A Population-Based Cohort Study of Occupational Exposure to Magnetic Fields and Cardiovascular Disease Mortality

ANNA R. COOPER, MPH, EDWIN VAN WIJNGAARDEN, PHD, SUSAN G. FISHER, PHD, M. JACOB ADAMS, MD, MPH, MICHAEL G. YOST, PHD, AND JOSEPH D. BOWMAN, PHD

PURPOSE: This cohort study aims to examine cardiovascular disease (CVD) mortality risks among workers in occupations potentially exposed to magnetic fields (MF).
METHODS: Risks for major CVD mortality by potential job-related MF exposure were examined in a sample of U.S. workers from the National Longitudinal Mortality Study using multivariate proportional hazards models.
RESULTS: After adjustment for demographic factors, there were no significant excess risks between individuals with medium (0.15 to <0.20 μT), high (0.20 to <0.30 μT), or very high (⩾0.30 μT) exposure levels as compared with individuals with background exposure levels of MF (<0.15 μT) for the CVD mortality outcomes. Indirect adjustment for potential confounding by current smoking prevalence did not change the pattern of these results.
CONCLUSION: Our study does not provide evidence for an association between occupational MF exposure and CVD mortality risk.
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KEY WORDS: Magnetic Fields, Occupational Exposure, Cardiovascular Disease, Mortality, Cohort Study.

INTRODUCTION

During the past decade, exposure to magnetic fields (MF) has been evaluated as a risk factor for cardiovascular disease (CVD) in several cohort and case-control studies. Among the first of these studies, Savitz and colleagues (1), in a large cohort of electric utility workers, reported an increased risk of acute myocardial infarction (AMI) (relative risk [RR] = 1.5; 95% confidence interval [CI] = 1.4–1.7) and arrhythmia-related mortality (RR = 3.3; 95% CI = 1.8–5.9) in the highest exposure category after controlling for the effects of age, calendar year, race, social class, and work status. Subsequent studies have attempted to reproduce this finding but without success. This inconsistency has been attributed to potential confounding and other biases (2–5).

The majority of studies investigated industry-based cohorts and thus had limited ability to adjust for potentially important demographic factors and CVD risk factors such as cigarette smoking. Furthermore, the findings from these investigations may not be appropriate for broader, nonindustry, populations. To address these limitations, we evaluated the hypothesis that occupational exposure to MF is associated with CVD-related mortality risk in a population representative of the general U.S. population, and with more information on potentially important confounders. Secondarily, we evaluated the extent of confounding by cigarette smoking using indirect methods.

METHODS

Study Population

The current study examined the association between occupational MF exposure and CVD mortality using the National Longitudinal Mortality Study (NLMS). The NLMS is a prospective cohort study of mortality among a national sample of the noninstitutionalized U.S. population identified from the Current Population Survey (CPS) of the Bureau of Census in March 1979, April 1980, August 1980, December 1980, and March 1981. For confidentiality reasons, a representative subset of 5 of the original 12 CPS cohorts is available for public use. The available data do not include any personal identifiers, geographic references, specific NLMS cohort references, or identifiable time components. The current study was limited to individuals (n = 307,012) for whom occupational codes were available that allowed us to estimate potential occupational exposure to MF. Unemployed and retired individuals were excluded from the analysis as described in a previous study (6).

From the Department of Community and Preventive Medicine, University of Rochester School of Medicine and Dentistry, New York (A.R.C., E.V.W., S.G.F., J.A.); Department of Environmental and Occupational Health Sciences, School of Public Health and Community Medicine, University of Washington, Seattle (M.G.Y.); and Engineering and Physical Hazards Branch, National Institute for Occupational Safety and Health, Cincinnati, Ohio (J.D.B.).
Address correspondence to: Edwin van Wijngaarden, PhD, Department of Community and Preventive Medicine, University of Rochester School of Medicine and Dentistry, 601 Elmwood Avenue, Box 644, Rochester, NY 14642. Tel.: 585-275-1985; fax: 585-461-4532. E-mail: edwin_van_wijngaarden@urmc.rochester.edu.
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Selected Abbreviations and Acronyms

