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**REPORT OF THE COMMITTEE TO RECOMMEND A  
NEW MORTALITY BASIS FOR INDIVIDUAL  
ANNUITY VALUATION  
(DERIVATION OF THE 1983 TABLE *a*)**

INTRODUCTION

**I**N DECEMBER, 1979, Mr. Ted Becker, chairman of the NAIC (C4) Life, Accident, and Health Insurance Technical Subcommittee Task Force on Valuation and Nonforfeiture Value Regulation, asked the Society of Actuaries to "form one or more committees to study the possible need for new mortality bases or tables in the following areas: (1) individual and group annuities (mortality and adequacy of improvement projection factors); or settlement options." The Technical Task Force request went on to say: "If it is concluded that one or more additional new bases or tables are needed, then the committee or committees would commence directly with developing new bases or tables just as soon as possible." With the agreement of then President Vogel and then President-Elect Leckie, a committee was formed to study the need for a new individual annuity mortality basis. A corresponding committee was named to examine the need for a new group annuity table. By June, 1980, the staffing of the individual annuity committee, the "Committee to Recommend a New Mortality Basis for Individual Annuity Valuation," was complete.<sup>1</sup> The charge to the committee, as printed in the Society's *Year Book*, is as follows:

To evaluate the need for new mortality tables and projection factors and, if it finds a need, develop new tables and/or projection factors. The new mortality tables would be recommended for possible adoption by appropriate authorities for valuation of reserves on individual annuities and settlement option contracts.

The committee reviewed an advance copy of the report "Mortality under Individual Immediate Annuities, Life Income Settlements, and Matured Deferred Annuities between 1971 and 1976 Anniversaries," published in the 1979 Reports Number of the *Transactions*. The committee compared the 1971-76 experience with the experience that was used as the basis of the

<sup>1</sup> Committee membership: Robert J. Johansen, *chairman*; Gayle E. Emmert, Thomas R. Huber, Harry I. Klaristenfeld, John B. Kleiman, Robert S. Rubinstein, John H. Welch, and Richard K. Wong.

1971 Individual Annuity Mortality (1971 IAM) Table—in both cases looking at ratios of actual to expected deaths (by amounts of annual income) based on the 1971 IAM Table.

In August, 1980, the committee chairman reported at the meeting of the NAIC (C4) Life, Accident and Health Insurance Technical Subcommittee that, on the basis of preliminary studies, it appeared to the committee that the 1971 table would not be adequate during the 1980s and that a simple age setback would not be appropriate. Further, the slope of the Projection Scale B mortality improvement factors was such that the factors would not adjust adequately for the recent improvement in mortality at the high ages. Any proposed new set of improvement factors would be substantially higher at the older ages.

Table 1 of this report compares the mortality experience used as the basis for the 1971 IAM with the 1971-76 experience on immediate annuities, matured deferred annuities, and settlement options, after adjusting the 1971-76 experience so that it would have the same proportions of exposures by kind of contract as in the 1971 IAM basic data experience. The experience is by amount of annual income, and the mortality ratios are ratios of actual to expected mortality on the 1971 IAM Table.

If we assume that the 1971-76 experience is centered on 1973, then it is apparent that the 1971 IAM already provided less than the desired 10 percent margin at ages 80 and over. Given another ten years of mortality improvement, a new valuation mortality table reflecting improved mortality at the older ages would appear to be needed for the period from 1983. In addition, mortality rates for the United States population and other sources for years

TABLE 1  
MORTALITY COMPARISON  
EXPERIENCE USED AS BASIS FOR 1963 EXPERIENCE TABLE VERSUS 1971-76  
ADJUSTED EXPERIENCE ON INDIVIDUAL IMMEDIATE ANNUITIES, MATURED  
DEFERRED ANNUITIES, AND SETTLEMENT OPTIONS COMBINED  
(Expected Deaths on 1971 IAM Table)

Attained Ages	"1963" Experience (1)	Adjusted 1971-76 Experience (2)	Ratio [(2) ÷ (1)] (3)
Male:			
60-69 .....	127.8%	108.8%	85.1%
70-79 .....	126.7	123.3	97.3
80 and over .....	121.1	108.0	89.2
Female:			
60-69 .....	127.8	123.2	96.4
70-79 .....	126.7	109.7	86.6
80 and over .....	119.3	103.7	86.9

subsequent to 1973 indicated that there had been substantial reductions in mortality at the higher ages through the later 1970s.

