Causes of Male Excess Mortality: Insights from Cloistered Populations

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THAT WOMEN ON AVERAGE live longer than men has been known at least since the middle of the eighteenth century when Struyck (1740) and Deparcieux (1746) constructed the first life tables separated by sex. The finding of male excess mortality was confirmed with the introduction of official population statistics in all Western societies and has been documented in Sweden from 1751 onward (Tabutin 1978).[1] The survival advantages of women increased continuously during the twentieth century, and this became one of the central subjects in mortality research. In Germany, for instance, the differences in life expectancy at birth changed from a relatively constant female advantage of three years before World War II to the present level of more than six years. In most other industrialized countries, the gap in mortality by sex began to widen after World War I (Stolnitz 1956), particularly in the United States and in England and Wales (Wiehl 1938). This development coincided with an increase among men in mortality due to cardiovascular diseases, cancer, and accidents and a fall in maternal mortality and in causes of death related to pregnancy (Lopez 1983). A detailed analysis of recent mortality data, however, seems to indicate a change in this trend. In Germany and in most other industrialized countries, the sex-specific mortality gap has been slowly narrowing since the beginning of the 1980s (Büttner 1995; Trovato and Lalu 1996, 2001; Newman and Brach 2001; Luy 2002a). Opinions differ regarding expected future trends. Some American demographers assume that male excess mortality will increase again (Carter and Lee 1992), while others predict a further narrowing of the gap (Bell et al. 1992). Estimates of future mortality trends in Germany also diverge. While the Federal Statistical Office assumes sex-specific mortality differences will widen again (Statistisches Bundesamt 2000), Birg (2000) assumes a slight reduction in male excess mortality. A better understanding of the causes of mortality differences between women and men is necessary both to determine whether male excess mortality could be reduced and to project future trends.

Hypotheses about causes of male excess mortality

A great deal of research has been conducted on the subject of sex-specific mortality differences (lengthy reviews can be found in Nathanson 1984; Wingard 1984; Waldron 1985; Lang et al. 1994; Carey and Lopreato 1995; Luy 2002a). The hypotheses advanced to explain male excess mortality fall into two basic categories: the biological approach (focusing on biological and genetic factors, thus factors largely beyond human control) and the nonbiological approach (focusing on behavioral and environmental factors, thus factors directly or indirectly influenced by human action). According to the biological approach, women are less prone to disease for anatomic and physiological reasons (e.g., Lopez 1983; Waldron 1983a, 1985; Nathanson 1984). The female survival advantage is assumed to be a consequence of the additional X chromosome (Smith and Warner 1989; Skuse et al. 1997; Puck and Willard 1998; Kraemer 2000; Christensen et al. 2000, 2001) and endogenous female hormones (Winkelstein et al. 1958; London et al. 1961; Kannel et al. 1976; Grodstein et al. 1997; Horiuchi 1997; Klotz and Stauffer 2003), which should protect women most notably against ischemic heart disease. Male excess mortality exists in most animal species (Hamilton 1948; Comfort 1979; Smith 1989; Carey and Judge 2000), and among humans higher male mortality rates hold among children (Aaby 1998) and even among infants and in the prenatal period, when the higher rates cannot be caused by sex-specific behavioral differences (Wingard 1982; Lopez 1983; Dinkel 1984; Waldron 1985; Hazzard 1986). Thus, the existence of at least a biological basis for the female survival advantage is undoubted (Hayflick 1982).

On the other side, advocates of the behavioral hypotheses argue that society and culture influence men to lead more dangerous lifestyles (in terms of smoking habits, alcohol consumption, diet, exercise, reckless driving, and so on), that men are subjected to greater health risks at work, and that men are generally more exposed to and susceptible to social and psychological stress. Probably the largest contribution to increasing male excess mortality is made by nicotine consumption (Retherford 1975; Nathanson 1984; Waldron 1985; Pampel and Zimmer 1989; Rogers et al. 2000), which is expressed by the higher male mortality caused by lung cancer and heart failure (Waldron 1976, 1986; United Nations Secretariat 1988). This phenomenon has been documented in many studies (e.g., Hammond 1966; Preston 1970; Burbank 1972; Johnson 1977; Holden 1983; Miller and Gerstein 1983; Rogers and Powell-Griner 1991; Hummer et al. 1998; Nilsson et al. 2001; Payne 2001). Smoking also appears to play a considerable role in the currently observable gradual narrowing of the sex differentials in mortality since the share of female smokers has increased greatly in recent decades (Waldron 1993; Lopez et al. 1994; Nathanson 1995; Trovato and Lalu 1998; Pampel

2002, 2003). A survival advantage among women may also be conferred by the tendency for women to consult a doctor more often than men both on noticing symptoms of illness and for health care needs related to childbearing (Hazzard 1986). This tendency could lead to recognition of serious diseases in time to treat them successfully (Lang et al. 1994). However, the contribution of this factor to the sex differences in mortality is the subject of controversy (Dinkel 1984; Verbrugge 1985; Johansson 1991).

Social stress is seen as another basic causal factor for increasing male excess mortality, above all in connection with ischemic heart disease (Waldron 1995). In this context Jenkins introduced the term "Type A behavior," which is characterized by intense striving for achievement, competitiveness, easily provoked impatience, time urgency, abruptness of gesture and speech, overcommitment to vocation or profession, and excesses of drive and hostility (Jenkins 1976: 1034). In Western societies, Type A behavior is found more frequently among men since it is strongly linked with professional life and social status (Waldron 1978, 1985; Hayes and Feinleib 1980; Nathanson 1984). Because lifestyles generally differ with the level of social status, sex differences in mortality could also be affected by the fact that men and women are not equally distributed within various social classes (see, e.g., Davidson and Townsend 1982; Marmot et al. 1984; Schepers and Wagner 1989; Lahelma and Valkonen 1990; Johansson 1991; Klein 1993; Valkonen 1993; Vallin 1995; Helmert et al. 1997; McDonough et al. 1999; Rogers et al. 2000; Anson 2003). Nathanson and Lopez (1987) hypothesized that the extent of male excess mortality is almost exclusively determined by the harmful lifestyles of men of low socioeconomic status. Also Wingard et al. (1983) found that differences in mortality by sex are larger at lower than at higher social class levels. Finally, probably also connected with lifestyle and living conditions, mortality of both sexes is differentiated by marital status with stronger effects on men, resulting in a smaller male disadvantage among the married than among the unmarried population (Carter and Glick 1976; Nathanson 1984; Gärtner 1990; Rogers 1995a; Martikainen and Valkonen 1996).

