High-Risk Occupations for Breast Cancer in the Swedish Female Working Population

Marina Pollán, MD, MPH, and Per Gustavsson, MD, PhD

ABSTRACT

Objectives. The purpose of this study was to estimate, for the period 1971 through 1989, occupation-specific risks of breast cancer among Swedish women employed in 1970.

Methods. Age–period standardized incidence ratios were computed. Log-linear Poisson models were fitted, with geographical area and town size taken into account. Risks were further adjusted for major occupational group, used as a proxy for socioeconomic status. Risk estimators were also calculated for women reporting the same occupation in 1960 and 1970.

Results. Most elevated risks among professionals, managers, and clerks were reduced when intragroup comparisons were carried out, indicating the confounding effect of socioeconomic status. Excess risks were found for pharmacists, teachers of theoretical subjects, schoolmasters, systems analysts and programmers, telephone operators, telegraph and radio operators, metal platers and coaters, and hairdressers and beauticians, as well as for women working in 1960 and 1970 as physicians, religious workers, social workers, bank tellers, cost accountants, and telephonists.

Conclusions. While the high risks observed among professional, administrative, and clerical workers might be related to lower birth rates and increased case detection, excess risks found for telephone workers and for hairdressers and beauticians deserve further attention. (*Am J Public Health.* 1999;89:875–881)

Most of the known risk factors for breast cancer—namely, early menarche, late menopause, late or null first-term pregnancy, lactation, hormone-replacement therapy, and obesity—can be seen as measures of the cumulative exposure of the breast to estrogen and, perhaps, progesterone.[1] However, it has been estimated that as much as 53% of the incidence rate cannot be explained by these factors.[2] Allowance should therefore be made for other environmental exposures, among which occupational exposures might play an important role.[3]

Studies have shown an increased risk of breast cancer associated with several occupations.[4–14] The positions most frequently reported are teachers,[6,7,9,12,13] administrative workers,[4,6,12] religious workers,[4,6,9] and health care workers.[6,7,9,10,14]

Record linkage between the Swedish cancer registry and a population registry comprising all individuals included in the 1970 census (with information on occupation and residence in 1970, occupation in 1960, and date of death) rendered it possible to construct a retrospective cohort that was followed up over a 19-year period. The goal of the present study was to estimate the occupation-specific risk of breast cancer among the female members of this cohort. As a means of obtaining more valid estimators, relative risks were adjusted for other important confounders (county and town size), and the definition of occupation was refined by means of computing relative risks for those women reporting the same occupation in both censuses.

Methods

The base population for this historical cohort study was made up of all Swedish women who (1) were gainfully employed at the time of the 1970 census, (2) had also been present in the country during the 1960 census, and (3) were still alive and older than 24 years as of January 1, 1971. The sample included 1 101 669 women who were aged 25 to 64 years at the beginning of the study and who were subsequently followed up for 19 years until the end of 1989.

Information was drawn from 2 linked data sets. The first was the Swedish cancer environment registry, which provides information on incident cancer cases (reporting rate: 95%–98%),[15,16] including occupation, residence, and certain demographic variables from the 1960 and 1970 censuses. This registry was used to compute specific rate numerators; breast cancer was defined as any case classified under code 170 of the *International Classification of Diseases, 7th Revision.*[16] The second data set was a background population registry comprising all individuals included in the 1970 census, with information on occupation in 1960, occupation and residence in 1970, and date of death. This registry was used to calculate specific rate denominators.

During the study period, death was the only event defined as end of follow-up. Women not reported as deceased were considered to be alive until the 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.[17–19]

Marina Pollán is with the Cancer Epidemiology Unit, National Centre for Epidemiology, Carlos III Institute of Health, Madrid, Spain. Per Gustavsson is with the Department of Occupational Health, Karolinska Hospital, and the Department of Public Health Sciences, Karolinska Institute, Stockholm, Sweden.

Requests for reprints should be sent to Marina Pollán, MD, MPH, Cancer Epidemiology Unit, National Centre for Epidemiology, Carlos III Institute of Health, Sinesio Delgado, 6, 28029 Madrid, Spain (e-mail: mpollan@isciii.es).

This paper was accepted November 11, 1998.

In the 1970 census, occupations were coded according to the Nordic Classification of Occupations.[20] Almost exactly the same codes were used in the 1960 census. Each occupation is represented by a 3-digit number. The first digit refers to 1 of 10 major occupational groups (0–9), with higher numbers indicating manual occupations and lower numbers indicating occupations involving more education and a higher socioeconomic status.

The overall person-time that each woman 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 (less than 2000, 2000–20 000, 20 000–100 000, or more than 100 000 inhabitants), (4) age group (in 5-year categories ranging from 25–29 to 75–79 years), and (5) calendar time period (1971–1975, 1976–1980, 1981–1985, and 1985–1989). The variables of occupation, county, and town size, because they were drawn from the 1970 census, were regarded as fixed; age and period were time dependent. Clayton's algorithm was used in calculating the exact number of person-years.[21]

Age-standardized incidence rates per occupation for the entire period were computed with the European population as the standard. Cumulative risk from 25 to 79 years of age was also assessed. This risk can be interpreted as the theoretical probability of a 25-year-old woman in a given occupation developing breast cancer before the age of 80 years, assuming that she were not to die from any other cause.[22]

The relative risk of breast cancer was estimated on the basis of the standardized incidence ratio: the ratio of the observed to the expected number of cases in any given occupation. Incidence ratios were adjusted by age and period, the overall cohort being used to provide reference rates. The expected number of cases was then generated by applying the specific reference rates to the person-years in each age and period stratum. Under the Poisson distribution, confidence intervals for standardized incidence ratios were computed via Byar's approximation.[21] Because of the low numbers of women in certain occupations, only occupations involving at least 200 exposures and a minimum of 10 observed cases were considered. Standardized incidence ratios were also computed for the 10 major occupational groups.

