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MORTALITY RATES BY MARITAL STATUS

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ABSTRACT

It has long been recognized that mortality rates for adults increase sharply by attained age and that at most ages male mortality is markedly higher than female mortality. Less is known about the differences in mortality rates by marital status, though as long ago as 1940 it was noted that the unmarried die faster.

Data published by the Office of the Actuary, Social Security Administration, based on census and death records centered around 1960 and 1980, make possible a detailed analysis of mortality by marital status. Mortality rates for the unmarried are higher than those for the married at nearly all ages and for both males and females. The differences are surprisingly large, exceeding male/female differences for many of the age groups. Moreover, the unmarried/married differences appear to be widening.

The reasons are not obvious, though several explanations have been suggested. Interactions with other mortality factors, such as race or smoking habits, may play a part. The paper attempts to assess the validity of the explanations offered but comes to no firm conclusions.

I. PURPOSE, METHODS, AND SCOPE

The purposes of this paper are (1) to demonstrate and quantify death rate differences by marital status, (2) to explore the reasons *why* mortality rates for the unmarried so greatly exceed those for the married, and (3) to encourage actuaries and others to contribute their thoughts on these perplexing matters.

The methods employed are (1) a review of the pertinent literature and a presentation and analysis of some recently available data and (2) the use of these and other data to test the explanations that have come forth.

The scope of this paper is limited; it presents no new data, performs no experiments, advances no theories, and comes to no definite conclusions. Nevertheless, it attempts to set forth the present state of knowledge on one aspect of human mortality, a subject close to the heart of actuarial science.

II. REVIEW OF LITERATURE AND PRESENTATION OF DATA

A. Early Studies

Early studies of mortality by marital status are summarized in *Length of Life*, written by Dublin et al. in 1949 [2]. The authors state that, although there were some studies of mortality by marital status in the early part of the 20th century, the first comprehensive study in the U.S. was based on registered deaths in 1940 and the census of that year. Death rates per thousand for white males, white females, colored males, and colored females, and for five-year age groups from 20 to 75, were presented separately for the married and for three classes of the unmarried: the never-married, the widowed, and the divorced. The pertinent table, presented in Dublin as Table 38 but attributed to E.H. Pitney [4], is reproduced as Table 1.

With a single exception, all the unmarried exhibit higher death rates than the married; the excess mortality is about 40 percent for the never-married (those termed "single" in the table), 75 percent for the widowed, and 100 percent for the divorced, though with considerable variation by age, sex, and race. The one exception is for white females age 20–24, where the married death rate is 1.7 per thousand, and the never-married death rate is 1.5 per thousand. Dublin's explanation for this one exception is the mortality associated with pregnancy and childbirth. There is no comment on the contrary results for colored females.

Similar studies were published for 1949–51 and for 1959–61. Discrepancies in the reporting of marital status on death certificates and census records were suspected as being responsible for at least part of unmarried/married differences, and a correction to the 1959–61 results was undertaken. Kitagawa and Hauser [3] found that the "uncorrected" marital status differentials exaggerated the higher mortality of the widowed and divorced, but otherwise the original findings were reasonably accurate.

B. Newly Available Data

The newly available data analyzed in this paper were published in May 1984 and February 1992 by the Office of the Actuary, Social Security Administration. The pertinent documents are *Actuarial Study 92*, "Social Security Area Population Projections: 1984" [5] and *Actuarial Study 106*, "Social Security Area Population Projections: 1991" [6].

TABLE 1

DEATH RATES PER 1,000 ACCORDING TO MARITAL STATUS AND AGE SEPARATELY FOR WHITE AND COLORED PERSONS BY SEX, UNITED STATES, 1940 [4]

Race, Sex, Marital Status	Relative Index, Ages 20 and Over*	Age								
		20–24	25–34	35–44	45–54	55–59	60–64	65–69	70–74	75 and Over
White Males										
Single	140	2.5	4.0	8.1	16.2	27.7	37.4	51.9	74.4	131.7
Married	100	1.7	2.2	4.2	9.8	18.3	27.1	39.4	60.5	114.5
Widowed	173	7.8	7.8	10.6	19.2	31.0	40.6	56.3	79.3	163.3
Divorced	218	4.8	7.8	13.4	25.1	38.3	51.9	73.4	114.2	215.9
White Females										
Single	117	1.5	2.4	4.0	7.9	14.0	20.9	32.0	52.1	125.6
Married	100	1.7	2.0	3.5	7.0	12.6	19.2	30.4	49.1	92.6
Widowed	135	4.1	4.1	4.9	9.3	15.6	23.4	35.3	56.8	129.8
Divorced	174	3.3	3.5	5.5	10.5	17.7	28.5	46.7	86.9	197.8
Colored Males										
Single	155	7.1	12.1	18.8	30.5	43.6	54.2	58.0	89.6	137.9
Married	100	4.8	6.5	10.6	20.2	29.2	35.6	39.9	57.0	93.8
Widowed	214	19.6	21.6	26.1	46.8	62.0	65.7	66.2	84.4	147.6
Divorced	203	10.2	14.4	24.3	41.6	51.4	72.1	74.1	115.3	192.9
Colored Females										
Single	143	6.6	9.6	14.4	24.4	38.9	47.1	46.2	65.1	126.5
Married	100	5.1	6.5	10.3	17.4	25.4	29.6	32.7	49.8	87.5
Widowed	149	9.6	11.6	15.9	28.1	41.2	48.0	41.8	59.8	100.6
Divorced	167	5.3	7.9	13.3	23.9	42.3	53.2	62.3	112.9	192.2

*To compute this index, the age-specific death rates were first standardized for ages 20 and over on the basis of the age distribution of the total population of the United States in 1940; the relative index is the ratio of the standardized rate for each marital status to that for the married (=100).

As their titles imply, *Actuarial Studies 92* and *106* are descriptions of the process by which the population covered for Old-Age, Survivors, and Disability Insurance (OASDI) is projected into the future. Projections of fertility, mortality, immigration, marriage, and divorce are all required for estimation of receipts and benefits under the OASDI system. Because eligibility for many categories of OASDI benefits depends upon marital status, the population is projected by marital status, as well as by age and sex.

For this paper, the data of most interest appear in Table 10 of *Actuarial Study 92*, and in Table 11 of *Actuarial Study 106*. Both tables show central death rates by age group, sex, and marital status. The differences are only that the former table is based on census and death records centered in 1960, whereas the latter table shows the same calculations for 1980. Table 10 from *Actuarial Study 92* is reproduced here as Table 2.

The marital status headings are as follows: the "married" column represents persons legally married at the time of enumeration, and the "single" column (which might have been called the "never-married") plus the columns headed "widowed" and "divorced" make up the three categories of what this paper calls the "unmarried." (Some unmarried persons with multiple past marriages may be both widowed and divorced, in which case they are classified according to the most recent event).

C. Quantification of Unmarried/Married Mortality Effects

Table 3 is identical with Table 10 in *Actuarial Study 92*, except that (1) death rates have been expressed per thousand and rounded to three significant figures and (2) an "unmarried" column, combining its three distinct categories, has been added. The number of persons in each marital status category, needed to make the "unmarried" calculation shown, can be found in Table 18d of *Actuarial Study 92*.

In the study of mortality differences, results are often displayed in the form of life expectancies, the average remaining lifetime for a person alive at age x, according to the mortality table upon which the calculation is based. This approach obscures the pattern of differences by attained age, but is otherwise valid *if* the individuals studied maintain their distinctive status (for example, gender) throughout the remainder of their life [2]. But the unmarried often marry, and many of the currently married are later widowed or divorced. Life expectancies lose their meaning as the individuals studied shift back and forth between the categories under examination. For this and other reasons, the following analysis is

TABLE 2

CALENDAR YEARS 1959–61 AVERAGE CENTRAL DEATH RATES, BY AGE, SEX AND MARITAL STATUS (PER HUNDRED THOUSAND) [5]

Age	Total	Marital Status			
		Single	Married	Widowed	Divorced
		Male			
15–19	127.2	125.8	132.9	392.4	176.1
20–24	180.5	219.4	125.9	655.5	367.1
25–29	170.8	282.7	129.7	705.2	463.0
30–34	200.9	405.6	157.0	651.4	607.0
35–39	284.8	590.6	228.5	846.7	920.0
40–44	461.1	884.7	382.4	1,195.3	1,414.4
45–49	745.9	1,250.8	633.8	1,627.9	2,091.8
50–54	1,223.6	1,805.9	1,056.4	2,407.4	3,019.1
55–59	1,806.4	2,345.7	1,585.6	3,113.3	3,974.6
60–64	2,842.6	3,741.0	2,504.8	4,308.7	5,518.6
65–69	4,155.2	5,318.7	3,663.5	5,807.8	7,319.6
70–74	5,945.1	7,490.7	5,236.5	7,464.3	9,302.7
75–79	8,765.3	10,504.4	7,680.1	10,339.7	12,629.6
80–84	13,845.8	15,869.5	12,131.9	15,346.5	18,773.8
85–89	19,734.5	21,708.0	18,353.1	21,313.3	26,246.9
90–94	29,590.2	31,069.7	27,814.8	30,773.8	36,691.8
		Female			
15–19	53.7	51.8	59.4	273.6	117.4
20–24	70.1	91.3	58.0	247.3	143.7
25–29	87.7	161.4	73.7	240.2	180.4
30–34	122.5	245.1	104.2	330.1	247.9
35–39	178.1	322.7	154.4	388.1	338.9
40–44	275.8	436.8	240.9	516.2	483.4
45–49	417.1	559.6	370.4	680.9	621.9
50–54	631.3	712.8	560.4	945.0	849.6
55–59	902.0	884.6	802.1	1,217.4	1,147.2
60–64	1,471.2	1,449.5	1,291.2	1,818.9	1,719.8
65–69	2,259.8	2,115.2	1,998.9	2,597.3	2,526.0
70–74	3,671.4	3,458.3	3,252.0	3,985.3	3,995.0
75–79	6,133.9	5,944.8	5,330.5	6,456.7	6,745.4
80–84	10,797.9	10,835.8	9,396.5	11,023.1	11,724.1
85–89	15,419.7	15,419.7	14,186.1	16,036.5	16,961.7
90–94	24,312.5	24,312.5	22,853.8	24,798.8	26,743.8

Note: The average central death rate is the ratio of the average annual number of deaths during the period in the tabulated age group to the mid-period population in that age group.

in the form of annual death rates by attained age. No calculation of life expectancies is attempted.

Table 3 clearly shows that in 1960 the death rates for the unmarried exceeded those for the married for both sexes and for all age groups except the youngest (15–19). The excess deaths of the unmarried can be quantified either as deaths-per-thousand difference or by the unmarried/

TABLE 3

CENTRAL DEATH RATES BY AGE GROUP, SEX, AND MARITAL STATUS BASED ON 1960–61 DATA (PER THOUSAND)

Age Group	Total	Married	Unmarried	Unmarried		
				Never-Married	Widowed	Divorced
			Male			
15–19	1.27	1.33	1.26	1.26	3.92	1.76
20–24	1.80	1.26	2.21	2.19	6.56	3.67
25–29	1.71	1.30	2.93	2.83	7.05	4.63
30–34	2.01	1.57	4.34	4.06	6.51	6.07
35–39	2.85	2.28	6.60	5.91	8.47	9.20
40–44	4.61	3.82	9.99	8.85	12.0	14.1
45–49	7.46	6.34	14.7	12.5	16.3	20.9
50–54	12.2	10.6	21.8	18.1	24.1	30.2
55–59	18.1	15.9	29.1	23.5	31.1	39.7
60–64	28.4	25.0	42.7	37.4	43.1	55.2
65–69	41.6	36.6	57.9	53.2	58.1	73.2
70–74	59.5	52.4	75.7	74.9	74.6	93.0
75–79	87.7	76.8	105	105	103	126
80–84	138	121	155	159	153	188
85–89	197	184	215	217	213	262
90–94	296	278	309	311	308	367
			Female			
15–19	0.537	0.594	0.523	0.518	2.74	1.17
20–24	0.701	0.580	0.949	0.913	2.47	1.44
25–29	0.877	0.737	1.68	1.61	2.40	1.80
30–34	1.22	1.04	2.56	2.45	3.30	2.48
35–39	1.78	1.54	3.43	3.23	3.88	3.39
40–44	2.76	2.41	4.71	4.37	5.16	4.83
45–49	4.17	3.70	6.22	5.60	6.81	6.22
50–54	6.31	5.60	8.62	7.13	9.45	8.50
55–59	9.02	8.02	11.4	8.85	12.2	11.5
60–64	14.7	12.9	17.4	14.5	18.2	17.2
65–69	22.6	20.0	25.2	21.2	26.0	25.3
70–74	36.7	32.5	38.1	34.6	39.9	40.0
75–79	61.3	53.3	64.1	59.4	64.6	67.5
80–84	108	94.0	101	108	100	117
85–89	154	142	159	154	160	170
90–94	243	229	248	243	248	267

married ratio. Because in this case the excess deaths are not independent of age (as they might be for the excess deaths resulting from some catastrophic event assumed to affect all ages alike), this paper measures excess mortality via the appropriate ratios. More specifically, in this paper the unmarried/married ratio is that between the unmarried and married death rates for a specific age and sex. For males in the age group 45–49, for example, the 1960 unmarried/married ratio is 14.7/6.34=2.32; for females in the age group 45–49, the ratio is 6.22/3.70=1.68. Whatever was causing the unmarried status to show higher mortality for this age group was more potent among men than women. Clearly unmarried/married effects and male/female effects are interacting. To account for this interaction, it is necessary to study male/female ratios as well.

As a first step in that direction, this paper defines the male/female ratio as that between the male and female death rates for a specific age and marital status. Within the age group 45–49, the male/female ratio for the married is 6.34/3.70=1.71; for the unmarried, 14.7/6.22=2.36.

Despite the interactions, it is possible to separate the sex and marital status effects by combining the two unmarried/married ratios into one unmarried/married *factor* and the two male/female ratios into one male/female *factor*. If, in each case, the two ratios are replaced by their geometric mean, it can be shown that the resulting *factors* have the characteristics that (1) the product of the two factors reproduces the unmarried male/married female ratio, while (2) the quotient of the two factors reproduces the unmarried female/married male ratio. In the age group 45–49 example, the unmarried/married factor becomes (2.31×1.68)exp0.5=1.97; the male/female factor (1.71×2.36)exp0.5 =2.01. As a check, note that 1.97×2.01=3.96=unmarried male/married female and that 1.97/2.01=0.982=unmarried female/married male. For this age group, the unmarried/married and male/female factors are both very close to 2, with the male/female factor just a shade larger. At this age (in 1960) the death rate for married men exceeds that for unmarried women, but by less than 2 percent.