In addition to this group of arguments combining behavioral and societal factors are explanations exclusively based on environmental factors differently influencing male and female mortality. Preston (1976) argued that economic modernization has improved the status of women more than that of men, which has led to a greater reduction in mortality among women. Similarly, Ram (1993) identified the position of women and the degree of modernization of society as the decisive causes for the extent of male excess mortality. In populations directly involved in the two World Wars the increasing sex mortality gap might also be linked to the impact of the wars on risk selection of men and women. Many male war victims were selected among the so-called good risks (healthy persons in good physical condition), whereas females who died during and immediately after the two World Wars were subject to poor nutrition, hygiene, medical treatment, and other stress factors that largely affected the "poor risks," persons who were physically weaker and less healthy (Dinkel 1984). By contrast, Horiuchi (1983) assumes that the impact of war on increasing male excess mortality operates exclusively through the poor nutritional status of the population in the postwar years. As a result of sex-specific anatomic characteristics (greater female ability to store energy in the form of body fat), the nutritional deficit affected mainly adolescent men at the end of the war by causing increased susceptibility to cardiovascular diseases later in life. This thesis receives support from recent mortality analyses showing that male excess mortality is particularly high among those cohorts who were children and adolescents at the end of World War II (Luy 2002a).

Ultimately, it has proven impossible to explain the observed trends in sex-specific mortality differences by relying solely on one of the two groups of theories just mentioned (a conclusion arrived at by Verbrugge 1989; Johansson 1991; Rogers 1995b; Waldron 2000). For this reason, many authors have attempted to determine the relative contributions of biological, behavioral, and environmental factors to the differences in life expectancy between men and women (Pressat 1973; Wingard 1982, 1984; Lopez 1983; Waldron 1983a, 1983b; Stillion 1985; Holden 1987; Pampel and Zimmer 1989; Gage 1994; Lang et al. 1994).[2] There are several routes through which biological factors could not only be responsible for a basic female survival advantage but also contribute to the widening of the mortality gap by sex in the twentieth century. Some biological differences between the sexes may affect mortality at all ages and thus increase their influence on overall mortality with an increase of life expectancy (Birg 1996); or, as another consequence of the general mortality decline, there may be biological factors that affect sex mortality differences especially at higher ages and thus exerted little impact at a time when only a small fraction of persons of either sex reached advanced ages. Biological factors could also indirectly contribute to increasing male excess mortality in interaction with behavioral and environmental factors. Smoking, unhealthy diet, excessive body weight in relation to height, lack of exercise, and stress are thought to operate primarily by raising mortality from coronary heart disease. That female hormones protect women against this kind of disease provides a clear example of how biological differences between the sexes could play an important mediating role between nonbiological factors and ultimate mortality (see Retherford 1975).

A better understanding of the actual absolute contribution of biological factors to mortality differences by sex requires a special population group with homogeneous lifestyles and environmental mortality risks of men and women that allow an analytical separation of the two categories of possible causes. Since women and men usually are subject to differing environmental influences, it is impossible at the general population level to standardize for behavioral and environmental factors and thus to quantify the biological influence (Waldron 1983b). Some investigations have been undertaken based on groups of individuals among whom men and women are comparable in one or several behavioral patterns that are relevant to mortality. For instance, studies of nonsmokers (Hammond 1966) and Seventh Day Adventists (Philips et al. 1980; Berkel and de Waard 1983) show a lower male excess mortality than found in the general population. But in these special population groups, apart from the specific behavioral patterns, environmental conditions are not homogeneous for women and men, for instance regarding the kind of occupation (Waldron 1983a). The group of persons among whom behavioral and environmental conditions for men and women are probably as close to being equal as can be found in modern societies are the members of religious orders. The investigation of mortality differences by sex in the cloistered population can provide important information for estimating the contribution of biology to male excess mortality. If biological causes are mainly responsible for this excess, the cloistered and general populations should show almost no differences in the extent of male excess mortality. If, however, behavioral or environmental factors are the main cause of the higher life expectancy of women, mortality differences by sex should largely disappear among the cloistered population.

The advantages of and the precedents for using cloistered populations for mortality research

In the present study, mortality data on 11,624 Catholic nuns and monks in religious orders in Bavaria are compared with data on the general German population over the same time period, 1890–1995.

All members of religious orders are characterized by clearly defined features that largely distinguish them from the general population. Nuns and monks live according to a "simple lifestyle" determined by vows (living in poverty, chastity, and obedience), with similar daily regimes as regards time for sleep, work, study, and recreation, and with respect to diet, housing, and medical care. This holds especially in the case of communities belonging to religious orders with similar rules like those included in the present study.[3] The first vows are preceded by at least twelve months' novitiate. During this trial period candidates are screened for psychological suitability as well as physical health. Hence, the members of religious orders form a select group of individuals in good and stable mental and physical condition at the time of entry. In comparison to the general population, members of the orders live a life sheltered from societal stress factors. They have to look after neither themselves nor a family, and do not suffer from marital problems or from financial burdens or worries linked to bringing up children and saving for old age. Nuns and monks are not burdened by various forms of competition or by the need for occupational advancement and social climbing. Cloistered life is not entirely free of pressure and stress, but the forms of interpersonal conflicts are very different from those of a worldly society. A mortality analysis of nuns and monks can rule out a whole range of factors that influence mortality and that are also discussed as causes of the sex-specific differences in life expectancy:

—the different behavioral patterns of women and men regarding pursuit of harmful lifestyles,

—different propensities of women and men to work in hazardous occupations,

—maternal mortality and causes of death linked to pregnancy,

—the unequal roles of husband and wife,

—the degree of modernization of society,

—the increased stress load of Type A persons,

—nutritional differences between women and men, and

—the differences in social status and their potential sex-specific impact.

Regarding the last point, lifestyles and living conditions of nuns and monks are more similar to those of higher social status groups and of married women and men among the general population than to those of lower social status groups and unmarried people. The educational level especially among monks is considerably higher than in the general population, but mortality differences between members of religious orders according to level of education are found neither in male nor in female communities (Luy 2003).

