

ARE SEX MORTALITY DIFFERENTIALS BIOLOGICALLY CAUSED?¹

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SEVERAL previous studies by demographers have drawn attention to the continuous divergence of male and female expectations of life in this country since 1900. Wiehl in 1938 pointed out the widening gap between the sexes, suggested the need for research into the causes, and called for medical specialization in care for men just as gynecologists have specialized in care of women.³ Yerushalmy in a sex and age investigation of our population composition showed the striking increases which had occurred in the percentage of women among the older people of our country during the period from the census of 1920 to that of 1940.⁴ More recently, Bowerman has produced new data which prove that the gap has continued to widen rather than to narrow.⁵

In 1900, the white women of this country enjoyed but a 2.85 year advantage over comparable males in expectation of life at birth. By 1950, this female advantage had doubled to 5.8

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² From the University of North Carolina.

³ Wiehl, Dorothy G.: Sex Differences in Mortality in the United States. *Milbank Memorial Fund Quarterly*, April, 1938, xvi, pp. 145-55.

⁴ Yerushalmy, Jacob: The Age-Sex Composition of the Population Resulting from Natality and Mortality Conditions. *Milbank Memorial Fund Quarterly*, January, 1943, xxi, pp. 37-63.

⁵ Bowerman, Walter G.: Annuity Mortality. *Actuarial Society of America: Transactions*, 1950, II, Part 2, pp. 76-102.

years, and the national abridged tables for 1954 show a difference of 6.2 years.

Why have men not profited from the better conditions of this century to the same extent as women? What are the chances that their days of life can be prolonged to equal those of the female sex?

Such questions raise further ones. Are these differentials in rates of dying chiefly reflections of the greater sociocultural pressures and strains which our culture lays upon male shoulders? Or are the differentials rather to be associated mainly with biological factors related to sex? If the former is the case, then probably little can be done to enable men to enjoy a life as long as women's. Short of a profound cultural revolution in our society, it appears that men must continue to experience greater stresses. However, if sex-linked biological factors principally underlie the differentials, the prognosis is more hopeful. It seems likely in this case that medical research can isolate the factors responsible for greater female viability, and use this knowledge to advantage in the treatment of middle-aged and old men, assuming of course that this can be done without disturbing psychological balance or causing observable physical reactions.

A quickening of interest in the problem of the diverging death trends of our men and women has occurred during the past few years and has resulted in a rather large amount of journal literature upon the question. However, most of this has been descriptive and speculative rather than analytic and research-oriented. The present article reports upon the results of a study which has attempted to shed some light upon the problem through the tools of demographic research.

RESEARCH DESIGN

There seems to be no question that the differentials between the sexes in perinatal and infant mortality are due to biological rather than to sociocultural factors.⁶ Accordingly, this study

⁶ The most pertinent and forceful of the many studies showing the existence
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is concerned only with that part of the life from age fifteen onwards.

The design chosen was that of the "ex post facto experiment." Thus the problem was one of finding a male group and a female group in which cultural stresses and strains had been so standardized between sexes that one could observe the operation of biological factors in comparative isolation.

The subjects chosen for study were teachers and personnel of administrative staffs of Roman Catholic religious Brotherhoods and Sisterhoods engaged in educational work. Communities of these which operated hospitals were eliminated from the universe, and in communities actually studied the life records of Brothers and Sisters devoting their energies to household and manual duties were discarded as were those of infirmarians and nurses (who are in charge not of extern patients but of sick members).

Also eliminated from consideration were the records of those who had served in foreign missions, those who had been married before entrance into religious life, the foreign-born, the non-white, and those who had entered into the religious community on or after their twenty-seventh birthday. The reason for all these eliminations was the imposition of controls that would yield as homogeneous a group of subjects as possible.

While in the general public single men are more given to dissipation than single women, a life of dissipation is equally out of the question for both sexes in religious communities. Moreover, Brothers are not subject to military service after their entrance into religious life. Further, the daily regime of Brothers and Sisters is extremely similar as regards time for sleep, work, study, and recreation, and with respect to diet, housing, and medical care. (However, the life of the young Sisters seems to be slightly more stressful.)

It must be admitted that the Brothers are more likely to smoke and to take an occasional drink. Only recently have Sisters of these differentials is that of Sam Shapiro: *The Influence of Weight, Sex, and Plurality on Neonatal Loss in the United States. American Journal of Public Health and the Nation's Health*, 1954, XLIV, pp. 1142-1153.

ters been permitted to smoke and only in a limited number of communities. An important factor that is not controlled because of the absence of relevant data is the relative incidence of obesity or of overeating within each sex group. However, it may be observed that Sisters do not have the same motives for slimness found among their sex in the general public.

Such control of sociocultural factors, it was assumed, would permit the desired operation of biological factors working in comparative isolation. Five highly significant sources of differential stress between the sexes had been eliminated: (1) male service in the armed forces; (2) greater male liberty to dissipate; (3) the dissimilar roles of husband and wife; (4) male employment in hazardous and life-shortening occupations; and (5) the employment of men and women in diverse occupations. Other sources of differential sociocultural stress also appear to have been eliminated or greatly curtailed. Maternal mortality, of course, had also been excluded by the very nature of the female group under observation.⁷

Health requirements suitable for the teaching occupation were demanded of candidates for entrance into the religious life by both Brothers and Sisters during the entire period of observation. Such screening was based upon personal knowledge of the candidate's past health, his or her condition at time of entrance, and the person's health record during the one or more years of trial before the first vows are pronounced. It appears that Sisters required a medical examination by a physician earlier and more widely than the Brothers. This requirement seems to have become the common practice by about 1930.