Note that the male/female factor calculated above, 2.01, is not identical to 7.46 (the all male q for the age group) divided by 4.17 (the all female). This latter ratio (1.79) understates the true sex effect because of interaction. For this age group in 1960, 14 percent of the males were unmarried, versus 18 percent of the females. Other problems with confounding due to interaction are examined in Section III.

Table 4 is an extension of the age group 45–49 example to other age groups. All of Table 4 can be calculated directly from Table 3. Of especial note, Table 4 shows that:

1. The unmarried/married ratio is higher for males than for females; the male/female ratio is higher for the unmarried than the married. These inequalities hold, not only in the age group 45–49, but generally throughout the adult ages. Marital status effects are stronger for males than for females.
2. The unmarried/married ratio for age group 15–19 is 0.946 for males and 0.881 for females, the only points in the entire array where the death rates for the married exceed those for the unmarried. The unmarried/married factor, also less than unity for this young age group, is 0.91.
3. The unmarried/married factor exceeds the male/female factor for ages 25–44, while the reverse is true at both younger and older ages. It follows that the death rates for unmarried females exceed those for married males only at the middle ages, 25–44.
4. The unmarried/married factor starts below unity, rises until it reaches a peak of more than 2.5 at ages 30–39, and then falls slowly to 1.09 for ages 90–94.
5. The combined effect of male sex and the unmarried state reaches a zenith of 4.27 for age group 35–39. Here the unmarried/married factor is 2.53, to be multiplied by the male/female factor of 1.69.

D. Twenty Years of Change

Table 5 is the 1980 counterpart of Table 3. Note that the mortality rates generally improved over the two decades. Table 6 expresses each rate from Table 5 as a percentage of that from Table 3. For only five (all male) of the 64 age/sex/marital status groups did mortality rates increase. For all the female subgroups and for most of the 30 or older males, mortality rates declined. For high age married females, mortality rates were nearly cut in half.

The 20-year mortality improvement displayed is more married than unmarried and more female than male, leading to the assumption that the unmarried/married and male/female factors increased. Table 7, when compared with Table 4, confirms this assumption.

The bar graphs in Figures 1 and 2 depict the unmarried/married factors and the male/female factors, respectively, for both 1960 and 1980. While

TABLE 4

1960 RATIO OF CENTRAL DEATH RATES

Age Group	Unmarried to Married		Male to Female		Unmarried Male/ Married Female	Unmarried Female/ Married Male	Marital Factor	Sex Factor
	Male	Female	Unmarried	Married				
15–19	0.946	0.881	2.405	2.237	2.117	0.394	0.91	2.32
20–24	1.754	1.636	2.327	2.171	3.807	0.754	1.69	2.25
25–29	2.261	2.283	1.744	1.761	3.981	1.297	2.27	1.75
30–34	2.766	2.455	1.697	1.507	4.167	1.629	2.61	1.61
35–39	2.883	2.219	1.926	1.479	4.273	1.499	2.53	1.69
40–44	2.613	1.957	2.119	1.587	4.147	1.237	2.26	1.83
45–49	2.313	1.681	2.355	1.711	3.957	0.982	1.97	2.01
50–54	2.066	1.539	2.531	1.885	3.894	0.816	1.78	2.18
55–59	1.835	1.418	2.559	1.977	3.628	0.717	1.61	2.25
60–64	1.703	1.351	2.445	1.941	3.304	0.697	1.52	2.18
65–69	1.579	1.259	2.299	1.833	2.895	0.687	1.41	2.05
70–74	1.446	1.172	1.987	1.611	2.328	0.728	1.31	1.79
75–79	1.364	1.202	1.635	1.439	1.965	0.834	1.28	1.53
80–84	1.277	1.079	1.528	1.291	1.649	0.836	1.17	1.41
85–89	1.171	1.124	1.347	1.294	1.514	0.869	1.15	1.32
90–94	1.111	1.084	1.247	1.217	1.353	0.891	1.09	1.23

TABLE 5

CENTRAL DEATH RATES BY AGE GROUP, SEX, AND MARITAL STATUS BASED ON 1980–81 DATA (PER THOUSAND)

Age Group	Total	Married	Unmarried	Unmarried		
				Never-Married	Widowed	Divorced
			Male			
15–19	1.36	1.69	1.35	1.35	9.33	4.00
20–24	1.94	1.36	2.18	2.12	11.0	4.30
25–29	1.92	1.23	3.01	2.76	11.2	4.58
30–34	1.92	1.28	4.04	3.55	11.5	5.00
35–39	2.42	1.72	5.88	5.92	11.9	5.63
40–44	3.58	2.76	7.76	7.46	12.0	7.74
45–49	5.81	4.59	12.9	12.4	12.7	13.4
50–54	9.33	7.55	20.2	19.9	17.5	21.5
55–59	14.5	12.3	27.1	25.6	24.1	30.4
60–64	22.0	19.3	36.6	34.0	34.7	41.5
65–69	33.4	29.5	53.6	47.6	55.6	57.4
70–74	49.9	44.4	73.0	71.5	71.6	78.6
75–79	73.2	62.4	112	129	106	130
80–84	110	93.2	148	195	140	173
85–89	164	142	189	261	184	193
90–94	220	193	240	322	232	230
			Female			
15–19	0.518	0.507	0.517	0.515	2.70	0.750
20–24	0.603	0.405	0.749	0.719	2.74	1.05
25–29	0.675	0.465	1.16	1.11	2.82	1.20
30–34	0.826	0.606	1.64	1.79	2.85	1.38
35–39	1.22	0.950	2.38	2.78	3.00	2.06
40–44	1.95	1.58	3.61	4.09	3.81	3.33
45–49	3.19	2.65	5.39	5.44	5.87	5.08
50–54	4.96	4.22	7.56	7.54	7.76	7.35
55–59	7.46	6.35	10.5	11.6	10.1	10.8
60–64	11.3	9.39	15.1	16.1	14.8	15.7
65–69	17.1	14.3	20.5	21.1	19.8	24.8
70–74	26.2	21.4	30.0	31.8	29.2	37.2
75–79	41.3	34.1	44.5	49.6	43.1	63.4
80–84	71.0	51.8	76.0	83.2	74.6	99.2
85–89	118	78.9	129	147	127	126
90–94	180	127	195	236	192	170

the 1960 and 1980 graphs for each factor have the same general shape, at nearly every age in the entire display the 1980 factors are the larger.

The fact that the male/female factors increased is significant, but the point here is that unmarried/married factors increased over the 20 years, thus widening the death rate differences by marital status. In 1960 unmarried persons in their 30s died at 2.5+ times the rate for the same

TABLE 6

MORTALITY IMPROVEMENT: 1980 DEATH RATES AS A PERCENTAGE OF 1960 DEATH RATES

	Married		Unmarried	
Age Group	Male	Female	Male	Female
15–19	127.5%	85.4%	107.5%	98.9%
20–24	107.9	69.8	98.5	78.9
25–29	94.8	63.1	102.7	68.7
30–34	81.8	58.2	93.2	64.3
35–39	75.1	61.5	89.2	69.6
40–44	72.1	65.5	77.7	76.6
45–49	72.4	71.6	88.1	86.7
50–54	71.5	75.2	95.9	87.7
55–59	77.3	79.1	92.9	92.6
60–64	76.9	72.7	85.7	86.6
65–69	80.4	71.4	92.5	81.4
70–74	84.7	65.7	96.4	78.6
75–79	81.2	64.1	107.1	69.5
80–84	76.8	55.1	95.6	75.1
85–89	77.6	55.6	87.8	80.8
90–94	69.5	55.6	77.7	78.7

aged married, a result difficult enough to explain, but by 1980 this ratio had increased to nearly 3.

The seeming anomaly for age group 15–19, where the unmarried/married ratios were less than unity for both sexes in 1960, persists in 1980. While the unmarried/married ratio for females increased (to go slightly above 1), that for males decreased. Coincidentally, these small changes offset, and the unmarried/married factors for both years are shown as 0.91.

The range of ages for which the unmarried/married factor exceeds the male/female factor, indicating that married males die less often than unmarried females, moved from 25–44 in 1960 to 30–49 in 1980. (In 1980 the unmarried/married and male/female factors were almost exactly equal for age group 50–54, indicating that married males and unmarried females in their early 50s had nearly identical death rates.)

Tables 4 and 7 indicate that the unmarried/married ratios reach a peak at about age 35 and then decline. The deaths-per-thousand differences between the unmarried and married death rates, however, continue their rise with advancing age. Note that, as shown in Table 8, in 1980 the unmarried death rates at the highest ages exceeded those for the married by approximately 50 deaths per thousand.

TABLE 7

1980 RATIO OF CENTRAL DEATH RATES

Age Group	Unmarried to Married		Male to Female		Unmarried Male/ Married Female	Unmarried Female/ Married Male	Marital Factor	Sex Factor
	Male	Female	Unmarried	Married				
15–19	0.798	1.021	2.615	3.341	2.667	0.305	0.91	2.96
20–24	1.601	1.849	2.904	3.356	5.369	0.551	1.72	3.12
25–29	2.449	2.484	2.608	2.645	6.477	0.939	2.47	2.63
30–34	3.148	2.713	2.459	2.121	6.675	1.279	2.92	2.28
35–39	3.426	2.511	2.467	1.807	6.194	1.389	2.93	2.11
40–44	2.815	2.288	2.149	1.747	4.918	1.309	2.54	1.94
45–49	2.812	2.033	2.394	1.729	4.867	1.175	2.39	2.04
50–54	2.774	1.795	2.768	1.791	4.968	1.002	2.23	2.23
55–59	2.209	1.659	2.572	1.931	4.266	0.859	1.91	2.23
60–64	1.899	1.611	2.421	2.051	3.896	0.785	1.75	2.23
65–69	1.817	1.436	2.612	2.065	3.751	0.696	1.62	2.32
70–74	1.645	1.402	2.435	2.076	3.415	0.676	1.52	2.25
75–79	1.799	1.306	2.519	1.829	3.289	0.714	1.53	2.15
80–84	1.591	1.468	1.948	1.799	2.861	0.816	1.53	1.87
85–89	1.324	1.631	1.465	1.804	2.389	0.904	1.47	1.63
90–94	1.243	1.534	1.231	1.521	1.889	1.009	1.38	1.37

FIGURE 1

UNMARRIED/MARRIED MORTALITY FACTORS FOR 1960 AND 1980

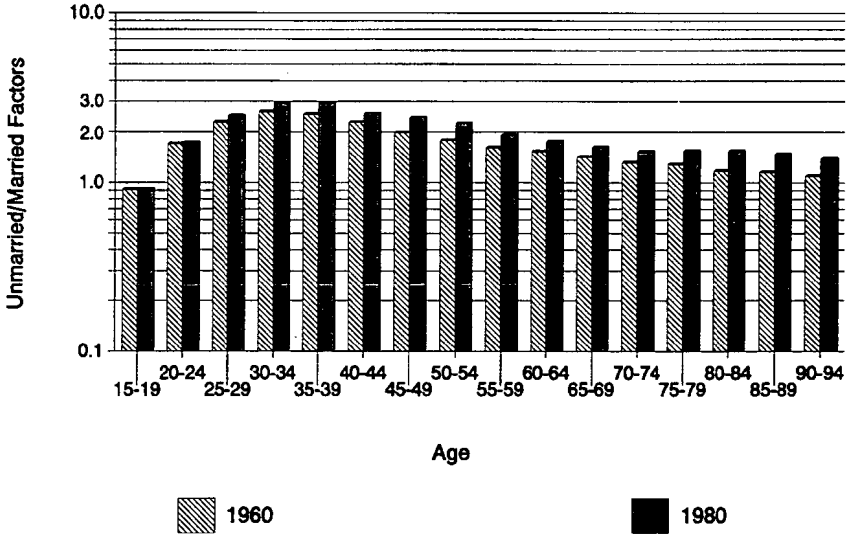

FIGURE 2

MALE/FEMALE MORTALITY FACTORS FOR 1960 AND 1980

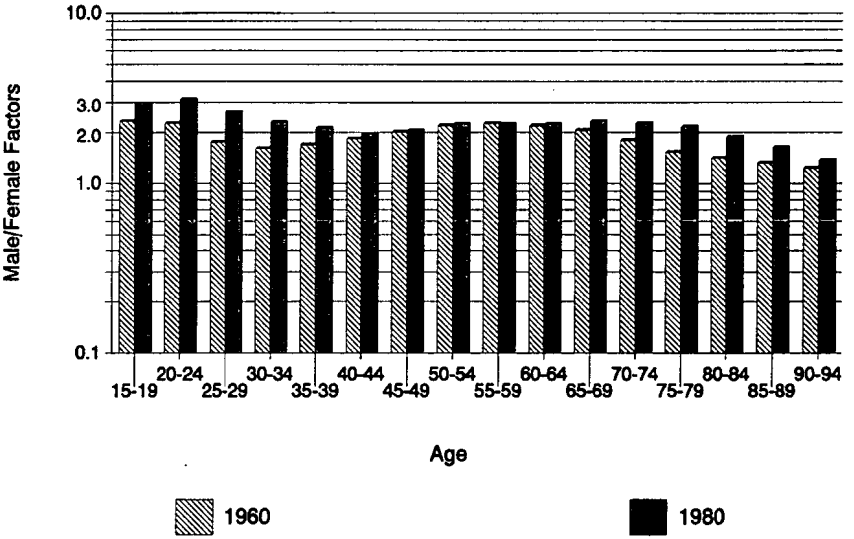

TABLE 8

UNMARRIED DEATH RATES IN EXCESS OF MARRIED DEATH RATES PER THOUSAND, 1980, FROM TABLE 5

Age Group	Male	Female
35–39	4.17	1.44
40–44	5.01	2.03
45–49	8.32	2.74
50–54	12.7	3.35
55–59	14.8	4.18
60–64	17.3	5.73
65–69	24.1	6.22
70–74	28.8	8.60
75–79	49.8	10.4
80–84	55.0	24.2
85–89	46.2	49.8
90–94	46.9	67.9

E. Components of the Unmarried

To this point the emphasis has been on the mortality experience of the unmarried as a whole, but Tables 3 and 5 make it possible to look at the never-married, the widowed, and the divorced separately.

Tables 9 and 10 are derivatives of Tables 3 and 5, respectively, which show, for each age-sex group, the percentage of the unmarried in the three classifications. They also set forth the ratio of the death rates for each component of the composite *of all unmarried.*

The never-married column of Table 9 shows ratios less than unity for the younger ages, but generally higher than unity at the highest ages. The crossing points, however, are different for males and females. For women, the never-married die faster than the divorced/widowed at most ages above 30, while for men this situation does not exist until age 75.