Breast cancer risk showed a geographical variation, with Stockholm and Malmöhus as areas of highest incidence and the northern counties as areas of lowest incidence; risk also tended to be greater for urban than for rural areas. Since occupations are not uniformly

TABLE 1—Breast Cancer Incidence per Occupational Group and for Those Occupations With at Least 10 Cases Observed and a 10% Excess Risk

Group and Occupational Code	Adjusted Rate[a]	Cumulative Risk[b]	Observed Cases	Expected Cases	SIR[c]	95% CI
Group 0: professional and technical work	161	9.0	6630	5928	112	109, 115
002 Electrical engineer	204	9.9	18	12	149	88, 236
003 Mechanical engineer	171	8.6	20	15	135	82, 208
006 Engineer and technician, other	163	9.1	25	22	114	74, 169
008 Technical assistant	166	7.8	109	90	121	99, 145
011 Chemist	193	9.4	25	16	152	99, 225
014 Laboratory technician	159	8.1	114	98	116	96, 140
031 Physician	216	11.8	59	40	147	112, 190
032 Dentist	201	11.0	52	37	140	105, 184
040 Registered nurse	172	9.9	754	643	117	109, 126
041 Midwife	178	9.7	47	37	128	94, 170
045 Medical technician	173	9.6	122	99	123	102, 147
046 Pharmacist	234	13.2	83	55	150	120, 186
047 Physiotherapist, occupational therapist	160	8.1	159	136	117	99, 136
050 Principal, headmaster	178	10.1	21	17	122	75, 186
051 University, higher education teacher	182	9.6	46	34	137	100, 183
052 Teacher in theoretical subjects	188	10.5	409	315	130	118, 143
053 Formal schoolmaster	190	10.6	827	651	127	119, 136
054 Teacher: painting, music, physical education	168	9.5	292	249	117	104, 132
055 Teacher in vocational subjects	193	11.0	131	100	131	110, 156
056 Preprimary education teacher	170	9.2	154	133	116	99, 136
058 Other educational worker	188	9.9	45	34	134	98, 179
068 Other religious worker	224	11.3	22	15	149	94, 226
081 Sculptor, painter, photographer, artist	172	9.2	35	29	122	85, 170
085 Journalist, editor	169	8.3	70	57	122	95, 154
086 Performing artist	272	18.8	32	20	157	107, 222
088 Other literary and artistic worker	180	8.3	15	10	150	84, 247
091 Accountant, auditor	196	10.3	19	14	132	80, 207
092 Social worker	178	9.8	281	226	124	110, 140
093 Librarian, archivist, curator	172	8.4	144	118	122	103, 144
096 Staff officer	183	9.2	97	71	137	111, 167
097 Systems analyst, programmer	196	9.1	24	13	179	115, 267
098 Other professions, technical & related	198	12.2	43	33	129	93, 174
Group 1: administrative and managerial	177	9.7	403	320	126	114, 139
101 Government legislator and administrator	200	10.7	165	116	142	122, 166
118 Other business manager	172	9.9	216	178	121	106, 138
Group 2: bookkeeping and clerical work	165	9.3	6115	5382	114	111, 117
201 Bookkeeper and cashier	165	9.0	1084	929	117	110, 124
203 Bank teller	194	11.7	97	79	122	99, 149
290 Secretary, typist	176	9.8	1416	1172	121	115, 127
291 Computer operator	165	8.6	174	153	114	98, 132
293 Travel agency employee	192	9.1	23	16	143	91, 215
294 Forwarding and shipping agent	141	5.6	10	9	118	56, 217
295 Property and store manager	156	8.8	40	35	114	81, 155
296 Insurance rater, claims adjuster	182	9.2	135	100	135	113, 160
297 National insurance office worker	197	12.3	87	71	123	98, 151
298 Cost accountant, estimating clerk	249	17.7	26	18	147	96, 215
299 Nonspecified clerical work	161	9.2	2517	2268	111	107, 115
Group 3: sales work	138	7.9	3691	3858	96	93, 99
313 Advertising personnel	179	8.2	29	20	143	96, 205
Group 4: agriculture, forestry, and fishing	115	6.5	1264	1587	80	82, 93
418 Other agricultural, horticultural, livestock worker	162	7.5	10	8	129	62, 237
Group 5: mining and quarrying	119	5.0	4	4	104	28, 267
Group 6: transport and communications	150	8.6	1076	1044	103	97, 109
653 Telephone operator	217	14.3	157	123	128	109, 150
654 Office telephonist	164	9.0	347	303	115	103, 127
655 Telegraph and radio operator	193	9.4	43	29	147	106, 197

