SMRs were seen in skilled construction workers (2.03), waiting staff (1.95), domestic workers (1.84), other catering workers (1.68), cleaners (1.45) and cooks (1.41). SMRs were significantly lower in doctors (0.39), other professional workers (0.41), secondary/ tertiary teachers (0.46), primary school teachers (0.54), administrative technicians (0.68) and non-public facing administrative assistants (0.69). There were also lower SMRs that were borderline significant for hairdressers and barbers (Table 4.2).

By industry, there were significantly higher SMRs in workers in waste disposal/ sanitation and similar activities (2.94), drinking establishments (2.24), households with employees (1.83), cleaning services (1.72), associative and recreational activities (1.61), building/ structural construction (1.72), restaurants (1.59) and hotels/ similar (1.55). Significantly lower SMRs were associated with computer services, extractive/ mining industry, secondary/ tertiary education, primary education and healthcare activities, with SMRs of 0.72 or less. Tax/ accounting advisory services and other retail trade were other industries showing a slightly lower (but nonsignificant) SMR (Table 4.4).

IARC does not list any carcinogens of possible workplace exposure for this cancer, whether of sufficient or limited evidence in humans. However, exposure to HPV in sex workers could be considered of occupational origin^{25-27,109}. Apart from that, IARC identifies several nonoccupational risk factors with sufficient evidence in humans, including 12 types of HPV, HIV type 1, oestrogen/ progestogen contraceptives, exposure in utero to diethylstilbestrol, and tobacco smoking. Limited evidence also supports a role for 8 other types of HPV²⁶⁻²⁷. The presence of HPV, a sexually transmitted infection, is considered a necessary condition for the development of this cancer, so it is the most important risk factor³¹.

Some authors have hypothesised that occupational exposure to tetrachloroethylene (used in dry cleaning), solvents or metals could increase the risk of developing this cancer¹¹⁰⁻¹¹¹. The results of this study show that the risk of death from cervical cancer is concentrated in construction and some services (especially catering/ hospitality, cleaning and household activities), and that there is a very pronounced inverse socioeconomic gradient, with a higher risk in socio-economically disadvantaged women. These results are consistent with some previous studies^{42,111-112}. However, unlike other studies, it was not observed here a higher risk in metal workers¹¹⁰. The incidence of this cancer is conditioned by socioeconomic factors that determine the probability of an HPV infection as well as coverage by and adherence to screening programmes^{25,27,113}. This would explain the socioeconomic inequalities in mortality. When identifying possible occupational risk factors for this cancer, it is essential to control for the confounding effect of HPV infection¹¹⁰.

4.20. Cancer of the corpus uteri

There were 624 deaths, with an ASDR of 1.2/ 100 000 person-years in women. By occupation, there were significantly high SMRs in textile workers (1.55), domestic workers (1.43), farmers (1.42), and sales assistants (1.34). There was also a borderline higher risk in businesswomen/ business managers. There were significantly low SMRs in cooks (0.49) and primary school teachers (0.66).

The industries associated with a significantly high risk were metallurgy (3.60), sales of motor vehicles/ components (2.36), retail food trade (1.71) and farming/ forestry (1.36). Primary education was associated with a significantly low risk (0.67).

IARC does not list any carcinogens of possible workplace exposure for this cancer, whether of sufficient or limited evidence in humans, but it does contemplate some nonoccupational risk factors with sufficient evidence: oestrogen or oestrogen/ progestogen menopausal therapy, and tamoxifen; and with limited evidence: diethylstilbestrol²⁵⁻²⁷. An increased risk is also associated with the use of oestrogen and oestrogen/ progestogen in contraceptives and menopause treatments. Available data support the protective role of physical activity and weight loss for reducing the risk of this cancer^{28,31,114}. Environmental endocrine disruptors have also been identified as contributors to weight gain¹¹⁵. Likewise, organochloride solvents and other substances with oestrogenic properties, which can act as endocrine disruptors, are associated with endometriosis. However, no clear association has been established for cancer of the corpus uteri¹¹⁶.

The results of this study do not show a clear occupational pattern in terms of the distribution of mortality due to uterine cancer. This is consistent with a previous study in the Nordic countries⁴², and it suggests that occupational factors are probably of limited relevance in the development of this cancer. Indeed, there are few studies in this field. In one, authors found a higher risk in sales assistants, teachers, and security workers¹¹², and in another, a higher risk in women who had worked for over 10 years in the production of silk textiles¹¹⁷. Finally, the Nordic study identified a lower risk in drivers⁴².

4.21. Ovarian cancer

There were 2582 deaths, with an ASDR of 4.89/ 100 000 person-years in women. The workers with a statistically higher risk of developing this cancer were glass/ ceramic/ nonmetallic mineral workers (2.30), other mechanics (1.81), street hawkers (1.49), and caregivers/ personal assistants (1.34). There was also a slightly higher risk in primary school teachers, a significantly lower SMR in food industry workers (0.67), and a borderline lower risk in domestic workers (Table 4.2).

By industry, there were no statistically significant differences in the SMRs between categories, but the chemical industry, secondary/ tertiary education and primary education showed a borderline higher risk, and households with employees showed a borderline lower risk (Table 4.4).

IARC identified asbestos (all forms) as a carcinogen of possible workplace exposure with sufficient evidence in humans for this cancer, and ionising radiation as an agent with limited evidence. Moreover, it includes tobacco smoking and oestrogen menopausal therapy as nonoccupational risk factors with sufficient evidence, and perineal use of talc-based body powder as having limited evidence²⁵⁻²⁷. Other risk factors include advanced age; overweight or obesity; fertility treatment; having children later or never having a full-term pregnancy; a history of breast cancer; having certain family cancer syndromes or a family history of ovarian cancer, breast cancer, or colorectal cancer³¹; and exposure to combustion fumes, solvents or silica powder¹¹⁸⁻¹²⁰. Pregnancy, breastfeeding, and oral contraceptives decrease the risk of this cancer³¹.

The results of this study do not show a clear occupational pattern in ovarian cancer mortality, which is consistent with some previous studies^{42,121}. However, other previous studies have observed a higher risk in hairdressers/barbers^{42,111,121}, which is not in line with our results and could

be due to exposure to dyes (aromatic amines, aminophenols), solvents, propellants and aerosols. A greater risk has also been observed in women working in dry cleaning, printing, graphic arts, agriculture, pharmaceuticals, nursing and teaching; however, our results do not support this connection^{42,119}. The greater risk identified in glass/ceramic/nonmetallic mineral workers and other mechanics could be related to asbestos exposure.

4.22. Testicular cancer

There were 185 deaths, with an ASDR of 0.2/ 100 000 person-years in men. By occupation, a statistically high SMR was observed only in livestock workers (3.57), while no occupations showed a statistically lower risk. By industry, cleaning services (4.03) and livestock/ hunting (3.02) were associated with a significantly higher SMR. No industries showed a significantly lower SMR.

IARC does not list any carcinogen of possible workplace exposure with sufficient evidence in humans for testicular cancer, but it does point to limited evidence supporting the carcinogenic effects of exposure to DDT, the solvent dimethylformamide, and the industrial surfactant agent perfluorooctanoic acid. Moreover, it also includes some nonoccupational risk factors with limited evidence: exposure in utero to diethylstilbestrol and the occupation of firefighters²⁵⁻²⁷. Available evidence has not yet enabled the consistent and definitive identification of occupational risk factors^{120,122}. Some suggested risk factors include prenatal exposure to biocides, solvents and fertilizers that can act as endocrine disruptors¹²³⁻¹²⁴, high temperatures in genital areas, and sedentarism¹²⁵. Meanwhile, a possible protective factor is exercise in childhood and adolescence¹²⁶.

The results of this study are not conclusive because they are based on a low n° of deaths. In any case, they do not show a clear pattern of risk distribution, as there are relatively high (but non-significant) risks in both skilled and unskilled occupations. Other authors have also found similar difficulties derived from the low incidence of this cancer^{18,120,122}. A previous study reported a higher risk of this cancer in highly skilled professions¹²⁷, a finding not corroborated by our results. Other studies have found an excess risk across a range of jobs, including administrative workers, executives and sales assistants¹²⁵; doctors, artists, clergy, printers and administrative workers⁴²; farmers or former agricultural workers¹²⁶ or firefighters¹²³ (although for the latter the results are inconsistent⁶⁰). With respect to prenatal exposure, a large Nordic study did not find statistically significant associations with the father's or mother's work in agriculture¹²⁴.

4.23. Kidney cancer

There were 3231 deaths, with an ASDR of 2.7/ 100 000 person-years in men and 0.9/ 100 000 in women. The occupations associated with significantly higher SMRs were other semiprofessional workers (1.42), mechanics and operators of electric/ electronic equipment (1.39), and sales/ financial agents (1.21). Data also suggested an increased risk in metal workers. On the other hand, SMRs were significantly lower in skilled construction workers (0.80) and also slightly lower in carpenters and wood/ paper workers, cleaners and executives (Table 4.2).

The industries associated with a significantly increased risk were metallurgy (1.82), other business services (1.38), and land transport (1.21), while SMRs approaching a statistically significant increase were restaurants and central public services. No occupation was observed to have a significantly lower SMR, but a few showed borderline reduced risks: other intermediation, primary education, and building/ structural construction (Table 4.4).

IARC includes ionising radiation and trichloroethylene as Group 1 carcinogens for kidney cancer with possible occupational exposure, whereas factors with limited evidence are arsenic and its inorganic compounds, cadmium and its compounds, the surfactant agent perfluorooctanoic

acid, and unspecified agents from printing processes and welding fumes. In addition, tobacco smoking is recognised as a nonoccupational risk with sufficient evidence of carcinogenicity²⁵⁻²⁷. Arsenic, trichloroethylene, and cadmium are still regularly used in many industries^{25,128}.