For the widowed, the young age ratios are high. Young widows and widowers for some reason are more likely to die than those who have never married. But widows above age 35, and widowers above age 65, are generally as good a risk as the never-married.

Divorcees below age 30 of both sexes appear to have higher mortality than the never-married, but lower than the few widow(er)s. Male divorced show higher mortality than the never-married at all ages, but female divorcees above age 25 do about as well as the never-married.

There are some changes in Tables 9 and 10 as the focus shifts to 1980. For example, the high mortality rates for male divorcees above age 35

TABLE 9

COMPONENTS OF THE UNMARRIED IN 1960: PERCENTAGES OF AND RATIOS TO ALL UNMARRIED

Age Group	Never Married		Widowed		Divorced	
	Percentage	Ratio	Percentage	Ratio	Percentage	Ratio
			Male			
15–19	99.9	0.999	—	3.199	0.1	1.401
20–24	99.1	0.994	—	2.969	0.9	1.663
25–29	94.8	0.964	0.4	2.404	4.9	1.579
30–34	86.2	0.934	2.1	1.501	11.7	1.398
35–39	78.2	0.895	5.1	1.283	16.8	1.394
40–44	75.7	0.885	6.5	1.196	17.8	1.416
45–49	67.7	0.853	12.8	1.111	19.6	1.427
50–54	58.1	0.827	21.6	1.103	20.3	1.383
55–59	48.9	0.806	31.2	1.069	19.9	1.366
60–64	41.3	0.877	42.2	1.011	16.4	1.294
65–69	34.7	0.919	54.7	1.004	10.5	1.265
70–74	27.1	0.989	66.6	0.986	6.2	1.228
75–79	21.1	1.003	74.6	0.987	4.3	1.206
80–84	16.7	1.024	79.9	0.991	3.1	1.212
85–89	13.1	1.011	84.5	0.992	2.4	1.222
90–94	10.9	1.005	87.3	0.995	1.8	1.187
			Female			
15–19	99.5	0.996	—	5.231	0.5	2.245
20–24	93.1	0.961	0.4	2.606	4.4	1.514
25–29	72.9	0.958	1.4	1.428	17.1	1.073
30–34	46.8	1.087	5.1	1.289	26.8	0.969
35–39	33.6	1.165	9.2	1.133	28.5	0.989
40–44	27.1	1.131	16.3	1.095	27.5	1.025
45–49	23.8	1.009	28.1	1.094	21.4	0.999
50–54	20.2	0.997	43.1	1.096	15.9	0.985
55–59	16.6	1.103	57.1	1.071	11.1	1.009
60–64	13.8	1.062	68.9	1.042	7.2	0.986
65–69	11.9	1.032	77.6	1.032	4.2	1.004
70–74	10.3	1.061	83.3	1.046	2.6	1.048
75–79	8.9	1.114	87.2	1.008	1.9	1.053
80–84	8.1	1.095	89.1	0.989	1.5	1.157
85–89	7.5	1.139	89.8	1.006	1.3	1.064
90–94	7.2	1.209	90.3	1.001	1.6	1.079

TABLE 10

COMPONENTS OF THE UNMARRIED IN 1980: PERCENTAGES OF AND RATIOS TO ALL UNMARRIED

Age Group	Never Married		Widowed		Divorced	
	Percentage	Ratio	Percentage	Ratio	Percentage	Ratio
			Male			
15–19	99.9	0.997	—	6.901	0.1	2.959
20–24	97.5	0.973	—	5.057	2.5	1.978
25–29	87.1	0.917	0.2	3.718	12.7	1.522
30–34	68.7	0.878	0.6	2.831	30.7	1.236
35–39	51.7	1.007	1.6	2.016	46.7	0.956
40–44	43.9	0.961	3.5	1.545	52.5	0.996
45–49	43.3	0.959	8.2	0.981	48.5	1.039
50–54	42.2	0.985	15.1	0.865	42.9	1.062
55–59	39.9	0.944	23.1	0.892	37.1	1.124
60–64	36.2	0.929	32.7	0.949	31.1	1.136
65–69	31.7	0.889	41.9	1.039	26.3	1.072
70–74	24.5	0.979	57.2	0.981	18.4	1.077
75–79	17.1	1.148	72.6	0.942	10.3	1.162
80–84	11.7	1.317	82.6	0.947	5.7	1.165
85–89	8.4	1.384	87.6	0.977	3.9	1.019
90–94	6.3	1.341	90.1	0.968	3.6	0.957
			Female			
15–19	99.5	0.996	—	5.222	0.5	1.451
20–24	93.1	0.961	0.4	3.661	6.5	1.402
25–29	72.9	0.958	1.4	2.444	25.7	1.042
30–34	46.8	1.087	5.1	1.734	48.1	0.837
35–39	33.6	1.165	9.2	1.258	57.1	0.862
40–44	27.1	1.131	16.3	1.055	56.7	0.922
45–49	23.8	1.009	28.1	1.089	48.2	0.942
50–54	20.2	0.997	43.1	1.026	36.8	0.971
55–59	16.6	1.103	57.1	0.956	26.3	1.031
60–64	13.8	1.062	68.9	0.978	17.2	1.041
65–69	11.9	1.032	77.6	0.968	10.4	1.208
70–74	10.3	1.061	83.3	0.975	6.4	1.241
75–79	8.9	1.114	87.2	0.969	4.1	1.424
80–84	8.1	1.095	89.1	0.982	2.9	1.305
85–89	7.5	1.139	89.8	0.988	2.8	0.981
90–94	7.2	1.209	90.3	0.984	2.7	0.871

in 1960 have largely disappeared by 1980. Whether the differences between 1960 and 1980 are significant is left to the determination of the reader.

F. A Changing Marital Status Profile

Mortality by marital status has been studied here age-by-age, with emphasis on 1960 and 1980. There seems to be no obvious tie-in between the widening differences in death rates by marital status and the changing profile of marital status within the U.S. Nonetheless, the data on the proportion of persons married, by age and sex, for census years back to 1940, are readily available from *Actuarial Studies 92* and *106*. Table 11 shows these percentages for 1940, 1960, and 1980, and for the pre-census year 1989, separately by age group and sex.

In general, the proportion of adults married has been declining, after reaching a peak at about 69 percent for males and 66 percent for females in 1960. Reasons for the decline in the percentage of adults married are not within the scope of this paper, but will surely include the tendency of younger men and women to live together without marriage, to remain single longer, and to divorce more readily.

These forces are partly counteracted by ever-lengthening human life, resulting in later termination of long-term marriages by death and, hence, an increasing percentage of marriage among those over 65. As 1989 began, among those age 65 and older, 75 percent of men and 40 percent of women were married.

III. WHY IS UNMARRIED MORTALITY HIGHER?

The data in Section II clearly demonstrate that the differences between unmarried and married mortality rates are indeed substantial, particularly at ages 25–54: in 1980 the unmarried death rates were more than twice the married death rates. At higher ages the unmarried/married factors fall from 1.91 to 1.38, but the extra mortality, expressed as deaths per thousand, continues to rise with advancing age. The curious mind searches for the reasons why such large differences exist and why they appear to be widening.

The "genetic" explanation, used by some to account for female longevity superiority, clearly cannot be extended to unmarried/married mortality differences. A person's genes do not change when he or she is married, widowed, or divorced. It seems that we must search among

TABLE 11

PERCENTAGE MARRIED BY AGE, SEX, AND DATE

Age Group	July 1940	July 1960	July 1980	Jan 1989
		Male		
15–19	2.4%	5.0%	3.6%	1.4%
20–24	27.3	41.7	29.5	21.0
25–29	61.9	72.5	59.7	48.0
30–34	68.3	83.8	75.2	64.6
35–39	77.5	86.9	82.8	72.3
40–44	79.1	87.1	84.4	77.8
45–49	79.3	86.2	84.9	78.9
50–54	78.4	84.6	85.0	79.9
55–59	76.3	82.7	85.0	81.3
60–64	71.9	80.8	84.2	81.5
65–69	64.9	79.1	84.2	80.4
70–74	61.3	73.6	78.6	78.0
75–79	61.2	64.0	72.5	74.5
80–84	55.0	52.7	62.2	69.1
85–89	41.3	39.8	46.9	54.2
90–94	26.5	26.7	31.7	36.9
95+	16.7	14.3	15.4	18.2
15+	58.6%	68.9%	62.1%	59.1%
15–64	58.3	68.7	60.4	50.7
65+	61.4	70.4	74.7	75.2
		Female		
15–19	12.2%	15.5%	9.9%	4.7%
20–24	49.4	64.1	43.7	34.2
25–29	74.0	85.3	68.2	62.1
30–34	77.6	88.5	77.6	71.6
35–39	80.6	87.5	80.8	75.6
40–44	80.7	86.7	81.4	75.0
45–49	77.7	81.8	79.9	74.9
50–54	72.8	75.7	76.7	74.0
55–59	66.4	69.2	72.2	70.3
60–64	56.1	60.8	65.1	65.6
65–69	41.9	50.8	55.2	57.5
70–74	34.4	40.0	43.7	47.4
75–79	34.3	28.3	30.4	33.7
80–84	30.8	19.7	20.9	23.6
85–89	23.5	14.8	15.8	17.7
90–94	15.4	9.6	10.6	11.9
95+	9.1	3.4	5.3	5.5
15+	60.5%	66.3%	57.9%	56.1%
15–64	62.9	71.0	61.5	59.6
65+	36.3	38.0	38.5	40.3

environmental, psychological, or sociological factors to reach a creditable explanation for the differences demonstrated.

In this section, the explanations that earlier writers have suggested, plus some that have been put forth in various communications with the author, are examined in light of the data presented in Section II.

A. Selection at Marriage

One possibility expressed by early writers [2], [3] is that marriage involves a form of self-selection. Robust men and women are likely to get married, usually before age 30, but sickly or weaker persons may be less so. This "explanation" is bolstered by the 1940 study previously noted, which identified the causes of death particularly associated with death rate differences between the married and the never-married, and found them to be tuberculosis, syphilis, pneumonia/influenza, cirrhosis of the liver, and accidents (in that order) among men, and tuberculosis, cancer of the breast, pneumonia/influenza, suicide, and accidents among women. Tuberculosis, which typically attacks near the usual ages for first marriage and which might well cause either partner in a prospective marriage to reconsider, might be a strong suspect for the "selection at marriage" explanation.

However convincing this argument may have been a half-century ago, the case is weaker today. That the divorced and widowed show higher death rates at the young adult ages than the never-married is a contraindication, as is the persistence of the unmarried/married difference to the higher ages, where the never-married are very few and any selection effect might be thought to have worn off. The pattern of unmarried/married differences, strongest at ages 25–50 and reversed at ages 15–19, does not support this explanation. Moreover, tuberculosis and syphilis are no longer important causes of death among young adults, married or unmarried.

B. Responsibility

Another possibility is that marriage itself, because of the extra responsibility to spouse and children that marriage entails, leads to a more careful lifestyle. That young men take greater risks than young women, and hence die more often from accidents or violence, is often part of the explanation why male/female death rate differences are so pronounced at the young adult ages. That the unmarried/married differences are shown

to be stronger among men than women perhaps lends some credence to this "responsibility" explanation.

On the other hand, there are contraindications in the data presented earlier. That the unmarried die faster is true for women as well as men, and it is more true at ages above 30 than below. In fact, married men have no lower death rates than the unmarried at ages 15–19.

C. Living Arrangements and Reciprocal Care-Giving

Not all unmarried live alone, and some of the married do, but even so a high percentage of those who live without another adult in the household are unmarried. Man is a gregarious animal, and it may well be that living with another adult, someone with whom the person can share the vicissitudes of life, may be an important psychological advantage. Whether the receipt of support, or the giving of the same, is the more powerful influence toward lower death rates is conjectural; probably both are important. The widowed or divorced, persons who once had this support but no longer do, have suffered a trauma from which some, particularly at the older ages, do not recover.

This explanation was advanced by members of the actuarial staff of the Social Security Administration, with whom this author has been in contact. If valid, this rationale suggests that women can live without a spouse more successfully than men.

D. Interactions

We have seen earlier that overall ratios of male-to-female death rates can be misleading, if some other important factor is interacting and if the male and female data have different proportions of the interacting variable. Similarly the unmarried/married factors computed in Section II may be misleading if the unmarried, more than the married, are subject to some other source of higher mortality.

Kitagawa and Hauser [3] suggest that the interaction of socioeconomic factors and marriage may be an explanation for the higher mortality of the unmarried. If a lower socioeconomic status can be shown to be positively correlated with both excess mortality and the unmarried state, then the possibility of exaggerated marital status effects in socioeconomically mixed data exists. Proof of either of these correlations is, however, lacking, and the magnitude of the marital status differences seems to throw strong doubt on the explanatory power of this interaction.

The 1960 and 1980 data presented earlier are not separated by race. Census data that are so separated have rather consistently shown that non-whites in the U.S. die faster than whites. This extra racially enumerated mortality may in fact be a mask for something else, for example, socioeconomic class, but it is nonetheless a statistical fact that must be dealt with. If it could then be shown that fewer non-whites are married, it may be inferred that the race-marital status interaction explains a part of the marital status effects observed.

The 1940 data presented earlier, which show 1940 mortality rates by age, sex, marital status, *and race*, can be analyzed to show that the marital status effect is strong for both whites and non-whites and that racial differences in the percentage married cannot account for any important part of the unmarried/married effects observed in race-combined data.

Another example of an interaction explanation is in relation to smoking habits. It is by now well-documented that death rates for smokers are higher than those for nonsmokers. If it could be proven that a higher percentage of the unmarried smoke than the married, then the combining by smoking habits may tend to overstate the unmarried/married factors.

Table 12 calculates smoker/nonsmoker differences, corrected for gender interaction, based on the division of the CSO 1980 Basic Table (male and female separately) into smoker and nonsmoker components, and compares these with the unmarried/married factors of Table 7. The unmarried/married factors are in general larger, but not by much. If it could be assumed that *all* the unmarried were smokers and *all* the married were nonsmokers, we might conclude that smoking differences accounted for most of the marital status differences, but of course this assumption is contrary to fact.

