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MORTALITY AT AGES 65 AND OVER IN A MIDDLE-CLASS POPULATION

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ABSTRACT

In the fall of 1959 the American Cancer Society began a comprehensive epidemiologic study of over one million men and women drawn mainly from the middle-class population [4]. The experience among the subjects of this study who were initially at least 65 years old or who subsequently attained age 65 was analyzed by attained age, age at entry, calendar-year periods, cause of death, and a number of demographic and other factors.

Three sets of mortality tables were prepared: for the total population, for the ostensibly healthy, and for those not in good health. The aggregate experience among the male subjects under study was similar to the contemporary experience among standard ordinary male risks insured 16 years or longer. The corresponding experience among female subjects was lower than that among standard ordinary female risks insured 16 years or longer.

The death rates among the ostensibly healthy subjects of either sex resembled closely the contemporary select mortality rates among standard ordinary risks in the age range 65–74. Thus the experience in this study among the ostensibly healthy subjects provides credible estimates of the mortality likely to be experienced among standard ordinary risks at the advanced ages, where adequate information from insurance sources is lacking. The death rates among the ostensibly healthy subjects in this study also furnish a more relevant standard of normal mortality at ages 65 and over than either population death rates or ultimate death rates among insured lives.

This paper examines the effects of selection procedures such as those used in epidemiologic studies and suggests that similar procedures could be employed to select standard ordinary insurance risks at the older ages. The analysis of mortality by cause shows that selection has little effect on cancer death rates and that most of the excess mortality among those not in good health can be attributed to extra mortality from heart disease.

Analysis of the mortality at ages 65 and over according to demographic and personal characteristics indicates that a good family history of longevity and higher educational attainment have an appreciable effect on

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mortality up to age 85. A history of smoking or heavy drinking affects mortality adversely into the nineties as does widowed or divorced status in either sex.

PRINCIPAL TOPICS COVERED

This paper describes the mortality experience at ages 65 and over in a selected middle-class population. A detailed examination of this experience leads to the following major findings:

1. The select and aggregate death rates developed in this study for ostensibly healthy subjects closely resemble those of corresponding standard ordinary insured lives at entry ages from 65 into the seventies. At entry ages 75–84 the select and aggregate death rates among the ostensibly healthy subjects provide highly credible estimates of the mortality among corresponding standard ordinary insured lives, assuming selection procedures similar to those used in the study. The death rates observed in this study can serve as a basis for extending ordinary insurance coverages more confidently to much older ages than has been done, at a time when the economic circumstances of the elderly have improved materially.

2. The aggregate death rates observed among men in the total population under study are very similar to those on standard ordinary insurance issued 16 or more years ago, while the corresponding death rates among women are somewhat lower than on standard ordinary insurance issued 16 or more years ago. These results reflect the class selection and the physical screening implicit in the criteria used respectively to enroll the population under study and to issue standard ordinary insurance 16 or more years ago. The experience obtained in this study by means of selection procedures characteristic of epidemiologic investigations suggests the feasibility of simpler approaches to the selection of lives at ages 65 and over.

3. The death rates developed in this study among the ostensibly healthy subjects furnish a more appropriate standard of expected mortality than general population death rates (or even ultimate death rates among insured lives) where the objective is to estimate the departures from normal mortality produced either by physical impairments or special hazards to health in an otherwise healthy middle-class population. A more relevant standard of expected mortality is particularly in order for most studies of occupational hazards where calculation of expected deaths by reference to general population death rates may significantly underestimate the extra mortality involved.

4. Analyses of the mortality according to a number of demographic and personal characteristics indicate that many of these characteristics cease to have any appreciable impact on mortality beyond age 85. Family history of longevity and educational attainment illustrate this observation. One the other hand, a history of smoking or heavy drinking among men continues to affect mortality adversely into the nineties, as does widowed or divorced status in either sex. Even small percentage departures from average mortality at the advanced ages may represent substantial increases or decreases in absolute death rates.

AMERICAN CANCER SOCIETY STUDY

The experience in this paper was developed from a prospective epidemiologic investigation launched by the American Cancer Society in the fall of 1959 to learn how personal characteristics, living styles, and environmental conditions influence health and longevity [4]. Some 68,000 volunteers, working for the American Cancer Society, enlisted more than a million of their friends, neighbors, and relatives for this study and traced over 98 percent of them over a twelve-year period. Long-lived men and women were followed for an additional seven years to the middle of 1979. Some 466,277 men and women out of this million attained age 65 or over in the course of the investigation, and they constitute the population under study in this paper.

These subjects were enrolled in small and large cities in twenty-five states by volunteers who were predominately white middle-class women. Accordingly, the subjects were drawn largely from the middle class. Relatively few individuals from the lower socioeconomic segments of the general population were included, while itinerants and institutionalized individuals were to all intents and purposes excluded. Table 1 shows the composition of the population in this study by sex, race, nativity, marital status, and educational attainment.

The subjects were registered in family groups with at least one member over age 45. All members of a household over age 30 were asked to answer a detailed four-page questionnaire dealing with family history of longevity, personal medical history, present physical complaints, personal habits (including smoking, drinking, and diet), educational attainment, occupational exposures, and a number of other personal characteristics that affect death rates. Four times during the course of the investigation (the last being in 1972) the subjects were requested to answer another questionnaire intended to elicit additional information.

The investigation has assembled a very large body of data on the relationship of numerous personal characteristics to mortality. Records on

TABLE 1

CHARACTERISTICS OF POPULATION UNDER STUDY

	AMERICAN CANCER SOCIETY STUDY, 1959, AGES 65 AND OVER		U.S. POPULATION, 1960, AGES 65 AND OVER	
	Males	Females	Males	Females
Race:				
White	97 %	96%	92%	92.7%
Black	2	2	7	6.9
Other	1	2	1	.4
Nativity:				
Native	90	92	78	82.0
Foreign-born	8	6	22	18
Other	2	2	.....	.....
Marital status:				
Married	94	69	60	36.0
Single	1.5	7	8	9
Widowed	4	30	19	52
Separated or divorced	.5	3	4	3
Educational attainment:				
Grammar school or less	58	53	73	66.0
High school	11	16	18	25
Some college	31	31	9	9

over a million people have made it possible to explore the mortality associated with single characteristics or with combinations of characteristics, apart from the effects of other factors. Although the main thrust of the investigation was to elucidate the hazards associated with smoking [11, 12], it was also carefully designed to encompass numerous other factors implicated in the development of various health hazards. More than seventy reports based on this huge data bank have been published to date.

This paper centers on the mortality experience at ages 65 and over as affected by the selection processes employed in this study and by recent mortality declines. The total number of persons in the study was 466,277, comprising 208,983 men and 257,294 women who were either 65 or older in July 1960 or attained age 65 subsequent to enrollment up to June 30, 1972. These persons were all traced to June 30, 1972, except that long-lived men and women, defined as men born in 1887 or earlier and women born in 1885 or earlier, were traced to June 30, 1979 and their experience to June 30, 1979 is included in the study. The total experience, subdivided into ostensibly healthy subjects and others, was analyzed by attained age, by age at entry for the periods from July 1, 1960 to June 30, 1965, from July 1, 1965 to June 30, 1970, from July 1, 1970 to June 30, 1975, and from July 1, 1975 to June 30, 1979, by cause of death, and by certain personal characteristics, including race, nativity, and marital status, per-

sonal habits as to smoking and drinking, educational attainment, and family history of longevity.

An important feature of this study lies in the subdivision of the population under study into (1) subjects in impaired health, as indicated by the presence of illness at time of enrollment, by a personal history of heart disease, stroke or cancer, or by marked overweight, and (2) subjects in ostensibly good health, as indicated by absence of all of the above-mentioned findings.

The pronounced differentials in death rates observed between the subjects in ostensibly good health and those in impaired health indicate what can be accomplished with appropriate selection procedures.

Where feasible, comparisons have been made between the mortality experience of the subjects in this paper and the contemporary select and ultimate experience among lives insured under standard ordinary policies as well as with the experience among medicare recipients. At the advanced ages, comparisons were made not only with the mortality among medicare recipients but also with estimated death rates in the general population.

The mortality statistics presented in this paper reflect the sharp decreases in death rates at ages 65 and over recorded since the mid 1960s. Between 1968 and 1978 the death rates among medicare recipients and insured lives declined 14–19 percent at attained ages 65–74, by 13–23 percent at attained ages 75–84, and by 9–19 percent at attained ages 85 and over, with the higher reductions generally applying to women and the lower reductions to men.

ACCURACY AND BASIS OF REPORTED AGES

Much time and effort was devoted to improving the accuracy of the ages reported. This was done in part by checking the ages reported at time of enrollment against the ages given in the last supplementary questionnaire. Inasmuch as a very high proportion of the subjects at the advanced ages had died by June 30, 1979, it was further possible in the case of deaths to check the age stated at time of enrollment against the date of birth given on the death certificate. Internal evidence such as the ages of the wife, husband, siblings, parents, and children in the family group frequently provided additional checks. The ages of the mothers and fathers of the subjects at time of birth of the subjects were particularly valuable as a check on the ages of the enrolled. A special review was made of the ages given by 106 men and 354 women who attained age 100 or over; this review showed that the oldest man in the study had attained age 109 and the oldest woman age 114.

In addition, tests were conducted as to which age basis—the original age at time of enrollment, the youngest age reported, the oldest reported age, the latest reported age, or an average age—produced the most credible set of death rates, the smoothest progression of death rates, and the fewest large deviations from a moving average. These different age bases did not result in significantly different sets of death rates. After making the corrections indicated by the checks mentioned above, it was decided to calculate death rates on the basis of the ages given at time of enrollment.

EXPERIENCE BY ATTAINED AGE

The ungraduated death rates for individual attained ages were calculated from the actual deaths and person-years of exposure on the basis of the ages as originally reported. The graduated death rates were derived from the ungraduated death rates by applying the Whittaker-Henderson Type B graduation formula (with a smoothing coefficient of 500,000), which gives weight to the person-years of exposure at individual attained ages. These graduated death rates are believed to provide a good indication of the underlying mortality patterns, inasmuch as the Whittaker-Henderson Type B formula does not of itself tend to introduce significant distortions. Tables 2, 3, and 4 present the ungraduated and graduated mortality rates by attained age for all participants in the study, for those in ostensibly good health, and for those in impaired health, respectively.

The death rates by attained age among the ostensibly healthy subjects were appreciably lower than those of all participants through the nineties. In the case of ostensibly healthy men, the graduated death rates varied from 74 percent of those among all male participants at age 65 to 77 percent at age 75, 87 percent at age 85, and 94 percent at age 95. The corresponding figures for women were 67 percent, 68 percent, 77 percent, and 90 percent, respectively. The attained-age death rates among ostensibly healthy men were nearly 10 per 1,000 lower than those of all male participants at ages 65–74 and 17–20 per 1,000 lower at ages 75 and over. The corresponding differentials among women increased from about 6 per 1,000 at attained ages 65–74 to nearly 25 per 1,000 at ages 85 and over.

Subjects classified as in impaired health experienced significantly higher attained-age mortality than that of all participants through the nineties. In the case of men in impaired health, the graduated death rates ranged from 134 percent of those among all male participants at age 65 to 125 percent at age 75, 112 percent at age 85, and 105 percent at age 95. The corresponding figures for women were 125 percent, 118 percent, 109 percent, and 105 percent, respectively. The attained-age death rates among men in impaired health were about 12 per 1,000 higher than those of all

TABLE 2

MORTALITY RATES—TOTAL POPULATION IN STUDY

AGE	DEATHS		EXPOSURE		UNGRADUATED DEATH RATE			GRADUATED DEATH RATE			RATIO TO PRECEDING AGE			RATIO OF FEMALE TO MALE
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
65	3,549	1,726	132,719	160,097	.01801	.02674	.01078	.01797	.02653	.01085	.....	.....	.....	.4088
66	3,407	1,872	123,307	150,742	.01926	.02763	.01242	.01932	.02816	.01211	1.0750	1.0612	1.1162	.4300
67	3,498	1,841	113,980	140,969	.02094	.03069	.01306	.02099	.03031	.01349	1.0865	1.0763	1.1138	.4450
68	3,497	1,957	105,375	132,245	.02295	.03319	.01480	.02295	.03292	.01500	1.0936	1.0864	1.1124	.4557
69	3,422	2,092	96,726	122,780	.02512	.03538	.01704	.02516	.03598	.01663	1.0963	1.0927	1.1083	.4622
70	3,507	2,112	88,473	113,688	.02779	.03964	.01858	.02758	.03944	.01833	1.0958	1.0963	1.1022	.4647
71	3,482	2,205	81,145	105,941	.03040	.04291	.02081	.03017	.04323	.02017	1.0942	1.0961	1.1004	.4665
72	3,470	2,057	73,373	97,098	.03242	.04729	.02118	.03302	.04725	.02231	1.0943	1.0930	1.1063	.4721
73	3,477	2,180	66,302	89,287	.03636	.05244	.02442	.03621	.05141	.02496	1.0968	1.0880	1.1189	.4856
74	3,278	2,314	58,996	81,178	.03989	.05556	.02851	.03977	.05567	.02818	1.0982	1.0830	1.1288	.5061
75	3,135	2,380	52,528	73,757	.04367	.05968	.03227	.04368	.06014	.03188	1.0984	1.0803	1.1315	.5301
76	2,978	2,406	46,342	66,194	.04784	.06426	.03635	.04797	.06497	.03599	1.0981	1.0802	1.1290	.5540
77	2,889	2,350	40,449	58,814	.05278	.07142	.03996	.05265	.07026	.04049	1.0976	1.0815	1.1251	.5764
78	2,591	2,399	34,870	51,921	.05749	.07430	.04620	.05777	.07610	.04544	1.0973	1.0832	1.1221	.5971
79	2,550	2,333	30,031	45,422	.06472	.08491	.05136	.06341	.08259	.05091	1.0976	1.0853	1.1205	.6164
80	2,277	2,217	25,356	39,373	.06943	.08980	.05631	.06970	.08978	.05707	1.0991	1.0870	1.1209	.6357
81	2,061	2,147	21,376	34,198	.07572	.09642	.06278	.07684	.09775	.06406	1.1025	1.0888	1.1225	.6554
82	1,886	2,114	17,836	29,370	.08473	.10574	.07198	.08501	.10658	.07197	1.1063	1.0903	1.1234	.6752
83	1,672	2,009	14,623	24,861	.09323	.11434	.08081	.09421	.11625	.08074	1.1082	1.0908	1.1220	.6946
84	1,509	1,895	12,056	20,769	.10370	.12517	.09124	.10428	.12666	.09028	1.1069	1.0896	1.1181	.7128
85	1,603	1,747	11,011	17,395	.11793	.14558	.10043	.11496	.13766	.10046	1.1025	1.0868	1.1128	.7298
86	1,475	1,639	9,782	14,526	.12811	.15079	.11283	.12601	.14907	.11120	1.0960	1.0829	1.1069	.7460
87	1,348	1,627	8,563	13,401	.13545	.15742	.12141	.13731	.16090	.12247	1.0897	1.0793	1.1013	.7612
88	1,269	1,670	7,441	12,226	.14944	.17054	.13659	.14894	.17319	.13428	1.0847	1.0764	1.0964	.7753
89	1,171	1,537	6,338	10,839	.15765	.18476	.14180	.16097	.18598	.14667	1.0808	1.0739	1.0923	.7886

