ORIGINAL ARTICLE

Occupations with increased risk of pancreatic cancer in the Swedish population

J Alguacil, M Pollán, P Gustavsson

Occup Environ Med 2003;**60**:570–576

See end of article for authors' affiliations

Correspondence to: Dr M Pollán, Cancer Epidemiology Unit, National Centre for Epidemiology, Carlos III Institute of Health, Sinesio Delgado, 6, 28029 Madrid, Spain; mpollan@isciii.es

Accepted 27 September 2002

Aims: To identify occupations with increased risk of pancreatic cancer in the Swedish population gainfully employed in 1970 over the period 1971–89.

Methods: The base population was made up of Swedish men (1 779 646) and Swedish women (1 101 669) gainfully employed at the time of the 1970 census and were still alive and over age 24 on 1 January 1971. Information was drawn from two data sets: the Swedish cancer environment register and a background population register. After 19 years of follow up, 4420 men and 2143 women were diagnosed with histologically confirmed incident pancreatic adenocarcinoma. Log linear Poisson models were fitted, allowing for geographical area and town size. Risk estimators were also calculated for workers reporting the same occupation in 1960 and 1970.

Results: Among women, a statistically significant risk excess of pancreatic cancer was observed for "educational methods advisors", "librarian, archivist, curator", "motor vehicle driver", "typographer, lithographer", "purser, steward, stewardess", "other housekeeping and related workers", and the groups of occupations of "electrical, electronic, and related" and "glass, pottery, and tile workers". Men showed a higher incidence of pancreatic cancer among "technical assistants", "travelling agents", "other metal processing workers", "baker and pastry cook", "docker and freight handler", and "waiters".

Conclusions: This study does not indicate that occupational factors play an important role in the aetiology of pancreatic cancer in Sweden. Few occupations were at increased risk of pancreatic cancer in both men and women, and the associations observed are in accordance with some previous studies from Western countries.

Pancreatic cancer is a highly lethal malignancy whose aetiology is largely unknown. The only firmly established and modifiable risk factor is cigarette smoking, but it explains only a fraction of cases.[1] Factors suspected of causing moderate increases in risk include diabetes, chronic pancreatitis, and some dietary components.[1] The association between occupational exposures and pancreatic cancer remains controversial. A meta-analysis on occupation and pancreatic cancer suggested that some occupational exposures—chromium, nickel, silica, organic solvents, polycyclic aromatic hydrocarbons, and organochlorine insecticides—may increase the risk of this neoplasm.[2] Other specific agents pointed out as candidates to increase the risk of pancreatic malignancies include asbestos, ionising radiations, and some anilines.[1 3] Some specific occupations have putatively been associated with pancreatic cancer: dry cleaners, leather tanners, farmers, mechanics, metallurgic workers, and rubber, printing, petrol, and chemical industries.[1 4–7] However, occupational studies have often been negative, and no single occupation has consistently been shown to increase the risk of this malignancy.[8]

Incidence and mortality rates of pancreatic cancer in Scandinavian countries have been reported to be consistently higher than in the rest of Europe.[8–10] It is unknown to what extent such increase is related to the accuracy of death certification, differences in lifestyle, or other environmental factors.[10]

Record linkage between the Swedish cancer register and a population register comprising all individuals in the 1970 census—with information on occupation and residence in 1970, occupation in 1960, and date of death—allowed us to construct a retrospective cohort that was followed up over a 19 year period. The goal of the present study was to estimate occupation specific risk of pancreatic cancer among the population in this cohort.

Main messages

- Overall, occupational exposure does not play a major role in adenocarcinoma of the pancreas in Sweden.
- The risk excess observed in metal workers among men and women deserves further research to clarify the accuracy of and reasons for these findings.
- Farming related occupations did not show an increased risk of adenocarcinoma of the pancreas.
- The increased risks of pancreatic cancer observed in some occupations might be due to cigarette consumption.
- Many occupations entailing sedentary work showed an increased risk of pancreatic cancer.

Policy implications

- Tobacco cessation programmes should be encouraged in the workplace.
- Physical activity should be encouraged among workers with sedentary occupations.

MATERIALS AND METHODS

The base population for this historical cohort study was comprised of all Swedish men and women who: were gainfully employed at the time of the 1970 census, were present in the country during the 1960 census, and were still alive and over age 24 as of 1 January 1971. This encompassed 1 779 646 men and 1 101 669 women, aged 25–64 years at the beginning of the study and subsequently followed up for 19 years until the end of 1989. The total of 31 668 842 person-years among men

Table 1 Pancreatic cancer risk for occupations with at least five observed cases and a 10% excess risk; men