E. Social Interaction

In 1979 Berkman and Syme published a study [1] designed to assess the relationship between social and community ties and mortality. On the basis of interviews and questionnaires, 4,725 persons who were 1965 residents of Alameda County, California were classified as having either "high" or "low" levels of "social interaction"; then the 371 deaths over the next seven years were followed and analyzed. Mortality rates for persons with low levels of social interaction were substantially higher than those for persons with high levels for both sexes and at all three

TABLE 12

COMPARISON OF UNMARRIED/MARRIED AND SMOKER/NONSMOKER FACTORS

Age	Unmarried/Married Factor from Table 7	Smoker/Nonsmoker Factor from Split of 1980 CSO
15–19	0.91	1.42
20–24	1.72	1.51
25–29	2.47	1.65
30–34	2.92	1.89
35–39	2.93	2.03
40–44	2.54	2.14
45–49	2.39	2.16
50–54	2.23	2.09
55–59	1.91	1.88
60–64	1.75	1.64
65–69	1.62	1.48
70–74	1.52	1.35
75–79	1.53	1.23
80–84	1.53	1.16
85–89	1.47	1.08
90–94	1.38	1.02

age groups. The authors concluded that adults with minimum human contact die faster than those with wide and frequent social interaction.

The Berkman and Syme study suggests that marriage and social interaction may be highly correlated in contemporary U.S. society and, hence, that marital status effects on human mortality may be largely the same as the effects of differences in social interaction. Fortunately, the Alameda County data also recorded marital status, so the study produces unmarried/married ratios as well as social interaction ratios. A comparison of these ratios from the Berkman and Syme data is set forth in Table 13.

Note that, in the Alameda County study, the marital status effect in males exceeds that in females (as in the census-derived data presented earlier), but only for two of the three age groups, and that the reverse is true for "social interaction."

TABLE 13

COMPARISON OF MARITAL STATUS AND SOCIAL INTERACTION FACTORS FROM THE BERKMAN-SYME STUDY

Age	Marital Status: Unmarried/Married Ratio	Social Interaction: Low/High Ratio
	Male	
30–49	2.9	2.0
50–59	2.3	2.0
60–69	1.3	1.5
	Female	
30–49	1.3	2.9
50–59	1.4	1.5
60–69	1.5	1.7

IV. CONCLUSIONS

That the married show lower mortality rates than the unmarried seems well-documented. For ages from 25 to 55, the unmarried/married mortality factor is above 2 and seems to be increasing. At many ages being married is a better sign of lower potential mortality than being female. The author finds this phenomenon surprising and hence brings it to the attention of actuaries and demographers.

Because marriage per se can hardly be the "cause" of the lower mortality demonstrated, marriage (in the legal sense) must be closely associated with some other variable associated with lower mortality. Living with another adult may or may not be that variable. If living with another is not the best of the explanations here considered, perhaps a correlate, the degree of social interaction, is.

Demonstration will be lacking, however, until or unless death records, like census results, can be sorted in terms of household arrangements. When and if data based on the census year 1990 become available, it may be possible to discern whether the 1960–1980 trends have continued and whether the AIDS epidemic has introduced still another explanation of why the unmarried, and males, have higher mortality.

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DISCUSSION OF PRECEDING PAPER

ROBERT L. BROWN:

I thank Charles Trowbridge for writing this fine paper. It is an important addition to the actuarial literature. On a more personal level, it stimulated me to do further research on the issues raised, and I now find myself immersed in this matter. I can see that much more work deserves to be done on many of the issues presented by Trowbridge's introductory work.

I began my work with a review of the literature. Through a computer search, I was able to find three textbooks and more than 30 published papers on topics that have a direct impact on the issues raised by Trowbridge.

The oldest textbook referenced is also the one most cited in the papers reviewed. It is a book written by Evelyn Kitagawa and Philip Hauser, published in 1973, *Differential Mortality in the United States: A Study in Socio-Economic Epidemiology*. In this book, the authors bring together findings of three studies of the Population Research Center at the University of Chicago. Their analysis is formulated on a rich and extensive database, which helps to explain the longevity of the acceptance of the findings. Among the more significant conclusions of this work are the following:

- The data show large mortality differentials by socioeconomic status.
- Future mortality reduction may be achieved more readily through programs designed to improve the socioeconomic conditions of the disadvantaged than through further advances in biomedical knowledge (from which the lower socioeconomic components of the population do not seem to benefit anyway).
- Mortality rates are negatively correlated with education (and, at the time of this study, this factor was more important for women than men, a result that seemed to derive from the higher mortality associated with childbirth, and the negative correlation of pregnancy and education).
- Similarly, mortality rates were negatively correlated with income; this was, however, more important for males than females at the time of the study. If income decreases with sickness before death, then these data may overrate the importance of income somewhat (however, other

studies quoted later have shown that income level remains important even after retirement when earnings have ceased).

- Class differences in mortality are greatest in the young adult and middle years.
- Education and income have important independent relationships with mortality (that is, they do not just double-measure the same effect).
- However, education is probably the single most important indicator of socioeconomic status for mortality analysis.
- Married persons have lower mortality rates. This effect is more pronounced for males than for females. The authors attribute the difference to behavioral constraints on married males, versus single males. There is also a selection factor in the differences (that is, healthier people have a better chance of getting married), which is discussed in more detail later in this discussion.
- For females, mortality rates are negatively correlated with the number of children borne (that is, the more children, the healthier the profile) until one gets to very large families (five or more children) when the trend reverses. Beyond five, the number of children is positively correlated with mortality.
- Young nonwhites have elevated mortality rates, especially males. While not quantifiable, there were indications that this factor was, at least in part, socioeconomic.
- There were also geographic differences in mortality rates and urban-rural differences. Readers are referred to the original material for details on these variables.
- If the mortality levels associated with white men and women having one or more years of college education could obtain for all men and women, more than one-sixth of adult white deaths and more than one-third of adult nonwhite deaths might have been prevented.
- There is great potential for decreasing mortality through improved social and economic conditions of nonwhites in the nation.
- The disparity of mortality had not diminished over the period 1930 to 1960 in Chicago (where longitudinal data were available).
- The authors conclude that the most important next gain in mortality reduction is to be achieved through improved social-economic conditions rather than through increments to and application of biomedical knowledge (which never seems to reach the disadvantaged anyway).

A second textbook reviewed is *Social Psychology of Health and Illness*, edited by Glenn S. Sanders and Jerry Suls (1982). This is truly a

social-psychology book that does not add much to the debate engendered by Trowbridge's paper. Of some interest, however, is an argument in the book that not all social support is beneficial. Support must be of high quality to be helpful (for example, if your caregiver is depressed about your illness and shows it, it may make matters worse, not better). Situations in which couples can offer mutual and (relatively) equal support seem to be positive, as are self-help groups.

A third textbook, *Social Support and Health*, edited by Sheldon Cohen and S. Leonard Syme (1985) is also only tangentially interesting. This book focuses on the process and sociology of social support rather than on the results. However, the following may be of interest:

- The social network provides information on good health care.
- The social network provides support and care in and of itself.
- The social network constrains its members to healthy activity.
- Lack of a social network and its intimacy is stressful.

In addition to these three textbooks, we found more than 30 papers in learned journals that seemed relevant to this topic. These papers were reviewed in detail by a graduate student, John Di Meo. The bibliography lists these papers, and Mr. Di Meo's reviews of them can be obtained from me at my *Directory* address.

Highlights from the papers reviewed include:

- Married individuals are more successful in obtaining and following prescribed treatments.
- With regard to mortality that is largely unaffected by social factors (for example, leukemia), no significant differences are noted among the different marital states.
- Selectivity (that is, only healthy people get married) plays a minor role. This is partly indicated by the fact that the widowed, who have been selected for marriage, display the highest mortality rates. Also, selectivity should persist throughout all causes of mortality, but instead appears to affect only those causes that are a function of social behavior (for example, not leukemia).
- Keyfitz suggests that selection cannot wholly account for all the mortality differences, because this would mean that both males and females would benefit equally from marriage. Further, the mortality ratios by marital status have increased over time. Can it be argued that the process of selection has strengthened over time?
- It is not the mere diversion offered by social activities that is of benefit, because passive and solitary leisure activities were found to be

associated with *increased* mortality. It appears that, to have a beneficial impact, an activity must engender a greater active effort to come in contact with others.

- Marriage provides the individual with social, psychological and material support, making one's life safer and more predictable. Since marriage bonds the individuals to a social group that entails certain obligations, expectations, and support, persons who are married would tend to practice safety in their environment and diligence in diet, lifestyle, and health matters. While selection does play a part, the "protection" aspect of marriage plays a much more significant role.
- Several papers stress the importance of "social ties" that normally come with marriage. One study also suggested that in addition to the presence of social ties, the *perception* of having social support is an important predictor of mortality.
- The ability to communicate one's feelings through the intimacy of marriage is also listed as an important factor favoring the married.
- Recent marital transitions altered the mortality of males but did not affect the mortality of females nearly as much (some authors say not at all when other factors such as changes in economic status are factored in). Authors suggest that perhaps the unhealthy behaviors predominant among unmarried males become unappealing once married. Societal pressure or risk-averse wives encourage married males to adopt more healthy lifestyles. Females naturally live less risky lifestyles and therefore do not benefit so much from the protection of the married status. Also, because married females are traditionally responsible for maintaining social ties, males who are no longer living with their wives because of divorce or death may find their access to said social networks, and the related mortality rate benefits, limited.
- In short, it would appear that the protection offered by marriage to males is in its social support but for females operates mainly through economic factors.

One paper that is tangentially interesting is by Wolfson et al. [31]. This is a very powerful paper for two reasons. First, it depends on a longitudinal study of male mortality by income level, which means that it is not subject to the problems associated with a cross-sectional study (that is, a snapshot at a single point in time). Second, the database is large. The data come from the Canada Pension Plan and include 55,101 male deaths from September 1, 1979 to September 30, 1988 and corresponding earnings records from 1966 to 1988.

By graphing mortality against preretirement income, the study shows that the mortality differentials by income level are maintained through the study period, that the curves do not cross, and that the distances between them gradually become wider.

The authors note that their study group shows a positive correlation between age and income. That is, as the group got older (within the working years) on average, the group earned higher incomes. Thus, the mortality differentials do not follow from an explanation that sickness causes decreases in both income and life expectancy. Even with rising incomes with age (that is, contrary to being sick), life expectancy is still correlated strongly with income level.

The authors state that if the entire population studied had experienced the mortality of the top 20 percent of earners from ages 65 to 75, the impact on life expectancy would be the same as removing cancer as a cause of death from ages 65 to 75. This could mean that money spent on trying to fight cancer might be just as effective if used to equalize the income of the bottom 80 percent of the population with the top 20 percent.

Further, early retirees (who are not disabled) have higher mortality than late retirees (who are not disabled) and display a steeper gradient with earnings.

The authors then do a sophisticated multivariant analysis including the marital status variable, an age-at-retirement variable, an earnings variable (and some others including a disability status variable). The results show that married males have significantly higher survival probabilities at all retirement ages. There is a monotone-increasing relationship between survival probability and age at retirement. Higher earnings always entail higher survival probabilities, but the magnitude of this earnings gradient tends to narrow for later retirement ages. The effect is similar but somewhat more variable among not-married men.

The authors conclude that an extra dollar of income offers decreasing "protective effect" at higher income levels than at lower incomes (an intuitively plausible result). However, an extra dollar of income in any of the earning years has the same protective effect (that is, whether just prior to retirement or from earlier years). This may fit with the notion that permanent rather than transitory earnings is the key variable. In turn, it suggests that there are long-term effects of earnings on mortality, with lagged associations of as much as decades (which would be missed in a normal cross-sectional analysis).

The authors conclude with a concern that poorer males may be receiving either less or poor-quality health care. Alternatively, there must be aspects of lifestyle that vary systematically with earnings that are not affected by health care.

The authors also question the "actuarially neutral" Canada/Quebec Pension Plan (C/QPP) early-retirement pension reduction factors given the higher life expectancy of those who retire late. Finally, they point out that if those with higher income live longer, then the provision of constant government-funded retirement benefits to all Canadians is a regressive public policy (that is, the rich benefit more than the poor).

In a related Statistics Canada report [30], the authors note that life expectancy is strongly and positively correlated with income. More interestingly, however, the report determines that all income quintiles had substantial life expectancy gains between 1971 and 1986, with the gains being larger in the poorer quintiles.

In particular, in 1971, shortly after the introduction of universal Medicare in Canada, the disparity in life expectancy between the top and bottom income quintiles was more than six years for men and nearly three years for women. By 1986, the disparity was approximately five and a half years for men and nearly two years for women.

Could it be, therefore, that providing universal Medicare in Canada was causal in diminishing the differences in life expectancy between income strata? More generally, does the provision of social security, in general, enhance life expectancy?

Statistics from Trowbridge (and others) clearly indicate a correlation between marital status and longevity. Other studies show a correlation between income and longevity. Could both marital status and income be indicators of well-being and security? Being married, while a source of increased social interaction, is also equally a source of security in that there exists a caregiver if and when needed. The availability of higher levels of disposal income also provides a source of enhanced security in that this allows the owner to purchase support in the form of home care, assistive devices, and so on and also enhances the ability to be socially active.

Is there evidence therefore that the provision of social security is a cause of enhanced life expectancy?

The Trowbridge study makes available to us some well-defined statistics that can be used to analyze ratios of mortality by marital status. In particular, detailed data are available for the years 1960 and 1980.

Similar data (although broken down into slightly different age groupings) are available from Statistics Canada publications for every year from 1951 to 1990. Thus, it is easy to construct mortality ratios by marital status similar to those analyzed by Trowbridge based on Canadian data.

Having both Canadian and U.S. data for 1960 and 1980 provides us with the opportunity to attempt to determine whether the provision of social security (all sources including universal Medicare) enhances life expectancy. The theory behind the analysis is to compare the progress in mortality improvement by marital status between 1960 and 1980 in the two countries.

In 1960, Canada was only just starting to introduce universal Medicare. In fact, full coverage of both hospital and physician services was not complete until 1971. In terms of retirement income security, Canada introduced a widely expanded social security system in 1966 when it introduced the C/QPP and the Guaranteed Income Supplement. In 1975, the Spousal Pension Allowance was introduced.

Thus, between 1960 and 1980, Canada went from a social security system that was slightly less protective than that available in the U.S. to a system that was far more protective.

Given that fact, if the existence of economic security enhances life expectancy, then comparing the improvement in mortality ratios by marital status between Canada and the U.S. between 1960 and 1980 should provide evidence of this being true. For the hypothesis to be true, mortality ratios by marital status in 1960 in Canada should be similar to or even greater than those in the U.S., while the same ratios in 1980 should be different from and less than those in the U.S. Clearly, if the provision of economic security drives life expectancy, then the importance of being married in Canada in 1980 should be significantly less than in 1960. Between 1960 and 1980, differences in mortality in favor of those who are married widened in the U.S. Again, this theory would predict that in Canada, marital status would be less important in 1980 than in 1960 and that there would be less improvement amongst married persons versus unmarried persons (relatively speaking) in that period.