Continued

TABLE 1—*Continued*

Group and Occupational Code	Adjusted Rate[a]	Cumulative Risk[b]	Observed Cases	Expected Cases	SIR[c]	95% CI
Group 7: production I	132	7.9	1855	2016	92	88, 96
713 Hatmaker and milliner	178	9.6	38	32	121	85, 165
757 Metal plater and coater	376	23.1	12	6	204	105, 356
779 Nonspecificied woodworker	186	12.6	15	12	126	70, 207
Group 8: production II	128	7.6	1361	1550	88	83, 93
808 Other printing worker	177	11.4	26	23	116	76, 170
814 Glass, ceramic painter, and decorator	187	9.3	10	8	131	63, 242
851 Rubber products worker	170	11.5	44	39	113	82, 152
854 Photographic laboratory worker	168	8.8	25	21	118	76, 174
Group 9: services and military work	129	7.4	6889	7599	91	89, 93
917 Purser, steward, stewardess	159	7.0	22	19	115	72, 175
941 Hairdresser, beautician	158	8.7	284	258	110	98, 124
946 Photographer	187	13.0	20	17	120	74, 186

Note. SIR = standardized incidence ratio; CI = confidence interval.
[a]Per 100 000 person-years using European standard population.
[b]Per 100 person-years.
[c]Using age- and period-specific rates for the whole cohort as standard.

distributed geographically, a more detailed analysis was carried out for occupations with standardized incidence ratios greater than 110 to take these possible confounders into account. Sweden is divided into 24 counties. To simplify analysis, counties were grouped into 5 categories based on their standardized incidence ratio: (1) less than 90, (2) between 90 and 95, (3) between 95 and 105, (4) between 105 and 110, and (5) more than 110.

On the assumption that the observed number of cases was distributed in each stratum as a Poisson variable, log-linear Poisson models were fitted in which occupations were compared, with geographical risk area and town size taken into account. In these models, the number of expected cases was introduced as an offset.[21] Given that the expected number was computed on the basis of the age- and period-specific reference rates, the relative risk for each occupation was likewise age and period adjusted.

As a means of taking into account the relationship between social class, lifestyle, and occupation, the same analysis was carried out for the selected occupations, but this time solely with other occupations in the same major group (i.e., those with the same first digit) as the reference.

In occupations that still showed an excess risk of at least 10%, relative risks were calculated separately for women reporting such occupations in both censuses and for those reporting such occupations in 1970 but not in 1960. In each case, the relative risk was calculated with the other occupations in the same major group as the reference. Furthermore, risk gradients were computed, with greater exposure (at least in terms of years) assumed among women reporting the same occupation in both censuses. In all instances, geographical area and town size were also considered.

Results

During the follow-up, 29 284 breast tumors were reported in the study cohort. The overall standardized rate was 143.8 cases per 100 000 person-years, and the cumulative risk for the 25- to 79-year age group was 8.5%. Table 1 depicts the adjusted rates, cumulative risks, and standardized incidence ratios for major occupational groups and for occupations with an incidence ratio of 110 or higher. There were substantial intergroup differences, with incidence rates considerably higher among administrators, clerks, and professionals and lower among workers in agriculture, production, and services.

Of the 270 occupations reported in 1970, 143 involved more than 200 women and at least 10 observed cases. Half of those with a standardized incidence ratio greater than 110 (Table 1) corresponded to professional and technical staff (group 0). Among respondents with these occupations, systems analysts and programmers showed the highest standardized incidence ratio (179), and positions involving more than 30% excess risk included electrical engineers, mechanical engineers, physicians, dentists, pharmacists, different types of teachers, religious workers, artists, and staff officers. Government legislative and administrative workers in group 1 and travel agency employees, insurance raters, and cost accountants and estimating clerks in group 2 recorded an excess risk of more than 30%. Other job codes with a similar excess risk were those corresponding to working proprietors, advertising personnel, telegraph and radio operators, glass and ceramic painters, and metal platers and coaters, with the last-mentioned registering the highest standardized incidence ratio (204).

In general, relative risks from Poisson models taking geographical area and town size into account (see Table 2) were lower than the corresponding standardized incidence ratios as a result of the positive confounding effect of these 2 variables.

In intragroup comparisons that took as a reference only job codes having the same first digit (Table 2), attenuation of risks toward unity was also observed in groups 0, 1, and 2. Some occupations failed to show a 10% excess risk and were not considered in subsequent analyses. In contrast, there were increases in relative risks for most occupations in groups 3 through 9—a finding that was to be expected in view of the exclusion of high-risk occupations in groups 0 through 2 from the reference category.

The only job classifications associated with excess risk that attained statistical significance were pharmacists, teachers in theoretical subjects, schoolmasters, systems analysts and programmers, telephone operators, office telephonists, telegraph and radio operators, metal platers and coaters, and hairdressers and beauticians.

For job codes exhibiting at least a 10% excess risk in the right-hand side of Table 2, Table 3 sets out the relative risks for (1) women reporting such occupations in 1970 but not in 1960 and (2) women reporting the same such occupations in both censuses. Again, the reference group was formed by the other job codes having the same first digit. In some instances, the number of cases in the second category was too small to allow conclusions to be drawn, but a statistically significant gradient was found for physicians, pharmacists, teachers in theoretical subjects, schoolmasters, social workers, telephone operators, office telephonists, telegraph and radio operators, and hairdressers and beauticians. Moreover, an almost statistically significant gradient was found for religious workers and for cost accountants and estimating clerks.

It is interesting to note that some of the occupations with excess risks that failed to reach statistical significance in the previous analysis (see Table 2) registered a significant excess risk among women reporting such occupations in both censuses; this was true of physicians, religious workers, social workers, bank tellers, and cost accountants and estimating clerks.