TABLE 2—*Continued*

Age	Deaths		Exposure		Ungraduated Death Rate			Graduated Death Rate			Ratio to Preceding Age			Ratio of Female to Male
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
90	1,055	1,563	5,271	9,562	.17650	.20015	.16346	.17349	.19927	.15971	1.0778	1.0714	1.0889	.8015
91	927	1,424	4,287	8,180	.18858	.21624	.17408	.18653	.21299	.17339	1.0752	1.0689	1.0857	.8141
92	686	1,271	3,081	6,847	.19712	.22265	.18563	.20013	.22709	.18770	1.0729	1.0662	1.0825	.8265
93	535	1,103	2,204	5,645	.20869	.24274	.19539	.21429	.24148	.20259	1.0708	1.0634	1.0793	.8389
94	397	882	1,530	4,028	.23012	.25948	.21897	.22893	.25607	.21792	1.0683	1.0604	1.0757	.8510
95	266	677	1,037	2,838	.24335	.25651	.23855	.24383	.27075	.23345	1.0651	1.0573	1.0712	.8622
96	196	498	690	1,933	.26458	.28406	.25763	.25872	.28542	.24890	1.0611	1.0542	1.0662	.8720
97	153	356	443	1,281	.29524	.34537	.27791	.27333	.29997	.26403	1.0565	1.0510	1.0608	.8802
98	86	216	259	828	.27783	.33205	.26087	.28743	.31432	.27864	1.0516	1.0478	1.0553	.8865
99	49	148	158	533	.28509	.31013	.27767	.30090	.32843	.29260	1.0469	1.0449	1.0501	.8909
100	30	99	101	347	.28795	.29703	.28530	.31364	.34233	.30577	1.0423	1.0423	1.0450	.8932
101	25	83	70	217	.37631	.35714	.38249	.32556	.35603	.31802	1.0380	1.0400	1.0401	.8933
102	12	36	39	117	.30769	.30769	.30769	.33656	.36957	.32925	1.0338	1.0380	1.0353	.8909
103	8	18	25	71	.27083	.32000	.25352	.34659	.38299	.33934	1.0298	1.0363	1.0307	.8860
104	4	24	14	51	.43077	.28571	.47059	.35559	.39630	.34823	1.0260	1.0348	1.0262	.8787
105	6	10	10	23	.48485	.60000	.43478	.36350	.40952	.35585	1.0222	1.0334	1.0219	.8689
106	2	4	4	12	.37500	.50000	.33333	.37028	.42266	.36217	1.0187	1.0321	1.0178	.8569
107	1	3	2	8	.40000	.50000	.37500	.37593	.43572	.36719	1.0153	1.0309	1.0138	.8427
108	0	1	1	5	.16667	.00000	.20000	.38045	.44870	.37089	1.0120	1.0298	1.0101	.8266
109	1	0	1	5	.16667	1.00000	.00000	.38383	.46161	.37329	1.0089	1.0288	1.0065	.8087
110	.....	1	.....	5	.20000	.....	.20000	.38611	.....	.37441	1.0059	.....	1.0030	.....
111	.....	1	.....	3	.33333	.....	.33333	.38727	.....	.37424	1.0030	.....	.9996	.....
112	.....	1	.....	2	.50000	.....	.50000	.38733	.....	.37281	1.0002	.....	.9962	.....
113	.....	0	.....	1	.00000	.....	.00000	.38630	.....	.37010	.9973	.....	.9927	.....
114	.....	1	.....	1	1.00000	.....	1.00000	.38416	.....	.36613	.9945	.....	.9893	.....

TABLE 3

MORTALITY RATES—OSTENSIBLY HEALTHY PERSONS

AGE	DEATHS		EXPOSURE		UNGRADUATED DEATH RATE			GRADUATED DEATH RATE			RATIO TO PRECEDING AGE			RATIO OF FEMALE TO MALE
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
65	1,523	502	76,217	69,433	.01390	.01998	.00723	.01381	.01974	.00728				.3691
66	1,420	537	69,931	63,973	.01461	.02031	.00839	.01480	.02086	.00821	1.0718	1.0567	1.1272	.3937
67	1,461	519	63,841	58,425	.01619	.02288	.00888	.01607	.02242	.00918	1.0852	1.0751	1.1182	.4095
68	1,404	543	58,111	53,971	.01737	.02416	.01006	.01757	.02440	.01020	1.0937	1.0881	1.1113	.4182
69	1,402	575	52,725	49,255	.01939	.02659	.01167	.01929	.02675	.01128	1.0979	1.0964	1.1052	.4216
70	1,428	581	47,718	44,790	.02172	.02993	.01297	.02119	.02943	.01241	1.0984	1.1000	1.1006	.4218
71	1,381	546	43,310	41,061	.02284	.03189	.01330	.02326	.03236	.01367	1.0979	1.0999	1.1010	.4222
72	1,355	533	38,741	36,924	.02495	.03498	.01444	.02556	.03553	.01514	1.0987	1.0977	1.1078	.4261
73	1,385	585	34,599	33,447	.02895	.04003	.01749	.02810	.03887	.01692	1.0995	1.0940	1.1178	.4354
74	1,283	563	30,479	29,787	.03063	.04209	.01890	.03089	.04235	.01907	1.0990	1.0897	1.1270	.4503
75	1,273	568	26,845	26,537	.03449	.04742	.02140	.03396	.04604	.02164	1.0994	1.0869	1.1345	.4700
76	1,140	573	23,423	23,365	.03661	.04867	.02452	.03738	.05002	.02466	1.1009	1.0865	1.1394	.4929
77	1,092	583	20,360	20,431	.04106	.05363	.02854	.04127	.05446	.02814	1.1039	1.0889	1.1414	.5167
78	1,013	575	17,453	17,657	.04523	.05804	.03256	.04568	.05951	.03211	1.1070	1.0927	1.1412	.5396
79	1,050	560	14,901	15,113	.05364	.07047	.03705	.05069	.06527	.03661	1.1096	1.0967	1.1399	.5609
80	871	534	12,488	12,823	.05551	.06975	.04164	.05637	.07182	.04168	1.1120	1.1004	1.1385	.5803
81	858	485	10,487	10,906	.06278	.08182	.04447	.06289	.07931	.04738	1.1158	1.1044	1.1370	.5974
82	713	508	8,632	9,165	.06861	.08260	.05543	.07042	.08787	.05377	1.1196	1.1079	1.1348	.6119
83	652	442	7,051	7,532	.07502	.09247	.05868	.07900	.09755	.06084	1.1219	1.1101	1.1315	.6237
84	605	453	5,750	6,124	.08910	.10522	.07397	.08855	.10826	.06859	1.1209	1.1098	1.1273	.6335
85	668	374	5,291	4,994	.10131	.12625	.07489	.09882	.11979	.07700	1.1160	1.1065	1.1226	.6428

TABLE 3—*Continued*

Age	Deaths		Exposure		Ungraduate Death Rate			Graduated Death Rate			Ratio to Preceding Age			Ratio of Female to Male
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
86	650	357	4,716	4,136	.11376	.13783	.08632	.10955	.13185	.08611	1.1085	1.1007	1.1184	.6531
87	594	364	4,127	3,872	.11976	.14393	.09401	.12052	.14422	.09598	1.1002	1.0938	1.1146	.6655
88	566	411	3,592	3,598	.13588	.15757	.11423	.13167	.15676	.10666	1.0925	1.0870	1.1113	.6804
89	516	382	3,060	3,521	.13645	.16863	.10849	.14301	.16943	.11823	1.0861	1.0809	1.1084	.6978
90	468	385	2,568	2,919	.15546	.18224	.13189	.15467	.18228	.13075	1.0815	1.0758	1.1059	.7173
91	421	370	2,082	2,527	.17162	.20221	.14642	.16678	.19540	.14428	1.0783	1.0720	1.1035	.7384
92	295	346	1,451	2,138	.17860	.20331	.16183	.17954	.20895	.15885	1.0765	1.0693	1.1010	.7602
93	224	317	1,014	1,780	.19363	.22091	.17809	.19317	.22313	.17451	1.0759	1.0678	1.0986	.7821
94	162	237	689	1,252	.20556	.23512	.18930	.20793	.23813	.19132	1.0764	1.0672	1.0963	.8034
95	108	165	459	869	.20557	.23529	.18987	.22403	.25414	.20932	1.0774	1.0673	1.0941	.8236
96	68	138	284	587	.23651	.23944	.23509	.24165	.27133	.22858	1.0787	1.0676	1.0920	.8425
97	61	102	184	382	.28799	.33152	.26702	.26089	.28978	.24911	1.0796	1.0680	1.0898	.8597
98	35	64	103	234	.29377	.33981	.27350	.28180	.30957	.27091	1.0801	1.0683	1.0875	.8751
99	18	34	57	144	.25871	.31579	.23611	.30441	.33074	.29399	1.0802	1.0684	1.0852	.8889
100	9	38	31	94	.37600	.29032	.40426	.32874	.35331	.31835	1.0799	1.0683	1.0828	.9010
101	8	15	17	40	.40351	.47059	.37500	.35481	.37731	.34398	1.0793	1.0679	1.0805	.9117
102	3	5	5	20	.32000	.60000	.25000	.38261	.40273	.37089	1.0784	1.0674	1.0782	.9209
103	1	3	1	11	.33333	1.00000	.27273	.41216	.42959	.39909	1.0772	1.0667	1.0760	.9290
104	.....	3	.....	6	.50000	.....	.50000	.44346	.....	.42857	1.0759	.....	1.0739	.....
105	.....	1	.....	1	1.00000	.....	1.00000	.47650	.....	.45935	1.0745	.....	1.0718	.....

TABLE 4

MORTALITY RATES—PERSONS NOT IN GOOD HEALTH

AGE	DEATHS		EXPOSURE		UNGRADUATED DEATH RATE			GRADUATED DEATH RATE			RATIO TO PRECEDING AGE			RATIO OF FEMALE TO MALE
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
65	2,026	1,224	56,503	90,663	.02208	.03586	.01350	.02206	.03561	.01359	.....	.....	.....	.3818
66	1,987	1,335	53,375	86,769	.02370	.03723	.01539	.02366	.03774	.01500	1.0726	1.0600	1.1037	.3976
67	2,037	1,322	50,138	82,494	.02533	.04063	.01603	.02556	.04040	.01656	1.0805	1.0704	1.1034	.4099
68	2,093	1,414	47,264	78,274	.02794	.04428	.01806	.02776	.04354	.01827	1.0861	1.0779	1.1033	.4195
69	2,020	1,517	44,000	73,526	.03010	.04591	.02063	.03022	.04715	.02012	1.0886	1.0829	1.1015	.4267
70	2,079	1,531	40,754	68,898	.03292	.05101	.02222	.03292	.05120	.02211	1.0892	1.0857	1.0988	.4318
71	2,101	1,659	37,834	64,880	.03661	.05553	.02557	.03584	.05558	.02430	1.0887	1.0855	1.0990	.4372
72	2,115	1,524	34,632	60,174	.03838	.06107	.02533	.03902	.06017	.02682	1.0886	1.0827	1.1039	.4457
73	2,092	1,595	31,703	55,840	.04212	.06599	.02856	.04255	.06490	.02987	1.0905	1.0786	1.1137	.4602
74	1,995	1,751	28,517	51,390	.04688	.06996	.03407	.04648	.06977	.03349	1.0924	1.0751	1.1213	.4800
75	1,862	1,812	25,682	47,220	.05040	.07250	.03837	.05079	.07489	.03760	1.0927	1.0733	1.1226	.5020
76	1,838	1,833	22,919	42,828	.05584	.08020	.04280	.05545	.08038	.04209	1.0918	1.0733	1.1195	.5237
77	1,797	1,767	20,089	38,383	.06095	.08945	.04604	.06046	.08631	.04696	1.0903	1.0738	1.1156	.5441
78	1,578	1,824	17,417	34,264	.06583	.09060	.05323	.06586	.09273	.05226	1.0893	1.0744	1.1130	.5636
79	1,500	1,773	15,130	30,309	.07203	.09914	.05850	.07178	.09974	.05811	1.0899	1.0755	1.1118	.5826
80	1,406	1,683	12,869	26,550	.07836	.10925	.06339	.07839	.10737	.06463	1.0921	1.0765	1.1122	.6019
81	1,203	1,662	10,889	23,292	.08382	.11048	.07135	.08584	.11562	.07197	1.0950	1.0769	1.1136	.6225
82	1,173	1,606	9,204	20,205	.09449	.12744	.07949	.09419	.12448	.08021	1.0973	1.0766	1.1144	.6443
83	1,020	1,567	7,571	17,328	.10390	.13472	.09043	.10339	.13386	.08932	1.0977	1.0754	1.1136	.6672
84	904	1,442	6,306	14,644	.11198	.14336	.09847	.11330	.14371	.09922	1.0959	1.0735	1.1109	.6904
85	935	1,373	5,720	12,401	.12737	.16346	.11072	.12379	.15399	.10984	1.0926	1.0716	1.1070	.7133
86	825	1,282	5,066	10,390	.13632	.16285	.12339	.13474	.16477	.12107	1.0885	1.0700	1.1023	.7348
87	754	1,263	4,436	9,529	.14443	.16997	.13254	.14616	.17616	.13288	1.0847	1.0691	1.0975	.7543
88	703	1,259	3,849	8,628	.15725	.18264	.14592	.15811	.18827	.14524	1.0818	1.0687	1.0931	.7715
89	655	1,155	3,278	7,588	.16657	.19982	.15221	.17066	.20112	.15818	1.0794	1.0682	1.0891	.7865