As stated previously, Statistics Canada has produced mortality rates for Canadians split by gender and marital status since 1951. (Anyone wishing the crude data can contact me at my *Directory* address.) In terms of this discussion of Trowbridge's paper, we calculated the ratios in Table 1 from the Canadian data (thanks to Ken Seng Tan for the analysis).

TABLE 1

CANADIAN MORTALITY RATES BY GENDER AND MARITAL STATUS, 1951–1990

Year	15–24	25–44	45–64	65+
		Ratio for Single Male to Married Male		
1951	1.421	1.944	1.502	1.385
1960	1.178	1.768	1.507	1.366
1970	1.829	1.921	1.684	1.294
1980	2.076	2.720	2.073	1.495
1990	2.328	3.344	2.648	1.728
		Ratio for Divorced and Widowed Male to Married Male		
1951	9.631	3.352	1.877	1.811
1960	10.305	3.258	1.982	1.756
1970	4.988	3.668	2.591	1.807
1980	2.147	4.077	2.313	2.018
1990	3.871	3.379	2.272	1.918
		Ratio for Single Female to Married Female		
1951	1.024	1.466	1.214	1.527
1960	1.023	1.584	1.404	1.533
1970	1.489	1.910	1.375	1.473
1980	2.349	2.323	1.617	1.755
1990	1.836	2.433	1.835	2.022
		Ratio for Divorced and Widowed Female to Married Female		
1951	4.463	1.784	1.429	1.714
1960	3.163	1.692	1.596	1.826
1970	8.027	3.618	1.722	1.733
1980	6.895	3.078	1.663	2.107
1990	5.545	2.317	1.789	2.226
		Ratio for Single Male to Single Female		
1951	1.802	1.632	1.857	1.179
1960	2.651	1.778	1.964	1.400
1970	2.717	1.735	2.429	1.528
1980	2.696	2.127	2.449	1.689
1990	2.870	2.323	2.557	1.683
		Ratio for Divorced and Widowed Male to Divorced and Widowed Female		
1951	2.802	2.313	1.971	1.373
1960	7.499	3.068	2.271	1.510
1970	1.374	1.749	2.983	1.813
1980	0.950	2.406	2.658	1.897
1990	1.580	2.465	2.250	1.697
		Ratio for Married Male to Married Female		
1951	1.299	1.231	1.501	1.300
1960	2.302	1.593	1.829	1.571
1970	2.211	1.725	1.983	1.739
1980	3.050	1.817	1.911	1.982
1990	2.263	1.690	1.772	1.969

Trowbridge's paper presents data for 1960 and 1980 only. Trowbridge also compares data for "unmarried" to "married" where "unmarried" combines single, widowed and divorced. To highlight a comparison between the Canadian data and the Trowbridge data, certain data are presented in Tables 2 and 3 for 1960 and 1980 only.

Remember that the Canadian statistics are for the age groups 15–24, 25–44, 45–64 and 65+. The data in Tables 2 and 3 are based on a three-year average central death rate (for example, 1960 is actually the average of 1959, 1960 and 1961), whereas all previous Canadian data were based on single-year death rates (for example, just 1960).

These mortality improvement factors are startling. Table 3 tells us that nonmarried males and young nonmarried females have not experienced any improvement in mortality over the 20-year period from 1960 to 1980. In fact, there has been a deterioration in experience. Some of that may have to do with the time period being measured. For example, in a recent presentation to the Actuarial Research Conference, Brown and Abraham (see "Trends in Certain Causes of Death at Young Ages in Canada," *ARCH* 1995.1) showed recent significant improvements in mortality rates at the young ages, especially for males. In fact, the data showed that the mortality hump for males in their 20s had disappeared by the early 1990s. If one were to calculate the above mortality improvement factors for Canada from 1970 to 1990, the factors shown in Table 4 result. While Table 4 may provide us with a level of optimism, we cannot use these figures in any comparative analysis with those in the Trowbridge paper because we do not have the corresponding U.S. data for 1990 or 1970.

Thus, returning to a comparative analysis between the Canadian and U.S. experience, the following conclusions can be drawn from the data.

- The ratios of nonmarried to married mortality are generally smaller for Canada than for the U.S. for both years analyzed and for both sexes prior to age 65 but larger after age 65; that is, marital status is not as important a predictor of mortality for Canada as it is for the U.S. prior to age 65, but is more important after age 65.
- The ratios for single males to single females are smaller for Canada than for the U.S. (although Trowbridge uses ratios of nonmarried to nonmarried); that is, generally, gender is not as important a variant for mortality for Canada as it is for the U.S.
- The ratios for married males to married females are slightly smaller in Canada than those in the U.S., but almost equal.

TABLE 2

COMPARISON OF TROWBRIDGE AND CANADIAN MORTALITY RATIOS FOR 1960 AND 1980

1960				1980			
Trowbridge Data		Canadian Data		Trowbridge Data		Canadian Data	
Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios
Nonmarried Male to Married Male							
15–19	0.946	15–24	1.181	15–19	0.798	15–24	2.076
20–24	1.754			20–24	1. 601		
25–29	2.261			25–29	2.499		
30–34	2.766			30–34	3.148		
35–39	2.883	25–44	1.824	35–39	3.426	25–44	2.911
40–44	2.613			40–44	2.815		
45–49	2.313			45–49	2.812		
50–54	2.066			50–54	2.774		
55–59	1.835	45–64	1.630	55–59	2.209	45–64	2.171
60–64	1.703			60–64	1.899		
65–69	1.579			65–69	1.817		
70–74	1.446			70–74	1.645		
75–79	1.364	65+	1.623	75–79	1.799	65+	1.833
80–84	1.277			80–84	1.591		
85–89	1.171			85–89	1.324		
90–94	1.111			90–94	1.243		

TABLE 2—*Continued*

1960				1980			
Trowbridge Data		Canadian Data		Trowbridge Data		Canadian Data	
Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios
Nonmarried Female to Married Female							
15–19	0.881	15–24	1.023	15–19	1.021	15–24	2.380
20–24	1.636			20–24	1.849		
25–29	2.283			25–29	2.484		
30–34	2.455			30–34	2.713		
35–39	2.219	25–44	1.601	35–39	2.511	25–44	2.558
40–44	1.957			40–44	2.288		
45–49	1.681			45–49	2.033		
50–54	1.539			50–54	1.795		
55–59	1.418	45–64	1.513	55–59	1.659	45–64	1.649
60–64	1.351			60–64	1.611		
65–69	1.259			65–69	1.436		
70–74	1.172			70–74	1.402		
75–79	1.202	65+	1.775	75–79	1.306	65+	2.051
80–84	1.079			80–84	1.468		
85–89	1.124			85–89	1.631		
90–94	1.084			90–94	1.534		

TABLE 2—*Continued*

1960				1980			
Trowbridge Data		Canadian Data		Trowbridge Data		Canadian Data	
Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios
Nonmarried Male to Nonmarried Female							
15–19	2.405	15–24	2.659	15–19	2.615	15–24	2.661
20–24	2.327			20–24	2.904		
25–29	1.744			25–29	2.608		
30–34	1.697			30–34	2.459		
35–39	1.926	25–44	1.815	35–39	2.467	25–44	2.067
40–44	2.119			40–44	2.149		
45–49	2.355			45–49	2.394		
50–54	2.531			50–54	2.768		
55–59	2.559	45–64	1.970	55–59	2.572	45–64	2.551
60–64	2.445			60–64	2.421		
65–69	2.299			65–69	2.612		
70–74	1.987			70–74	2.435		
75–79	1.635	65+	1.436	75–79	2.519	65+	1.772
80–84	1.528			80–84	1.948		
85–89	1.347			85–89	1.465		
90–94	1.247			90–94	1.231		

TABLE 2—*Continued*

1960				1980			
Trowbridge Data		Canadian Data		Trowbridge Data		Canadian Data	
Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios	Age Group	Mortality Ratios
Married Male to Married Female							
15–19	2.237	15–24	2.302	15–19	3.341	15–24	3.050
20–24	2.171			20–24	3.356		
25–29	1.761			25–29	2.645		
30–34	1.507			30–34	2.121		
35–39	1.479	25–44	1.593	35–39	1.807	25–44	1.817
40–44	1.587			40–44	1.747		
45–49	1.711			45–49	1.729		
50–54	1.885			50–54	1.791		
55–59	1.977	45–64	1.829	55–59	1.931	45–64	1.911
60–64	1.941			60–64	2.051		
65–69	1.833			65–69	2.065		
70–74	1.611			70–74	2.076		
75–79	1.439	65+	1.571	75–79	1.829	65+	1.982
80–84	1.291			80–84	1.799		
85–89	1.294			85–89	1.804		
90–94	1.217			90–94	1.521		

TABLE 3

MORTALITY IMPROVEMENT: 1980 DEATH RATES AS A PERCENTAGE OF 1960 DEATH RATES

Age Group	Married				Nonmarried			
	Male		Female		Male		Female	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
15–19	127.5	69.3	85.4	53.7	107.5	114.0	98.9	113.9
20–24	107.9		69.8		98.5		78.9	
25–29	94.8		63.1		102.7		68.7	
30–34	81.8		58.2		93.2		64.3	
35–39	75.1	70.1	61.5	62.2	89.2	110.9	69.6	97.4
40–44	72.1		65.5		77.7		76.6	
45–49	72.4		71.6		88.1		86.7	
50–54	71.5		75.2		95.9		87.7	
55–59	77.3	82.6	79.1	78.4	92.9	109.7	92.6	85.9
60–64	76.9		72.7		85.7		86.6	
65–69	80.4		71.4		92.5		81.4	
70–74	84.7		65.7		96.4		78.6	
75–79	81.2	87.9	64.1	68.9	107.1	99.9	69.5	81.0
80–84	76.8		55.1		95.6		75.1	
85–89	77.6		55.6		87.8		80.8	
90–94	69.5		55.6		77.7		78.7	

TABLE 4

CANADIAN MORTALITY IMPROVEMENT 1990 VERSUS 1970

Age Group	Married		Nonmarried	
	Male	Female	Male	Female
15–24	54.1	52.9	68.8	65.2
25–44	53.5	54.6	88.3	58.9
45–64	63.1	70.6	80.3	80.3
65+	78.9	69.7	90.6	90.6

- The improvement factors from 1960 to 1980, for married males and females, show more improvement for Canada than for the U.S. at the younger ages, but less improvement for Canada than for the U.S. at the older ages. As in the U.S., female mortality improved more markedly than male mortality for the period from 1960 to 1980.
- Improvements in mortality for nonmarried males and females are generally smaller for Canada than for the U.S. (and deterioration is larger). Again, single females have shown more improvement (or less

deterioration) in both Canada and the U.S. Finally, mortality for married people improved more than mortality for nonmarried (as in the the U.S.).

What does this all mean?

It would be nice to be able to analyze data that exclude homicides. Canada has a much lower homicide rate than the U.S. The homicide rate for males in the U.S. in 1991 was 16.6 per 100,000 (*Metlife Statistical Bulletin*, April-June 1994). For males aged 15–24, it was 37 per 100,000 in 1991, and for males aged 25–34, it was 29. The homicide rate for males in Canada, in 1989, was approximately 3.5 per 100,000 for males aged 15–24, and 4.0 for males aged 25–34 (Brown and Abraham, op. cit.). Thus, there is almost a tenfold difference in these rates between Canada and the U.S. Were these differences to be removed, then the U.S. ratios would move toward the Canadian ratios. Unfortunately, the data necessary to do this analysis are not available. However, it is safe to say that marriage and gender are not "as important" in Canada, prior to age 65, at least partly because of the impact of homicides.

At the beginning of this discussion, I hypothesized that the existence of social security might be a cause of enhanced life expectancy. I went on to say that for this hypothesis to be true, then post-65 mortality ratios by marital status in 1960 in Canada should be similar to or even greater than those in the U.S. They are greater. The same ratios in 1980 should be significantly less important than in 1960. The Canadian data show that marital status is *more* important in 1980 than in 1960 because the mortality ratios of nonmarried to married for both males and females in 1980 exceed the same ratios from 1960. Finally, the improvement in mortality for marrieds was greater than that for nonmarrieds for the period from 1960 to 1980, a period when Canada introduced significantly expanded social security safety nets, and a period when the hypothesis required less improvement in married mortality than in nonmarried mortality (even in the period from 1970 to 1990, "married" mortality also improved more than "nonmarried" mortality).

Thus, on all three counts the hypothesis fails. In short, there is no evidence from these data that the provision of additional social security in Canada over the period of analysis has, in and of itself, enhanced life expectancy at all.

In closing, I again want to thank Charles Trowbridge for his addition to the actuarial literature. It has stimulated me to much further thought,

and I intend to continue to pursue the issues introduced herein to a greater extent.

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KEN FAGG:

The statement that the unmarried die faster is rather misleading. It seems to imply that getting married leads to lower mortality. However, the tables in Mr. Trowbridge's paper do not compare like with like. Getting married is a strong form of selection. It is rare for seriously disadvantaged people, and others with high mortality rates, to get married. When they do, it is news.

The less likely (or even impossible) to marry group includes those in poor health, the disabled, drug addicts, alcoholics, homosexuals, those who engage in hazardous activities (explorers, oil-rig workers, ground troops, etc.), and many others. Perhaps manual workers (whose mortality rates are normally higher than those of clerical workers) may also be more likely than clerical workers to cohabit (rather than marry). This would also affect the single versus married rates.

A fair comparison would exclude from the investigation all those who would not marry because of their handicap. It is not easy to undertake such an investigation, especially if it includes people who would marry, or have married, late in life.

To determine whether getting married leads to lower or higher mortality, the investigator really needs two groups that are identical in all respects (age, health, habits, etc.) except that one group is married and the other has never been. Even then there are problems if anyone changes marital status, because this will affect the average mortality of both groups. If someone marries, the married group will have a new healthy life joining, leaving the higher-risk lives still unmarried. To be certain that the two groups are identical, it would be necessary to have, amongst other things, stringent medical examinations and a carefully devised set of questions on health, lifestyle, etc.

But unless like is compared with like, the tables of statistics are of little value. All that can be done is to state the obvious: that the average mortality of married lives is lower than the average mortality of unmarried lives. No conclusions can be drawn about the effects of marriage on mortality. Mr. Trowbridge's statement that "the differences noted can hardly be accounted for by marriage selection alone" is an unproven assertion. The effects of marriage selection may be much greater than

he thinks. (Or they could be much less than he thinks.) Until someone investigates, we can only speculate.