However, in addition to the characteristics monks and nuns share are other mortality-relevant characteristics on which they differ. After World War II smoking became common in male religious communities, while it remained forbidden in nunneries. It is impossible to measure the extent of smoking among monks and thus its influence on their mortality. It is also impossible to assess the influence of drinking habits since there is no information available about alcohol consumption by the members of the religious orders studied. Another important factor that is not controlled because of lack of data is the relative incidence of obesity within the cloistered populations. However, it can be assumed that nuns do not have the same motives for slimness found among women in the general population. Furthermore, the members of religious orders are not free of the influences of war, since monks served in both World Wars. Of the monks included in this study and deceased during the first half of the twentieth century, 34.3 percent died during war service, which is 13.6 percent of all recorded deaths of monks in the entire observation period 1890–1995. Consequently, if a war-related selection effect exists among men in the general German population, it also exists among monks in the Bavarian cloistered population. Finally, occupational activities of nuns and monks differ and indeed such differences caused different mortality risks in the observation period before World War II. While most monks practiced as priests throughout the observation period, nuns mainly served as nurses in hospitals until the middle of the twentieth century. Since infectious diseases, predominantly tuberculosis, were the major causes of death at that time, nuns lived with an elevated risk of infection. This caused a high rate of mortality among female members of religious orders, above all in young adult ages, in the last decades of the nineteenth and the first decades of the twentieth century, as shown in several studies (Cornet 1890; Kruse 1900; Fecher 1927a, 1927b; Schömig 1953; Taylor et al. 1959). Since the end of World War II nuns have worked mainly as school and kindergarten teachers—occupations different from those of monks, but presumably entailing no sex-specific health risks.

The high tuberculosis mortality of nuns in the decades around 1900 is not the only special feature of diseases connected with cloistered life. Medical studies have revealed other causes of death that differ in prevalence between cloistered and general populations. In 1842, the Italian doctor Rigoni-Stern determined in his study of the death register in Verona of 1760–1839 that among women unmarried life, and especially life in religious communities, increases the incidence of breast cancer, while married life increases the incidence of cervical cancer.[4] More recently Versluys (1949), Gagnon (1950, 1953), Schömig (1953), Taylor et al. (1959), and Fraumeni et al. (1969) determined that nuns show higher cancer mortality, and above all much higher breast cancer mortality, than the general female population, but considerably lower cervical cancer mortality (see also Kinlen 1982). The finding regarding lower cervical cancer mortality has been questioned by Towne (1955), Skrabanek (1988), and Griffiths (1991) because of methodological problems and an insufficient number of cases in the studies.

There is very little research on the increased or reduced prevalence of specific diseases and causes of death among male members of religious orders. Groen et al. (1962) found a lower frequency of heart attacks among 349 monks than in the general Belgian and Dutch populations. McCullagh and Lewis (1960) found a similar result in their study of 44 US monks.[5] Another special feature of cloistered populations is that some members engage in missionary activity in developing countries. Since particularly in female communities only the healthiest persons are selected for missionary work and thus they exhibit better survival rates than those who remained at home (Luy 2003), they must not be excluded when mortality of the members of religious orders is analyzed.

This article follows a long tradition of studies about the mortality characteristics of nuns and monks: studies focused on the mortality patterns of this special population group (Deparcieux 1746; Casper 1835; Westergaard 1882; Cornet 1890; Kruse 1900; Boldrini and Uggé 1926; Fecher 1927a, 1927b; Gagnon 1950, 1953; Schömig 1953; Towne 1955; Madigan 1957;

Taylor et al. 1959; Fraumeni et al. 1969; King and Bailar 1969; Le Bras and Dinet 1980; Kinlen 1982; de Gouw et al. 1995; Butler and Snowdon 1996; Dinkel and Luy 1999; Luy 2002b, 2003) and studies to obtain information about human survival and health conditions in pre-statistical periods (Dinet 1978; Salvini 1979; Hatcher 1986; Harvey 1993; Davis 1998; Harvey and Oeppen 2001).[6] Differences in mortality by sex between the members of religious orders and the general population have also been analyzed in the past. Madigan (1957) exploited data from women's and men's religious communities in the United States to examine whether socio-cultural or biological factors were responsible for growing sex-specific mortality differences; he limited his study to teaching and administrative staff. During his observation period, 1900–54, the life expectancy of nuns increased, especially from age 45 onward, while that of monks remained almost unchanged. Consequently, the mortality gap between nuns and monks widened from decade to decade in a way similar to the gap between women and men in the general US population. Madigan concluded that biological factors are much more important for the differences in survival conditions of men and women than unequal socio-cultural and economic burdens. Although criticized for being restricted to teaching and administrative staff (King and Bailar 1969; Waldron 1983a; Nathanson 1984), Madigan's classic study is still frequently quoted as representative of the biological perspective in this field of research (e.g., Daw 1961; Retherford 1975; Lopez 1983; Stillion 1985; Ram 1993; Rogers et al. 2000). The largest problem of the Madigan study is the relatively small number of deaths occurring inside the male communities. The standard deviation stated in a footnote yields a 95 percent confidence interval for the difference between nuns and monks of 1.02 to 4.15 years in life expectancy at age 15 for the entire observed time span. This in itself considerably restricts the validity of his results. Since Madigan constructed life tables for four ten-year periods and one five-year period from these data, one must conclude that the statistical validity of the results of the study is too weak.

A study of Bavarian cloistered populations

In contrast to most other studies about members of religious orders in which the data stem from questionnaires completed by members of the communities, the data in this study were collected directly from the archives of 11 Bavarian Catholic cloisters. Since a mortality study of nuns and monks requires the life histories of all members of the orders, such an intensive and complete data collation is indispensable. Even persons who left the community after only a few days lived for a certain time with the risk of dying as a member of the order and hence must be included in the analysis. Various sources were used to obtain complete data sets for each community included in the study. The main source was the "profession books" of the communities, in which all members of the order are listed with their complete life histories. Other sources included cemetery registers, schematisms, necrologies, congregation documents, computer files, and index cards with information about individual nuns and monks. It was possible to obtain data for the complete populations of all 11 communities, totaling 11,624 persons. A minor qualification is that in one men's cloister data on members who had left voluntarily or had been expelled were not available. However, the error caused by this is negligible, since most of the members who left or were expelled from the male orders left the community in the first year, before taking their first vows. Hence, the missing information results in the loss of only a few person-years lived in the cloistered population. Data about cause of death were available only for one female community; thus no comparative analysis of sex-specific mortality by cause could be undertaken.

Mortality differences by sex in the general German population changed considerably after World War II. For this reason, in comparing cloistered and general populations, it makes sense to select observation periods of equal length for times preceding and following World War II. Since the life tables for the general German population are period life tables, period tables are also calculated for the cloistered population. The periods chosen for the life tables for the Bavarian nuns and monks must be wide enough so that the numbers of person-years and deaths in the communities in all age groups are sufficiently large to make possible statistically significant results. In the case of the Bavarian cloistered population, 30 calendar years proved to be the minimally sufficient observation period. The years 1940 to 1945 were excluded from the analysis because many monks served and died as military personnel in these years and because no official life table exists for the German general population for the war years. The periods 1890–1920, 1895–1925, 1900–30, 1905–35, and 1910–40 were selected for the cloister life tables prior to World War II. The postwar periods selected are 1946–76, 1950–80, 1955–85, 1960–90, and 1965–95. To make appropriate comparisons, in each case the German life tables in the middle of the observation period for the cloistered population were used. After 1945 life tables for the general population were limited to West Germany. For the periods 1900–30 and 1905–35 there are no comparable official German life tables. The observation period 1955–85 for the religious orders was compared to the German life table of 1970–72, since this life table is based on the census of 1971 and thus provides more reliable results than the centered life table 1969–71, which was based on the by then distant census of 1961.

