Journal of Gerontology: SOCIAL SCIENCES
1996, Vol. 51B, No. 4, S201–S208

Trends in Mortality in Older Women: Findings From the Nun Study

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During this century, Catholic sisters have remained constant in many life-style characteristics such as smoking and reproduction (Catholic sisters are nonsmoking and nulliparous). It is therefore of interest to compare trends in the health of elderly Catholic sisters to those in the general population. In this study, mortality rates at ages 50 to 84 years in a population of 2,573 Catholic sisters were compared to those in the general population during the years 1965 to 1989. The Catholic sisters had a mortality advantage that increased dramatically over calendar time, and from early to more recent birth cohorts. This coincided with increases in smoking by U.S. women, while during the same time period the Catholic sisters had very low rates of mortality from smoking-related diseases. The Catholic sisters had high rates of mortality from cancers of the breast and reproductive organs, suggesting an effect of nulliparity manifested in older women.

AGE-SPECIFIC mortality rates in 50- to 84-year-old U.S. women have decreased by about 2 percent per year during the latter half of this century (Taeuber, 1991). Undoubtedly, changes in life style, environment, and medical care services have contributed to this decrease. However, some changes in the life styles of U.S. women may have been detrimental, leading to a slower decrease in mortality than was otherwise possible. An important example is the increase in cigarette smoking during the middle and latter part of this century (U.S. DHHS, 1992). Cigarette smoking probably caused the dramatic increase in lung cancer mortality in U.S. women after 1960 (Becket, 1993; Samet, 1993; Sherman, 1991; U.S. DHHS, 1989) and may have added to mortality from other cancers, cardiovascular diseases, and non-malignant respiratory diseases (Sherman, 1991; U.S. DHHS, 1980, 1983, 1990).

Some U.S. populations such as Mormons, Seventh-day Adventists, and Catholic sisters (nuns) have maintained more stable and, in some ways, healthier life-style practices during this century than has the U.S. general population. For example, our study population of older Catholic sisters in the School Sisters of Notre Dame religious congregation have had similar occupations, living arrangements, and reproductive history. They have never smoked tobacco, and they have seldom drunk alcohol. Due to this constancy of life style, Catholic sisters may provide a standard for exploring the health effects of certain life-style changes in the general U.S. female population. Catholic sisters also present an opportunity to study the well-established effects of nulliparity on mortality from breast cancer in older women (Ewertz, 1993; Kelsey, Gammon, and John, 1993; Vatton and Kvinnsland, 1992) and they present an opportunity to study the possible effects of nulliparity on mortality from cancers of the reproductive organs in older women.

Previous studies have compared mortality rates in U.S. Catholic sisters to the general population with an emphasis on cancers of the breast and reproductive organs. Taylor, Carroll, and Lloyd (1959) studied mortality occurring during 1900 to 1954 in 2,637 Catholic sisters from three orders in Massachusetts and New York. These Catholic sisters were born in the years 1870 to 1909. Fraumeni et al. (1969) studied mortality occurring in the same period for Catholic sisters from 41 U.S. communities, and concentrated their analyses on 7,308 Catholic sisters born in the years 1850 to 1889. There were previous studies of mortality in Catholic sisters in the U.S. and elsewhere, but they were not designed in a way that allowed the estimation of rates of mortality from breast cancer and cancer of the reproductive organs.

The study of Taylor, Carroll, and Lloyd (1959) and the study of Fraumeni et al. (1969) both found that rates of mortality from breast cancer were relatively high in Catholic sisters, particularly after age 60. There was evidence for a crossover in one study (Taylor, Carroll, and Lloyd, 1959) in which the rates for breast cancer mortality were lower than those in the general population before age 50, but higher than those in the general population after age 50. The higher risk after age 50 is consistent with studies of risk factors for breast cancer, which have found an increased risk associated with nulliparity (with a relative risk between 1.2 and 1.7). Most studies reporting the age at diagnosis have found this effect only in women older than 40 to 45 years (Kelsey, Gammon, and John, 1993).

The study of Taylor, Carroll, and Lloyd (1959) and the study of Fraumeni et al. (1969) both found that the rates of mortality from cancers of the reproductive organs were relatively low in Catholic sisters. However, Fraumeni et al. (1969) found a crossover after age 70, above which the rates were relatively high in the Catholic sisters. They also observed a crossover for uterine cancer alone, and a possible crossover for cancer of the ovary and Fallopian tubes. Taylor, Carroll, and Lloyd (1959) observed what may have been a small crossover for cancer of the reproductive organs after age 70, and a clearer crossover after age 60 for cancer of the ovary and Fallopian tubes. This suggests that a

crossover may exist in the effect of nulliparity on cancers of the reproductive organs, although it may occur much later than the crossover observed for breast cancer.