Occupational codes and job titles		Observed	SIR*	RR†	95% CI‡
Sector 0	**Professionals and technicians**	677	96.0		
001	Architect and building engineer	111	112.2	1.19	(0.97 to 1.46)
008	Technical assistant	5	267.6	2.80	(1.16 to 6.75)
012	Physicist	5	128.9	1.30	(0.54 to 3.15)
014	Laboratory technician	10	135.6	1.43	(0.77 to 2.68)
031	Physician	22	140.8	1.47	(0.96 to 2.24)
050	Principal, headmaster	14	120.9	1.28	(0.75 to 2.17)
054	Teacher of music, arts, or crafts	16	136.6	1.45	(0.88 to 2.39)
061	Minister, priest	15	111.2	1.20	(0.72 to 2.00)
085	Journalist, editor	14	118.0	1.20	(0.71 to 2.04)
092	Social workers	9	136.3	1.43	(0.74 to 2.76)
096	Staff officer	28	117.8	1.23	(0.84 to 1.79)
Sector 1	**Administrators and managers**	172	97.1		
111	Managing director	77	112.9	1.33	(0.98 to 1.79)
Sector 2	**Bookkeepers and clerical workers**	218	115.5		
292	Bank employee	12	178.1	1.49	(0.83 to 2.67)
299	Non-specific clerical workers	74	134.1	1.25	(0.95 to 1.66)
Sector 3	**Sales workers**	349	110.5		
301	Working proprietor, wholesale	18	132.7	1.23	(0.77 to 1.98)
311	Insurance representative and agent	8	136.2	1.22	(0.61 to 2.46)
321	Travel agent	52	163.4	1.55	(1.15 to 2.08)
338	Filling stat. attend., demonstr.	15	119.2	1.12	(0.67 to 1.89)
Sector 4	**Agriculture, forestry, and fishing workers**	457	81.3		
403	Forestry supervisor	21	110.2	1.28	(0.82 to 1.99)
413–15	Hunt and livestock	18	115.9	1.42	(0.89 to 2.28)
Sector 5	**Mining and quarrying**	24	94.4		
Sector 6	**Transport and communications**	385	108.2		
601	Ship deck officer	10	123.7	1.16	(0.62 to 2.17)
633	Motor vehicle driver, tramdriver	205	112.6	1.13	(0.92 to 1.38)
644	Road traffic supervisor	20	164.5	1.52	(0.97 to 2.38)
662	Messenger	24	134.9	1.16	(0.76 to 1.76)
699	Non specif. transport and commun. workers	5	149.3	1.34	(0.55 to 3.24)
Sector 7–8	**Production**	1856	104		
735	Blacksmith, forger	17	111.8	1.12	(0.69 to 1.80)
738	Other metal processing workers	13	175.0	1.94	(1.12 to 3.34)
742	Watchmaker	5	128.4	1.23	(0.51 to 2.96)
745	Gold and silver smith	5	171.4	1.56	(0.65 to 3.75)
753	Sheet metal workers	31	114.4	1.11	(0.78 to 1.58)
755	Welder and flame cutter	52	112.1	1.12	(0.85 to 1.48)
764–68	Electronic related workers	41	134.0	1.31	(0.96 to 1.79)
764	Radio and TV assembler and repairman	15	122.6	1.17	(0.71 to 1.95)
766	Telephone-telegraph instal repair	11	120.9	1.21	(0.67 to 2.19)
768	Other electrical and electronic workers	15	161.9	1.54	(0.93 to 2.57)
774	Frame, circular sawyer, and planer	23	116.8	1.32	(0.87 to 1.99)
795	Glazier	7	155.6	1.48	(0.70 to 3.10)
821–29	Food processing workers	77	125.5	1.24	(0.99 to 1.56)
821	Grain mill and oil press workers	6	145.6	1.55	(0.69 to 3.45)
822	Baker and pastry cook	31	148.3	1.42	(1.00 to 2.03)
826	Butcher and meat preparer	26	145.5	1.40	(0.95 to 2.06)
831–39	Chemical and laboratory	39	112.6	1.12	(0.82 to 1.54)
839	Non-specif. chemic. cellulose workers	13	153.6	1.43	(0.83 to 2.46)
851	Rubber products workers	16	148.6	1.45	(0.88 to 2.37)
856	Stone cutter and carver	8	145.8	1.59	(0.79 to 3.19)
857	Paper product workers	6	120.8	1.27	(0.57 to 2.84)
874	Construction machine operator	33	113.4	1.17	(0.83 to 1.66)
876	Greaser	7	156.7	1.57	(0.75 to 3.29)
882	Docker and freight handler	28	164.1	1.61	(1.11 to 2.33)
Sector 9	**Services and military workers**	282	122.2		
901	Firefighter	10	135.7	1.11	(0.59 to 2.08)
908	Other civilian protection service workers	31	155.5	1.30	(0.90 to 1.89)
911	Catering supervisor	11	139.4	1.15	(0.63 to 2.10)
921	Waiters	12	266.3	2.08	(1.16 to 3.73)
932	Cleaner	18	141.6	1.17	(0.73 to 1.89)
941	Hairdresser, beautician	18	135.3	1.13	(0.70 to 1.82)
948	Other service workers	6	196.9	1.57	(0.70 to 3.52)

*SIR, age and period standardised incidence ratio using the whole cohort as reference.
†RR, relative risk adjusted by age, period, geographical category, and town size, using other occupations in the same sector as reference.
‡CI, confidence intervals for the RR.

after 19 years of follow up ended with 5620 newly diagnosed pancreatic cancer cases. Among women, these figures were 20 087 479 person-years and 2657 cases. The resulting standardised rates were 18.4 and 13.8 cases per 100 000 person-years, using the standardised European population as reference, respectively among men and women, while the cumulative risk for ages 25–79 were 1.4% among men and 1.1% among women. After excluding histological pancreatic tumours other than adenocarcinoma of the pancreas, we ended with 4420 cases of pancreatic adenocarcinoma in men and 2143 in women, the case population used for this study.

Information was drawn from two data sets. The first source of data was the Swedish cancer environment register, comprising all cancer cases including information on occupation, residence,

Table 2 Pancreatic cancer risk for occupations with at least four observed cases and a 10% excess risk; women

