AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 37 - 339 - 348 (2000)

Mortality Among Catholic Nuns Certified as Radiologic Technologists

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Background *Several studies have shown that Catholic nuns have a different mortality experience than women of similar age in the general population. We had a unique opportunity to evaluate mortality patterns of nuns identified in an occupational study of nearly 145,000 radiologic technologists (73% female).*

Methods *A total of 1,103 women were classified as nuns based on their titles of "Sister" or "SR". Their mortality experience was compared to other female radiologic technologists and to U.S. white females.*

Results *Five hundred eighty-three nuns (53%) were deceased as of January 1, 1995. Compared to other technologists, nuns were at significantly increased risk of dying from all causes (Standardized mortality ratio (SMR) = 1.1; 95% Confidence interval (CI) = 1.0–1.2, stomach cancer (SMR = 2.7; 95% CI = 1.2–5.4), diabetes (SMR = 2.2; 95% CI = 1.0–4.1), ischemic heart disease (SMR = 1.2; 95% CI = 1.1–1.4), all digestive diseases (SMR = 2.0; 95% CI = 1.3–3.0), and gastric and duodenal ulcers (SMR = 8.3; 95% CI = 2.3–21.3). In contrast, we observed a significant deficit in lung cancer (SMR = 0.5; 95% CI = 0.2–0.9), no deaths from cervical cancer, and a breast cancer risk 10% lower than expected (SMR = 0.9; 95% CI = 0.6–1.3). When compared to U.S. females, nuns experienced significantly reduced mortality from all causes (SMR = 0.8; 95% CI = 0.7–0.9), cervical cancer (SMR = 0.0; 95% CI = 0.0–0.7), all endocrine, metabolic and nutritional diseases (SMR = 0.5; 95% CI = 0.3–0.9), all circulatory diseases (SMR = 0.7; 95% CI = 0.7–0.8) including ischemic heart disease and cerebrovascular disease, and all respiratory diseases (SMR = 0.5; 95% CI = 0.3–0.8), and a nearly signifcant deficit of diabetes (SMR = 0.6; 95% CI = 0.3–1.0). In contrast, nuns had an almost 3-fold greater risk of tuberculosis (SMR = 2.9; 95% CI = 1.4–5.3) and a 20% excess of breast cancer (SMR = 1.2; 95% CI = 0.8–1.7). The breast cancer excess was concentrated among nuns first certified before 1940 (SMR = 2.0; CI = 1.3–3.0), when radiation doses were possibly the highest, but the risk did not increase with increasing length of certijication.*

Conclusions *Compared with the general population, the mortality experience of nuns was favorable and rejected the "healthy worker effect" commonly seen in occupational studies. Patterns observed for breast and cervical cancer possibly indicate differences in reproductive and sexual activities associated with belonging to a religious order. The possibility of a radiation-related excess for breast cancer among nuns certified before 1940 cannot be completely discounted, although there was no dose-response relationship*

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Contract sponsor: National Cancer Institute, U.S. Public Health Service; Contract numbers: N01-CP-21015, N01-CP-61006, N01-CP-81058, N01-CP-05609, and N01-CP-40514

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Accepted 7 December 1999

with a surrogate measure of exposure (number of years certified). When their mortality experience was compared with other radiologic technologists, the influence of lifestyle factors was not apparent. **Am.** J. Ind. Med. 37:339–348, 2000.
Published 2000 *Wiley-Liss, Inc.*†

KEY WORDS: Catholicism; nuns; mortality; neoplasms; cohort study; epidemiology

INTRODUCTION

For nearly 300 years [Ramazzini, 1713], the disease patterns of Catholic nuns have prompted interest into the role of lifestyle behaviors, reproductive patterns, and exposures associated with religious life. Early investigations, which relied upon relative frequencies for specific causes of death, suggested excesses of tuberculosis [Fecher, 1927] and cancers of the breast [Schomig, 1953; Gagnon, 1955; Nix, 1964; Fecher, 1972], ovary [Nix, 1964; Fecher, 1972], stomach [Schomig, 1953], and large intestine [Nix, 1964; Fecher. 19721. Also reported were deficits for cancers of the cervix [Gagnon, 1950; Schomig, 1953; Gagnon, 1955; Nix, 1964: Fecher, 1972], lung [Schomig, 1953; Nix, 1964; Fecher, 1972], esophagus [Schomig, 1953], and liver and biliary passages [Fecher, 1927; Gagnon. 1950; Schömig, 1953: Fecher, 1972]. Comprehensive historical reviews of these early studies were provided by Taylor et al. [1959], Fraumeni et al. [1969], and Fecher [1972].

