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Occupational exposure to magnetic fields in relation to male breast cancer and testicular cancer: a Swedish case-control study

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Occupational exposure to extremely low-frequency magnetic fields (MF) was studied in 56 male subjects with breast cancer (adenocarcinoma) diagnosed in 1985-91, and 144 subjects with testicular cancer (seminoma and non-seminoma), diagnosed in 1985-87. The cases were compared with 1,121 control subjects from a previous case-control study on MF and cancer. Exposure assessment was based on the job held longest during the decade before diagnosis linked to a job exposure matrix based on MF measurements. The results refer to an estimated average mean of > 0.28 μT (Q4) and > 0.40 μT (P90, part of Q4) with ≤ 0.15 μT (Q1) as reference. For breast cancer, the odds ratios (OR) and the 95 percent confidence intervals (CI) were 0.7 (CI = 0.3-1.9) and 0.7 (CI = 0.2-2.3), respectively. For men 60 years or younger, the corresponding estimates were OR = 0.9 (CI = 0.2-4.5) and 1.5 (CI = 0.3-8.3). For testicular cancer, the ORs were 1.3 (CI = 0.7-2.5) and 2.1 (CI = 1.0-4.3), and for men 40 years or younger the ORs were 1.9 (CI = 0.8-4.4) and 3.9 (CI = 1.4-11.2). The results were mainly attributable to non-seminoma, the more malignant type of testicular cancer. Our conclusion is that the results for male breast cancer, based on limited numbers, fail to support the suggested association with MF exposure. The results for testicular cancer gave some support to the hypothesis of a hormonal link between MFs and cancer, and should be further explored. *Cancer Causes and Control* 1997, 8, 184-191

Key words: Magnetic fields, male breast cancer, non-seminoma, seminoma, Sweden, testicular cancer.

Introduction

Male breast cancer and testicular cancer are both rare diseases, but they differ markedly concerning age distribution and rate of occurrence over time. Breast cancer affects mostly men above 40 years of age. In 1991, the annual incidence in Sweden was 0.4 per 100,000 (standardized to the world population), and it has been nearly constant during the last three decades. For testicular cancer, the corresponding incidence was 5.2, and the disease affects preferably men under the age of 40 years. Since the late 1960s, a twofold increase in incidence has been

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reported in Sweden. Similar increases have been reported in other populations.[1-5] Little is known about the etiology of both male breast cancer and testicular cancer but epidemiologic studies have suggested a hormonal dysfunction as well as environmental factors.

A family history of breast cancer increases the risk of the disease not only in women but also in men. This has been shown in some case-control studies[6-9] with odds ratios (OR) of 1.9-6.7.

Cryptorchidism (undescended testis) in early childhood is an established risk factor for testicular cancer[1,4,5,10-13] (with relative risks [RR] about two to four, consistently) and cryptorchidism has also been suggested to be a risk factor for breast cancer in men.[6,14]

Since the first report in 1991[15] of an association between occupational MF exposure and male breast cancer, some studies,[16-20] but not all[21,22] have lent support to the possibility of an association. Elevated risk estimates often have been confined to younger ages.[15,18] Studies on MFs and testicular cancer are scarce, with no support for an association.[17,23] In an analysis on registry data,[24] we observed an association between MF exposure and testicular cancer, particularly for younger ages. This outcome caused us to investigate this type of cancer further.

The aim of this study was to examine the relationship between occupational exposure to magnetic fields and male breast cancer and testicular cancer.

Materials and methods

The study is an extension of a previous case-control study on leukemia and brain tumors.[25] In principle, the same methodology has been used and cases of male breast cancer and testicular cancer are compared with the former control group. Cases and controls are men, 20 to 64 years of age in 1980. The cases were diagnosed before age 70 years.

Cases

Breast cancer. Due to the low incidence rate of breast cancer in men, all cases of breast adenocarcinoma (ICD-7[26] code 170), occurring in the whole of Sweden during 1985-91, were selected from the Cancer Register. We obtained 92 persons eligible for the study.