TABLE 4—*Continued*

Age	Deaths		Exposure		Ungraduated Death Rate			Graduated Death Rate			Ratio to Preceding Age			Ratio of Female to Male
	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	
90	587	1,178	2,703	6,642	.18887	.21717	.17736	.18379	.21462	.17167	1.0770	1.0671	1.0853	.7999
91	506	1,054	2,205	5,653	.19852	.22948	.18645	.19743	.22861	.18563	1.0742	1.0652	1.0813	.8120
92	391	925	1,630	4,709	.20760	.23988	.19643	.21145	.24287	.19998	1.0710	1.0624	1.0773	.8234
93	311	786	1,190	3,865	.21701	.26134	.20336	.22572	.25718	.21459	1.0675	1.0589	1.0731	.8344
94	235	645	841	2,776	.24330	.27943	.23235	.24002	.27131	.22926	1.0633	1.0549	1.0684	.8450
95	158	512	578	1,969	.26305	.27336	.26003	.25403	.28504	.24371	1.0584	1.0506	1.0630	.8550
96	128	360	406	1,346	.27854	.31527	.26746	.26745	.29819	.25767	1.0528	1.0461	1.0573	.8641
97	92	254	259	899	.29879	.35521	.28254	.28008	.31062	.27095	1.0472	1.0417	1.0515	.8723
98	51	152	156	594	.27067	.32692	.25589	.29180	.32228	.28342	1.0418	1.0375	1.0460	.8794
99	31	114	101	389	.29592	.30693	.29306	.30259	.33314	.29503	1.0370	1.0337	1.0410	.8856
100	21	61	70	253	.25387	.30000	.24111	.31245	.34322	.30572	1.0326	1.0303	1.0362	.8907
101	17	68	53	177	.36957	.32075	.38418	.32141	.35259	.31544	1.0287	1.0273	1.0318	.8946
102	9	31	34	97	.30534	.26471	.31959	.32945	.36129	.32412	1.0250	1.0247	1.0275	.8971
103	7	15	24	60	.26190	.29167	.25000	.33656	.36936	.33171	1.0216	1.0224	1.0234	.8981
104	4	21	14	45	.42373	.28571	.46667	.34274	.37685	.33816	1.0183	1.0203	1.0194	.8973
105	6	9	10	22	.46875	.60000	.40909	.34795	.38376	.34344	1.0152	1.0183	1.0156	.8949
106	2	4	4	12	.37500	.50000	.33333	.35219	.39011	.34753	1.0122	1.0166	1.0119	.8908
107	1	3	2	8	.40000	.50000	.37500	.35546	.39591	.35043	1.0093	1.0149	1.0084	.8851
108	0	1	1	5	.16667	.00000	.20000	.35776	.40115	.35216	1.0065	1.0132	1.0049	.8779
109	1	0	1	5	.16667	1.00000	.00000	.35912	.40585	.35272	1.0038	1.0117	1.0016	.8691
110	.....	1	.....	5	.20000	.....	.20000	.35954	.....	.35213	1.0012	.....	.9983	.....
111	.....	1	.....	3	.33333	.....	.33333	.35904	.....	.35040	.9986	.....	.9951	.....
112	.....	1	.....	2	.50000	.....	.50000	.35761	.....	.34754	.9960	.....	.9918	.....
113	.....	0	.....	1	.00000	.....	.00000	.35528	.....	.34355	.9935	.....	.9885	.....
114	.....	1	.....	1	1.00000	.....	1.00000	.35203	.....	.33843	.9909	.....	.9851	.....

male participants at ages 65–74 and about 16 per 1,000 higher at ages 75–84. The corresponding differentials among women increased from about 4 per 1,000 at attained ages 65–74 to 10 per 1,000 at ages 85 and over.

The graduated death rates for the ostensibly healthy men and women exceeded the graduated death rates for all participants in the study at ages 99 and over. The graduated death rates for men and women in impaired health (at time of enrollment) fell below the graduated rates for all participants in the study at ages 101 and over. Crossovers of this kind in mortality curves have been observed in the case of whites versus nonwhites in the general population of the United States and standard versus substandard ordinary insurance risks. One of the explanations offered for this phenomenon is that a higher level of mortality in midlife among those with lesser vitality increases the average vitality of the survivors at the advanced ages, which tends to produce lower death rates in extreme old age. Conversely postponement of deaths among those with greater vitality tends to decrease the average vitality of those surviving to the advanced ages, resulting in higher death rates in extreme old age.

At entry into the study, the ostensibly healthy men constituted about 44 percent of all male participants at age 65, decreasing to 41 percent at age 95. The ostensibly healthy women accounted for only 30 percent of all female participants at age 65 at entry, decreasing to 24 percent at age 95. It appears that women are much more aware of and more likely to report health impairments than men. The proportion of ostensibly healthy persons in the general population will probably increase in the years to come, at least in the sixties and seventies, as living and health standards continue to improve.

The death rates of female subjects increased in relation to the death rates of male subjects from about 40 percent at age 65 to 90 percent at age 100. This was true of the ostensibly healthy subjects as well as of those in impaired health.

At the advanced ages the graduated mortality rates in the life table for all participants in the study are based on fewer than 100 deaths in the case of men aged 98 or older and in the case of women aged 100 or older. The life table terminates at age 109 for men and 114 for women. There are no indications in this study that death rates at ages under 105 exceeded 0.5 in either sex.

The graduated death rates for all participants and for the subjects in impaired health continue to show exponential increases of the same order as at attained age 65 up to about attained age 90 in the case of men and up to about attained age 85 in the case of women. The graduated death rates for the ostensibly healthy males exhibit exponential increases of the

same order as at attained age 65 past attained age 100, but the ostensibly healthy females show such exponential increases only up to about age 85. The subjects in ostensibly good health come closer to experiencing death rates that follow the Gompertz curve than do the subjects in impaired health, suggesting that more homogeneous populations can more readily be characterized by a Gompertz curve.

LIFE EXPECTANCY AMONG HEALTHY LIVES AND OTHERS

The understanding gained from studies of the mortality among healthy lives was utilized by William Farr in developing the Healthy English Life Table No. 1 in 1859. He observed that the experience of the healthy lives "expresses very accurately the actual duration of life among the clergy and other classes of the community living under favorable circumstances."

Table 5 shows the life expectancies at ages 65, 75, 85, and 95 for all the participants in this study, for the ostensibly healthy participants, and for those not in good health, as well as the corresponding life expectancies for lives insured under standard ordinary policies, based on select and ultimate experience (Basic Table 1965–70), and for whites in the general population. The table indicates that the experience among the ostensibly healthy participants in this study expresses accurately the actual duration of life among standard ordinary policyholders aged 65 at issue, on a select and ultimate mortality basis. This also appears to be the case for age 70 at issue based on less clear-cut data.

The life expectancies of all male participants in this study closely resemble those of standard ordinary male policyholders at ages 65, 75, and

TABLE 5

LIFE EXPECTANCIES (IN YEARS) IN CURRENT STUDY COMPARED WITH INSURED LIVES AND UNITED STATES WHITE POPULATION

AGE	CURRENT STUDY			INSURED LIVES		U.S. POPULATION: WHITES
	Total	Ostensibly Healthy	Not in Good Health	Ultimate Experience*	Select Experience*	
Males:						
65	14.44	16.28	12.79	14.26	16.50	13.02
75	8.89	10.02	7.94	8.75	.....	8.06
85	4.97	5.38	4.61	4.86	.....	4.63
95	2.83	2.87	2.73	.....	.....	2.67
Females:						
65	18.72	21.02	17.67	17.81	21.00	16.93
75	11.35	13.04	10.68	10.63	.....	10.21
85	6.03	6.93	5.71	5.76	.....	5.54
95	3.24	3.34	3.16	.....	.....	3.04

* Basic Table 1965–70.

85, calculated on the ultimate 1965–70 Basic Table. The life expectancies of all female participants in this study exceed those of standard ordinary female policyholders calculated on the ultimate 1965–70 Basic Table at ages 65 and 75, but at age 85 are almost the same.

The life expectancies of males in impaired health are lower than those of males in the general population up to about age 95, but females in impaired health show higher life expectancies than those of females in the general population.

In considering the current levels of mortality among the ostensibly healthy subjects, note that the life expectancy of persons aged 70 at the present time resembles closely that of persons aged 65 thirty years ago, and that the life expectancy of persons aged 75 now is similar to that of persons aged 70 in 1950.

EXPERIENCE BY CALENDAR YEAR

Tables 6, 7, and 8 present the attained-age experience in this study analyzed by calendar-year periods 1960–65, 1965–70, 1970–75, and 1975–79.

Table 9 shows the changes in death rates approximately over these periods in the white population of the United States, among medicare

TABLE 6

MORTALITY BY ATTAINED AGE AND CALENDAR YEARS
TOTAL POPULATION IN STUDY
MORTALITY RATES

ATTAINED AGE	1960–65 (1)	1965–70 (2)		1970–75 (3)		1975–79 (4)		1960–79 (5)
	Death Rate	Death Rate	Ratio to Death Rate (1)	Death Rate	Ratio to Death Rate (2)	Death Rate	Ratio to Death Rate (3)	Death Rate
Males:								
65–69	.0299	.0298	100%	.0289	97%	.....	.....	.0304
70–74	.0457	.0469	103	.0441	94	.....	.....	.0467
75–79	.0653	.0701	107	.0690	98	.....	.....	.0693
80–84	.0987	.1051	106	.1024	97	.....	.....	.1031
85–89	.1550	.1605	104	.1595	99	.1624	102%	.1592
90–94	.2286	.2302	101	.2099	91	.2159	103	.2199
95–99	.3089	.3088	100	.2982	96	.2597	87	.2899
Females:								
65–69	.0132	.0131	100	.0124	95	.....	.....	.0134
70–74	.0226	.0216	96	.0201	93	.....	.....	.0223
75–79	.0406	.0389	96	.0384	99	.....	.....	.0401
80–84	.0701	.0709	101	.0646	91	.....	.....	.0699
85–89	.1151	.1202	104	.1233	103	.....	.....	.1202
90–94	.1862	.1934	104	.1802	93	.1705	95	.1822
95–99	.2464	.2618	106	.2715	104	.2351	97	.2556

TABLE 7

MORTALITY BY ATTAINED AGE AND CALENDAR YEARS
OSTENSIBLY HEALTHY PERSONS
MORTALITY RATES

ATTAINED AGE	1960–65 (1)	1965–70 (2)		1970–75 (3)		1975–79 (4)		1960–79 (5)
	Death Rate	Death Rate	Ratio to Death Rate (1)	Death Rate	Ratio to Death Rate (2)	Death Rate	Ratio to Death Rate (3)	Death Rate
Males:								
65–69	.0191	.0228	119%	.0243	107%	.....	.....	.0225
70–74	.0308	.0356	116	.0368	103	.....	.....	.0351
75–79	.0445	.0559	126	.0583	104	.....	.....	.0541
80–84	.0713	.0866	121	.0879	102	.....	.....	.0833
85–89	.1239	.1427	115	.1519	106	.1487	98%	.1440
90–94	.1689	.2155	128	.1993	92	.1994	100	.2012
95–99	.....	.2922	.....	.2691	92	.2496	93	.2668
Females:								
65–69	.0076	.0094	124	.0092	98	.....	.....	.0091
70–74	.0135	.0151	112	.0149	99	.....	.....	.0151
75–79	.0255	.0271	106	.0288	106	.....	.....	.0277
80–84	.0474	.0536	113	.0517	96	.....	.....	.0520
85–89	.0718	.0921	128	.1087	118	.....	.....	.0951
90–94	.1427	.1635	115	.1560	95	.1482	95	.1559
95–99	.....	.2177	.....	.2321	107	.2205	95	.2270

TABLE 8

MORTALITY BY ATTAINED AGE AND CALENDAR YEARS
PERSONS NOT IN GOOD HEALTH
MORTALITY RATES

ATTAINED AGE	1960–65 (1)	1965–70 (2)		1970–75 (3)		1975–79 (4)		1960–79 (5)
	Death Rate	Death Rate	Ratio to Death Rate (1)	Death Rate	Ratio to Death Rate (2)	Death Rate	Ratio to Death Rate (3)	Death Rate
Males:								
65–69	.0413	.0394	95%	.0361	92%	.....	.....	.0404
70–74	.0594	.0603	102	.0545	90	.....	.....	.0599
75–79	.0825	.0853	103	.0823	96	.....	.....	.0847
80–85	.1181	.1240	105	.1197	97	.....	.....	.1218
85–89	.1723	.1772	103	.1686	95	.1799	107%	.1733
90–94	.2461	.2412	98	.2216	92	.2381	107	.2369
95–99	.3089	.3161	102	.3229	102	.2745	85	.3067
Females:								
65–69	.0166	.0159	96	.0153	96	.....	.....	.0165
70–74	.0274	.0259	95	.0239	92	.....	.....	.0268
75–79	.0470	.0456	97	.0445	97	.....	.....	.0467
80–84	.0778	.0792	102	.0722	81	.....	.....	.0780
85–89	.1277	.1319	103	.1305	99	.....	.....	.1305
90–94	.1957	.2050	105	.1927	94	.1835	95	.1940
95–99	.2464	.2750	112	.2933	107	.2442	83	.2678

recipients, and among standard ordinary insured lives whose policies had been in force 16 years or longer. The figures indicate that the reductions in mortality were relatively small during 1963–68 but increased markedly during 1968–73 and further during 1973–78. The improvements in mortality noted in the general population at ages 65 and over are believed to be less credible than those recorded among medicare recipients. It is noteworthy that the declines in death rates among medicare recipients were similar to those in the ultimate experience among standard ordinary insured lives.