A study of Catholic and Anglican sisters in Britain (Kinlen, 1982) considered mortality over the years 1910 to 1978 in vegetarian and nonvegetarian sisters from five religious orders. The nonvegetarian population, which is more similar to our study population, consisted of 1,044 Catholic sisters from three orders. In this population, the rates of mortality from breast and ovarian cancer were near, but slightly higher than, those in the general population. The rate of mortality from uterine cancer was lower than that in the general population. Age-specific rates were not presented.

In the present study we compared mortality rates in a population of 2,573 Catholic sisters to the mortality rates in the general population of U.S. White females. These Catholic sisters were born in the years 1886 to 1916. They were the source population for the 678 participants in the Nun Study, which is a longitudinal study of aging and Alzheimer's disease.

We compared the Catholic sisters to the general population with respect to trends over time in all-cause mortality rates during the calendar years 1965 to 1989, for ages 50 to 84 years. Using an available subset of death certificates for the Catholic sisters, we then compared the populations with respect to proportionate mortality from specific causes of death. We gave particular attention to diseases associated with tobacco smoking, and to cancers of the breast and reproductive organs.

METHODS

Study Population

The study population consisted of members of the School Sisters of Notre Dame, an international religious congregation of Catholic sisters. This congregation has members living in the Eastern, Midwestern, and Southern regions of the United States. The study population included all U.S. members who were born during the years 1886 to 1916, and who survived to the year 1965. Out of the 3,926 U.S. members born during those years, 2,573 contributed person-years to the age groups and time periods considered in the present analysis (i.e., they experienced an age between 50 and 84 years during the years 1965 to 1989). Mortality before age 50 was not considered because of the relatively small number of deaths.

Approximately 99 percent of the Catholic sisters were White and of European descent, and the non-White sisters were primarily Hispanic. Some Catholic sisters left the congregation (6%), mostly (88%) before the age of 50 years. We considered those who left the congregation after age 50 to be right censored at the time of leaving (i.e., they contributed person-years to the mortality rate calculations while they were active members). Some Catholic sisters joined the congregation outside the United States (1.5%), and these sisters contributed person-years only after they immigrated to the U.S.

Dates of birth and death for each Catholic sister were obtained from archives maintained at the convents (e.g., birth certificates, baptismal records, death certificates, and other convent records). Death certificates were available from convent archives for a subset of 454 Catholic sisters who died during the ages and time periods considered in this analysis. All time periods and age groups were represented approximately equally in this subset, excepting the time period 1965 to 1969, which was underrepresented. We know of no reason to suspect biased selection with respect to the cause of death. Coding of death certificates was done according to the ninth revision of the International Classification of Diseases (ICD-9) by a trained nosologist.

Survival Analyses

Analysis of all-cause mortality was done for the entire study population of 2,573 Catholic sisters. The total number of deaths upon which this analysis was based was 1,103, and the cause-specific analysis was done using a subset of 454 deaths. Rates of all-cause and cause-specific mortality for White women in the U.S. were obtained from the Centers for Disease Control and Prevention of the National Center for Health Statistics, and compiled by the Mortality and Population Data System at the University of Pittsburgh for use with the Occupational Mortality Analysis Program (Marsh et al., 1986).

All-cause mortality. — Standardized mortality ratios (SMRs) were used for the all-cause mortality comparisons. An SMR is defined as the ratio of the observed number of deaths in the Catholic sisters to the expected number of deaths based on age-specific (5-year) and calendar year-specific (5-year) mortality rates for the U.S. general population of White females. The resulting ratios were multiplied by 100 to obtain percentages. Individual SMRs were calculated for each of the 5-year age groups (i.e., 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, and 80–84 years) during each of the 5-year time (calendar year) periods (i.e., 1965–1969, 1970–1974, 1975–1979, 1980–1984, and 1985–1989). SMRs were obtained using standard methods (Breslow and Day, 1988; Monson, 1974), and their confidence intervals were based on the Poisson distribution (Bailar and Ederer, 1964).

Weighted least squares regression analysis and Poisson regression analysis were used to investigate trends in the SMRs across time periods, age groups, and birth cohorts (defined later). In the least squares regression analysis, the SMR for each "cell" (i.e., 5-year age group and 5-year time period) was weighted by the inverse of the expected frequency for that cell, based on the rates in the U.S. White female population. (This is the inverse of the variance for the SMR, under the assumption that the cell frequency has a Poisson distribution with a mean equal to the above-expected frequency.) For any collection of cells, the weighted mean of the cell SMRs was then equal to the usual pooled SMR for the combined cells. Poisson regression analyses (Breslow et al., 1983) were also used to assess multiplicative effects, rather than the additive effects assumed in the least squares models. This was done as a confirmatory analysis, in order to assure that our results were independent of the model assumptions.