As can be seen in Table 1, Bavarian nuns and monks spent between 8,369 and 95,268 person-years in the 11 communities in the ten observa-

TABLE 1 Numbers of individuals, deaths, and person-years at risk lived above age 25 among Bavarian nuns and monks during the observation periods

	Bavarian nuns				Bavarian monks			
Period	Individuals	Deaths	Person-years	CDR	Individuals	Deaths	Person-years	CDR
1890–1920	2,135	318	23,788	13.4	761	141	8,369	16.8
1895–1925	2,685	395	30,836	12.8	1,027	152	10,408	14.6
1900–30	3,410	464	39,404	11.8	1,299	155	13,086	11.8
1905–35	4,096	556	49,528	11.2	1,614	191	16,686	11.4
1910–40	4,400	661	60,954	10.8	1,775	231	21,111	10.9
1946–76	4,452	1,554	95,268	16.3	1,851	568	38,193	14.9
1950–80	4,296	1,676	92,782	18.1	1,812	623	37,952	16.4
1955–85	4,082	1,802	87,945	20.5	1,788	679	37,194	18.3
1960–90	3,828	1,873	81,518	23.0	1,744	739	35,753	20.7
1965–95	3,543	1,929	73,507	26.2	1,702	785	33,593	23.4

CDR = crude death rate (deaths per 1,000 person-years at risk lived).

tion periods. The number of deaths ranges from 141 to 1,929. Because of the periodical irregularity of entries into the cloisters, the number of years lived in the communities is much higher in the periods after 1945. The temporal trends in the crude death rates of the female and male members of the orders are roughly similar but the rates cross over between the pre- and postwar periods. The age structure of the religious orders is characterized by many young adults entering up to the 1950s and a subsequent steep reduction in the number of new entries, particularly among the female communities (Luy 2002b). Consequently, the crude death rates provide no direct information about the mortality levels of nuns and monks, but reflect the considerable aging of the cloistered populations in the more recent observation periods. The average age at entry differs only slightly between the female and male members of the orders as well as between the observation periods; it remains between ages 23 and 24 years. In total, the demographic characteristics and trends of the nuns and monks analyzed are practically identical. The case numbers, however, are more than twice as high in the women's communities, a difference that has implications for the statistical significance of the results. The life tables for the cloistered populations start with age 25 since the years at risk and the number of deaths are too small for younger ages as a consequence of the average age at entry.

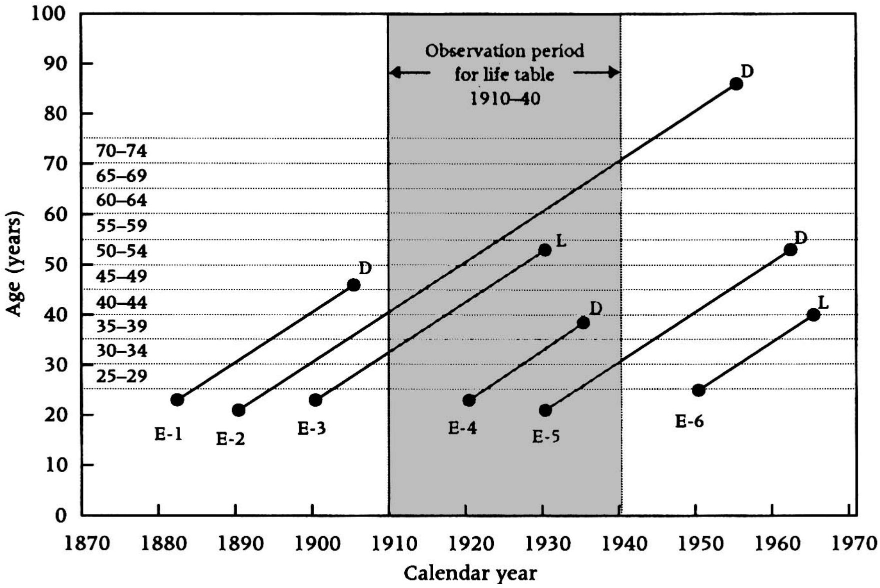
In the official German life tables, the probabilities of dying are measured directly for all ages by single years. This procedure is not applicable if there is only a small number of events and a long observation period. Thus, the life tables for the cloistered population must be abridged life tables with five-year age intervals. The life tables for Bavarian nuns and monks are calculated following the procedure proposed by Chiang (1984). This method performs best when comparing the various methods of constructing abridged life tables based on the official complete German life tables, and it produces statistically significant deviations only in the highest age groups. The procedure is based on age-specific death rates, which are transformed into probabilities of dying ${}_nq_x$ by the formula

$$ {}_nq_x = \frac{n\,{}_nM_x}{1+n(1-{}_nf_x)\,{}_nM_x}\ , $$

where n denotes the width of the age interval (x to x+n), ${}_nM_x$ is the age-specific death rate, and ${}_nf_x$ is the fraction of last age interval of life. The age-specific death rate ${}_nM_x$ is defined by the number of deaths in the age interval (x to x+n) divided by the number of person-years lived in this interval. To construct a period life table from data on the life histories of the members of religious orders (dates of birth, of entry, and of death or exit), one must determine the total number of years at risk in the observation periods of nuns and monks in the various age intervals. Since only lifetime inside the communities is analyzed, the date of birth is needed solely to determine the age at entry and at death or exit. After entering the community, each member of the order spends a certain number of years there until dying or leaving. When these years lived as a member of the religious order fall in one or more of the observation periods, they must be split into the age groups lived within the observation periods. The procedure is illustrated in Figure 1 using the Lexis diagram for the period life table 1910–40. The figure depicts life courses of six members of religious orders who entered their communities aged 20–25. Entry is represented by an "E" at the beginning of the cloister lifelines (in combination with the individual number of the member of the order). The cloistered lives of the observed persons end either by death, "D," or by leaving the community, "L." The cloister lifelines lying between the two events represent the number of years lived by the persons in a religious community and are known exactly for each member of the orders.