Testicular cancer. All cases of testicular cancer (ICD-7 code 178), involving the two histologic groups, seminoma and non-seminoma, occurring in 11 counties of the middle of Sweden during 1985-87, were selected from the Cancer Register. Altogether, we obtained 214 eligible subjects, 133 seminoma and 81 non-seminoma.

Controls

The control subjects were selected randomly from the Census of 1980 and matched by age – two controls for each of the former cases diagnosed during 1983-87. In all, 1,700 controls were selected from 11 counties of the middle of Sweden, representing one-half of the male working population. Only those who were alive at the time of the investigation (1,561) were included in the study.

Participation

According to the regulations of the Cancer Register, we had to obtain permission from the responsible physicians of the clinics to contact the patients, or, if deceased, their close relatives. Nearby 100 clinics were contacted. Fifteen cases with breast cancer were excluded because of the following: (i) being outside the target diagnosis; (ii) either no permission to contact or the hospital records were untraceable; (iii) a close relative was not available. The corresponding number for testicular cancer was 29. The target number of subjects left for the study was 77 cases of breast cancer and 185 cases of testicular cancer (Table 1).

A questionnaire was sent to the subjects or to their close relatives, and 63 subjects (81.8 percent) with breast

Table 1. Study groups and participation; Swedish occupational magnetic-field study on male breast cancer, 1985-91, and testicular cancer, 1985-87

	Male breast cancer		Testicular cancer		Controls	
	No.	%	No.	%	No.	%
Cancer Register and Census, 1980	92	100.0	214	100.0	1,700	100.0
Outside the target diagnoses	2	2.2	3	1.4	—	—
No permission to contact, or hospital records untraceable	7	7.6	18	8.4	—	—
No close relative	6	6.5	8	3.7	(139 deaths)	
Target number for questionnaire	77	100.0	185	100.0	1,561	100.0
Close relatives	13	16.9	12	6.5	—	—
Participation	63	81.8	144	77.8	1,121	71.8

Table 2. Number of subjects by diagnoses and age; Swedish occupational magnetic-field study on male breast cancer, 1985-91, and testicular cancer, 1985-87

	Age at diagnosis (yrs)					
	Total	**≤ 30**	**31-40**	**41-50**	**51-60**	**> 60**
Breast cancer	63	0	1	7	19	36
Testicular cancer						
Seminoma	94	9	44	26	12	3
Non-seminoma	50	19	24	6	1	0
Controls	1,121	36	121	208	324	432

cancer and 144 subjects (77.8 percent) with testicular cancer responded to the questionnaire. The corresponding figure for the control group was 1,121 (71.8 percent) (Table 1). The age distributions of the participants are shown in Table 2.

Exposure assessment

Questionnaire. The questionnaire covered the subject's work history, occupational factors (solvents, oil products, pesticides), smoking habits, and other factors outside work.

Each occupation, held longer than one year, was coded according to the Nordic version of the International Standard Classification of Occupations (ILO:ISCO 1958), as it was used in the Census of 1980.

Job exposure matrix and complementary measurements. In the analyses, we considered only the job held longest during the 10-year period before diagnosis. The jobs were linked to job values based on MF measurements obtained in the previous case-control study. The principles of the measurements have been described elsewhere.[25,27]

To follow the same criteria that we have used previously, 15 new measurements had to be done. Six of the target subjects were still working at the same workplace; for the other nine, we had to use a surrogate person, and for six of them even a surrogate workplace. The additional measurements were performed during May through September 1995.

In order to facilitate comparisons between the former and the present study, the same MF measures have been analyzed. For each occupation, the arithmetic mean across subjects within the job was computed for the different measures (workday mean, median, standard deviation, and proportion of time exceeding 0.20 μT). All individuals within an occupation were given the same job value.

