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The burden of occupational cancer in Great Britain

Results for bladder cancer, leukaemia, cancer of the lung, mesothelioma, non-melanoma skin cancer and sinonasal cancer

Prepared by **Imperial College London** and the **Health and Safety Laboratory** for the Health and Safety Executive 2007

RR595
Research Report

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Results for bladder cancer, leukaemia, cancer of the lung, mesothelioma, non-melanoma skin cancer and sinonasal cancer

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The aim of this project was to produce an updated estimate of the current burden of occupational cancer specifically for Great Britain. The primary measure of the burden of cancer used was the attributable fraction (AF), ie the proportion of cases that would not have occurred in the absence of exposure. Data on the risk of the disease due to the exposures of interest, taking into account confounding factors and overlapping exposures, were combined with data on the proportion of the target population exposed over the period in which relevant exposure occurred. Estimation was carried out for carcinogenic agents or exposure circumstances that were classified by the International Agency for Research on Cancer (IARC) as Group 1 or 2A carcinogens with strong or suggestive human evidence. Estimation was carried out for 2004 for mortality and 2003 for cancer incidence for cancer of the bladder, leukaemia, cancer of the lung, mesothelioma, non-melanoma skin cancer (NMSC), and sinonasal cancer.

The proportion of cancer deaths in 2004 attributable to occupation was estimated to be 8.0% in men and 1.5% in women with an overall estimate of 4.9% for men plus women. Estimated numbers of deaths attributable to occupation were 6,259 for men and 1,058 for women giving a total of 7,317. The total number of cancer registrations in 2003 attributable to occupational causes was 13,338 for men plus women. Asbestos contributed the largest numbers of deaths and registrations (mesothelioma and lung cancer), followed by mineral oils (mainly NMSC), solar radiation (NMSC), silica (lung cancer) and diesel engine exhaust (lung and bladder cancer). Large numbers of workers were potentially exposed to several carcinogenic agents over the risk exposure periods, particularly in the construction industry, as farmers or as other agricultural workers, and as workers in manufacture of machinery and other equipment, manufacture of wood products, land transport, metal working, painting, welding and textiles. There are several sources of uncertainty in the estimates, including exclusion of other potential carcinogenic agents, potentially inaccurate or approximate data and methodological issues. On balance, the estimates are likely to be a conservative estimate of the true risk. Future work will address estimation for the remaining cancers that have yet to be examined, together with development of methodology for predicting future estimates of the occupational cancers due to more recent exposures.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

First published 2007

ACKNOWLEDGEMENTS

Funding was provided by the Health and Safety Executive and managed through the Health and Safety Laboratory. We would like to thank Damien McElvenny for initiating the project and Gareth Evans for his management role; Andy Darnton and John Hodgson from the HSE were responsible for the work on mesothelioma. The contributions to the project and advice received from many other HSE and HSL staff are gratefully acknowledged. Two workshops were held during the project bringing together experts from the UK and around the world. We would like to thank all those who participated and have continued to give advice and comment on the project.

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INTRODUCTION

The Health and Safety Executive (HSE) wishes to update its assessment of the relative importance of occupational cancer in relation to other health and safety outcomes, and develop appropriate practical measures to reduce the incidence of occupational cancer in Great Britain (GB); a sound evidence base is required to aid development of strategies for targeting priorities for action. The HSE currently relies on estimates of the effects of occupation on cancer mortality in the US made by Doll & Peto in 1981 for burden estimation. The proportion of cancer they attributed to occupation was about 4% of all US cancer deaths with an uncertainty range of 2% to 8%. The overall aims of this project, carried out by Imperial College London in collaboration with the Health and Safety Laboratory (HSL), were:

- to produce an updated estimate of the current burden of occupational cancer specifically for Great Britain
- to produce an estimate of the future occupational cancer burden in Great Britain based on recent and current exposures, together with the method for updating this in future
- where the data are sufficiently detailed, to break any headline estimates down into exposure-cancer combinations

The outcomes from the first phase of the project are presented in this report together with an overview of the methodology developed, the data used, and estimates of the current burden due to past occupational exposures for the following cancers; cancer of the bladder; leukaemia; cancer of the lung; mesothelioma; non-melanoma skin cancer; and sinonasal cancer. These cancers were chosen as being likely to have a high burden due to occupational exposures. Two international workshops were held during the first phase of the project to discuss and consolidate the methodological approaches used.

