Health and Safety Executive

The burden of occupational cancer in Great Britain

Ovarian cancer

Prepared by the **Health and Safety Laboratory**, the **Institute of Occupational Medicine** and **Imperial College London** for the Health and Safety Executive 2012

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Research Report

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The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer was the attributable fraction (AF) being the proportion of cases that would not have occurred in the absence of exposure; and the AF was used to estimate the number of attributable deaths and registrations. The study involved obtaining data on the risk of the cancer due to the exposure of interest, taking into account confounding factors and overlapping exposures, as well as the proportion of the target population exposed over the relevant exposure period. Only carcinogenic agents, or exposure circumstances, classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens were considered. Here, we present estimates for cancer of the ovary that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

The estimated total (female) AF, deaths and registrations for ovarian cancer related to overall occupational exposure (occupation as a hairdresser or barber) is 0.54% (95%Confidence Interval (CI)= 0.00-1.22), which equates to 23 (95%CI= 0-52) deaths and 33 (95%CI= 0-76) registrations.

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EXECUTIVE SUMMARY

The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer used in this project was the attributable fraction 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. This involved obtaining data on the risk of the disease due to the exposure of interest, taking into account confounding factors and overlapping exposures, and 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 classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens. Here, we present estimates for cancer of the ovary that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

Occupation as a hairdresser or barber has been classified by IARC as a probable human carcinogen for cancer of the ovary. Due to assumptions made about cancer latency and working age range, only cancers in ages 25+ in 2005/2004 could be attributable to occupation. For Great Britain in 2005, there were 4234 total deaths in women aged 25+ from ovarian cancer; in 2004, there were 6197 total registrations for ovarian cancer in women aged 25+.

The estimated total (female) attributable fraction from occupational exposure overall and for occupation as a hairdresser or barber for ovarian cancer is 0.54% (95%Confidence Interval (CI)=0.00-1.22), which equates to 23 (95%CI=0-52) deaths and 33 (95%CI=0-76) registrations.

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1 INCIDENCE AND TRENDS

Ovarian Cancer (ICD-10 C56; ICD-9 183) in terms of incidence is the sixth most common female cancer worldwide (and in terms of deaths worldwide it is the seventh most common female cancer, accounting for approximately 4% of female cases), with an estimated 204,000 new cases and 125,000 deaths in 2002 (Parkin *et al*, 2005). Incidence rates are the highest in developed countries, in particular, Europe and North America where rates exceed 9 per 100,000. The lowest rates, below 6 per 100,000, are mainly observed in Africa and Asia. Rates have been slowly increasing in many Western countries and Japan. Within Europe, the lowest rates are in the south (Greece, Portugal and Cyprus), while the highest are in the North and East (Lithuania, Denmark, Czech Republic and Estonia).

Between 80% and 90% of ovarian cancers are termed ‘epithelial’, meaning the condition is due to abnormal changes on the surface layer of the ovaries. The remaining cases are mostly ‘germ cell’ tumours, which are a group of cancers of the egg making cells (such as ovarian teratoma). Other types of cancer can affect the ovary (such as sarcomas) but these are very rare. Ovarian cancers are typically grouped according to their behaviour: how quickly they develop; and cell type from which they originate. Approximately 15% of epithelial tumours are borderline ovarian tumours meaning that they are unlikely to spread and therefore are easier to cure. The remaining tumours are well differentiated, moderately differentiated or undifferentiated, depending on how developed and specialised the affected cells are. There are many different types of this cancer, some of which include serious, endometrioid type and unclassifiable tumours. Over half the diagnosed cases of epithelial ovarian cancer are of the serious type and a further 10% are unclassifiable (Cancer Research UK 2008). A family history of ovarian cancer and/or breast cancer heightens the risk of developing the condition. In the UK, it is believed that approximately 5% of cases may be hereditary. Another highly influential factor is a woman’s ovulation history. Higher rates of the disease occur among women who do not have any children, and the risk decreases with the number of pregnancies. A raised risk has also been reported for women who had a late menopause or who are infertile (Hankinson, Danforth 2006, Quinn *et al*, 2001).

In the UK and Ireland in the 1990s, ovarian cancer accounted for around 1 in 20 diagnosed female cancer cases, and 1 in 17 female deaths from cancer (Walsh, Cooper 2005). Overall, the age-standardised incidence rate was 18 per 100,000, and the age-standardised mortality rate was 11.5 per 100,000. The incidence rate in older women (aged over 65 years) has been gradually increasing, however, in women under 65 years of age the rate has been relatively stable. Increased mortality rates in older women were also observed, with the highest increase in women aged 75 years and over. In women under 55 years of age, mortality rates have declined.