For the 100 most common jobs in Sweden, the job exposure matrix (JEM) has been published.[27]

Exposure classification. A quartile determination (Q1-Q4) was obtained through a frequency analysis of the job values of the control subjects. The first quartile was used as the reference. For the median, the second quartile encompassed only 0.019 μT units, and therefore, the first and second quartiles were used together as the reference. In order to evaluate further exposure response relationships, one more exposure category was added, *i.e.*, the group above the 90th percentile (P90).

Those who were unemployed (retired or studying) most of the time 10 years before the diagnosis were excluded from the analyses.

Confounding and effect modification

Age. Age adjustment was based on five-year intervals. To test the hypothesized effect modification by age, we stratified data for breast and testicular cancer at the cut-points of 60 and 40 years, respectively.

Education. As a surrogate for social class, we used information about education. At least 12 years of theoretical education was classified as 'high' educational level; less than 12 years was considered 'low.'

Solvents. We used three categories of solvent exposure, based on data from workplace interviews.[25] If no one within an occupation claimed that solvents were used, the job was labeled 'no solvents.' If more than 50 percent of the workers claimed that solvents were used, the job was placed in the category of 'probably solvents.' All other jobs were categorized as 'possibly solvents.'

A family history of breast cancer. For the controls, data on familial breast cancer was not available. Six persons (9.4 percent) with breast cancer reported an affected mother; two (3.2 percent), an affected father; and 11 (17.5 percent) reported an affected sister. Ten persons (7.0 percent) with testicular cancer reported an affected mother, and one (0.7 percent) reported an affected sister.

A history of cryptorchidism. The prevalence of cryptorchidism in early childhood was not requested either in our previous study. Three persons (4.8 percent) with breast cancer and 25 (17.9 percent) with testicular cancer reported cryptorchidism as a child.

Statistical methods

The relative risk (RR) was calculated as the odds ratio (OR), with the corresponding 95 percent confidence interval (CI).[28] Logistic regression was used adjusting for age only, and subsequently for age, education, and solvents. Solvent exposure then was treated as a dichotomy (no solvents and possibly solvents taken together). The RR estimates for both models are presented in the tables to illustrate the influence/lack of influence from education and solvents. Discrepancies among tables regarding the number of subjects are explained by internal non-response. In the evaluation of the P90 exposure group, Q4 was split into P90 and Q4 excluding P90, otherwise the entire Q4 was entered into the model.

Tests for trend (not shown in tables) were done by estimating the linear increase in risk across quartiles, with four levels of exposure (values one through four) entered into the regression as a continuous variable.

Results

Breast cancer

Exposure based on mean values showed slightly elevated ORs in the two lowest exposure categories, and no association for exposures above 0.28 μT (Table 3). A similar tendency was seen for the median analysis. The elevated ORs were confined to cases 60 years or younger. Of the three exposed cases in the mean P90 group, there was one railroad conductor/traffic controller, one welder, and one furnace operator.

The results were not compatible with any linear increase in risk across quartiles. For subjects 60 years or younger, OR = 1.0 (CI = 0.7-1.5), based on mean values and median values as well.

Neither standard deviation nor time above 0.20 μT showed any significance for the disease (not shown).

Testicular cancer

For exposure based on mean values, there was a tendency of an elevated OR for all quartile levels, with the highest OR on the P90-level (Table 4). Analyses of the median showed a tendency of an increase in risk with increasing exposure. Time above 0.20 μT showed an equal OR for the P90 group as was seen for the median, and exposure based on the standard deviation gave risk estimates close to unity (not shown).