AMI = acute myocardial infarction
BOC = Bureau of Census
CI = confidence interval
CPS = Current Population Survey
CVD = cardiovascular disease
ELF = extremely-low frequency
HWE = healthy worker effect
HR = hazard ratio
ICD = International Classification of Diseases
JEM = job-exposure matrix
MF = magnetic fields
NDI = National Death Index
NHIS = National Health Interview Survey
NLMS = National Longitudinal Mortality Study
RR = relative risk
TWA = time-weighted average

Exposure Assessment

Job titles in the NLMS were classified according to 1970 Bureau of Census (BOC) occupational codes. To determine potential MF exposure for each job reported in the NLMS, we first converted the 1970 BOC occupational codes to 1980 BOC occupational codes. Subsequently, these 1980 BOC codes were linked with a job-exposure matrix (JEM) developed previously by Bowman and colleagues (7). Personal monitoring and spot measurements on power-frequency magnetic fields were compiled based on a comprehensive search of the peer-reviewed literature and nonpublished sources. Workday average magnetic field measurements were pooled to estimate arithmetic and geometric mean exposure for 32.1% of the 502 1980 BOC occupations. Estimations based on categories judged to have similar magnetic field exposures were assigned to those occupations lacking direct measurements (52.7%). Where reliable exposure estimates were not possible (15.2% of the 1980 BOC occupations), subjects holding these jobs in the NLMS (3.6% of eligible population) were excluded from our analyses. Given the high correlation between geometric and arithmetic means in this JEM (data not shown), we linked each 1980 BOC occupation only to the arithmetic mean estimates of magnetic field exposure.

In the current analysis, magnetic field exposures were divided a priori into three intervals (<0.15, 0.15 to <0.20, $\geqslant 0.20$ μT), analogous to prior studies. Furthermore, given the sizable number of CVD deaths in the greater than 0.20 μT exposure group, we also examined exposure–response relationships using four categories (<0.15, 0.15 to <0.20, 0.20 to <0.30, and $\geqslant 0.30$ μT).

Mortality Outcomes

Cohort members were followed for mortality using the National Death Index (NDI) to identify the event and cause of death, classified according to ICD-9 codes. In addition to overall CVD mortality, we classified death from specific CVD outcomes as follows: (1) arrhythmia-related deaths (ICD-9 codes 426 and 427); (2) acute myocardial infarction (ICD-9 code 410); (3) coronary heart disease (CHD) (ICD-9 codes 411–414); and (4) atherosclerosis-related deaths (ICD-9 code 440). A total of 4,958 (1.56% of the study population) CVD deaths, including 264 arrhythmias, 1,929 AMI deaths, 56 atherosclerosis deaths, and 1,061 CHD deaths were found in a 9-year follow-up period (1980–1989) among those with known occupation codes and mean MF exposure values.

Covariates

Health behaviors and comorbid conditions, such as physical activity or diabetes, were not collected in the CPS and, therefore, were not available in the NLMS. Therefore, we were not able to consider some of the strongest CVD risk factors, such as physical inactivity, obesity/body mass index, diabetes, blood pressure, abnormal lipid profile, history of cardiac event, tobacco use, and alcohol use (8). Nevertheless, other important demographic variables were readily available and were accounted for in our analyses (age, sex, race, Hispanic origin, highest level of education completed, annual household income, and marital status). Although data on cigarette smoking was not present in this data set, we controlled for this covariate using methods to indirectly adjust for confounding after obtaining occupation-specific data on current smoking from external sources (described in Statistical Analysis).

