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Cancers attributable to occupational exposures in the UK in 2010

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The International Agency for Research on Cancer (IARC, 2010a) has classified 107 agents, mixtures or exposure circumstances as Group 1 (carcinogenic to humans), many of which are encountered in occupational settings, for example, asbestos and cadmium. An additional 58 agents, mixtures or exposure circumstances have been classified as Group 2A (probably carcinogenic to humans). Those with occupational significance include diesel fumes and benzidine-based dyes (IARC, 2010a). Table 1 (adapted from Siemiatycki et al, 2004) shows the most important occupational exposures in these two categories.

A comprehensive analysis of occupational exposures, with quantitative estimates of the cancers attributable to them, has been carried out by Imperial College London and the Health and Safety Laboratory on behalf of the Health & Safety Executive by Rushton et al (2007). This analysis has been updated and extended, based on mortality in Britain in 2005 and incidence in 2004 (Rushton, et al, 2010). Here, we have applied the population-attributable fractions (PAFs) for Great Britain, as estimated in this paper, to the estimated cancer incidence in UK in 2010.

METHODS

The methodology used to estimate PAFs of each cancer is described in the papers by Rushton et al (2007, 2010). The carcinogenic agents or exposure circumstances identified for each cancer were those classified by the IARC as Group 1 or 2A carcinogens (IARC, 2010a). Estimation of PAFs requires data on the relative risk of each exposure, and the prevalence in the general population.

Risk estimates were obtained from key studies, meta-analyses or pooled studies, taking into account quality, such as relevance to Britain, sample size, extent of control for confounders, adequacy of exposure assessment, and clarity of case definition. Where possible, risk estimates that had been adjusted for important non-occupational confounding factors, for example, smoking status, were selected. In general, dose–response risk estimates were not available from the epidemiological literature, nor were proportions of those exposed at different levels of exposure over time available for the working population of Britain. However,

where possible risk estimates were obtained for an overall 'lower' level and an overall 'higher' level of exposure to the agents of concern.

With respect to the latency between exposure and the elevated risk of cancer, a 'relevant exposure period' was defined. For solid tumours a latency of 10–50 years was assumed; for haematopoietic neoplasms it was 0–20 years.

The proportion of the population exposed to each carcinogenic agent or occupation was obtained from the total number of people employed and the numbers potentially exposed to the carcinogens of interest in each relevant industry/occupation within Britain. If the study from which the risk estimates were obtained was population based, an estimate of the proportion of the population exposed was derived directly from the study data. If the risk estimate was obtained from an industry-based study, national data sources, the CARcinogen EXposure (CAREX) database, the UK Labour Force Survey (LFS) or Census of Employment (CoE) was used to obtain the proportions exposed to the carcinogens concerned in Britain. Adjustment factors were applied to the data to take account of the change in numbers employed and the employment turnover during the 'relevant exposure period'.

The studies from which risk estimates were taken were often mortality studies only and PAFs derived from these were applied to numbers of registrations. The PAFs published by Rushton et al (2010) have been applied to the estimated numbers of cancers in the UK in 2010, with the following exceptions:

- We exclude occupationally induced non-melanoma skin cancers, for the reasons stated in the introduction – primarily that enumeration of such tumours is very far from complete (so that including them among the total cancers attributable to different exposures is misleading).
- PAFs due to occupational exposure to environmental tobacco smoke are included with other tobacco-related cancers in Chapter 2 (Parkin, 2011).

RESULTS

Table 2 shows the estimated number of new cancer cases in 2010 for 22 types of cancer, the PAFs (from Rushton et al, 2010) and the estimated numbers of cases due to occupational exposures. The

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Table 1 Occupational exposures linked to cancer risk and industries in which exposures can occur

Type of exposure	Industries with possibility for exposure
Aromatic amines	Previously used as intermediates in manufacture of dyes and pigments, textiles, paints, plastics, paper, drugs and pesticides, and as antioxidants in preparation of rubber for tyres and cables
Arsenic	Mining, (copper) smelting, vineyard workers, pesticide production (arsenical pesticides)
Asbestos	Shipbuilding, construction, mining and milling, by-product manufacture, insulating, sheet-metal workers, asbestos cement industry
Benzene	Production, solvents in the shoe production industry, chemical pharmaceutical and rubber industries, printing industry, gasoline additive
Diesel	Transportation workers/drivers, bus drivers, road maintenance, mechanics and garage workers, dock workers
Formaldehyde	Production, pathologists, medical laboratory technicians, plastics, textile and plywood industry
Leather dust	Boot and shoe manufacture and repair
Certain metal compounds (cadmium and cadmium compounds, chromium VI compounds, nickel compounds, iron and steel founding, nickel sulphides and oxides, beryllium)	Iron and steel founding; house painting and paper hanging; smelting, metal founding and welding; occupations that involve manufacture of cadmium oxide, cadmium alloys and cadmium pigments; production of nickel-cadmium batteries; recapture of zinc during zinc refining; chromate production; chromate pigment production; chromium plating; mechanics and those working with iron and metal ware; plumping
Mineral oils	Metal workers; printing industry
Polycyclic aromatic hydrocarbons	Industries with exposure to soots, coal tars, coal-tar pitches, aluminium production (pitch volatiles); e.g. chimney sweeps, coal gasification, coke production, coal-tar distillation, paving and roofing, smelting and metal founders, engine and motor exhausts
Radon	Workers in underground haematite mines
Silica	Mining; stone quarrying; granite production; ceramic and pottery industries; steel production
UV radiation	Outdoor occupations
Vinyl chloride	Production of vinyl chloride and polyvinyl chloride; plastics, rubber and resins manufacturing; car interior workers; furniture makers; transportation workers
Wood dust	Furniture and cabinet-making and construction, logging and sawmill workers, pulp and paper and paperboard industry

Adapted from Siemiatycki et al (2004).