Occupational codes and job titles		Observed	SIR*	RR†	95% CI‡
Sector 0	**Professionals and technicians**	343	91.6		
057	Educational methods advisors	6	238.2	2.58	(1.15 to 5.80)
093	Librarian, archivist, curator	14	159.3	1.74	(1.02 to 2.97)
096	Staff officer	8	165.8	1.79	(0.89 to 3.62)
098	Other professionals and technicians	4	173.9	1.88	(0.70 to 5.04)
Sector 1	**Administrators and managers**	21	87.8		
Sector 2	**Bookkeepers and clerical workers**	352	104.4	0.99	(0.88 to 1.11)
201–09	Cashiers and bank workers	104	118.1	1.21	(0.96 to 1.52)
201	Bookkeeping and cashier workers	70	116.6	1.16	(0.89 to 1.51)
204	Cashier retail store and restaurant	30	129.0	1.27	(0.88 to 1.85)
291	Computer operator	12	179.4	1.71	(0.96 to 3.05)
296	Insurance rater, claims adjuster	12	174.1	1.59	(0.89 to 2.84)
297	Employee in national insurance office	6	153.6	1.51	(0.67 to 3.38)
Sector 3	**Sales workers**	293	100.8		
331	Commer. traveller, buyer, dealer	16	153.2	1.53	(0.92 to 2.55)
Sector 4	**Agriculture, forestry, and fishing workers**	109	81.8		
413	Livestock workers	18	120.0	1.48	(0.89 to 2.46)
Sector 5	**Mining and quarrying**	1	425.5		
Sector 6	**Transport and communications**	70	101.2		
633	Motor vehicle driver, tram driver	9	222.9	2.50	(1.24 to 5.07)
Sector 7–8	**Production**	300	114		
718	Other sewing workers	15	137.7	1.31	(0.78 to 2.20)
731–39	Metal workers	5	200.9	1.82	(0.75 to 4.42)
761–69	Electrical, electronic, and related	26	192.1	1.72	(1.15 to 2.57)
764–68	Electronic related workers	25	186.5	1.66	(1.10 to 2.51)
768	Other electrical and electronic workers	23	177.5	1.55	(1.01 to 2.39)
771–79	Carpenters	8	116.1	1.13	(0.56 to 2.29)
772	Bench carpenter and cabinet maker	5	124.3	1.31	(0.54 to 3.19)
801–09	Printing workers	15	131.7	1.12	(0.66 to 1.88)
801	Typographer, lithographer	7	276.3	2.29	(1.08 to 4.86)
811–19	Glass, pottery, and tile workers	10	251.0	2.39	(1.27 to 4.49)
819	Non-specif. glass, pott., tile workers	4	376.9	3.84	(1.42 to 10.4)
828	Other food processing workers	4	205.2	1.96	(0.73 to 5.25)
858	Other production workers	5	120.1	1.12	(0.46 to 2.71)
861	Unskilled manual workers	5	131.5	1.18	(0.49 to 2.85)
Sector 9	**Services and military workers**	654	103.0		
911	Catering supervisor	32	119.9	1.17	(0.82 to 1.67)
912	Cook	36	116.1	1.14	(0.82 to 1.60)
917	Purser, steward, stewardess	6	535.5	5.17	(2.31 to 11.6)
918	Other housekeeping and related workers	6	298.9	2.85	(1.28 to 6.37)
942	Bath attendant	6	143.0	1.38	(0.62 to 3.09)

*SIR, age and period standardised incidence ratio using the whole cohort as reference.
†RR, relative risk adjusted by age, period, geographical category, and town size, using other occupations in the same sector as reference.
‡CI, confidence invervals for the RR.

and different demographic variables from the 1960 and 1970 censuses.[11 12] This register was used to compute specific rate numerators, with pancreatic cancer defined as any case with code 157 of the International Classification of Diseases (7th revision). The second data source comprised all individuals in the 1970 census, with information on occupation and residence in 1970, occupation in 1960, and, if applicable, date of death. This register was used to calculate specific rate denominators.

During the study period, death was the only event defined as end of follow up. Participants not reported as dead were considered to be alive until end of follow up. This led to a slight overestimation of person-years, since those who emigrated were not withdrawn. Nevertheless, the annual emigration rate among Swedish citizens was very low, approximately 1 per 1000.[13–15]

In the 1970 census, occupations were coded according to the Nordic Classification of Occupations.[12] Nearly the same codes were used in the 1960 census. Every occupation is represented by a three-digit number. The first digit refers to one of 10 major occupational sectors (0–9), where higher numbers indicate manual occupations, and lower numbers, occupations requiring a longer education and higher socioeconomic status.

The overall person-time that each person contributed to the study was allocated to the corresponding cells of the variables of stratification. These variables were:

(1) Occupation

(2) County of residence in 1970

(3) Size of town of residence in 1970 (under 2000; 2000–20 000; 20 000–100 000; >100 000 inhabitants)

(4) Five year age group, from 25–29 to 75–79

(5) Calendar time period (1971–75, 1976–80, 1981–85, and 1985–89).

The exact number of person-years was calculated using Clayton's algorithm.[16] Age standardised incidence rates per occupation for the whole period were computed using the age distribution of the European population as standard. Standardised incidence ratios (SIR) were calculated for men and women separately in each occupation. SIRs were adjusted by age and period using the whole cohort to provide the reference rates. On the assumption that the observed number of cases was distributed in each stratum as a Poisson variable, we fitted log linear Poisson models, comparing occupations against others in the general cohort, adjusting for geographical risk area and town size. Given that the expected number was computed on the basis of the age and period specific reference rates, relative risk (RR) for each occupation was likewise age and period adjusted.

Counties were grouped into three SIR based categories (<90, 90–110, and >110). To take into account the relation between social class, lifestyle (mainly tobacco consumption), and occupation, the same analysis was carried out for the selected occupations, but this time solely taking other occupations in the same major group (that is, those with the same first digit) as reference.