KENNETH W. FAIG, JR.:

Mr. Trowbridge makes a valuable contribution to the study of human mortality through his analysis of the 1940, 1960 and 1980 Social Security data. Mr. Trowbridge is probably correct that most of the mortality differential between the unmarried and married may be attributed to "environmental, psychological, or sociological factors." It is possible, however, to propose other theories. One might propose that the mortality differential between the unmarried and the married is attributable, at least in part, to the greater frequency of sexual intercourse between married persons as compared to unmarried persons.

This contention is supported by the data developed by Laumann, Gagnon, Michael and Michaels for their study.* Table 3.4 of this work (shown in part on the next page) displays data on frequency of partnered sex of study participants over the past year according to marital status.

While cohabitants have a higher proportion of very frequent sex (4+ times per week) than marrieds, the proportion of moderately frequent sex (a few times per month or 2–3 times per week) is not significantly higher for cohabitants than for marrieds. I suspect that longer-term cohabitants display a frequency of sex distribution very comparable to that of marrieds. Marrieds and cohabitants both display markedly higher proportions of moderately frequent sex than persons belonging to neither class.

Laumann et al. also cite (Figure 3.1) data from the National Health and Social Life Survey (NHSLS) and the General Social Survey (GSS) showing that the proportion of persons with no sexual partners in the last year holds at 10–15% for both sexes between ages 18 and 54 but climbs rapidly at older ages, more rapidly for females than for males. (In fairness to the libido of mature women, one must note that many of their male partners have died.) If sexual relations are a contributing factor to the marital mortality factors observed by Mr. Trowbridge, the greater proportions of sexual inactivity at the higher ages could account for part

*LAUMANN, E.O., GAGNON, S.H., MICHAEL, R.T., AND MICHAELS, S. *The Social Organization of Sexuality*. Chicago and London: University of Chicago Press, 1994.

TABLE 3.4 FROM LAUMANN ET AL.

Sex	Status	Not At All	A Few Times per Year	A Few Times per Month	2/3 Times per Week	4+ Times per Week	N
Male	Never married, not cohabiting	22.0	26.2	25.4	18.8	7.6	382
Male	Never married, cohabiting	0.0	8.5	35.6	37.3	18.6	59
Male	Married	1.3	12.8	42.5	36.1	7.3	687
Male	Divorced/separated/widowed, not cohabiting	23.8	22.5	28.5	20.5	4.6	151
Male	Divorced/separated/widowed, cohabiting	0.0	8.3	36.1	44.4	11.1	36
Female	Never married, not cohabiting	30.2	23.5	26.0	13.3	7.0	315
Female	Never married, cohabiting	1.4	6.9	31.9	43.1	16.7	72
Female	Married	3.0	11.9	46.5	31.9	6.6	905
Female	Divorced/separated/widowed, not cohabiting	34.3	23.2	21.9	16.8	3.7	297
Female	Divorced/separated/widowed, cohabiting	0.0	9.4	39.6	39.6	11.3	53

of the "wearing off" of the marital factors at those ages. As Mr. Trowbridge points out, however, the marital mortality advantage remains substantial even at the highest ages. I believe that mutual affection and caregiving are probably the largest contributory factors to the remaining advantage.

Certainly, the frequency of sexual relations among the married cannot constitute a full explanation of the mortality advantage enjoyed by the married. As observed by Laumann et al., cohabitants excel marrieds in the proportion practicing very frequent partnered sex and about equal marrieds in the proportion practicing moderately frequent partnered sex. Cohabitants are a component of the "unmarried" portion the Social Security data.

Mr. Trowbridge comments upon self-selection as a possible explanation for the marital mortality advantage. If we consider that in most cultures the married state has been the normative state for reproduction, it is not surprising that the married state is correlated with favorable mortality. Successful childbearing and childrearing in and of themselves exercise an evolutionary bias in favor of the married state.

Perhaps part of the difficulty in understanding the marital mortality advantage is the fact that in most modern societies marriage is a legal state evidenced by a civil and/or an ecclesiastical record. Common sense leads one to believe that a legal status evidenced by a vital record should not in and of itself create any statistical mortality advantage. The argument that the married status promotes the good regard of society and social interaction seems to be weakening with the increased incidence of cohabitation in many modern societies.

The idea that the predominant natural order whereby the human species forms permanent partnerships for reproduction mirrors a supernatural order in which the ministers of a sacramental marriage are infused with supernatural graces (including the good health necessary to attain the primary end of sacramental marriage) is restricted in modern society to certain religions. The modern mind rejects the idea that a mere status should influence mortality; St. Thomas Aquinas, by way of contrast, would probably have found nothing mysterious about the observation that partners in both natural and sacramental marriages enjoy mortality favorable to their state in life. In the mind of Aquinas, this grace or favor would surely have been infused in the married by the Creator in order that the command given to the human race in Genesis 1:28 be realized.

The modern mind, by way of contrast, must struggle for genetic factors favorable to mortality that may be correlated with the married state.

The fact that the marital mortality advantage observed by Mr. Trowbridge has increased over the period 1940–80 certainly strengthens one's belief that genetic correlates continue to work in favor of marriage and reproduction. During this same period there has been the greatest use of artificial contraception for family planning within recorded human history. One might have a concern that this limitation of family size would dampen the prevalence of the favorable genetic correlates associated with the married state, but in the short term this has not been observed. While the twentieth century has seen the largest number of persons involved in nonmarital partnered sex in recorded human history, the patterns of sexuality observed by Laumann et al. (Chapter 5) make clear that such partnerings are still deviations from a monogamous norm.

Indeed, to the extent that sexuality is involved at all in the marital mortality advantage, it may be that the ready availability of a partner for the satisfaction of sexual needs is its greatest benefit. Many modern minds reject the Pauline theology of the obligation to render the marital debt (1 Corinthians 7:3–4), but in actual practice many married persons defer to the needs of their spouses. This was indeed the very good of which St. Paul wrote when he distinguished the relative virtues of the married and unmarried states (1 Corinthians 7:8–9). The finding of Laumann et al. that persons with only one sexual partner in the last year enjoy the highest level of perceived happiness (Chapter 10) may also be significant for the mortality advantage enjoyed by the married.

When we consider that sexually transmitted diseases—including life-threatening diseases like AIDS—are still rampant among us, the predominance of traditional partnered monogamous sex observed by Laumann et al. (Chapter 5) may constitute an important part of the mortality advantage of the married state. It is clear that receptive anal intercourse has been a primary means of AIDS contagion among non-IV-drug users in western society. The low frequencies of anal intercourse observed by Laumann et al. (Table 3.6) provide some hope that the contagion of this modern plague may have some bounds. The association of the contagion with multiple-partner vaginal intercourse in other societies remains, however, very disturbing.

I suspect that long-term cohabitants exhibit many common characteristics with marrieds. If increasing numbers of cohabitants elect to reproduce and to rear children without contracting marriage, cohabitants may

eventually enjoy the same mortality advantages as marrieds. However, the greater facility of dissolving a cohabitation, as opposed to dissolving a marriage, may limit the extent to which childbearing cohabitants will enjoy the evolutionary success of their married counterparts.

The same type of evolutionary bias can be argued for the female mortality advantage. Because the female of the species is the vessel in which the human embryo develops before birth, the health and well-being of the female partner are far more critical to the reproductive success of the human race than that of the male partner. Indeed, a child engendered in the normative pattern (that is, sexual intercourse) may be born live some nine months after the death of its father, but only minutes after the death of its mother. In addition, in many societies women have historically borne the major burden of childrearing. Thus, it comes as no surprise that natural selection has favored female longevity significantly more than it has favored male longevity.

The low prevalence of the married state at ages 15–19 in the U.S. (the author's Table 11) may be significant for the unusual marital status mortality ratio observed at these ages. Perhaps very young marrieds exercise less "self-selection" than older marrieds. (The incidence of marriage contracted at these ages because of pregnancy is certainly still significant.) In addition, marriage at very young ages may be correlated with unfavorable socioeconomic factors.

Mr. Trowbridge's discussion of the "grief" component of high widowed status mortality rates is very significant. This mortality component has not been adequately considered by our profession, despite the fact that it affects actuarial computations relating to insurance (for example, second-to-die policies issued to spouses) and pensions (for example, joint and survivor annuities). By leveraging the assumption of independence only for common accidents, we may charge too little for second-to-die assurances and too much for joint and survivor annuities issued to married persons. While second-to-die assurances may be considered an anomaly produced by federal estate taxation in the U.S., millions of married retirees worldwide have had to make pension elections based on existing joint and survivor annuity mathematics.

I believe that mutual caregiving and affection are the primary natural benefits of the married state. Today many persons try to "engineer" their lifestyles in a manner favorable to good health and low mortality, but the helplessness of any married person in the face of his or her partner's mortality remains nearly complete. Nevertheless, because death records

in the U.S. are for the most part public, it should be possible to perform research to enable actuaries to factor the "grief" factor into their calculations.

I believe that we can and should promote lifestyle choices and social policies that favor good health and extended useful lifetimes, to the degree consistent with our societal norms of freedom of choice. For example, the extirpation of firearms and harmful drugs like alcohol and nicotine from our society would doubtless improve mortality, but it is doubtful whether such a course would be consistent with the high valuation of individual freedoms in most western societies. By way of contrast, some of these restrictions already exist in many eastern societies, but are generally perceived by westerners as unduly restrictive of individual freedoms.

Some of the same questions arise in the discussion of governmental regulation of human sexuality and the married state. For example, if adultery imperils the health and happiness of married persons, ought society to impose sanctions against it? If the obligations of the married state promote the welfare of children, ought society to restrict childbearing by nonmarried couples? These are very difficult questions. Society must provide the answers, but actuaries and other professions can contribute to their rational consideration.

Mr. Trowbridge's treatment of the influence of marital status upon mortality usefully reinforces our knowledge that between the poles or well-known factors that favor life extension and well-known factors that favor life contraction, there lies a vast territory of little-understood factors.

Like birth and marriage, death creates a vital record in most modern societies, but surely the immediate and contributory causes of death enumerated in such records tell only part of the story. For the widowed and the aged, we wonder how many death certificates ought really to record the cause of death as grief, loss or sheer loneliness. As actuaries, we must surely be grateful that birth, marriage, and death exhibit underlying patterns that enable us to help to design individual and governmental financial security programs that benefit our society. Mr. Trowbridge's discussion of the mortality advantage enjoyed by married persons helps point out that our actuarial models and paradigms do not provide a full explanation of the patterns that we observe and attempt to model. Perhaps the understanding of the underlying "why" of these statistics, so vital to each of our lives, is best left to the human heart.

NOREEN GOLDMAN* AND GRAHAM LORD:

Mr. Trowbridge has brought to the attention of *Transactions* readers a topic that has fascinated researchers for many years: differences in mortality by marital status. Although Mr. Trowbridge presents this subject as one that has received little attention since it was first noted in 1940, there have actually been *hundreds* of studies on industrialized countries—*dating as far back as the mid-19th century* [4]—demonstrating that married men and women have greater longevity, and experience better health in general, than single, divorced and widowed persons [6]. See, for example, Ross et al. [12], Hu [10], and Wyke and Ford [17] for recent reviews of the literature. Unfortunately, Trowbridge cites only three such studies and thus falls short of his promise to "set forth the present state of knowledge on one aspect of human mortality."

In the current paper, Mr. Trowbridge uses death registration and census data for 1960 and 1980 to examine mortality patterns by marital status by gender and over time. More extensive analyses of death registration data have been carried out by other researchers on richer data sets. For example, Hu and Goldman [11] use multivariate Poisson models to estimate the effects of age, gender, time period, and the size of the marital group on marital status specific mortality for the U.S., as well as for 15 other industrialized countries, during the past several decades.

A more serious limitation of the paper is Mr. Trowbridge's attempt to use these cross-sectional data to make inferences about the reasons for the observed mortality patterns. Social scientists have long recognized that longevity differences between the married and unmarried are likely to arise both from selection processes (that is, mentally and physically healthier persons are more likely to get married in the first place) and from causal mechanisms sometimes referred to as marriage protection (that is, the social, psychological, economic, and environmental benefits associated with having a spouse). Researchers have explicitly investigated some of the hypotheses put forth by Trowbridge and the actuarial staff of the Social Security Administration. In particular, social scientists have demonstrated that the increased social ties and networks that result

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from marriage facilitate access to medical information and services, constrain risk-taking behavior and encourage healthy behavior, act as a buffering mechanism in stressful situations, substitute for formal health care, and provide additional economic resources that affect the frequency and quality of health care services (for example, Berkman [1], Blazer [3], Umberson [14], and Weiss [15]). Researchers have also investigated the hypothesis that departures from the married state (namely, becoming widowed or divorced) are stress-provoking crises that ultimately lead to higher mortality.

While much remains to be learned about the specific pathways involved in producing the health advantage of the married, it is unlikely that more can be gleaned by analyses of death registration records or of cross-sectional data in general [5]. In particular, the use of cause-of-death data or age patterns of mortality to assess the strength of health-related selection into first marriage is unjustifiable and problematic [6], [7]. Since the late 1970s, researchers have relied increasingly on prospective survey data to explore the relationship between marital status and health status [8]. Without doubt, these longitudinal community surveys carried out in the U.S. and Europe ([2], [3], [9], [13], [16], [18])—only one of which receives mention in the current paper—have been the most promising studies to date for establishing the effects of marital status, and of related social and economic factors, on health and mortality.

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ROBERT J. JOHANSEN:

There is an old joke that married men do not really live longer—it only seems longer. Mr. Trowbridge has substituted facts for appearances.

I am indebted to Mr. Trowbridge for examining the fascinating area of unmarried/married mortality differences and investigating the interacting relationships of male/female and marital status. The growing number of divorced persons makes the differences of more than academic interest, and the relative mortality of widowed persons may be of interest to issuers of second-to-die policies.

Apparently there were studies of unmarried/married mortality in the U.K. prior to 1940. Recall the chapter on double decrement in Spurgeon's *Life Contingencies* [2], which included a portion of a life table of numbers of bachelors living, marrying and dying (as bachelors), as well as married men living and dying. My copy was the third edition published in 1932; the first was published ten years earlier. The source of the data was not identified except as compiled from "statistics giving full particulars of dates of birth, marriage, etc." It covered only three ages. Out of curiosity, I calculated central death rates for both bachelors and married men. As shown in the table below, bachelor rates not only were higher but also increased faster than those of married men.

	Central Death Rates per 1,000		Ratio
Age	Bachelors	Married Men	Bachelors/Married
30	8.1	6.3	129%
31	9.1	6.2	147
32	10.7	6.3	170

According to Spurgeon's table, the decrement from bachelors marrying was substantial, more than 7% annually for the three ages.