Table 6 shows that the attained-age death rates in the total population under study remained at about the same levels in the first ten years following enrollment, and were at somewhat lower rates in the 1970s. The underlying downtrends in mortality (observed in the experience among insured lives and among medicare recipients) did not begin to make them-

TABLE 9

CHANGES IN DEATH RATES 1963–78
U.S. WHITE POPULATION, MEDICARE RECIPIENTS, AND
INSURED LIVES ULTIMATE EXPERIENCE

AGE GROUPS	MALES			FEMALES		
	1963–68	1968–73	1973–78	1963–68	1968–73	1973–78
U.S. white population:						
65–69	−2.6%	−5.5%	−12.3%	− 4.7%	−10.6%	− 8.9%
70–74	+5.4	−8.3	−10.4	− 3.0	−10.9	−12.6
75–79	+0.4	+1.6	− 9.4	− 5.6	− 3.6	−13.8
80–84	−6.9	+1.2	− 5.4	− 9.4	− 8.4	−10.1
Medicare recipients:						
65–69	.....	−6.0	− 9.6	.....	− 9.1	− 8.2
70–74	.....	−3.9	− 8.0	.....	− 5.8	−12.7
75–79	.....	−4.8	− 8.3	.....	− 8.7	−15.3
80–84	.....	−3.9	−10.3	.....	−10.0	−14.8
85–89	.....	−5.3	− 7.8	.....	− 9.3	−13.3
90–94	.....	−7.9	− 8.1	.....	− 9.3	− 9.2
	1960/65–1965/70	1965/70–1970/75	1970/75–1975/79	1960/65–1965/70	1965/70–1970/75	1970/75–1975/79
Insured lives ultimate experience:						
65–69	−4.0%	−9.6%	− 9.2%	−17.3%	− 9.4%	− 0
70–74	−4.5	−7.1	− 8.9	−10.4	−10.0	−14.2
75–79	−2.8	−4.8	−10.6	0	−13.1	−11.5
80–84	−3.6	−5.2	− 7.3	− 5.2	− 6.5	−13.0
85–89	−2.2	−3.4	− 7.1	− 7.4	− 4.7	−14.1
90–94	−8.8	−4.2	− 2.7	−12.0	−14.8	

selves manifest in the total population under study until the 1970s, in part because the experience in the total population masks somewhat the different patterns of mortality among the ostensibly healthy subjects and among those not in good health.

Table 7 shows that the attained-age death rates among the ostensibly healthy subjects were significantly lower in the first five years following enrollment than in the later 1960s or in the 1970s. It is clear that in the case of the ostensibly healthy subjects more intensive selection was effective in lowering death rates to levels considerably below those experienced by the subjects in impaired health. The lower death rates among the ostensibly healthy subjects in the years immediately following enrollment reflect the exclusion of the seriously ill at time of enrollment and the further selection involved in setting up the ostensibly healthy classification. The subsequent increases in their death rates with duration, arising from the waning of the effects of physical selection, were not offset by the underlying mortality downtrends until the later 1970s among males and until the early 1970s among females in most age groups.

Table 8 shows that the attained-age death rates among subjects in impaired health were at about the same level in the first five years following enrollment as in the next five years, but decreased thereafter. Mortality investigations of persons in impaired health have repeatedly shown that the highest relative mortality among them usually occurs in the early years. The findings in this paper are in line with this observation. The underlying mortality downtrends were not fully felt among the subjects in impaired health until the early 1970s.

EXPERIENCE BY AGE AT ENTRY

The levels of mortality observed in this study by age at entry and duration reflect the effects of one or more selection procedures and of continuing downtrends in underlying death rates.

The experience among the ostensibly healthy subjects exhibits the effects of initial selection for inclusion in the study and of further selection that excluded persons who indicated on the questionnaire that they were ill at time of enrollment, had a history of serious illness such as heart disease, stroke, or cancer, or were markedly overweight.

Tables 10, 11, and 12 present the experience in this paper, analyzed by age at entry and duration, for the total population, ostensibly healthy persons, and those in impaired health, respectively.

While the subjects in this study were actually enrolled beginning in the fall of 1959, the experience was traced only from July 1, 1960. Accordingly, part of the first nine months of experience after enrollment were in effect

omitted, and the first classification by duration shown in the tables as durations 1–5 actually covers, on the average, the experience from four to five months after enrollment to five years and four to five months after enrollment. Durations 6–10 begin, on the average, at five years, four or five months after enrollment, and so on.

Note that the death rates for durations 11–15 and 16–19 are affected by the underlying downtrends in mortality to a much greater degree than those for durations 1–5 and 6–10.

TABLE 10

MORTALITY BY AGE AT ENTRY AND DURATION
TOTAL POPULATION IN STUDY

Ages at Entry	Durations 1–5 1960–65	Durations 6–10 1965–70	Durations 11–15 1970–75	Durations 16–19 1975–79
Males:				
65–69	.0395	.0624	.0822	.....
70–74	.0598	.0960	.1462	.....
75–79	.0859	.1439	.2029	.3074
80–84	.1391	.2210	.3029	.....
85–89	.1985	.3015	.4767	.....
90–94	.3478	.4375	.....	.....
Females:				
65–69	.0189	.0323	.0469	.....
70–74	.0332	.0576	.0903	.....
75–79	.0590	.1045	.1722	.2494
80–84	.1023	.1779	.2593	.3757
85–89	.1595	.2619	.3569	.4691
90–94	.2511	.3715	.5313	.....

TABLE 11

MORTALITY BY AGE AT ENTRY AND DURATION
OSTENSIBLY HEALTHY PERSONS

AGES AT ENTRY	DURATIONS 1–5 1960–65		DURATIONS 6–10 1965–70		DURATIONS 11–15 1970–75		DURATIONS 16–19 1975–79	
	Death Rate	Ratio*	Death Rate	Ratio*	Death Rate	Ratio*	Death Rate	Ratio*
Males:								
65–69	.0263	67%	.0490	79%	.0702	85%	.....	.....
70–74	.0397	66	.0768	80	.1332	91	.....	.....
75–79	.0597	69	.1210	84	.1992	98	.2796	91%
80–84	.1021	73	.1977	89	.2739	90	.3750	.....
85–89	.1558	78	.2537	84	.4861	102	.....	.....
Females:								
65–69	.0113	60	.0221	68	.0450	96	.....	.....
70–74	.0194	58	.0420	73	.0772	85	.....	.....
75–79	.0396	61	.0800	77	.1473	86	.2226	89
80–84	.0637	62	.1492	84	.2269	88	.3682	103
85–89	.1175	74	.2083	80	.3873	109	.5294	.....

* Ratio to total population death rate.

TABLE 12

MORTALITY BY AGE AT ENTRY AND DURATION
PERSONS NOT IN GOOD HEALTH

AGES AT ENTRY	DURATIONS 1–5 1960–1965		DURATIONS 6–10 1965–1970		DURATIONS 11–15 1970–1975		DURATIONS 16–19 1975–1979	
	Death Rate	Ratio*	Death Rate	Ratio*	Death Rate	Ratio*	Death Rate	Ratio*
Males:								
65–69	.0524	133%	.0773	124%	.0970	118%	.....	.....
70–74	.0770	129	.1159	121	.1618	111	.....	.....
75–79	.1067	124	.1657	115	.2272	112	.3472	113%
80–84	.1626	117	.2331	105	.3302	109	.....	.....
85–89	.2160	109	.3299	109	.4700	99	.....	.....
Females:								
65–69	.0232	123	.0383	119	.0540	115	.....	.....
70–74	.0397	120	.0658	114	.0997	108	.....	.....
75–79	.0662	112	.1152	110	.1851	107	.....	.....
80–84	.1141	112	.1892	106	.2749	106	.3789	101
85–89	.1717	108	.2826	109	.3410	96	.....	.....

* Ratio to total population death rate.

Table 10 indicates the death rates by age at entry and duration for the total population in the study.

Table 11 shows the death rates by age at entry and duration for ostensibly healthy persons in the study. The death rates for durations 1–5 among these subjects ranged from 66 to 78 percent of the corresponding death rates in the total male population and from 58 to 74 percent in the total female population, with the highest figures applying to ages 85–89 at entry and the lowest figures applying to ages 70–74 at entry. For durations 6–10 the corresponding figures increased to 75–89 percent in the case of males and to 68–84 percent in the case of females. For durations 11–15 the corresponding figures rose further to 85–102 percent in the case of males, and to 85–109 percent in the case of females.

A comparison between the death rates among ostensibly healthy persons aged 65–69 at entry in this study with the corresponding death rates in the Select Basic Table 1965–70 indicates they experienced about 50 percent higher mortality at durations 1–5 and 6–10 but a similar progression of death rates with duration.

Table 12 shows the death rates by age at entry and duration for persons not in good health in this study. The death rates for durations 1–5 among them range (with increasing age) from 133 to 109 percent of the corresponding death rates in the total male population and from 123 to 108 percent in the total female population, with the highest figures applying

to ages 65–69 at entry and the lowest figures applying to ages 85–89 at entry. For durations 6–10 the differentials decreased to 124–109 percent in the case of males and to 119–109 percent in the case of females. For durations 11–15 the corresponding figures dropped further to 118–99 percent in the case of males and to 115–96 percent in the case of females.

The subjects in impaired health aged 65–69 at entry in this study experienced more than double the mortality rates in the Select Basic Table 1965–70 at durations 1–5 and 6–10.

FACTORS IN THE SELECTION PROCESS

In the early 1800s it was already understood that the mortality of insured lives was lower than that of the general population because the former had to pass a medical examination and other standards of insurability. J. A. Higham and W. Sprague studied the mortality of insured lives by age at entry and duration, and Sprague called attention to the offsetting effects of antiselection by life insurance applicants and to the possible effects of antiselection on withdrawals. At about the same time, John Finlaison demonstrated the distinctly lower mortality among annuitants, particularly female annuitants, as exemplifying the effects of class selection.

Actuaries have focused attention primarily on temporary initial selection produced by physical screening, the effects of which are well illustrated in the experience among standard ordinary insurance risks. They have become increasingly concerned with the effects of class selection, which reflects the disparate mortality levels associated with different socioeconomic levels and different modes of living. However, the information available on the effects of selection among insured lives has been limited largely to ages under 70. The experience in this study sheds some new light on the effects of both physical screening and class selection at ages 65 and over. However, because of the sharp declines in mortality at these ages since the mid 1960s, it has been difficult to measure temporary initial selection accurately. The effects of the initial physical screening normally wear off with the passage of time, but the resulting rise in mortality with duration has during the past fifteen years been largely offset by the underlying downtrends in death rates.

The experience in this study indicates that the criteria established for enrollment in the American Cancer Society's study produced mortality in the total male population that closely resembles that on standard ordinary insurance after it has been in force 16 years or longer. This finding reflects not only the middle-class origins of the subjects in the study but also the exclusion at time of enrollment of (1) the seriously ill at time of

enrollment, (2) those otherwise unable to complete questionnaires, (3) individuals in medical and other custodial institutions, (4) itinerant individuals, and (5) most persons at the lowest socioeconomic levels. These exclusions involve both class selection and partial filtering out of the seriously ill and those unable to function.

If not excluded by the above criteria, individuals with serious physical impairments and serious medical histories were enrolled in the study.

The data indicate that a much higher proportion of the subjects enrolled in the study were native born, attended college, and were married than is the case in the general population, and more, especially women, continued working beyond age 65. The enrolled women appear to have been a more select group in other respects, even as compared with women insured under standard ordinary policies. This is confirmed by their having experienced lower mortality than that of women insured under standard ordinary policies.

It is not surprising that more intensive selection, intended to eliminate those in definitely poor health at time of enrollment, those with a personal history of heart disease, stroke, or cancer, and the markedly overweight, produced a classification, here designated as ostensibly healthy, which exhibits death rates at entry ages under 75 similar to those on a select and ultimate basis among standard ordinary insurance policyholders.

From a practical point of view it is highly significant that even the partial filtering out of the seriously ill and those unable to function sufficed to lower the mortality of the total population to about the level of ultimate death rates among insured lives.

COMPARISONS WITH OTHER EXPERIENCE

Table 13 presents a comparison of the graduated death rates by attained age in this study with the corresponding ultimate experience among standard ordinary insured lives and with the experience among medicare recipients for approximately similar periods of time. The ultimate experience among standard ordinary insured risks had been compiled from the figures published in the *Reports* issues of the *Transactions of the Society of Actuaries*. The experience among medicare recipients has been derived from the paper "Recent Trends in the Mortality of the Aged" by John C. Wilkin [19]. The mortality experienced in this study and the medicare experience were both graduated by the same formula.