Cause-specific mortality. — Comparisons of cause-specific mortality were done using standardized proportional

mortality ratios (SPMRs). An SPMR is defined as the proportion of all deaths in the study population attributed to a particular disease or external cause, divided by the expected proportion based on age-specific (5-year), calendar year-specific (5-year), and cause-specific mortality rates in the standard population (Monson, 1974; Zeighami and Morris, 1983). One a priori hypothesis was that diseases associated with smoking would be underrepresented in the Catholic sisters. We also hypothesized that breast cancer, and possibly cancers of the reproductive organs, would be overrepresented in the Catholic sisters. We obtained SPMRs for each 5-year age group in each 5-year time period, and these were used to obtain SPMRs for the pooled age groups and time periods. Confidence intervals were obtained using the method described by Miettinen (1976).

RESULTS

All-Cause Mortality

We compared all-cause mortality rates in the population of 2,573 Catholic sisters to those in the U.S. general population of White women, using standardized mortality ratios (SMRs). The SMR for ages 50 to 84 years during 1965 to 1989 was 73% (95% C.I. 69%–77%). Thus, the observed mortality in the Catholic sisters was 73 percent of the expected mortality based on age-specific (5-year) and calendar time-specific (5-year) mortality rates in the U.S. population of White women.

Age-specific and calendar time-specific SMRs are presented in Table 1. All of these SMRs were below 100%, and most of the 95 percent confidence intervals did not contain 100%. Within each time period, the SMRs increased with age. For most ages there was a decrease in the SMRs over calendar time, most dramatically for the ages 70 to 79 years. A notable exception was the age group 80–84 years, for which the SMRs were consistently between 80% and 84%. The lowest SMRs were between 45% and 55%, which occurred in the youngest ages in each calendar time period. There was a strong decreasing trend from the earliest birth-years to the more recent birth-years.

Each of the diagonals in Table 1 from the upper left corner to the lower right corner corresponds to a birth cohort of individuals (Catholic sisters and U.S. White women) born within a 10-year period. The diagonals have been labeled according to the median birth year for the Catholic sisters in each birth cohort (i.e., 1913, 1909, 1904, 1899, and 1890). The SMRs for diagonals 1913, 1904, and 1894 have been underlined to aid the reader. For example, the diagonal 1913 begins at the calendar time period 1965–69 in the age group 50–54, and it includes the values 55%, 45%, 55%, 54%, and 54%. This diagonal contains data on individuals born in the years 1910–1919, which we will refer to as the 1913 birth cohort. The diagonals 1909 through 1890 contain data on individuals born in the (overlapping) birth-year intervals 1905–1914, 1900–1909, 1895–1904, 1890–1899, and 1886–1894, respectively. The birth-years for the Catholic sisters were evenly distributed in each birth cohort except 1913, which included Catholic sisters born in the years 1910 to 1916, and 1890, which included Catholic sisters born in the years 1886 to 1894.

The birth cohorts overlapped in birth years because most individuals contributed to two adjacent diagonals. For example, a Catholic sister born in 1903 was 61 years old at the beginning of 1965, and she contributed person-years to the first cell of the diagonal 1904 until she reached age 65 on her birthday in 1968. Then she contributed person-years to the first cell of diagonal 1899 until 1970, when she began to contribute person-years to the second cell of diagonal 1904. This alternation continued until 1989, or until she died or left the congregation.

There was a systematic decrease in SMRs across birth cohorts from the earliest (1890) to the most recent (1913). To describe this trend, Table 2 presents SMRs for each birth cohort (pooled over the age groups or time periods). These pooled SMRs decreased systematically from 86% for birth cohort 1890 (95% C.I. 74%–100%) to 53% for birth cohort 1913 (95% C.I. 41%–67%). We also calculated SMRs for each age group (pooled across calendar time periods), and for each calendar time period (pooled across age groups). There was an increasing trend in the pooled SMRs with age, and there was a weak decreasing trend in the pooled SMRs over calendar time.