Discussion

This study focused on occupations posing increased risk of breast cancer among Swedish women employed in 1970. After adjustment for age, period of diagnosis, geographical area, and town size, 25 occupations were identified with a relative risk greater than 1.20 in comparison with other job classifications in the same major occupational group (used as a proxy for education level and other socioeconomic factors). Of these positions, 8 had elevated risk that attained statistical significance: pharmacists, certain types of teachers, schoolmasters, systems analysts and programmers, telephone operators, office telephonists, telegraph and radio operators, metal platers and coaters, and hairdressers and beauticians. Another 6 positions were shown to have a significantly elevated risk among women reporting them in both 1960 and 1970: physicians, religious workers, social workers, bank tellers, cost accountants and estimating clerks, and office telephonists. Furthermore, a statistically significant gradient in risk was obtained for physicians, pharmacists, teachers, social workers, telephone operators, office telephonists, telegraph and radio operators, and hairdressers and beauticians when occupational groups were subdivided; women reporting such jobs in both censuses were considered to represent a category of higher exposure.

The definition of exposure was limited in this population study; however, the availability of additional information about the 1960 census allowed us to increase the specificity of this definition by considering the subcohort of women exposed in both censuses. This is one of the strengths of the present study. Standardized incidence ratios were computed with only age and period taken 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 standardization in controlling for confounding.[23] However, the general theory of goodness-of-fit analysis in Poisson regression requires the number of expectations per stratum not to be overly small.[23] 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 (i.e., different age groups and periods),[21] thereby increasing their stability and rendering the regression analysis more efficient.

TABLE 2—Breast Cancer Risk for Occupations With a Minimum of 10 Observed Cases and a 10% Excess Risk, Adjusted for Age, Period, Geographical Category, and Town Size

Occupational Code	Reference: All Other Occupations		Reference: Other Occupations in Same Group	
	RR[a]	95% CI	RR[a]	95% CI
002 Electrical engineer	1.40	0.88, 2.23	1.28	0.81, 2.03
003 Mechanical engineer	1.29	0.83, 1.99	1.18	0.75, 1.80
006 Engineer and technician, other	1.11	0.75, 1.64	1.00	0.67, 1.48
008 Technical assistant	1.16	0.96, 1.40	1.05	0.87, 1.27
011 Chemist	1.42	0.96, 2.11	1.30	0.87, 1.92
014 Laboratory technician	1.14	0.95, 1.37	1.02	0.85, 1.23
031 Physician	1.39	1.08, 1.80	1.27	0.98, 1.64
032 Dentist	1.35	1.03, 1.77	1.22	0.93, 1.60
040 Registered nurse	1.17	1.09, 1.26	1.05	0.97, 1.13
041 Midwife	1.30	0.98, 1.73	1.16	0.87, 1.55
045 Medical technician	1.19	1.00, 1.42	1.08	0.90, 1.29
046 Pharmacist	1.47	1.18, 1.82	1.32	1.07, 1.64
047 Physiotherapist, occupational therapist	1.16	0.99, 1.36	1.04	0.89, 1.22
050 Principal, headmaster	1.19	0.77, 1.82	1.07	0.70, 1.65
051 University, higher education teacher	1.29	0.97, 1.72	1.18	0.88, 1.57
052 Teacher in theoretical subjects	1.28	1.16, 1.41	1.16	1.05, 1.28
053 Formal schoolmaster	1.30	1.22, 1.40	1.18	1.09, 1.27
054 Teacher: painting, music, physical education	1.18	1.05, 1.32	1.05	0.94, 1.19
055 Teacher in vocational subjects	1.31	1.10, 1.55	1.17	0.99, 1.39
056 Preprimary education teacher	1.13	0.97, 1.33	1.02	0.87, 1.19
058 Other educational worker	1.31	0.98, 1.76	1.18	0.88, 1.58
068 Other religious worker	1.47	0.97, 2.24	1.33	0.88, 2.02
081 Sculptor, painter, photographer, artist	1.15	0.83, 1.61	1.04	0.75, 1.45
085 Journalist, editor	1.14	0.90, 1.44	1.04	0.82, 1.32
086 Performing artist	1.45	1.02, 2.05	1.32	0.93, 1.87
088 Other literary and artistic worker	1.35	0.81, 2.24	1.24	0.75, 2.07
091 Accountant, auditor	1.25	0.80, 1.95	1.14	0.72, 1.78
092 Social worker	1.23	1.10, 1.39	1.11	0.98, 1.25
093 Librarian, archivist, curator	1.18	1.00, 1.39	1.07	0.90, 1.26
096 Staff officer	1.30	1.06, 1.59	1.18	0.97, 1.44
097 Systems analyst, programmer	1.65	1.11, 2.46	1.51	1.01, 2.26
098 Other professions, technical and related	1.22	0.91, 1.65	1.11	0.82, 1.50
101 Government legislator and administrator	1.34	1.15, 1.56	1.21	0.99, 1.48
118 Other business manager	1.16	1.02, 1.33	0.93	0.76, 1.13
201 Bookkeeper and cashier	1.13	1.06, 1.20	1.04	0.97, 1.11
203 Bank teller	1.22	1.00, 1.50	1.12	0.92, 1.37
290 Secretary, typist	1.15	1.09, 1.21	1.06	0.99, 1.12
291 Computer operator	1.08	0.93, 1.25	0.99	0.85, 1.15
293 Travel agency employee	1.33	0.88, 1.99	1.21	0.81, 1.83
294 Forwarding and shipping agent	1.12	0.60, 2.08	1.03	0.55, 1.91
295 Property and store manager	1.09	0.80, 1.48	1.00	0.73, 1.36
296 Insurance rater, claims adjuster	1.24	1.04, 1.46	1.13	0.95, 1.34
297 National insurance office worker	1.20	0.97, 1.48	1.10	0.89, 1.36
298 Cost accountant, estimating clerk	1.39	0.94, 2.04	1.27	0.86, 1.87
299 Nonspecified clerical work	1.08	1.04, 1.13	0.97	0.92, 1.02
313 Advertising personnel	1.32	0.92, 1.91	1.42	0.97, 2.05
418 Other agricultural, horticultural, livestock worker	1.29	0.69, 2.40	1.37	0.73, 2.60
653 Telephone operator	1.27	1.08, 1.48	1.31	1.11, 1.56
654 Office telephonist	1.10	0.99, 1.22	1.15	1.01, 1.31
655 Telegraph and radio operator	1.40	1.04, 1.88	1.41	1.04, 1.92
713 Hatmaker and milliner	1.19	0.86, 1.63	1.27	0.92, 1.76
757 Metal plater and coater	2.02	1.15, 3.56	2.14	1.21, 3.77
779 Nonspecified woodworker	1.40	0.84, 2.32	1.44	0.87, 2.40
808 Other printing worker	1.09	0.74, 1.60	1.24	0.84, 1.83
814 Glass, ceramic painter, and decorator	1.35	0.72, 2.50	1.50	0.80, 2.80
851 Rubber products worker	1.08	0.80, 1.45	1.14	0.84, 1.56
854 Photographic laboratory worker	1.12	0.76, 1.66	1.29	0.87, 1.92
917 Purser, steward, stewardess	1.12	0.74, 1.70	1.24	0.82, 1.89
941 Hairdresser, beautician	1.09	0.97, 1.23	1.21	1.08, 1.37
946 Photographer	1.17	0.75, 1.81	1.30	0.84, 2.01