Cohort studies generally supported the earlier findings [Taylor et al., 1959; Fraumeni et al., 1969; Kinlen, 1982; Butler and Snowdon, 1996]. In addition, low risks were reported for respiratory, cerebrovascular, and ischemic heart diseases [Butler and Snowdon, 1996]. Previous studies typically used rates prevailing in the general population for comparison, which may have resulted in confounding due to the "healthy worker effect" of working nuns [Monson, 1986]. The identification of 1,103 nuns within a national cohort of radiologic technologists offered a unique opportunity to compare mortality among nuns with other women who were similarly certified as proficient in the field of radiation technology.

MATERIALS AND METHODS

A cohort of approximately 145,000 U.S. residents who were certified by the American Registry of Radiologic Technologists (ARRT) during 1926–80 is under study to evaluate cancer risks associated with occupational exposure to radiation [Boice et al., 1992. 1995; Doody et al., 1995, 1998]. Seventy-three percent of the registrants were female. During a manual review of ARRT records, abstractors noted that a large percentage of the early registrants were Catholic nuns. Our recent finding of increased mortality from breast cancer among radiologic technologists who were first certified before 1940 and for long duration [Doody et al., 1998] prompted further evaluation to determine whether this excess risk was due in part to the large proportion of nuns among the group certified before 1940. The computerized database was searched for women with titles of "Sister" and "SR" and addresses and affiliations were manually reviewed to verify that women so identified were in all likelihood Catholic nuns.

Vital status was ascertained, as previously described [Doody et al., 1998], through January 1, 1995. Deaths were identified from a number of sources, including the Social Security Death Master File, the National Death Index (NDI). and ARRT records. Death certificates were obtained and coded by nosologists according to the Eighth revision of the International Classification of Diseases [National Center for Health Statistics, 1967] by using the rules that were in effect at the time of the death. Since eligibility for the study required certification for at least two years, accrual of person-years of observation began two years after date of certification. Follow-up ended at the earliest of date of death, date last known vital status, or January 1, 1995, with one exception. For technologists who were last known alive in 1979 or later, had good social security numbers, and were not found deceased through linkage with NDI. follow-up was extended to January 1, 1995. The number of person-years added as a result of this decision was relatively small (<4% of total) and the patterns in the standardized mortality ratios (SMRs) were unchanged.

The mortality experience of nuns was compared against other female radiologic technologists and, for comparability with previous reports, against U.S. white females. Numbers of cause-specific expected deaths were calculated by multiplying the age- and calendar-specific woman-years at risk (in 5-year periods) by the mortality rates in each comparison group [Monson. 1974]. SMRs were computed for internal cohort and general population comparisons by dividing the number of observed deaths by the number of deaths expected in the respective comparison group. Exact methods were used to calculate 95% confidence limits [Breslow and Day. 1987]. Patterns in risk were further evaluated by birth cohort (< 1890, 1890–99, 1900–09, 1910+) and attained age (< 50, 50–59, 60–69, 70+).

RESULTS

Our search within the ARRT computerized database for women with titles of "Sister" and "SR" identified 1,103

nuns among the female radiologic technologists. Table I presents demographic characteristics of nuns and other female technologists. Nuns tended, on average, to be born and certified earlier in calendar time, older when certified, and certified for longer duration. While nuns represented approximately 1% of all female technologists, they accounted for nearly 24% of the women certified before 1940. Nuns were significantly less likely than other technologists to be certified in specialties other than radiography (i.e., nuclear medicine or radiotherapy). On an average, nuns had substantially longer follow-up (35.9 years) than other technologists (23.6 years). More than half (583) of the 1,103 nuns were found to have died, whereas only 5% of other technologists were deceased.