Tables 2-1, 2-2, 2-3, and 2-4 (reproduced here from the report "Mortality under Individual Immediate Annuities, Life Income Settlements, and Matured Deferred Annuities between 1971 and 1976 Anniversaries," *TSA, 1979 Reports*) show the recent trends in mortality experienced under the different

TABLE 2-1

COMPARISON OF MORTALITY RATIOS ON INDIVIDUAL IMMEDIATE NONREFUND ANNUITIES—MALE LIVES  
EXPERIENCE BETWEEN 1948 AND 1976 ANNIVERSARIES  
EXPECTED DEATHS BASED ON ANNUITY TABLE FOR 1949 ULTIMATE AND 1971 INDIVIDUAL IMMEDIATE ANNUITY TABLE  
BASED ON AMOUNTS OF ANNUAL INCOME

ATTAINED AGES	a-1949 ULTIMATE						1971 IAM	
	1948-53	1953-58	1958-63	1963-67	1967-71	1971-76	1967-71	1971-76
Contract Years 1-5								
Under 60 .....	<i>127%</i>	<i>211%</i>	*	<i>101%</i>	*	*	*	*
60-69 .....	123	90	66%	72	88%	90%	117%	119%
70-79 .....	83	78	71	75	96	86	129	115
80 and over ...	76	96	49	77	65	53	87	70
All ages .....	86%	89%	58%	76%	78%	70%	104%	93%
All ages adjusted ..	85%	89%	59%	76%	80%	70%	106%	93%
Contract Years 6 and Over								
Under 60 .....	95%	168%	<i>334%</i>	<i>98%</i>	*	<i>91%</i>	*	<i>116%</i>
60-69 .....	101	127	116	92	115%	110	153%	147
70-79 .....	128	97	101	81	108	93	145	125
80 and over ...	93	107	98	87	82	77	103	96
All ages .....	105%	106%	100%	86%	88%	82%	111%	104%
All ages adjusted ..	102%	105%	100%	86%	89%	82%	114%	104%
All Contract Years								
Under 60 .....	106%	180%	<i>189%</i>	<i>101%</i>	<i>145%</i>	70%	N.A.	88%
60-69 .....	108	115	93	77	95	97	126%	129
70-79 .....	118	93	92	78	102	90	136	121
80 and over ...	91	106	90	84	77	72	97	91
All ages .....	102%	103%	91%	82%	84%	78%	108%	101%
All ages adjusted ..	100%	103%	91%	82%	85%	78%	109%	101%

NOTE.—Mortality ratio in italics where 10-49 contracts terminated by death. N.A. = not available.

\* Fewer than 10 contracts terminated by death.

kinds of annuities. The trend strengthens the perceived need to replace the 1971 IAM Table.

An added reason for recommending a new mortality table is the trend toward permitting higher interest rates for valuation reserves, thus cutting down potential interest margins that could otherwise provide the additional reserves required to provide for increasing longevity. (It should be noted,

TABLE 2-2

COMPARISON OF MORTALITY RATIOS ON INDIVIDUAL IMMEDIATE NONREFUND ANNUITIES—FEMALE LIVES  
EXPERIENCE BETWEEN 1948 AND 1976 ANNIVERSARIES  
EXPECTED DEATHS BASED ON ANNUITY TABLE FOR 1949 ULTIMATE AND 1971 INDIVIDUAL IMMEDIATE ANNUITY TABLE  
BASED ON AMOUNTS OF ANNUAL INCOME