Persons 1 and 6 are not relevant to the life table for the period 1910–40 (the shaded area in Figure 1) since they did not spend any year in their communities in this period (person 1 died before 1910, and person 6 entered the community after 1940). For the other four persons, the time spent inside the communities within the period 1910–40 must be split into the respective five-year age intervals. In the years 1910 to 1940 the persons depicted in Figure 1 spent a total of ten years in the age interval 25–29 (person 4 five years and person 5 five years). In the age interval 30–34 the total of years lived is eight (person 3 two and a half years, person 4 five years, and person 5 half a year), and in the age interval 35–39 eight and a

FIGURE 1 Observed life courses of six members of religious orders illustrated in a Lexis diagram



NOTE: For discussion see text.

half years (person 3 five years and person 4 three and a half years). Since the data in this study provide precise information about each person's life events, such an exact splitting of the lifetime spent inside the religious communities within the period of observation can be done. In order to calculate age-specific death rates for the cloistered population, one must determine the number of deaths in the communities within the observation periods. Of the six persons from Figure 1, only one death in the age interval 35–39 would be included in the life table calculation for the period 1910–40 (the death of person 4 at age 38.5 years).

Chiang's method uses the fraction of the last age interval of life ${}_nf_x$ to transform the age-specific death rates into probabilities of dying. Even with the assumption of stationary conditions on which each life table is based, Chiang's method provides correct results only if the prevailing ${}_nf_x$ values are known precisely. Each approximation of ${}_nf_x$ leads automatically to a distortion of the calculated life table parameters. In this study, the exact ${}_nf_x$ values for the cloistered population can be obtained directly from the data. Probabilities of dying can be calculated from the age-specific death rates, and finally complete life tables can be constructed.

A comparison of life tables for different mortality levels generally shows that mortality does not differ to the same degree in all age groups. In order to locate the sex-specific mortality differences in the age spectrum of the cloistered and general populations, one may split the total difference in life expectancy into the absolute contributions of the individual five-year age intervals. As Arriaga (1984) has shown, the contribution of the individual age groups to the total difference in life expectancy results from the interaction of different effects: (1) the effect due to the exclusive change in mortality in each particular age group and (2) the effect of the interaction between the exclusive effect of each age group and the overall effect. The first effect is composed of a direct effect and an indirect effect. Since in a population with low mortality in a specific age group fewer persons die than in a population with higher mortality (direct effect), the additional survivors alone result in a higher number of survivors at all subsequent ages even in the case of then identical survival conditions (indirect effect). For analyzing age-specific mortality differences of two populations, the direct effect provided by the different age groups is the decisive parameter and is preferred in this study to the probabilities of dying that are used traditionally. The absolute contributions of the direct effect to a total difference in life expectancy are quantitatively simpler to interpret than differences between the ${}_nq_x$ values. An additional advantage of the direct effect is that its values for different age groups can be summed to measure the impact of mortality disparities for wider age ranges. According to Arriaga (1984), the direct effect ${}_nDE_x$ of mortality differences in a specific age interval (x to $x+n$) on the total difference in e_x between two populations A and B is calculated by

$${}_nDE_x = \frac{l_x^A}{l_a^A}\left({}_ne_x^B - {}_ne_x^A\right),$$

with l denoting the survival function of the life table, n the number of single age groups in the observed age interval, x the initial age of this age interval, a the age at which the total life expectancy is calculated (in the present study $a = 25$), and ${}_ne_x$ the temporary (or partial) life expectancy for the observed age interval (x to $x+n$), representing the average number of years lived exclusively within the ages x to $x+n$. A and B represent the two populations being compared, in this study either cloistered and general or female and male populations.

Results

Table 2 compares the life expectancy at age 25 (e_{25}) for Bavarian nuns and monks in all observation periods to the e_{25} values from the corresponding German life tables. The sex-specific differences in e_{25} for the cloistered and the general populations are also provided. Values for the cloistered group that deviate from the corresponding values for the general population at the 95 percent confidence level are marked with an asterisk.[7] Both in women's communities and in the general female population, mortality fell

TABLE 2 Life expectancy at age 25 (e_{25}) for women and men in the general German population and for Bavarian nuns and monks and sex-specific differences in e_{25}

General German population				Bavarian nuns and monks			
Life table	Women	Men	Difference	Life table	Nuns	Monks	Difference
1901–10	40.8	38.6	2.2	1890–1920	37.3*	36.2*	1.1
1910–11	41.3	39.4	1.9	1895–1925	38.2*	38.0	0.2
				1900–30	40.1	40.7	–0.6
				1905–35	41.1	41.3	–0.2
1924–26	43.9	42.7	1.2	1910–40	42.1*	42.0	0.1
1960–62	50.3	45.8	4.5	1946–76	49.1*	48.4*	0.7*
1964–66	50.9	45.9	5.0	1950–80	50.1*	49.1*	1.0*
1970–72	51.1	45.7	5.4	1955–85	51.0	50.2*	0.8*
1974–76	51.8	46.1	5.7	1960–90	51.9	50.3*	1.6*
1979–81	53.1	47.0	6.1	1965–95	52.9	50.6*	2.3*

* Statistically significant deviation from the general population at the 95 percent confidence level.

considerably during the entire study period. A direct comparison of these two population groups shows that the nuns in all periods before World War II show a statistically significant lower life expectancy at age 25. Among monks, the corresponding value deviates statistically significantly from that of German men only in the first observation period. Among both nuns and monks, this disadvantage is caused almost exclusively by excess mortality in the young adult ages. Hence, in the life table 1890–1920 for monks from age 30 on, no statistically significant difference in life expectancy can be found in comparison with the German life table 1901–10 (data not shown). The same holds for nuns in the periods 1890–1920 and 1895–1925 from age 35, and for the period 1910–40 from age 30.