TABLE I. Characteristics of Nun and Other Female Radiologic Technologists

	Nun technologists		Other female technologists	
Characteristic	Number	Percent	Number	Percent
Total subjects	1,103		104,219	
Person-years	39,589		2,461,557	
Length of follow-up (years)	(35.9)[a]		(23.6)	
Vial status as of 1/1/95				
Alive	453	41.1	98,439	94.5
Dead	583	52.9	5.295	5.1
Lost to follow-up	67	6.1	485	0.5
Birth year	(1908)		(1945)	
< 1900	357	32.4	685	0.7
1900-09	263	23.8	1,653	1.6
1910-19	221	20.0	3,005	2.9
1920-29	128	11.6	5,221	5.0
1930-39	103	9.3	13,701	13.1
1940-49	23	2.1	33,087	31.7
1950+	8	0.7	46,867	45.0
Calendar year first certified	(1943)		(1968)	
1926-39	452	41.0	1,437	1.4
1940-49	297	26.9	3,797	3.6
1950-59	230	20.9	13,289	12.8
1960+	124	11.2	85,696	82.2
Age at certification	(35.4)		(22.2)	
< 20	7	0.6	10,361	9.9
20-24	129	11.7	76,519	73.4
25-29	189	17.1	8,455	8.1
30-34	229	20.8	3,976	3.8
35-39	212	19.2	2,487	2.4
40+	337	30.6	2,421	2.3
Number of years certified	(26.4)		(21.1)	
< 10	89	8.1	6,019	5.8
10-19	212	19.2	38,383	36.8
20-29	358	32.5	39,145	37.6
30-39	314	28.5	17,496	16.8
40+	130	11.8	3.176	3.0
Type of certification				
Radiography	1,084	98.3	96,876	93.0
Nuclear medicine	6	0.5	1,866	1.8
Therapy	0	0.0	564	0.5
Combination	13	1.2	4,913	4.7

[a] Numbers in parentheses are average values

A total of 250 nuns (23%) completed a baseline questionnaire during 1984–87 providing information on work history as a radiologic technologist, prevalent cancers, and cancer risk factors. To date, 200 nuns (18%) have completed a second survey for cancer incidence; 97% of nun respondents reported being Catholic compared to 38% of other technologists, lending some validation to their classification as "nuns". Nuns were less likely than other technologists to ever smoke cigarettes (11% cf 50%) and to consume one or more alcoholic drinks per week (6% cf 39%).

Compared to other technologists, nuns had a significant 10% excess risk of dying from all causes (Table II). Mortality from cancer of all sites, however, was 10% lower, owing primarily to a significant 50% deficit of lung cancer. Nuns had a significant threefold increased risk of stomach cancer, a twofold greater risk of central nervous system tumors (based on five observed deaths), and a 30% increased risk of leukemia (seven observed deaths), but no excess of breast cancer (SMR = 0.9).

In addition, nuns had a significant 20% higher risk of dying from ischemic heart disease than other female technologists. A significant twofold greater risk for diseases of the digestive system was observed. with the risk for gastric or duodenal ulcers being eight times higher than expected (4 observed deaths). Nuns were also twice as likely as other technologists to die of tuberculosis or diabetes, while modest deficits were observed for respiratory diseases and all external causes.

In contrast, when compared to U.S. females, nun technologists had significant deficits in total mortality: all endocrine, metabolic, and nutritional diseases; all circulatory diseases, including ischemic heart disease and cerebrovascular disease; and all respiratory diseases. Nuns had a 40% lower risk of diabetes and no excess for all digestive diseases, while modest excesses were seen for breast and stomach cancers. The patterns of risk for other causes of death resembled the internal comparison with other technologists. Nuns experienced a 10% deficit in overall cancer mortality, notably for lung and cervical cancers, and all external causes. as well as a greater risk for tuberculosis. plus suggestive excesses for leukemia. brain and other CNS tumors. and ulcers.

An examination of risks by birth cohort (< 1890. 1890–99, 1900–09, 1910+) revealed significant declines from the earliest to the latest birth cohorts for deaths from all causes, lung cancer, breast cancer. all circulatory diseases, particularly ischemic heart disease. all respiratory diseases, and all external causes (Table III). A signifcant increasing trend in tuberculosis deaths was observed. owing to a ninefold risk among nuns born during 1900–09.

Examination of the patterns of risk by attained age categories (< 50. 50–59, 60–69.70+) revealed significantly decreasing risk with increasing age for all infectious and parasitic diseases. owing to a decline in tuberculosis. and for ischemic heart disease (Table IV). Risk of pancreatic cancer increased significantly with age. No other significant trends were observed.