Table 3 Pancreatic cancer risk for occupations with at least four observed cases and a 10% excess risk; men reporting the same occupation in both censuses

Occupational codes and job titles		Observed	SIR*	RR†	95% CI‡
001	Architect and building engineer	67	110.7	1.17	(0.91 to 1.51)
031	Physician	19	142.8	1.49	(0.94 to 2.35)
050	Principal, headmaster	6	135.8	1.44	(0.64 to 3.22)
054	Teacher of music, arts, or crafts	11	150.9	1.61	(0.89 to 2.92)
061	Minister, priest	13	112.7	1.22	(0.70 to 2.12)
085	Journalist, editor	9	122.5	1.25	(0.65 to 2.42)
111	Managing director	32	103.5	1.23	(0.82 to 1.84)
292	Bank employee	7	280.7	2.24	(1.05 to 4.78)
301	Working proprietor, wholesale	10	211.2	1.97	(1.05 to 3.70)
311	Insurance representative and agent	5	156.0	1.38	(0.57 to 3.35)
321	Travel agent	26	170.8	1.60	(1.07 to 2.40)
403	Forestry supervisor	14	103.2	1.21	(0.70 to 2.07)
413–15	Hunt and livestock	9	107.3	1.31	(0.68 to 2.53)
644	Road traffic supervisor	6	207.4	1.84	(0.82 to 4.13)
662	Messenger	6	189.4	1.63	(0.72 to 3.66)
735	Blacksmith, forger	10	110.0	1.10	(0.59 to 2.05)
738	Other metal processing workers	6	340.7	3.92	(1.76 to 8.75)
742	Watchmaker	5	147.4	1.41	(0.59 to 3.40)
753	Sheet metal workers	23	141.8	1.36	(0.90 to 2.05)
755	Welder and flame cutter	30	113.7	1.12	(0.78 to 1.60)
764–68	Electronic related workers	12	159.8	1.56	(0.88 to 2.76)
764	Radio and TV assembler and repairman	5	119.6	1.15	(0.48 to 2.78)
768	Other electrical and electronic workers	4	222.7	2.14	(0.80 to 5.71)
774	Frame, circular sawyer, and planer	6	150.0	1.65	(0.74 to 3.68)
795	Glazier	6	187.3	1.77	(0.79 to 3.94)
821–29	Food processing workers	48	126.2	1.24	(0.93 to 1.66)
822	Baker and pastry cook	24	133.7	1.29	(0.86 to 1.93)
826	Butcher and meet preparer	15	156.0	1.48	(0.89 to 2.46)
851	Rubber products workers	10	184.6	1.79	(0.96 to 3.33)
856	Stone cutter and carver	4	141.2	1.51	(0.57 to 4.04)
874	Construction machine operator	15	124.4	1.29	(0.78 to 2.14)
882	Docker and freight handler	18	230.5	2.20	(1.38 to 3.50)
883	Store and warehouse workers	49	135.3	1.30	(0.98 to 1.72)
901	Firefighter	8	136.2	1.12	(0.55 to 2.26)
921	Waiter	6	221.1	1.67	(0.74 to 3.78)
932	Cleaner	5	236.4	1.87	(0.77 to 4.54)
941	Hairdresser, beautician	17	134.1	1.12	(0.69 to 1.84)

*SIR, age and period standardised incidence ratio using the whole cohort as reference.
†RR, relative risk adjusted by age, period, geographical category, and town size, using other occupations in the same sector as reference.
‡CI, confidence intervals for the RR.

For occupations that still showed an excess risk of at least 10%, relative risks (RRs) were calculated separately: for subjects reporting such occupations in both censuses; and for those reporting such occupations in 1970 but not in 1960. In each case, the RR was calculated taking the other occupations in the same major group as reference. Furthermore, assuming greater exposure (at least in terms of years) for individuals reporting the same occupation in both censuses, the statistical significance of a gradient of risk was obtained. In order to obtain more valid estimates, RR were adjusted for other important confounders (county and town size), and definition of occupation was further refined by means of additionally computing RRs for those participants reporting the same occupation in both censuses.

RESULTS

In our cohort, pancreatic cancer incidence varied markedly among Swedish counties. The highest SIR for men (1.33) and women (1.37) was registered in Västerbotten North Sweden and the lowest (0.63 in men and 0.62 in women) in Kristianstad South Sweden. The same was true for urban and rural areas, with the incidence rate ratio for towns with more than 100 000 inhabitants versus those with less than 2000 being 1.42 for men and 1.22 for women. These factors were potential confounders in our study, since some occupations are more predominant in urban than in rural areas, and vice versa. In general, RRs from Poisson models taking geographical area and town size into account were lower than the corresponding SIRs. The mentioned attenuation might be due to the confounding effect of these two variables.

RRs for the 10 major occupational sectors (first digit of the occupational codes) showed some differences, ranging from 0.89 among men (0.82 among women) for "administrative and managerial personnel" to 1.19 among "services and military workers" (1.17 in "production workers" among women). When comparing risk estimates as a result of intragroup comparisons (taken as reference subjects with job codes having the same first digit) versus risk estimates taking all the population as reference, attenuation of the risks towards unity was observed for intragroup comparisons in occupational sectors with lower education and socioeconomic status in both sexes. This might be due to a higher prevalence of pancreatic cancer risk factors in these main occupational sectors.

From the 279 different occupations reported among men in 1970, 140 had at least five observed cases and their RR were computed using Poisson models. Among these occupations, 69 showed a standardised incidence ratio greater than 110, of which 53 showed a relative risk for pancreatic cancer equal or higher to 1.1 (table 1). Statistically significant RRs were observed among "technical assistants", "travelling agents", "other metal processing workers", "baker and pastry cook", "docker and freight handler", and "waiters". Relative risks over 1.5 were seen also among "road traffic supervisors", "gold and silver smiths", "telephone-telegraph install repair", "grain mill and oil press workers", "stone cutters and carvers", "greasers", and "other service workers" (table 1). In most cases, when restricting the analyses to those aged under 65,

Table 4 Pancreatic cancer risk for occupations with at least four observed cases and a 10% excess risk; women reporting the same occupation in both censuses