Identified risks of possible workplace exposure include occupational chrome and chromates, cutting oils, diesel combustion fumes, polycyclic aromatic hydrocarbons^{118,129}, and other chlorates like tetrachloroethene¹³⁰. Nonoccupational risk factors include alcohol use, arterial hypertension and some of its treatments as diuretics or phenacetin (the latter prohibited due to its carcinogenic effects), advanced kidney diseases, family history and syndromes, and some rare diseases^{31,129}.

The results of this study show a higher risk of this cancer in some occupations and industries (metallurgy, land transport, and mechanics and operators of electric/ electronic equipment), which could be compatible with exposure to carcinogens known to have a possible occupational origin. However, it is not possible to rule out the role of tobacco use and other factors like obesity and physical inactivity, which could confound these relationships. Previous studies have found higher risks in a variety of occupations and industries, including painters; aircraft mechanics; shipbuilders; agricultural and livestock workers; dry cleaners; mechanical engineers; manufacturers of electronic and electrical equipment; tanners; dye workers; firefighters; printers; cleaners; executives; railroad workers; taxi, bus, and tram drivers; highway construction workers; and workers in the chemical, rubber, food, and welding industries^{97,118,128,131-132}.

4.24. Brain and central nervous system (CNS) cancer

There were 6748 deaths, with an ASDR of 5.1/ 100 000 person-years in men and 3.1/ 100 000 in women. There were no significant differences between occupations, although SMRs were slightly higher in assembly workers and others in the manufacturing industry, public-facing and non-public-facing administrative assistants, and sales assistants (Table 4.2).

By industry, sales of motor vehicles/ components was associated with a statistically higher SMR (1.35), while tax/ accounting advisory services, central administration services and associative and recreational activities all showed borderline increased mortality. None of the industries showed a significantly lower SMR than any others, although there was a trend observed for farming/ forestry, the plastic/ rubber industry, building/ structural construction and building/ structural finishing (Table 4.4).

Few brain and CNS tumours are associated with a known risk factor. As Group 1 carcinogens with possible workplace exposure, IARC only recognises ionising radiation. Limited evidence also supports a role for exposure to radiofrequency electromagnetic fields (including from wireless phones)²⁵⁻²⁷. Some people with genetic disorders and hereditary syndromes also have an increased risk for these cancers, along with people who have received radiotherapy for tumours in other sites³¹. A few studies have suggested that using mobile phones could possibly increase the risk for some brain tumours, but most of the more robust have not observed an effect for this exposure or for exposure to low-frequency electromagnetic fields, albeit the evidence available is still scant³¹. Some studies have identified an increased risk for certain brain tumours in people exposed to carbon tetrachloride, lead, iron, petroleum or oil mist; however, results are not conclusive¹³³⁻¹³⁵.

In general, the results of this study do not show any increase in brain or CNS cancer mortality in occupations/ industries that could involve exposure to known human carcinogens. The few published studies have pointed to a high risk in social sciences professionals, agricultural producers, printers and publishers, physicians and health workers, and public safety and protection work^{42,136}.

4.25. Thyroid cancer

There were 373 deaths, with an ASDR rate of 0.25/ 100 000 person-years in men and 0.22/ 100 000 in women. Significantly high SMRs were not observed for any occupation, but high SMRs bordering on statistical significance were seen in shoe/ leather workers (2.50) and livestock workers (1.78); SMRs were also slightly higher for workers in the textile industry and assembly workers/ other manufacturing industry workers. The only occupation associated with a significantly low SMR was cleaner (0.33).

The only industry showing a significantly high SMR was the shoe/ leather industry (2.37); a borderline high SMR was also observed for the retail food trade (1.58). No industries were associated with a significantly low SMR.

IARC includes ionising radiation and radioiodines, including iodine-131, as Group 1 carcinogens for thyroid cancer²⁵⁻²⁷. Other agents of possible occupational exposure that could increase the risk of this cancer are aromatic hydrocarbons (benzene), anions (perchlorate, nitrates), pesticides, heavy metals (cadmium, aluminium, lead, mercury), solvents, formaldehyde, asbestos, and organic and inorganic gases¹³⁷⁻¹³⁹.

Nonoccupational risk factors include hyperparathyroidism, diabetes, obesity or high BMI, genetic factors, and excessive or insufficient iodine intake. Moreover, consumption of alcohol, tobacco and vegetable seem to have a protective effect^{31,140}. The results of this study are based on a small n° of deaths due to thyroid cancer in the shoe/ leather industry. The findings also show a high risk in textile and livestock workers, who may be exposed to chemicals that alter the thyroid function. However, it cannot be ruled out the potential confounding effect of insufficient vegetable intake or obesity. These results are fairly consistent with previous reports, which have also found a higher risk associated with the same occupations¹³⁷⁻¹³⁹. Some authors have also identified an increased risk in healthcare professionals, carpenters and wood/ paper workers, and workers on electrical lines¹³⁸⁻¹³⁹, although neither our results nor those from other studies⁴² are consistent with those findings.

4.26. Leukaemia

There were 4024 deaths, with an ASDR of 2.9/ 100 000 person-years in men and 1.9/ 100 000 in women. Occupations associated with significantly high SMRs were other unskilled workers (1.52), street hawkers (1.44), and other business owners (except farmers and restaurant owners) (1.19). A nonsignificant high risk was observed for plumbers and farmers. Nurses/ health technicians (0.69), janitors/ security guards (0.70) and other mechanics (0.80) showed significantly lower SMRs, and data were also suggestive of a lower risk for secondary/ university teachers (Table 4.2).

The furniture manufacturing industry showed a significantly higher SMR (1.27), while borderline significant increases were observed in tax/ accounting advisory services, building/ structural installations, building/ structural construction, farming/ forestry, and other retail trade. Healthcare services were associated with a significantly lower SMR (0.77), while the SMRs for sea/ air transport, mechanical machinery manufacture and other food industries showed low SMRs bordering on statistical significance (Table 4.4).

IARC includes 10 Group 1 carcinogens for leukaemia and/ or lymphoma with possible workplace exposure. Four of these have radioactive agents or ionising radiation (X-gamma radiation, fission products -including strontium-90-, phosphorus-32 and thorium-232), while five are chemicals (benzene, butadiene, formaldehyde, lindane and pentachlorophenol). The remaining exposure is to the rubber production industry. Limited evidence also supports a role for radioiodines, radon-222, benzene, DDT, diazinon, malathion, glyphosate, dichloromethane, ethylene oxide, styrene, trichloroethylene, polychlorinated biphenyls, polychlorophenols (combined exposures), tet-

achlorodibenzo-para-dioxin and activities of firefighters and oil refining, and maternal exposure to painting (childhood leukaemia). For benzene, the evidence in humans is sufficient for certain leukaemias and limited for others. Moreover, nonoccupational carcinogens with sufficient evidence in humans are tobacco smoking as well as six infectious agents (including HIV-1, HTLV-1, HCV and *Helicobacter pylori*) and 11 cytostatic medicines or immunosuppressants. There is also limited evidence for the role of second-hand tobacco smoking and magnetic fields of extremely low frequency (both for childhood leukaemia), infectious agents (HBV, *Plasmodium falciparum*), and six medicines, most of them cytostatic substances²⁵⁻²⁷.

Although there are various occupations with possible exposure to ionising radiation, most of the evidence for a causal relationship comes from survivors of atomic bombs and radiotherapy patients. Workers in the rubber industry, painting industry, oil refineries, chemical production (especially gasoline), and parts manufacturing may be exposed to benzene. Workers exposed to vehicle emissions like street hawkers, drivers, petrol station workers, tradespeople, construction, personal services and other industries may also be at increased risk^{30,141}. Butadiene is used in the plastic/rubber industry and is also present in vehicle emissions⁵⁴. Formaldehyde is used in many industries, including those producing plastics, textiles, resins, wood conglomerates, furniture, paper, construction and healthcare activities, thus many occupations are exposed to this substance^{30,141}.

The results of this study show a high risk in occupations/ industries like street hawkers, other unskilled workers, furniture/ similar products manufacture, agriculture and construction. These results are only partially consistent with previous studies, which have identified a high risk of leukaemia in public safety personnel, engineers, farmers and other agricultural workers, fishers, healthcare professionals, construction workers, cleaners, caregivers and porters¹⁴²⁻¹⁴³. In this study we did not detect an excess risk in healthcare activities.

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Table 4.1. Age- and sex-standardised mortality rates for occupational cancers included in Spanish Royal Decree 1299/2006 and level of statistical significance*, by occupation. Spain, 2001-2011.