Since stable death rates were desired, a large number of

⁷ A detailed discussion of the research design will be found in a previous article by Rupert B. Vance and Francis C. Madigan, S.J.: *Differential Mortality and the "Style of Life" of Men and Women: Research Design*. *TRENDS AND DIFFERENTIALS IN MORTALITY*. 1955 Annual Conference of the Milbank Memorial Fund. New York, Milbank Memorial Fund, 1956, pp. 150-163. A later and more comprehensive treatment is also available in the writer's unpublished doctoral dissertation available in the University of North Carolina Library: *The Differential Mortality of the Sexes, 1900-1954: Cultural and Biological Factors in the Diverging Life Chances of American Men and Women*. University of North Carolina, Chapel Hill, 1956.

years of exposure to risk of dying was needed. Because the number of religious persons, especially of Brothers, was limited, the person-year of life was chosen as the unit of study, and the period of observation was extended from January 1, 1900 to December 31, 1954.

Sampling lists of all teaching communities of Brothers and Sisters in the United States were prepared from various editions of *THE OFFICIAL CATHOLIC DIRECTORY*.⁸ A sample of twenty-two Brothers' communities and of fifty-three Sisters' communities was drawn by probability sampling from these lists. In terms of members living in 1927, which we treated as the mid-year of the study, the sample of Brothers comprised 100 per cent of the Brothers' universe, while that of the Sisters included 59.3 per cent of the Sisters' universe. The response from these communities was good with twenty communities of Brothers cooperating, representing more than 98 per cent of the Brothers' membership as measured in terms of 1927, and with forty-one communities of Sisters cooperating, representing 83.9 per cent of the membership in the Sisters' sample as measured, again, in terms of 1927.

In each of these communities life records were collected for the full membership of Brothers and Sisters since January 1, 1900, with the exception of persons who had not persevered for some part of three calendar years in the community. (The person-years in religious life of these latter were estimated on a sample basis.) All deaths were recorded, even if such death had occurred within the calendar year of entrance. When eliminations had been made according to the "experimental" controls described above, this left 9,813 life records of Brothers and 32,041 for Sisters.

In studying the literature, it had appeared to us that the greater weight of expert opinion lay on the side favoring biological factors as the principal causes for the sex differentials in the death rates. Accordingly, the research hypotheses were

⁸ *THE OFFICIAL CATHOLIC DIRECTORY*. Milwaukee, Wiltzius and Company, 1900-1911. New York, Kenedy and Son, 1912-1955.

framed from this point of view and were expressed as follows:

1. Given two groups of American adults, one all male, the other all female, both drawn from the universe of healthy, native white persons in the United States who have reached age fifteen: if both groups are subjected to closely similar socio-cultural stresses and strains over a long period of time, the female group will continue to show significantly more favorable death rates than the males.

2. The mortality differentials between the two experimental groups will not differ significantly from the patterns exhibited by the national population, or else will show increased female superiority.

While these hypotheses assume for testing purposes that biological factors linked with sex chiefly underlie women's pervasive advantage in length of life, and that the differing amounts of sociocultural stress borne by men and women have little relation to this female advantage, neither hypothesis should be misinterpreted to mean that social strains and pressures are believed to be unimportant in the chain of events which leads to an individual's death. In fact, evidence is strong that social strains may play a leading role in the deaths of both sexes. Rather, proper interpretation of these hypotheses understands them to mean that, other things being equal, the same objective stresses and strains upon equal numbers of men and women will lead to the deaths of more men than women during a given period of time.

METHODOLOGY

From the life records of these Sisters and Brothers age-specific death rates by ten year age groups were worked out for each decade, 1900–1950, and for the five years, 1950–1954, as well as for the entire period, 1900–1954. Ratios were formed by dividing the death rates of Brothers by those of American native white males, and the rates of Sisters by the corresponding females. Life tables were developed by the Reed-Merrell method for the same age groups and periods.⁹

⁹ Quality checks were designed to keep error from all sources under control at two per cent or less. This error will be further reduced in forthcoming studies.

THEORETICAL MODEL

On the assumption that the Brothers and Sisters studied constitute a group in which sociocultural stresses have been very greatly standardized between sexes, what results would indicate that such sociocultural factors are chiefly responsible for the differentials in mortality trends of American men and women? On the other hand, what results would point to biological factors as being the chief agents?

If the death rates of the Brothers should prove to have been lower than those of males of the general public, while Sisters exhibited death rates approximately equivalent to those of Brothers, the sociocultural hypothesis would be confirmed. For this would show that the variation in death rates of each sex is closely associated with variations in the amount of sociocultural stresses undergone.

On the other hand, this null hypothesis would be rejected and the biological hypothesis strengthened if the differences between the death rates of Brothers and Sisters should remain rather similar to the differentials found between death rates of men and women of the general public.

However, two points need emphasis here. The first concerns the Brothers. No matter which hypothesis is actually closer to the truth, Brothers should have experienced death rates somewhat lower than those of white males of the general public, at least at ages under forty-five. First of all, they presumably suffer accident rates—especially motor vehicle accident rates—far below those of white males of the same age. Secondly, they would not have been exposed to the disabilities often resulting from military service (except Brothers who had been in service before entrance, none of whom would have been admitted to religious life if they had shown serious disability). Thirdly, their occupation, teaching, seems to be less stressful and dangerous than that of the average white male outside religious life. Finally, they have not carried on their shoulders the worries of a husband or a father about the security of his family.

The second point relates to the Sisters. Young Sisters at least (those up to about age 40) lead a life which appears more stressful than that of the average female in the general public. They teach long hours, and work on college and graduate degrees during their spare time. Most of them do not have a summer vacation but rather attend classes, teach catechism, take parish censuses, or participate in other activities.

Accordingly, even if sociocultural factors should be only of slight importance in relation to the observed sex mortality differentials of the general public, one would still not anticipate finding that young Sisters, at least, had experienced greater gains over females of the general public in mortality rates than Brothers had made over the corresponding males. Thus if Sisters have experienced significantly lower death rates than Brothers, and if at the same time the gains they made over females of the general public were not much smaller than those made by Brothers over the males, this would constitute strong evidence for rejecting the second null hypothesis. This hypothesis states that although biological factors may prove more important than sociocultural stresses, nevertheless sociocultural stresses still will be found to play an important part in the total effect of differential sex mortality.