Occupational codes and job titles		Observed	SIR*	RR†	95% CI‡
093	Librarian, archivist, curator	5	214.2	2.35	(0.97 to 5.70)
201–09	Group of bank workers	29	114.5	1.17	(0.80 to 1.72)
204	Cashier, retail store and restaurant	7	164.5	1.62	(0.77 to 3.43)
296	Insurance rater, claims adjuster	6	193.3	1.73	(0.77 to 3.90)
721–22	Shoe workers	4	186.4	1.99	(0.74 to 5.35)
758	Other engin. and building metal workers	5	183.3	1.60	(0.66 to 3.87)
764–68	Electronic related workers	5	145.4	1.21	(0.50 to 2.96)
768	Other electrical and electronic workers	5	145.4	1.20	(0.49 to 2.93)
801–09	Printing workers	5	147.1	1.22	(0.50 to 2.96)
911	Catering supervisor	13	143.1	1.41	(0.81 to 2.44)
912	Cook	13	124.0	1.18	(0.68 to 2.04)

*SIR, age and period standardised incidence ratio using the whole cohort as reference.
†RR, relative risk adjusted by age, period, geographical category, and town size, using other occupations in the same sector as reference.
‡CI, confidence intervals for the RR.

risks estimates remained unchanged (data not shown). Some occupations suspected of increasing pancreatic cancer risk showed slightly increased risks: "motor vehicle drivers", "blacksmiths", "watchmakers", "butcher and meet preparer", "chemical and laboratory", "shoe workers", "rubber product workers", "cleaners", and "hairdressers". No excess of risk was observed among male "farmers", "gardeners", or "dry cleaners".

Women reported 270 different occupations in total. About one third (n = 77) of them showed at least four pancreatic cancer cases and were considered in the following analyses. Thirty two of these occupations had standardised incidence ratio greater than 110, and 26 had a relative risk for pancreatic cancer over 1.1 (table 2). In one third of them, the increased RR reached statistical significance, although most of these were low numbers. These occupations included "educational methods advisors", "librarian, archivist, curator", "motor vehicle driver", "typographer, lithographer", "purser, steward, stewardess", "other housekeeping and related workers", "other electric and electronic workers", and the groups of occupations of "glass, pottery, and tile workers". When restricting the analyses to those aged under 65, risks estimates tended to increase slightly (data not shown). Some occupations believed to increase the risk of pancreatic cancer showed little risk: "launderer and dry cleaner" (RR = 1.08, 95% CI: 0.68 to 1.73) and "textile worker" (RR = 1.06, 95% CI: 0.82 to 1.37), or null risk (farming) among women.

For job codes shown as having at least a 10% excess risk in the SIR, tables 3 and 4 set out the RRs for men and women respectively reporting occupations in both censuses (1960 and 1970). Only those occupations with an RR over 1.1 and at least four cases are shown. Both sexes showed excess of pancreatic cancer in occupations entailing food processing, "hunt and livestock", "metal workers", and "electronic related workers". Among men (table 3), most significant associations showed higher estimates except for "waiters", and in general, RRs tended to increase. When restricting the analyses among those aged under 65 years, RRs changed slightly, although they increased notably among "other metal processing workers" (RR = 4.50, 95% CI: 1.45 to 14.0), "sheet metal workers" (RR = 1.81, 95% CI: 1.12 to 2.93), "frame, circular sawyer, and planer" (RR = 2.37, 95% CI: 0.89 to 6.35), and "rubber products workers" (RR = 2.09, 95% CI: 0.94 to 4.67). Among women, with the exception of shoe workers (RR = 1.66, 95% CI: 0.74 to 5.35), after limiting the analyses to those reporting the same occupation in both censuses (table 4) point estimates of RRs only changed slightly.

DISCUSSION

From the results from this study, occupation seems to play a small role in pancreatic cancer aetiology in the Swedish population. A few occupations showed an increased risk of pancreatic cancer in both men and women, and the associations observed were in accordance with previous studies.

"Gold and silver smiths" among men, and workers on electronics among both sexes showed an increased risk of pancreatic cancer. A possible exposure among those workers could be chlorinated solvents while cleaning the material they work with. A recent meta-analysis studying the association between chlorinated solvents and pancreatic cancer, reported that polychlorinated biphenyls, trichloroethylene, methylene chloride, and vinyl chloride (but not carbon tetrachloride) could be associated with pancreatic cancer.[3] The authors of the study also point out a possible interaction between these solvents and other pancreatic carcinogens.[3] However, due to the high correlation of exposure among those compounds, the specific responsible agent is difficult to identify. A case-control study in Shanghai reported an increased risk among workers in "electrical, electronics, and related", and attributed the increase of risk to electric magnetic fields.[17] Electromagnetic fields exposure has been suggested to suppress pineal gland production of melatonin, thereby promoting the occurrence of cancer.[18] Also, it has been hypothesised to alter normal removal of damaged cells; to affect hormone release; and to influence cellular growth and differentiation.[19] Other exposures among these workers include cutting oils and PCBs.

Another occupation showing increased risk among men and women is the group of metal workers. This increase in the risk is consistent with findings of many previous epidemiological studies,[17 20–24] but not all.[1 25] PAHs might explain the risk excess among those workers. The carcinogenic properties of benzo[a]pyrene are widely known; considering its presence in tobacco smoke (the only well established risk factor for pancreatic cancer) we find this excess credible. The review of the epidemiological evidence of cancer in aluminium reduction plant workers by Ronneberg and Langmark suggested an association between pancreatic cancer and potroom workers.[26]

The increase among stone cutters in men, and glass, pottery, and tile workers among women has been also reported in other studies,[17] including a nationwide case-control study in Finland.[6 27] Inorganic dust might be the most prevalent exposure among those workers.