DISCUSSION

Overall, the risk of death for nun technologists was lower than the risk among U.S. females but slightly higher than among other female technologists. Our finding of a significantly lower overall mortality among nuns than U.S. females is consistent with results of two follow-up studies of about 2,600 nuns each [Taylor et al., 1959; Butler and Snowdon, 19961, and possibly reflects the selective entry of healthy women into religious orders, as well as a general survival advantage associated with not smoking in the orders. The significantly greater risk observed in all-cause mortality for nuns compared with other female technologists was due primarily to an excess in circulatory diseases among nuns born before 1890. The SMRs for total mortality declined significantly from the earliest to the more recent birth cohorts regardless of comparison group and, in fact, mortality was significantly below both comparisons for those born in 1910 or later. Reasons for the excess mortality risk in cardiovascular disease among nuns in the early birth cohort are unclear, but may reflect differences in diet, physical activity, or predisposing medical conditions. It has been reported that. traditionally, nuns have ignored the preventive aspects of medical care, failed to report health problems, and refrained from receiving medical care and taking medication [Hickey and Kalish, 1969].

The two- to three-fold increased risk of tuberculosis observed among nuns is consistent with early reports that suggested that this condition was common among nuns working in health care settings during the early part of this century [Fecher, 1927; Taylor et al., 1959]. The tuberculosis death rate among nuns has declined dramatically over time [Fecher. 1972].

The observed excess of stomach cancer in the current study (based on eight deaths) is in contrast to a deficit reported by Fraumeni et al. [1969] in a cohort analysis of 32,000 nuns. Although ionizing radiation is known to cause stomach cancer [Griem et al., 1994; Ron et al., 1994], one would have expected a greater risk for nuns compared with U.S. females. rather than with other female technologists as we observed. It is noteworthy that nuns typically lived in communities where diets were characteristically high in fats and starches and often deficient in vitamins [Nix. 19571. Several studies have suggested an excess risk of stomach cancer associated with high starch diets, perhaps due to physical irritation of the gastric mucosa, reduced gastric mucus production, and decreased availability of nutrients that inhibit nitrosation in gastric juice [Nomura. 1996]. Unfortunately. we have no information on dietary or other risk factors (e.g., *Helicobacterpylori* infection) for gastric

TABLE II. Observed Cause-Specific Deaths Through 1/1/95 among Nun Radiologic Technologists, Expected Deaths Based on Other Female Radiologic Technologists and U.S. White Females, Standardized Mortality Ratios (SMR), and 95% Confidence Intervals (CI)