FINDINGS

Results confirm both research hypotheses and indicate (1) that biological factors are *more* important than sociocultural pressures and strains in relation to the differential sex death rates; and (2) that the greater sociocultural stresses associated with the male role in our society play only a small and unimportant part in producing the differentials between male and female death rates.

ANALYSIS OF RESULTS BY EXPECTATION OF LIFE¹⁰

In general, life expectations of Brothers at all ages but the

¹⁰ The abridged life tables from which these expectations were drawn will be found in the writer's dissertation: *The Differential Mortality of the Sexes*, pp. 225-252. The fractions upon which the death rates were based will also be found in this place.

oldest (where the frequencies were very small) proved to be considerably greater than those of white males of the general public.¹¹ Such a result was to have been anticipated under either biological or sociocultural hypotheses.

The important point, however, is that Sisters' expectations of life did not in general recede from the favored position of white females. Rather, they too usually made gains over these females. Table 1 shows that in thirty-eight cases Sisters had greater expectations of life than these white females, whereas the latter had greater expectations in only four cases.

Moreover, in these culturally standardized groups, Sisters' and Brothers' expectations of life did not tend to vary about the same means, but Sisters consistently exhibited greater expectations of life, and Brothers shorter expectations. Only seven times in the abridged life tables did Brothers enjoy longer expectations of life, while Sisters were favored in this manner thirty-three times. It is noteworthy that most of the Brothers' advantage came at ages 15–34 when they would be favored by accident rates, and in the years 1900–1919 when young Sisters appear to have had extremely high rates of tuberculosis.¹²

Comprehension of these results is aided by studying expectation of life at age 15, which summarizes results for the entire period of religious life from entrance until death; and expectation of life at age 45, which summarizes the experience for middle and old age only. This latter expectation is particularly important, in fact is crucial in this research design, be-

¹¹ When comparing Brothers' expectations with those of males of the general public, one must bear in mind that a small part of the Brothers' advantage is a statistical artifact. In the first four decades, for the age group 85 years and above, the central death rate used for the life tables of both Brothers and Sisters was the United States native white rate as common to both sexes. This device was employed because of the paucity of Brothers at these ages, and because of the desire to hold constant death rates of Brothers and Sisters at previous ages, while still finishing off the tables. A similar procedure was used in the first two decades for ages 75–84. Stable Brothers' rates—if they had been obtainable—would probably have been nearer those of native white males than the rates for both sexes taken together. On the other hand, Sisters' expectations were somewhat deflated, since in general at these ages the actual rates of Sisters were more favorable than the native white rates not specific for sex.

¹² See footnotes 14–19.

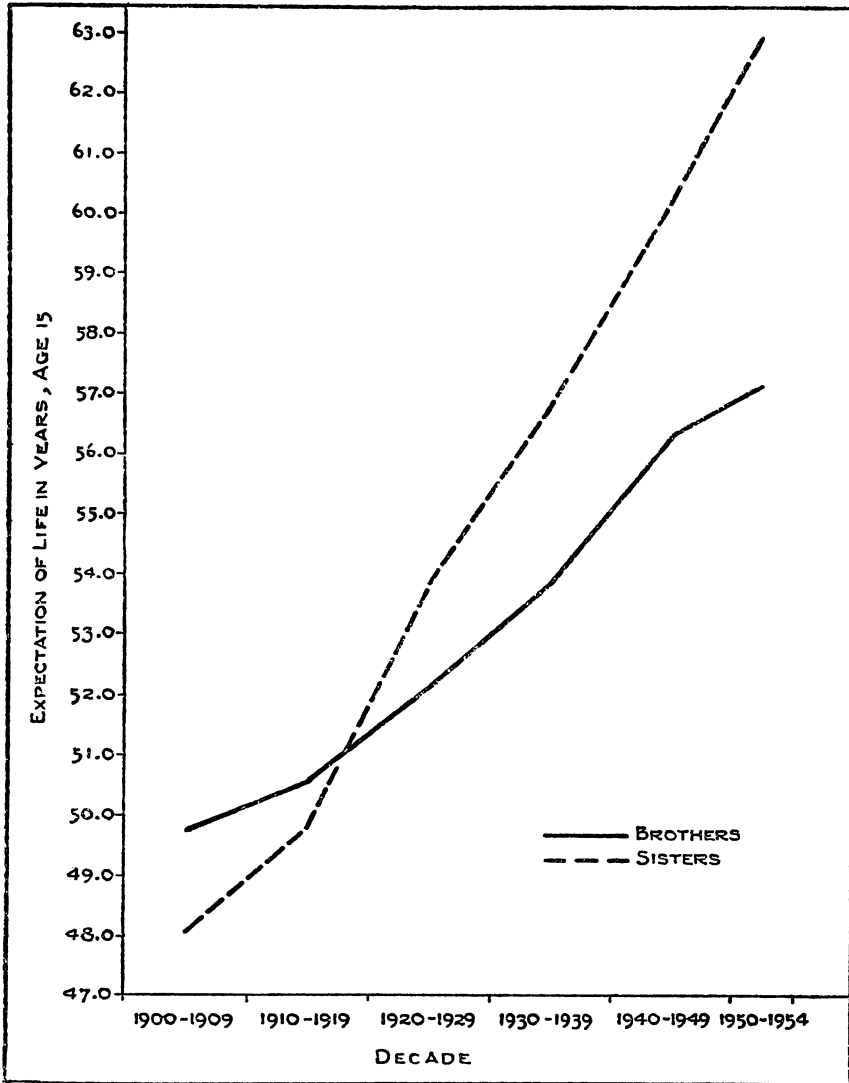


Fig. 1. Expectations of life in years at age 15, Brothers and Sisters, 1900-1954. See Table 1.

cause if social pressures were the main reason for the differentials in death rates of men and women in our general public, then at ages 45 and above in these standardized groups Brothers' and Sisters' death rates should show great convergence. For in the general public it is during the years from 45 to 65 that men seem to undergo greatest social strains and pressures.