Similarly to our study, an increased pancreatic cancer risk has been observed among workers who hold sedentary jobs,[4 27 28] a factor which may activate a biological pathway involving obesity.[8 29–32] Lack of physical activity could possibly explain the results for librarian/archivist/curators, teachers, cashiers, working proprietors, managing directors, bank employees, and clerical workers. In the absence of any other exposure these associations might indicate a role for lack of physical activity in pancreatic cancer.[31]

The observed increased risk among printing workers in women was mainly due to typographers and lithographers. Other studies have also reported increased risk of pancreatic cancer among printing workers.[33–36] A study published in the early 1990s reported increased mortality from diabetes mellitus and pancreatic cancer among Swedish pulp and paper mill workers.[37] However, other studies in northen European countries did not observe any association with pancreatic cancer among those workers.[38 39]

We did not observe an excess risk among female hairdressers,[40] but we found a slight increase in the risk of pancreatic cancer among male hairdressers. A Finnish cohort of hairdressers showed increased risks of pancreatic cancer among both men and women,[41] as did another case-control study, also in Finland.[27] Some of the dyes used by hairdressers are aromatic amines; a number of aromatic amines have proved to be pancreatic carcinogens in animal models, and it has been suggested that they may play a role in human pancreatic cancer.[42] An excess of pancreatic cancer has also been reported in some studies of exposure to dyes and aniline derivatives.[5 25 43–45]

Although some recent publications support the association between pesticide use and pancreatic cancer in different countries,[2 5 46] the lack of association between farming and pancreatic cancer in our study is in accordance with other reports from studies developed in Sweden among male farmers,[47] female farmers,[48] and pesticide applicators.[49] Some explanations include the fact that spray seasons are short and control of toxic pesticides is probably the strictest in the world in Sweden; active ingredients are therefore restricted, exposure levels probably relatively low (except maybe in greenhouses), and cumulated exposures low because of both low levels and low time fractions of exposure. Also, while other studies reported increased risk among textile workers,[17 27 28 50] we did not find indications of such an association among Swedish women. The most recent mortality analysis from a Russian cohort of shoe workers[51] was not able to replicate the initially observed excess of pancreatic cancer.[52] Other recent European studies have not found increased risk of pancreatic cancer among shoe workers.[53] "Waiters and waitresses", "store and warehouse workers", "working proprietors", and "travelling agents" showed increased risk of lung and bladder cancer in our cohort. A higher consumption of cigarette smoking in these groups might explain the excess of observed cases of pancreatic cancer. Other associations putatively related to cigarette smoking would include staff officers and food processing work related occupations. A higher tobacco consumption among Swedish brewery workers was suggested as the explanation for the highest incidence of pancreatic cancer in this occupational sector.[54] The pattern of RR between size of population and cancer observed in pancreatic cancer can be also observed in lung cancer. The fact of controlling for population size, and using as a reference population other workers within occupational sectors might provide some adjustment for tobacco consumption. The point risk estimate for waiters decreased from 2.36 to 2.08 when workers from the same main occupational sector were used as reference to compute the RRs.

Other limitations of this study include the heterogeneity of exposures within job titles (ensuing uncertainties in attributing chemical agents as explanations); the lack of adjustment from well known risk factors for pancreatic cancer, namely cigarette smoking, diabetes, chronic pancreatitis, and body mass index; and the high number of comparisons run. However, most results are consistent with international literature, thus reducing their likelihood of being chance findings. As the referent population only includes working individuals, it is unlikely to be confounding due to differences in confounding factors between the Swedish working population and the Swedish general population employed, although differences in tobacco consumption across the different occupations are probable. In Sweden the prevalence of smoking among males was around 35% during the 1980s, declining linearly to 18% at the start of the twenty first century, while the corresponding figure among women during the 1980s was around 30%, declining slowly since then to 20% in 2000.[55] A prospective study reported an RR for pancreatic cancer among female current smokers of 1.7 versus never smokers, and the relations with amount smoked daily and age at starting smoking were not pronounced.[56] The relatively low prevalence of smoking in the Swedish population during the study follow up, the modest magnitude of association between smoking and pancreatic cancer (versus the association between cigarette smoking and cancers from the upper respiratory tract, lung, or stomach), and the fact that the point estimate for most statistically significant associations is higher than the putative RR for cigarette smoking in the Swedish population somehow limit (but do not completely remove) the potential of having confounded results from tobacco consumption in our study.

Diagnostic misclassification has been shown to seriously bias risk estimates for pancreatic cancer.[57–59] While many other studies included other histology diagnoses, we only considered in our study histologically confirmed pancreatic cancer cases with adenocarcinoma of the pancreas (the most frequent pancreatic malignancy). Even though the definition of the exposure is limited in this population study, the availability of additional information about the 1960 census allowed us to increase the specificity of this definition considering the subcohort of subjects exposed in both censuses. SIRs were computed taking only age and period into account, since the reference rates proved to be unstable when stratification for geographical area and town size was attempted. As an alternative, Poisson regression analysis possesses major advantages over standardisation in controlling for confounding.[60] However, the general theory of goodness of fit analysis in Poisson regression requires the number of expectations per stratum not to be too small.[60] In our models, the total number of cases for any occupation was split into the corresponding categories, producing strata with very low figures. Nevertheless, the use of observed and expected values afforded the opportunity of collapsing the different strata (that is, different age groups and periods), thereby increasing their stability and rendering regression analysis more efficient.

Although occupation might play a small role in pancreatic cancer in the Swedish population, a few occupations were found to increase the risk of pancreatic cancer in both men and women, and some occupations entailing exposure to chlorinated hydrocarbons solvents and PAHs deserve further research to clarify the accuracy of and reasons for these findings.

ACKNOWLEDGEMENTS

We thank the Center for Epidemiology at the National Board of Health and Welfare for making the database available for researchers. Dr Pollan's stay in Sweden was supported by a grant from the Health Research Fund of the Spanish Ministry of Health (Fondo de Investigación Sanitaria, grant BAE 96/5050).