Currently the condition accounts for 2% of new cancer cases and is the most common gynaecological cancer in UK women. In Great Britain, the numbers diagnosed steadily increased from around 6,100 in 1995 to 6,600 in 2001 (Table 1), after which the numbers decreased to approximately 6,200 in 2004. Long-term trends in the incidence and mortality were studied based on notifications of cancer cases and deaths in England, Wales and Scotland over the past ten-years. On average 6,453 women were diagnosed with ovarian cancer in Great Britain, with the highest average annual incidence occurring in Wales at 26.4 per 100,000. The crude rate appears to be relatively stable in England (around 21 per 100,000) and Scotland (around 18 per 100,000). Crude rates for Wales appear to be fluctuating between 24 and 30 per 100,000 females.

Table 1 Number of ovarian cancer registrations in England, Wales and Scotland for 1995-2004.

Year	England	Wales	Scotland
1995	5252 (21.1)	368 (24.7)	573 (17.9)
1996	5301 (21.2)	379 (25.4)	674 (20.7)
1997	5437 (21.7)	402 (26.9)	673 (21.3)
1998	5529 (22.0)	417 (27.9)	599 (18.5)
1999	5434 (21.6)	442 (29.6)	601 (18.3)
2000	5400 (21.5)	403 (26.9)	643 (19.5)
2001	5635 (22.3)	374 (24.9)	602 (18.0)
2002	5511 (21.7)	403 (26.7)	633 (18.7)
2003	5515 (21.7)	416 (27.5)	633 (18.8)
2004	5293 (20.7)	362 (23.8)	619 (17.8)
Average	5431 (22.2)	397 (26.4)	625 (18.9)

Source: ONS MB1 Series (ONS 2007a), Welsh Cancer Intelligence & Surveillance Unit (WCISU 2008), Information Services Division (ISD 2008). Numbers in brackets are crude rates per 100,000

The numbers that die from the condition steadily increased until 2002 (Table 2), from around 4,300 to 4,500. They are now starting to decrease, with approximately 4,200 deaths due to ovarian cancer being reported in 2005. On average 4,358 women die from ovarian cancer in Great Britain. The crude rates in England/Wales and Scotland appear to be similar in recent years. Prior to 2002, the crude rate for England/Wales was relatively high at approximately 150 per 1,000,000 females. Ovarian cancer is predominantly a disease of older, post-menopausal women. Almost 85% of cases are diagnosed in women over 50 years, with rates peaking in the range 70-84 years. The mortality pattern broadly follows that of incidence, peaking in women aged between 75 and 84 years.

Table 2 Number of deaths from ovarian cancer in England, Wales and Scotland 1999-2005.

Year	England and Wales	Scotland
1999	3955 (148)	403 (11.1)
2000	3909 (146)	409 (11.2)
2001	4071 (151)	378 (10.3)
2002	4097 (151)	413 (11.1)
2003	3983 (108)	419 (11.0)
2004	3804 (102)	429 (10.9)
2005	3874 (102)	366 (9.6)
Average	3956 (129.7)	402 (10.7)

Source: ONS DH2 Series (ONS 2007b), Welsh Cancer Intelligence & Surveillance Unit (WCISU 2008), Information Services Division (ISD 2008). Numbers in brackets are crude rates per 1,000,000 for England/Wales and per 100,000 for Scotland

Ovarian cancer has the lowest survival rate of all the gynaecological cancers, largely because it is often at an advanced stage when diagnosed. For patients diagnosed with this cancer during 1996-1999 in England and Wales, the five-year relative survival rate was 36%, with corresponding one-year survival rate of 65% (Walsh, Cooper 2005). Generally, the five-year relative survival rate varies between 5% and 90% depending on the stage of disease and age at diagnosis. Patients with advanced stage ovarian cancer have a significantly lower five-year survival rate than patients with early stage ovarian cancer (Stage 1: 90%, Stage 2: 60-70%, Stage 3: 15-35% and Stage 4: 5-14%). Survival rates decline steeply with age; the five-year survival rate in the youngest age group (under 40) is about 69% but is only about 12% in women aged over 80 years (Cancer Research UK 2008). In 2004, the cancer mortality to incidence ratio for cancer of the ovary (C56) was 0.68 (ONS 2006).

2 OVERVIEW OF AETIOLOGY

There are no known causes of ovarian cancer, but several factors are considered to influence its development. The two most influential risk factors are increasing age and the presence of specific inherited gene mutations, in particularly those of the BRCA-1 and BRCA-2 genes. Other non-occupational risk factors include heightened body mass index, suffering from endometriosis and postmenopausal hormone use. In addition, several protective factors have been associated with the condition; these include oral contraceptive use, tubal ligation or hysterectomy and lactation (Hankinson, Danforth 2006). The underlying reason suggested for these reductions in risk is that during these periods the ovaries usually do not produce eggs, thus there is no need for the cells to divide (Cancer Research UK 2008).