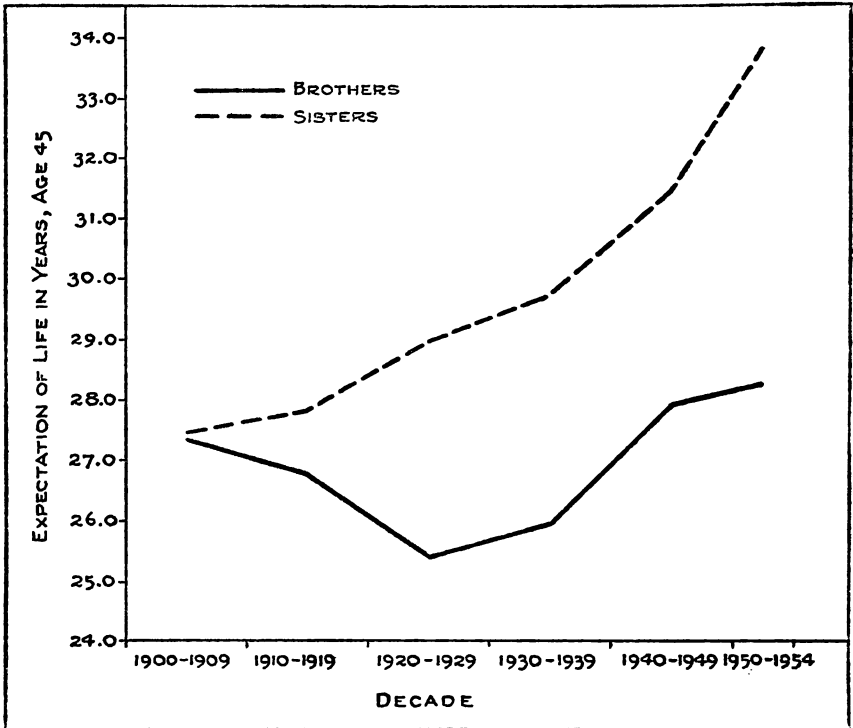


Fig. 2. Expectations of life in years at age 45, Brothers and Sisters, 1900-1954. See Table 1.

Accordingly, one would expect such pressures to exert an ever greater cumulative weight and to exact an increasing toll in the years following age 45. Therefore, on the hypothesis of sociocultural causation, standardization of such pressures ought to result in Brothers' and Sisters' death rates which vary about the same averages for each age group.

Figures 1 and 2 (which are based upon Table 1) make it abundantly clear that such convergence has not occurred at the middle and older ages, and they also show that even at age 15 the expectations have favored Sisters without exception from the third decade onwards. A comparison of the two figures also makes it evident that the Brothers' chief period of advantage was between ages 15 and 44.

The trends over time are important, too, for the consistency of the trend lines at age 15 minimizes the probability that Sis-

Table 1. Expectations of life in years at specified ages, Brothers and Sisters, and white males and females of the United States death registration states, with ratios of female to male expectancies, 1900-1954.

GROUP	AGES							PERIOD
	15	25	35	45	55	65	75	
E.G.M. ¹	49.72	41.98	35.13	27.35	21.96	14.97	7.18	1900-09 ²
E.G.F.	48.03	41.25	34.96	27.45	19.69	12.74	7.18	
Ratio	.97	.98	1.00	1.00	.90	.85	1.00	
U.S.M.	46.58	38.66	31.18	24.04	17.22	11.38	6.80	1900-11
U.S.F.	48.46	40.46	32.96	25.48	18.30	12.10	7.26	
Ratio	1.04	1.05	1.06	1.06	1.06	1.06	1.07	
E.G.M.	50.58	42.67	35.25	26.76	19.99	12.26	7.27	1910-19 ²
E.G.F.	49.80	42.46	35.65	27.81	20.15	12.69	7.27	
Ratio	.98	1.00	1.01	1.04	1.01	1.04	1.00	
U.S.M.	48.32	40.20	32.41	24.93	17.81	11.73	7.02	1909-21
U.S.F.	49.90	41.72	33.98	26.22	18.79	12.36	7.41	
Ratio	1.03	1.04	1.05	1.05	1.06	1.05	1.06	
E.G.M.	52.13	43.41	34.58	25.42	17.09	10.40	5.92	1920-29 ²
E.G.F.	53.83	45.11	37.01	28.97	20.75	13.55	8.32	
Ratio	1.03	1.04	1.07	1.14	1.21	1.30	1.41	
U.S.M.	50.06	41.69	33.54	25.64	18.28	11.99	7.16	1919-31
U.S.F.	51.84	43.40	35.30	27.18	19.50	12.78	7.59	
Ratio	1.04	1.04	1.05	1.06	1.07	1.07	1.06	
E.G.M.	53.85	44.17	34.58	25.96	18.52	12.20	6.83	1930-39
E.G.F.	56.78	47.31	38.32	29.74	21.65	14.28	8.48	
Ratio	1.05	1.07	1.11	1.15	1.17	1.17	1.24	
U.S.M.	51.36	42.53	33.84	25.58	18.16	11.92	7.10	1929-41
U.S.F.	54.54	45.52	36.72	28.14	20.16	13.18	7.74	
Ratio	1.06	1.07	1.09	1.10	1.11	1.11	1.09	
E.G.M.	56.32	46.60	36.99	27.95	19.80	13.24	7.81	1940-49
E.G.F.	60.18	50.39	40.77	31.47	22.81	14.74	8.71	
Ratio	1.07	1.08	1.10	1.13	1.15	1.11	1.12	
U.S.M.	53.26	44.10	35.02	26.37	18.72	12.41	7.47	1939-51
U.S.F.	57.73	48.28	38.99	30.01	21.66	14.28	8.40	
Ratio	1.08	1.09	1.11	1.14	1.16	1.15	1.12	
E.G.M.	57.14	47.37	37.61	28.27	20.21	12.85	7.75	1950-54
E.G.F.	62.97	52.97	43.25	33.83	24.87	16.55	9.62	
Ratio	1.10	1.12	1.15	1.20	1.23	1.29	1.24	
U.S.M.	54.4	45.2	35.9	27.1	19.3	13.0	8.0	1952
U.S.F.	59.9	50.3	40.8	31.6	23.0	15.3	9.1	
Ratio	1.10	1.11	1.14	1.17	1.19	1.18	1.14	

¹ E.G.M. and E.G.F. refer, respectively, to the Brothers and Sisters studied; U.S.M. and U.S.F. refer, respectively, to the white male and female populations of the expanding registration states. Decade expectations for the registration states' population were found by averaging the two values given for the triennium at each census date beginning and ending a decade, except the rates for 1952 which are the rates for this year.