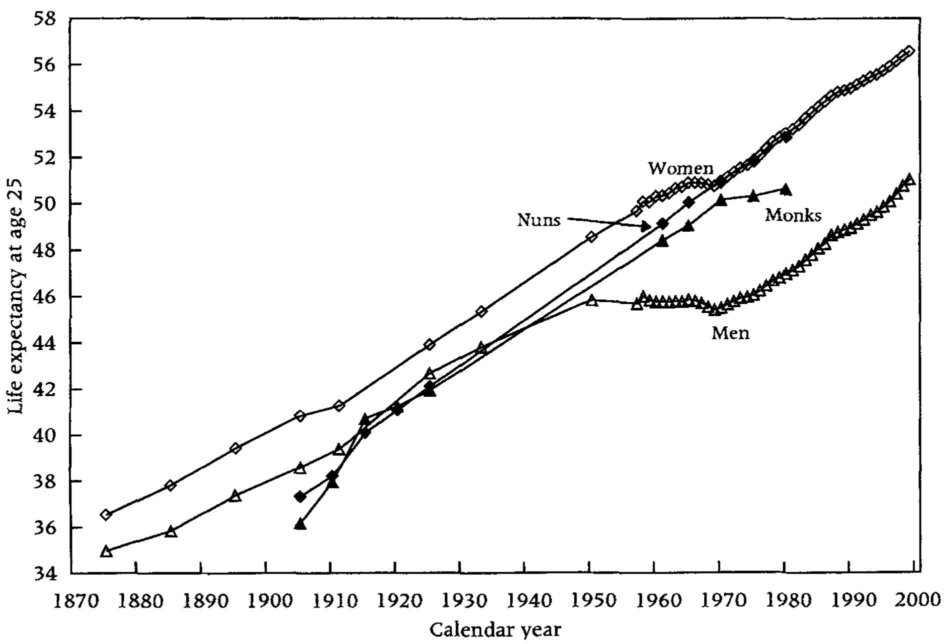
In the observation periods after World War II, life expectancy at age 25 among nuns is statistically significantly below the comparable value for women of the general German population only in the first two life tables. After these periods, life expectancy at age 25 in the two population groups is virtually identical without any statistically significant deviations. The monks by contrast show a statistically significantly higher life expectancy than German men in all postwar periods. The difference in life expectancy at age 25 is in some cases more than four years.[8] The high life expectancy of monks has the effect that, in the cloistered population in the total investigation period after 1945, the sex-specific differences lie statistically significantly below these differences in the general population. In the years before World War II, there is no observation period in which statistically significant differences can be measured between the members of religious orders and the general population. Moreover, the last two life tables for the

Bavarian communities (1960–90 and 1965–95) are the only ones in which a statistically significant difference in life expectancy at age 25 between nuns and monks can be measured. In all other observation periods no statistically significant sex mortality differences can be found in the cloistered population.

Figure 2 shows graphically what has just been described. The observed values are placed in the midpoint of each observation period of the life tables for Bavarian nuns and monks, as well as for German women and men. The graphs show clearly that male excess mortality in the general German population begins to rise around 1950. Among the members of religious orders no sex-specific difference can be seen until this time, a situation that is attributable to the relatively poor survival conditions of nuns in the first decades of the twentieth century. The reason for this will be discussed in more detail below in the analysis of age-specific mortality.

A stagnation, even a slight fall in the parameter e_{25} can be ascertained for several years among the general German population in the second half of the twentieth century. Among men, this period covers roughly 20 years (1950–70), whereas among women it covers only about five years (1965–70). Consequently, the sex-specific mortality differences in the general German population widened most markedly in the years between 1950 and

FIGURE 2 Trends in life expectancy at age 25 for German women and men and for Bavarian nuns and monks represented at the mid-calendar year of the observation period, 1870–2000



1965. Neither the long stagnation among German men nor the short plateau among the general female population can be observed in the cloistered population. Until the period around 1970, both nuns and monks follow an almost linear trend in the increase of life expectancy at age 25 in which women led the way. Since, unlike other German women, nuns did not experience an interruption of this trend, in the 1955–85 life table (period around 1970) any differences between Bavarian nuns and German women have disappeared. Because monks, unlike men in the general German population, show almost the same improvements as the female populations until this period, mortality differences by sex among members of religious orders did not change remarkably in comparison to the prewar periods. In the two last observation periods, however, the monks no longer follow this trend. Consequently, the sex difference in e_{25} expands appreciably in the cloistered population. Although two observation values departing from the prior trend are hardly sufficient to infer a general change in trends, they provide an interesting basis for ongoing observation and analysis. In fact, this result could be the consequence of the spread of smoking among monks but not among nuns in the second half of the twentieth century, resulting in decreased improvements in survival conditions in male communities—comparable to the development among German men between 1950 and 1970. The advantage of nuns over monks in life expectancy at age 25 in the last life table is roughly two years, hence comparable to the female advantage over males in the general population before World War II.

Insights into the causes of these results can be gained by analyzing age-specific mortality. The analysis uses the measure of the direct effect, which describes the number of years which the exclusive mortality differences in a specific age group contribute to the entire difference in life expectancy between two populations. In the following, the analysis is restricted to the age groups 25–74, since a comparison of life tables constructed using different methods for the cloistered and the general populations could lead to slight distortions at the highest ages. For selected observation periods Table 3 gives, for five-year age groups, the number of years that are contributed solely by the direct effect to the difference in life expectancy between members of religious orders and the general population. Positive values represent higher mortality within the general population, whereas negative values indicate higher mortality within the cloistered population. The values for the five-year age intervals are not affected by setting the maximum age at 75 years in these calculations.

In the periods before World War II, Bavarian nuns exhibit higher mortality than German women, especially at ages 25–49, resulting in a statistically significant lower life expectancy at age 25. This is not surprising in light of the findings of earlier studies about mortality in religious orders, and it is attributable to the high level of tuberculosis mortality among nuns

TABLE 3 Age-specific contributions, in years, of the direct effect on differences in life expectancy between ages 25 and 75 between the cloistered and general populations, shown separately by sex, in five observation periods

	Mid-calendar year of observation period									
	1910		1925		1961		1970		1980	
Age	BNGW	BMGM	BNGW	BMGM	BNGW	BMGM	BNGW	BMGM	BNGW	BMGM
25–29	–0.114	–0.082	–0.064	–0.004	–0.002	0.013	0.001	0.019	0.006	0.009
30–34	–0.056	–0.085	–0.043	–0.020	–0.011	0.007	–0.002	0.020	–0.003	0.005
35–39	–0.040	0.015	–0.030	0.000	0.007	–0.012	0.010	0.001	0.010	–0.010
40–44	–0.057	–0.045	–0.035	–0.020	–0.024	0.019	–0.005	0.034	0.002	0.015
45–49	–0.030	–0.004	–0.030	–0.034	–0.018	0.002	–0.002	0.018	–0.001	0.012
50–54	0.000	0.043	–0.008	0.022	–0.035	0.027	–0.017	0.052	–0.006	0.053
55–59	0.005	0.175	0.013	–0.009	–0.001	0.068	0.000	0.081	–0.006	0.058
60–64	0.049	–0.211	0.029	–0.074	–0.042	0.047	–0.027	0.063	–0.010	0.063
65–69	–0.085	0.027	0.004	–0.067	–0.026	0.057	–0.011	0.098	–0.052	0.074
70–74	0.038	0.028	0.054	–0.085	–0.023	–0.018	–0.017	0.114	–0.023	0.077
25–49	–0.297	–0.201	–0.201	–0.078	–0.049	0.029	0.001	0.091	0.015	0.031
50–74	0.008	0.062	0.092	–0.213	–0.127	0.182	–0.072	0.408	–0.096	0.325
25–74	–0.289	–0.140	–0.109	–0.291	–0.176	0.211	–0.071	0.499	–0.081	0.356