Statistical Analysis

Proportional hazards model. To incorporate time-to-event information into estimations of relative risk, the risk of CVD mortality in relation to magnetic field exposure was examined using a proportional hazards model. Survival (in days) was defined as the time from cohort enumeration (the beginning of follow-up) to the date of CVD death. The design of the public use data set is such that follow-up time starts for all records at the same hypothetical date (July 1, 1980) and continues as indicated to mortality or censorship. Censorship was defined as either death by another cause or alive at the end of follow-up. The maximum duration of follow-up was 9 years or 3,288 days. Multivariate models controlled for demographic variables (age, sex, race, Hispanic origin, marital status) and indicators of socioeconomic status (household income and education completed). Hazard ratios (HR) of death and corresponding 95% CI levels were reported for the higher exposed groups (medium, high, and very high MF) in comparison to the low/background exposed group for overall CVD death and each of the four specific CVD outcomes. The proportionality assumption appeared to be met for all models based on examining log–log survival curves. All analyses were carried out using SAS, version 9.1 (SAS, Cary, NC).

Sensitivity Analysis

We used the well-established indirect adjustment method to quantitatively estimate potential effects of current cigarette smoking on the estimated measures of association between occupational MF exposure and CVD mortality in the NLMS cohort (9). This method is based on estimates of the magnitude of the association between the confounder and the disease outcome in the target population (*RR*), and the prevalence of the confounder in the exposed (p_1) and unexposed (p_0) populations. Based on the available literature, the following relative risks were used for the association between current cigarette smoking (compared with never smokers) and CVD outcomes (*RR*): 2.0 for overall CVD mortality (10); 2.5 for CHD (11); 2.5 for arrhythmia given that 85% of sudden cardiac death are attributed to arrhythmias (12); 1.4 and 2.2 for acute myocardial infarction among men and women, respectively (13); and 1.6 for atherosclerosis (14, 15).

To estimate the prevalence of the confounder in exposed and unexposed populations, we used previously published estimates of current cigarette smoking according to occupation from the 1980 National Health Interview Survey (NHIS) (16). It is noteworthy that these prevalence data were also collected in a nationally representative sample, and in approximately the same time period (1978–1980) as when the NLMS cohort was established. Therefore, the smoking prevalence estimates from NHIS are assumed to be directly representative of smoking habits in the NLMS cohort. Using these data, the mean current smoking prevalence for each magnetic field exposure group was assessed. For example, the smoking prevalence across all jobs constituting the magnetic field category with exposures less then 0.15 μT was averaged to determine the mean current smoking prevalence in the low/background exposure category; this value was the prevalence of the confounder among the unexposed population (p_0). Smoking prevalence was estimated in a similar fashion for the other magnetic field exposure groups (p_1). Because the NHIS data did not contain individual prevalence estimates for each occupation found in the NLMS cohort, we used prevalence estimates for 12 broad occupational categories to determine current smoking prevalence for each magnetic field exposure category. The mean smoking prevalence for each broad occupational category is displayed in the Appendix. Each 1970 BOC occupational code was assigned the appropriate prevalence estimate to estimate the current smoking prevalence among those individuals. For example, all individuals with a 1970 BOC code of 001–195 received the current smoking prevalence of 25.6%.

Finally, the relative risk due to confounding (RR_C) was computed according to an equation presented previously that uses p_1, p_0, and *RR* (9). Subsequently, the relative risk indirectly adjusted for the suspected confounder (RR_{adj}) was calculated as the ratio of the crude relative risk (RR_{crude}), which in this case is the HR from our proportional hazards regression model, over RR_C (9).

RESULTS

In the NLMS, almost 50% of individuals were grouped into the high exposure category of at least 0.20 μT (Table 1). Crude associations of each covariate available in the NLMS with overall CVD mortality among those with background MF exposure level are also presented in Table 1. All covariates displayed were associated with overall CVD mortality as well as specific CVD outcomes (data not shown), and were therefore all included as potential confounders in our regression models. Gender, income, and education seemed to be most unevenly distributed by MF exposure level.

Crude hazard ratios for all CVD deaths were higher among individuals with occupations of potentially increased MF exposure but adjustment for demographic factors resulted in HRs close to the null. This pattern was similar for mortality from specific CVD outcomes (Table 2).