	Nuns	Other female technologists			U.S. females		
Cause of death (ICD-8th Revision)	Observed	Expected	SMR	CI	Expected	SMR	CI
All causes (000–999)	583	526.00	1.1	1.02–1.2	731.77	0.8	0.7–0.9
Infective, parasitic diseases (000–139)	13	7.66	1.7	0.9–2.9	9.77	1.3	0.7–2.3
Tuberculosis (010–019)	10	5.19	1.9	0.9–3.5	3.47	2.9	1.4–5.3
All malignant neoplasms (140–209)	128	145.54	0.9	0.7–1.1	141.50	0.9	0.8–1.1
Oral cavity, pharynx (140–143)	0	1.63	0.0	0.0–2.3	1.71	0.0	0.0–2.2
Esophagus (150)	1	1.20	0.8	0.0–4.6	1.29	0.8	0.0–4.3
Stomach (151)	8	2.95	2.7	1.2–5.4	6.16	1.3	0.6–2.6
Colon (153)	18	21.13	0.9	0.5–1.4	18.13	1.0	0.6–1.6
Rectum (154)	4	5.46	0.7	0.2–1.9	4.03	1.0	0.3–2.5
Liver (155–156)	2	2.36	0.9	0.1–3.1	4.33	0.5	0.1–1.7
Pancreas (157)	8	5.06	1.6	0.7–3.2	7.36	1.1	0.5–2.1
Larynx (161)	0	0.03	0.0	0.0–126.3	0.34	0.0	0.0–10.7
Lung (162)	8	16.73	0.5	0.2–0.9	16.10	0.5	0.2–0.98
Bone (170)	0	0.06	0.0	0.0–57.1	0.53	0.0	0.0–6.9
Skin (172–173)	0	1.43	0.0	0.0–2.6	1.72	0.0	0.0–2.1
Breast (174)	32	35.07	0.9	0.6–1.3	26.07	1.2	0.8–1.7
Cervix (180)	0	2.39	0.0	0.0–1.5	5.24	0.0	0.0–0.7
Uterine corpus (181–182)	4	3.96	1.0	0.3–2.6	5.45	0.7	0.2–1.9
Other female genital (183–184)	10[a]	7.63	1.3	0.6–2.4	9.17	1.1	0.5–2.0
Bladder (188)	2	2.52	0.8	0.1–2.9	2.47	0.8	0.1–2.9
Kidney (189)	1	3.29	0.3	0.0–1.7	2.29	0.4	0.0–2.4
Eye (190)	0	0.00	0.0	—	0.14	0.0	0.0–26.6
Brain, other CNS (191–192)	5	2.54	2.0	0.6–4.6	2.56	2.0	0.6–4.6
Thyroid (193)	0	0.38	0.0	0.0–9.6	0.60	0.0	0.0–6.2
Lymphoma (200)	2	2.79	0.7	0.1–2.6	2.05	1.0	0.1–3.5
Hodgkin's disease (201)	0	0.63	0.0	0.0–5.8	0.75	0.0	0.0–4.9
Multiple myeloma (203)	3	0.97	3.1	0.6–9.1	2.06	1.5	0.3–4.3
Leukemia (204–207)	7	5.32	1.3	0.5–2.7	4.83	1.5	0.6–3.0
Benign neoplasms (210–239)	1	1.15	0.9	0.0–4.8	2.32	0.4	0.0–2.4
Endocrine, nutrdional.metabolic (240–279)	11	7.72	1.4	0.7–2.6	20.88	0.5	0.3–0.9
Diabetes mellitus (250)	10	4.64	2.2	1.03–4.0	18.30	0.6	0.3–1.01
Diseases of Mood (280–289)	3	2.12	1.4	0.3–4.1	2.56	1.2	0.2–3.4
Mental disorders (290–317)	6	6.71	0.9	0.3–2.0	4.77	1.3	0.5–2.7
Diseases of nervous system (320–389)	3	4.55	0.7	0.1–1.9	8.65	0.4	0.0–1.01
Diseases of circulatory system (390–458)	278	246.74	1.1	1.00–1.3	377.27	0.7	0.7–0.8
Ischemic heart disease (410–414)	172	138.73	1.2	1.1–1.4	206.26	0.8	0.7–0.97
Cerebrovasculardisease (430–438)	62	58.29	1.1	0.8–1.4	80.81	0.8	0.6–0.98
Diseases of respiratory system (460–519)	22	25.84	0.9	0.5–1.3	41.88	0.5	0.3–0.8
Diseases of digestive system (520–577)	26	12.83	2.0	1.3–3.0	25.66	1.0	0.7–1.5
Ulcer, gastric and duodenal (531–533)	4	0.48	8.3	2.3–21.3	2.60	1.5	0.4–3.9
Diseases of genitourinary system (580–629)	9	6.98	1.3	0.6–2.5	15.60	0.6	0.3–1.1
Diseases of skin (680–709)	0	1.30	0.0	0.0–2.8	1.12	0.0	0.0–3.3
Diseases of musculoskeletal system (710–738)	3	2.91	1.0	0.2–3.0	2.42	1.2	0.3–3.6
Accidents. poisonings and violence (800–998)	12	16.04	0.8	0.4–1.3	20.86	0.6	0.3–1.01

[a]Includes nine cancers of ovary and one of vulva

TABLE III. Observed Cause-Specific Deaths Through 1/1/95 among Nun Radiologic Technologists, Standardized Mortality Ratios (SMR) Relative to Other Female Technologists, and 95% Confidence Intervals (CI), by Birth Cohort