Epidemiological studies have consistently reported reduced risks associated with ovarian cancer and oral contraceptive use (IARC 1999, IARC 2007). In 48 studies there was a reduction in risk, in particular, an association with duration of use. The reduction was reported to be approximately 50% for women who had used the contraceptive for at least 5 years. The reduction was found to persist for at least 20 years after cessation. A woman's history of ovulation appears to play a major role in the development of the disease, therefore, factors such as parity and oral contraceptive use along with age, should be taken into account, if possible, when assessing the associations between ovarian cancer and occupational exposures.

The Occupational Health Decennial Supplement reported mortality by job code (1979-1980, 1982-1990) and cancer incidence (1981-1987) in men and women aged 20-74 years in England (Drever 1995). For ovarian cancer an elevated risk was found in women who worked as printing machine minders and as a draughtsperson, which was reflected by the elevated PRRs and PMRs for these occupations (Table 3). Occupational exposure as a hairdresser (or barber) has been shown to have an increased risk of ovarian cancer (Siemiatycki *et al,* 2004). However, this occupation was not found to have a significant PRR or PMR in the supplement. Other exposures that have been shown to be associated include asbestos, radiation and talc (Hankinson, Danforth 2006).

Table 3 Job codes with significantly high PRRs and PMRs for ovarian cancer. Women aged 20-74 years, England, 1979-90.

Job Group		Registrations	PRR	95% CI	Deaths	PMR	95% CI
SIC code	**Description**	**(1981 – 1987)**			**(1979 – 1980 and 1982 – 1990)**		
Women							
003	Personnel managers etc				38	142	100-195
006	Sales managers etc				73	146	115-184
009	Other administrators	54	135	102-177	143	120	101-142
011	Teachers nec				740	130	121-140
020	Physiotherapists				28	161	107-234
031	Draughtsperson				18	198	118-313
047	Farmers				94	123	100-151
051	Launderers and dry cleaners	48	139	103-185	90	80	64-98
096	Printing machine minders	10	233	112-429			

Source: Drever *et al.* (1995) Occupational Health Decennial Supplement

Recent figures are available from the Occupational Health Decennial Supplement for mortality for the period 1991-2000 in men and women aged 20-74 years in England (Table 4) (Coggon *et al,* 2009). For ovarian cancer the risk was greatest in warp preparers, bleachers, dyers & finishers, medical radiographers and physiotherapists. In comparison to the previous supplement, school teachers and physiotherapists are the only occupations that re-appear, with lower PMRs in both.

Table 4 Job codes with significantly high PMRs for ovarian cancer. Women aged 20-74 years, England 1991 - 2000.

Job Group		Deaths	Expected deaths	PMR	Lower 95% CI	Upper 95% CI
SIC code	**Description**	**1991 – 2000**				
Women						
011	School Teachers	906	713.4	127.0	119	135.5
019	Medical Radiographers	22	13.2	167.1	105	253.0
020	Physiotherapists	36	23.4	153.7	108	212.8
038	Production and maintenance managers	76	59.5	127.7	101	159.8
053	Office Workers and Cashiers	4119	3957.4	104.1	101	107.3
073	Warp Preparers, Bleachers, dyers & finishers	16	8.8	181.1	104	294.0
098	Tailors & Dressmakers	102	81.7	124.9	102	151.6

Source: Coggon *et al.* (2009) Occupational mortality in England and Wales, 1991-2000.

IARC have assessed the carcinogenicity of a number of substances and occupational circumstances with those classified as Group 1 having sufficient evidence in humans and those classified as Group 2A having limited evidence in humans. Table 5 shows agents and exposure circumstances classified as Group 1 or 2A for ovarian cancer. From the information included in the IARC assessments Siemiatycki *et al.* (2004) further classified the evidence as strong or suggestive, which can also be found in Table 5. There is suggestive evidence that exposure as a hairdresser or barber is associated with an increased risk of work-related ovarian cancer.

Table 5 Occupational agents, groups of agents, mixtures, and exposure circumstances classified by the IARC Monographs, Vols 1-77 (IARC, 1972-2001), into Groups 1 and 2A, which have the ovary as the target organ.

Agents, Mixture, Circumstance	Main industry, Use	Evidence of carcinogenicity in humans*	Strength of evidence$^{\$}$	Other target organs
Group 1: Carcinogenic to Humans				
Agents & groups of agents				
None identified				
Exposure circumstances				
None identified				
Group 2A: Probably Carcinogenic to Humans				
Agents & groups of agents				
None identified				
Exposure circumstances				
Hairdressers & barbers	Dyes (aromatic amines, amino-phenols with hydrogen peroxide); solvents; propellants; aerosols	Limited	Suggestive	Bladder Lung NHL

* Evidence according to the IARC monograph evaluation; $^{\$}$ taken from Siemiatycki *et al.* (2004)

2.1 EXPOSURES

2.1.1 Hairdressers and barbers

IARC have recently carried out an updated review of the evidence regarding cancer among hairdressers and barbers. Neither the summary nor the Monograph (Volume 99) is yet available.