BNGW = difference between Bavarian nuns and German women. BMGM = difference between Bavarian monks and German men.
NOTE: Positive values represent higher mortality within the general population; negative values represent higher mortality in the cloistered population. Observation periods for German women and men are three years around indicated mid-calendar year (with the exceptions of the life tables 1910–11 and 1970–72), for Bavarian nuns and monks 30 years around indicated mid-calendar year.

at that time. In the one female community with complete data on cause of death, some three quarters of all deaths between ages 25 and 35 occurring before World War II were attributed to tuberculosis. Among women of the same age in the general German population, the share of tuberculosis deaths was about 11 percent in the 1920s. In the first observation period after World War II, nuns in almost all age groups are disadvantaged compared to other German women, but to a much lesser degree than in the first half of the twentieth century. In the subsequent observation periods, the survival conditions of Bavarian nuns and German women in all age intervals are almost identical, the direct mortality effect being very near zero.

A completely different picture can be seen among men when age-specific mortality of the cloistered and the general German populations is compared. Monks, too, have higher mortality than their counterparts in the general population in the observation periods before World War II. However, these disadvantages are embedded in the overall age spectrum, rather than being concentrated in the young adult ages, indicating the absence of excess tuberculosis mortality in male communities at that time. The exception is the period around 1910, where monks in the age group 25–49 show similar excess mortality to nuns, which probably explains the higher overall mortality of monks in the period 1890–1920 compared to German men. In comparison to the survival conditions of the general population, the excess mortality of monks in the period around 1910 is in total considerably lower than that of nuns. The same holds for the ages 25–49 in the period around 1925. In the second half of the twentieth century, monks in almost all age groups show much lower mortality than the general male population. The largest mortality differences arise in the age group 50–74. Above age 50, the survival advantage of Bavarian monks compared with other German men increases gradually with age, especially in the periods around 1970 and 1980.

Additional information to address the question of causality is provided by Table 4, which shows the age-specific contributions of the direct effect between ages 25 and 75 on the sex-specific differences in life expectancy in the cloistered and the general populations, with positive values representing female survival advantages and negative values representing male survival advantages. Up to and including the period around 1970 monks in the age group 25–49 had lower mortality than nuns. This can be seen particularly in the observation period around 1925. It is notable that even in the periods around 1961 and 1970 the mortality of monks in the young adult ages is lower than that of nuns. Before World War II men in the general population in some parts of this age group also showed advantages over women, which reflect a high level of maternal mortality (e.g., Stolnitz 1956; Imhof 1979; Gehrmann 1984). But after 1945, mortality among German men in all age groups is higher than among women. Reduced maternal mortality alone cannot explain these changes, since otherwise monks in the

TABLE 4 Age-specific contributions, in years, of the direct effect on sex differences in life expectancy between ages 25 and 75, shown separately for the general and for the cloistered populations, in five observation periods

	Mid-calendar year of observation period									
	1910		1925		1961		1970		1980	
Age	GWM	BNM	GWM	BNM	GWM	BNM	GWM	BNM	GWM	BNM
25–29	–0.005	–0.037	0.004	–0.056	0.011	–0.005	0.012	–0.006	0.009	0.007
30–34	–0.006	0.022	–0.002	–0.024	0.009	–0.010	0.011	–0.010	0.008	0.000
35–39	–0.002	–0.054	–0.003	–0.032	0.008	0.027	0.013	0.022	0.011	0.031
40–44	0.018	0.006	0.003	–0.013	0.012	–0.030	0.019	–0.020	0.019	0.006
45–49	0.035	0.009	0.010	0.014	0.020	0.000	0.025	0.005	0.030	0.018
50–54	0.049	0.005	0.018	–0.012	0.041	–0.020	0.041	–0.028	0.048	–0.010
55–59	0.060	–0.105	0.030	0.051	0.079	0.010	0.072	–0.010	0.071	0.007
60–64	0.057	0.321	0.039	0.139	0.121	0.037	0.118	0.034	0.106	0.036
65–69	0.042	–0.054	0.042	0.111	0.136	0.062	0.162	0.063	0.147	0.032
70–74	0.030	0.032	0.039	0.166	0.118	0.138	0.174	0.058	0.182	0.102
25–49	0.041	–0.053	0.013	–0.111	0.060	–0.018	0.080	–0.010	0.077	0.061
50–74	0.238	0.199	0.167	0.454	0.495	0.227	0.568	0.117	0.554	0.167
25–74	0.279	0.147	0.179	0.344	0.555	0.209	0.648	0.107	0.631	0.228

GWM = difference between German women and German men. BNM = difference between Bavarian nuns and monks.
NOTE: Positive values represent higher mortality within the male populations; negative values represent higher mortality in the female populations. Observation periods for German women and men are three years around indicated mid-calendar year (with the exceptions of the life tables 1910–11 and 1970–72), for Bavarian nuns and monks 30 years around indicated mid-calendar year.

young adult ages would not show lower mortality than nuns, for whom this cause of death is absent. In the last observation period, however, in the total age group 25–49 nuns have an advantage in the direct effect over monks of 0.06 years, which is very similar to the advantage of German women over men. In the age group 50–74, monks without exception show higher mortality than nuns. The excess mortality of monks appears in the observation periods after World War II approximately from age 55 onward; in the periods before the war such a clear picture is not visible.

In the sum of direct effects between ages 25 and 75 in the German general population, a clear increase in the sex-specific differences can be seen after World War II; however, no further increase took place between 1970 and 1980. This indicates that age groups above 75 years are exclusively responsible for the further increase in male excess mortality after 1970 as is indicated by changes in the value of e_{25} shown in Table 2. In contradistinction to the significant increase in the sum of direct effects between ages 25 and 75 in the general population from roughly 0.2 years before World War II to 0.6 years after 1945, the corresponding values for nuns and monks fluctuate around 0.2 years with no recognizable trend over the entire observed time span.[9] These results suggest a constant survival advantage for women, similar in the cloistered and in the general populations before World War II, that amounts to roughly 0.2 years in the direct effect between ages 25 and 75. While the survival advantage for women in the general population increased in the second half of the twentieth century, the survival difference between female and male members of Bavarian religious orders remained more or less unchanged.

