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Cancer Mortality Among Women Employed in Health Care Occupations in 24 U.S. States, 1984–1993

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Background *Health care workers are potentially exposed to a number of carcinogens. Studies among women in this field have focused on white nurses; however, workers in many health care occupations share exposures experienced by nurses.*

Methods *Cancer mortality was examined among female health care workers using death certificate data collected in 24 U.S. states from 1984 through 1993. Cancer mortality odds ratios (MORs) were calculated by race (white, black) and age group.*

Results *White nurses had a 30% elevation of mortality due to liver cancer and myeloid leukemia. White registered nurses (RNs) had a small excess and white licensed practical nurses (LPNs) had a small deficit of mortality due to breast cancer. Ovarian cancer was in excess among RNs, but decreased among LPNs. Among black nurses, excesses of death due to kidney cancer (MOR = 1.7) and multiple myeloma (MOR = 1.3), and a significant 50% deficit in mortality due to cancer of the esophagus were found. Black RNs, but not LPNs, had an excess of breast cancer (MOR = 1.3; 95% CI = 1.0–1.5). Ovarian cancer was elevated by 30% in both RNs and LPNs. Excess deaths due to cancers of the breast, ovary, and uterus occurred among white physicians. Among black physicians, lung cancer was significantly elevated (MOR = 2.8). White pharmacists had significant excesses of breast (MOR = 1.5) and ovarian (MOR = 2.4) cancers, and myeloid leukemia (MOR = 2.0). White clinical laboratory technicians had excess deaths from several cancers. The greatest excess was for myeloid leukemia (MOR = 2.3; 95% CI = 1.5–3.4). Excesses among radiologic technologists included cancers of the lung, pancreas, breast, uterus, and ovary.*

Conclusion *Several findings reported here warrant further investigation. In particular, excesses of myeloid leukemia among nurses, pharmacists, and clinical laboratory technicians and liver cancer among nurses should be investigated in studies with data on occupational and other exposures. Patterns of mortality from breast and ovarian cancers found in this study must be evaluated further in studies with data on reproductive history.* Am. J. Ind. Med. 36:159–165, 1999. *Published 1999 Wiley-Liss, Inc.*†

KEY WORDS: cancer; mortality; health care; women; occupation

INTRODUCTION

Health care workers are potentially exposed to numerous suspected and established carcinogens, including radiation, chemotherapeutic drugs, and viruses [Hewitt et al., 1993]. For example, antineoplastic drugs are most commonly used as a treatment for cancer, but they are also used

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as therapeutic agents for multiple sclerosis, psoriasis, and rheumatoid arthritis. Also, exposure may occur during the preparation or administration of the drugs through absorption by direct contact with skin or by inhalation of the aerosolized drugs [Stellman and Zoloth, 1986; Stellman, 1987]. Therefore, nurses and physicians in a number of specialties and other health care workers who prepare therapies or work in areas in which these therapies are prepared or administered may be exposed to these agents. Physicians [Skov et al., 1990] and nurses [Skov et al., 1992] with potential occupational exposure to antineoplastic drugs have been found to be at increased risk of leukemia. Exposure to ionizing radiation is also a concern in health care. Exposure may occur through the use of X-rays or through the use of radioactive materials used in either diagnosis or treatment. Ionizing radiation is a risk factor for leukemia and cancers of the lung and breast [UN Scientific Committee on the Effects of Ionizing Radiation, 1993].

Epidemiologic investigations of cancer risk among female health care workers have mainly focused on white nurses [Katz, 1983; Bulbulyan et al., 1992; Morton, 1995; Sankila et al., 1990; Gunnarsdóttir and Rafnsson, 1995, 1997; Habel et al., 1995; Coogan et al., 1996; Threlfall et al., 1985; King et al., 1994] and radiologic technologists [Wang et al., 1990; Boice et al., 1995; Doody et al., 1998]. However, exposures experienced by nurses are shared by a number of health care workers. We studied cancer mortality among both black and white female health care workers in a number of occupations with potential exposure to suspected or established carcinogens.