Since the early twentieth century, hairdressers have made use of a wide range of products, including hair colourants and bleaches, shampoos and conditioners. Several thousand chemicals are found in formulations of these products. Hair colourants are classified as permanent (primarily aromatic amines and aminophenols with hydrogen peroxide), semi-permanent (nitro-substituted aromatic amines, aminophenols, aminoanthraquinones and azo dyes), and temporary (high-molecular-weight or insoluble complexes and metal salts, such as lead acetate). The numerous individual chemicals used in hair colourants have varied over time. Only permanent and semi-permanent hair colourants are used to a significant extent by hairdressers (IARC 1993).

In 1993, IARC concluded that there was an excess risk of cancer among people employed as a hairdresser, or barber (IARC 1993). The profession was subsequently categorised as a group 2A carcinogen. The strongest evidence cited was for excess risks for cancer of the urinary bladder in males. There was conflicting evidence for ovarian cancer with three studies finding an excess risk (one significant) and one showing no effect. However, specific exposures of hairdressers and barbers had not been evaluated in the epidemiological studies.

The terms hairdresser, cosmetologist and beautician tend to be used interchangeably. The products used by hairdressers are similar to the retail products sold for home use. Thus, there is potential for exposure outside the workplace, although these exposures tend to be of lower frequency and duration.

In 1983, Kono *et al.* (1983) published a report investigating causes of death among Japanese female beauticians. Information was collected on 7,736 female beauticians who were registered between 1948 and 1960 in Fukuoka Prefecture at the Department of Public Health. The follow-up period was from 1953 to 1978, in which time 488 deaths (5 due to ovarian cancer) were recorded. The general Fukuoka Prefecture population was used for reference. A non-significant excess was observed for cancer of the ovary (SMR=1.36, 95% CI=0.44-3.16, n=5). Estimates were not adjusted for potential confounders, and the study did not investigate length of exposure.

Spinelli *et al.* (1984) collected information on all deaths occurring in the province of British Columbia over the period 1950 through 1978 from the Division of Vital Statistics. All subjects that were over 20 years of age at death with complete records were included in the analysis. The cohort consisted of 254,901 males and 165,913 females. All subsequent estimates were age adjusted. An elevated risk of death from cancer of the ovary was found in female cosmetologists and hairdressers (PMR=204, 95% CI=88-403, p<0.1, n=8). However all the deaths occurred in women aged under 65, giving a significant mortality risk of PMR=234 (95% CI=101-462, p<0.05, n=8). The authors note that these calculations were based on a reference group of about 166,000 females who were predominantly housewives (90%). If these women were housewives due to having more children, on average, then they may have been at reduced risk of cancer, which could potentially elevate the observed PMR. In order to examine this, calculations were calculated based on non-housewives, and in the 20-65 age group, the risk was still elevated (PMR=198), but not statistically significant.

Teta *et al.* (1984) examined cancer incidence in 13,650 (11,845 female and 1,805 male) Connecticut cosmetologists, who had held a hairdressing licence for more than 5 years and had trained before 1966. The follow-up for cancer began in 1935 and continued through 1978. The general Connecticut population was used for comparison. An elevated risk of the condition, with borderline significance, was reported with SIR=134 (95% CI=99-178, n=48). Examining incidence by year of entry and length of time from entry to diagnosis (latency) yielded some significant results. In particular, significant excesses were recorded for females entering the occupation in the period 1925-1934 (SIR=189, p<0.01, n=25), as well as females with a follow-up period of 15-24 years (SIR=167, p<0.05, n=17), this elevated risk continued for increasing follow-up time, although not significantly. Consequently the authors investigated the risks associated with obtaining a first licence prior to 1935 and after 1935, a significant risk was only evident in the prior 1935 sub-group (1925-1935: SIR=188, 95% CI=122-278, n=25 and 1935-1974: SIR=102, 95% CI=65-153, n=23). Unfortunately, the authors were unable to obtain reproductive histories; therefore, the estimates are unadjusted.

A cohort of 3,637 female and 168 male hairdressers in Finland from the Finnish Cancer Registry was followed up for cancer incidence through the period 1970-1987. The study by Pukkala *et al.* (1992) was restricted to members of the association who were born in or before 1946 and were members between 1970 and 1982. Risk estimates were age adjusted. During the 18-year follow-up there were 21 observed cases resulting in a significantly elevated risk (SIR=1.64, 95% CI=1.02-2.51, n=21). To study the possible bias due to the "healthy worker effect", data from the first five years of follow-up were analysed separately. For ovarian cancer, the period from 1970 to 1975 again gave significant estimates with SIR=2.61 (95% CI=1.13-5.13, n=8). During the first two periods of study, 1970-1981, the risk continued to be significantly elevated (SIR=2.26, 95% CI=1.26-3.73, n=15). The excess risks observed throughout the study period were also found to increase with age.