The age-specific analyses, showed that the increase in risk was attributable to subjects 40 years or younger (Table 4). The results based on mean values showed about a fourfold increase in risk for subjects in the highest exposure group (P90). Among the 14 exposed cases, there were three forestry and logging workers; two postmen and sorting clerks; four building caretakers; and one of each of the following occupations: shop manager, furnace operator, fine mechanics, blacksmith, and sheet- and coarse metal worker. The results based on median values were in accordance with an exposure-response relationship with an OR of 2.8 (CI = 1.1-6.9) for the P90-group. The test for trend gave OR = 1.2 (CI = 1.0-1.6) for both the mean and the median analyses.

The effect modification by age was mainly dependent on the non-seminoma cases (Table 4). The overall high OR for mean MF exposure are due partly to the low number of cases in the reference group. The results based on median values, however, indicate an exposure-

Table 3. Odds ratio (OR) of male breast cancer ($n = 56$) by magnetic field (MF) exposure; job held longest during the 10 years before diagnosis, Swedish occupational MF study on male breast cancer, 1985-91

Estimate of average daily exposure	Q1[a]		Q2		Q3		Q4		P90	
	Ref. OR	No.[b]	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.
Mean	≤ 0.15 μT		0.16-0.19 μT		0.20-0.28 μT		≥ 0.29 μT		≥ 0.41 μT	
All breast cancer[d]	1.0	11/258	1.3 (0.6-2.9)	17/285	1.3 (0.6-2.9)	17/273	0.9 (0.4-2.2)	11/282	0.9 (0.3-2.7)	4/107
All breast cancer[e]	1.0	11/247	1.2 (0.6-2.7)	17/280	1.3 (0.6-2.8)	17/272	0.7 (0.3-1.9)	11/278	0.7 (0.2-2.3)	4/106
≤ 60 years[e]	1.0	3/161	2.9 (0.7-11.1)	9/166	2.5 (0.6-9.5)	8/156	0.9 (0.2-4.5)	5/187	1.5 (0.3-8.3)	3/68
Median	≤ 0.11 μT				0.12-0.16 μT		≥ 0.17 μT		≥ 0.20 μT	
All breast cancer[d]	1.0	26/552			1.7 (0.9-3.1)	22/284	0.6 (0.3-1.4)	8/262	0.8 (0.3-2.4)	4/101
All breast cancer[e]	1.0	26/536			1.7 (0.9-3.1)	22/280	0.6 (0.3-1.4)	8/261	0.8 (0.3-2.4)	4/100
≤ 60 years[e]	1.0	10/325			2.2 (0.8-5.7)	11/181	0.7 (0.2-2.4)	4/164	0.9 (0.2-4.2)	2/62

[a] Quartiles. P90 is 90th percentile, part of Q4. Q1+Q2 for median reference.
[b] No. of cases/controls.
[c] CI = 95% confidence interval.
[d] Adjusted for age.
[e] Adjusted for age, education, and solvents.

Table 4. Odds ratio (OR) of testicular cancer ($n = 134$) by magnetic field (MF) exposure; job held longest during the 10 years before diagnosis, Swedish occupational MF study on testicular cancer, 1985-87