Discussion and conclusions

The gains in survival during the twentieth century are almost identical among nuns and monks and largely correspond to the trend among women in the general German population. Improvements in survival among German men lag considerably. As a result, the widening difference in life expectancy of men and women in the general German population is not seen among the Bavarian cloistered population until around 1970. The low but persistent sex-specific mortality differences between the members of religious orders may be attributable to biological factors. If the average age at death of the stationary life table populations increases in the course of 100 years, in principle the absolute direct or indirect contribution of biological factors to the difference between the sexes could have increased as well. This could be another explanation for the increasing male excess mortality in the two most recent life tables for the cloistered population. But, as mentioned above, this widening of mortality differences by sex between members of religious orders could also be due to behavioral factors, since after World War II smoking became common among monks but is still strictly forbidden in female communities. However, this changing trend cannot be interpreted on the basis of only two measured values, especially in view of the previous constant long-term trend and in the absence of data on causes of death among monks. It will be interesting to chart subsequent mortality trends. If the plateau of survival improvements for monks continues, monks will have a life expectancy distinctly below both groups of women, approaching the level of life expectancy found among men in the general population. If the plateau ends and the linear pattern of increasing life expectancy resumes, the monks will be midway between German women and German men. It is highly unlikely that the life expectancy of monks will rise enough to reach the level of either group of women in the next several decades.

Although women in the general German population differ from Bavarian nuns in their lifestyles and environmental conditions (for instance regarding missionary activity), the two groups show almost identical survival conditions in the second half of the twentieth century. This result calls for careful interpretation. Persistent major causes of death that are closely linked to the reproductive role differ in incidence between the cloistered and the general populations. Consequently, the advantages and disadvantages of celibate life could theoretically cancel each other out by coincidence in this comparison. The remarkable mortality differences between nuns and German women before World War II were caused by the elevated tuberculosis mortality among young nuns. But why is there no difference in life expectancy between nuns and women in the general population in the postwar period despite their different behavioral patterns? Are the behavioral patterns of men and women in the general population so different that, when compared to the members of religious orders, one can observe a clear mortality difference among men but no difference among women?

The United Nations Secretariat (1988) found the greatest contributions to mortality differences by sex in the industrialized countries in the age groups 45–74 (see also Nathanson 1984; Nikiforov and Mamaev 1998). This is roughly the same age range in which monks after World War II have the greatest advantage in comparison with the general male population (see Table 3). But what in these age groups distinguishes men in the general population so distinctly from nuns and monks, as well as from the general female population? The explanation can only be found in different lifestyles (such as higher nicotine and alcohol consumption among men) or in different socioeconomic burdens. On the basis of the current study one can conclude that:

1. The changes in mortality differences by sex in the general population are caused by the fact that improvements in men's survival conditions are lagging behind improvements among women; and
2. Biological factors cannot explain this development.

If factors beyond human control were responsible for the existence and above all the widening of the sex mortality differences, they would have influenced all population groups equally and should not have differed so clearly between the cloistered and the general populations. The lower mortality of monks as against nuns in some young age groups until the period around 1970 clearly shows the potential for mortality reductions among men. This should by no means be interpreted to mean that biological factors play no role, or play only a decreasing role, in explaining mortality differences between men and women. Prenatal losses and infant mortality, which are considerably sex-differentiated and on principle cannot be dependent on behavior, indicate the impact of biological factors. Consequently only a combination of biological and nonbiological factors can be responsible for overall male excess mortality, whereas behavioral factors are likely to be the major cause for the considerable widening of sex mortality differences in the general population. Since lifestyles and environmental conditions among monks are more similar to those of men with higher than with lower social status, these results strongly confirm the hypothesis of Nathanson and Lopez (1987) that the extent of male excess mortality in the general population is mainly determined by the harmful lifestyles of blue-collar men; thus, "in order to establish a basis for predicting future change, we should direct our attention to the probabilities of change in male, not (as popularly believed) in female gender-roles and structural locations" (Nathanson and Lopez 1987: 132). It is in fact quite possible, however, that the effects of biological differences by sex vary in different environmental conditions. For example, the absence of reproduction in the cloistered population has almost no effect in a comparison with the general population of a contemporary developed country, but the effect could be different under other circumstances where reproduction plays a major role in mortality conditions. In any event, under the standardization of behavioral and environmental conditions between nuns and monks, biological factors at most confer a survival advantage for women of about one year in remaining life expectancy at young adult ages.

Notes

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1 The only exception is Ireland, where males had a higher life expectancy at birth than females until the 1920s (Stolnitz 1956).

2 An evolutionary explanation combining biological and behavioral arguments is given by Carey and Lopreato (1995), who connect the excess mortality of males with their biological role of finding a partner for reproduction, which leads to dangerous and risky behaviors (see also Partridge and Hurst 1998).

3 Before secularization took hold during the first half of the nineteenth century, living conditions of monks were on average considerably better than those of nuns. Differences in level of poverty, access to heat, food quality, and the like, which may have a significant impact on mortality, do not exist between modern female and male cloisters.

4 The results of Rigoni-Stern's work were translated and published in English by De Stavola (1987). This phenomenon of higher breast cancer mortality but lower cervical cancer mortality among nuns was first reported in 1713 by Ramazzini (cited in Fraumeni et al. 1969: 456; Griffiths 1991: 798); however, Rigoni-Stern is usually credited with its discovery.

5 However, Mackenbach et al. (1993) described self-reported morbidity of 134 surveyed monks as similar to that in the general population, but rates of disability related to activities of daily living were much higher among monks.

6 A new dimension of the analysis of cloister data was introduced recently by David Snowdon's "Nun Study," in which this population group was analyzed in depth, especially in the medical and psychological fields (a compilation of the many essays from this study can be found in Luy 2002b; the first book publication originating from this project is Snowdon 2001). Another study using data on Trappist and Benedictine monks was conducted by Barrow et al. (1960) to examine the effect of nutrition differences on serum lipids.

7 The highly complex derivation of the formulas to determine variance and standard deviation for e_x is described in detail by Chiang (1984) and Silcocks et al. (2001). The relatively simple approximation formula used in the present study and proposed by Chiang (1984) for estimating the variance of the parameter e_x has proved to be a suitable estimation procedure in empirical tests (Golbeck 1992).

8 Because of the omission of a few person-years lived among monks, these differences between Bavarian monks and German men are likely to be in fact slightly higher. But it has to be stressed that most of these years at risk lost to the analysis belong to ages below age 25, which do not influence the results of this study.

9 The cases of lower differences in the sum of direct effects between ages 25 and 75 can be largely explained by the excess mortality of nuns in the young adult ages in the life table for the periods around 1910 (0.15 years) and 1970 (0.11 years), and the high difference in the life table for the period around 1925 (0.34 years) by the comparatively high excess mortality of monks in the age groups 60–74.

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