In 1994, Boffetta *et al.* (1994) conducted an incidence study on 29,279 female hairdressers. The hairdressers were obtained from the 1970 censuses of Sweden, Norway, Finland (age 25-64 years), and Denmark (age 20-64 years). A National Cancer Registry exists in these four countries so all 127 ovarian cancer cases were identified (Denmark: 36, Sweden: 44, Norway: 14 and Finland: 33). The overall female population from the censuses was used as the reference and all estimates were age adjusted. Data from Sweden, Norway and Finland covered the period 1971 to 1985, whereas data from Denmark covered the period 1971 to 1987. The overall SIR was elevated with value 1.18 (95% CI=0.98-1.40, n=127). The excess was only found in Denmark and Finland with SIRs of 1.23 (95% CI=0.86-1.70, n=36) and 1.88 (95% CI=1.29-2.63, n=33) respectively. The greatest risk in the earliest period of follow-up was found in Denmark, Finland and Sweden; Denmark (1971-1980): SIR=1.39, n=20, Finland (1971-1975): SIR=2.70, n=12 and Sweden (1971-1975): SIR=1.17, n=15, whereas for Norway the greater risk was in the period 1976-1980 (SIR=1.45, n=7). Assuming a constant rate for Denmark in the period 1971-1980, the combined rates for 1971-1975, 1976-1980 and 1981-1985 were 1.4 (95% CI=1.0-1.9), 1.1 (95% CI=0.8-1.6) and 1.1 (95% CI=0.8-1.4) respectively. This study adds some evidence in favour of the presence of an association between hairdressers and ovarian cancer; however, the inconsistencies between the countries suggest that the occupational risk may depend on exposure circumstances over time and geographical factors.

Occupations, as reported in the 1970 census by all actively employed women (892,591) in Finland, were coded for job title and followed up for cancer incidence (Vasama-Neuvonen *et al*, 1999). Follow-up of the female population born in 1906-1945 was completed from 1971 through 1996. In total 5,072 primary ovarian cancers were identified. Estimates were adjusted for age, time period and social status, but not for reproductive variables. There were 57 cases of ovarian cancers for occupation as a hairdresser or barber resulting in a significantly elevated SIR of 1.3 (95% CI=1.0-1.7, n=57).

In 2001, Lamba *et al.* (2001) reported results of a mortality analysis on 38,721 deaths in 24 US states between 1984 and 1995, among hairdressers and barbers. All subjects within the study were aged 20 years and above. Female barbers were excluded from the analysis due to low number of deaths (400). Among the female hairdressers, there were 23,582 deaths of which 322 (285 white and 37 non-white) were due to ovarian cancer. All non-cancer deaths were used as the referent group. Mortality from cancer of the ovary was elevated for non-white women only (MOR=1.22, 95% CI=0.89-1.69, n=37). Elevated mortality risks were also observed for white women aged over 40 years and non-white women aged over 60 years, although no estimates were given.

Shields *et al.* (2002) conducted a study of ovarian cancer and occupation in the Swedish population. Information was collected on women who took part in the 1960 and 1970 censuses. The cohort was followed from 1971 to 1990 for death and cancer incidence. A total of 9,591 cases were identified among 1,670,517 women. Risk estimates were age adjusted and a comparison group of all women employed in 1960 or 1970 was used, so that housewives were excluded from the analysis. The analysis assumed that women who were employed in the same occupation during the 1960 and 1970 censuses were likely to be employed there for the whole 10 year period, thus this could be used as a surrogate for long-term exposure. Two main analyses were carried out, one by occupation and a further one by industry. Occupation as a hairdresser or beautician, in 1960 or 1970 only, gave a reduced risk of cancer with RRs of 0.87 (95% CI=0.6-1.2, n=36) and 0.56 (95% CI=0.3-0.9, n=14) respectively. However, for long-term exposure (occupation as hairdresser in 1960 and 1970) there was an elevated risk (RR=1.21, 95% CI=0.9-1.6, n=51). The second analysis found that working in hair cutting and beauty salons, again in 1960 or 1970 only, was associated with a reduced risk (0.88, 95% CI=0.6-1.2, n=37 and 0.50, 95% CI=0.3-0.9, n=12 respectively). A non-significant elevated risk of 1.26 (95% CI=0.96-1.7, n=52) was found for long-term exposure. Hairdressers or beauticians who worked in 1970 only were found to be at significantly lower risk in both analyses. This could be due to the reduction in the use of carcinogenic substances in this cohort over time. However, no information on lifestyle factors, such as parity and oral contraceptive use was available, so any associations may be reflective of these as well as occupational exposures.

A further study in 2003 used the Swedish Family-Cancer Database (Czene, Tiikkaja & Hemminki 2003). From this database, the economically active population who were aged between 15 and 60 years at the 1960 census were used. The study included individuals who recorded occupation as a hairdresser in any of the four censuses (1960, 1970, 1980 and 1990). The remaining economically active population was used for reference. Follow-up of the cohort was via the Swedish Cancer Registry and ended in 1998. In total there were 38,866 female hairdressers in the analysis of which 192 were ovarian cancer cases resulting in an SIR of 1.11 (95% CI=0.96-1.28). Of the women who were recorded in the 1960 census an SIR of 0.97 (95% CI=0.80-1.16, n=111) was obtained.