² Because of the paucity of native Brothers at ages 75 and above in the decade 1900-1909, at ages above 85 in the 1910-1919, 1920-1929, and 1930-1939 decades, life tables for both Brothers and Sisters for these decades were finished off by using for both sexes the age-specific death rates of the United States native white population, as unsplit for sex. Interpolation between decades gave the decade value. This device permitted the finishing of the tables while keeping constant any differences Brothers and Sisters had manifested at younger ages.

SOURCES: For United States rates, 1900-1951: United States National Office of Vital Statistics: United States Life Tables, 1949-1951, VITAL STATISTICS, SPECIAL REPORTS, Vol. XLI, 1954, p. 30.

For United States rates, 1952: United States National Office of Vital Statistics, VITAL STATISTICS OF THE UNITED STATES, 1952, Vol. I. Washington, United States Government Printing Office, 1955, Table H, p. xxvi.

For Brothers and Sisters: Francis C. Madigan, S.J.: The Differential Mortality of the Sexes, 1900-1954. (Unpublished Doctoral Dissertation, University of North Carolina, Chapel Hill, 1956), pp. 118-120 and pp. 225-252. This source gives the abridged tables as well as the central death rates on which they were based.

ters' advantages after 1919 are due to chance factors, while the consistent upward secular trend of Sisters at age 45 and the fluctuation of Brothers' expectations around a mean of about 27.5 years of remaining life, appears even more cogent.

Are these differences between Brothers' and Sisters' expectations of life statistically significant? If so, the null hypothesis that sociocultural factors are the chief reasons for the differentials between male and female death rates may be rejected.

In order to make this test, the data for the entire period of observation were pooled. Since the proportional age and decade distributions of Sisters resembled those of Brothers very closely, it was not necessary to weight Sisters' decade death rates to those of Brothers. However, the rates of United States native white males and females were weighted to those of Brothers and Sisters, respectively, in order to develop tables for comparison.

Table 2. Expectations of life in years at specified ages, Brothers and Sisters, and native white males and females of the United States death registration states,¹ with ratios of female to male expectancies, for the period 1900-1954.

GROUP	AGES							PERIOD
	15	25	35	45	55	65	75	
E.G.M.	54.00	44.80	35.62	26.71	19.09	12.27	7.14	1900-54
E.G.F.	56.58	47.75	39.35	30.75	22.45	14.78	8.92	
Ratio	1.05	1.07	1.10	1.15	1.18	1.20	1.25	
U.S.M.	51.80	43.09	34.41	26.08	18.57	12.23	7.47	1900-53
U.S.F.	55.12	46.34	37.82	29.34	21.27	14.07	8.41	
Ratio	1.06	1.08	1.10	1.13	1.15	1.15	1.13	

Standard error of \hat{e}_{15} (E.G.M.) is .574.

Standard error of \hat{e}_{15} (E.G.F.) is .221.

Standard error of \hat{e}_{45} (E.G.M.) is .569.

Standard error of \hat{e}_{45} (E.G.F.) is .202.

Standard error of difference between \hat{e}_{15} (E.G.M.) and \hat{e}_{15} (E.G.F.) is .615. Z is 4.20.

P is less than .001.

Standard error of difference between \hat{e}_{45} (E.G.M.) and \hat{e}_{45} (E.G.F.) is .605. Z is 6.61.

P is less than .001.

¹ United States rates for 1950-1953 are for white, not native white persons.

SOURCES: For Brothers and Sisters: *The Differential Mortality of the Sexes*, p. 126.

For United States population: Life tables developed from native white rates of United States population of Death Registration States as described in Table 3, weighted for each decade and age group, by sex, according to the proportion of the number of person-years lived by each experimental sex group in each decade and age group to the total person-years lived by that sex in that age group, 1900-1954. These tables are given in *The Differential Mortality*, pp. 249-252.

Such pooling gave more stable death rates; they were based on totals of 788 deaths and 130,863 person-years of life for Brothers, and of 6,144 deaths and 718,435 person-years of life for Sisters. The resulting expectations of life are set forth in Table 2.

When expectations of life at age 15 and at age 45 were tested, the advantages of Sisters in both cases proved significant at beyond the .001 level. Thus the first research hypothesis, that biological factors mainly underlie the differential death rates, was supported. It is interesting to note in this connection that in Table 2 the ratios showing Sisters' advantages became larger at each successive age interval—exactly the opposite of what would be expected under the sociocultural hypothesis. A somewhat similar trend appears in the ratios for the national population.

ANALYSIS OF RESULTS BY AGE-SPECIFIC DEATH RATES¹³

We now turn our attention to the second research hypothesis, that not only are sociocultural pressures less important than biological factors in relation to the mortality differentials of the sexes, but they are of comparatively small importance in this respect. This hypothesis was examined by means of age-specific death rates.

A point of interest in regard to Table 3, which presents these death rates, is the spatial location of rates which favor Brothers over Sisters. If one imagines a rectangle enclosing the first three age groups, ages 15–44, and the first four decades, 1900–1939, he will discover that within this rectangle the rates of Sisters are higher than those of Brothers ten times out of twelve, 83 per cent. On the other hand, outside of this rectangle, he will discover that the Sisters are favored twenty-eight times out of a possible thirty-two, while Brothers' rates were lower only three times. In other words, 77 per cent of all rates unfavorable to Sisters are found within these early ages during the period 1900–1939. On the other hand, Sisters showed a

¹³ The fractions upon which these rates were based will be found in the writer's dissertation, *The Differential Mortality*, pp. 225–253.