METHODOLOGY

For each cancer, information was obtained on the incidence, mortality and survival trends in GB and an overview of the aetiology was carried out, including latency, and known and suspected causal factors, including occupationally related factors. The primary measure of the burden of cancer in this project was the attributable fraction (AF) i.e. the proportion of cases that would not have occurred in the absence of exposure; this was then used to estimate the attributable numbers. There are several methods for estimating the AF but all depend on knowledge of the risk of the disease due to the exposure of interest and the proportion of the target population exposed. Estimation was carried out for 2004 for mortality and 2003 for cancer incidence.

The overall attributable fraction was calculated on a ‘cancer by cancer’ basis as follows:

1. Known and suspected occupational exposures (either defined by substance or occupation) for the cancer were identified. The carcinogenic agents or exposure circumstances were identified for each cancer as those classified by the International Agency for Research on Cancer (IARC) as a Group 1 or 2A carcinogens. Those agents with strong evidence of carcinogenicity in humans were defined for the purpose of this study as ‘established’ carcinogens and those with suggestive evidence of carcinogenicity in humans were defined as ‘uncertain’ carcinogens.

2. Where possible, account was taken of overlapping and multiple exposures.

3. Potential confounding factors for the cancer were identified, e.g. smoking status. Where possible, risk estimates (relative risks (RR)), adjusted for the effects of confounding and for interactions, were obtained.

4. Risk estimates were obtained from key studies, meta-analyses or pooled studies, taking into account quality, such as relevance to GB, large sample size, effective control for confounders, adequate exposure assessment, and clear case definition. Dose-response risk estimates were generally not available in the epidemiological literature nor were proportions of those exposed at different levels of exposure over time available for the working population in GB. However, where possible risk estimates were obtained for an overall 'lower' level and an overall 'higher' level of exposure to the agents of concern. Where no estimate could be identified for very low/background/environmental levels of exposure, an RR of one was arbitrarily assigned, which gives a zero AF.

5. The 'relevant exposure period' (REP) was defined as the period during which exposure occurred that was relevant to the development of the cancer in the target year 2004. For solid tumours a latency of 10-50 years was assumed giving a REP of 1955-1994; for haematopoietic neoplasms 0-20 years latency was assumed giving a REP of 1985-2004.

6. 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 GB.
   a. If the risk estimate was obtained from an industry-based study, national data sources, the CARcinogen EXposure (CAREX) database, the annual Labour Force Survey (LFS) or Census of Employment (CoE) were used to obtain the proportions exposed to the carcinogens concerned in GB. Adjustment factors were applied to the data to take account of the change in numbers employed and the employment turnover over the REP. Exposed numbers were allocated to a 'higher' or 'lower/background' exposure group based on the industries and occupations covered in the studies from which the risk estimates were obtained. CAREX exposed numbers were not available separately for men and women and were thus divided between men and women according to an estimate of relative proportions based on numbers in the appropriate occupation by industry codes from the 1991 census.
   b. 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.

7. For risk estimates from an industry based study, Levin's equation was used to calculate the AF. If a population-based study was used for the estimate of risk, Miettinen's equation was used to calculate the AF. For mesothelioma, the AF was derived directly from studies of UK mesothelioma cases.

8. For each cancer, AFs for all the relevant exposures were combined into a single estimate of attributable fraction taking into account overlapping exposures.

9. For each estimated AF based on a single estimate of RR, a confidence interval that takes into account random error was calculated. Confidence intervals for all estimates will be developed in the second phase of the project.

10. The combined AF for each cancer was multiplied by the number of deaths and/or registrations for the target year in GB i.e. 2004 for mortality and 2003 for cancer

registrations, to give an estimation of the numbers of cancer cases attributable to occupation. The studies from which risk estimates were taken were often mortality studies only and AFs derived from these were applied to numbers of registrations.

11. The attributable numbers for each cancer were summed, and divided by total cancer numbers to obtain an overall AF for cancer due to occupation nationally at the target date.

RESULTS

The overall occupational AFs for the six cancers investigated so far are summarised in the table below. 6.0% of cancer deaths in men and 1.0% in women in GB have been estimated to be due to occupation when taking into account established carcinogens only (total deaths due to occupation for the six cancers over all cancer deaths). The estimates were 8.0% and 1.5% respectively for established plus uncertain carcinogens, giving 4.9% overall (based on deaths).