Occupation	Lung	Mesothelioma	Larynx	Bladder	Squamous cells of the skin	Lymphoma	Myeloma	Prostate ⁺	Liver	Paranasal sinuses	Ear and nasal cavity ⁺⁺
Farmers	0.96 ^a	0.63 ^a	1.21 ^b	0.95	1.55 ^a	1.04	1.01	1.08	0.88 ^b	1.56 ^c	0.58
Livestock workers	0.83 ^c	0.58	1.06	0.72 ^b	2.27 ^b	0.77	0.84	0.89	0.88	0.91	0.00
Fishers/Sailors	1.37 ^c	0.54	1.57 ^a	0.72	0.70	1.24	0.92	0.89	1.16	1.37 ^b	0.00
Miners and similar	1.30 ^c	1.02	1.90 ^c	0.62	0.00	1.19	0.89	0.51	1.11	1.58	0.00
Construction managers	0.99	1.57	0.66 ^a	0.94	0.97	1.16	1.04	1.02	0.97	1.31	0.00
Skilled construction workers and similar	1.26 ^c	0.80	1.53 ^c	1.13 ^a	0.96	1.01	1.06	1.09	1.05	1.10 ^c	0.94
Unskilled construction workers	1.42 ^c	0.70	1.90 ^c	1.23 ^a	0.96	0.74 ^a	1.08	1.20	1.28 ^b	1.07 ^c	1.08
Plumbers	1.09	2.85 ^c	0.98	1.03	0.41	1.00	0.98	0.78	1.28 ^a	0.79 ^a	0.00
Electricians	1.00	1.78 ^a	0.97	1.02	1.62	1.03	0.72	1.27	1.01	0.50	0.00
Painters and similar	1.21 ^c	1.56	0.96	1.26	1.46	1.09	0.96	0.85	1.25 ^a	1.41 ^c	0.00
Carpenters and wood/paper workers	0.96	0.95	1.21	0.99	0.35	1.06	1.05	1.16	0.93	2.39	2.89
Metal workers	1.11 ^c	1.83 ^c	1.10	1.14 ^a	0.93	0.98	0.84	1.02	1.08	1.45	1.01
Textile workers	0.86	0.86	0.99	1.18	0.65	1.04	1.16	0.67	0.76	1.41	0.00
Shoe/leather workers	0.87	0.31	1.33	1.27	0.76	0.70	0.85	0.92	0.99	0.00	0.00
Glass/ceramic/nonmetallic mineral workers	1.02	1.90	1.23	0.94	0.00	1.04	0.94	0.84	1.45 ^a	0.00	0.00
Plastic/rubber workers	0.93	2.91 ^c	1.20	1.17	0.00	0.61	1.04	1.13	0.82	0.00	0.00
Other chemical industry workers	0.94	1.87 ^a	0.84	0.98	0.99	1.13	1.30	0.71	1.15	1.96	5.29 ^b
Food industry workers	0.98	1.18	0.86	1.21	0.71	0.86	1.02	1.22	0.98	0.96 ^b	0.00
Graphic artists	1.07	0.73	1.07	1.16	0.93	1.07	0.89	1.15	1.51 ^c	0.00	0.00
Mechanics/operators of electric/electronic equipment	0.97	1.40	0.82	0.87	1.51	1.16	1.24	0.96	0.93	0.00	2.40
Other mechanics	0.97	1.09	0.92	0.92	0.58	0.97	0.99	0.96	0.84 ^b	0.90	0.63
Assembly workers/other manufacturing industry workers	1.07	1.53	1.20	1.07	1.16	0.98	1.05	1.12	1.06	0.75	0.00
Drivers	1.03	0.89	0.91	1.00	0.84	1.07	0.94	1.03	1.03	0.79	0.94
Industrial moving machinery operators	1.13 ^b	0.68	1.22	0.99	0.87	0.96	0.88	1.55 ^b	1.00	1.69	0.00
Unloaders and similar	1.18 ^b	2.55 ^b	1.46	1.27	1.33	1.09	0.71	1.05	1.31	2.45 ^b	0.00
Secondary/ tertiary teachers	0.75 ^c	0.63	0.40 ^c	0.76 ^b	0.14 ^a	0.78 ^a	1.03	0.75 ^a	0.70 ^c	0.29 ^c	2.44
Primary teachers and similar	0.75 ^c	0.77	0.65 ^b	0.84	0.59	0.92	0.78	0.87	0.86	1.28 ^c	1.78
Medical doctors and similar	0.81 ^c	0.70	0.44 ^c	0.77	1.98 ^a	0.66 ^a	0.83	0.94	0.76 ^b	0.50 ^c	4.32 ^b
Nurses/health technicians	1.01	0.71	0.95	0.75	1.23	1.16	0.97	1.02	0.85	0.64 ^b	0.00
Auxiliary nurses and similar	1.04	1.45	0.79	0.98	0.65	1.16	0.99	1.09	1.21	0.00	0.00
Engineers and similar	0.76 ^c	0.85	0.44 ^c	0.61 ^b	1.79	0.74	0.93	0.78	0.58 ^c	0.00 ^c	1.70
Engineering technicians and similar	0.83 ^c	0.83	0.54 ^c	0.87	1.43	0.79 ^a	0.98	0.80	0.68 ^c	0.93 ^c	0.68
Lawyers and similar	0.97	1.00	0.29 ^c	1.21	0.47	1.12	0.97	0.97	0.85	0.97 ^b	0.00
Other professional workers	0.84 ^b	0.00 ^a	0.50 ^a	0.92	1.41	0.77	1.04	0.88	0.91	0.00 ^b	2.67
Other semiprofessional workers	0.91	0.40	0.56 ^a	1.25	0.92	0.65 ^a	0.93	0.91	0.86	0.00	2.63
Artists /models /athletes	1.00	0.92	0.96	0.82	0.86	1.28	1.28	1.13	0.98	1.73	0.00
Police officers and similar	1.03	1.27	1.26 ^b	1.00	0.93	1.06	1.61 ^c	0.90	1.09	1.51	0.77
Administrative technicians	1.02	1.30	0.64 ^b	0.99	0.73	1.05	1.09	0.88	0.95	0.25	0.69
Public-facing administrative assistants	1.03	0.79	1.16	0.92	0.47	1.02	1.02	1.06	1.03	0.78	0.52
Non-public facing administrative assistants	0.96	0.84	0.83	0.88	1.09	0.99	0.95	0.85	0.92	0.91	1.03

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Occupation	Lung	Mesothelioma	Larynx	Bladder	Squamous cells of the skin	Lymphoma	Myeloma	Prostate ⁺	Liver	Paranasal sinuses	Ear and nasal cavity ⁺⁺
Cooks	1.15 ^c	1.18	1.21	1.32 ^b	1.60	0.93	0.72	0.92	1.38 ^b	1.14	0.00
Waiting staff	1.27 ^c	0.55	1.49 ^c	1.40 ^a	0.49	1.02	1.07	1.07	1.48 ^c	0.64 ^c	0.92
Other catering workers	1.09 ^a	0.77	1.06	1.23	1.38	1.17	1.27	1.16	1.36 ^b	0.58	0.00
Hairdressers/barbers and similar	0.91	2.79 ^b	0.76	0.74	0.00	1.10	1.45	0.68	1.24	0.00	0.00
Caregivers/personal assistants	1.05	1.36	1.16	0.89	0.79	0.85	1.01	0.80	1.03	3.33	2.29
Domestic workers	0.75 ^c	1.05	0.94	1.24	0.33	1.03	1.02	0.68	1.19	0.00 ^b	0.00
Cleaners	1.09 ^b	1.32	1.84 ^c	1.10	1.55	1.17	1.04	1.12	1.22 ^b	1.76 ^c	1.41
Janitors/security guards	1.16 ^c	1.23	1.14	1.17	1.22	1.11	1.03	0.86	1.34 ^c	1.59 ^c	2.73
Other unskilled workers	1.07	1.12	1.86 ^c	1.40 ^c	2.01	0.96	1.00	0.77	0.80	1.33 ^a	0.00
Executives	0.87 ^c	0.79	0.52 ^c	0.82 ^b	0.77	1.06	1.03	1.04	0.83 ^b	0.51 ^c	0.48
Businesspeople/business managers	0.80 ^c	0.81	0.66 ^c	1.03	0.70	1.05	0.94	0.87	0.95	1.76 ^b	1.77
Other business owners (except farmers and restaurant owners)	0.90 ^c	0.98	0.71 ^b	0.89	0.94	1.03	0.95	1.04	0.90	1.08 ^c	0.59
Sales/financial agents	0.96	0.92	0.83	1.05	1.09	1.10	0.95	1.16	1.12	0.96 ^b	1.37
Sales assistants	0.92 ^b	0.87	0.97	1.09	1.63 ^a	0.96	1.01	0.99	1.01	0.52	0.92
Street hawkers	1.09	0.79	1.22	0.90	0.00	0.90	0.53	1.00	1.24	0.98	5.53 ^b
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* a: p < 0.05; b: p < 0.01; c: p < 0.001.

⁺ Age-adjusted mortality rates in men.

⁺⁺ Nasal cavity and middle ear

Table 4.2. Age- and sex-standardised mortality rates for occupational cancers included in Spanish Royal Decree 1299/2006 and level of statistical significance*, by occupation. Spain, 2001-2011.