Note. RR = relative risk; CI = confidence interval.
[a]For each occupation in comparison with others.

TABLE 3—Breast Cancer Risk for Selected Occupations: Number of Cases and Relative Risks

Occupational Code	Women Reporting Occupation Only in 1970 Census			Women Reporting Occupation in Both Censuses			
	Observed	RR[a]	95% CI	Observed	RR[a]	95% CI	P[b]
002 Electrical engineer	17	1.27	0.79, 2.04	1	1.50	0.21, 10.65	.29
003 Mechanical engineer	19	1.18	0.75, 1.85	1	0.90	0.13, 6.39	.56
011 Chemist	20	1.37	0.88, 2.12	5	1.07	0.45, 2.58	.30
031 Physician	20	0.93	0.60, 1.45	39	1.55	1.13, 2.12	.02
032 Dentist	16	1.19	0.73, 1.94	36	1.23	0.89, 1.71	.17
041 Midwife	21	1.14	0.74, 1.75	26	1.18	0.80, 1.73	.32
046 Pharmacist	36	1.19	0.86, 1.65	47	1.45	1.09, 1.93	.01
051 University, higher education teacher	43	1.19	0.88, 1.61	3	0.96	0.31, 2.99	.34
052 Teacher in theoretical subjects	267	1.13	1.00, 1.28	142	1.22	1.03, 1.44	<.01
053 Formal schoolmaster	264	1.03	0.91, 1.17	563	1.26	1.15, 1.37	<.01
055 Teacher in vocational subjects	111	1.20	1.00, 1.45	20	1.03	0.66, 1.60	.13
058 Other educational worker	45	1.21	0.90, 1.62	0	0.00	...	...
068 Other religious worker	11	0.97	0.54, 1.76	11	2.09	1.16, 3.78	.05
086 Performing artist	19	1.41	0.90, 2.21	13	1.21	0.70, 2.09	.19
088 Other literary and artistic worker	14	1.36	0.80, 2.30	1	0.56	0.08, 4.01	.61
091 Accountant, auditor	17	1.14	0.71, 1.83	2	1.13	0.28, 4.51	.60
092 Social worker	196	1.04	0.90, 1.20	85	1.31	1.06, 1.63	.03
096 Staff officer	97	1.18	0.97, 1.44	0	0.00	...	...
097 Systems analyst, programmer[c]	24	1.51	1.01, 2.26	0	0.00	...	...
098 Other professions, technical and related	41	1.12	0.82, 1.52	2	0.89	0.22, 3.56	.56
101 Government legislator and administrator	146	1.22	0.99, 1.50	19	1.15	0.72, 1.84	.10
203 Bank teller	71	1.02	0.81, 1.30	26	1.52	1.04, 2.24	.10
293 Travel agency employee	18	1.29	0.81, 2.05	5	0.99	0.41, 2.39	.49
296 Insurance rater, claims adjuster	81	1.10	0.88, 1.37	54	1.17	0.89, 1.53	.16
297 National insurance office worker	66	1.02	0.80, 1.30	21	1.49	0.97, 2.29	.17
298 Cost accountant, estimating clerk	16	0.99	0.60, 1.61	10	2.35	1.26, 4.37	.05
313 Advertising personnel	28	1.53	1.05, 2.22	1	0.48	0.07, 3.44	.15
418 Other agricultural, horticultural, livestock worker	7	1.15	0.54, 2.45	3	2.49	0.80, 7.76	.18
653 Telephone operator	27	1.00	0.68, 1.47	130	1.41	1.17, 1.70	<.01
654 Office telephonist	234	1.08	0.93, 1.25	113	1.32	1.08, 1.62	.01
655 Telegraph and radio operator	18	1.05	0.66, 1.68	25	1.87	1.26, 2.79	.01
713 Hatmaker and milliner	18	1.23	0.78, 1.97	20	1.31	0.84, 2.04	.15
757 Metal plater and coater	11	2.11	1.17, 3.83	1	2.38	0.34, 16.93	.01
779 Nonspecified woodworker	15	1.51	0.91, 2.52	0	0.00	...	...
808 Other printing worker	23	1.22	0.81, 1.85	3	1.40	0.45, 4.36	.27
814 Glass, ceramic painter, and decorator	7	1.64	0.78, 3.45	3	1.25	0.40, 3.90	.30
851 Rubber products worker	31	1.17	0.81, 1.68	13	1.09	0.63, 1.90	.47
854 Photographic laboratory worker	20	1.28	0.82, 2.00	5	1.32	0.55, 3.17	.28
917 Purser, steward, stewardess	21	1.29	0.84, 1.98	1	0.70	0.10, 5.01	.41
941 Hairdresser, beautician	85	1.09	0.88, 1.35	199	1.27	1.11, 1.47	<.01
946 Photographer	12	1.31	0.74, 2.31	8	1.28	0.64, 2.56	.28