		Birth cohort				
Cause of death (ICD-8th revision)		<1890	1890–99	1900–09	1910+	P-trend[a]
	Persons	178	179	263	483	
	Person-years	5,032	6,991	10,550	17,016	
	Mean (year)	1885	1895	1905	1946	
All causes (000–999)	Observed	172	165	166	80	
	SMR	1.38	1.14	1.10	0.76	(<0.0001)
	CI	1.2–1.6	0.98–1.3	0.9–1.3	0.6–0.9	
Infectious, parasitic diseases (000–139)	Observed	0	3	9	1	
	SMR	0.00	1.51	5.35	0.87	0.39
	CI	0.0–1.3	0.3–4.4	2.4–10.2	0.0–4.9	
Tuberculosis (010–019)	Observed	0	2	7	1	
	SMR	0.00	1.51	8.74	2.32	0.03
	CI	0.0–12.1	0.2–5.5	3.5–18.0	0.0–12.9	
All malignant neoplasms (140–209)	Observed	24	33	45	26	
	SMR	0.67	1.05	1.17	0.65	0.30
	CI	0.4–1.00	0.7–1.5	0.9–1.6	0.4–0.95	
Stomach (151)	Observed	2	2	1	3	
	SMR		1.49	1.17	3.95	—
	CI	—	0.2–5.4	0.0–6.5	0.8–11.5	
Colon (153)	Observed	5	3	7	3	
	SMR	0.60	0.59	1.66	0.85	0.54
	CI	0.2–1.4	0.1–1.7	0.7–3.4	0.2–2.5	
Pancreas (157)	Observed	1	2	3	2	
	SMR	∞	1.69	1.92	0.86	—
	CI	—	0.2–6.1	0.4–5.6	0.1–3.1	
Lung (162)	Observed	3	2	2	1	
	SMR	4.89	0.87	0.36	0.12	(0.005)
	CI	0.98–14.3	0.1–3.1	0.0–1.3	0.0–0.7	
Breast (174)	Observed	8	9	13	2	
	SMR	0.73	1.65	1.46	0.21	(0.04)
	CI	0.3–1.4	0.8–3.1	0.8–2.5	0.0–0.7	
Other female (183–184)	Observed	0	4	3	3	
	SMR	0.00	2.81	1.27	0.91	(0.41)
	CI	0.0–6.8	0.8–7.2	0.3–3.7	0.2–2.7	
Endocrine, nutritional. metabolic diseases	Observed	4	3	2	2	
(240–279)	SMR	15.11	1.19	0.69	0.99	(0.14)
	CI	4.1–38.7	0.2–3.5	0.1–2.5	0.1–3.6	
Diabetes mellitus (250)	Observed	4	2	2	2	
	SMR	∞	1.81	1.01	1.28	—
	CI	—	0.2–6.5	0.1–3.7	0.1–4.6	
Diseases of circulatory system (390–458)	Observed	92	92	71	23	
	SMR	1.53	1.16	0.99	0.64	(0.0001)
	CI	1.2–1.9	0.9–1.4	0.8–1.3	0.4–0.96	
Ischemic heart disease (410–414)	Observed	56	59	48	9	
	SMR	1.77	1.31	1.15	0.44	(<0.0001)
	CI	1.3–2.3	1.00–1.7	0.9–1.5	0.2–0.8	

TABLE III. *(continued)*

Cause of death (ICD-8th revision)		Birth cohort				
		< 1890	1890–99	1900–09	1910+	P-trend[a]
Cerebrovascular disease (430–438)	Observed	19	20	14	9	
	SMR	1.22	1.00	0.91	1.20	0.96
	CI	0.7–1.9	0.6–1.6	0.5–1.5	0.6–2.3	
Diseases of respiratory system (460–519)	Observed	7	7	4	4	
	SMR	4.66	1.14	0.40	0.49	(0.02)
	CI	1.9–9.6	0.5–2.4	0.1–1.02	0.1–1.3	
Diseases of digestive system (520–577)	Observed	7	5	7	7	
	SMR	5.51	1.71	1.57	1.68	(0.24)
	CI	2.2–11.4	0.6–4.0	0.6–3.2	0.7–3.5	
Diseases of genitourinary system (580–629)	Observed	1	2	5	1	
	SMR	1.35	0.99	1.80	0.69	(0.61)
	CI	0.0–7.5	0.1–3.6	0.6–4.2	0.0–3.8	
Accidents, poisonings, violence (800–998)	Observed	6	3	1	2	
	SMR	2.23	0.87	0.22	0.38	(0.049)
	CI	0.8–4.9	0.2–2.5	0.0–1.2	0.0–1.4	

[a]Values shown in parentheses denote decreasing trends.

cancer. A common etiology may also be involved in the observed excess for gastrointestinal diseases, especially gastric and duodenal ulcers.

It is unclear why nuns had higher risks for digestive diseases, ulcers, and diabetes when compared to other technologists but not to the general population. Nuns may be more similar to the heterogeneous general population with respect to prevalence of infection, as well as dietary and weight patterns. H. pylori is known to be prevalent among groups typically served by nuns, including institutionalized [Malaty et al., 1996; Bohmer et al., 19971 and socioeconomically disadvantaged [Malaty and Graham, 1994; Replogle et al., 1995] populations. Responses by 250 nuns and 69,267 other technologists to a survey conducted during 1984–87 revealed that nuns had a higher median weight than other technologists in all birth cohorts (< 1900, 1900–09, ..., 1950+).