Occupation	Mouth/ pharynx	Oesophagus	Stomach	Colon/ rectum	Pancreas	Breast ⁺	Cervix ⁺	Ovary ⁺	Kidney	Brain ⁺⁺	Leukaemia
Farmers	1.25 ^a	0.95	1.11 ^b	0.93 ^a	0.87 ^b	0.83 ^b	1.22	1.11	0.98	0.98	1.08
Livestock workers	0.94 ^c	0.97	1.23 ^b	0.91	0.78 ^b	0.70 ^b	1.28	1.21	1.07	0.96	1.09
Fishers/Sailors	1.59 ^c	1.67 ^c	1.44 ^b	0.82	1.28	0.95	2.05	1.34	0.99	1.03	0.97
Miners and similar	1.37 ^c	1.05	1.15	1.16	1.18	1.14	0.00	0.62	0.99	0.91	1.28
Construction managers	0.89	0.83	1.13	0.91	1.01	1.35	1.82	0.70	0.96	1.00	0.93
Skilled construction workers and similar	1.52 ^c	1.36 ^c	1.24 ^c	0.98	1.00	1.06	2.03 ^a	0.73	0.80 ^b	0.96	1.04
Unskilled construction workers	1.94 ^c	1.88 ^c	1.39 ^c	1.05	1.02	0.89	1.87	0.88	0.90	0.88	1.01
Plumbers	1.28	1.20	0.95	1.05	1.10	1.90 ^a	0.00	0.39	0.89	0.85	1.30
Electricians	1.09	1.19	1.23 ^a	1.17 ^a	1.17	1.49 ^a	2.05	0.94	0.99	1.01	1.07
Painters and similar	1.72 ^c	1.30 ^a	1.26 ^a	1.08	1.17	1.65	2.67	1.37	1.15	1.11	0.94
Carpenters and wood/paper workers	0.98	1.09	1.14	0.99	0.98	0.80	0.56	1.11	0.76	0.92	0.96
Metal workers	1.06 ^c	1.16 ^a	1.08	1.04	1.11	0.79	1.40	0.88	1.15	1.03	1.05
Textile workers	0.72 ^b	0.84	1.06	0.90	1.00	0.88	1.03	1.08	1.00	0.95	1.02
Shoe/leather workers	1.25	0.77	1.21	0.99	0.98	1.11	1.55	0.50	0.92	0.96	0.96
Glass/ceramic/nonmetallic mineral workers	1.07	1.02	1.04	1.09	1.02	0.82	2.29	2.30 ^a	0.62	0.80	0.60
Plastic/rubber workers	0.70	0.93	1.08	1.04	0.75	1.06	0.89	1.64	0.90	1.01	0.76
Other chemical industry workers	0.92	0.82	1.01	1.03	0.97	1.02	0.00	0.96	1.12	0.92	1.05
Food industry workers	1.36	1.15	1.00	1.00	0.97	0.76 ^b	1.21	0.67 ^a	1.00	0.97	0.89
Graphic artists	1.12	1.22	1.08	0.94	1.20	1.28	0.97	0.83	1.06	1.18	1.04

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Occupation	Mouth/ pharynx	Oesophagus	Stomach	Colon/ rectum	Pancreas	Breast*	Cervix*	Ovary*	Kidney	Brain**	Leukaemia
Mechanics/operators of electric/ electronic equipment	0.92	1.00	0.86	0.99	0.95	0.90	0.91	0.84	1.39 ^b	1.09	1.05
Other mechanics	0.90	0.97	1.05	0.97	0.97	1.04	0.73	1.81 ^a	0.98	1.02	0.80 ^a
Assembly workers/other manufacturing industry workers	1.07	0.95	0.99	1.01	1.05	0.67 ^a	0.91	1.05	0.78	1.26	0.87
Drivers	0.98	0.97	1.12 ^b	1.05	1.03	1.16	1.34	0.98	1.02	1.00	1.03
Industrial moving machinery operators	1.12 ^b	0.82	1.26 ^a	1.03	1.10	1.33	3.11	0.57	1.02	1.00	1.17
Unloaders and similar	1.52 ^b	1.60 ^b	1.19	1.07	1.20	0.74	1.30	1.38	0.96	0.99	1.26
Secondary/ tertiary teachers	0.48 ^c	0.63 ^c	0.63 ^c	0.98	0.87	1.22 ^c	0.46 ^c	1.03	0.95	1.02	0.85
Primary school teachers and similar	0.53 ^c	0.61 ^c	0.79 ^b	0.89 ^a	0.96	1.14 ^b	0.54 ^c	1.12	0.78	0.94	0.99
Medical doctors and similar	0.40 ^c	0.62 ^b	0.59 ^a	0.74 ^c	1.06	1.03	0.39 ^b	1.11	1.15	0.88	0.85
Nurses/health technicians	0.63	0.95	0.90	0.89	0.92	0.97	0.78	0.92	1.09	1.02	0.69 ^a
Auxiliary nurses and similar	0.98	0.82	1.04	0.96	1.06	0.98	0.91	1.00	0.96	1.00	0.97
Engineers and similar	0.46 ^c	0.61 ^b	0.50 ^c	0.77	1.07	0.87	0.93	0.41	0.80	0.90	0.96
Engineering technicians and similar	0.59 ^c	0.84	0.74 ^c	0.91	1.06	1.12	0.80	1.00	1.10	0.93	0.95
Lawyers and similar	0.64	0.54 ^b	0.63 ^b	1.06	1.31 ^a	0.94	0.48	0.86	1.14	0.95	1.02
Other professional workers	0.68 ^b	0.75	0.85	1.12	0.96	1.33	0.41 ^a	1.12	0.85	0.87	0.73
Other semiprofessional workers	0.81	0.79	0.72 ^a	1.21 ^a	1.21	1.13	0.54	0.71	1.42 ^a	1.08	1.05
Artists/models/athletes	0.91	0.88	0.83	1.11	0.85	1.03	1.05	0.98	1.30	0.97	0.89
Police officers and similar	1.01	0.97	0.95	1.01	0.96	1.43 ^b	1.13	1.49	1.10	1.08	1.07
Administrative technicians	0.88	0.97	0.90	1.06	0.99	1.14 ^b	0.68 ^b	1.08	0.84	1.02	1.02
Public-facing administrative assistants	1.08	1.13	0.97	1.03	1.02	1.06	0.85	0.97	1.10	1.10	0.94
Non-public-facing administrative assistants	0.89	0.94	0.86 ^b	1.10 ^a	1.06	1.13 ^b	0.69 ^a	1.02	0.96	1.09	1.05
Cooks	1.18 ^c	1.30 ^a	1.19 ^a	1.10	1.01	0.85 ^a	1.41 ^a	0.96	1.08	0.92	1.10
Waiting staff	1.42 ^c	1.41 ^c	1.15 ^a	1.10	1.09	0.93	1.95 ^c	1.12	1.11	0.91	1.02
Other catering workers	1.01 ^a	1.30 ^a	0.91	1.07	0.91	0.80 ^a	1.68 ^a	0.86	1.06	0.97	0.99
Hairdressers/barbers and similar	0.96	0.83	1.00	1.04	0.79	1.11	0.46	0.92	1.04	1.01	0.91
Caregivers/personal assistants	1.26	0.99	0.82	1.08	1.26 ^a	1.00	1.08	1.34 ^a	0.72	0.90	0.96
Domestic workers	1.56 ^c	1.21	1.16 ^b	0.92	1.06	0.75 ^c	1.84 ^b	0.85	1.05	1.05	1.02
Cleaners	1.32 ^b	1.41 ^c	1.17	0.95	1.02	0.85 ^c	1.45 ^b	0.94	0.84	1.02	1.03
Janitors/security guards	1.60 ^c	1.25 ^a	1.05	1.04	0.98	1.00	1.26	0.73	1.03	1.06	0.70 ^a
Other unskilled workers	1.41	1.20	1.28	1.13	0.65 ^a	0.88	0.68	1.35	1.02	1.01	1.52 ^a
Executives	0.47 ^c	0.56 ^c	0.76 ^c	0.94	0.87 ^a	1.24 ^b	0.87	0.81	0.88	1.06	0.99
Businesspeople/business managers	0.76 ^c	0.87	0.96	0.98	0.98	1.01	0.73	0.95	1.09	0.97	0.96
Other business owners (except farmers and restaurant owners)	0.58 ^c	0.63 ^c	0.85 ^b	0.99	0.97	0.91	1.02	0.96	1.05	1.01	1.19 ^a
Sales/financial agents	0.78	0.81 ^a	0.84 ^a	1.12 ^b	0.96	1.14	1.11	1.19	1.21 ^a	0.95	1.04
Sales assistants	0.89 ^b	0.94	0.99	0.99	1.09	1.01	1.06	0.98	1.03	1.08	0.93
Street hawkers	1.19	1.19	1.17	1.24 ^b	1.07	0.91	0.60	1.49 ^a	1.35	0.84	1.44 ^a
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* a: p < 0.05; b: p < 0.01; c: p < 0.001

* Age-adjusted mortality rate in women

** Central nervous system and brain

Table 4.3. Age- and sex-standardised mortality rates for occupational cancers included in Spanish Royal Decree 1299/2006 and level of statistical significance*, by industry. Spain, 2001-2011.