Table: Estimated attributable fractions, deaths and registrations by cancer site

Cancer site:	***Attributable Fraction***			***Attributable Deaths***		***Attributable Registrations***	
	Male	***Female***	***Total (based on deaths)***	***Male***	***Female***	***Male***	***Female***
Established carcinogens only (IARC Group 1 and 2A, strong human evidence)							
Bladder	1.3%	0.6%	1.0%	40	10	89	17
Leukaemia	0.3%	0.5%	0.2%	4	5	5	6
Lung	16.5%	4.5%	11.6%	3,137	599	3,509	680
Mesothelioma	85-90%	20-30%	74-80%	1,450	75	1,450 #	75 #
NMSC	11.8%	3.0%	8.4%	38	6	3,992	855
Sinonasal	34.1%	10.8%	23.4%	24	6	74	18
AFs for six cancers combined				6.0%	1.0%	5.4%	1.0%
Established + Uncertain carcinogens (IARC Group 1 and 2A, strong and suggestive human evidence)							
Bladder	11.6%	2.0%	8.3%	362	32	816	57
Leukaemia	2.7%	0.8%	1.7%	58	11	93	15
Lung	21.6%	5.5%	15.0%	4,106	728	4,594	826
Mesothelioma	98% *	90% *	97%*	1,650	270	1,650 #	270 #
NMSC	11.8%	3.0%	8.4%	38	6	3,992	855
Sinonasal	64.3%	18.4%	43.3%	45	11	140	31
Total				6259	1058	11284	2054
Total all cancers in GB				78,237	71,666	167,506	164,586
AFs for six cancers combined (out of all GB cancers)			4.9%	8.0%	1.5%	6.7%	1.2%

*Includes cases described as due to paraoccupational or environmental exposure to asbestos.
Taken as equal to attributable deaths for this short survival cancer.

Summary and Conclusions

This study has provided a robust estimate of the current burden of six cancers due to past occupational exposures of 8% for men and 1.5% for women. On balance, this is likely to be a conservative estimate of the true risk for reasons discussed above. Large numbers of workers were potentially exposed to several carcinogenic agents over the risk exposure periods, particularly in the construction industry, as farmers and other agricultural workers, as workers in manufacture of machinery and other equipment, the manufacture of wood products, land transport, metal working, painting, welding and textiles.

The current burden of the six cancers due to occupational causes is based on exposures experienced up to 50 years ago. Many of the exposures will have been at much higher levels than those existing today. Other exposures have all but disappeared due to the reduction of the industry or the substitution of hazardous substances by other agents. However, the long latency of some cancers means that numbers of deaths and registrations due to past high exposures will continue to be substantial in the near future (particularly asbestos-related cancers). For some exposures, such as wood dust, very recent dust measurements have shown continuing high exposures. Where the burden was estimated for an occupation such as painting or welding, this was carried out because of the multiplicity of potential causal agents and the difficulty of attributing risk to a single agent. Although some hazards may have been removed within these occupations, such as certain solvents in paints, others may still remain, such as silica. In addition there will be considerable numbers of workers exposed at low levels; smaller relative risks and a high proportion of exposure at low levels may contribute substantially to both high attributable fractions and numbers.

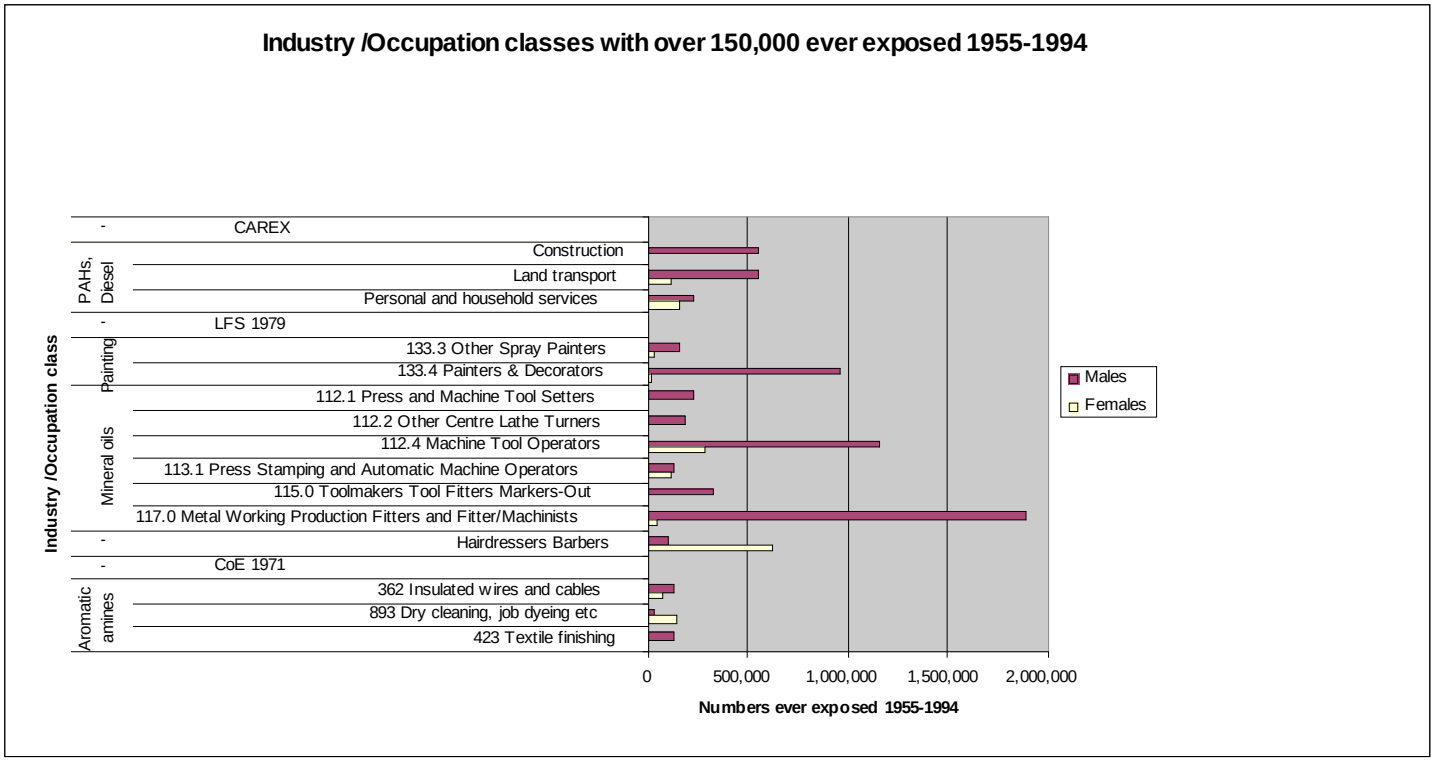
There remain a considerable number of known carcinogens for which an estimate of the burden due to occupation has not yet been made in this project. In addition, the potential that exposure to other unknown occupational carcinogens and work-related factors such as psychological stress and shift work could contribute to increased cancer risk has not yet been addressed.