The estimated smoking prevalence in each of the magnetic field exposure groups was similar although those with higher magnetic field exposure were slightly more likely to smoke: 33.6% in the low/background category, 34.1% in the medium exposure group, 36.8% in the high exposure group, and 39.6% in the very high exposure category. Given these minor differences between exposure groups, it is not surprising that indirect adjustment for current smoking did not materially affect the results shown in Table 2 with the relative risk due to confounding ranging from 1.00 to 1.06 depending on the MF exposure level and disease outcome (data not shown). The risk estimates reported in Table 2 are no greater than 6% of those found after indirectly controlling for smoking.

DISCUSSION

Despite some evidence for the biological underpinnings of an increased CVD risk in relation to MF (17–24), epidemiological studies of the possible association between MF and CVD have reported conflicting results, primarily because later studies were not able to confirm the findings reported by Savitz and colleagues (1, 4). Differences in analytical methods are suspected to contribute to this inconsistency. In particular, most prior analyses were unable to address many demographic and behavioral factors that may influence the risk of CVD mortality. Additionally, the

TABLE 1. Association of demographic covariates with cardiovascular disease mortality risk and magnetic field exposure

	All Cardiovascular Disease		Low MF exposure		Medium MF exposure		High MF exposure		Very High MF exposure	
Demographic Variable	Obs (%)	Crude HR (95% CI)*	N	%	N	%	N	%	N	%
Total	4958 (100)		76308	24.9	81063	26.4	97197	31.7	52444	17.1
Sex										
Male	3816 (77)	1.0 (Ref)	34427	20.0	37677	21.9	63713	37.1	36092	21.0
Female	1142 (23)	0.43 (0.37–0.49)	41881	31.0	43386	32.1	33484	24.8	16352	12.1
Age										
< 35 years	157 (3)	1.0 (Ref)	42477	27.1	37912	24.2	49674	31.7	26646	17.0
35 – 45	403 (8)	6.5 (4.4–9.6)	13993	24.7	16402	28.9	17068	30.1	9299	16.4
45 – 55	1042 (21)	24.8 (17.5–35.1)	10520	22.2	13999	29.5	14866	31.3	8258	17.0
55 – 65	1829 (37)	55.2 (39.4–77.5)	7110	20.2	9863	28.1	11619	33.1	6551	18.6
65 – 75	1115 (22)	123.7 (86.9–176.0)	1927	20.5	2512	26.7	3366	35.7	1615	17.1
75+	412 (8)	331.1 (220.9–496.4)	281	18.3	375	24.4	604	39.3	275	17.9
Race										
White	4383 (88)	1.0 (Ref)	66862	24.6	74324	27.4	86075	31.7	44295	16.3
Black	481 (10)	1.4 (1.1–1.7)	7139	26.6	4693	17.5	8475	31.6	6514	24.3
Other	94 (2)	0.9 (0.6–1.4)	2307	26.7	2046	23.7	2647	30.7	1635	18.9
Hispanic										
All Other	4863 (98)	1.0 (Ref)	72703	25.0	77912	26.8	91826	31.6	48411	16.6
Hispanic or Spanish	95 (2)	0.3 (0.2–0.5)	3605	22.3	3151	19.5	5371	33.2	4033	25.0
Marital Status										
Married	3646 (74)	1.0 (Ref)	44113	23.1	53346	28.0	60391	31.7	32770	17.2
Widowed	516 (10)	4.2 (3.5–5.1)	2184	25.3	2426	28.1	2498	29.0	1512	17.5
Divorced	362 (7)	1.2 (1.00–1.5)	5847	27.2	6100	28.4	5859	27.3	3652	17.0
Separated	97 (2)	0.7 (0.5–1.2)	1898	26.8	1628	23.0	2124	30.0	1426	20.2
Never Married	332 (7)	0.3 (0.2–0.3)	21491	27.9	17095	22.2	25796	33.4	12757	16.5
Annual Household Income										
< $15,000	2239 (48)	1.0 (Ref)	25451	24.7	21755	21.1	35102	34.0	20857	20.2
$15,000–24,999	1208 (26)	0.5 (0.5–0.6)	22659	24.5	23982	26.0	29051	31.5	16665	18.0
$25,000+	1203 (26)	0.6 (0.5–0.7)	24832	25.7	31122	32.2	28216	29.2	12573	13.0
Education										
Elementary grades 0–4	169 (3)	1.0 (Ref)	536	15.0	253	7.1	1565	43.8	1222	34.2
Elementary grades 5–7	390 (8)	1.2 (0.7–2.0)	1642	17.9	954	10.4	3661	39.9	2914	31.8
Elementary grades 8	651 (13)	0.8 (0.5–1.4)	3052	20.1	1889	12.4	6192	40.7	4075	26.8
High School levels 1–3	877 (18)	0.4 (0.2–0.6)	11173	22.9	7565	15.5	18554	38.1	11413	23.4
High School levels 4	1654 (33)	0.4 (0.2–0.6)	25253	20.7	35288	28.9	39182	32.1	22445	18.4
College Level 1–3	593 (12)	0.2 (0.1–0.4)	14332	26.1	19487	35.5	14045	25.6	6986	12.7
College Level 4	352 (7)	0.3 (0.2–0.4)	10228	33.0	10155	32.8	8089	26.1	2511	8.1
College Level 5+	270 (5)	0.3 (0.2–05)	10069	45.3	5452	24.5	5865	26.4	844	3.8