Note. RR = relative risk; CI = confidence interval.
[a]Adjusted for age, period, geographical category, and town size. Reference: other occupations in the same group.
[b]Testing linear trend among exposed categories.
[c]This occupation did not exist in the 1960 classification.

To our knowledge, this is the only study of its kind to take geographical area and town size into account. In our cohort, breast cancer incidence rates varied markedly among Swedish counties. The highest incidence (161.2 per 100 000 residents) was registered in Malmöhus (southern Sweden), and the lowest (110.2 per 100 000 residents) was registered in Norrbotten (in the north). The same was true for urban and rural areas; the incidence rate ratio for towns with more than 100 000 inhabitants vs those with less than 2000 inhabitants was 1.27. These factors proved to be confounders in our study, since some occupations are more predominant in urban than in rural areas, and vice versa. Adjusted relative risks for most job titles were lower than their corresponding standardized incidence ratios. These factors can be seen as markers of other environmental exposures; for instance, the urban excess of breast cancer has been partly attributed to nutritional differences as well as to an older average age at first childbirth.[24]

It was not possible to take into account several well-known risk factors for breast cancer, namely, family history of breast cancer, menopausal status, age at menarche, parity, age at first childbirth, and body mass index. Although case–control studies including such factors have shown no difference between crude and adjusted occupational risk estimates,[4,5,8,25] their role as confounders cannot be ruled out.

A consistent association between high socioeconomic status and breast cancer risk has been observed.[3,26,27] In our study, half of all job titles with standardized incidence ratios in excess of 110 corresponded to professionals and technicians (group 0), and another 20% involved administrative, managerial, or clerical workers (groups 1 and 2), a finding in line with the excess of breast cancer reported for these occupational groups.[5,6,9,12,13,27,28] We attempted to allow for these differences by calculating the relative risk for each job code, using the other occupations in the same major group as the reference. These analyses yielded lower relative risks only in groups of higher socioeconomic levels.

The same selective reduction of relative risks was found in another study,[5] confirming the confounding role of socioeconomic status. The relationship between socioeconomic level and breast cancer incidence has been ascribed to differences in reproductive history, including older age at first childbirth and lower number of children among more affluent women.[6,29] As mentioned earlier, however, none of these factors have substantially succeeded in explaining the risk found in other studies for professionals and administrative workers.[4,5,8] An alternative hypothetical explanation may lie in the lack of physical activity involved in most of these occupations. Physical exercise has proved to be protective with respect to breast cancer,[5,28] although this association has not always been found.[30] Finally, a detection bias is possible owing to the reported increased use of mammography concomitant with higher educational attainment.[6] Mammography came into widespread use for population screening around 1985 and would have affected the present study to a small degree. It is still possible, however, that women of higher socioeconomic status are more prone to seek medical care for breast problems.

In spite of the high number of comparisons run in this study, certain results proved consistent, thus reducing their likelihood of being chance findings. Physicians, pharmacists, some teachers in theoretical subjects, schoolmasters, religious workers, and social workers reporting these job codes in both censuses showed an elevated risk relative to other professionals and technicians. The excess risk for teachers is consistent with most,[6,7,9,12,13] but not all,[4] studies on this topic. The same is true for religious and social workers, whose risk has been ascribed to their having no children or low numbers of children.[4,6,9] All of these occupations can be regarded as sedentary, which might account for a portion of the observed risk.[28]

Among health care professionals, physicians in both censuses registered a 55% excess risk relative to other professionals and technicians, while pharmacists recorded a 45% excess risk. The relative risk for dentists was also elevated (23%) but was not significant. In the former Soviet Union, physicians, as a group, were shown to have the highest breast cancer mortality rate,[7] and a Chinese study reported an elevated incidence among female diagnostic x-ray workers.[31] Despite the small numbers exposed, ionizing radiation might be related to the high risk observed in physicians; indeed, physicians are exposed to other established or potential carcinogenic agents,[8] but better detection among this occupational group could also serve to explain their risk. Another study confirmed a moderately increased risk among pharmacists, although this result was not statistically significant.[6] A number of studies have reported an elevated risk of breast cancer among registered nurses.[7,9,10,14] In our analyses, nurses exhibited a significant (17%) excess risk vs the remainder of the female working population, yet no increased risk was found when the comparison group was restricted to other professionals and technicians.