MATERIALS AND METHODS

In a collaborative effort by the National Cancer Institute, the National Institute for Occupational Safety and Health, and the National Center for Health Statistics, a database has been established including industry and occupational titles and cause of death from the death certificates in 24 U.S. states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Washington, West Virginia, Wisconsin, Vermont) for the years 1984 through 1993. Occupational and industry information listed on death certificates are reported by next-of-kin as the decedents' usual occupation and industry. The 1980 Bureau of the Census Index of Industries and Occupations [US Department of Commerce, 1982] was used to code occupation and industry.

Mortality odds ratios (MORs) and 95% confidence intervals (CI), calculated according to Miettinen and Wang [1981], were used to estimate the relative risk of death by cancer site among registered nurses (RNs); licensed practical nurses (LPNs); physicians; other practitioners, which included practitioners not elsewhere classified (n.e.c.), dentists, and optometrists; pharmacists; clinical laboratory technologists; health technologists; radiologic technologists; and dental hygienists and assistants. All noncancer deaths were used as the referent category. For each cancer site, expected numbers of deaths were calculated for age, race, and calendar year. Race (white vs. black) and age-specific (20–39, 40–59, 60–74, and 75+) MORs were calculated where numbers permitted. We reported MORs only for cancer sites with five or more cases in one of the races and focused on elevations or deficits of 30% or greater.

RESULTS

Results for RNs and LPNs combined are shown in Table I. There were 14,740 cancer deaths among white nurses. Deaths due to liver cancer and myeloid leukemia were in excess. A deficit of mortality was observed for cervical cancer. There was no elevation of either breast or ovarian cancers in this group. However, results varied by type of nurse. MORs for ovarian (MOR = 1.3) and breast cancers (MOR = 1.2) were higher than expected for registered nurses, but lower than expected for LPNs. Brain cancer deaths were also in excess among RNs, but not among LPNs. Among black nurses, 1,634 cancer deaths occurred. The MORs were elevated for kidney cancer and multiple myeloma. Fewer deaths than expected were seen for esophageal cancer. Unlike white nurses, the risk of dying due to breast, ovarian, and brain cancers did not differ between RNs and LPNs.

Analyses stratified by age revealed that among white nurses the excess of liver cancer was due solely to elevations in the two older age groups (ages 60–74, MOR = 1.4; age 75+, MOR = 1.5). Myeloid leukemia was in excess among older nurses with the greatest excess in women age 60–74 years (MOR = 1.4). For black nurses, a nonsignificant excess of mortality due to liver cancer was seen in the age group 60–74. An elevation of kidney cancer among black nurses was seen among women in all age groups except the youngest. Multiple myeloma was elevated only in women age 60–74 (MOR = 1.7).

Cancer MORs for physicians, pharmacists, and the combined group of practitioners (''other practitioners'') are shown in Table II. Among white physicians, there were 229 cancer deaths, which was slightly greater than the number expected. Excesses of deaths due to cancers of the breast, uterus, and ovary were seen. There was a large excess of lung cancers among black physicians, although this estimate was based on only four cases. White pharmacists had an excess of overall cancer deaths (n = 193), breast, ovary, leukemia and aleukemia, and myeloid leukemia. Among white women who had occupations in the ''other practitioners'' category, there were 110 cancer deaths, an excess of 50%. Increased risks of mortality from breast and brain

TABLE I. Mortality by Selected Cancer Site Among Female Nurses in 24 U.S. States, 1984–1993*