*HR = hazard ratio as determined by a proportional hazards model for subset of cohort with Low MF Exposure.

classification of CVD outcomes on death certificates is suspected to be quite inaccurate and may vary somewhat across countries.

Few prior investigations into the potential MF–CVD association used nationally-representative populations and may therefore have limited generalizability beyond the industries on which the studies were based. The current prospective study contributes novel information to this literature because we examined this association in a nationally representative U.S. cohort (NLMS) using a newly developed and extensive JEM. Furthermore, we addressed potential confounding from a variety of demographic factors and cigarette smoking. In the United States, we are aware of only one other study using nationally representative data that adjusted for cigarette use and other relevant potentially confounding variables. However, it relied on deceased cases and controls and used proxy response to account for frequency and amount of cigarette use and other relevant covariates (3).

Limitations regarding the measurement of MF exposure and CVD mortality should be considered. Magnetic field exposure was not measured directly in this study. Direct measurement of burden/dose for MF is currently unavailable for most historic cohort analyses. Historic exposure is often reconstructed using surrogate measures, such as job titles, where exposure intensity data are limited or unavailable (25). Job-exposure matrices create classification systems whereby exposure levels are estimated by job title and duration of exposure. Drawing from other sources, such as job titles, industry, and occupation records, JEMs are especially useful when it is not possible to question subjects directly (26). Although using occupational categories is a common

TABLE 2. Hazard ratio and 95% confidence interval for the association between cardiovascular disease mortality and magnetic field exposure