The comparison with the ultimate mortality among insured lives shows that the total male population in this study exhibited death rates almost identical with the death rates in the ultimate experience among standard ordinary male policyholders over the entire period 1960–74. The total

TABLE 13

COMPARISON OF DEATH RATES IN CURRENT STUDY WITH INSURED LIVES AND MEDICARE RECIPIENTS

ATTAINED AGES	CURRENT STUDY				INSURED LIVES							
					1960–65		1965–70		1970–75		1960–75	
	1960–1965	1965–1970	1970–1975	1960–1975	Death Rate	Ratio	Death Rate	Ratio	Death Rate	Ratio	Death Rate	Ratio
Males:												
65–69	.0299	.0298	.0289	.0304	.0326	109%	.0313	105%	.0283	98%	.0307	101%
70–74	.0457	.0469	.0441	.0467	.0490	107	.0468	100	.0435	99	.0464	97
75–79	.0653	.0701	.0690	.0693	.0744	114	.0723	103	.0688	100	.0768	104
80–84	.0987	.1051	.1024	.1031	.1133	115	.1092	104	.1035	101	.1087	105
85–89	.1550	.1605	.1595	.1592	.1639	106	.1603	100	.1548	97	.1597	100
90–94	.2286	.2302	.2099	.2199	.2379	104	.2170	94	.2078	99	.2209	100
Females:												
65–69	.0132	.0131	.0124	.0134	.0180	136	.0149	114	.0135	109	.0155	116
70–74	.0226	.0216	.0201	.0223	.0289	128	.0259	120	.0233	116	.0260	117
75–79	.0406	.0389	.0384	.0401	.0483	119	.0481	124	.0418	109	.0461	115
80–84	.0701	.0709	.0646	.0699	.0815	116	.0773	109	.0723	112	.0770	110
85–89	.1151	.1202	.1233	.1202	.1338	116	.1239	103	.1181	96	.1253	104
90–94	.1862	.1934	.1802	.1822	.2184	117	.1921	99	.1636	91	.1914	104

TABLE 13—*Continued*

Attained Ages	Current Study			Medicare					
	1965–1970	1970–1975	1965–1975	1968–70		1971–75		1968–75	
				Death Rate	Ratio*	Death Rate	Ratio*	Death Rate	Ratio*
Males:									
65–69	.0298	.0289	.0294	.0388	130%	.0370	128%	.0377	128%
70–74	.0469	.0441	.0456	.0567	121	.0539	122	.0548	121
75–79	.0701	.0690	.0696	.0821	117	.0789	114	.0801	115
80–84	.1051	.1024	.1038	.1218	116	.1166	114	.1185	114
85–89	.1605	.1595	.1600	.1740	103	.1679	105	.1710	107
90–94	.2302	.2099	.2160	.2446	106	.2345	111	.2384	110
Females:									
65–69	.0131	.0124	.0128	.0184	140	.0173	140	.0178	140
70–74	.0216	.0201	.0209	.0297	138	.0272	135	.0283	135
75–79	.0389	.0384	.0387	.0496	128	.0458	119	.0470	121
80–84	.0709	.0646	.0679	.0837	118	.0765	118	.0816	118
85–89	.1202	.1233	.1216	.1395	116	.1302	106	.1340	110
90–94	.1934	.1802	.1872	.2060	107	.1919	106	.1971	105

* Ratio to most nearly corresponding death rates current study.

female population in this study experienced death rates somewhat lower than the death rates in the ultimate experience among standard ordinary female policyholders over the entire period—about 15 percent lower at attained ages under 80 but only about 4 percent lower at attained age 90.

In the early 1960s the population under study was still in the early years following initial selection. The male death rates were somewhat lower than the corresponding ultimate death rates among standard ordinary insured male lives, while the female death rates were very much lower than the corresponding ultimate rates among insured lives.

In the later 1960s the male death rates in this study were only slightly lower than the corresponding ultimate death rates among insured lives, but the female death rates in this study continued appreciably lower. In the early 1970s the male death rates in this study were virtually identical with the corresponding ultimate mortality among insured lives, but the female death rates in this study remained at a lower level.

Comparison with medicare recipients shows that the subjects in this study experienced distinctly lower mortality than medicare recipients. The differentials were greater for women than for men. Over the entire period 1968–75, the excess mortality among male medicare recipients varied from 28 percent at attained age 65 to 7 percent at attained age 85, while the differentials among female medicare recipients ranged from 40 percent at attained age 65 to 10 percent at attained age 85.

The excess mortality in the general population as compared with the population in this study was even greater than for medicare recipients.

Table 14 presents the graduated death rates in this study at ages 95 and over compared with corresponding death rates among medicare recipients and those in the general population, as developed by Francisco Bayo and Joseph F. Faber in their paper "Mortality Experience around Age 100" [2]. For males the graduated death rates in this study at ages 95 and older rise from 93 percent of the rates among medicare recipients at age 95 to about the level of mortality among medicare recipients at ages 101. For females the graduated death rates remain at about 90 percent of those among medicare recipients throughout this age range. At ages 95 through 100 the graduated death rates are distinctly under .4. At ages over 100 the numbers of deaths at individual ages fall below 30.

MORTALITY BY CAUSE OF DEATH

The experience in this study by cause of death is detailed in Tables 15, 16, and 17 for the total population, the ostensibly healthy lives, and those not in good health, respectively. The experience is given by sex and attained-age groups for the major causes of death.

The causes of death in this study were taken from official death certificates. The accuracy of the causes of death given on death certificates has been questioned on the ground that aging is accompanied by progressive declines in physiological functions, so that injuries or disorders which would not threaten life at younger ages can result in death when physiological functions are at a very low level. In other words, it is suspected that the underlying causes of death are not infrequently missed at the advanced ages. This should be recognized in interpreting death rates by cause at ages 85 and over.

All forms of heart disease accounted for 46–48 percent of all male deaths in the total population and ranged from 41 to 50 percent of all female deaths. At attained ages 65–74 the proportion of deaths due to all forms of heart disease was 48 percent in the case of males and 41 percent in the case of females. These figures are similar to the proportions of deaths due to all forms of heart disease among insured lives.

Among the ostensibly healthy lives in this study, all forms of heart disease accounted for 46–53 percent of all male deaths, the proportion rising with advancing age. The corresponding figures for females ranged from 35 to 50 percent.

TABLE 14

COMPARISONS AT AGES 95 AND OVER

AGE	MEDICARE RECIPIENTS		U.S. VITAL STATISTICS		CURRENT STUDY	
	Death Rate	Deaths	Death Rate	Deaths	Death Rate	Deaths
Males:						
95	.292	4,350	.288	6,098	.271	266
96	.304	3,790	.299	4,598	.285	196
97	.316	2,690	.308	3,237	.300	153
98	.328	1,890	.315	2,395	.314	85
99	.339	1,360	.321	1,704	.328	49
100	.349	915	.323	1,070	.342	30
101	.356	610	.323	743	.356	25
102	.363	380	.321	495	.376	12
103	.367	235	.315	319	.....	.....
104	.374	170	.308	219	.....	.....
Females:						
95	.259	4,540	.257	12,682	.233	677
96	.274	4,025	.270	9,765	.244	498
97	.289	3,100	.282	7,477	.264	356
98	.305	2,340	.293	5,747	.279	216
99	.321	1,710	.304	3,986	.293	148
100	.338	1,200	.314	2,992	.306	99
101	.354	820	.323	2,054	.318	83
102	.372	565	.333	1,404	.329	36
103	.389	400	.342	1,059	.339	18
104	.408	370	.350	721	.348	24

TABLE 15

MORTALITY BY CAUSE OF DEATH TOTAL POPULATION

AGE GROUPS	MALES							FEMALES						
	Current Study			U.S. 1968		Insured Lives		Current Study			U.S. 1968		Insured Lives	
	Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Rate	% Total Deaths
All causes:														
65–74	34,587	36.8	.....	50.3	.....	40.3	.....	20,356	17.0	.....	36.2	.....	25.6	.....
75–84	23,548	79.7	.....	100.0	.....	86.2	.....	22,250	50.0	.....	68.9	.....	68.8	.....
85–94	10,466	175.9	.....	.....	.....	.....	.....	14,463	141.0	.....	200.1	.....	.....	.....
95 and over	829	292.3	.....	.....	.....	.....	.....	2,155	262.3	.....	.....	.....	.....	.....
Heart disease:														
65–74	16,681	17.7	48	22.9	46	18.8	47	8,385	7.0	41	11.2	43	10.7	42
75–84	10,898	36.9	46	46.0	46	39.6	.....	10,237	23.0	46	32.3	47	32.2	47
85–94	4,856	81.6	46	100.5	.....	.....	.....	7,080	69.0	49	96.5	48	.....	.....
95 and over	399	140.7	48	.....	.....	.....	.....	1,075	130.8	50	.....	.....	.....	.....
Coronary heart disease:														
65–74	14,101	14.9	41	21.4	43	17.4	43	6,432	5.4	32	.....	.....	.....	.....
75–84	8,920	30.2	38	43.0	43	36.6	42	7,571	17.0	34	.....	.....	.....	.....
85–94	3,727	62.6	35	92.5	.....	.....	.....	4,979	48.5	34	.....	.....	.....	.....
95 and over	291	102.6	35	.....	.....	.....	.....	728	88.6	34	.....	.....	.....	.....

TABLE 15—*Continued*

Age Groups	Males							Females						
	Current Study			U.S. 1968		Insured Lives		Current Study			U.S. 1968		Insured Lives	
	Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Deaths	Rate	% Total Deaths	Rate	% Total Deaths	Rate	% Total Deaths
Cerebro-vascular lesions:														
65–74	3,219	3.4	9	4.5	9	3.2	8	2,452	2.1	12	.....	.....	.....	.....
75–84	3,531	12.0	15	13.8	14	11.3	13	4,115	9.3	18	.....	.....	.....	.....
85–94	1,916	32.2	18	35.6	.....	.....	.....	3,153	30.7	22	.....	.....	.....	.....
95 and over	154	54.3	19	.....	.....	.....	.....	434	52.8	20	.....	.....	.....	.....
Cancer (all forms):														
65–74	7,192	7.6	21	.....	.....	.....	.....	5,602	4.7	28	.....	.....	.....	.....
75–84	3,840	13.0	16	.....	.....	.....	.....	3,435	7.7	15	.....	.....	.....	.....
85–94	1,192	19.0	11	.....	.....	.....	.....	1,120	10.9	8	.....	.....	.....	.....
95 and over	50	17.6	6	.....	.....	.....	.....	87	10.6	4	.....	.....	.....	.....
Accidents:														
65–74	726	0.8	2	.....	.....	.....	.....	478	0.4	2	.....	.....	.....	.....
75–84	419	1.4	2	.....	.....	.....	.....	483	1.1	2	.....	.....	.....	.....
85–94	227	3.8	2	.....	.....	.....	.....	358	3.5	2	.....	.....	.....	.....
95 and over	24	8.5	3	.....	.....	.....	.....	37	4.5	2	.....	.....	.....	.....
Influenza and pneumonia:														
65–74	530	0.6	2	.....	.....	.....	.....	226	0.2	1	.....	.....	.....	.....
75–84	579	2.0	3	.....	.....	.....	.....	537	1.2	2	.....	.....	.....	.....
85–94	447	7.5	4	.....	.....	.....	.....	527	5.1	4	.....	.....	.....	.....
95 and over	44	15.5	5	.....	.....	.....	.....	110	13.4	5	.....	.....	.....	.....

Among those in impaired health in this study, all forms of heart disease accounted for 45–50 percent of all male deaths, the proportion falling with advancing age. The corresponding figures for females ranged from 44 to 50 percent, again rising with advancing age. It appears that among males in impaired health all forms of heart disease were a particularly important cause of death at attained ages 65–84.

TABLE 16

MORTALITY BY CAUSE OF DEATH: OSTENSIBLY HEALTHY LIVES

AGE GROUPS	MALES				FEMALES			
	Deaths	Death Rate per 1,000	% Total Deaths	Difference in Deaths per 1,000*	Deaths	Death Rate per 1,000	% Total Deaths	Difference in Deaths per 1,000*
All causes:								
65–74	14,042	27.2	100%	− 9.4	5,484	11.4	100%	− 5.6
75–84	9,267	62.9	100	−16.8	5,281	35.3	100	−14.7
85–94	4,564	159.6	100	−16.3	3,343	116.2	100	−24.8
95 and over	311	272.6	100	−19.7	567	237.5	100	−24.8
Heart disease:								
65–74	6,411	12.4	46	− 5.3	1,932	4.0	35	− 3.0
75–84	4,107	27.9	44	− 9.0	2,237	18.6	53	− 4.4
85–94	2,100	73.5	46	− 7.9	1,656	54.3	47	−14.7
95 and over	166	145.4	53	+ 4.7	281	117.7	50	−13.1
Coronary heart disease:								
65–74	5,573	10.8	40	− 4.1	1,555	3.2	28	− 2.2
75–84	3,393	23.0	37	− 7.2	1,686	11.3	32	− 5.7
85–94	1,609	56.3	35	− 6.3	1,170	38.4	33	−10.1
95 and over	123	107.8	40	+ 5.2	190	79.6	34	− 9.0
Cerebro-vascular lesions:								
65–74	1,168	2.3	8	− 1.1	601	1.3	11	− .8
75–84	1,294	8.8	14	− 3.2	904	5.9	17	− 3.4
85–94	855	29.9	19	− 2.3	771	25.3	9	− 5.4
95 and over	50	43.8	16	−10.5	123	51.5	8	− 1.3
Cancer (all forms):								
65–74	3,470	6.7	25	− .9	1,886	3.9	34	− .8
75–84	1,832	12.4	20	− .6	1,086	7.3	21	− .1
85–94	542	19.0	12	0	325	10.7	9	− .2
95 and over	26	22.8	8	+ 5.2	23	9.6	4	− 1.0
Accidents:								
65–74	373	.7	2	− .1	179	.4	4	0
75–84	208	1.4	2	0	148	1.0	3	− .1
85–94	100	3.5	2	− .3	72	2.3	2	− 1.2
95 and over	4	.....	.....	.....	.....	8	.....	.....
Influenza and pneumonia:								
65–74	200	.4	1	− .2	58	.1	1	− .1
75–84	198	1.3	2	− .7	133	.9	3	− .3
85–94	175	6.1	4	− 1.4	130	4.2	4	− .9
95 and over	9	8.0	3	.....	29	12.1	5	.....

* As compared with total population death rates per 1,000.