MacArthur *et al.* (2007) used case-control methods to investigate breast and reproductive cancer mortality in British Columbia. Female residents of British Columbia, who were 20 years of age or older and died between 1950 and 1994 were included in the analysis. Data were obtained from the Vital Statistics Agency and information on occupation and cause of death was taken from death certificates. Up to four controls (non-cancer deaths) were randomly sampled from the Vital Statistics Agency and matched on age at death and year of death. In total there were 5,070 ovarian cancer deaths eligible for study. No information was available on potential risk factors, thus no subsequent estimates were adjusted. In the analysis hairdressers experienced significantly elevated mortality between 1950 and 1968. However, this association was not present in the remaining time periods (1969-1982 and 1983-1994), or in the overall analysis (results not given).

3 ATTRIBUTABLE FRACTION ESTIMATION

3.1 GENERAL CONSIDERATIONS

Substances and Occupations

The substances considered in the estimation of the attributable fraction (AF) for ovarian cancer are those outlined in Table 6.

Table 6 Substances considered in the estimation of the attributable fraction for ovarian cancer

Agents, Mixture, Circumstance	AF calculation	Strength of evidence	Comments
Group 1: Carcinogenic to Humans			
Agents, groups of agents			
None identified			
Exposure circumstances			
None identified			
Group 2A: Probably Carcinogenic to Humans			
Agents & groups of agents			
None identified			
Exposure circumstances			
Hairdressers and barbers	Yes	Suggestive	

Data Relevant to the Calculation of AF

The two data elements required are an estimate of relative risk (RR), and either (1) an estimate of the proportion of the population exposed (Pr(E)) from independent data for Great Britain, or (2) an estimate of the proportion of cases exposed (Pr(E|D)) from population based study data.

The RR chosen from a 'best study' source is described for each exposure, with justification of its suitability. Information on the 'best study' and independent data sources for the proportion of the population exposed are also summarised for each exposure in the appropriate section below. In the absence of more precise knowledge of cancer latency, for solid tumours a latency of up to 50 years and at least 10 years has been assumed for all types of the cancer. Therefore it is assumed that exposure at any time between 1956 and 1995 (the Risk Exposure Period, REP) can result in a cancer being recorded in 2004 as a registration or in 2005 as an underlying cause of death. Although strictly speaking the REP for cancer registrations recorded in 2004, the year for which estimation has been carried out, would be 1955-1994, for simplification the years 1956 to 1995 have also been used, as for deaths, as the proportion exposed will not be affected. For an independent estimate of the proportion of the population exposed, numbers of workers ever exposed during this period are estimated by extrapolating from a point estimate of exposed workers taken from the period. If this is from CAREX relating to 1990-93, an adjustment is made to take account of gross changes in employment levels which have occurred particularly in manufacturing industry and the service sector across the REP. Otherwise a point estimate that represents numbers employed as close as possible to about 35 years before the target year of 2005 is used, as this is thought to represent a 'peak' latency for the solid tumours, and is also close to the mid-point of the REP for estimating numbers ever exposed across the period (for which a linear change in employment levels is implicitly assumed). Where the Census of Employment is used, the point estimate data are for 1971. Where the LFS is used, the first year available and therefore used is 1979. A turnover factor is applied to estimate numbers ever exposed during the REP, determined mainly by the estimate of staff turnover per year during the period. For each exposure therefore, if an AF has been based on independent estimates of numbers exposed, the table of results includes the point estimate of numbers employed, the adjustment factor for CAREX if applicable, the staff turnover estimate, and the resulting estimate of numbers ever exposed during the REP. Other estimates used in the calculations that remain constant across exposures (unless otherwise stated) are given below:

- Number of years in REP = 40
- Proportion in the workplace ever exposed is set to one, i.e. all are assumed to be exposed, in the absence of more detailed information. Where sources other than CAREX are used for the point estimate of numbers exposed, such as the LFS or Census of Employment, a precise as possible definition of workers exposed is sought.
- Numbers ever of working age during the target REP = 19.4 million men, 21.0 million women. This is the denominator for the proportion of the population exposed, and is based on population estimates by age cohort in the target year.
- Total deaths from ovarian cancer, Great Britain, 2005 = 4234 for women aged 25+ (3868 in England and Wales, 366 in Scotland)
- Total registrations for ovarian cancer, Great Britain, 2004 = 6197 for women aged 25+ (5215 in England, 365 Wales, 617 in Scotland).

Attributable numbers are estimated by multiplying the AF by the total number of cancers in GB. Only cancers which could have been initiated during the risk exposure period are counted, taking normal retirement age into account. Therefore for solid tumour cancers, total deaths or registrations recorded at all adult ages (25+) are used to estimate attributable numbers, and for short latency cancers, deaths and registrations for ages 15-84 for men and 15-79 for women are used.