Studies based on census data are subject to reporting errors made by respondents; those who are widowed or divorced may describe themselves as married, whereas death certificates are more likely to be correct. This has the effect of increasing exposures on married and decreasing exposures on widowed and divorced. Because the latter two are smaller groups, the effect is greater.

As for the effects of marriage as a selection process, it is a continuous process because some of the never-married marry each year. Such continuous selection must then increase the proportion of those who will never marry because of some physical or mental condition that might also affect mortality.

Noting the substantial increase in the proportion of divorced persons, I tried to test whether this would have an effect on relative mortality of divorced versus married. Using the data in Tables 3 and 5 in the paper, I compared the ratios of divorced to married mortality for 1960 and 1980. Although there were small increases and decreases for various age groups, there seemed to be no real change except for a small increase for females over age 50. Judging from this, the theory that higher mortality is associated with being divorced seems to be reinforced.

Mr. Trowbridge mentioned smoking as one factor that might account for some of the mortality differences. An article in a recent *Metlife Statistical Bulletin* [1] shows substantial differences in mortality of men and women according to income and level of education. The table below is based on age-adjusted mortality rates to permit comparison.

AGE-ADJUSTED MORTALITY RATES*—U.S. WHITE POPULATION, AGES 25–64

	Year	Low Education	High Education	Low Income	High Income
Male	1960	9.0	5.8	NA	NA
	1986	7.6	2.8	16.0	2.4
Female	1960	5.3	3.4	NA	NA
	1986	3.4	1.8	6.5	1.6

*Rates per 1,000 adjusted on 1940 U.S. total population.
NA: Rates are not available.

My thanks to Mr. Trowbridge for bringing this subject to our attention and bringing us up-to-date. He has also demonstrated the usefulness of population data and analyses available from government agencies.

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BERTRAM M. KESTENBAUM:

Mr. Trowbridge provides an interesting introduction to the subject of mortality differentials by marital status in the U.S. I hope that my discussion will move us closer towards achieving his stated objective, "to set forth the present state of knowledge" on this subject. I briefly address

(1) data availability, (2) a caveat about the accuracy of rates, (3) Mr. Trowbridge's proposed measure of the sex factor in mortality, (4) some contributions in the literature, and (5) mortality and marital status differentials by race and socioeconomic status.

Data Availability

Mortality rates for any year specific to any characteristic or combination of characteristics are easily calculated from the counts of deaths during the year (or of deaths during N years centered on the reference year, divided by N) and counts of population at midyear, both with the required specificity. In particular, the annual number of deaths by the combination of marital status, age, sex, and race are available for years after 1978 (and for 1959–61 and 1949–51 as well) in the annual compendium, *Vital Statistics of the United States, Volume II, Part A* [5]. At the time of this writing, data for 1989 are the latest published, and data for 1990 are available pending publication. The published data are presented for 10-year age groups and an "age 75 and over" category; data files are made available to users, such as our Office of the Actuary in the Social Security Administration, who require greater age detail.

Population counts by the combination of marital status, age (in five-year groups), sex, and race for mid-March of each year, based on marital status information collected in the March supplement to the monthly Current Population Survey sample and postcensal population estimates, are published in the annual report, "Marital Status and Living Arrangements: March 19__" [1]. For decennial census years these counts are also available for Census Day, April 1, from the census.

A Caveat

I have observed that because of the seasonal pattern of marriage, the marital status distribution at the middle or end of March differs somewhat from the average marital status during the year. (Our office is familiar with the following similar phenomenon: Social Security benefits are payable under certain conditions to high school students age 18 last birthday; the number of such beneficiaries increases substantially from one month to the next during the school year as more and more seniors attain their 18th birthday.) The difference may have a substantial impact on the accuracy of rates for categories with small numbers, such as the category of married men ages 15–19.

Sally Clarke of the National Center for Health Statistics graciously tabulated for me the distribution of marriages by month for a recent year, both for all marriages and for marriages where the groom was age 15–19, and the results are shown in Table 1. I had expected the seasonality to be more pronounced for very young people than for all marriages, reasoning that many very young people would schedule their weddings after graduation or during the summer break, but it was, in fact, less pronounced. Nevertheless, there clearly is a seasonal pattern to all marriages and to marriages with a very young groom.

TABLE 1

MARRIAGES IN 1988 BY MONTH: PERCENTAGE DISTRIBUTION
(SOURCE: NATIONAL CENTER FOR HEALTH STATISTICS)

Month	All Marriages	Marriages Where Groom Is Age 15–19
Total, all months	100.0%	100.0%
January	4.6	6.1
February	5.8	7.5
March	5.8	7.1
April	8.2	7.8
May	9.6	7.8
June	11.1	10.9
July	10.2	10.3
August	10.1	9.8
September	10.1	8.5
October	9.8	7.9
November	7.1	7.4
December	7.7	9.0

Mr. Trowbridge pointed out the exceptional case of men ages 15–19, where the mortality differential was *unfavorable* to married persons both in 1960 and in 1980. Some rough calculations of mine suggest that the death rate for married males ages 15–19 may be overstated by about 5 percent because of the seasonality phenomenon, enough to erase the differential observed for 1960, although not for 1980. Also, because of the small number of deaths in this category, only about 200 annually, there are concerns about data accuracy.

Measuring the Sex Factor in Mortality

Mortality differentials by marital status are large and growing. Furthermore, the differentials are larger for men than for women. By implication, sex differences in mortality are larger for unmarried persons than for married persons. Accordingly, Mr. Trowbridge recommends that the geometric mean of the two male/female ratios (one for married persons, one for unmarried persons) be used to measure the sex factor in mortality, rather than the conventional measure, which does not take the sex/marital status interaction into explicit account.

Unfortunately, the proposed measure suffers from the shortcoming that it gives equal weight to married persons and unmarried persons in deriving the sex factor. This seems inappropriate, particularly for age groups such as the 15–19 group that are dominated by persons of one marital type.

Contributions in the Literature

A review of the literature on the subject of mortality differentials by marital status uncovers important contributions by Gove in 1973 [3], by Hu and Goldman in 1990 [4], and by Sheps in 1961 [6]. The first of these discusses the male-female difference in mortality differentials by marital status and also features an analysis of these differentials by cause of death. It demonstrates that the differentials are pronounced for causes related to one's psychological state or patterns of behavior, such as suicide and homicide, cirrhosis of the liver, and lung cancer.

The paper by Hu and Goldman argues that the effects of selection diminish as the size of the less-typical group increases. Thus, for example, in a society in which many never marry, the excess mortality in the never-married group will be less than in a society in which marriage is very much the norm and few but the ill or handicapped remain single. This, I think, could be the explanation for the decrease from 1960 to 1980 in the excess mortality of divorced men in certain age groups, which Mr. Trowbridge points out.

Mr. Trowbridge also remarks on "the persistence of the unmarried/married difference to the higher ages, where the never-married are very few and any selection effect might be thought to have worn off." Again, the explanation may be that the never-married group is less healthy on average when only few members remain than when it is larger. A point made by Sheps is also relevant: selection is having an impact on the

married group, as less-healthy members are exiting the group through divorce and widowhood.

Interaction with Other Correlates of Mortality

The scholarly consensus seems to be that the mortality differential by marital status cannot be fully accounted for by any single explanation, but must be attributed to several factors: selection, the psychological benefits of marriage, the more healthy behavior of married persons, and the correlations of both mortality and marital status with other variables, such as race and socioeconomic status.

Differences in *mortality* both by race and by socioeconomic status are well-documented. Differences in *marital status* by race are very large: overall, whites are about 50 percent more likely than blacks to be married, and the differences are large in every sex-age category [1]. Differences in marital status by socioeconomic status are also substantial. For example, for men ages 45–54 in 1980, the median incomes in 1979 were $10,393 for single persons and $18,570 for married persons, and the proportions who were high school graduates were 58 percent for single persons and 67 percent for married persons [2].

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FRANK E. KNORR:

Mr. Trowbridge's analysis of mortality differences among married, widowed, divorced, and never-married people is a welcome addition to the actuarial literature. Also, the reasons suggested for such differences provide valuable insights.

Marriage is often described as the joining of two people into one. It may be of interest to calculate the mortality rates of such a marriage unit as joint life mortality rates. That is, a marriage mortality rate would be defined as the probability that at least one of the couple will die during the year. At age 35 such a marriage mortality rate is calculated to be 2.3 per thousand based on mortality rates of married males (1.5) and females (0.79). This rate is less than the single life mortality rate of an unmarried 35-year-old, which is calculated to be 3.5 based on a weighted average of male and female rates in the unmarried population (4.9 and 2.0, respectively).

If two people truly become one in marriage, then one would expect both to die at the same time. Such a high correlation in deaths would result in very few widowed people and extremely high mortality rates among the widowed. Even without marriage, people who are close might be expected to have a positive correlation because of deaths being caused by the same contagious disease or the same accident or even the same hazardous lifestyle. Also, if certain needs are no longer met because of the death of one of the partners, the death of the second person may be hastened. Evidence of such a correlation has been found [2]. High mortality observed for young widowed men in Mr. Trowbridge's paper is a result of this correlation. One study [1] also suggests that high widowed mortality is a result of remarriage among the healthiest people.

It might be argued that a marriage mortality rate should not be compared with a mortality rate for the unmarried category that includes widowed people. After all, mortality rates of the widowed measure the second death of the married couple (mortality rates of the married people measure only the first death). Among the subgroups in the unmarried category, widowed people have the highest mortality at younger ages. Even without this subgroup, the single-life mortality rate of the unmarried would still be greater than the joint-life marriage mortality rate at age 35.

Near age 55, the marriage mortality rate becomes greater than the single life unmarried rate. At age 55 the former is 15.5 (based on 10. and 5.4), while the latter is 14.6 (based on 24. and 9.2). With the entire set of marriage mortality rates calculated, marriage life expectancies can also be determined. At age 35 this is calculated to be 35 years, and at age 55 this is 19 years. The corresponding life expectancies for unmarried

people are 37 years and 21 years, respectively. Life expectancies, however, may be misleading because movement among the various marital statuses is not recognized.

My final observation is a word of caution to others who might wish to analyze mortality by marital status. If age groupings become too large at younger ages, married people will be concentrated at the higher ages of the group. If age groupings become too large at older ages, married people will be concentrated at the lower ages of the group.

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CECIL J. NESBITT:

This is a good paper for the *Transactions* for several reasons. First, it displays the actuarial-numerical-statistical skills of the author that, when applied to data from various sources, gives an interest-provoking analysis of unmarried/married mortality ratios. Second, by drawing on data from 1940, 1960, and 1980, the author provides insight into the progress of the unmarried/married mortality differences, and thereby lays the groundwork for a study to be derived from 1990 data. Third, the paper contrasts the differential mortality between unmarried and married groups with the well-known differential between male and female mortality experience.

The author allows for the interaction between these two causes of mortality differential by development of the marital factor and the sex factor displayed in Table 4 and in Figures 1 and 2. These results invite comparison with factors based on 1990 data, which may be in process.

I applaud the author's decision, stated under Table 2, to do his analysis by means of the annual death rates by attained age, rather than by means of expectancies of life. Long-term expectations of life without some allowance for nuclear holocaust are, in my opinion, seriously misleading. Also, it might be interesting to cast the paper's findings in terms of survival, rather than mortality, rates. This is a second suggestion for following up the results of this paper.

The author has given us a searching analysis of a mortality phenomenon that may need more recognition in practice as the future unfolds.

Projections for Old-Age, Survivors and Disability Insurance systems already take the phenomenon into account. Consequently, much of the author's analysis is developed from data published by the Office of the Actuary, Social Security Administration.

(AUTHOR'S REVIEW OF DISCUSSIONS)

CHARLES L. TROWBRIDGE:

I very much appreciate the eight fine discussions of my paper. This review groups the comments by the aspects of the general subject treated, rather than replying to each discussant in turn. The outline is as follows:

1. Inadequacy of the paper's literature search
2. Matters of data accuracy
3. Certain technical matters
4. The same phenomena in other countries
5. Selection at marriage
6. Why higher mortality among the widowed?
7. A new explanation
8. What does 1990 data show?

1. Inadequacy of Literature Search

This review of the discussions must start with an admission. As I see it now, my "review of the pertinent literature" was clearly inadequate and hence the resulting reference list far too short. Until alerted by some correspondence with Noreen Goldman in September 1994, I was simply unaware of the vast literature on the subject from demographers and social scientists. For much of the past year I have been trying to catch up.

Rob Brown is another actuary coming to this subject more or less from scratch, but his academic base has enabled him to conduct the extensive literature search reported as a part of his discussion.

Noreen Goldman's references to older literature, not only the list that appears in the Goldman-Lord discussion but also lists to which she refers, are even more extensive.

Bert Kestenbaum refers to two papers not mentioned by the others; Robert Johansen notes an old table in Spurgeon; and Kenneth Faig adds some data from still another source.

All in all, as Dr. Goldman wrote me some time ago, ". . . hundreds of articles have been written on this subject during the last 20 years."

That the paper failed in its attempt "to set forth the present state of knowledge on one aspect of human mortality" is by now quite evident, but the eight discussions bring us a bit closer to this goal.

2. Matters of Data Accuracy

Mr. Johansen suggests that the census overcounts the married, while undercounting the widowed and divorced. He assumes that "those who are widowed or divorced may describe themselves as married." If so, and if such errors are substantial, then the higher mortality for the unmarried is largely explained.

The classification of the population by marital status is calculated for each census year via the "long form" of the census enumeration. Only 20 percent of the households are asked to complete this longer form, so the actual counts are multiplied by five to arrive at the published figure. Sheps (Mr. Kestenbaum's reference [6]) has more to say about data reliability.

As a very rough check on Mr. Johansen's possibility, I have computed the amount of married overcount that would be necessary to explain all the unmarried/married differences, at age 30–34 male in 1980. I found that 33% of those reporting themselves as married (some 2.3 million persons) would have to be misclassified.

Mr. Kestenbaum demonstrates a seasonal pattern to marriages, which concentrate in the summer months. My calculation from his Table 1 shows that the mean date for all 1988 marriages was only a few days after midyear, so the basic assumption that changes in marital status are spread equally throughout the calendar year does not seem to be unduly violated. Perhaps Mr. Kestenbaum's point is that the decennial census is taken as of April 1, not July 1, and that among those who marry within a particular year, less than half will have married in the first three months. It follows that for ages at which marriages exceed "unmarriages" (generally the lower adult ages), the percentage married in the April count will be lower than that on the following July 1. Note that a correction for this effect would tend to pull the unmarried/married factors up at the usual ages for first marriage.