Estimate of average daily exposure	Q1[a]		Q2		Q3		Q4		P90	
	Ref. OR	No.[b]	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.
Mean	≤ 0.15 μT		0.16-0.19 μT		0.20-0.28 μT		≥ 0.29 μT		≥ 0.41 μT	
All testicular cancer[d]	1.0	25/258	1.5 (0.8-2.6)	36/285	1.5 (0.8-2.8)	28/273	1.5 (0.8-2.6)	45/282	2.1 (1.0-4.3)	18/107
All testicular cancer[e]	1.0	25/247	1.3 (0.7-2.4)	36/280	1.4 (0.8-2.7)	28/272	1.3 (0.7-2.5)	45/278	2.1 (1.0-4.3)	18/106
All testicular cancer ≤ 40 yrs[e]	1.0	13/41	1.7 (0.8-4.0)	22/39	2.3 (1.0-5.7)	17/23	1.9 (0.8-4.4)	34/49	3.9 (1.4-11.2)	14/10
Seminoma ≤ 40 yrs[e]	1.0	11/41	0.9 (0.3-2.4)	11/39	1.5 (0.5-4.0)	10/23	0.9 (0.3-2.4)	16/49	1.8 (0.5-6.4)	7/10
Non-seminoma ≤ 40 yrs[e]	1.0	2/41	7.1 (1.4-35.6)	11/39	7.1 (1.3-38.1)	7/23	8.1 (1.7-39.4)	18/49	16.1 (2.7-94.5)	7/10
Median	≤ 0.11 μT				0.12-0.16 μT		≥ 0.17 μT		≥ 0.20 μT	
All testicular cancer[d]	1.0	64/552			1.1 (0.7-1.7)	34/284	1.3 (0.8-2.2)	36/262	1.4 (0.7-2.8)	16/101
All testicular cancer[e]	1.0	64/536			0.9 (0.5-1.5)	34/280	1.3 (0.8-2.1)	36/261	1.4 (0.7-2.7)	16/100
All testicular cancer ≤ 40 yrs[e]	1.0	41/85			0.8 (0.4-1.8)	20/36	1.8 (0.9-3.4)	25/31	2.8 (1.1-6.9)	14/10
Seminoma ≤ 40 yrs[e]	1.0	27/85			0.6 (0.2-1.5)	10/36	1.1 (0.5-2.5)	11/31	1.5 (0.5-5.0)	5/10
Non-seminoma ≤ 40 yrs[e]	1.0	14/85			1.3 (0.4-4.1)	10/36	2.9 (1.2-7.0)	14/31	4.6 (1.5-13.6)	9/10

[a] Quartiles. P90 is 90th percentile, part of Q4. Q1+Q2 for median reference.
[b] No. of cases/controls.
[c] CI = 95% confidence interval.
[d] Adjusted for age.
[e] Adjusted for age, education, and solvents.

response pattern with ORs of 1.3 (CI = 0.4-4.1) in Q3 and 2.9 (CI = 1.2-7.0) in Q4. For the P90 group, the OR was 4.6 (CI = 1.5-13.6). For all non-seminoma, the average increase in risk by quartiles was 50 to 70 percent; ORs were 1.5 (CI = 1.1-2.1) and 1.7 (CI = 1.2-2.3), based on mean and median values, respectively.

In the analyses of a possible interaction between MF exposure and solvents, the numbers were limited, but the highest risk estimate was observed for subjects probably exposed to both solvents and high MFs, based on mean values (OR = 3.8; CI = 1.1-13.1) (Table 5).

Discussion

In the present study, the control group from a previous study was used, and two new case groups were added. As far as possible, the same protocol that was used previously has been applied to the new study. Still, the procedure may have entailed methodologic shortcomings.

The data collection of controls and cases were carried out during different time periods, 1988-91 *cf* 1994-95. In the meantime, the question of a relationship between MF and cancer was debated in the community, and the awareness of a potential risk could give rise to recall bias and to differential nonresponse. In order to evaluate the potential problems, we utilized the information on occupation recorded at the 1980 Census, linked with the JEM, to get an estimate unaffected by any recall bias for comparison.

The study participants as well as the entire target group of cases were analyzed. Results including nonparticipants were consistent with the results for participants only, arguing against a differential nonresponse. On the other hand, the levels of the ORs clearly were reduced for all testicular cancer, but still elevated (while the figures for breast cancer were somewhat higher). Registry-based cohort results often seem to be weaker compared with corresponding results from case-control studies,[25,29] and this may be due to recall bias in case-control studies. However, a more plausible explanation is that the data obtained from case-control studies often are more valid and better synchronized to the time of observation targeted. In this analysis, the census data reflect the occupation held during one particular week, and the information from census data is more fragmentary than that obtained from the study questionnaires.

The coding of occupations of cases was done by two persons independently, one of whom was ignorant about the case-status and ignorant about the JEM. When there was disagreement (18 out of 207 cases), the code entailing the lowest MF exposure was chosen.