Table 1. Standardized Mortality Ratios (95% C.I.) for a Population of Catholic Sisters Compared to the U.S. Female Population, for 5-year Age Groups and 5-year Calendar Year (time) Periods

Age Group	Birth-year[a] Cohorts (Diagonals)	Calendar Time Period				
		1965–69	1970–74	1975–79	1980–84	1985–89
50–54	1913	55 (22,113)				
55–59	1909	66 (37,109)	45 (20, 89)			
60–64	1904	60 (36, 95)	53 (31, 85)	55 (29, 94)		
65–69	1899	58 (38, 85)	69 (47, 99)	68 (45, 98)	54 (32, 85)	
70–74	1894	90 (69,114)	69 (50, 92)	67 (47, 92)	72 (52, 97)	54 (35, 78)
75–79	1890	92 (73,114)	75 (59, 95)	82 (64,104)	66 (49, 86)	60 (44, 78)
80–84			82 (65,101)	80 (64, 99)	80 (63, 99)	84 (68,103)

[a]The diagonals are labeled according to the median birth year for the Catholic sisters in each birth cohort.

However, it is clear that the variables birth cohort, age, and calendar time were confounded. For example, earlier birth cohorts were represented by older age groups, as were the later calendar time periods. We used weighted least squares and Poisson regression analyses to assess the trends in the SMRs over birth cohorts, age, and calendar time. Then we used these techniques to adjust the estimated trends over birth cohorts and calendar time for the uneven distribution of the age groups along each of these variables. Since any two of the variables birth cohort, age, and calendar time determined the third, it was impossible to separate the effects of all three variables simultaneously.

To test for trends in the SMRs, we considered the median birth year for each birth cohort, the midpoint for each age group, and the midpoint for each calendar time period as continuous independent variables. In weighted least-squares regression analyses the strongest linear predictor was birth cohort ($R^2 = .61, p < .001$) followed by age ($R^2 = .43, p < .001$), and calendar time ($R^2 = .04$, $p = .33$). With adjustment for age, however, the trend in the SMRs over calendar time became highly significant ($p < .001$), and it was estimated that within age groups the SMRs decreased by .93 points per year (95% C.I. 0.45–1.41) over the period of this study. With adjustment for age, the trend in the SMRs over the birth cohorts remained highly significant ($p < .001$). Notably, the trend with age was only marginally significant after adjustment for birth cohort ($p = .05$).

In further analyses, the variables birth cohort, age, and calendar time were considered to be categorical in weighted least squares regression models. These models explained only a slightly higher proportion of the variability in SMRs. For example, the best (categorical) predictor of the SMRs was again birth cohort ($R^2 = .64, p = .001$) followed by age ($R^2 = .45, p = .08$), and calendar time ($R^2 = .07, p = .84$). The model with categorical versions of age and calendar time gave an R^2 value of .76, as compared to an R^2 value of .68 for the model assuming linear trends in the SMRs over age and calendar time.

The same pattern was observed in analogous Poisson regression analyses, so that the general findings are independent of whether we assume additive or multiplicative effects. For example, Poisson regression analyses showed significant log-linear trends in the SMRs with birth cohort ($p = .003$) or age ($p = .05$), but not calendar time ($p = .74$), and with adjustment for age the log-linear effect of calendar time became highly significant ($p < .001$).

The mortality advantage (i.e., savings) in the Catholic sisters relative to the general population, or the SMRs subtracted from 100 percent, is illustrated in Figure 1. These values are shown for the same age groups and time periods as in Table 1. The advantage generally decreases with age, increases with calendar time within each age group, and increases in more recent birth cohorts.

As we will discuss later, the trends in SMRs may have been largely due to the increase in cigarette smoking by U.S. women. This is supported by the cause-specific mortality comparisons, and by the timing of the trends in all-cause mortality. However, one alternative explanation is that relatively healthier women were recruited to be Catholic sisters in later years. Information on 3,926 sisters born during 1886 to 1916 is available on their place of birth and their age at profession (i.e., the age when they took their vows and formally joined the congregation). We categorized the sisters according to their birth year, which we divided into 5-year intervals from 1886 to 1915. We found that the average age at profession decreased slightly for the Catholic sisters who were born more recently: for Catholic sisters born in 1886–1890, 1891–1895, 1896–1900, 1901–1905, 1906–1910, and 1911–1915, the average ages at profession were 24.8, 24.4, 24.2, 23.8, 23.2, 22.3, and 22.5 years, respectively. The percent born outside the U.S. decreased steadily over the same birth-year intervals: the respective percentages were 20, 14, 15, 13, 7, 5, and 3 percent. To determine whether the latter trend could have affected the results, we repeated our analyses including only those Catholic sisters who were born in the U.S. The results of these restricted analyses were qualitatively identical to the results of the unrestricted analyses.

Further characteristics were available for a subset of 678

Table 2. Standardized Mortality Ratios (SMRs) for a Population of Catholic Sisters by Birth Cohort, Age Group, and Calendar Year (time) Period (with 95% C.I.)