Future work will address estimation of the current burden due to occupational exposures for the remaining cancers that have yet to be examined, together with development of appropriate methodology for predicting future estimates of the occupational cancers due to more recent exposures. Other measures of burden will also be calculated such as Years of Life Lost (YLL) and Disability-Adjusted Life Years (DALY).

Table 4 Sources of data for calculation of the AF

Agent/ Exposure scenario	*Level of exposure*	*Source study data*						*Data for proportion of the population exposed*			
		Reference	***Study type***	***Male/ Female***	***Mortality /Cancer incidence***	***Exposure scenario***	***RR (95% CI) ****	***Source***	***Numbers: Male***	***Numbers: Female***	***Numbers: Total***
Mineral oils	Higher	Tolbert (1979)	Review	M+F	Mortality and Incidence	Metal machining, print press operating and cotton and jute spinning	1.39 (1.20,1.61) Random effects model average of case-control and population-based studies	LFS 1979	1,215,812	78,198	1,294,010
	Lower & no exposure						1.00		65,384	4,936	70,320
Aromatic amines		Sorahan et al (1998)	West Midlands hospital-based case-control studies	M+F	Incidence	Cable manufacturing industry	2.46 (1.20, 5.04) [A]	CoE 1971	34,325	12,132	46,457
						Dyestuffs	2.61 (0.98, 7.00) [A]		24241	27433	51874
						Textile printing and dyeing	2.32 (0.98, 5.45) [A]		52842	21682	74524
						Leather work	2.51 (1.44, 1.53) [A]		16,449	4,364	20,813
						MOCA: Industrial chemicals	1.70 (1.05, 2.76) [A]	CAREX	10	3	13
						Rubber products	1.89 (1.34, 2.66) [A]		168	53	221
						Plastic products	1.73 (1.17, 2.55) [A]		154	48	202
						Benzidine-based dye manufacture	2.32 (0.98, 5.45) [A]		14	4	18

Figure 3


Industry /Occupation classes with over 150,000 ever exposed 1955-1994
Industry /Occupation class
-
CAREX
PAHs, Diesel
Construction
Land transport
Personal and household services
-
LFS 1979
Painting
133.3 Other Spray Painters
133.4 Painters & Decorators
Mineral oils
112.1 Press and Machine Tool Setters
112.2 Other Centre Lathe Turners
112.4 Machine Tool Operators
113.1 Press Stamping and Automatic Machine Operators
115.0 Toolmakers Tool Fitters Markers-Out
117.0 Metal Working Production Fitters and Fitter/Machinists
-
Hairdressers Barbers
-
CoE 1971
Aromatic amines
362 Insulated wires and cables
893 Dry cleaning, job dyeing etc
423 Textile finishing
Males
Females
0
500,000
1,000,000
1,500,000
2,000,000
Numbers ever exposed 1955-1994