Authors' affiliations

J Alguacil, Occupational and Environmental Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, NIH, DHHS, Bethesda, Maryland, USA
M Pollán, Cancer Epidemiology Unit, National Centre for Epidemiology, Carlos III Institute of Health, Madrid, Spain
P Gustavsson, Department of Occupational and Environmental Health, Stockholm Centre for Public Health, Stockholm, Sweden

REFERENCES

1 **Weiderpass E**, Partanen T, Kaaks R, *et al*. Occurrence, trends and environment etiology of pancreatic cancer. *Scand J Work Environ Health* 1998;**24**:165–74.

2 **Ojajarvi A**, Partanen TJ, Ahlbom A, *et al*. Occupational exposures and pancreatic cancer: a meta-analysis. *Occup Environ Med* 2000;**57**:316–24.
3 **Ojajarvi A**, Partanen T, Ahlbom A, *et al*. Risk of pancreatic cancer in workers exposed to chlorinated hydrocarbon solvents and related compounds: a meta-analysis. *Am J Epidemiol* 2001;**153**:841–50.
4 **Alguacil J**, Porta M, Benavides FG, *et al*. Occupation and pancreatic cancer in Spain: a case-control study based on job titles. PANKRAS II Study Group. *Int J Epidemiol* 2000;**29**:1004–13.
5 **Alguacil J**, Kauppinen T, Porta M, *et al*. Risk of pancreatic cancer and occupational exposures in Spain. PANKRAS II Study Group. *Ann Occup Hyg* 2000;**44**:391–403.
6 **Kauppinen T**, Partanen T, Degerth R, *et al*. Pancreatic cancer and occupational exposures. *Epidemiology* 1995;**6**:498–502.
7 **Pietri F**, Clavel F. Occupational exposure and cancer of the pancreas: a review. *Br J Ind Med* 1991;**48**:583–7.
8 **Anderson KE**, Potter JD, Mack TM. Pancreatic cancer. In: Schottenfeld D, Fraumeni JF Jr, eds. *Cancer epidemiology and prevention*. New York: Oxford University Press, 1996:725–71.
9 **Parkin DM**, Pisani P, Ferlay J. Estimates of the worldwide incidence of 25 major cancers in 1990. *Int J Cancer* 1999;**80**:827–41.
10 **Fernandez E**, La Vecchia C, Porta M, *et al*. Trends in pancreatic cancer mortality in Europe, 1955–1989. *Int J Cancer* 1994;**57**:786–92.
11 **Barlow L**, Eklund G. [Opening of a new database for research scientists. FoB 60 and 70 linked with the cancer registry]. *Lakartidningen* 1995;**92**:1344–7.
12 **Center for Epidemiology**. *Cancer-Miljöregistret 1960–70 [Cancer environment register 1960–1970, in Swedish]*. EpC Report 1994 4. Stockholm: Center for Epidemiology, Swedish National Board of Health and Welfare, 1994.
13 **Statistics Sweden**. *Statistical yearbook 1981*. Stockholm: Statistics Sweden, 1981.
14 **Statistics Sweden**. *Statistical yearbook 1982/3*. Stockholm: Statistics Sweden, 1983.
15 **Statistics Sweden**. *Statistical yearbook 1991*. Stockholm: Statistics Sweden, 1991.
16 **Breslow NE**, Day NE. *Statistical methods in cancer research, Vol II. The design and analysis of cohort studies*. Lyon: IARC Sci Pub, 1987:82.
17 **Ji BT**, Silverman DT, Dosemeci M, *et al*. Occupation and pancreatic cancer risk in Shanghai, China. *Am J Ind Med* 1999;**35**:76–81.
18 **Stevens RG**, Davis S, Thomas DB, *et al*. Electric power, pineal function, and the risk of breast cancer. *FASEB J* 1992;**6**:853–60.
19 **Wertheimer N**, Leeper E. Adult cancer related to electrical wires near the home. *Int J Epidemiol* 1982;**11**:345–55.
20 **Maruchi N**, Brian D, Ludwig J, *et al*. Cancer of the pancreas in Olmsted County, Minnesota, 1935–1974. *Mayo Clin Proc* 1979;**54**:245–9.
21 **Rockette HE**, Arena VC. Mortality studies of aluminum reduction plant workers: potroom and carbon department. *J Occup Med* 1983;**25**:549–57.
22 **Mur JM**, Moulin JJ, Meyer-Bisch C, *et al*. Mortality of aluminium reduction plant workers in France. *Int J Epidemiol* 1987;**16**:257–64.
23 **Silverstein M**, Park R, Marmor M, *et al*. Mortality among bearing plant workers exposed to metalworking fluids and abrasives. *J Occup Med* 1988;**30**:706–14.
24 **Mallin K**, Rubin M, Joo E. Occupational cancer mortality in Illinois white and black males, 1979-1984, for seven cancer sites. *Am J Ind Med* 1989;**15**:699–717.
25 **Mack TM**, Peters JM, Yu MC, *et al*. Pancreas cancer is unrelated to the workplace in Los Angeles. *Am J Ind Med* 1985;**7**:253–66.
26 **Ronneberg A**,.Langmark F. Epidemiologic evidence of cancer in aluminum reduction plant workers. *Am J Ind Med* 1992;**22**:573–90.
27 **Partanen T**, Kauppinen T, Degerth R, *et al*. Pancreatic cancer in industrial branches and occupations in Finland. *Am J Ind Med* 1994;**25**:851–66.
28 **Pietri F**, Clavel F, Auquier A, *et al*. Occupational risk factors for cancer of the pancreas: a case-control study. *Br J Ind Med* 1990;**47**:425–8.
29 **Friedman GD**, van den Eeden SK. Risk factors for pancreatic cancer: an exploratory study. *Int J Epidemiol* 1993;**22**:30–7.