Birth Cohorts		Age Groups		Calendar Time Periods	
Cohort[a]	SMR	Group	SMR	Period	SMR
1913	53 (41, 67)	50–54	55 (22,113)	1965–69	79 (68, 90)
1909	64 (54, 75)	55–59	57 (36, 86)	1970–74	72 (63, 81)
1904	72 (63, 82)	60–64	56 (42, 75)	1975–79	75 (65, 85)
1899	74 (65, 85)	65–69	63 (51, 76)	1980–84	71 (61, 81)
1894	81 (71, 92)	70–74	72 (62, 82)	1985–89	69 (59, 81)
1890	86 (74,100)	75–79	75 (67, 84)		
		80–84	81 (73, 90)		

[a]The birth cohorts are labeled by the median birth year for the Catholic sisters in that birth cohort.

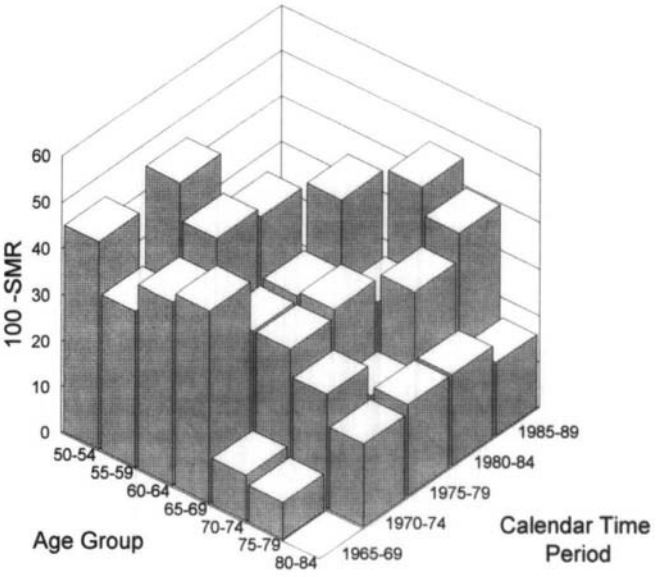

Figure 1. Standardized mortality ratios (SMRs) for the age groups and time periods shown in Table 1, subtracted from 100%. This gives the mortality advantage (i.e., savings) in the Catholic sisters relative to the general population.

Table 3. Standardized Proportional Mortality Ratios (SPMRs) and Estimated Cause-Specific SMRs for a Population of Catholic Sisters, for Causes of Death Related to Smoking or Reproduction (with 95% C.I.)

Cause of death[a]	Observed Number of Deaths in the Catholic Sisters	SPMR	Estimated[b] SMR
Smoking-related cancers	13	50 (30, 84)	37 (22, 62)
Cancer of the respiratory system	3	26 (9, 74)	19 (7, 54)
Other smoking-related cancers	10	69 (37,126)	50 (27, 92)
Non-malignant respiratory disease	17	65 (41,103)	48 (30, 75)
Cerebrovascular disease	45	77 (59,101)	56 (43, 75)
Ischemic heart disease	151	102 (89,116)	74 (64, 86)
Breast cancer	26	182 (125,264)	133 (91,194)
Cancers of the reproductive organs	23	222 (150,329)	162 (109,241)
Uterine cancers	10	209 (114,381)	152 (83,279)
Cancers of other reproductive organs	13	233 (138,394)	170 (100,288)
External causes	10	99 (54,183)	73 (39,134)
All other causes	169	105 (93,119)	77 (67, 88)

[a]Categories (ICD-9 codes). Smoking-related cancers: respiratory (160–165), buccal cavity and pharynx (140–149), esophagus (150), stomach (151), pancreas (157), kidney, bladder, and other urinary organs (188–189); Breast cancer (174–175); Reproductive organ cancers: uterine (179–182), other reproductive organs (183–184); Cerebrovascular disease (430–438); Ischemic heart disease (410–414); Non-malignant respiratory disease (460–519); External causes (800–999).

[b]The estimated cause-specific SMRs are the SPMRs multiplied by the all-cause SMR (.73). These estimate the rate for that cause in the Catholic sisters divided by the rate for that cause in the U.S. White female population. The C.I. limits account for sampling error in the all-cause SMR.

members of our study population who survived to 1991 and participated in the Nun Study (a longitudinal study of aging and Alzheimer's disease). For example, data were available on education. For the Catholic sisters born in 1891–1895, 1896–1900, 1901–1905, 1906–1910, and 1911–1915 the respective percentages having at least a high school diploma were 93, 80, 88, 87, 92, and 96, with an overall percentage of 89. The respective percentages having a college degree were 79, 61, 81, 76, 81, and 86, with an overall percentage of 79. These percentages increased somewhat from the earlier to the later birth cohorts. However, as presented later, the level of education also increased among elderly women from these birth cohorts in several U.S. community surveys. It should be noted that these data are subject to survival effects, which should introduce a bias toward higher education levels at older ages.