Economic activity	Lung	Mesothelioma	Larynx	Bladder	Squamous cells of the skin	Lymphoma	Myeloma	Prostate ⁺	Liver	Paranasal sinuses	Ear and nasal cavity ⁺⁺
Farming/forestry	0.93 ^c	0.49 ^c	1.11	0.91	1.52 ^a	1.04	0.99	1.06	0.83 ^c	1.24	0.54
Livestock/hunting	0.85 ^c	0.96	1.12	0.79 ^a	1.97 ^a	0.94	0.82	0.92	0.81	1.45	0.00
Fishing	1.38 ^c	1.18	1.49 ^a	0.90	1.22	1.21	0.57	0.98	0.99	1.19	3.52
Extractive/mining industry	1.26 ^b	0.00	1.51	1.02	0.00	1.29	1.44	0.89	1.22	0.00	0.00
Meat industry	0.85 ^a	0.53	0.61	0.81	0.65	1.01	1.53	1.48 ^a	0.92	0.00	0.00
Other food industry	0.96	1.08	0.99	0.90	1.42	1.00	1.21	1.07	0.95	1.44	2.01
Textile industry	0.85 ^c	0.99	0.78	0.95	1.63	0.96	1.02	0.84	0.87	1.48	0.00
Shoe/leather industry	0.88 ^a	0.46	0.88	1.07	0.57	0.93	1.07	0.92	0.99	0.00	3.20
Wood/paper industry	0.96	0.69	1.24	0.98	0.00	1.11	1.22	1.14	0.68 ^b	2.08	0.00
Editing/graphic arts	0.98	1.24	0.95	1.13	0.56	1.00	0.92	1.04	1.31 ^b	0.56	1.57
Glass/ceramic/nonmetallic minerals industry	1.02	2.00 ^b	1.15	0.94	0.00	0.90	0.57	1.09	0.99	2.50	1.76
Plastic/rubber industry	0.94	1.88 ^a	1.01	1.09	0.44	0.89	1.11	0.90	0.72 ^a	1.74	0.00
Chemical industry	0.92 ^a	1.27	0.74	0.92	1.09	0.97	1.34	0.73	0.87	0.00	1.48
Metallurgy	1.11 ^a	2.61 ^c	1.43 ^a	0.97	1.35	0.68	0.43	1.10	1.00	0.88	4.72 ^a
Tools/metal products manufacture	1.09 ^b	1.49 ^a	0.85	1.14	0.65	1.01	1.24	1.06	1.03	1.76	0.00
Mechanical machinery manufacture	0.93 ^a	1.05	0.80	0.82	0.39	1.04	1.10	0.94	0.88	0.78	3.20 ^a
Electrical/electronic devices manufacture	1.00	1.01	0.54 ^a	0.86	1.02	0.94	1.19	0.90	0.89	1.01	0.00
Vehicle/transport equipment manufacture	1.00	2.14 ^c	0.92	1.05	0.59	1.12	0.66	0.73 ^b	0.96	1.45	1.57
Furniture/similar products manufacture	0.92 ^a	1.07	0.86	1.00	0.91	0.97	1.22	1.00	0.73 ^b	2.25	3.76 ^a
Maintenance/repair of motor vehicles	0.85 ^c	0.91	1.05	1.01	0.87	1.00	0.60	0.91	0.95	1.26	1.20
Energy and water production/distribution	1.00	1.61	0.75	0.86	1.27	1.11	0.67	1.24	0.95	0.00	0.00
Building/structural construction	1.20 ^c	0.78	1.37 ^c	1.08 ^a	0.98	0.98	1.09	1.10	1.03	0.72	0.75
Building/structural finishing	1.06	1.46	1.17	1.18	1.63	0.82	0.75	1.13	1.10	1.78	1.31
Building/structural installations	1.06	2.18 ^c	0.98	1.02	1.33	1.23	0.90	0.92	1.16	0.36	0.00
Land transport	1.03	1.05	0.94	1.04	0.84	1.06	0.97	0.99	1.07	0.92	0.42
Sea/air transport	0.97	0.71	1.20	0.89	0.61	1.12	0.81	1.12	1.09	0.00	0.00
Other transport activities	1.05	1.02	1.00	0.95	0.56	0.90	0.93	1.04	1.10	0.56	3.11
Sales of motor vehicles/components	0.88 ^b	0.83	0.90	1.06	0.60	1.09	0.94	0.93	0.97	0.59	1.66
Wholesale food trade	0.94	0.94	0.84	0.99	0.66	0.68 ^a	0.69	0.83	0.95	0.00	1.86
Other wholesale trade	1.00	1.13	0.73 ^b	1.01	1.21	1.03	0.99	1.09	1.05	0.74	0.68
Retail food trade	0.87 ^c	0.71	0.72 ^a	1.17	0.61	1.03	0.93	1.03	0.86	1.68	0.00
Other retail trade	0.89 ^c	0.77	0.81 ^a	1.07	1.47	0.96	0.86	1.04	0.99	0.91	0.69
Hotels and similar	1.05	0.80	1.12	1.18	0.93	1.00	1.27	0.93	1.22 ^a	0.48	0.00
Restaurants	1.19 ^c	0.84	1.35 ^b	1.24 ^b	1.11	1.14	0.80	1.12	1.57 ^c	1.50	0.72
Drinking establishments	1.31 ^c	0.65	1.53 ^b	1.75 ^c	0.62	1.01	1.32	1.24	1.48 ^c	1.27	0.00
Post/telecommunications	0.92 ^a	0.91	0.68 ^a	0.86	0.22	0.98	0.77	0.90	1.04	0.84	1.24
Financial intermediation	0.87 ^c	0.72	0.67	0.77 ^b	0.96	0.99	1.05	0.91	0.74 ^c	1.18	2.09
Other intermediation	0.98	0.86	1.00	0.86	1.55	0.99	1.13	1.24	1.07	2.15	0.00
Computer services	0.90	0.89	0.38 ^b	0.61 ^a	1.42	0.89	1.69	0.82	0.60 ^b	0.91	0.00

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Economic activity	Lung	Mesothelioma	Larynx	Bladder	Squamous cells of the skin	Lymphoma	Myeloma	Prostate ⁺	Liver	Paranasal sinuses	Ear and nasal cavity ⁺⁺
Technical services	0.93	1.16	0.42 ^c	0.97	1.07	0.51 ^b	0.92	0.72	0.58 ^c	0.00	0.00
Tax/accounting advisory services	1.04	0.41	0.65 ^b	1.16	0.24	0.99	0.65	1.06	1.05	1.47	0.00
Cleaning services	1.12 ^a	1.42	1.31	1.19	1.18	1.04	0.99	1.00	0.98	2.00	1.92
Other business services	1.20 ^c	1.48	1.19	1.33 ^a	0.69	1.18	1.72	1.19	1.40 ^b	0.67	0.00
Central public services	1.04 ^a	1.05	1.08	0.98	1.19	1.08	1.21	1.04	1.11 ^a	0.90	0.63
Provision of public services to the community	0.99	1.16	1.18	0.88	0.92	0.99	1.14	0.81	0.95	0.59	0.90
Primary education	0.81 ^c	0.84	0.76 ^a	0.79 ^a	0.76	0.88	0.82	0.97	0.83 ^a	1.11	1.52
Secondary/tertiary education	0.78 ^c	0.66	0.47 ^c	0.82 ^a	0.34 ^a	0.99	0.95	0.71 ^b	0.83 ^a	0.47	1.36
Healthcare services	0.98	0.79	0.78 ^a	0.86	1.19	0.96	0.98	0.87	0.93	0.72	2.06
Waste disposal/sanitation and similar activities	1.25 ^c	1.57	2.52 ^b	1.14	0.80	1.36	1.06	1.38	1.58 ^b	0.00	0.00
Social services	0.96	0.98	1.06	1.02	2.42 ^a	0.86	1.45	0.67	0.93	0.91	2.46
Associative and recreational activities	1.08 ^b	0.89	1.27	0.98	1.18	0.93	0.84	1.07	1.20	1.45	2.70
Personal services	0.97	1.88	0.86	1.15	0.89	1.07	1.43	1.06	1.12	0.00	0.00
Households with employees	0.91 ^b	0.89	1.22	0.91	0.75	1.04	0.91	0.69	1.37 ^c	0.92	0.00
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* a: p < 0.05; b: p < 0.01; c: p < 0.001

⁺ The results refer to the age-adjusted mortality rate in men

⁺⁺ Nasal cavity and middle ear

Table 4.4. Age- and sex-standardised mortality rates for occupational cancers included in Spanish Royal Decree 1299/2006 and level of statistical significance*, by industry. Spain, 2001-2011.

Economic activity	Mouth/pharynx	Oesophagus	Stomach	Colon/ rectum	Pancreas	Breast ⁺	Cervix ⁺	Ovary ⁺	Kidney	Brain ⁺⁺	Leukaemia
Farming/forestry	1.14 ^b	0.86 ^a	1.12 ^b	0.93 ^b	0.85 ^c	0.80 ^c	1.23	1.07	0.99	0.93	1.07
Livestock/hunting	0.92	0.98	1.24 ^b	0.92	0.81 ^a	0.69 ^b	1.36	1.18	0.88	0.99	1.05
Fishing	1.49 ^b	1.45 ^a	1.37 ^b	0.88	1.21	0.89	1.52	1.14	1.25	1.09	0.84
Extractive/mining industry	1.33	1.32	1.18	1.18	1.28	1.69	0.00	0.81	1.40	1.06	1.41
Meat industry	1.11	1.32	1.28	0.96	0.80	0.71	0.48	0.62	0.84	0.89	0.99
Other food industry	1.00 ^c	0.94	1.05	0.99	1.09	0.92	1.07	0.85	1.07	0.97	0.81
Textile industry	0.57	0.96	1.06	0.95	0.93	0.92	0.93	1.10	0.85	0.91	1.04
Shoe/leather industry	1.05	0.68	1.03	1.01	1.10	1.14	1.56	0.54	0.90	0.98	0.98
Wood/paper industry	1.02	1.04	1.15 ^a	1.02	0.96	1.34	0.97	0.70	0.87	1.01	0.94
Editing/graphic arts	0.89	1.01	0.77	1.10	1.04	1.18	0.64	1.07	0.98	0.91	1.07
Glass/ceramic/nonmetallic minerals industry	0.96	0.83	1.08	0.94	0.93	1.07	1.85	1.08	0.93	0.89	1.05
Plastic/rubber industry	0.80	1.10	1.11	0.96	1.00	1.08	0.98	0.88	0.96	0.75	1.09
Chemical industry	0.86	0.70 ^a	0.91	1.09	1.00	1.13	0.66	1.43	0.98	1.05	0.93
Metallurgy	1.38 ^b	1.29	1.05	1.18 ^a	1.07	1.45	0.73	0.87	1.82 ^c	1.18	0.93
Tools/metal products manufacture	1.02	1.13	1.07	1.02	1.05	1.18	1.01	1.41	0.93	1.01	1.09
Mechanical machinery manufacture	0.95	1.06	1.07	1.03	0.97	0.83	0.71	0.83	0.96	1.09	0.80
Electrical/electronic devices manufacture	0.79	0.92	1.08	1.13	1.09	1.06	1.04	0.85	0.89	0.98	1.04
Vehicle/transport equipment manufacture	0.81 ^a	0.83	1.06	1.00	0.97	0.79	0.62	1.05	0.83	1.10	1.03