The importance of all forms of heart disease as a cause of excess mortality is brought out by the fact that the extra mortality from this group of diseases was, at attained ages under 95, responsible for more than half the mortality differential between the total population and the ostensibly healthy, and also for more than half the mortality differential between

TABLE 17

MORTALITY BY CAUSE OF DEATH: PERSONS NOT IN GOOD HEALTH

AGE GROUPS	MALES				FEMALES			
	Deaths	Death Rate per 1,000	% Total Deaths	Excess Deaths per 1,000*	Deaths	Death Rate per 1,000	% Total Deaths	Excess Deaths per 1,000*
All causes:								
65–74	20,545	48.4	100%	+11.6	14,872	20.9	100%	+ 3.9
75–84	14,281	96.4	100	+16.7	16,969	57.5	100	+ 7.5
85–94	5,902	191.0	100	+15.1	10,920	151.3	100	+10.3
95 and over	518	305.6	100	+13.3	1,588	272.4	100	+10.1
Heart disease:								
65–74	10,270	24.2	50	+ 6.5	6,453	9.1	44	+ 2.1
75–84	6,791	45.9	48	+ 9.0	8,000	27.1	47	+ 4.1
85–94	2,756	89.1	47	+ 7.5	5,424	75.1	50	+ 6.1
95 and over	233	137.5	45	− 3.2	794	136.2	50	+ 5.4
Coronary heart disease:								
65–74	8,728	20.6	43	+ 5.7	4,877	6.8	33	+ 1.4
75–84	5,527	37.3	39	+ 7.1	5,885	19.9	35	+ 2.9
85–94	2,116	68.4	36	+ 5.8	3,809	52.8	35	+ 4.3
95 and over	168	99.1	32	− 3.5	538	92.3	34	+ 3.7
Cerebro-vascular lesions:								
65–74	2,051	4.8	10	+ 1.4	1,851	2.6	12	+ 0.5
75–84	2,237	15.1	16	+ 3.1	3,211	10.9	19	+ 1.6
85–94	1,061	34.3	18	+ 2.1	2,382	33.0	22	+ 2.3
95 and over	104	61.4	20	+ 7.1	311	53.4	26	+ 0.6
Cancer (all forms):								
65–74	3,722	8.8	18	+ 1.2	3,716	5.2	24	+ 0.5
75–84	2,008	13.6	14	+ 0.6	2,349	8.0	14	+ 0.3
85–94	587	19.0	10	0	795	11.0	7	+ 0.1
95 and over	24	14.2	5	+ 3.4	64	11.0	4	+ 0.4
Accidents:								
65–74	353	.8	2	0	299	.4	2	+ 0.5
75–84	211	1.4	1	0	335	1.1	2	+ 0.3
85–94	127	4.1	2	+ 0.3	286	4.0	3	+ 0.1
95 and over	20	11.8	4	.....	29	5.0	2	.....
Influenza and pneumonia:								
65–74	330	.8	2	+ 0.2	168	.2	1	0
75–84	381	2.6	3	+ 0.6	404	1.4	3	+ 0.2
85–94	272	8.8	5	+ 1.3	307	5.5	4	+ 0.4
95 and over	35	20.4	7	+ 4.9	81	13.9	5	+ 0.5

* As compared with total population death rates per 1,000.

those in impaired health and the total population. The death rates from all forms of heart disease among the ostensibly healthy males at attained ages 75–94 varied from 70 to 90 percent of those in the total population; the corresponding figures for females at attained ages 85–94 ranged from 55 percent to 80 percent.

Among males in the total population in this study, coronary heart disease accounted for 41 percent of all deaths at attained ages 65–74 decreasing to 35 percent at attained ages 85 and older. Among females in the total population coronary heart disease accounted for about a third of all deaths. Among ostensibly healthy persons at attained ages under 75, coronary heart disease took a somewhat lesser toll than in the total population. Among persons in impaired health, coronary heart disease took a somewhat greater toll than in the total population.

The proportion of deaths due to cerebrovascular lesions increased with advance in age among males and was lower among ostensibly healthy lives than among persons in impaired health. Further, it decreased with advancing age among ostensibly healthy females, but rose sharply with advancing age among females in impaired health.

The death rates from all forms of cancer were generally only slightly lower among ostensibly healthy subjects than in the total population and the death rates from this cause among subjects not in good health were only slightly higher than those in the total population. In other words, physical screening had little effect on cancer death rates.

All forms of cancer together accounted for 21 to 6 percent of all male deaths in the total population, the proportion decreasing with advancing age from 21 percent at attained ages 65–74 to 6 percent at attained ages 95 and over. In the case of females the proportion decreased from 28 percent at attained ages 65–74 to 4 percent at attained ages 95 and over. These figures are similar to the proportions of deaths from all forms of cancer among insured lives.

The proportions of deaths due to cancer are appreciably higher among the ostensibly healthy persons, ranging from 25 percent to 8 percent in males and from 34 percent to 4 percent in females, the proportions decreasing with advancing age. The corresponding proportions of deaths due to cancer were distinctly lower among those in impaired health, ranging from 18 percent to 5 percent in males and from 24 percent to 4 percent in females. It is clear that the proportion of deaths from cancer is relatively greatest among ostensibly healthy persons, even though the actual death rates from cancer among ostensibly healthy lives are lower than in the total population.

Death rates from influenza and pneumonia at attained ages under 95

were only somewhat lower among the ostensibly healthy subjects than in the total population, and the death rates from this cause among subjects not in good health were only somewhat higher than in the total population at these ages. Influenza and pneumonia were proportionally higher as causes of death among men in impaired health as compared with men in ostensibly good health.

Mortality from accidents was slightly lower among the ostensibly healthy subjects than in the total population, and was the same or slightly higher among the subjects not in good health than in the total population under study.

MORTALITY ACCORDING TO SPECIAL CHARACTERISTICS

Mortality at the older ages is known to be significantly affected by various demographic and social characteristics and personal habits as well as by family history of longevity. Tables 18, 19, and 20 analyze the total experience in this study by sex by attained-age groups according to a number of special characteristics.

Table 18 focuses on race, nativity, and marital status. When white mortality is taken as the standard, black males in this study experienced only 8 percent higher death rates at attained ages 65–74, only 5 percent higher death rates at attained ages 75–84, and registered somewhat lower mortality at ages 85 and over. Black middle-class males exhibited little excess mortality compared with middle-class white males. Black females in this study experienced nearly 50 percent higher death rates at attained ages 65–74 but only 6 percent higher death rates at ages 75–84 compared with middle-class white females, and somewhat lower mortality at ages 85 and over. As previously noted, the middle-class white females in this study were a highly selected group.

Middle-class persons of other races recorded some extra mortality as compared to whites.

When mortality among the native-born is taken as the standard, foreign-born middle-class males showed slightly lower death rates than native-born middle-class males at ages under 85, but foreign-born middle-class women registered somewhat higher death rates than native-born women.

Taking death rates among the married as the standard, single men at attained ages 65–84 experienced about 20 percent higher death rates, but single women at these ages showed only about 10 percent higher mortality; single men and women aged 85 or over recorded slightly higher mortality than the married. The extra mortality among widowers ranged from about 33 percent at attained ages 65–74 to 20 percent at ages 75–84 and 15 percent at ages 85 and over. Widows experienced about 20 percent higher

mortality than married women at attained ages 75–84 but only 13 percent higher mortality at ages 85 and over. Divorced men registered over 40 percent higher mortality at attained ages 65–74 and nearly 25 percent higher death rates at ages 75–84. Divorced women experienced nearly 70 percent greater mortality at attained ages 65–74 but only about 15 percent higher death rates at ages 75–84.

TABLE 18

MORTALITY BY RACE, NATIVITY AND MARITAL STATUS

AGE GROUPS	MALES			FEMALES		
	Deaths	Death Rate per 1,000	Ratio	Deaths	Death Rate per 1,000	Ratio
Race:						
White:						
65–74	33,983	38.5	100%	19,687	17.9	100
75–84	23,736	84.2	100	22,146	52.8	100
85 and over	10,589	182.0	100	15,769	153.2	100
Black:						
65–74	635	41.6	108	578	26.1	146
75–84	528	88.1	105	490	56.1	106
85 and over	261	166.8	92	321	142.8	93
Other:						
65–74	376	40.6	105	365	20.2	113
75–84	314	91.4	109	521	57.5	109
85 and over	148	186.0	105	437	154.2	108
Nativity:						
Native-born:						
65–74	31,000	38.7	100	18,067	17.7	100
75–84	20,849	84.4	100	19,671	52.0	100
85 and over	8,894	182.1	100	13,677	152.0	100
Foreign-born:						
65–74	2,251	35.7	92	1,159	19.5	110
75–84	2,260	81.8	97	1,900	60.1	116
85 and over	1,384	180.0	100	1,655	158.0	104
Marital status:						
Married:						
65–74	33,222	38.2	100	13,358	17.1	100
75–84	21,698	82.7	100	9,073	47.8	100
85 and over	8,111	176.7	100	2,964	140.0	100
Single:						
65–74	497	45.3	119	1,389	18.9	111
75–84	445	101.8	123	1,778	52.0	109
85 and over	211	196.5	111	1,197	148.5	106
Widowed:						
65–74	723	50.7	133	4,846	20.4	119
75–84	1,973	99.6	120	10,915	57.9	121
85 and over	2,439	201.7	114	11,241	158.0	113
Divorced or separated:						
65–74	233	54.1	142	671	28.7	168
75–84	170	102.0	123	569	54.4	114
85 and over	81	.....	100	240	142.4	102

Table 19 focuses on smoking and drinking habits. Taking death rates among nonsmokers as the standard, current male smokers show about 75 percent extra mortality at attained ages 65–74, nearly 50 percent extra mortality at ages 75–84, and some 29 percent higher death rates at ages 85 and over. Current women smokers recorded somewhat lesser extra mortality.

Taking light and moderate drinkers as the standard, male heavy whiskey drinkers registered from 40 to 50 percent extra mortality at attained ages 65–74, about 30 percent at ages 75–84, and 10–15 percent at ages 85 and over. There were relatively few women heavy whiskey drinkers, and the excess mortality among them was approximately the same as among corresponding men.

Table 20 presents an analysis of the mortality experience according to educational attainment and according to family history of longevity.

If the mortality among grammar-school graduates is taken as the stan-

TABLE 19

MORTALITY BY SMOKING AND DRINKING HABITS

AGE GROUPS	MALES			FEMALES		
	Deaths	Death Rate per 1,000	Ratio	Deaths	Death Rate per 1,000	Ratio
Smoking habits:						
NSR† or long-time ex-smoker:						
65–74	8,845	29.4	100%	15,751	17.0	100%
75–84	8,947	74.9	100	20,266	51.8	100
85 and over	5,138	174.5	100	15,417	152.7	100
Current or recent smoker:						
65–74	11,664	52.1	177	1,763	28.2	166
75–85	3,865	109.1	146	589	66.9	129
85 and over	637	200.4	114	125	156.0	102
Other smoking:						
65–74	14,485	37.8	129	3,116	20.4	120
75–84	11,766	86.1	115	2,302	60.9	118
85 and over	5,223	186.0	106	985	155.6	102
Drinking habits:						
Whiskey 6 or more drinks a day:						
65–74	344	57.5	151	32	23.4	129
75–84	148	111.8	133	18	53.3	101
85 and over	40	204.1	115	10	169.0	118
Whiskey 4–5 drinks a day:						
65–74	815	53.0	139	95	29.1	161
75–84	337	106.2	127	46	75.0	142
85 and over	81	195.7	110	17	127.8	89
Whiskey less than 4 drinks a day:						
65–74	33,740	38.1	100	20,878	18.1	100
75–84	23,932	83.8	100	23,610	52.8	100
85 and over	10,683	177.2	100	16,704	143.7	100

†NSR — never smoked regularly

dard, male high-school graduates experienced about 10 percent lower mortality at attained ages 65–84, while men with some college education experienced 10–20 percent lower mortality. The differentials according to educational attainment among women were somewhat greater.

In the analysis according to family history of longevity, a good history was defined as having one or both parents dead after age 80 or still living and over age 70, an average history was defined as having both parents dead before age 80 but at least one surviving to age 70, and a poor family history was defined as having both parents dead before age 70. There was little difference in mortality between men with an average and a poor family history. Such histories in men were associated with about 25 percent excess mortality at attained ages 65–74 and 15 percent excess mortality at ages 75–84. The penalties of a poor family history were somewhat greater in women—about 40 percent excess mortality at attained ages 65–74 and about 30 percent excess mortality at ages 75–84. At ages 85 and over, family history had little effect on the mortality experienced.

TABLE 20

MORTALITY BY SCHOOLING AND FAMILY HISTORY OF LONGEVITY

AGE GROUPS	MALES			FEMALES		
	Deaths	Death Rates per 1,000	Ratio	Deaths	Death Rates per 1,000	Ratio
Schooling:						
Grammar school or less:						
65–74	20,157	40.6	100%	10,949	19.7	100%
75–84	15,890	87.6	100	14,335	56.3	100
85 and over	7,246	184.7	100	10,845	157.2	100
High school:						
65–74	3,933	38.3	94	3,315	17.3	88
75–84	1,876	80.8	92	2,880	51.5	91
85 and over	699	179.2	97	1,885	148.4	94
Some college or graduate:						
65–74	10,372	35.0	86	6,009	15.9	81
75–84	6,147	77.6	89	5,248	45.3	80
85 and over	2,609	188.5	102	3,242	143.0	91
Family history of longevity:						
Good:						
65–74	14,846	34.4	100	8,080	15.4	100
75–84	10,183	77.1	100	8,564	46.0	100
85 and over	4,832	176.9	100	6,767	146.8	100
Average:						
65–74	8,845	42.1	122	5,219	19.5	127
75–84	5,896	88.8	115	5,674	55.7	121
85 and over	2,299	187.4	106	3,660	157.6	107
Poor:						
65–74	4,738	43.6	127	3,055	21.3	138
75–84	3,030	89.8	116	3,257	60.7	132
85 and over	1,208	186.4	105	1,932	154.8	105

SOME CONCLUSIONS

The more important findings of this study are the following.

1. A population selected from the middle class by criteria customarily used in epidemiologic investigations conducted through the medium of questionnaires is likely to experience death rates resembling the contemporary ultimate rates for standard ordinary insured lives. Even lower death rates may result if the class selection is more discriminating, as appears to have been the case of women in this study.