Outcome	Exposure Level	Population at risk	Obs	Crude HR (95% CI)	Adjusted HR (95% CI)*
All CVD					
	< 0.15 μT	76308	912	1.0 (Ref)	1.0 (Ref)
	0.15 – <0.20 μT	81063	1237	1.24 (1.15–1.35)	1.03 (0.95–1.12)
	0.20 – <0.30 μT	97197	1687	1.42 (1.31–1.53)	0.93 (0.86–1.00)
	⩾ 0.30 μT	52444	949	1.48 (1.36–1.61)	0.98 (0.90–1.08)
Arrhythmia					
	< 0.15 μT	76308	55	1.0 (Ref)	1.0 (Ref)
	0.15 – <0.20 μT	81063	55	0.94 (0.65–1.34)	0.84 (0.58–1.21)
	0.20 – <0.30 μT	97197	94	1.34 (0.97–1.84)	0.91 (0.66–1.26)
	⩾ 0.30 μT	52444	51	1.35 (0.93–1.95)	0.90 (0.62–1.31)
AMI					
	< 0.15 μT	76308	341	1.0 (Ref)	1.0 (Ref)
	0.15 – <0.20 μT	81063	460	1.24 (1.09–1.42)	0.97 (0.84–1.11)
	0.20 – <0.30 μT	97197	695	1.57 (1.39–1.78)	0.96 (0.84–1.08)
	⩾ 0.30 μT	52444	371	1.56 (1.35–1.79)	1.01 (0.85–1.14)
Atherosclerosis					
	< 0.15 μT	76308	11	1.0 (Ref)	1.0 (Ref)
	0.15 – <0.20 μT	81063	17	1.32 (0.65–2.68)	1.04 (0.51–2.13)
	0.20 – <0.30 μT	97197	13	0.85 (0.40–1.80)	0.48 (0.22–1.04)
	⩾ 0.30 μT	524444	12	1.45 (0.67–3.14)	0.85 (0.39–1.87)
CHD					
	< 0.15 μT	76308	201	1.0 (Ref)	1.0 (Ref)
	0.15 – <0.20 μT	81063	279	1.30 (1.09–1.54)	1.06 (0.89–1.27)
	0.20 – <0.30 μT	97197	338	1.32 (1.11–1.55)	0.85 (0.72–1.01)
	⩾ 0.30 μT	52444	210	1.52 (1.26–1.83)	1.02 (0.83–1.23)

*Adjusted for sex, age, race, Hispanic origin, marital status, income, and education completed.

proxy for estimating exposure, there are potentially large variations in exposure within each category. Thus, this proxy measure for exposure is potentially imprecise. Nevertheless, the JEM used here allows for the analysis of large epidemiologic data sets.

Extremely-low-frequency (ELF) magnetic fields are time-varying vectors whose frequency, polarization, and spatial orientation have all been linked to biologic effects (27). Therefore, the time-weighted average (TWA) MF magnitude in the ELF band measured for these job-exposure matrices could be misclassifying MF exposures and biasing risk estimates toward the null. Finally, these exposure data are unable to assess other aspects of occupational EMF, such as electric fields, electric shocks, and radio-frequency radiation, all of which have been reported to be associated with chronic diseases.

In the current study, last or current job at the time of the CPS survey was collected for the NMLS cohort and, therefore, was used for exposure classification. However, persons may incur varied exposure levels if occupation changed over time. The stability of the workforce with respect to exposure classification is a common limitation in occupational cohort studies. If individuals of occupations classified as highly exposed have a high turn-over rate for other careers, the exposure assessment will be inappropriate. The NLMS involved only one assessment of occupation title for each cohort member; thus, it was not possible to assess whether the exposure groups differed in job title stability. However, current occupation was reported as an appropriate surrogate for longest-held job in an analysis of the NHIS cohort (28).

This study had a high percentage of persons, approximately 48%, in the top two MF exposure levels (>0.20 μT). We suspect this exposure distribution is due to our use of the arithmetic mean MF exposures; in contrast, other studies used the geometric mean for exposure estimates that results in a lower percentage of persons in the most highly exposed categories (7). Nevertheless, geometric and arithmetic means assigned to jobs in the JEM used here are highly correlated ($r = 0.9$). Therefore, the choice of exposure metric does not greatly affect the relative ranking of exposure level among individuals in epidemiological studies, and would therefore not substantially impact exposure–response relationships.

With respect to the disease variable, the research question addresses mortality and not morbidity. Death certificates are known to be fallible sources of information, presenting the possibility of disease misclassification (29), the effect of which on our risk estimates is uncertain (30). Moreover, by assessing only death, we are examining only the highest level of severity and will not able to capture any mild and hidden disease effects (if any) of the exposure.