Occupation, economic activity and cancer mortality in Spain: executive summary

Economic activity	Mouth/pharynx	Oesophagus	Stomach	Colon/ rectum	Pancreas	Breast*	Cervix*	Ovary*	Kidney	Brain**	Leukaemia
Furniture/similar products manufacture	0.89	0.81	1.00	1.01	0.95	1.03	1.19	1.33	0.88	1.05	1.27 ^a
Maintenance/repair of motor vehicles	0.78	0.80	0.88	0.98	1.05	1.05	1.30	1.29	1.19	0.89	0.94
Energy and water production/distribution	1.11	1.32 ^a	0.80	1.02	1.18	1.51 ^a	0.68	1.07	1.16	1.19	0.76
Building/structural construction	1.39 ^c	1.33 ^c	1.19 ^c	0.97	0.98	1.20 ^a	1.72 ^a	0.83	0.92	0.97	1.07
Building/structural finishing	1.42 ^c	1.36 ^b	1.38 ^c	1.13 ^a	1.05	0.71	0.93	0.77	0.90	0.82	0.83
Building /structural installations	1.25 ^b	1.06	1.13	1.08	1.20 ^a	0.84	0.79	1.12	0.88	0.94	1.21
Land transport	0.90	0.89	1.02	1.01	0.99	1.13	1.11	1.24	1.21 ^a	0.95	1.05
Sea/air transport	0.92	0.74	0.74	0.98	1.30 ^a	1.48 ^b	0.52	0.93	0.83	0.73	0.57
Other transport activities	1.08	1.19	1.04	1.01	0.90	0.92	0.99	0.69	0.83	0.96	0.93
Sales of motor vehicles/components	0.68 ^b	0.96	1.13	1.02	1.03	1.43 ^b	1.31	0.94	1.23	1.35 ^b	0.95
Wholesale food trade	0.94	0.92	0.94	0.91	1.01	0.89	1.08	0.62	1.07	1.12	1.04
Other wholesale trade	0.82 ^a	0.82 ^a	0.94	1.07	1.01	0.90	0.81	0.83	1.08	0.99	1.16
Retail food trade	0.95	0.83	0.98	0.97	1.01	0.90	0.97	1.07	0.91	0.95	0.99
Other retail trade	0.86 ^a	0.98	1.00	1.04	1.06	1.03	0.83	0.95	1.03	1.03	0.97
Hotels and similar	1.22	1.17	1.00	1.01 ^b	1.01	0.84 ^a	1.55 ^b	0.98	0.80	0.99	0.99
Restaurants	1.36 ^a	1.28 ^b	1.04	1.11	1.03	0.86 ^a	1.59 ^c	0.95	1.17	0.96	0.96
Drinking establishments	1.32	1.57 ^c	0.91	1.10	0.97	0.81	2.24 ^c	1.09	0.82	0.97	0.88
Post/telecommunications	0.86	0.92	0.79 ^a	0.96	0.96	1.05	0.57	0.73	1.10	1.00	0.81
Financial intermediation	0.73 ^c	0.76 ^b	0.81 ^b	1.07	1.01	1.24 ^c	0.88	0.98	0.98	1.03	0.96
Other intermediation	0.70	0.93	0.96	1.00	1.14	1.08	1.17	0.88	0.59	0.96	0.86
Computer services	0.76	0.90	0.80	0.83	1.06	0.89	0.00 ^b	1.10	0.74	0.97	0.96
Technical services	0.50 ^c	0.69 ^a	0.61 ^c	0.97	1.01	0.93	0.62	0.82	1.25	0.89	1.07
Tax/accounting advisory services	0.68 ^b	0.71	0.65 ^c	1.03	1.27 ^b	0.88	0.59	1.01	1.06	1.17	1.24
Cleaning services	1.36 ^a	1.13	1.30 ^b	1.04	1.09	0.80 ^c	1.72 ^c	0.94	1.04	0.99	1.00
Other business services	0.84	1.09	0.92	1.10	1.11	1.09	0.64	1.44	1.38 ^a	0.99	0.89
Central public services	1.13 ^a	1.08	0.89 ^b	1.01	1.00	1.16 ^c	0.87	0.97	1.10	1.08	1.00
Provision of public services to the community	0.86	0.90	0.87	0.97	0.91	1.20 ^a	0.15 ^b	1.18	0.98	1.09	1.08
Primary education	0.60 ^c	0.59 ^c	0.83 ^b	0.92	1.03	1.09 ^a	0.60 ^c	1.10	0.82	0.94	1.00
Secondary/tertiary education	0.48 ^c	0.71 ^c	0.73 ^c	0.94	0.87 ^a	1.22 ^c	0.46 ^c	1.16	0.94	1.05	0.96
Healthcare services	0.64 ^c	0.78 ^b	0.82 ^c	0.88 ^b	1.04	1.00	0.72 ^b	1.03	0.95	1.01	0.77 ^b
Waste disposal/sanitation and similar activities	1.37	1.34	1.32 ^b	1.02	0.97	1.04	2.94 ^a	0.73	0.73	0.94	1.09
Social services	1.31	1.01	1.05	1.09 ^c	0.94	0.95	1.27	1.08	1.21	0.92	1.25
Associative and recreational activities	1.20	1.13	0.94	1.23	1.05	1.24 ^b	1.61 ^a	0.94	1.18	1.17	0.88
Personal services	0.62 ^a	0.66	0.97	0.97	0.92	1.08	0.67	0.87	1.06	1.07	1.12
Households with employees	1.54 ^c	1.34 ^a	1.04	0.95	1.01	0.77 ^c	1.83 ^c	0.89	0.90	1.04	0.96
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* a: p < 0.05; b: p < 0.01; c: p < 0.001

^a Age-adjusted mortality rate in women

⁺⁺ Central nervous system and brain

5. CONCLUSIONS

In general, for analysed cancers, highly qualified workers presented a lower risk of mortality than workers in occupations requiring fewer skills. This pattern is similar in men and women for most cancer sites. However, there are some exceptions, like lung cancer, where the highest mortality risk in men was concentrated in manual labourers and in women, in highly qualified professionals.

In the cohort of workers studied, there were no data available on specific workplace exposures or unhealthy behaviours, making it impossible to identify which factor(s) could be behind the excess mortality risk observed for certain occupations or economic activities. In some cancers, both occupational exposures and risky behaviours could explain the high mortality observed in some occupations or industries. For example, in men, several occupations that present a high risk of lung cancer are associated with well-known Group 1 human carcinogens. However, these occupations are also characterised by a high prevalence of tobacco smoking, the most important causal factor in lung cancer. Similarly, the high mortality due to kidney cancer observed in certain occupations/ industries, like the metallurgy, land transport, and glassmaking and ceramics, could be attributable to workplace exposures. However, the role of obesity and sedentarism cannot be ruled out in occupations like driving and activities like land transport.

5.1. Possible implication of workplace exposure in occupations and industries identified as having an excess risk of mortality, according to tumour site

Some findings confirm the available evidence, whether this is based on the IARC list of Group 1 or 2A carcinogens, on the Spanish job-exposure matrix (MatEmESp), or on the scientific literature on occupational exposures. At the same time, this study has also identified high risk in some other occupations/ industries for which no such evidence exists, while for others still, the results obtained are not consistent with the high risk detected by IARC. Table 5.1.1 presents the occupations/ industries showing the highest excess mortality according to occupational cancers defined by the Spanish Royal Decree 1299/ 2006. Table 5.1.2 does the same for the rest of the analysed cancers.

Summarising the most relevant results for occupational cancer:

- (1) The findings on lung cancer are consistent with the available evidence for metal and steel workers, fishers/ sailors, miners and construction workers. However, it was not observed a higher risk among workers in the rubber industry or graphic arts, as identified by IARC.
- (2) In mesothelioma, the findings are consistent with existing evidence for most occupations (plumbers, other chemical industry workers, electricians and metal workers, unloaders) and industries (glass/ ceramic/ nonmetallic minerals industry, building/ structural installations). The results of this study for painters, an occupation listed by IARC, did not reach statistical significance. Based on results obtained, there does not seem to be any evidence of increased risk for the occupations of hairdressers or personal services, or for the industries of waste disposal/ sanitation and similar activities, editing/ graphic arts or personal services in women.
- (3) In laryngeal cancer, the findings are consistent with existing evidence for workers in the extractive/ mining industry, fishing, metallurgy, building/ structural construction and drinking establishments. On the other hand, it was not observed an excess risk in the occupations exposed to the production of rubber or sulphur mustards, as identified by IARC.
- (4) For bladder cancer, findings are consistent with existing evidence for workers in maintenance/ repair of motor vehicles and in restaurants; in contrast, it was not found evidence supporting an excess risk of mortality in the textile industry, hairdressers, painters or aluminium production.

Table 5.1.1. High-risk occupations and industries, according to the occupational cancer sites identified in Spanish Royal Decree 1299/ 2006.