Other characteristics were common to all of the Catholic sisters. They never smoked cigarettes, were nulliparous, seldom drank alcohol, were life-long educators or domestic workers, lived communally in convents, had similar social support and social networks, and had similar access to preventive and medical care services.

Cause-Specific Mortality

We used the available subset of death certificates for the Catholic sisters to obtain standardized proportional mortality ratios (SPMRs) for the pooled age groups and calendar time periods (Table 3). We focused mainly on diseases related to smoking or reproduction. The SPMRs are illustrated in Figure 2, which includes a reference line at 100 percent. An SPMR of 100 percent is achieved when the proportion of all deaths due to a particular cause in the study population is equal to the expected proportion based on the age- and calendar time-specific mortality rates in the general population.

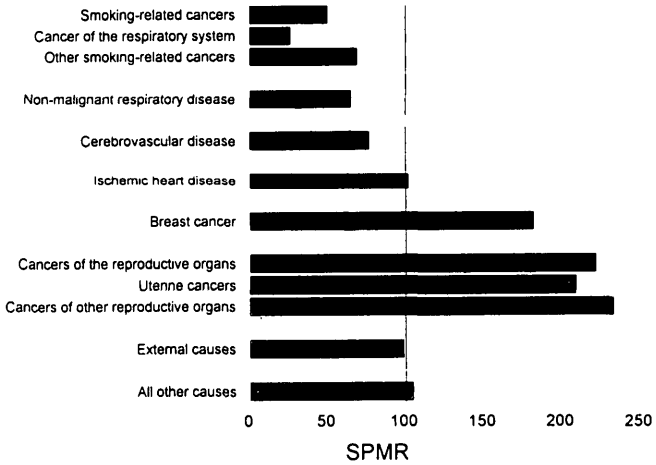

Figure 2. Standardized proportional mortality ratios (SPMRS) for the causes of death shown in Table 3. An SPMR of 100 percent indicates that the proportion of all deaths due to the particular cause in the study population is equal to the expected proportion based on mortality rates in the general population.

Diseases related to smoking. — The following cancers were defined as "smoking-related": buccal cavity, pharynx, respiratory system, esophagus, stomach, pancreas, kidney, bladder, and other urinary organs (Sherman, 1991). These cancers caused a much smaller proportion of deaths in the Catholic sisters than in the general population (SPMR = 50%, 95% C.I. 30%–84%). The most dramatic contrast between the Catholic sisters and the general population was observed in the case of respiratory cancers, for which the proportion of deaths in the Catholic sisters was only 26 percent of that in the general population (SPMR = 26%, 95% C.I. 9%–74%).

Mortality due to non-malignant respiratory disease was disproportionately low in the Catholic sisters (SPMR = 65%, 95% C.I. 41%–103%), as was mortality due to cerebrovascular disease (SPMR = 77%, 95% C.I. 59%–101%). Mortality due to ischemic heart disease in the Catholic sisters made up about the same proportion of all deaths as in the general population (SPMR = 102%, 95% C.I. 89%–116%).

It is important to note that the above results do not reflect the low overall mortality rates in the Catholic sisters relative to the general population (the all-cause SMR was 73%, with 95% C.I. 69%–77%). Ideally, for each cause of death one would like to obtain the cause-specific SMR, or the ratio of the mortality rate for that cause in the Catholic sisters to the mortality rate for that cause in the general population (Breslow and Day, 1988; Monson, 1974). Using the method of Kupper et al. (1978), an approximation of the cause-specific SMR was obtained by multiplying the SPMR by .73 (i.e., multiplying the cause-specific SPMRs by the all-cause SMR for the Catholic sisters). The resulting estimates are presented in Table 3, with 95 percent confidence intervals accounting for sampling error in the all-cause SMR. Because ischemic heart disease was the primary cause of death, it was not surprising that the estimated SMR for ischemic heart disease (SMR = 74%, 95% C.I. 64%–86%) was close to the SMR for all-cause mortality.

Out of the total of 62 categories and subcategories for causes of death that were considered (some of which are presented in Table 3), only one disease not related to smoking had an SPMR significantly lower than 100%. This was diabetes mellitus, with an SPMR of 25% (95% C.I. 9%–70%).