Cancer site	White n, MOR (95% CI)	Black n, MOR (95% CI)
All cancers	14,740, 1.0 (1.0–1.0)	1,634, 1.1 (1.1–1.2)
Lip, salivary glands and buccal cavity	65, 0.7 (0.5–0.9)	11, 1.0 (0.6–1.9)
Esophagus	112, 0.9 (0.8–1.1)	17, 0.5 (0.3–0.8)
Stomach	259, 0.9 (0.8–1.0)	54, 1.2 (0.9–1.5)
Colon	1,563, 1.0 (1.0–1.1)	188, 1.2 (1.0–1.4)
Rectum	171, 0.8 (0.7–0.9)	17, 0.9 (0.6–1.4)
Liver	78, 1.3 (1.1–1.7)	9, 1.2 (0.6–2.3)
Pancreas	786, 1.1 (1.0–1.1)	105, 1.2 (1.0–1.4)
Lung	3,010, 1.0 (1.0–1.1)	308, 1.2 (1.1–1.3)
Soft tissue sarcoma	113, 1.2 (1.0–1.4)	13, 1.0 (0.6–1.7)
Melanoma	192, 1.1 (0.9–1.3)	4, 1.1 (0.4–3.0)
Breast		
All	2,902, 1.1 (1.0–1.1)	346, 1.2 (1.1–1.4)
RN	2,342, 1.2 (1.1–1.2)	234, 1.3 (1.1–1.5)
LPN	560, 0.8 (0.7–0.9)	112, 1.2 (1.0–1.4)
Ovary		
All	931, 1.1 (1.1–1.2)	75, 1.3 (1.0–1.6)
RN	779, 1.3 (1.2–1.4)	47, 1.3 (0.9–1.7)
LPN	152, 0.7 (0.6–0.8)	28, 1.3 (0.9–2.0)
Brain		
All	401, 1.2 (1.1–1.3)	16, 1.0 (0.6–1.7)
RN	326, 1.3 (1.2–1.5)	10, 1.0 (0.5–1.9)
LPN	75, 0.9 (0.7–1.1)	19, 1.0 (0.6–1.6)
Uterine	362, 1.0 (0.9–1.1)	53, 1.0 (0.8–1.3)
Cervix	169, 0.6 (0.5–0.7)	54, 0.9 (0.7–1.1)
Bladder	188, 0.9 (0.8–1.1)	20, 1.0 (0.6–1.4)
Kidney renal pelvis	245, 1.0 (0.4–1.1)	32, 1.7 (1.2–2.3)
Thyroid	31, 0.8 (0.6–1.2)	
Non-Hodgkin's lymphoma	637, 1.1 (1.1–1.2)	32, 1.2 (0.8–1.6)
Hodgkin's	51, 1.2 (0.9–1.6)	4, 1.3 (0.5–3.5)
Multiple myeloma	250, 1.0 (0.9–1.1)	57, 1.3 (1.0–1.7)
Leukemia and aleukemia	546, 1.1 (1.0–1.2)	42, 1.2 (0.9–1.6)
Myeloid leukemia	274, 1.3 (1.1–1.4)	21, 1.2 (0.8–1.9)

*Sites with five or more exposed cases in at least one race were included. MORs were calculated in cells with three or more exposed cases.

cancers were also seen. There were too few cancer deaths (<5) among black pharmacists and other practitioners to permit analyses.

Results for technologists, technicians, and dental hygienists and assistants are presented in Table III. There were 722 cancer deaths among white clinical laboratory technologists. This group experienced excess mortality from breast cancer, non-Hodgkin's lymphoma, multiple myeloma, and myeloid leukemia. There were 123 cancer deaths among black clinical laboratory technologists, which was slightly greater than expected. Excesses among this group were seen for colon cancer and leukemia and aleukemia.

Overall cancer mortality was elevated among white radiologic technologists and technicians (n = 250). Excesses of cancer deaths were seen for the individual sites of pancreas, lung, connective tissue, skin (melanoma), breast, ovary, and uterus. Black radiologic technologists and technicians had elevated MORs for all cancers combined (n = 25), and based on a small number of cases, cancers of the colon, pancreas, lung, and breast.

White health technologists experienced 416 cancer deaths. Excesses of brain and lung cancer deaths were observed. Among black health technologists, greater than expected numbers of deaths from all cancers combined (n = 102), lung, and ovarian cancers were seen.