Tumour site	High-risk occupations	High-risk industries
1. Lung cancer	Unskilled construction workers, fishers/ sailors, miners and similar, waiting staff, skilled construction workers	Fishing, drinking establishments, extractive/ mining industry, waste disposal/ sanitation and similar activities, building/ structural construction
2. Mesothelioma	Plastic/ rubber workers, plumbers, hairdressers/ barbers and similar, unloaders and similar, and workers in glass/ ceramics/ nonmetallic minerals	Metallurgy, building/ structural installations, vehicle/ transport equipment manufacture, glass/ ceramic/ nonmetallic minerals industry, plastic/ rubber industry
3. Laryngeal cancer	Miners and similar, unskilled construction workers, other unskilled workers, cleaners, fishers/ sailors	Waste disposal/ sanitation and similar activities, drinking establishments, extractive/ mining industry, fishing, metallurgy
4. Bladder cancer	Waiting staff, other unskilled workers, cooks, shoe/ leather workers, unloaders and similar	Drinking establishments, other business services, restaurants, cleaning services, hotels and similar
5. Squamous cell carcinoma of the skin	Livestock workers, other unskilled workers, medical doctors and similar, engineers and similar, sales assistants	Social services, livestock/ hunting, building/ structural finishing, textile industry
6. Lymphoma	Artists, models, athletes, fishers/ sailors, miners and similar, cleaners, other catering workers	Waste disposal/ sanitation and similar activities, extractive/ mining industry, building/ structural installations, fishing, and other business services
7. Myeloma	Police and similar, hairdressers/ barbers and similar, other chemical industry workers, artists, models, athletes	Other business services, computer services and central administration services
8. Prostate cancer	Industrial moving machinery operators, electricians, food industry workers, unskilled construction workers	Meat industry, waste disposal/ sanitation and similar activities, drinking establishments, energy and water production/ distribution, other intermediation
9. Liver cancer	Graphic artists, waiting staff, glass/ ceramic/ nonmetallic mineral workers, cooks, other catering workers	Waste disposal/ sanitation and similar activities, restaurants, drinking establishments, other business services, households with employees
10. Cancer of the paranasal sinuses	Caregivers/ personal assistants, Unloaders and similar, carpenters and wood/ paper workers, other chemical industry workers, businesspeople and business managers	Glass/ ceramic/ nonmetallic mineral industry, furniture/ similar products manufacture, other intermediation, wood/ paper industry
11. Cancer of the nasal cavity and middle ear	Street hawkers, other chemical industry workers, doctors and similar, carpenters and wood/ paper workers, janitors/ security guards	Metallurgy, furniture/ similar products manufacture, fishing, shoe/ paper industry, mechanical machinery manufacture

(5) For squamous cell carcinoma of the skin, the results corroborate available evidence on the risk associated with farmers/ livestock workers and associated economic activities. On the other hand, it was not observed any occupation or activity related to oil refineries or the occupational exposure to ultraviolet radiation, as documented elsewhere.

(6) With regard to lymphoma, the findings are consistent with previous evidence on industrial moving machinery operators, mechanics/ operators of electronic equipment and vehicle/ transport equipment manufacture. However, in other occupations and industries like manufacturing or maintenance of metal parts, paper/ wood, rubber and shoes, for which evidence exists, the results did not show any excess mortality.

(7-8) In myeloma and prostate cancer, the available evidence is very limited, although for both types a higher risk has been described in agricultural workers, which the present analysis did not show.

(9) For liver cancer, the findings here are consistent with available evidence supporting an increased risk for restaurant workers, graphic artists, nonmetallic mineral workers, and skilled construction workers (painters and plumbers) as well as unskilled construction workers. However, the results did not show an excess risk for workers in central administration services.

(10) For cancer of the paranasal sinuses, the findings are consistent with the available evidence on carpenters and wood/ paper workers. But in contrast to IARC, it was not identified an excess mortality risk associated with any occupation or industry related with exposure to leather or nickel.

(11) For cancer of the nasal cavity and middle ear, the excess of mortality observed is consistent with available evidence for metallurgy, furniture/ similar products manufacture, mechanical machinery manufacture and salespeople. Unlike IARC, though, no increased risk was observed in the textile or leather industries.

Summarising the most relevant results for other tumour sites:

(12) For cancer of the oral cavity and pharynx, the findings are consistent with available evidence on the excess mortality risk in painters, sailors and construction workers. On the other hand, it was not found any increased risk in workers exposed to ionising radiation, formaldehyde or sawdust.

(13) For oesophageal cancer, the findings confirm available evidence showing an increased risk for unskilled construction workers, fishers, sailors, waiting staff and other catering activities. However, no published reports corroborate the findings of excess mortality in workers in waste disposal/ sanitation and similar activities. Moreover, it was not observed any excess risk of mortality in the rubber production industry, exposure to which is included as an IARC Group 2A carcinogen.

(14) The findings for stomach cancer are consistent with the available evidence on the excess mortality risk in unskilled construction workers, fishers, sailors, painters and operators of moving machinery. The only industry included in the IARC Group 1 and 2A lists is rubber production, but the present analysis did not show any increased mortality for this industry.

(15) For colorectal cancer, the results of the present study are consistent with available evidence showing an excess risk for metal workers, construction workers and electricians. IARC does not include any occupations or industries within the Group 1 or 2A list for this tumour site.

(16) For pancreatic cancer, the results agree with existing evidence showing a higher risk of mortality in professionals, graphic artists, and workers in building/ structural installations, transport activities, the extractive/ mining industry and miners. However, no previously published scientific evidence shows an excess risk in fishers/ sailors, which it was detected in this study. Moreover, unlike previous reports, the present analysis did not show any excess risk in hospital workers; plastic and resins manufacturing; the chemical, steel and textile industries; or wastewater treatment – all factors that do appear in the IARC Group 2A list.

(17) For bone cancer, the findings do not correspond with the limited evidence for this tumour site or the related occupational exposures (radiation).

(18) For breast cancer, the results of this study are consistent with the available evidence showing an excess risk in police officers and in sea/ air transport. This analysis also revealed new occupations and industries, related to construction, that could increase the risk of mortality for this cancer.

(19) For cancer of the cervix uteri, the findings are consistent with the available evidence showing an excess risk in domestic workers and cleaners.

(20) In the case of cancer of the corpus uteri, there is scant evidence on occupational exposures, and the available evidence does not show a clear pattern of distribution of mortality according to occupation or economic activity, as observed here.

Table 5.1.2. High-risk occupations and industries, according to other cancer sites.

Tumour site	High-risk occupations	High-risk industries
12. Cancer of the oral cavity and pharynx	Unskilled construction workers, painters and similar, janitors/ security guards, fishers/ sailors and domestic workers	Households with employees, fishing, building/ structural finishing, building/ structural construction, metallurgy
13. Oesophageal cancer	Unskilled construction workers, fishers/ sailors, unloaders and similar, waiting staff, cleaners	Drinking establishments, fishing, building/ structural finishing, waste disposal/ sanitation and similar activities and households with employees
14. Stomach cancer	Fishers/ sailors, unskilled construction workers, other unskilled workers, industrial moving machinery operators, painters and similar	Building/ structural finishing, fishing, waste disposal/ sanitation and similar activities, cleaning services and the meat industry
15. Colorectal cancer	Street hawkers, Other semiprofessional workers electricians, miners and similar, other unskilled workers	Associative and recreational activities, extractive/ mining industry, metallurgy, building/ structural finishing and manufacturers of electronic and electrical equipment
16. Pancreatic cancer	Lawyers and similar, caregivers/ personal assistants fishers/ sailors, other semiprofessional workers, graphic artists	Sea/ air transport, tax/ accounting advisory services, building/ structural installations, extractive/ mining industry, fishing
17. Bone cancer	Hairdressers/ barbers and similar, businesspeople/ business managers, food industry workers, other catering workers, construction managers.	Personal services, households with employees, retail food trade, technical services and other food industry
18. Breast cancer	Plumbers, painters and similar, electricians, police and similar, construction managers	Extractive/ mining industry, energy and water production/ distribution, sea/ air transport, metallurgy, sale of motor vehicles
19. Cancer of the cervix uteri	Moving machinery operators, painters and similar, glass/ ceramics/ nonmetallic mineral workers, electricians, fishers/ sailors	Waste disposal/ sanitation and similar activities, drinking establishments, glass/ ceramics/ nonmetallic minerals, households with employees and cleaning services.
20. Cancer of the corpus uteri	Painters and similar, fishers/ sailors, moving machinery operators, electricians and lawyers	Metallurgy, sale of motor vehicles/ components, fishing, waste disposal/ sanitation and similar activities, wood/ paper industry
21. Ovarian cancer	Glass/ ceramic/ nonmetallic mineral workers, other mechanics, plastic and rubber workers, police and street hawkers	Other business services, chemical industry, tools/ metal products manufacture, furniture manufacturing, maintenance and repair of motor vehicles
22. Testicular cancer	Domestic workers, livestock workers, lawyers and similar, janitors/ security guards, nurses and health technicians	Cleaning services, livestock/ hunting, households with employees, metallurgy, wood/ paper industry
23. Kidney cancer	Other semiprofessional workers, mechanics and operators of electric/ electronic equipment, street hawkers, artists, models and athletes, sales/ financial agents	Metallurgy, extractive/ mining industry, other business services, technical services and fishing
24. Brain and central nervous system (CNS) cancer	Assembly workers, operators, graphic artists, painters and similar, public- and non-public-facing administrative assistants	Sales of motor vehicles/ components, energy and water production/ distribution, metallurgy, tax/ accounting advisory services, associative and recreational activities

Tumour site	High-risk occupations	High-risk industries
25. Thyroid cancer	Shoe/ leather workers, assembly workers and industrial moving machinery operators, textile workers, livestock workers and caregivers/ personal assistants	Shoe/ leather industry, retail food trade, plastics and rubber, energy and water production/ distribution, tools/ metal products manufacture
26. Leucemia	Other unskilled workers, street hawkers, plumbers, miners and similar, unloaders and similar	Extractive/ mining industry, furniture/ similar products manufacture, social services, tax/ accounting advisory services, building/ structural installations

(21) For ovarian cancer, the findings of an excess risk in glass/ ceramic/ nonmetallic mineral workers and other mechanics are consistent with the available evidence. However, the present analysis does not support a higher risk in hairdressers.