For each agent where data on worker numbers are only available for men and women combined (CAREX data), the assumed percentage of men is given in addition to the numbers exposed. The allocation to high and low, and occasionally negligible, exposure level categories, or division into separate exposure scenarios, is also included in these tables. Where no separate estimate of relative risk is available for the low exposure level category, an estimate is based on an average of the high/low ratios for cancer-exposure pairs for which data were available.

Full details of the derivation of the above factors and the methods of calculating AF are published separately. Unless otherwise stated, Levin’s method is used for estimates using independent estimates of numbers exposed, and Miettinen’s method is used for study based estimates. A summary of the methodology is given in the Statistical Appendix.

3.2 HAIRDRESSERS AND BARBERS

(a) Risk Estimate:

Exposure as a hairdresser or beautician has been consistently associated with an increased risk of ovarian cancer (Boffetta *et al,* 1994, Kono *et al,* 1983, Pukkala *et al,* 1992, Teta *et al,* 1984). For the purpose of the calculations that follow, a European study was deemed more appropriate, therefore, the studies by Kono *et al.* (1983), Spinelli *et al.* (1984), Teta *et al.* (1984), Lamba *et al.* (2001) and MacArthur *et al.* (2007) were excluded. Some of the studies showed a gradual decrease in risk over time. However, since there is uncertainty in whether the elevated risk in hairdressers really has disappeared an overall estimate has been used. The Swedish study by Shields *et al.* (2002) only included estimates for short term and long term exposure so could not be used. There is partial overlap between the remaining studies by Vasama-Neuvonen *et al.* (1999), Pukkala *et al.* (1992), Boffetta *et al.* (1994) and Czene at al. (2003). Out of the four studies it was decided that the one conducted by Boffetta had a more detailed description of the data sources and methodology and covered four European countries and thus the estimate to be used for the statistical analysis is SIR=1.18 (95% CI=0.98-1.40). The reported estimates were adjusted for age.

The chosen study conducted an incidence study on 29,279 female hairdressers (Boffetta *et al*, 1994). The hairdressers were obtained from the 1970 censuses of Sweden, Norway, Finland (age 25-64 years), and Denmark (age 20-64 years). The overall female population from the censuses was used as the reference population. The follow-up period was from 1971 through 1985 for Sweden, Norway and Finland and through 1987 for Denmark.

(b) Numbers Exposed:

According to the Labour Force Survey there were 128,566 workers (22,988 males and 105,578 females) employed as a hairdresser or barber (including managers) in 1979.

Table 7 Numbers of workers employed as hairdressers or barbers according to LFS in 1979

SIC code	Description	Male	Female	Total
44.3	Hairdressers and Barbers Managers	487	2080	2567
74.0	Hairdressers and Barbers	22501	103498	125999
TOTAL		**22988**	**105578**	**128566**

Table 8 Numbers of workers employed as hairdressers or in related occupations according to LFS in 2005

SOC code	Description	Male	Female	Total
1233	Hairdressers and Beauty Salon Managers and Proprietors	5896	20095	25991
6221	Hairdressers and Barbers	18226	131175	149401
6222	Beauticians and Related Occupations	1734	44579	46313
TOTAL		**25856**	**195849**	**221705**

(c) AF Calculation:

The estimated total (female) attributable fraction for ovarian cancer is 0.54% (95%CI=0.00-1.22), which equates to 23 (95%CI=0-52) deaths and 33 (95%CI=0-76) registrations (Table 9).

Table 9 Results for Ovarian Cancer and Employment as a Hairdresser or Barber

			Data		Calculations			Attributable Fraction (Levins[7]) and Monte Carlo Confidence Interval			Attributable Deaths			Attributable Registrations		
Risk Estimate Reference	**Exposure**	**Main Industry Sector[1]**	**RR[2]**	**Ne[3]**	**TO[4]**	**NeREP[5]**	**PrE[6]**	**AF**	**LL**	**UL**	**AN**	**LL**	**UL**	**AR**	**LL**	**UL**
Boffetta *et al.* (1994)	H	G-Q	1.18	105578	0.15	631937	0.0301	0.0054	0	0.0122	23	0	52	34	0	76
	H	All		105578		631937	0.0301	0.0054	0	0.0122	23	0	52	34	0	76
	All	All		105578		631937	0.0301	0.0054	0	0.0122	23	0	52	34	0	76

1. Specific scenario or main industry code (Table A1)
2. Relative risks selected from the 'best study'
3. Numbers exposed, allocated to women
4. Staff turnover (TO, Table A1)
5. Number ever exposed during the REP (Statistical Appendix equation 3)
6. Proportion of the population exposed (Pr(E), Statistical Appendix equation 4)
7. Statistical Appendix equation 1

4 OVERALL ATTRIBUTABLE FRACTION

4.1 EXPOSURE MAP

No exposure map is given since there is only one occupation investigated.