30 **Silverman DT**, Schiffman M, Everhart J, *et al*. Diabetes mellitus, other medical conditions and familial history of cancer as risk factors for pancreatic cancer. *Br J Cancer* 1999;**80**:1830–7.
31 **Michaud DS**, Giovannucci E, Willett WC, *et al*. Physical activity, obesity, height, and the risk of pancreatic cancer. *JAMA* 2001;**286**:921–9.
32 **Wolk A**, Gridley G, Svensson M, *et al*. A prospective study of obesity and cancer risk (Sweden). *Cancer Causes Control* 2001;**12**:13–21.
33 **Zoloth SR**, Michaels DM, Villalbi JR, *et al*. Patterns of mortality among commercial pressmen. *J Natl Cancer Inst* 1986;**76**:1047–51.
34 **Lloyd JW**, Decoufle P, Salvin LG. Unusual mortality experience of printing pressmen. *J Occup Med* 1977;**19**:543–50.
35 **Williams RR**, Stegens NL, Goldsmith JR. Associations of cancer site and type with occupation and industry from the Third National Cancer Survey Interview. *J Natl Cancer Inst* 1977;**59**:1147–85.
36 **Kernan GJ**, Ji BT, Dosemeci M, *et al*. Occupational risk factors for pancreatic cancer: a case-control study based on death certificates from 24 U.S. states. *Am J Ind Med* 1999;**36**:260–70.
37 **Wingren G**, Persson B, Thoren K, *et al*. Mortality pattern among pulp and paper mill workers in Sweden: a case-referent study. *Am J Ind Med* 1991;**20**:769–74.
38 **Rafnsson V**. Incidence of cancer among bookbinders, printers, photoengravers, and typesetters. *Occup Environ Med* 2001;**58**:523–7.
39 **Wiebelt H**, Becker N. Mortality in a cohort of toluene exposed employees (rotogravure printing plant workers). *J Occup Environ Med* 1999;**41**:1134–9.
40 **Lamba AB**, Ward MH, Weeks JL, *et al*. Cancer mortality patterns among hairdressers and barbers in 24 US states, 1984 to 1995. *J Occup Environ Med* 2001;**43**:250–8.
41 **Pukkala E**, Nokso-Koivisto P, Roponen P. Changing cancer risk pattern among Finnish hairdressers. *Int Arch Occup Environ Health* 1992;**64**:39–42.
42 **Anderson KE**, Hammons GJ, Kadlubar FF, *et al*. Metabolic activation of aromatic amines by human pancreas. *Carcinogenesis* 1997;**18**:1085–92.
43 **Mancuso TF**, el Attar AA. Cohort study of workers exposed to betanaphthylamine and benzidine. *J Occup Med* 1967;**9**:277–85.
44 **Depue RH**, Kagey BT, Heid MF. A proportional mortality study of the acting profession. *Am J Ind Med* 1985;**8**:57–66.
45 **Magnani C**, Coggon D, Osmond C, *et al*. Occupation and five cancers: a case-control study using death certificates. *Br J Ind Med* 1987;**44**:769–76.
46 **Ji BT**, Silverman DT, Stewart PA, *et al*. Occupational exposure to pesticides and pancreatic cancer. *Am J Ind Med* 2001;**39**:92–9.
47 **Wiklund K**, Dich J. Cancer risks among male farmers in Sweden. *Eur J Cancer Prev* 1995;**4**:81–90.
48 **Wiklund K**, Dich J. Cancer risks among female farmers in Sweden. *Cancer Causes Control* 1994;**5**:449–57.
49 **Wiklund K**, Dich J, Holm LE, *et al*. Risk of cancer in pesticide applicators in Swedish agriculture. *Br J Ind Med* 1989;**46**:809–14.
50 **Olsen JH**, Jensen OM. Occupation and risk of cancer in Denmark. An analysis of 93,810 cancer cases, 1970–1979. *Scand J Work Environ Health* 1987;**13**(suppl 1):1–91.
51 **Zaridze D**, Bulbulyan M, Changuina O, *et al*. Cohort studies of chloroprene-exposed workers in Russia. *Chem Biol Interact* 2001;**135–136**:487–503.
52 **Shan'gina OV**, Bul'bulian MA, Nikolaeva GM, *et al*. [New aspects of carcinogenic hazards in shoe industry (a retrospective epidemiological study)]. *Med Tr Prom Ekol* 1998:8–12.
53 **Fu H**, Demers PA, Costantini AS, *et al*. Cancer mortality among shoe manufacturing workers: an analysis of two cohorts. *Occup Environ Med* 1996;**53**:394–8.
54 **Carstensen JM**, Bygren LO, Hatschek T. Cancer incidence among Swedish brewery workers. *Int J Cancer* 1990;**45**:393–6.
55 **Statistics Sweden**. *Undersökning av levnadsförhållanden [Investigation of living conditions]*. Statistics Sweden, 8-24-2001, 2-6-2002.
56 **Nordlund LA**, Carstensen JM, Pershagen G. Cancer incidence in female smokers: a 26-year follow-up. *Int J Cancer* 1997;**73**:625–8.
57 **Malats N**, Real FX, Porta M. DDT and pancreatic cancer. *J Natl Cancer Inst* 1993;**85**:328–9.
58 **Porta M**, Malats N, Pinol JL, *et al*. Diagnostic certainty and potential for misclassification in exocrine pancreatic cancer. PANKRAS I Project Investigations. *J Clin Epidemiol* 1994;**47**:1069–79.
59 **Silverman DT**, Schiffman M, Devesa S. Diagnostic certainty in pancreatic cancer. *J Clin Epidemiol* 1996;**49**:601–3.
60 **Bithell JF**, Dutton SJ, Neary NM, *et al*. Controlling for socioeconomic confounding using regression methods. *J Epidemiol Community Health* 1995;**49**(suppl 2):S15–19.