In contrast to many previous studies, we were able to account for important demographic factors that may be related to health behaviors and comorbidity. Even so, there were several strong risk factors for CVD that were unavailable for adjustment, such as physical activity, overweight/obesity, and hereditary factors. These factors are unlikely to be associated strongly with MF exposure. Furthermore, we were able to control for the effects of income and education that are known to be correlated with unhealthy behaviors, such as physical inactivity and alcohol consumption (31, 32). Therefore, residual confounding is unlikely to result in the absence of a positive association between MF exposure and CVD mortality in this study, consistent with the view that residual confounding generally has a minor impact on epidemiologic findings (33).

Health utilization characteristics are a common concern in occupational epidemiologic analyses. Access to care can be influenced by several factors, such as occupational status (e.g., active, home-based, or retired), insurance type, and region of residence. Occupational status was not a concern in the present study as the eligible population did not include persons retired or unemployed. Whereas insurance coverage and geographic location may be associated with CVD mortality, there was a high degree of job heterogeneity within exposure levels based on the wide range of occupations thereby making them less likely to be associated with MF exposure.

Although our study was limited to employed persons, we suspect that the healthy-worker effect (HWE) was smaller in our study than in traditional industry-based cohort studies due to the population-based sampling of the NLMS cohort. That said, using a large population-based cohort does not mitigate a potential HWE (e.g., workers in jobs with higher MF exposure levels may be less likely to have chronic disease than those at lower levels of exposure); one advantage of industry cohort analyses is the ability to use internal controls, which are unavailable in population-based cohort analyses. Thus, there remain limitations to both analysis paradigms.

Although the adjustment was indirect, we were able to examine potential confounding by smoking. Our approach was limited in that both our MF exposure assessment and our control for smoking relied on job title linkage, which may introduce a spurious correlation between the exposure and confounder resulting in overadjustment for the effects of the confounder. This would be particularly concerning in situations in which indirect adjustment greatly impacts the association of interest. However, we did not find smoking to be a confounder of the MF–CVD association, which is consistent with the findings recently reported by Mezei and colleagues (3).

In conclusion, our study does not provide evidence to support an association between occupational exposure to magnetic fields and increased risk of CVD mortality using a nationally representative U.S. cohort. This finding is consistent with recent studies and reviews assessing this relationship (2–5).

The findings and conclusions in this study have not been formally disseminated by the U.S. National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

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APPENDIX

Broad occupational groups with corresponding 1970 BOC codes and percent current smoking from NHIS data set:

Broad	Occupational Group	1970 BOC	% Current Smoking(SE)
1	Professional and technical	001–195	25.5 (0.70)
2	Managers and administrators, no farms	201–245	35.7 (0.94)
3	Sales workers	260–296	34.7 (1.12)
4	Clerical workers	301–395	32.4 (0.67)
5	Crafts people	401–580	44.6 (0.89)
6	Operatives, except transportation	601–695	40.7 (1.04)
7	Transportation equipment operatives	701–715	48.7 (1.76)
8	Laborers, except farm	745–785	40.4 (1.64)
9	Farmers and farm managers	801,802	24.7 (2.20)
10	Farm laborers and foremen	821–824	29.6 (2.92)
11	Service except houshold	901–965	38.3 (0.99)
12	Private household	980–984	26.4 (3.05)

Indirect Adjustment for Confounding

The following equation was used to compute RR_C for each exposure group relative to the reference group:

$$RR_c = \frac{p_1 * RR + q_1}{p_0 * RR + q_0}$$

where p_1 = prevalence of the confounder among the exposed (0.15 to <0.20, 0.20 to <0.30, and ≥ 0.30 μT); p_0 = prevalence of the confounder among the unexposed (<0.15 μT); RR = relative risk between the confounder and disease (e.g., 2.0 for overall CVD mortality); $q_1 = 1 - p_1$; and $q_0 = 1 - p_0$.

Subsequently, the RR indirectly adjusted for the suspected confounder (RR_{adj}) is computed as the ratio of the crude relative risk (RR_{crude}), which in this case is the HR from our proportional hazards regression model (Table 2), over RR_C.