4.2 SUMMARY OF RESULTS

The results are summarised in Table 10 and Table 11.

Table 10 Summary of RR used to calculate AF

Agent	Exposure	RR	LL	UL
Hairdressers and barbers	All	1.18	0.98	1.4

Table 11 Results by agent and occupation

Agent	Numbers Ever Exposed	Proportion Ever Exposed	AF	MCLL	MCUL	Attributable Deaths	Attributable Registrations
Hairdressers & barbers	631937	0.0301	0.0054	0.0000	0.0122	23	34

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6. STATISTICAL APPENDIX

Formulae used in the estimation of AF

Levin's equation

AF = Pr(E)*(RR-1)/{1+Pr(E)*(RR-1)} (1)

where RR = relative risk, Pr(E) = proportion of the population exposed

A common denominator is used across exposure levels and industries for each exposure

Miettinen's equation

AF = Pr(E|D)*(RR-1)/RR (2)

where Pr(E|D) = proportion of cases exposed (E = exposed, D = case)

Turnover equation to estimate numbers ever employed during the REP

$$N_{e(REP)} = \sum_{i=a}^{i=b} l_{(adj15)i} * n_0/(R-15)\}$$

$$+ \sum_{k=0}^{k=(age(u)-age(1))} \sum_{j=c+k}^{j=d+k} \{l_{(adj15)j} * n_0 * TO /(age(u)-age(l)+1)\} \quad (3)$$

where $N_{e(REP)}$ = numbers ever employed in the REP

n_0 = numbers employed in the exposed job/industry at a mid-point in the REP

TO = staff turnover per year

R = retirement age (65 for men, 60 for women)

$l_{(adj15)i}$ = the proportion of survivors to age i of those alive at age 15 (from GB life tables)

a to b = age range achieved by the original cohort members by the target year (2004) (e.g. 65 to 100 for the solid tumour REP)

c to d = age range achieved by the turnover recruited cohort members by the target year (25 to 64 for the solid tumour REP)

age(u) and age(l) = upper and lower recruitment age limits (24 and 15)

The derivation and assumptions underlying this formula are described in the methodology technical report, available on the HSE website. The equation can be represented as a single factor acting as a multiplier for n_0, calculated by setting n_0 to 1 in the above equation, so that the factor varies only with TO see Table A1 below.

Equation to estimate the proportion of the population exposed

$Pr(E) = N_{e(REP)} / N_{p(REP)}$ (4)

where $N_{p(REP)}$ = numbers ever of working age during the REP from population estimates for the relevant age cohorts in the target year

Equation for combining AFs where exposed populations overlap but are independent and risk estimates are assumed to be multiplicative:

$AF_{overall} = 1 - \Pi_k(1-AF_k)$ for the k exposures in the set (5)

Table A1 Employment level adjustment and turnover factors used in the calculation of AF

		Main Industry Sector	Adjustment factor for change in employment levels*	Turnover per year
Men	A-B	Agriculture, hunting and forestry; fishing	1	7%
	C-E	Mining and quarrying, electricity, gas and water; manufacturing industry	1.4	9%
	F	Construction	1	12%
	G-Q	Service industries	0.9	11%
		Total	1	10%
Women	A-B	Agriculture, hunting and forestry; fishing	0.75	10%
	C-E	Mining and quarrying, electricity, gas and water; manufacturing industry	1.5	14%
	F	Construction	0.67	15%
	G-Q	Service industries	0.8	15%
		Total	0.9	14%

* Applied to CAREX data for the solid tumour REP only. Exposed numbers are obtained for a mid-point year in the REP where national employment data sources have been used (the LFS or CoE).

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The burden of occupational cancer in Great Britain

Ovarian cancer

The aim of this project was to produce an updated estimate of the current burden of cancer for Great Britain resulting from occupational exposure to carcinogenic agents or exposure circumstances. The primary measure of the burden of cancer was the attributable fraction (AF) being the proportion of cases that would not have occurred in the absence of exposure; and the AF was used to estimate the number of attributable deaths and registrations. The study involved obtaining data on the risk of the cancer due to the exposure of interest, taking into account confounding factors and overlapping exposures, as well as the proportion of the target population exposed over the relevant exposure period. Only carcinogenic agents, or exposure circumstances, classified by the International Agency for Research on Cancer (IARC) as definite (Group 1) or probable (Group 2A) human carcinogens were considered. Here, we present estimates for cancer of the ovary that have been derived using incidence data for calendar year 2004, and mortality data for calendar year 2005.

The estimated total (female) AF, deaths and registrations for ovarian cancer related to overall occupational exposure (occupation as a hairdresser or barber) is 0.54% (95%Confidence Interval (CI)= 0.00-1.22), which equates to 23 (95%CI= 0-52) deaths and 33 (95%CI= 0-76) registrations.

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