2. If such a population is further subdivided into the ostensibly healthy and the impaired lives, the latter being defined as those in poor health at time of entry into the study as well as those with personal histories of heart or other serious conditions, including marked overweight, then the ostensibly healthy lives, selected more carefully to eliminate those in poor health, are likely to experience death rates resembling the contemporary select rates for standard ordinary insured lives.

3. This study produced select and aggregate death rates at ages 65 and over for ostensibly healthy lives drawn from a middle-class population. It furnishes new and pertinent information on the effects of selection at ages 70 and over at entry as well as on aggregate mortality at these ages where satisfactory data from insurance experience are lacking.

4. The experience among the ostensibly healthy lives in this study provides an appropriate standard of expected mortality for middle-class persons aged 65 and over who have significant medical impairments or are subject to occupational hazards. Calculating expected mortality for such persons, particularly those affected by occupational hazards, by reference to general population death rates (or even ultimate mortality among insured lives) may materially underestimate the extra mortality involved.

5. The study highlights some of the characteristics associated with variations in mortality at ages 65 and over. Smoking appears as the factor carrying with it the highest extra mortality—in the case of males about 75 percent at attained ages 65–74 and about 50 percent at attained ages 75–84. Heavy drinking in men aged 65–74 was associated with extra mortality of 40–50 percent. Divorced men registered over 40 percent greater mortality than married men at ages 65–74, while widowers showed 33 percent higher mortality at these ages; divorced women experienced nearly 70 percent greater mortality at ages 65–74 than married women, but widows showed only 29 percent extra mortality. Male high-school graduates showed about 10 percent lower mortality than grammar-school graduates, while men with some college education experienced 10–20

percent lower mortality than grammar-school graduates; the differentials according to educational attainment were even greater among women. Small percentage mortality differentials at the advanced ages may represent high extra mortality. This is manifested in the excess death rates presented in Table 17.

SOME BROADER IMPLICATIONS

An understanding of the mortality levels and trends at ages 65 and over among middle-class men and women not only brings out the magnitude of the socioeconomic mortality differentials but also provides a more pertinent basis for financial planning by middle-class families and individuals past retirement age.

Based on the criteria used in this study, that is in self-rated health appraisals, about 55 percent of the men aged 65 were in impaired health, and this proportion increased to about 60 percent by age 90. The corresponding proportions for women rose from 70 percent at age 65 to 75 percent at age 90. There is considerable evidence that self-rated health appraisals are good predictors of mortality among the elderly [15], so that the figures from this study may be taken as a reasonable indication of the prevalence of more serious health impairments among elderly middle-class persons, as judged by themselves. Women are much more aware of health impairments than men, and women are more prone to report symptoms of impaired health.

The life expectancy of ostensibly healthy men was 16.3 years at age 65, or about 3¼ years greater than for men in the general population; at age 75 it was 10.0 years, or some 2 years greater than in the general population, and at age 85 it was 5.4 years, or ¾ of a year greater. The corresponding life expectancies for the ostensibly healthy women were 21.0, 13.0, and 6.9 years respectively, which were about 4, 3, and 1½ years greater respectively, than for women in the general population. It should be of special interest to actuaries that the life expectancy of ostensibly healthy men was about half a year shorter at age 65 than for males in the 1983 Basic Table for individual annuities [17, p. 695], about a year less at age 75, and about a third of a year less at age 85. However, the life expectancies of ostensibly healthy women were about 0.6 of a year longer at age 65 than for females in the 1983 Basic Table for individual annuities and about 0.2 of a year more both at age 75 and age 85. This points up the potential for still lower mortality from class selection among women annuitants. The greatly increased longevity of ostensibly healthy middle-class men and women at the advanced ages bespeaks clearly of extended nursing-home-care costs.

The mortality experience at the older ages according to personal characteristics shows clearly the adverse selection arising from the circumstances created by divorce and widowhood; these are associated with social costs that may dwarf the increased mortality. On the other hand, the beneficial effects associated with higher educational attainment, whether due to higher living standards or greater awareness of health hazards, point to a continued downtrend in death rates at these ages if educational levels keep on rising.

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DISCUSSION OF PRECEDING PAPER

ESTHER PORTNOY:

Messrs. Lew and Garfinkel have presented some interesting observations concerning mortality rates in an important segment of our population. My comments are primarily concerned with the oldest subgroup because of my own current interests.

The authors have used a Whittaker-Henderson graduation of mortality rates by age, stating that this method "does not of itself tend to introduce significant distortions." In fact, as Kimeldorf and Jones [2] pointed out, the Whittaker method can produce graduated rates that are negative or that exceed $+1$. This is more likely to occur at extreme values with low exposures (relative to the fit/smoothness constant) and will occur if the data for ages above 85 or 90 here are graduated alone. It is the dominating influence of the heavier exposures at ages under 85 that prevents this anomalous behavior in the present study.

Perhaps a better reason for the choice of graduation method is that it coincides with that used by Wilkin [3] in his study of medicare data to which the authors make some comparisons. The comparison is actually weakened by choosing the same parameter $k = 500{,}000$. In Wilkin's data, exposures ranged from 3.5 million males in the 65-69 age group, to 615,000 in the group at 85 and older, so that $k = 500{,}000$ is of the same order of magnitude as the yearly exposures for the younger ages. The corresponding exposures for the total population of the present study are about one-tenth as large. Thus, using $k = 500{,}000$ produces a graduation leaning more toward smoothness than Wilkin's graduation. If we instead use $k = 50{,}000$, there is very little change in graduated rates at the younger ages, but the effect is noticeable at ages above 100 (see table 1).

The previous comments must cast some doubt on conclusions about mortality rates at ages above 100 since some apparent patterns may be the result of a graduation that is too smooth and too dependent on data at younger ages. Fortunately, some of the conclusions can be tested directly, without graduation.

For example, consider the crossover in mortality rates between the ostensibly healthy and those not in good health at time of enrollment. For males, the crossover first appears at age 98, where the exposures are 103 and 156. If the mortality rates of the two groups were equal, then given a total of 86 deaths among the 259 individuals, we should expect $86 \times \frac{103}{259} = 34.2$ deaths in the first group, not much less than the observed 35 deaths.

TABLE 1

GRADUATED MORTALITY RATES
TOTAL POPULATION
Males

Age	$k = 500{,}000$	$k = 50{,}000$	Ratio	Age	$k = 500{,}000$	$k = 50{,}000$	Ratio
65	.02653	.02659	1.002	88	.17319	.17261	.997
66	.02816	.02809	.998	89	.18598	.18513	.995
67	.03031	.03033	1.001	90	.19927	.19851	.996
68	.03292	.03294	1.001	91	.21299	.21252	.998
69	.03598	.03586	.997	92	.22709	.22700	1.000
70	.03944	.03933	.997	93	.24148	.24190	1.002
71	.04323	.04321	1.000	94	.25607	.25709	1.004
72	.04725	.04743	1.004	95	.27075	.27237	1.006
73	.05141	.05168	1.005	96	.28542	.28743	1.007
74	.05567	.05575	1.001	97	.29997	.30185	1.006
75	.06014	.05998	.997	98	.31432	.31524	1.003
76	.06497	.06477	.997	99	.32843	.32763	.998
77	.07026	.07024	1.000	100	.34233	.33933	.991
78	.07610	.07623	1.002	101	.35603	.35074	.985
79	.08259	.08279	1.002	102	.36957	.36227	.980
80	.08978	.08969	.999	103	.38299	.37426	.977
81	.09775	.09725	.995	104	.39630	.38697	.976
82	.10658	.10598	.994	105	.40952	.40054	.978
83	.11625	.11605	.998	106	.42266	.41504	.982
84	.12666	.12721	1.004	107	.43572	.43052	.988
85	.13766	.13875	1.008	108	.44870	.44700	.996
86	.14907	.14993	1.006	109	.46161	.46448	1.006
87	.16090	.16099	1.001				

An appropriate statistical test for the significance of the crossover is based on the multinomial distribution. Given two groups of size n and m, subject to selection (in this example, death) at the same unknown rate, and given that a total of s of them are so selected, then the random number S_1 selected from the first group has a multinomial distribution:

$$Pr(S_1 = x) = \binom{n}{x}\binom{m}{s-x} \Big/ \binom{n+m}{s}, \quad x = 0,1,\ldots,\min(s,n).$$

The mean of S_1 is $sn/(n+m)$ and its variance is $snm/(n+m)^2$—here, 34.2 and 20.6. Thus, the observed value 35 is not improbable. For males and females separately at ages 98 and above, table 2 gives the upper critical values based on the given exposures and total deaths. That is, the number of deaths among the ostensibly healthy which would lead us to reject, at the 5 percent level, the hypothesis that rates for the ostensibly healthy are less than or equal to rates for those not in good health. The observed values are less than critical for males at all ages and for females except at age 100.

Although this test indicates that the observed crossover is not significant,

TABLE 2

Age	Males		Females	
	Critical value	Observed	Critical value	Observed
98	42	35	72	64
99	24	18	49	34
100	14	9	34	38
101	10	8	22	15
102	4	3	10	5
103	none	1	6	3
104	....	....	6	3
105	....	....	none	1

there is undeniably a deterioration of the advantage of the ostensibly healthy group. The authors repeat a perplexing explanation for this phenomenon, namely that "a higher level of mortality in midlife among those with lesser vitality increases the average vitality of survivors at the advanced ages, which tends to produce lower death rates in extreme old age.

This idea is initially appealing, but it does not stand up under closer scrutiny. Presumably, individual vitality varies within each of the two groups, and the passage of years eliminates the less vital in each group. Without further assumptions on the distribution of individual vitality within the two groups, we cannot be certain that the average vitality will rise more quickly in the group where it is initially lower. This could occur if group A contained one subgroup of less vital persons and another of more vital persons, while group B contained mostly persons of average vitality. A crossover would not occur if the distribution of individual vitality in group A was simply a downward translation of the distribution for group B. Since significant crossovers have been observed between races and sexes, it would be interesting to formulate some mathematical models of vitality in moderately heterogeneous groups and then see (perhaps by Monte Carlo experiments) how different the groups must be to produce a crossover.

In this instance, a simpler reason can be offered for the deteriorating advantage of the ostensibly healthy. There is clearly an element of subjectivity in the classification. Quite probably the two categories include sizeable subgroups of persons in a very similar health condition, the difference being that some are aware of, and others ignorant of or indifferent to relatively minor impairments. Over a period of years, these impairments may begin to exact a higher toll in the latter group.

A second matter concerning mortality rates in extreme age is the pattern of the ratio of female to male rates, given in the last columns of the authors' tables 2 through 4. The graduated ratio never exceeds 1 for both the ostensibly healthy and those not in good health. That is, no sex crossover like

that observed by Bayo and Faber [1] is seen here. (In the ungraduated data, female rates exceed male rates only at age 100 among the ostensibly healthy, ages 101, 102, and 104 among those not in good health.) The progression of graduated ratios is very nearly linear in each case, but the parameters are quite different. The ratio among the ostensibly healthy is lower at age 80, but it rises more rapidly and by age 100 exceeds the ratio among those not in good health. The apparent linearity is mostly a feature of the graduation. Linear regression on the ratios of ungraduated rates at ages 85 to 103 produces a correlation coefficient of about 70 percent, even after setting aside some obvious outliers. Nevertheless, the difference points up again the subjectivity and, in particular, the sex-dependence of the classification.

REFERENCES

1. BAYO, FRANCISCO, AND FABER, JOSEPH F. "Mortality Experience around Age 100," *TSA*, XXXV (1983), 37–59.
2. KIMELDORF, G.S., AND JONES, D.A. "Bayesian Graduation," *TSA*, XIX (1967), 66–112.
3. WILKIN, JOHN C. "Recent Trends in the Mortality of the Aged," *TSA*, XXXIII (1981), 11–44.

FRANCISCO R. BAYO:

I thank Messrs. Lew and Garfinkel for the wealth of data they have presented on mortality at the older ages from the epidemiological study of the American Cancer Society. Their insight into the quality of the data, careful analysis, and comparison with data from Social Security, Vital Statistics, and private life insurance demonstrate a depth of knowledge in this area that has seldom been displayed.

It is always interesting to note when two mortality curves crossover. This is, when beyond some age, the mortality rates on one of the curves change from being higher than those on the other curve to being lower. I have some doubts, however, about the authors' interpretation of crossovers in mortality curves. For example, I do not see the justification to state that this could be due to a weeding out process through which the early elimination of the weak members in a group results in an increase in the average vigor of the survivors. If this were the case, then the process would be operating in almost every group, and I would expect crossovers to be a widely observed phenomenon in mortality studies. But the fact is that crossovers are more the exception than the norm.

One of my difficulties in accepting their explanation is that while it is clearly based on a lack of homogeneity within the group (some members being significantly weaker while some others are significantly stronger), the analysis used to bring this out is performed on the basis of the usual actuarial

techniques which assume a high level of homogeneity. Can we logically talk about the underlying mortality curve of an everchanging homogeneous group of lives? I believe that a researcher needs to make up his mind as to whether there is sufficient homogeneity in a group to merit studying the group's underlying mortality curve and how it changes from age to age. If the level of homogeneity is too low and the composition of the group is changing from age to age, the researcher should recognize that such data would not permit a single underlying mortality curve to be discovered.

Over the years, a significant amount of analysis and development has already been done assuming high levels of homogeneity. What is needed now is theoretical research into the effect of a relaxation of the homogeneity requirement. The possibilities are too numerous to list in this discussion. One example would be to investigate the mortality pattern if the overall group being studied were made up of subgroups each of which has its own underlying geometrically increasing mortality curve.

It is also interesting to note the authors' observation that although both personal habits and family history of longevity strongly affect the chances of attaining old age, it is basically the personal habits that determine the chances of retaining extreme old age. This means that parents can help us attain a merry old age—but once there, we are on our own!