A 20% greater risk of breast cancer compared to U.S. females agrees with previous studies based on general population comparisons [Tayloret al., 1959; Fraumeni et al., 1969; Butler and Snowdon, 19961, and is consistent with an increased risk associated with nulliparity [Henderson et al., 1996]. The lack of an increased overall risk for nuns compared to other technologists may reflect similarities in reproductive risk factors, since women in the labor force are more likely than nonworking women to be nulliparous or to delay childbearing [McLaughlin et al., 19861, and socioeconomic or educational status. This pattern could also be explained by a radiation effect, with nuns having exposures that were greater than women in the general population and generally similar to other technologists. A large proportion of the nuns worked in the early years, when radiation exposures were higher and safety precautions were less stringent. In a pattern similar to that found for all female technologists compared to U.S. females [Doody et al., 1998], risk was elevated among nuns certified before 1940 compared to other technologists (SMR = 1.2; CI = 0.8–1.8) and to women in the general population (SMR = 2.0; CI = 1.3–3.0). For both comparisons, risk declined significantly with more recent calendar periods of certification (P-trend < 0.01). In contrast to findings based on the entire cohort, risk did not increase with increasing duration of certification among those certified < 1940 (based on 24 cases). Unfortunately, number of years certified was the best available measure of exposure for decedents. A review of employment history data, as reported on questionnaires by approximately 300 female technologists who were certified before 1940, indicated that most (89%) worked in the field for a number of years before they were certified (average. 4.5 years). We are also aware that some percentage of technologists renew their certification annually even when not working in the field to avoid having to retest for certification following a lapse. Thus, number of years certified is, at best, a crude measure of exposure.

The absence of cervical cancer in our study is consistent with previous reports on nuns [Tayloret al., 1959; Fraumeni et al., 1969; Butler and Snowdon, 1996], whose celibate lifestyle precludes sexual transmission of the human papilloma virus, the primary risk factor for cervical cancer [Schiffman et al., 19961.

TABLE IV. Observed Cause-Specific Deaths Through 1/1/95 among Nun Radiologic Technologists, Standardized Mortality Ratios (SMR) Relative *to* Other Female Technologists, and 95% Confidence Intervals (CI), by Attained Age

Cause of death (ICD-8th revision)		Attained age				
		< 50	50–59	60–69	70+	P-trend[a]
	Persons	979	1,016	933	723	
	Person-years	13,528	9,420	8,242	8,400	
	Mean (age)	42	54	64	79	
All causes (000–999)	Observed	31	37	91	424	
	SMR	1.49	0.86	0.81	1.21	0.06
	CI	1.01–2.1	0.6–1.2	0.7–1.00	11–1.3	
Infectious. parasitic diseases (000–139)	Observed	7	0	1	5	
	SMR	6.41	0.00	0.38	1.19	(0.003)
	CI	2.6–13.2	0.0–23.6	0.0–2.1	0.4–2.8	
Tuberculosis (010–019)	Observed	6	0	1	3	
	SMR	5.81	0.00	0.41	1.39	—
	CI	2.1–12.7	—	00–2.3	0.3–4.1	
All malignant neoplasms (140–209)	Observed	8	13	31	76	
	SMR	1.04	0.64	0.65	1.01	0.12
	CI	0.5–2.1	0.3–1.1	0.4–0.9	0.8–1.3	
Stomach (151)	Observed	1	1	3	3	
	SMR	2.56	1.50	5.19	2.15	(0.96)
	CI	0.0–14.2	0.0–8.4	1.04–15.2	0.4–6.3	
Colon (153)	Observed	1	2	2	13	
	SMR	0.70	1.38	0.19	1.35	0.09
	CI	0.0–3.9	0.2–5.0	0.0–0.7	0.7–2.3	
Pancreas (157)	Observed	0	0	1	7	
	SMR	0.00	0.00	0.69	2.56	0.049
	CI	0.0–130.4	0.0–3.9	0.0–3.9	1.02–5.3	
Lung (162)	Observed	0	2	1	5	
	SMR	0.00	0.81	0.21	0.53	0.90
	CI	0.0–9.9	0.1–2.9	0.0–1.2	0.2–1.2	
Breast (174)	Observed	1	4	11	16	
	SMR	0.56	0.72	0.94	0.94	0.58
	CI	0.0–3.1	0.2–1.9	0.5–1.7	0.5–1.5	
Other female (183–184)	Observed	1	1	3	5	
	SMR	0.74	1.07	0.95	2.10	0.24
	CI	0.0–4.1	0.0–5.9	0.2–2.8	0.7–4.9	
Endocrine, nutritional, metabolic diseases (240–279)	Observed	1	0	1	9	
	SMR	1.42	0.00	0.88	1.59	0.63
	CI	0.0–7.9	0.0–11.9	0.0–4.9	0.7–3.0	
Diabetes mellitus (250)	Observed	1	0	1	8	
	SMR	1.73	0.00	1.26	2.47	0.57
	CI	0.0–9.6	0.0–48.1	0.0–7.0	11–4.9	
Diseases of circulatory system (390–458)	Observed	6	15	37	220	
	SMR	1.20	1.08	0.83	1.18	0.22
	CI	0.4–2.6	0.6–1.8	0.6–1.1	1.03–1.3	
Ischemic heart disease (410–414)	Observed	3	10	19	140	
	SMR	2.00	1.72	0.78	1.29	(0.03)
	CI	0.4–5.8	0.8–3.2	0.5–1.2	11–1.5	