The relative risk of women working as systems analysts and programmers in 1970 was 1.51 with respect to other professionals. The risk for women in this job category in both censuses could not be computed, since the occupation was not included in the Nordic Classification of Occupations in 1960. The risk could hypothetically be related to these women's moderate exposure to electromagnetic fields.[32] The possible link between electromagnetic fields and increased breast cancer incidence has been supported by experimental findings.[33] Whereas some epidemiological studies of occupational exposure to electromagnetic fields and risk of cancer are in agreement with this hypothesis,[8,34,35] others are not.[36,37] In our study, several job categories regarded as involving exposure to electromagnetic fields (e.g., electrical engineers, telephone operators, and telegraph and radio operators) also produced high relative risks. There were too few women in other positions that involve exposure to electromagnetic fields (e.g., electricians, wire and line workers) for any conclusions to be drawn. It is interesting to note that occupational exposure to electromagnetic fields has been rather consistently linked to breast cancer among men in several studies.[38–40]

Most occupations involving administrative, managerial, and clerical tasks did not register an elevated risk in comparison with other jobs in the same group. The 2 exceptions were bank tellers and cost accountants/estimating clerks; both involved significant relative risks for women employed in these occupations in 1960 and 1970. Other studies have consistently reported a higher risk for these occupations but have failed to conduct intragroup comparisons.[4–6,9,12,13,27,28] In one case, the association disappeared after adjustment for education[5]; in other cases, this adjustment failed to reduce the observed risk.[12,27]

In relation to other transport and communication positions, the relative risks found for telephone operators, telegraph and radio operators, and even office telephonists are very consistent, showing a dose–response gradient and yielding an excess risk of more than 30% among women reporting these occupations in both censuses. This result agrees with a mortality-data–based cohort study conducted in the telephone industry in the United States.[11] As mentioned earlier, exposure to electromagnetic fields is among the factors that can give rise to such excess.

Among production workers, only metal platers and coaters exhibited a significant excess risk, even though only 205 women reported this occupation in 1970. Metal plating and coating involves exposure to hexavalent chromium, cadmium, and organic solvents, the first two established carcinogens and the third a suspected carcinogen. On the basis of experimental data, an etiological role for organic solvents in female breast cancer has been hypothesized, although epidemiological evidence is inconclusive.[41] Finally, in the services group, hairdressers and beauticians registered an increased risk with a dose–response gradient. This relationship has been found in some studies[4,8,9] but not in others.[27,42] It has been suggested that cosmeticians may be at increased risk of breast cancer because of occupational exposure to hair dyes,[8,43] but their risk could also be related to other exposures, since most studies have failed to detect any association between self-reported exposure to hair dyes and breast cancer.[43,44]

In summary, this study not only furnishes valuable information on occupational risks for breast cancer in women but also provides leads that merit fuller investigation. Some associations proved to be very stable even when intragroup comparisons were made. Further research is needed to clarify the accuracy of and reasons for these findings. □

Contributors

M. Pollán conducted data analysis and P. Gustavsson assisted with data interpretation. Both authors contributed to the writing of the paper.

Acknowledgments

Dr Pollán'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).

We thank the Center for Epidemiology of the National Board of Health and Welfare for making the database available for researchers, and we thank occupational hygienists Nils Plato and Gun Nise for valuable information and discussions regarding occupational exposures among Swedish women.

References

1. Henderson BE, Pike MC, Bernstein L, Ross RK. Breast cancer. In: Schottenfeld D, Fraumeni JF Jr, eds. *Cancer Epidemiology and Prevention*. 2nd ed. Oxford, England: Oxford University Press; 1996:1022–1039.
2. Madigan MP, Ziegler RG, Benichou J, Byrne C, Hoover RN. Proportion of breast cancer cases in the United States explained by well-established risk factors. *J Natl Cancer Inst*. 1995; 87:1681–1685.