MARVIN A. KASTENBAUM*:

I was pleased to read the authors' paper with its presentation of updated life tables for the American Cancer Society's large population study. To my knowledge, it is the first detailed account of longevity for males in over fifteen years, and the first account ever for females. As a professional statistician, my interest in life tables and their application dates from my work in radiation biology at Oak Ridge.

The principal contribution of this paper is its finding that the mortality experience of this large population group bears a remarkable similarity to that special segment of the population which is of interest to insurance professionals, namely standard ordinary insurance risks. This result, though surprising at first, is readily explained by the authors. They note that "these results reflect the class selection and physical screening implicit in the criteria used respectively to enroll the population under study."

As a statistician, I have always been concerned with the critical importance of selection procedures because they affect the validity of calculations and the reliability of projections. The authors' observations on how selection procedures determined the makeup of the resulting sample reinforce the

*Mr. Kastenbaum, not a member of the Society, is Director of Statistics at the Tobacco Institute.

lessons learned from the *Literary Digest* poll conducted before the presidential election of 1936. We should be grateful for this reminder.

In addition, I have found the authors' major analysis of this population, which they based on their characterization of its health status at enrollment, to be both innovative and informative. Specifically, I refer to the authors' emphasis on the classifications "ostensibly healthy" and "not in good health" rather than on personal lifestyle factors in their principal assessment of the data.

A question suggested by their work intrigues me. The authors have demonstrated the excellent predictive value of health characteristics at enrollment. How then do these health characteristics relate to the personal lifestyle factors at enrollment (marital status, schooling, drinking, smoking, and so on)? Unfortunately, the paper does not provide any information on this point.

My own curiosity, however, prompted me to review some of the earlier reports of this large population study. I found the mortality experience of nonsmokers to be quite similar to the authors' results on the "ostensibly healthy." This raised the possibility that some lifestyle factors may be indices of health status at enrollment. Its obvious relevance to insurance analysis suggests that this paper may serve as a basis for future consideration of this topic.

RICHARD T. SCHWARTZ:

The thorough and wide-ranging paper by Mr. Lew and Mr. Garfinkel was of particular interest to me because I recently completed a study of the mortality of the French family, based on a genealogical study published in 1982 by Dr. Robert Hughes French. Most of those who reached adulthood in the French family attended college and many attained higher degrees. There were many clergy in the group.

Of the 102 persons in the study, 51 were born before 1850 and 51 during the period 1850–99. A few cases were excluded because complete information was not available. Those born after 1899 were excluded because many were surviving at the time of the study and their histories were not complete.

In table 1 the average length of life for the 102 members of the French family is shown separately and combined for males and females, for two periods, 1849 and prior years and for 1850–99.

For male lives, the average length of life was about the same for each of the periods studied. For female lives, however, the average length of life was 52 years for those born before 1850, compared with 65 years for the 1850–99 group.

TABLE 1

Average Length of Life of Members of the French Family
By Sex and Year of Birth

Sex	Year of Birth	Average Length of Life (Number of Lives)
Male	1849 and prior	61.8 years (26 lives)
Female		51.9 years (24 lives)
Combined		57.1 years (50 lives)
Male	1850–99	59.8 years (25 lives)
Female		64.6 years (27 lives)
Combined		62.3 years (52 lives)
Male	1899 and prior	60.8 years (51 lives)
Female		58.6 years (51 lives)
Combined		59.7 years (102 lives)

Before 1850 there were six infant deaths (two male and four female). Between 1850 and 1900 there were only two infant deaths (one male and one female). This suggests that there was marked improvement in infant survival over the century. We have seen this continue up to the present.

In table 2 a comparison is made between French family longevity and results for the general population and also for insured life data in various countries.

TABLE 2

Average Length of Life for the French Family Compared with
Results for Other Studies

Source of Data	Period	Average Length of Life
Scotland - Censuses	1780 and 1787	39 years
England - Insured Lives	1838 and prior	42 years
The French Family	1849 and prior	57 years
United States - Insured Lives	1843-60	46 years
United States Census - Total Data	1900	47 years
The French Family	1850-99	62 years

For 1849 and prior, the French family showed an average length of life eighteen years longer than found in Scottish census data and fifteen years longer than for English insured life data.

For 1850-99, the French family showed an average length of life sixteen years greater than for U.S. insured life data for 1843-60, and fifteen years greater than for U.S. census data for 1900.

Table 3 shows a comparison of the percentage of lives attaining ages 70, 80, and 85 for the French family compared with results for the 1900-1902 U.S. census (whites only).

TABLE 3

Proportion of Lives in the French Family Attaining Advanced Ages Compared with Results for the General Population

Attained Age	Percent of Total Number of Lives	
	French Family	U.S. Census (White Lives) 1900–1902
Age 70 or older	50% (51 lives)	33%
Age 80 or older	24 (24 lives)	14
Age 85 or older	16 (16 lives)	6

The percentage of lives attaining the advanced ages of 70 to 85 was much greater during the period studied for the French family than for comparable white lives in the 1900–1902 census data.

These records for the French family go back to the nineteenth century, before the introduction of penicillin and other "wonder drugs" and before the advances of modern medicine.

Table 4 shows a comparison between the French family data and the Lew-Garfinkel data of those who attain age 65 and then survive to various higher ages.

TABLE 4

PROPORTION OF PEOPLE AGED 65 WHO SURVIVE TO VARIOUS HIGHER AGES FOR THE FRENCH FAMILY AND FOR THE LEW-GARFINKEL DATA

Attained Age (x)	French Family		Lew-Garfinkel Data		
	Number of Lives	Percentage	Ostensibly Healthy Percentage*	Not in Good Health Percentage	Combined Percentage*
	MEN				
65	31	100%	100%	100%	100%
70	27	87	89	81	86
75	15	48	74	59	67
80	9	29	50	38	46
85	5	16	35	19	26
90	4	13	16	7	11
	WOMEN				
65	25	100%	100%	100%	100%
70	24	96	95	92	94
75	22	88	88	80	84
80	15	60	76	63	68
85	11	44	58	41	47
90	4	16	35	20	24

*Based on $x - 65^p$ 65

Table 4 indicates great similarity between the French family data and the Lew-Garfinkel data. Among men, 87 percent of those who reached age 65 in the French family data reached age 70, compared with 86 percent in the Lew-Garfinkel data. For those attaining ages 75 to 85, there was a distinctly greater percentage in the Lew-Garfinkel data than in the French family study. However, there were relatively few lives in the French family study. Among women the percentages in the two studies were remarkably similar.

Two rather striking facts emerge from these studies. In the French family study based on births in the nineteenth century, half of the lives attained age 70 or older. In the Lew-Garfinkel data after attaining age 65, about half of the men and two-thirds of the women attained an age of 80 or older. These results are far superior to findings for the general population.

If the longevity of this particular group is typical of the "middle class" population of that era, then the question might be whether the life force of humans is really strengthening or whether we are just surviving longer because of our greater control over environmental hazards, better medical care, and improved public health services.

Other considerations which may affect our longevity are the tensions of modern times which range from faster and more exacting schedules (work, transportation, and so on), our compelling addictions (such as drugs, alcohol) and toxic waste hazards. The family circle of ancient times—grandparents, parents, children, grandchildren—is uncommon today. These adverse factors could also have an impact on survival, particularly at the middle and older ages.

COURTLAND C. SMITH:

Senior citizens constitute an opportunity market for life insurance. With inflation, older persons frequently have need for more life insurance, even if they have bought regularly in the past. Underwriting can be very productive. For each fifteen minutes of time, the underwriter is likely to produce more premium the older the applicant. The mortality statistics on older lives provide early usable feedback. The higher death rates yield statistically significant mortality figures sooner than on younger lives. Trends are favorable. It is at the older ages that we see the greatest improvements in claims rates.

Of course, there are dangers. Each underwriting requirement conceded by the marketers for the sake of volume costs more the older the risk. At ages 65–69 every table given away by the underwriter means $5–15 per 1,000 in extra claims, but less than $2.50 per 1,000 at ages 50–54, for example. Even a medical director can underprice older lives if he develops the notion that the typical life is a standard risk regardless of age. At ages 65 and over almost half the risks have some kind of medical impairment. Many show

multiple impairments of the sort seen in routine clinical practice, and the typical applicant is in the range of 150-300 percent of standard select depending on the market.

The Lew-Garfinkel paper is an important contribution to our knowledge. One would wish that the process of selection of the subjects had been described more explicitly. From personal communication with Mr. Lew, I gather that they were largely selected by middle-class women interviewers in neighborhoods canvassed at the time of initial contact, in 1959–60. The subjects answered questionnaires at that time and in intermittent follow-ups thereafter.

If this is correct, the subjects would indeed be largely middle class, as the authors suggest. Further, they would have been selected and classified into "healthy" and "not" on the basis of industry nonmedical underwriting standards as of about 1959–60, without the benefit of attending physicians' statements. The authors note that the death rates for the healthy subjects entering at ages 65–69 were about 150 percent of the corresponding 1965–70 Basic Table rates at durations 1–5 and 6–10, and over 200 percent of tabular for the comparable unhealthy subjects.

Apparently, full medical histories and examinations could have reduced the mortality experience among ostensibly healthy subjects at ages 65 and over in this study by up to a third. Interestingly, if the effect would have been to move borderline subjects to the unhealthy group, the mortality of the latter subjects would have been reduced as well.

(AUTHORS' REVIEW OF DISCUSSION)

EDWARD A. LEW AND LAWRENCE GARFINKEL:

We want to thank Mrs. Portnoy and Messrs. Bayo, Kastenbaum, Schwartz, and Smith for raising a number of important issues.

One of them, raised by Mrs. Portnoy, is whether the graduated death rates presented by us for ages above 100 are reasonable. She considers the graduation to have been too smooth and too dependent on the death rates at ages under 100. We judge the graduation to be highly acceptable not only because it is consistent with the ungraduated data but also because it is consistent with the mathematical form of the mortality curve observed at ages under 100 and with other relevant knowledge.

To be specific, our graduated death rates in the age range 101–109 reproduce 95 percent of the actual deaths recorded in the experience on males and 106 percent of the actual deaths recorded in the experience on females. Part of the relevant knowledge from outside sources indicates that our graduated death rates are somewhat below, and entirely consistent with, the corresponding death rates at ages 95–100 among medicare recipients as de-

scribed by Bayo and Faber in their paper "Mortality Experience Around Age 100." Another part of such knowledge shows that our graduated death rates for males correspond to about 90 percent of those calculated by Bayo and Faber for charter old age insurance beneficiaries in their paper. Still another bit of relevant knowledge shows that our graduated death rates at ages over 105 are close to the rates developed by A. R. Thatcher at ages over 105 on the basis of the 1960–79 deaths among cohorts born in England 1859–69 (A.R. Thatcher "Centenarians" *Population Trends* 25, HMSO, 1981). To quote Kimeldorf and Jones "A good graduation method. . . is one which makes maximal use, in some sense, of all aspects of prior opinion as well as the observed data."

There is no established theory for determining the value of the parameter K. We decided to use the same value of the parameter ($K = 500{,}000$) as Wilkins did, not merely because it facilitated comparisons with mortality rates among medicare recipients, but largely because this value of the parameter yielded graduated death rates that were consistent with relevant information about death rates from both internal and external sources. We want to thank Mrs. Portnoy for demonstrating that had we used a value of $K = 50{,}000$, the graduated death rates produced for males would not have differed by as much as 2.5 percent from those we presented at ages 101–109 and by less than 1 percent at ages below 101.

We presented "one of the explanations" offered for the phenomenon of crossover, because the subdivision of the total experience in our study into the ostensibly healthy and those in impaired health bears a great resemblance to the subdivision of the standard ordinary life insurance experience into preferred risks and other standard risks. Studies of comparative mortality among preferred risks and other standard risks at Metropolitan Life have exhibited a crossover which in the senior author's opinion could be most readily interpreted in terms of the explanation cited by us. It is pertinent to note here that given two populations with approximately the same span of life, a crossover will occur—usually at some advanced age—between the death rates in the population with lower mortality at the younger ages and the death rates in the population with higher mortality at the younger ages.

Other explanations of the crossover may appear more plausible in different circumstances. It would be highly instructive to test different models of vitality and heterogeneity in different populations, as proposed by Mrs. Portnoy and Mr. Bayo, but care should be taken that the assumptions made in such tests correspond to known facts or experience.

The phenomenon of crossover is not rare. It has been observed in various official life tables (eg. English Life Tables) and between different ethnic and national groups. The following brief bibliography attests to this finding:

1. Spiegelman, M. "The Longevity of Jews in Canada 1940–42," *Population Studies 2,* December 1948.

2. "Population Profile of Puerto Rico," *Statistical Bulletin, Metropolitan Life Insurance Co.,* June 1962.

3. Myers, R. J. "Analysis of Mortality in the Soviet Union According to 1958–59 Life Tables," *TSA* 1964.

4. Spiegelman, M. "Why Do These Mortality Curves Cross?" *New York Statistician,* April 1967.

5. Lew, E. A. and Seltzer, F. "Use of Life Table in Public Health," *Milbank Memorial Fund Quarterly,* October 1970.

Mr. Kastenbaum raises another fundamental issue of the interplay between health status as initially determined and life style factors. The records for the subjects in the American Cancer Society's study contain the information needed for an investigation of the kind Mr. Kastenbaum has in mind. A second study launched by the American Cancer Society in September 1982 ascertains which factors are usually found together (for instance heavy drinking and smoking) and which are uniquely determinative of lower or higher mortality.

Mr. Smith rightly points out that a more careful assessment of risks is necessary in underwriting appliciants at the older ages because even a small percentage difference in mortality at these ages translates into substantial extra dollar costs. The alternatives are either to accept such larger mortality costs and rely on modified nonmedical underwriting or to resort to medical examinations and produce mortality levels lower than those shown for ostensibly healthy lives in our study. With prospects of continued improvement in the health of the elderly and more effective containment of disease, a compromise in practical underwriting methods that minimize administrative costs should not be difficult to devise.

Mr. Schwartz reminds us that in addition to ostensibly healthy lives there have always been segments of the population characterized by very low mortality. We need to pay more attention to class selection as an underwriting instrument.