Cancers related to reproduction. — Breast cancer mortality was disproportionately high in the Catholic sisters (SPMR = 182%, 95% C.I. 125%–264%), as was mortality due to cancers of the reproductive organs (SPMR = 222%, 95% C.I. 150–329%). This was true for uterine cancers (SPMR = 209%, 95% C.I. 114%–381%) as well as for cancers of all other reproductive organs (SPMR = 233%, 95% C.I. 138%–394%). The estimated SMR for cancers of the reproductive organs was greater than 100% (SMR = 162%, 95% C.I. 109%–241%), as were the SMRs for uterine cancer (SMR = 152%, 95% C.I. 83%–279%) and for cancers of all other reproductive organs (SMR = 170%, 95% C.I. 100%–288%). The sample was too small to accurately compare proportions for cervical cancer, which would have helped to resolve the controversy regarding the hypothesized protective effect of celibacy (Griffiths, 1991). One death due to cervical cancer was observed in the Catholic sisters (SPMR = 60%, 95% C.I. 9%–415%).

Discussion

Overall, the all-cause mortality rate for the Catholic sisters was 73% (95% C.I. 69%–77%) of that expected based on the rates in the U.S. general population of White women. This advantage increased systematically over time (calendar year) in most age groups, indicating that the rate of all-cause mortality in the Catholic sisters decreased at a faster pace than in the general population. The strongest trend in the all-cause SMRs was across birth cohorts, rather than calendar years. This would be expected if the trends in SMRs were caused by changes across birth cohorts in life-style characteristics that tend to become fixed relatively early in life. For example, this would be expected if a primary cause of the trends was an increase in smoking by successive birth cohorts of U. S. women, a possibility discussed below.

Taylor, Carroll, and Lloyd (1959) compared all-cause mortality rates in three orders of Catholic sisters to the rates in the U.S. general population of White females, for mortality occurring in the years 1900 to 1954. For Catholic sisters born in the years 1870 to 1889, the authors calculated the probability of dying in the age interval 50 to 59 for the Catholic sisters who survived to age 50 years, the probability of dying in the age interval 60 to 69 for the Catholic sisters who survived to age 60 years, and the probability of dying in the age interval 70 to 79 for the Catholic sisters who survived to age 70 years. These probabilities were then divided by the corresponding probabilities in the general population. For the age intervals 50–59, 60–69, and 70–79 years the probabilities of dying were respectively 83, 86, and 103 percent of those in the general population. For Catholic sisters born in the years 1890 to 1909, for those who survived to age 50 years the probability of dying in the age interval 50 to 59 was 76 percent of the corresponding probability in the general population. These findings are consistent with ours, which suggest that Catholic sisters born before 1890 would have mortality rates closer to those in the general population. In the study of Kinlen (1982), mortality over the years 1910 to 1978 was considered for 1,044 nonvegetarian nuns from three orders. He found that the age- and time-adjusted rate of all-cause mortality in this population was about 80 percent of that in the general population.

In our cause-specific analyses, mortality from smoking-related diseases was much lower in Catholic sisters than in the general population of U.S. women. This was especially pronounced for the diseases most strongly associated with smoking, such as respiratory cancers. Together with the timing of the trend in the all-cause SMRs, this suggests that the increase in cigarette smoking by U.S. women was an important contributor to the increasing survival advantage enjoyed by the Catholic sisters. In three community surveys of noninstitutionalized elderly U.S. women in 1982, conducted as part of the Established Populations for Epidemiologic Studies of the Elderly project (Cornoni-Huntley et al., 1986), the more recent birth cohorts had a much higher percentage of women who currently or ever smoked regularly (Table 4). In the general population, following the mid-century increase in smoking, lung cancer mortality in U.S. women began to increase rapidly around 1960 and continued to increase until at least 1986 (U.S. DHHS, 1989). Mortality rates due to some other smoking-related causes of death also increased for U.S. White females during this calendar time period, for example non-malignant respiratory diseases (Ewertz et al., 1993). The proportion of deaths among U.S. women attributable to smoking was much higher in 1985 than in 1965 for many cancers, heart disease, cerebrovascular disease, and chronic obstructive pulmonary disease (U.S. DHHS, 1989).

Mortality due to breast cancer, uterine cancer, and cancers of other reproductive organs was disproportionately high in the Catholic sisters, consistent with an effect of nulliparity.

Any such effect may have been partially counteracted by the fact that the Catholic sisters lived otherwise healthy lives. For example, the effect of nulliparity on breast cancer may have been partially counteracted by the lack of cigarette smoking (Palmer and Rosenberg, 1993), and by the relatively low levels of alcohol consumption (Rosenberg, Metzger and Palmer, 1993). The results for breast cancer were consistent with earlier studies of U.S. Catholic sisters (Fraumeni et al., 1969; Taylor, Carroll, and Lloyd, 1959) and with studies of nulliparity in the general population (Kelsey, Gammon and John, 1993). In combination with the earlier studies of Catholic sisters, our results on cancers of the reproductive organs provide strong evidence for a cross-over at older ages, suggesting that nulliparity increases the risk of mortality from these cancers only in older women. Nulliparity was not reported in the presentation of the previously mentioned U.S. community surveys (Cornoni-Huntley et al., 1986), but in Table 4 we have included the percent of those surveyed who never married, and the percent with no living children (natural or adopted).