MFs are extremely variable, with a strong dependence on distance to the source and specific characteristics of the source, and this certainly means difficulties to obtain a precise exposure assessment. An exposure classification based on job values is likewise a rough estimate for the individual's exposure, but, above all, this misclassification should be nondifferential, driving the RRs toward unity.

Breast cancer cases were not selected from the same study base as that defined for the control subjects. In all, 28 (44 percent) of the cases were from the same geographic

Table 5. Age-adjusted odds ratio (OR) of male breast cancer and testicular cancer by magnetic field (MF) and solvents exposure; job held longest during the 10 years before diagnosis, Swedish occupational MF study on male breast cancer, 1985-91 and testicular cancer, 1985-87

Estimate of average daily exposure	Q1[a]		Q2		Q3		Q4		P90	
	OR (CI)[c]	No.b	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.	OR (CI)[c]	No.
Mean	≤ 0.15 μT		0.16-0.19 μT		0.20-0.28 μT		≥ 0.29 μT		≥ 0.41 μT	
All breast cancer										
No solvents	1.0 —	5/79	1.0 (0.3-2.9)	10/153	1.1 (0.3-3.6)	6/78	0.4 (0.1-2.3)	2/74	0.7 (0.1-5.9)	1/25
Possibly solvents	0.4 (0.1-1.4)	4/169	0.9 (0.3-3.0)	6/101	0.7 (0.2-2.1)	9/184	0.6 (0.2-2.5)	4/100	0.7 (0.1-3.7)	2/49
Probably solvents	2.8 (0.5-16.9)	2/10	0.5 (0.1-4.5)	1/31	3.3 (0.5-19.9)	2/11	0.7 (0.2-2.6)	5/108	0.4 (0.04-3.4)	1/33
All testicular cancer										
No solvents	1.0 —	9/79	1.1 (0.4-2.8)	13/153	2.3 (0.8-6.2)	12/78	1.3 (0.5-3.7)	10/74	1.8 (0.4-7.6)	4/25
Possibly solvents	1.0 (0.4-2.6)	16/169	1.7 (0.7-4.6)	14/101	1.2 (0.5-3.2)	14/184	1.4 (0.6-3.8)	14/100	1.5 (0.5-4.8)	7/49
Probably solvents	(no cancers)	—	2.4 (0.8-7.7)	9/31	1.0 (0.2-6.7)	2/11	1.6 (0.6-4.0)	21/108	3.8 (1.1 -13.1)	7/33
Median	≤ 0.11 μT				0.12-0.16 μT		≥ 0.17 μT		≥ 0.20 μT	
All breast cancer										
No solvents	1.0 —	9/154			1.2 (0.5-3.1)	11/140	0.5 (0.1-2.0)	3/90	0.5 (0.1-2.6)	2/66
Possibly solvents	0.7 (0.3-1.6)	14/336			1.5 (0.5-4.4)	6/63	0.3 (0.1-1.2)	3/135	(no cancers)	—
Probably solvents	0.7 (0.2-2.7)	3/62			1.2 (0.4-3.8)	5/81	1.8 (0.4-9.4)	2/17	2.5 (0.5-13.1)	2/15
All testicular cancer										
No solvents	1.0 —	17/154			1.4 (0.6-3.2)	12/140	1.7 (0.7-4.0)	15/90	1.8 (0.7-4.5)	11/66
Possibly solvents	1.1 (0.6-2.1)	34/336			1.8 (0.7-5.0)	7/63	1.5 (0.7-3.2)	17/155	0.7 (0.1-6.7)	1/20
Probably solvents	2.8 (1.1-7.1)	13/62			1.0 (0.4-2.3)	15/81	2.4 (0.6-10.2)	4/17	2.5 (0.6-10.6)	4/15

[a] Quartiles. P90 is 90th percentile, part of Q4. Q1+Q2 for median reference.
[b] No. of cases/controls.
[c] CI = 95% confidence interval.

area as the control subjects. When we used only these cases, the results were unchanged, but less precise.