(22) For testicular cancer, the results are similar to the available evidence in their general heterogeneity. Nevertheless, it is worth pointing out that the present analysis did not show an excess risk in agricultural workers.

(23) For kidney cancer, the results are largely in line with the high-risk occupations and industries identified previously, especially for industrial contexts. In contrast, the analysis does not support an excess risk in farmers, for which evidence does exist.

(24) For cancers of the brain and central nervous system, the findings corroborate the increased risk observed previously in some occupations and industries, for example industrial workers. However, overall the evidence for these tumours is very limited.

(25) For thyroid cancer, the results agree with the literature in showing an elevated risk in some occupations and industries like those related to textiles, shoes/ leather and livestock. However, no previous scientific evidence corroborates the observed findings of an excess risk in caregivers/ personal assistants and workers in energy and water production/ distribution or in plastics. Furthermore, and in contrast with existing evidence, the observed results did not show a higher mortality in occupations exposed to ionising radiation.

(26) For leukaemia, the results are consistent with previous evidence showing a higher risk in salespeople and workers across different industries; however, it was not observed any differences in occupations that could possibly be exposed to ionising radiation.

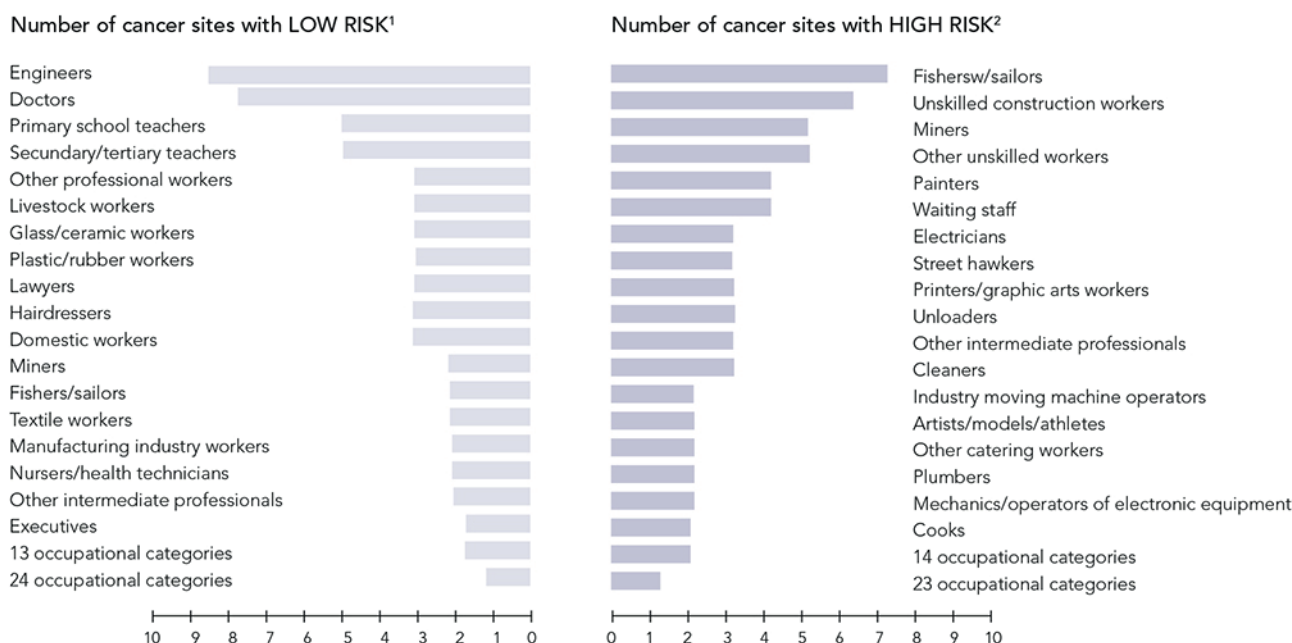
5.2. Occupations and industry sectors with high and low mortality across cancer sites

Some occupations and industries had high or low mortality rates across various cancer sites. To identify them, the highest and lowest SMRs of the top 5 occupations and top 5 industries were identified for the 15 cancers causing the highest mortality (≥ 3000 deaths each). These were lung, laryngeal and bladder cancer; lymphomas; prostate and liver cancers; cancer of the oral cavity and pharynx; oesophageal, stomach, colorectal, pancreatic, breast, and kidney cancers; and leukaemia.

Figure 5.2.1 shows the occupations with the greatest n° of cancers presenting low SMRs and high SMRs. Engineers showed a low risk of mortality in 9 cancers; doctors in 8; and primary, secondary and tertiary teachers in 5. In addition, fishers/ sailors presented high SMRs in 7 cancers; unskilled construction workers in 6; other unskilled workers in 5; and painters and waiting staff in 4.

Figure 5.2.2 shows the industries with the greatest n° of cancers presenting low SMRs and high SMRs. Technical services showed a low risk of mortality in 7 cancers, educational sectors in 6, and the meat industry and computer services in 5. In addition, the extractive industry and fishing showed a high risk in 8 cancers, sanitation in 7, and drinking establishments and metallurgy in 6.

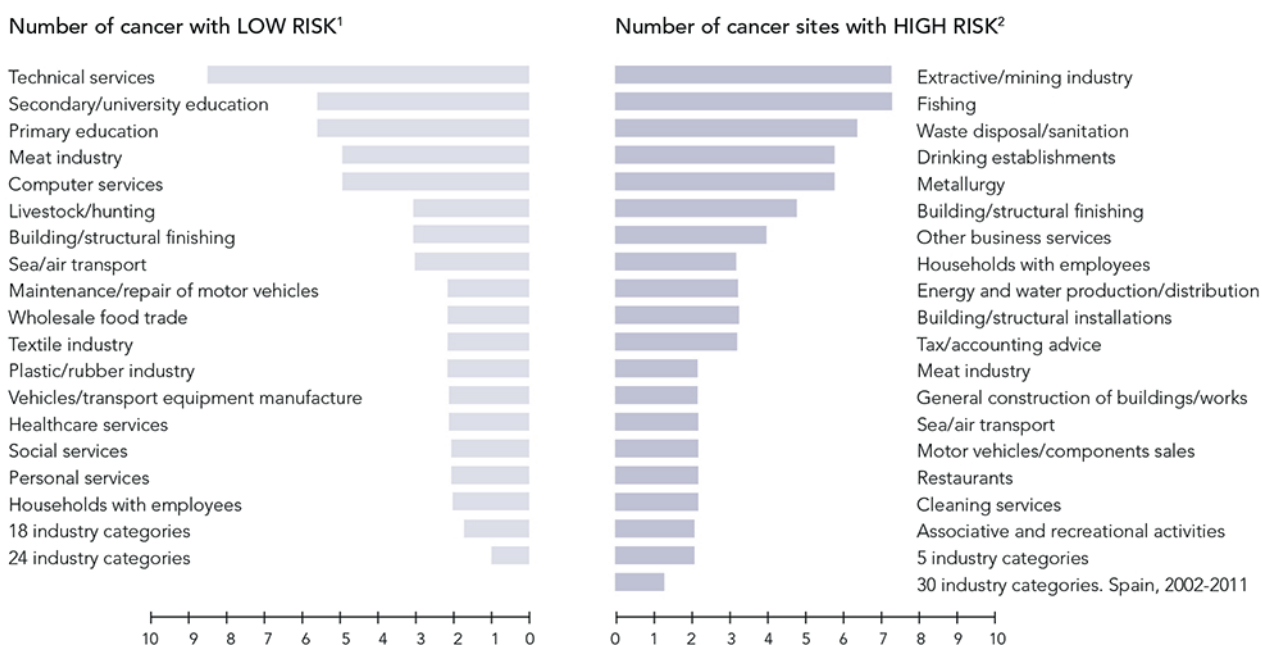
Figure 5.2.1. Ranking of occupations according to the number of main cancer sites for which each occupation shows low and high mortality risk from that cause. Spain, 2001-2011.



¹ Number of cancer sites (of a top 15 with > 3000 deaths) for which the standardized mortality ratio (SMR) was among the top 5 in the ranking of occupations. The cancer sites considered were: lung, larynx, bladder, lymphoma, prostate, liver, oral cavity/pharynx, esophagus, stomach, colon/rectum, pancreas, breast, kidney, brain/central nervous system, and leukaemia.

² Number of cancer sites (of a top 15 with > 3000 deaths) for which the standardized mortality ratio (SMR) was among the bottom 5 in the ranking of occupations.

Figure 5.2.2. Ranking of industries according to the number of main cancer sites for which each industry shows low and high mortality risk from that cause. Spain, 2002-2011.



¹ Number of cancer sites (of a top 15 with > 3000 deaths) for which the standardized mortality ratio (SMR) was among the top 5 in the ranking of industries. The cancer sites considered were: lung, larynx, bladder, lymphoma, prostate, liver, oral cavity/pharynx, esophagus, stomach, colon/rectum, pancreas, breast, kidney, brain/central nervous system, and leukaemia.

² Number of cancer sites (of a top 15 with > 3000 deaths) for which the standardized mortality ratio (SMR) was among the bottom 5 in the ranking of industries.



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