Table 2 Estimated fractions of cancer cases in UK, 2010, attributable to occupational exposures

Cancer site	ICD-10 code	Observed cases		PAF[a] (%)		Excess attributable cases	
		Males	Females	Males	Females	Males	Females
Nasopharynx	C11	267	178	11	2.5	29	4.5
Oesophagus	C15	5713	2819	3.3	1.1	189	31
Stomach	C16	4467	2577	3	0.3	134	7.7
Liver	C22	2270	1298	0.2	0.1	4.5	1.3
Pancreas	C25	4084	4280	0.02	0.01	0.8	0.4
Sino-nasal[b]	C30–31	279	173	46	20.1	128	35
Larynx	C32	1803	386	2.9	1.6	52	6.2
Lung[c]	C33	22 273	18 132	20.5	4.3	4566	780
Bone	C40–41	362	256	0.04	0.01	0.1	0.0
Mesothelioma[b]	C45	2077	462	97	82.5	2015	381
Soft-tissue sarcoma[b]	C49	867	623	3.4	1.1	29	6.9
Breast (female)	C50	—	48 385	—	4.6	—	2226
Cervix	C53	—	2691	—	0.7	—	19
Ovary	C56	—	6820	—	0.5	—	34
Kidney	C64–66, C68	5697	3365	0.04	0.04	2.3	1.3
Bladder	C67	6713	2572	7.1	1.9	477	49
Eye[b]	C69	210	172	2.9	0.4	6.1	0.7
Brain and CNS	C70–72	2799	1902	0.5	0.1	14	1.9
Thyroid	C73	602	1776	0.12	0.02	0.7	0.4
Non-Hodgkin lymphoma	C82–85, C96	6297	5305	2.1	1.1	132	58
Myeloma	C90	2506	1994	0.4	0.1	10	2.0
Leukaemia	C91–95	4639	3201	0.9	0.5	42	16
All[d]		158 667	155 584	4.9	2.4	7832	3662

Abbreviations: CNS = central nervous system; ICD = International Classification of Diseases; PAF, population-attributable fraction. [a]Rushton et al (2010). [b]Number of cases estimated from the UK population (2010) and rates in England in 2008. [c]Lung cancer PAF excludes occupational exposure to environmental tobacco smoke (ETS). [d]Excluding non-melanoma skin cancer.

total is an estimated 11 494 cases (7832 in men and 3662 in women), representing 3.7% of all cancers (excluding non-melanoma skin cancers). The most substantial numbers are lung cancers (exposures due to asbestos, silica, diesel engine exhausts, mineral oils), mesotheliomas (asbestos) and breast cancer, related to shift work that involves circadian disruption (IARC, 2010b).

DISCUSSION

Included in the evaluation of Rushton *et al* (2010) were non-melanoma skin cancers, the calculated PAF of which (4. 6%) was applied directly to the number of registrations in 2004. The latter may have been due to a lack of appreciation by the authors of the incomplete nature of cancer registration for non-melanoma skin cancer. Undercounting of such cancers is a consequence of the relatively trivial nature of the great majority, and many such cancers are treated without hospitalization or, probably, a biopsy. Registration is biased by cell type (basal cell cancers will certainly be undercounted), while some cancers – probably occupationally related ones – may be more completely identified.

Prevalence of exposure in the analysis by Rushton *et al* (2010) was estimated for a period of 10–50 years prior to 2005 for solid tumours, and 0–20 years for haematopoietic neoplasms. If exposure prevalence has been declining, and these latency periods are correct, it is possible that the numbers of attributable cancers for 2010 will be slightly overestimated (because the time since exposure is 5 years longer than for the estimates for 2005).

Several other studies have been carried out to estimate the proportion of cancers in a given population that are possibly the result of exposure to carcinogens in an occupational setting. Doll and Peto (1981) included occupational factors in their evaluation of the quantitative contribution of different factors to cancer mortality in the United States. In addition to the USA, estimates of the effect of occupational exposures on the burden of cancer have been made for the year 2000 for the populations of the Nordic countries (Dreyer *et al*, 1997), Australia (Fritschi and Driscoll, 2006) and France (IARC, 2007). Quantitative estimates of the carcinogenic effect of 11 occupational exposures worldwide in the year 2000 were made by Driscoll *et al* (2005).

These recent studies used a methodology similar to that of Rushton *et al* (2010) – the CAREX (CARcinogen Exposure) database – to provide national estimates of the proportions of workers exposed to different carcinogens and their levels of exposure (Finnish Institute of Occupational Health, 2009), and estimates of the relative risk of different exposures, drawn from literature reviews. There are differences not only in the choice of such studies (and hence of risks associated with occupational exposures, and different levels of exposure), but also in the precise choice of exposures, which can reasonably be considered to be carcinogenic in an occupational setting.

The Nordic study (Dreyer *et al*, 1997) estimated that verified industrial carcinogens will account for approximately 3% of all cancers in men and less than 0.1% of all cancers in women in the Nordic countries around the year 2000, while the French study estimated that 2.5% of cancers in men and 0.3% in women were caused by occupation.

See acknowledgements on page Si.

Conflict of interest

The author declares no conflict of interest.

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