All cancers combined (n = 583), colon, pancreatic, breast, and ovarian cancers and non-Hodgkin's lymphoma were significantly elevated among white dental hygienists and assistants. Black dental hygienists and assistants experienced excess mortality due to all cancers combined (n = 29), pancreatic, lung, and breast cancers.

DISCUSSION

Studies which have reported cancer mortality or incidence among female health care workers have mainly focused on nurses [Katz, 1983; Bulbulyan et al., 1992; Morton, 1995; Sankila et al., 1990; Gunnarsdóttir and Rafnsson, 1995; Habel et al., 1995; Coogan et al., 1996; Threlfall et al., 1985; King et al., 1994] and radiologic technologists [Wang et al., 1990; Doody et al., 1995, 1998; Boice et al., 1995]. We examined cancer mortality by occupation for several health care professions in addition to nurses and stratified by race (white/black) and age, where numbers permitted. A number of excesses and a few deficits were found for certain groups, which may be related to occupational exposures or other factors associated with the jobs.

An excess of liver cancer was observed among the older nurses, which may have been due to hepatitis B infection. Increased risk of liver cancer was not seen among younger nurses, who may have benefited from the hepatitis B vaccine, which was introduced in 1982. The majority of recipients of the vaccine have been younger nurses [Mundt, 1992]. Few studies of nurses included estimates for the risk of liver cancer. Those that did had too few cases for a meaningful evaluation [Sankila et al., 1990; Gunnarsdóttir and Rafnsson, 1995]. In the present study, there were too few cases in most of the other occupations to calculate a meaningful MOR.

Mortality due to myeloid leukemia was significantly elevated among pharmacists, nurses, and clinical laboratory technologists, and nonsignificant excesses were seen among other practitioners, health technologists, and dental hygien-

TABLE II. Mortality by Selected Cancer Sites Among Female Health Care Professionals in 24 U.S. States, 1984–1993[a]

Cancer site White Black	Physicians n, MOR (95% CI)	Pharmacists[b] n, MOR (95% CI)	Other practitioners[b] n, MOR (95% CI)
All cancers	229, 1.2 (1.1–1.5)	193, 1.3 (1.1–1.5)	110, 1.5 (1.2–1.8)
	12, 1.4 (0.8–2.6)		
Colon[b]	19, 1.0 (0.6–1.6)	20, 1.2 (0.8–1.8)	8, 1.0 (0.5–1.9)
Lung	34, 0.9 (0.7–1.3)	30, 1.0 (0.7–1.5)	19, 1.4 (0.9–2.2)
	4, 2.8 (1.1–6.0)		
Breast	53, 1.4 (1.0–1.8)	41, 1.5 (1.1–2.0)	23, 1.6 (1.1–2.4)
	3, 1.5 (0.5–4.4)		
Uterus[b]	10, 2.3 (1.3–4.3)	5, 1.4 (0.6–3.1)	
Ovary[b]	21, 2.0 (1.3–3.1)	20, 2.4 (1.6–3.7)	5, 1.2 (0.6–2.7)
Brain[b]	8, 1.7 (0.8–3.3)	5, 1.4 (0.6–3.2)	8, 4.2 (2.2–7.9)
Non-Hodgkin's lymphoma[b]	6, 0.9 (0.4–2.0)	9, 1.5 (0.8–2.8)	
Leukemia and aleukemia[b]	8, 1.2 (0.6–2.4)	11, 1.9 (1.0–3.4)	5, 1.7 (0.7–3.9)
Myeloid leukemia[b]	4, 1.3 (0.5–3.4)	5, 2.0 (2.8–4.6)	

[a]Sites with five or more exposed cases in at least one race were included. MORs were calculated in cells with three or more exposed cases.
[b]There were too few cases among black women to permit analyses.