An increase in risk of male breast cancer has been observed for persons working as furnace operators and as foundry- or steel workers.[21,30,31] Among our breast cancer cases, one furnace operator was observed. The MF exposure for this individual was 6.6 μT (daily mean). The job value for furnace operators was 10.1 μT.

The outcome on breast cancer failed to support the results from some previous studies, suggesting an association,[15-20] but it should be kept in mind that our study suffers from having few cases. In the study by Demers and co workers[16] comprising 227 cases, an OR of 1.8 (CI = 1.0-3.7) was found for all 'electrical' occupations, mainly attributable to young men exposed at least 30 years prior to the diagnosis. Less attention has been paid to female breast cancer in relation to occupational MF exposure. So far, the results have been inconsistent.[19,32,33]

An association was found between MF exposure and testicular cancer. The result was confined to subjects 40 years or younger, and this meant non-seminoma in particular. The occurrence of non-seminoma is about 10 years earlier than seminoma. It could be possible that a sensitivity to MFs in young adults might give rise to an earlier diagnosis. It should be noted that the importance of young age also was observed for brain tumors in our previous study[25] (OR = 3.9, CI = 1.4-10.7 for the P90 group). In a study of electric blankets, Verrault *et al*,[34] observed an RR of 1.4 (CI = 0.9-2.3) for non-seminoma, while the RR was 0.7 (CI = 0.5-1.2) for seminoma cases. Registry studies from Norway[17] and New Zealand[23] did not observe increased risks for 'electrical' occupations, while a Swedish registry study,[24] linking occupations to the same JEM as we used here, found an excess risk for testicular cancer. These cases (diagnosed between 1971-84) did not overlap with those of the present study. Further, an elevated risk has been reported for electricians by Van Den Eeden *et al*,[35] with an RR of 2.8 (CI = 1.2-6.4).

White-collar or professional occupations have been associated with an elevated risk of testicular cancer,[2,35-37] with ORs in the order of 1.3-6.0. On the other hand, some blue-collar occupations entailing high MF exposure[27] also have shown increased RRs for testicular cancer, for example, motor vehicle mechanics,[2,38] precision metal workers,[35] and metal-product manufacturing workers.[35]

Exposures to pesticides, different kinds of oil products, and solvents have been discussed in relation to male breast cancer as well as testicular cancer. Just a few cases were exposed to pesticides in our study, and oil products were more prevalent among the control subjects. Hence, their

importance as potential confounders must be negligible. We found a weak indication of an interaction between MF exposure and solvents for subjects with testicular cancer probably exposed to solvents and high MFs as well.

The hypothesis that heat exposure causes testicular insufficiency and hormonal changes that could lead to both male breast cancer and testicular cancer has been proposed by several researchers.[8,21,30,39,40] Heat exposure was not possible to control for in this study, and a potential confounding effect remains to be evaluated.

Cryptorchidism is found in approximately 10 percent of testicular cancer cases.[4] The prevalence was higher in our subjects, with 18.5 percent among seminoma and 16.7 percent among non-seminoma cases (4.8 percent among breast cancer cases). The study results did not change when cryptorchidism cases were removed from the analyses.

It has been suggested that MF exposure may cause a reduced circulating concentration of melatonin which could lead to an increased prolactin release by the pituitary gland and increased estrogen and testosterone release by the gonads,[41] which, in turn, could contribute to the development of breast and testicular cancer.[42] Our results give some support to the hypothesis that MF exposure is a contributory factor in the development of hormone-sensitive cancers, based on the findings for testicular cancer. Regarding breast cancer, the outcome does not support the hypothesis, although the possibility of an association cannot be rejected due to the limited numbers and limitations regarding the exposure assessment.

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