Table 3.—Specific death rates per 1,000 native white males and females of the United States, by age group and sex, 1900-1954.²

PERIOD	Group	AGES							
		15-24	25-34	35-44	45-54	55-64	65-74	75-84	85 and Over
1900-09	E.G.M.	4.96	8.10	7.30	18.34	18.97	(0/44)	—	—
	E.G.F.	7.20	9.63	7.94	9.70	19.26	44.75	<i>126.32^b</i>	—
1900-10	U.S.M. ^a	5.1	7.65	10.05	13.9	25.5	55.9	127.45	264.2
	U.S.F.	4.95	6.98	8.3	11.7	21.35	47.6	114.65	252.6
1910-19	E.G.M.	4.49	6.55	5.07	13.64	15.14	50.63	<i>216.22</i>	—
	E.G.F.	5.78	8.07	6.82	9.86	16.22	45.87	91.74 ^c	<i>97.56</i>
1910-20	U.S.M.	4.9	7.56	9.4	13.54	24.9	54.55	123.95	253.4
	U.S.F.	4.4	6.4	7.52	10.9	21.1	48.0	113.8	244.45
1920-29	E.G.M.	2.68	3.00	2.93	8.31	24.87	65.83	165.61	—
	E.G.F.	2.63	4.64	5.92	7.38	16.93	43.24	94.43	256.88
1920-30	U.S.M.	3.3	4.3	6.64	11.45	24.0	54.15	120.1	242.45
	U.S.F.	3.2	4.4	5.94	9.7	19.95	46.45	109.6	233.3
1930-39	E.G.M.	0.66	1.11	4.73	11.72	24.19	48.55	132.04	(9/13.5)
	E.G.F.	1.03	2.39	4.23	7.58	15.14	37.25	90.94	222.22 ^d
1930-40	U.S.M.	2.5	3.4	5.6	11.4	24.65	54.2	121.35	251.65
	U.S.F.	1.95	2.9	4.35	8.1	17.4	42.4	105.7	229.0
1940-49	E.G.M.	0.55	0.98	3.06	8.08	21.08	43.36	104.59	<i>255.81</i>
	E.G.F.	0.39	0.86	2.00	5.10	10.95	34.36	88.25	217.21 ^e
1940-50	U.S.M.	1.75	2.35	4.4	10.45	23.65	50.3	113.05	243.4
	U.S.F.	1.05	1.65	2.95	6.25	14.0	35.0	92.75	211.85
1950-54	E.G.M.	0.44	0.60	2.16	8.18	16.74	47.06	106.48	<i>245.61</i>
	E.G.F.	0.01	0.60	1.56	3.67	8.54	24.56	74.92	191.89 ^f
1950-53	U.S.M.	1.6	1.8	3.7	9.7	23.0	48.3	105.1	209.7
	U.S.F.	0.7	1.1	2.3	5.3	12.5	31.6	84.1	191.0
1900-54	E.G.M.	1.63	2.04	3.67	10.58	20.82	49.71	119.48	317.65
	E.G.F.	2.26	3.66	4.06	6.50	13.09	35.26	85.64	204.15
1900-53	U.S.M.	2.73	3.44	5.63	11.39	24.11	52.20	114.28	233.42
	U.S.F.	2.43	3.52	4.56	7.83	16.31	38.84	95.18	205.94

¹ Rates for white, rather than native white persons were used for the years 1950-1953.

² Rates for United States populations were computed by interpolating between rates for census years to secure a decade average. Results for ages 15-54 were corrected for the three decades 1900-1909, 1910-1919, and 1920-1929 by a factor obtained by forming a ratio between the average of yearly rates for the general white population for these years (in each decade) and the rates for the general white population after interpolation between census dates. Where interpolation had produced two decimal places, these places were both retained not to magnify the original rounding error.

^a United States rates are for the expanding Death Registration States.

^b *Italicized* rates are based on less than fifty person years.

^c The Brothers' rate for this age group was based on deaths and person years for ages 75-79 only. Accordingly, in forming the ratio of Table 4, and in the life table for 1900-1954, the corresponding five-year rate of Sisters was used, viz. 73.56.

^d For similar reasons, in forming the ratio of Table 4, and in the life table for 1900-1954, the five-year rate for ages 85-89 was used, viz. 204.35.

^e For similar reasons, in forming the ratio of Table 4, and in the life tables for 1940-1949, and for 1900-1954, the Sisters' rate for ages 85-94 only was used, viz. 215.92.

^f For similar reasons, in forming the ratio of Table 4, and in the life tables for 1950-1954, and for 1900-1954, the Sisters' rate for ages 85-99 only was used, viz. 190.77.

SOURCES: 1. For United States' rates, native white and white, respectively, 1900-1940: United States Bureau of the Census: VITAL STATISTICS RATES IN THE UNITED STATES, 1900-1940. Prepared by Forrest E. Linder and Robert D. Grove. Washington, United States Government Printing Office, 1943, Table 9, p. 186.

2. For United States' native white rates, 1950: United States National Office of Vital Statistics, Vital Statistics for Native White Males and Females (unpublished table, United States National Office of Vital Statistics, n.d.).

3. For United States' white rates, 1950-1953: United States National Office of Vital Statistics, VITAL STATISTICS OF THE UNITED STATES, 1953, Vol. I. Washington, United States Government Printing Office, 1956, Table AK, p. xlvi.

4. For United States' yearly white rates, 1900-1929, ages 15-54 (used in correction factors): United States National Office of Vital Statistics: Death Rates by Age, Race, and Sex: United States, 1900-1953: All Causes, VITAL STATISTICS, SPECIAL REPORTS, Vol. XLIII, 1956, pp. 14-15.