ists and assistants. Nurses exposed to chemotherapeutic agents have been found to have high concentrations of these drugs in their urine [Stellman and Zoloth, 1986; Mader et al., 1996]. Health care workers who do not have direct contact with anticancer agents may also be exposed. Mader et al. [1996] showed that concentrations of drugs can be detected in urine of those present in the room in which infusions were prepared, and among nurses who cared for patients who received chemotherapy. Drug concentrations were detected in the vomit and sweat of patients who received high-dose therapy; this could explain exposure among nurses who took care of infusion patients, but did not administer therapy. Also, through an experiment using simulation, Stellman [1987] found that traces of chemotherapeutic agents were detectable in workstations and on walls in rooms in which therapies were administered. Chromosomal damage has been associated with exposure among nurses [Goloni-Bertollo et al., 1992] and pharmacists [McDiarmid et al., 1992]. However, as we did not have data on subjects' exposures, we cannot conclude that the increases seen in the present study were due to occupational exposures. Excess risk of leukemia has been observed in previous studies of nurses [Gunnarsdóttir and Rafnsson 1995, 1997; Skov et al., 1992; Hewitt et al., 1993], as well as physicians [Skov et al., 1992]. The excess of myeloid leukemia in white nurses was due to elevations in nurses age 60 years and older. Although younger nurses are more likely to work directly with chemotherapeutic agents and have been found previously to be at increased risk of leukemia [Hewitt et al., 1993], the increase seen in our study may be the result of exposure to these drugs and may be the effect of latency.

An excess of mortality due to lung cancer was seen among black physicians, black and white radiologic technologists, both black and white health technologists, and black dental hygienists and assistants. Radiation is a known lung carcinogen [UN Scientific Committee on the Effects of Ionizing Radiation, 1993]; however, lung cancer was not related to radiation exposure among radiologic technologists in one study [Doody et al., 1998].

Black RNs, physicians, pharmacists, radiologic technologists, laboratory technicians, and dental hygienists had excesses of mortality due to breast cancer. The numbers of breast cancer deaths were so large that even small excesses were significant, such as that seen among white RNs. This may or may not be an important excess. All white nurses combined, black LPNs, and health technologists did not have an excess of breast cancer deaths. White LPNs had a deficit of risk. These findings suggest confounding by factors related to socioeconomic status (SES) or reproductive history, as many of the excesses were in high SES occupations requiring a college education. Findings of previous studies have been inconsistent with regard to the risk of breast cancer among nurses [Katz, 1983; Doebbert et al., 1988; Bulbulyan et al., 1992; King et al., 1994; Sankila et al., 1990; Habel et al., 1995; Coogan et al., 1996]. Some registry-based studies reported elevated mortality due to breast cancer [Bulbulyan et al., 1992; Morton, 1995]. A nested case-control study showed that risk depended on

TABLE III. Mortality by Selected Cancer Sites Among Female Technicians, Technologists, and Dental Hygienists and Assistants in 24 U.S. States, 1984–1993[a]