Table 4. Age-Specific Prevalence (%) in 1982 for Characteristics of Elderly Noninstitutionalized Women in Three U.S. Communities

		U.S. Population Surveys[a]		
Characteristic	Age Group	East Boston	Iowa	New Haven[b]
Ever smoked regularly	65–69	47	21	50
	70–74	34	17	44
	75–79	23	12	38
	80–84	13	5	16
	85+	10	6	7
Currently smoke regularly	65–69	27	10	28
	70–74	16	9	16
	75–79	8	3	19
	80–84	6	1	11
	85+	3	1	1
High school education or higher	65–69	29	65	42
	70–74	24	57	38
	75–79	16	51	38
	80–84	14	38	39
	85+	11	32	23
Never married	65–69	10	5	12
	70–74	11	4	12
	75–79	9	9	11
	80–84	6	8	9
	85+	5	10	14
No living children, natural or adopted	65–69	19	14	25
	70–74	24	15	22
	75–79	19	22	26
	80–84	20	19	33
	85+	16	24	32

[a]Noninstitutionalized elderly were surveyed in three communities as part of the project: The Established Populations for Epidemiologic Studies of the Elderly (EPESE). These communities were East Boston, Massachusetts; Iowa and Washington Counties, Iowa; and New Haven, Connecticut. Sample sizes for the respective age groups 65–69, 70–74, 75–79, 80–84, and 85+ were as follows: EB: 858, 628, 425, 262, 184; Iowa: 560, 588, 507, 359, 241; NH: 2319, 2032, 1781, 1069, 793.

[b]Data selected from: National Institute on Aging, U.S. Department of Health and Human Services: Established Populations for Epidemiologic Studies of the Elderly. National Institutes of Health Pub. No. 86-2443.

Although we have concentrated our discussion on smoking and nulliparity, there are certainly other differences between the Catholic sisters and the general population. Differences in diet, alcohol use, education, occupation, living arrangements, and access to medical care services may have contributed to the differences in mortality rates. In particular, the low rates of mortality from cardiovascular disease and diabetes may reflect differences in diet and exercise in the Catholic sisters in comparison with the U.S. population. For example, if fat consumption were lower in the Catholic sisters, then this might have contributed to the lower rate of mortality from ischemic heart disease (e.g., Seeman et al., 1993) and partially counteracted the higher rates of mortality from breast cancer (e.g., Ewertz, 1993; Lee et al., 1992), although studies of the relationship between fat consumption and breast cancer risk have been conflicting (Kelsey, 1993). Little information on diet and exercise is currently available for this population, but some Nun Study participants took part in a substudy of dietary patterns in 1986 (Brown et al., 1990). The 37 Catholic sisters included in this substudy were 76 to 91 years of age. In three meals consumed in one day, not including snacks, the mean intake (and standard deviation) of various nutrients were as follows: 1,138 kilocalories of energy (SD = 251), 41 grams of protein (SD = 13), 140 grams of carbohydrates (SD = 30), 48 grams of fat (SD = 15), and 325 milligrams of cholesterol (SD = 137).

In conclusion, the Catholic sisters had lower all-cause mortality rates than did the general population, and this mortality advantage increased over time, particularly from earlier to more recent birth cohorts. Analyses of specific causes of death, as well as the timing of the all-cause mortality trends, suggest that the lack of smoking in Catholic sisters played an important role in their increasing survival advantage. On the other hand, mortality from cancers of the breast and reproductive organs were disproportionately high in the Catholic sisters, suggesting an effect of nulliparity on mortality from these causes at older ages. Overall, the all-cause mortality decreases in the Catholic sisters may reflect what could have occurred in the U.S. general population of women, had they not adopted cigarette smoking.

ACKNOWLEDGMENTS

This study was funded by grants R01 AG-09862 and K04 AG-00553 from the National Institute on Aging. This study would not have been possible without the spirited support of the members, leaders, and health care providers of the School Sisters of Notre Dame religious congregation. The following were especially helpful in the present study: Mary Ann Kuttner, Marjorie Myers, and Del Marie Rysavy; Drs. Robert Moore, James Mortimer, and James Vaupel; Ms. Lydia Greiner.

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Received April 3, 1995
Accepted October 13, 1995