5. For United States' native white rates, 1900-1953: the decade rates, and the rates for 1950-1953 as shown in the table above. Each decade age-group death rate of males was weighted according to the proportion of the total person-years lived by Brothers in that decade age group. Females were similarly treated by weighting them to the distribution of Sisters' person-years.

6. For Brothers and Sisters' rates: The Differential Mortality of the Sexes, pp. 136-138, and p. 128.

clear advantage from age 45 upwards in all decades, and at all ages after 1939.

This finding supports the conclusion already reached in studying expectations of life that sociocultural pressures are not the main factors underlying sex differences in death rates, because it shows that Sisters enjoyed more favorable rates than Brothers at the crucial middle and older ages. It also indicates that Sisters' death rates at ages under 45 in the period 1900-1939 were anomalous. Analysis of the table for these ages and years makes it clear that Sisters' rates therein were at times exceptionally high. Since social pressures and degenerative diseases would hardly cause such high death rates between ages 15 and 24, and between ages 25 and 34, the conclusion seems warranted that some infectious or contagious disease or diseases plagued young Sisters in the early part of this century with unusually lethal effects.

A number of reasons suggest that this disease was tuberculosis. First, there was the greater difficulty of detecting incipient cases during the first quarter of the century in the medical examination required of candidates for admission, due to the less frequent use of X-ray pictures. Even in 1936, according to Dr. Frost, a large proportion of tubercular cases in the general public were not discovered until they had reached an advanced stage.¹⁴ We may be fairly sure that the same would be true among Sisters in regard to those incipient cases of tuberculosis which had escaped detection at time of entrance. Secondly, the dangers of infection would be multiplied by the close life of the Sisters among themselves in the Convent, and the lack of general understanding then prevalent of prophylactic methods to prevent the spread of the germ. "Age and prior exposure bring no such immunity against tuberculosis as they establish against many of the acute infections."¹⁵

¹⁴ Frost, Wade Hampton: How Much Control of Tuberculosis. *In* PAPERS OF WADE HAMPTON FROST, M.D. Ed., Kenneth F. Maxcy, M.D. New York, Commonwealth Fund, 1941, p. 607.

¹⁵ Frost, Wade Hampton: The Age Selection of Mortality from Tuberculosis in Successive Decades. *In* PAPERS OF WADE HAMPTON FROST, p. 594.

Again, the highest tuberculosis mortality of cohorts of birth appears to occur between ages 20–29.¹⁶ Moreover, it has been a fairly common observation that females between ages 10 and about 29 show higher susceptibility to tuberculosis than males of these ages, so much so, indeed, that in 1929 Sydenstricker called such women “relatively neglected groups” and found their death rates from tuberculosis were 59 per cent higher than the male rate at 10–14 years of age, 106 per cent higher at 15–19 years, and 43 per cent higher at 20–24 years.¹⁷

Finally, Fecher’s work¹⁸ as well as the British experience of 1930–1932¹⁹ makes it evident that Catholic Sisters and nuns aged 15 to 34 years during the period 1900–1932 had rates of tuberculosis which were unusually high and which were far above the rates for single women. Single women at these ages generally showed rates higher than those of married women or of males. Dr. Taylor found similar results among Sisters in three American communities she studied from their foundation in the last century up through 1953.²⁰

Ratios were formed from the values shown in Table 3 by dividing Brothers’ death rates by those of native white males, and Sisters’ death rates by those of native white females. In order not to bias the comparison, each ratio was weighted by the number of person-years out of the total that Brothers or Sisters had lived in the particular decade-age-group, and thus average weighted ratios were formed for ages 15–44, ages 15 and above, and ages 45 and above.

These average ratios show whether Brothers made greater gains over native white males than Sisters made over native

¹⁶ *Ibid.*, *American Journal of Hygiene*, 1939, xxx, Sec. A, p. 91, footnote (in letter of Dr. Frost to Dr. Sydenstricker, quoted.)

¹⁷ Sydenstricker, Edgar: *Tuberculosis Among Relatively Neglected Groups*. TRANSACTIONS OF THE NATIONAL TUBERCULOSIS ASSOCIATION, 1929, xxv, p. 268.

¹⁸ Fecher, Constantine J.: *THE LONGEVITY OF MEMBERS OF CATHOLIC RELIGIOUS SISTERHOODS*. Washington: Catholic University of America, 1927, pp. 42–44. Fecher is at present bringing his interesting study up to date.

¹⁹ Registrar General’s Office, *THE REGISTRAR GENERAL’S DECENNIAL SUPPLEMENT, ENGLAND AND WALES, 1931*. Part IIa. Occupational Mortality. London, His Majesty’s Stationery Office, 1938, Table 4c, p. 303.

²⁰ It is the writer’s understanding that Dr. Ruth Taylor and Mr. Ben Carroll of the National Institutes of Health expect to publish these results in the near future.

white females and vice versa. Thus they permit comparison of the differences of patterns between sexes in death rates for the "experimental" groups and for the national population. Where the ratios are equal, this shows that the patterns between sexes of the national groups are perfectly reflected in the differential rates of Brothers and Sisters. However, where male ratios are lower, this indicates that Brothers have made greater gains, and that there has been convergence between death rates of Brothers and Sisters, when these are measured from the positions of male and female of the national population. On the other hand, where female ratios are lower, it indicates Sisters have made greater gains, and that there has been divergence.

We may again ask, what results would lead to the non-rejection of the second null hypothesis, that sociocultural factors are of more than small importance in effecting the sex differences in mortality rates? Taking into account the lower accident rates of younger Brothers, and the less hazardous and stressful occupation in which they are engaged in comparison with that of the average native white male, as well as the fact that young Sisters are probably under greater stresses than the average native white female, non-rejection of the null hypothesis would call for large divergences from the patterns of the

Table 4. Average weighted ratios of Brothers' death rates to death rates of United States' native white males, and of Sisters' death rates to death rates of United States' native white females, for ages 15-44, 15 and all ages over, and 45 and all ages over, 1900-1954.¹

GROUP	1900-09	1910-19	1920-29	1930-39	1940-49	1950-54	1900-54	AGES
Brothers ²	.94	.84	.73	.36	.44	.36	.61	15-44
Sisters	1.26	1.18	.97	.80	.55	.44	.96	
Brothers	.97	.85	.77	.45	.50	.44	.66	15 and Over
Sisters	1.18	1.09	.93	.83	.66	.56	.92	
Brothers	1.13	.87	.96	1.00	.83	.84	.92	45 and Over
Sisters	.85	.86	.82	.90	.85	.71	.84	

¹ The United States rates for 1950-1954 used were for the white rather than the native white population.