Cancer site White Black	Clinical laboratory technician n, MOR (95% CI)	Radiologic technician n, MOR (95% CI)	Health technologist n, MOR (95% CI)	Dental hygienists and assistants n, MOR (95% CI)
All cancers	722, 1.2 (1.2–1.3)	250, 1.4 (1.2–1.6)	416, 1.2 (1.0–1.4)	583, 1.3 (1.2–1.4)
	123, 1.2 (1.0–1.5)	25, 2.6 (1.7–4.1)	102, 1.5 (1.2–1.9)	29, 1.8 (1.2–2.7)
Colon	53, 1.0 (0.8–1.3)	18, 1.1 (0.7–1.8)	35, 1.2 (0.8–1.7)	60, 1.3 (1.0–1.7)
	19, 2.0 (1.3–3.2)	3, 3.4 (1.1–10.0)	9, 1.4 (0.8–2.7)	
Liver[b]	3, 1.2 (0.4–4.0)	2, 2.7 (0.7–10.2)	2, 1.4 (0.3–5.3)	
Pancreas	32, 1.2 (0.9–1.7)	13, 1.7 (1.0–2.9)	20, 1.4 (0.9–2.1)	31, 1.4 (1.0–2.0)
	9, 1.7 (0.9–3.3)	3, 6.0 (3.3–11.0)	4, 1.1 (0.4–2.8)	3, 3.5 (1.3–9.9)
Lung	124, 0.9 (0.8–1.1)	56, 1.5 (1.1–2.0)	100, 1.4 (1.1–1.7)	108, 1.2 (1.0–1.4)
	21, 1.2 (0.8–1.8)	6, 3.8 (2.0–7.3)	29, 2.3 (1.6–3.4)	6, 2.3 (1.1–4.7)
Breast	184, 1.4 (1.2–1.6)	59, 1.4 (1.1–1.4)	87, 1.1 (0.9–1.4)	124, 1.4 (1.1–1.7)
	26, 1.1 (0.7–1.6)	5, 2.3 (1.0–5.4)	21, 1.4 (0.9–2.2)	9, 2.6 (1.4–5.0)
Cervix	14, 0.8 (0.5–1.4)		7, 0.7 (0.3–1.4)	8, 0.7 (0.4–1.4)
	9, 1.6 (0.8–3.0)			
Uterus	17, 1.3 (0.8–2.1)	4, 2.5 (1.3–4.9)	9, 1.2 (0.6–2.3)	11, 1.0 (0.6–1.8)
			3, 1.3 (0.5–3.9)	
Ovary	43, 1.2 (0.9–1.6)	20, 1.8 (1.2–2.8)	26, 1.3 (0.9–1.9)	46, 1.8 (1.3–2.4)
			7, 2.6 (1.3–5.4)	
Kidney	13, 1.4 (0.8–2.4)		7, 1.3 (0.6–2.7)	7, 0.9 (0.4–1.9)
	3, 2.2 (0.7–6.3)			
Brain[b]	21, 1.2 (0.8–1.9)	5, 0.9 (0.4–2.1)	17, 1.6 (1.0–2.5)	18, 1.4 (0.9–2.3)
Non-Hodgkin's lymphoma	31, 1.4 (1.0–2.0)	10, 1.5 (0.8–2.8)	17, 1.4 (0.9–2.2)	29, 1.6 (1.1–2.4)
	3, 1.5 (0.5–4.3)			
Multiple myeloma[b]	15, 1.7 (1.0–2.8)	3, 1.2 (0.4–3.5)	5, 1.0 (0.4–2.4)	9, 1.2 (0.6–2.3)
Leukemia and aleukemia	39, 1.9 (1.4–2.6)	4, 1.3 (0.5–3.2)	13, 1.1 (0.6–1.8)	7, 1.6 (0.8–3.3)
	7, 2.7 (1.3–5.4)			
Myeloid leukemia[b]	23, 2.3 (1.5–3.4)	4, 1.3 (0.5–3.2)	10, 1.6 (0.9–3.0)	11, 1.4 (0.8–2.5)

[a]Sites with five or more exposed cases in at least one race were included. MORs were calculated in cells with three or more exposed cases.
[b]There were too few cases among black women to permit analyses.

nursing specialty [Gunnarsdóttir and Rafnsson, 1997]. Increased risk of breast cancer occurred for geriatric, psychiatric, and pediatric wards, operating rooms, intensive care, and those handling cytostatics, while risks were low for all nurses combined and nurses who worked in primary care, medical, anesthesia, and surgery wards. Similar to our finding among black nurses, previous studies in which breast cancer risk was studied separately for RNs and LPNs also found that RNs had an elevation of breast cancer while LPNs did not [Sankila et al., 1990]. No significant increase in risk was seen among nurses in three case-control studies in which occupational data were obtained from participants [Habel et al., 1995; Coogan et al., 1996; Petralia et al., 1999]. Physicians have been found previously to be at an increased risk of breast cancer mortality [Bulbulyan et al., 1992]. However, there was no excess of the incidence of breast cancer in an additional study [Sankila et al., 1990]. In a large cohort of radiologic technologists, exposure was found to be related to mortality [Doody et al., 1998], but not incidence [Doody et al., 1995; Boice et al., 1995]. In another large cohort, the incidence of breast cancer was elevated among diagnostic X-ray workers [Wang et al., 1990].