TABLE IV. (*continued*)

Cause of death (ICD-8th revision)		Attained age				P-trend[a]
		<50	50–59	60–69	70+	
Cerebrovascular disease (430–438)	Observed	1	3	12	46	
	SMR	0.50	0.81	1.39	1.03	0.81
	CI	0.0–2.8	0.2–2.4	0.7–2.4	0.8–1.4	
Diseases of respiratory system (460–519)	Observed	1	1	2	18	
	SMR	2.69	1.26	0.48	0.87	(0.78)
	CI	0.0–15.0	0.0–7.0	0.1–1.7	0.5–1.4	
Diseases of digestive system (520–577)	Observed	1	2	4	19	
	SMR	0.58	1.22	1.95	2.52	0.07
	CI	0.0–3.2	0.1–4.4	0.5–5.0	1.5–3.9	
Diseases of genitourinary system (580–629)	Observed	0	0	2	7	
	SMR	0.00	0.00	5.07	1.31	0.42
	CI	0.0–4.1	0.0–9.6	0.6–18.3	0.5–2.7	
Accidents, poisonings, violence (800–998)	Observed	2	1	2	7	
	SMR	0.79	0.34	0.38	1.22	0.38
	CI	0.1–2.9	0.0–1.9	0.0–1.4	0.5–2.5	

[a]Values shown in parentheses denote decreasing trends

The observed deficit of lung cancer among nuns compared to other technologists and U.S. females resembles earlier reports [Kinlen, 1982; Butler and Snowdon, 19961, and is attributable to the lack of cigarette smoking among women in Catholic religious orders [Nix and Villarmbia, 19611. Among the nuns in our study who completed a questionnaire, only 11% reported ever smoking cigarettes compared to 50% of other female technologists. In 1985, it was estimated that cigarette smoking accounted for 79% of female lung cancers [Surgeon General, 19891. In this cohort of radiologic technologists, we previously reported that risk of lung cancer was not affected by occupational exposure to radiation [Doody et al., 1998].

Our study is one of the few cohort studies to evaluate the all-cause and cause-specific mortality among Catholic nuns, and the first to make comparisons with other working women. A major advantage of this study is the very long follow-up (mean, 36 years) and large percentage of subjects with complete follow-up (53% deceased). Limitations of our study include the small size of the cohort of nuns, possible misclassification of exposure based on number of years certified, restriction of disease outcomes to mortality data only. and a lack of individual data for decedents on smoking. alcohol consumption, diet, and other predisposing risk factors.

In summary, the mortality experience of nuns in our study of radiologic technologists resembles that reported in earlier studies of nuns with respect to comparisons with general population rates. However, when compared with other technologists, we observed excess mortality risks for all causes, stomach cancer, diabetes, ischemic heart disease, all digestive diseases, and gastric or duodenal ulcers, and a lower than expected risk for breast cancer. Because of their status as working women, the nuns are probably more similar to other technologists than to the general U.S. female population, in spite of differences in parity, diet, smoking, alcohol consumption, and other risk factors. Our findings underscore the importance of reproductive and lifestyle factors in the occurrence of cancer and other diseases, and the value of having an appropriate comparison group. There was little evidence to suggest that occupational radiation exposure contributes to the mortality patterns observed among nuns, although we could not exclude the possibility of a radiation-related excess for breast cancer among nuns certified as technologists before 1940. To clarify this issue, an exposure assessment effort is currently underway to estimate radiation exposures for all cohort members.

ACKNOWLEDGMENTS

We thank Jerry Reid of the American Registry of Radiologic Technologists for support to this research effort; Diane Kampa, Pat Rogers, and Deb Engelhard of the University of Minnesota for data collection coordination; Daniel Wilson and Kathy Chimes of Westat, Inc. for study and data management support; and Joe Barker, Bob Banks. and Dave Hacker of Information Management Services, Inc. for biomedical computing.

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