3. Certain Technical Matters

Cecil Nesbitt applauds my decision to concentrate on annual death rates by attained age and to ignore calculations of life expectancy. While

it is clear that he and I are essentially in agreement on where the emphasis should lie, we do not appear to be entirely together on why.

The usual computation of expectation of life carries an implicit assumption that future mortality will follow the same q_x's as those upon which the mortality table is based. Except where some assumption on future mortality improvement is incorporated, the calculation assumes that the q's remain unchanged; hence the life expectation calculated is a true expectation only if the best estimate of future mortality change is zero. Dr. Nesbitt seems to feel that life expectancies are overstated when the possibilities of nuclear holocast are ignored. Others may argue the exact reverse, that the usual life expectancies are understated, because mortality improvement clearly shown in the past is likely to continue. In any event, life expectancies, as Dr. Nesbitt states, are easily misinterpreted.

But my choice of the q_x's, not the e_x's, to represent mortality by marital status was not based on the general characteristics of life expectancy calculations, but rather on the impossibility of any meaningful life expectancy calculation by marital status when individuals change marital status so readily. This problem was recognized in the literature as far back as Dublin in 1949 (my reference [2]). It is just as true today. Dr. Nesbitt's suggestion of using survival rates (essentially ${}_tp_x$ where t is greater than 1), rather than mortality rates, has exactly the same problem.

Bert Kestenbaum's paragraph entitled "Measuring the Sex Factor in Mortality" indicates a preference for ratioing the q_x for all males (marital statuses combined) to that of the q_x for all females, rather than calculating the sex factor as defined in the paper. I continue to believe that the latter adjusts better for the sex/marital status interaction and hence is a better measure of the sex effect alone. It is true that the Trowbridge sex factor at a given age will be identical to the measure that Mr. Kestenbaum prefers only if the unmarried/married split is the same for males as for females, but I do not see this as a drawback.

To carry Mr. Kestenbaum's argument one step further, he would presumably measure the unmarried/married factor as the q_x for all unmarried (males and females combined) with the similar q_x for the married. This too suffers from an incorrect partition of the interaction.

The last paragraph on page 327 of the paper indicates that, for age group 45–49 in 1960, the sex factor under the Kestenbaum analysis is

1.79, contrasted with Trowbridge's 2.01. The corresponding marital factors are 1.95 and 1.97. At this age in 1960 the use of mixed data understates both factors, because the unfavored sex (males) has a lower percentage of its population exposed in the unfavored marital status (unmarried). At other ages the use of mixed data might overstate both factors.

Frank Knorr makes a very valid technical point in his final paragraph. Because mortality rates are more sensitive to age than to any other factor, any study of other variables must control for age. If age groupings become too large, age effects can confound the measure of the effect one seeks. My paper has used data by 16 age groupings, probably as many as is practically possible, but much of the work in this field has used 9, 7, or as few as 4. We shall face this problem again at a later point.

4. The Same Phenomena in Other Countries

At the time this paper was written, I had no information on mortality by marital status outside the U.S. Since then, I have discovered that the study of this subject has not been confined to North America and that similar results have been found elsewhere. Two of Mr. Brown's references, Livi-Bacci [19] and Hu-Goldman [15], report on cross-country studies. In particular, the latter, which studied 16 industrialized countries over broad time spans, gives a wealth of information.

There seems to be rather general agreement on at least these three matters: (1) the unmarried mortality rates are higher than the married, (2) this phenomenon, while true for both genders, is more true for males than for females, and (3) there is some tendency for the unmarried/married ratios to increase over time. The Trowbridge data for 1960 and 1980 agree. There is less agreement on detail and even less as to why.

Rob Brown has now furnished new data for Canada, which cover quite a span of time, including 1990. In attempting comparison with results reported in my paper, Mr. Brown runs into the difficulty that Canadian data are available only for four widely spaced age groups, the last of which is 65 and above. I suspect that his results understate mortality improvement at the older ages, because the only q_x he has is for 65+ and the average age of Canadian senior citizens is very likely growing.

5. Selection at Marriage

From the paragraphs labeled "Selection at Marriage" in the paper, it is obvious that I gave relatively little weight to the selection at marriage

argument. It is equally obvious that Ken Fagg disagrees. Mr. Johansen's remarks that marriage selection is a continuous process and that the continuation of this process must increase the proportion of the never-married who remain so for health reasons, bring me to the belief that he too is more impressed by the marriage selection argument than I.

Although the formal Goldman-Lord discussion says little about marriage selection, Dr. Goldman, in at least two papers cited by Brown (Kisker and Goldman [17] and Hu and Goldman [15]), has investigated a correlation that some think supports the selection at marriage explanation. This argument is stated briefly by Mr. Kestenbaum and will not be repeated here. Real students of the subject will find it worthwhile to read Hu and Goldman [15].

Today, I am impressed by the difficulty in proving, or disproving, marital selection as an important explanation for the marital status effects demonstrated. Mr. Fagg makes a suggestion on how the matter might be studied, but there are severe practical difficulties in following ". . . two groups that are identical in all respects except that one group is married and the other has never been."

We can be reasonably sure that marriage selection exists and that it accounts for some part of the results we get. We cannot be sure how much effect it has. Someday, perhaps, the longitudinal studies that Dr. Goldman refers to may throw light on this perplexing matter.

6. Why Higher Mortality among the Widowed?

Frank Knorr seems to be particularly interested in the high mortality rates shown for widows and widowers, especially at the younger ages. Life insurance policies that pay upon the second death of a married couple, as Mr. Johansen also suggests, raise the question of how the mortality risk of the widow(er) may be related to the cause or the timing of the previous death.

Mr. Knorr's third paragraph, referring to two different papers in nonactuarial journals, suggests that there is a high correlation between the dates of death of husband and wife, because of the same contagious disease, the same accident, or the same hazardous lifestyle, or because of what some observers call the "bereavement effect." These reasons are certainly plausible and no doubt have a bearing on the results shown. The data in my paper, however, are not rich enough to come to many firm conclusions. If we could study the mortality experience of widow(er)s

by duration (the length of time since the first death), we could separate the experience of recent widow(er)s from those where the first death occurred in the distant past and where any effects of the first death can be assumed to have worn off.

One assumption, however, is certainly justified. For very young age widows and widowers, the spousal death must have been fairly recent. That the relative mortality of young widows and widowers is much higher than that of older widow(er)s is consistent with the explanations offered, but why is the effect stronger among widowers than widows?

I find Mr. Knorr's second paragraph, showing that at the younger ages the chance of an unmarried person dying within a year is higher than the chance of either of a married couple dying, interesting though confusing. I assume Mr. Knorr would not price a joint-life policy on a married couple lower than a single-life policy on a unmarried person of the same age, despite the observation he makes. It is well to remember that this paper says nothing about death rates beyond one year of time and that being married today says little about tomorrow.

7. *A New Explanation*

Ken Faig offers still another explanation of why married persons have lower death rates. He presents a table from a 1994 study showing that, generally speaking, married persons have more frequent sex relations than the unmarried. This is hardly a surprising result, especially since the study notes one exception: that unmarried but cohabiting couples are at least as sexually active as the married.

For these results to have any bearing on the subject of the paper, it is obviously necessary to show, or at least to assume, that frequent monogamous sex somehow leads to lower mortality. Mr. Faig offers no direct evidence, though his comments about AIDS may be relevant.

Mr. Faig also "suspects that long-term cohabitants exhibit many common characteristics with marrieds." He might then argue that the observed mortality differences between the married and the unmarried might be even greater if all long-term cohabitants were classified as married. He might point to the 15–24 age groups, where cohabiting but unmarried couples may be thought to be concentrated and where the marital factors are lower than for higher age groups.

8. What Does 1990 Data Show?

The paper under discussion was written after the 1990 U.S. census was taken, after the 1989–1991 period for which deaths will be tabulated, but before the compilation and publication of all the data needed to display 1990 results in the same form as the 1960 and 1980 results. I was hopeful that the 1990 data might be available by the time this author's review came to be written and that the analysis thereof might be included.

As of April 15, 1995, the news on this front is neither all good nor all bad. On the negative side, Mr. Kestenbaum tells me that it is still too early for 1990 data in the same detail as that shown in the paper for 1960 and 1980 data. On the positive side, much of the data needed for seven ten-year age groups are now available. I thank Mr. Kestenbaum for helping me find it.

The deaths for 1990, by ten-year age groups, sex, marital status, and cause of death, are shown in Volume II of *Vital Statistics of the U.S.*, Section 1, pp. 386 to 410.

The corresponding 1990 census counts, by ten-year age groups, sex, and marital status were published in 1991 as *Current Population Reports, Population Statistics, Series P-20, No. 450.*

These two documents make it possible to display Table 1. Table 1 is the 1990 counterpart of Tables 3 and 5 in the paper, different from these 1960 and 1980 death rates in that there are only seven age groupings instead of 16. Similarly, Table 2 is the 1990 counterpart of Tables 4 (1960) and 7 (1980) in the paper, again with seven age groups.

My purpose in gathering and analyzing these new data is to determine whether the trends detected in comparing 1980 with 1960 data have continued for another decade. We can now compare 1980 and 1990 data, but only if we recast Tables 5 and 7 of the paper in terms of the smaller number of age groups to which 1990 data are still restricted. This consolidation has now been accomplished, though the 1980 counterpart of Table 1 is not here shown. Table 3 is the 1980 counterpart of Table 2, with which it can be directly compared.

Table 4 exhibits mortality improvement over the 1980s by seven age groups, sex, and unmarried versus married status. It has much in common with Table 8 of the paper, though its information in age groups is much less detailed. We note that mortality improvement over the ten-year period has been uneven, generally more than 1 percent per year,

TABLE 1

CENTRAL DEATH RATES BY AGE GROUP, SEX, AND MARITAL STATUS BASED ON 1990 DATA (PER THOUSAND)

Age Group	Total	Married	Unmarried	Unmarried		
				Never Married	Widowed	Divorced
			Male			
15–24	1.58	1.29	1.62	1.60	na	3.61
25–34	2.02	1.04	3.36	3.30	9.12	3.59
35–44	3.08	1.75	7.24	8.24	22.9	6.05
45–54	5.99	4.38	13.1	14.9	12.9	12.0
55–64	15.3	12.7	27.8	25.2	27.9	29.6
65–74	34.2	30.4	49.7	50.5	48.6	50.9
75+	103	85.3	144	175	140	140
			Female			
15–24	0.498	0.361	0.532	0.522	3.80	0.910
25–34	0.729	0.465	1.26	1.24	3.93	1.23
35–44	1.37	1.02	2.40	2.83	2.93	2.06
45–54	3.36	2.68	5.45	6.29	6.19	4.89
55–64	8.70	6.98	12.5	14.4	11.8	13.0
65–74	20.2	15.9	25.0	24.8	24.3	29.2
75+	84.7	46.1	47.9	110	97.0	95.6

TABLE 2

1990 RATIO OF CENTRAL DEATH RATES

Age Group	Unmarried to Married		Male to Female		Unmarried Male/ Married Female	Unmarried Female/ Married Male	Marital Factor	Sex Factor
	Male	Female	Unmarried	Married				
15–24	1.26	1.47	3.05	3.56	4.49	0.41	1.36	3.29
25–34	3.23	2.71	2.66	2.24	7.23	1.21	2.96	2.44
35–44	4.14	2.36	3.02	1.72	7.13	1.37	3.13	2.28
45–54	2.98	2.04	2.40	1.64	4.88	1.24	2.47	1.98
55–64	2.18	1.80	2.22	1.82	3.98	0.99	1.98	2.01
65–74	1.64	1.57	1.99	1.91	3.12	0.82	1.60	1.95
75+	1.69	2.12	1.47	1.85	3.13	1.15	1.90	1.65

but with notable exceptions. Note especially the increase in mortality for unmarried males age 35–44, and the small improvements for the unmarried of both sexes at ages under 35. Little or no improvement is shown for age 75+, but this is probably explained by ten years of increase in the average age of these 75 and up citizens.

As a result, the unmarried/married factors for 1990 exceed those for 1980, except for a tiny reversal at age 65–74. The sex factors for 1990 are also higher than for 1980, but only for ages below 55.

TABLE 3

1980 RATIOS OF CENTRAL DEATH RATES

Age Group	Unmarried to Married		Male to Female		Unmarried Male/ Married Female	Unmarried Female/ Married Male	Marital Factor	Sex Factor
	Male	Female	Unmarried	Married				
15–24	1.22	1.44	2.80	3.30	4.03	0.44	1.33	3.04
25–34	2.68	2.51	2.51	2.35	6.30	1.07	2.60	2.43
35–44	3.05	2.37	2.28	1.77	5.41	1.34	2.69	2.01
45–54	2.78	1.92	2.57	1.77	4.93	1.08	2.31	2.13
55–64	2.04	1.68	2.44	2.01	4.10	0.84	1.85	2.21
65–74	1.76	1.48	2.48	2.08	3.67	0.71	1.62	2.27
75+	1.83	1.75	1.84	1.77	3.23	0.99	1.79	1.81

TABLE 4

RATIO OF 1990 TO 1980 CENTRAL DEATH RATES

Age Group	Male		Female	
	Married	Unmarried	Married	Unmarried
15–24	0.922	0.951	0.853	0.875
25–34	0.826	0.996	0.868	0.938
35–44	0.797	1.083	0.821	0.818
45–54	0.719	0.770	0.778	0.828
55–64	0.823	0.880	0.906	0.967
65–74	0.854	0.793	0.933	0.988
75+	1.041	0.964	0.994	1.206

Finally, the 1990 deaths from "human immunodeficiency virus infection," as a percentage of all deaths within each of the 28 age/sex/marital status groups, is displayed as Table 5. AIDS deaths are more than 20 percent of total deaths for unmarried males 25–44, close to 10 percent for both groups of males 45–54 and for unmarried females 25–34. Elsewhere, with two minor exceptions, AIDS/HIV deaths are less than 5 percent of the total deaths.

I leave to the reader the interpretation of the interactions of Tables 2, 3, 4, and 5, but it seems to me that much of the 1980–1990 change can be attributed to HIV/AIDS.

TABLE 5

PERCENTAGE OF 1990 DEATHS HIV-RELATED

Age Group	Male		Female	
	Married	Unmarried	Married	Unmarried
15–24	1.0	1.5	1.5	1.4
25–34	5.1	21.8	3.7	8.6
35–44	4.8	24.7	1.9	5.9
45–54	11.9	9.9	0.2	1.0
55–64	0.3	1.8	0.1	0.2
65–74	0.1	0.2	*	0.1
75+	*	*	*	*

*Less than 0.1%.