3. Kelsey JL. Breast cancer epidemiology: summary and future directions. *Epidemiol Rev.* 1993;15:256–263.
4. Coogan PF, Clapp RW, Newcomb PA, et al. Variation in female breast cancer risk by occupation. *Am J Ind Med.* 1996;30:430–437.
5. Barbone F, Filiberti R, Franceschi S, et al. Socioeconomic status, migration and the risk of breast cancer in Italy. *Int J Epidemiol.* 1996; 25:479–487.
6. Rubin CH, Burnett CA, Halperin WE, Seligman PJ. Occupation as a risk identifier for breast cancer. *Am J Public Health.* 1993;83: 1311–1315.
7. Bulbulyan M, Zahm SH, Zaridze DG. Occupational cancer mortality among urban women in the former USSR. *Cancer Causes Control.* 1992;3:299–307.
8. Habel LA, Stanford JL, Vaughan TL, et al. Occupation and breast cancer risk in middle-aged women. *J Occup Environ Med.* 1995;37:349–356.
9. Morton WE. Major differences in breast cancer risks among occupations. *J Occup Environ Med.* 1995;37:328–335.
10. Gunnarsdóttir H, Rafnsson V. Cancer incidence among Icelandic nurses. *J Occup Environ Med.* 1995;37:307–312.
11. Dosemeci M, Blair A. Occupational cancer mortality among women employed in the telephone industry. *J Occup Environ Med.* 1994;36: 1204–1209.
12. 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; 59:1147–1185.
13. Costantini AS, Pirastu R, Lagorio S, Miligi L, Costa G. Studying cancer among female workers: methods and preliminary results from a record-linkage system in Italy. *J Occup Med.* 1994;36:1180–1186.
14. Sankila R, Karjalainen S, Laara D, Pukkala E, Teppo L. Cancer risk among health care personnel in Finland, 1971–1980. *Scand J Work Environ Health.* 1990;16:252–257.
15. Mattsson B. *Cancer Registration in Sweden* [thesis]. Stockholm, Sweden: Karolinska Institute; 1984.
16. *Cancer Incidence in Sweden 1993.* Stockholm, Sweden: Center for Epidemiology, Swedish National Board of Health and Welfare; 1996.
17. *Statistical Yearbook 1981.* Stockholm, Sweden: Statistics Sweden; 1981.
18. *Statistical Yearbook 1982/83.* Stockholm, Sweden: Statistics Sweden; 1983.
19. *Statistical Yearbook 1991.* Stockholm, Sweden: Statistics Sweden; 1991.
20. *Cancer-Miljöregistret 1960–70* [in Swedish]. Stockholm, Sweden: Center for Epidemiology, Swedish National Board of Health and Welfare; 1994.
21. Breslow NE, Day NE. *Statistical Methods in Cancer Research, Volume II: The Analysis of Cohort Studies.* Lyon, France: International Agency for Research on Cancer; 1987. IARC scientific publication 82.
22. Day NE. Cumulative rate and cumulative risk. In: Parkin DM, Muir CS, Whelan SL, Gao YT, Ferlay J, Powell J, eds. *Cancer Incidence in Five Continents.* Lyon, France: International Agency for Research on Cancer; 1992:862–864. IARC scientific publication 120.
23. Bithell JF, Dutton SJ, Neary NM, Vincent TJ. Controlling for socioeconomic confounding using regression methods. *J Epidemiol Community Health.* 1995;49(suppl 2):S15–S19.
24. Doll R. Urban and rural factors in the aetiology of cancer. *Int J Cancer.* 1991;47:803–810.
25. Doody MM, Mandel JS, Boice JD Jr. Employment practices and breast cancer among radiologic technologists. *J Occup Environ Med.* 1995;37:321–327.
26. Van Loon AJM, Burg J, Goldbohm A, van den Brandt PA. Differences in cancer incidence and mortality among socioeconomic groups. *Scand J Soc Med.* 1995;2:110–120.
27. Ewertz M. Risk of breast cancer in relation to social factors in Denmark. *Acta Oncol.* 1988; 23:787–792.
28. Zheng W, Shu XO, McLaughlin JK, Chow WH, Go YT, Blot WJ. Occupational physical activity and the incidence of cancer of the breast, corpus uteri and ovary in Shanghai. *Cancer.* 1993; 71:3620–3624.
29. Threlfall WJ, Gallagher RP, Spinelli JJ, Band PR. Reproductive variables as possible confounders in occupational studies of breast and ovarian cancer in females. *J Occup Med.* 1985; 27:448–450.
30. Dorgan JF, Brown C, Barrett M, et al. Physical activity and risk of breast cancer in the Framingham Heart Study. *Am J Epidemiol.* 1994; 139:662–669.
31. Wang J-X, Inskip PD, Boice JD Jr, Li B-X, Zhang J-Y, Fraumeni JF Jr. Cancer incidence among medical diagnostic x-ray workers in China, 1950 to 1985. *Int J Cancer.* 1990;45: 889–895.
32. Floderus B, Persson T, Stenlund C. Magnetic field exposures in the workplace: reference distribution and exposures in occupational groups. *Int J Occup Environ Health.* 1996;2: 226–238.
33. Preston-Martin S. Breast cancer and magnetic fields [editorial]. *Epidemiology.* 1996;7: 457–458.
34. Loomis DP, Savitz DA, Ananth CV. Breast cancer mortality among female electrical workers in the United States. *J Natl Cancer Inst.* 1994; 86:921–925.
35. Coogan PF, Clapp RW, Newcomb PA, et al. Occupational exposure to 60-hertz magnetic fields and risk of breast cancer in women. *Epidemiology.* 1996;7:459–464.
36. Guenel P, Rakmark P, Andersen JB, Lynge E. Incidence of cancer in persons with occupational exposure to electromagnetic fields in Denmark. *Br J Ind Med.* 1993;50:758–764.
37. Hardell L, Holmberg B, Malker H, Paulsson L-E. Exposure to extremely low frequency electromagnetic fields and the risk of malignant diseases—an evaluation of epidemiological and experimental findings. *Eur J Cancer Prev.* 1995;4(suppl 1):3–107.
38. Demers PA, Thomas DB, Rosenblatt KA, et al. Occupational exposure to electromagnetic fields and breast cancer in men. *Am J Epidemiol.* 1990;132:775–776.
39. Tynes T, Andersen A. Electromagnetic fields and male breast cancer. *Lancet.* 1990;1:1596.
40. Matanoski GM, Breysse PN, Elliott EA. Electromagnetic field exposure and male breast cancer. *Lancet.* 1991;1:737.
41. Labrèche FP, Goldberg MS. Exposure to organic solvents and breast cancer in women: a hypothesis. *Am J Ind Med.* 1997;32:1–14.
42. Kono S, Tokudome S, Ideda M, Yoshimura T, Kuratsune M. Cancer and other causes of death among female beauticians. *J Natl Cancer Inst.* 1983;70:443–446.
43. John EM, Kelsey J. Radiation and other environmental exposures and breast cancer. *Epidemiol Rev.* 1993;15:157–162.
44. La Vecchia C, Tavani A. Epidemiological evidence on hair dyes and the risk of cancer in humans. *Eur J Cancer Prev.* 1995;4:31–43.