Black RNs and LPNs, white RNs, pharmacists, physicians, dental hygienists, and assistants had elevated MORs for ovarian cancer. LPNs had a deficit of mortality due to ovarian cancer.

Comparing health care professionals or other professions to all other women may introduce a bias when studying breast and ovarian cancers because women of lower educational attainment or those who do not work outside of the home may be more likely to have their first birth at earlier ages and to have more children than professional women, or may be of lower SES. An example of how this difference could bias results was shown in a proportionate mortality

study of women in British Columbia [Threlfall et al., 1985; King et al., 1994]. In both follow-ups, there were significantly greater than expected breast and ovarian cancer deaths among nurses and physicians compared to all other employed women. However, these findings were not replicated when women with ''homemaker'' listed as her occupation were excluded from the analyses. In the present study, the excesses of breast and ovarian cancer seen among some of the health care professionals may reflect factors related to SES or reproductive history. However, research should be conducted to examine if the excesses are of the magnitude expected because of reproductive risk factors alone, or if other occupational exposures may contribute to risk.

Significantly fewer than expected deaths from cervical cancer were observed among white nurses and most other health professionals compared to the general population. This may be due to access to preventive health care and participation in regular gynecological exams, including pap smears.

Using death certificates for studies of occupation among women is potentially biased by inaccuracies of occupational information. Schade and Swanson [1988] reported a 40% error rate of ''usual occupation'' recorded on death certificates when compared with occupational histories. Inconsistencies with occupational histories may occur when a person has held more than one job. This may be a particularly important problem among women whose usual occupation may be listed as ''homemaker,'' even though they may have been employed outside the home earlier in life.

Associations for which there is little previous support in the literature may be spurious relationships, or may be newly uncovered associations related to occupational exposures. For example, pancreatic cancer was elevated among radiologic technologists. Although this cancer has not previously been reported to be elevated in radiologic technologists, it was correlated with radiation dose among workers at the Hanford site [Gilbert et al., 1993]. Clinical laboratory technicians had excesses of lymphatic and hematopoietic cancers. Laboratory workers previously were found to have excesses of lymphatic and hematopoietic cancers [Belli et al., 1992].

There were certain cancers that were elevated in one race or group of nurses. For one, brain cancer was elevated among white RNs, but not among any other group of nurses. There is some support in the literature for a positive association. Cancer of the nervous system was elevated in one study of nurses [Sankila et al., 1990], and a nonsignificant increase in brain cancer was found among nurses in Shanghai [Heineman et al., 1995]. Elevations of brain cancer cases [Gunnarsdóttir and Rafnsson, 1997] and deaths [Gunnarsdóttir and Rafnsson, 1995] were observed among Icelandic nurses. An excess of kidney cancer deaths was observed among black nurses in our study and in two previous studies [Sankila et al., 1990; Gunnarsdóttir and Rafnsson, 1995]. Excesses of multiple myeloma were seen among black nurses, but not among white nurses in our study. While inconsistency by race weakens a causal interpretation, it is possible that race is related to nursing subspecialty and therefore occupational exposures, or other nonoccupational exposures. More detail on work history and occupational exposures, as well as nonoccupational exposures and selection factors would help to clarify this association.

Occupational mortality studies based on death certificate data can provide useful information; however, the findings must be interpreted cautiously because of the inherent limitations of the data, such as possible misclassification of occupation or disease, lack of data on occupational exposure, and lack of information on confounders. Studies of health care workers in which information on specialty, occupational exposures, vaccinations, and potential confounders are necessary to clarify the results reported here and by other researchers.

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