² "Brothers" was used here as a shorthand expression for the death rates of Brothers divided by the death rates of United States native white males and weighted according to the number of person years of exposure; similarly "Sisters."

SOURCE: *The Differential Mortality of the Sexes*, pp. 169-171, and p. 173.

general public which would (a) be particularly manifested during the crucial middle and old-age periods of life, and (b) which would be in the direction of convergence between Brothers and Sisters' death rates, rather than in the direction of greater divergence.

The results shown in Table 4 do not present a picture of convergence of Sisters' death rates towards Brothers nor divergence from the general public pattern of superior female death rates at the middle and the old ages. An examination of this table reveals that Sisters exhibited as much superiority over Brothers at these ages as females over males of the general public. Almost all comparative gains of Brothers occurred at ages 15-44, a period in which it is difficult to believe that the underlying causation could have been influenced much by social stress and strain. Rather the difference, particularly in the last fifteen years of observation, appears due to gains of Brothers over native white males in lower death rates from motor vehicle and other types of accidents, on the one hand, and on the other to high death rates from infectious disease such as tuberculosis among Sisters in the first quarter of this century.

Tests of significance were made by weighted analyses of variance upon each of the values shown in Table 4.²¹ Brothers' ratios proved significantly lower than Sisters at ages 15-44 in the 1900, 1910, and 1950 decades, and for the period 1900-1954 (at .05 for each period, except 1910-19 when the difference was significant at .001). In the decades 1920, 1930, and 1940 the differences were not significant.

At all ages, 15 and above, Brothers' ratios proved significantly lower in the 1910, and the 1930 decades, as well as in the period 1900-1954. (The level of significance was .01 except for 1930 when it stood at .05.)

At ages 45 and above, no differences were significant within decades, but the Sisters' lower ratio for the entire period 1900-1954 was significant at the .01 level.

²¹ The Method of Fitting Constants was used to obtain adjusted sums of squares for sex and for age. Cf. Snedecor, George W.: *STATISTICAL METHODS*. Ames, Iowa, Collegiate Press, 1946, pp. 296-99.

Probably the Brothers' lower ratios at ages 15–44 would have been significant more often if more degrees of freedom had been available than the one and two present in each decade for sex differences, because the F scores were high. However, the number of degrees of freedom for ages 15 and above (all ages studied) ranged from one and five to one and seven.

Since there were no large departures among Brothers and Sisters at the middle and older ages from the patterns of female superiority observed in the general public and since, in fact, at these ages Sisters' ratios were generally somewhat lower, the null hypothesis was rejected and the research hypothesis, that sociocultural pressures made only small contributions to the differential mortality rates of the sexes, was supported. Because of the nature of the tests, it was not possible to set any precise level of probability for this rejection of the null hypothesis.

EVALUATION OF RESULTS

The finding that biological factors played by far the chief part in differentiating the death rates of members of the universe studied is very important. Since these members were native white Americans of sufficient health to be admitted into religious communities engaged in the active occupation of teaching, the results point to the operation of similar biological factors as the chief agents in the differential death rates of the two sexes of the American general public.

An interesting lead for further research is the notable, even spectacular improvement of young Sisters under observation from the early to the late years of the study. From showing the poorest records of the four populations compared in the period 1900–1909, they improved rapidly to exhibit by far the best mortality records for the years after 1939. This suggests the hypothesis that *under conditions of equal stress* women may be no more resistant to the *infectious* and *contagious* diseases than men—perhaps even less so—and that the gains which women have been making over men in this century may

be chiefly bound up with a greater constitutional resistance to the *degenerative* diseases. This would account for the remarkable improvement of young Sisters vis-a-vis the other three populations, because of the spectacular advances made during this century in controlling the ravages of the infectious and contagious diseases. If this hypothesis is borne out by further research, one might then say that the growing advantage of American women over men is a function of the transition from conditions when infectious and contagious diseases were the main causes of death to conditions wherein the degenerative diseases play this role.

Of course, an alternative hypothesis is possible. There may have been some hidden selection of Sisters in the earlier quarter of the century which operated at a much reduced degree in the second quarter. What this selection would be is obscure. None of the convents took in girls to "let them die in the religious life." Nor was the ascetical life of the Sisters apparently more rigorous than that of the Brothers, although both regimes were more severe at the start of the century than they are now. Further, the physical examination of candidates for admission seems to have been more careful than that of the Brothers rather than less painstaking.²²

The continuing phase of this study²³ should allow some test of these hypotheses, as well as the hypothesis that the chief reason for the poor showing of young Sisters during the first quarter century was tuberculosis. However, it is hoped that the results of the present study will stimulate further research by other interested parties, including both replications of the present study among other matched groups of men and women, and medical research, first, into causes of death which carry off

²² The writer learned these facts from a questionnaire which he circulated among the communities in his sample after the results had become available.

²³ In this further phase, causes of death will be analyzed for the Brothers and Sisters of the study. Dr. Rupert B. Vance of the University of North Carolina and Mr. William Haenszel and staff of the National Cancer Institute are collaborating with the writer in this extension of the study. Place of death is being secured from the communities in the sample, and the various state vital statistics offices will be searched for the death certificates.

more men than women when social stress differentials have been minimized, and, secondly, into specific biological factors which may be associated with the longer life of women. Such studies may advance the date when our men can enjoy an average lifetime as long as that of women.