ATTAINED AGES	<i>a</i> -1949 ULTIMATE						1971 IAM	
	1948-53	1953-58	1958-63	1963-67	1967-71	1971-76	1967-71	1971-76
	Contract Years 1-5							
Under 60 .....	<i>94%</i>	<i>111%</i>	<i>207%</i>	<i>382%</i>	<i>257%</i>	*	N.A.	*
60-69 .....	93	85	59	55	74	62%	102%	86%
70-79 .....	75	86	71	63	46	51	65	72
80 and over ...	63	65	75	68	65	51	82	63
All ages .....	73%	77%	73%	67%	59%	51%	77%	67%
All ages adjusted ..	70%	74%	73%	66%	59%	51%	77%	67%
	Contract Years 6 and Over							
Under 60 .....	<i>112%</i>	<i>101%</i>	<i>132%</i>	<i>119%</i>	<i>168%</i>	<i>503%</i>	N.A.	<i>613%</i>
60-69 .....	109	87	127	80	115	116	160%	163
70-79 .....	112	100	111	88	93	87	131	122
80 and over ...	101	97	99	93	90	75	112	93
All ages .....	105%	97%	102%	92%	91%	78%	115%	99%
All ages adjusted ..	103%	97%	102%	92%	91%	78%	116%	99%
	All Contract Years							
Under 60 .....	<i>106%</i>	<i>103%</i>	<i>160%</i>	<i>301%</i>	<i>227%</i>	<i>278%</i>	N.A.	<i>337%</i>
60-69 .....	104	87	102	63	88	85	121%	118
70-79 .....	106	98	102	77	69	73	98	102
80 and over ...	98	95	98	89	85	71	106	87
All ages .....	101%	96%	99%	86%	82%	72%	105%	92%
All ages adjusted ..	100%	95%	99%	86%	82%	72%	105%	92%

NOTE.—Mortality ratio in italics where 10-49 contracts terminated by death. N.A. = not available.

\* Fewer than 10 contracts terminated by death.

however, that under current conditions there are ample margins when valuation interest rates are compared with the rates available on current new investments, in contrast to the situation about three decades ago when valuation and new-money interest rates were much closer together.) Adoption by the states of the concept of dynamic interest rates for valuation may further erode interest rate margins available to cover inadequate or negative mortality margins, increasing the need for an adequate valuation table.

TABLE 2-3

COMPARISON OF MORTALITY RATIOS ON INDIVIDUAL IMMEDIATE REFUND  
ANNUITIES—MALE LIVES  
EXPERIENCE BETWEEN 1948 AND 1976 ANNIVERSARIES  
EXPECTED DEATHS BASED ON ANNUITY TABLE FOR 1949 ULTIMATE AND  
1971 INDIVIDUAL IMMEDIATE ANNUITY TABLE  
BASED ON AMOUNTS OF ANNUAL INCOME

ATTAINED AGES	a-1949 ULTIMATE						1971 IAM	
	1948-53	1953-58	1958-63	1963-67	1967-71	1971-76	1967-71	1971-76
	Contract Years 1-5							
Under 60 .....	215%	241%	127%	117%	235%	109%	N.A.	138%
60-69 .....	140	114	102	91	98	74	130%	99
70-79 .....	110	110	98	85	91	81	122	109
80 and over ...	109	92	86	75	70	79	97	103
All ages .....	122%	108%	96%	84%	87%	79%	117%	105%
All ages adjusted ..	120%	107%	96%	84%	89%	79%	118%	105%
	Contract Years 6 and Over							
Under 60 .....	154%	178%	125%	167%	86%	218%	N.A.	274%
60-69 .....	138	134	138	124	99	115	132%	153
70-79 .....	128	117	115	102	106	91	142	122
80 and over ...	100	107	103	103	103	85	130	109
All ages .....	146%	114%	109%	105%	104%	90%	134%	117%
All ages adjusted ..	113%	113%	110%	104%	104%	90%	134%	117%
	All Contract Years							
Under 60 .....	171%	189%	126%	135%	182%	139%	N.A.	176%
60-69 .....	139	129	121	98	98	82	131%	110
70-79 .....	124	116	111	94	99	86	132	116
80 and over ...	101	105	101	96	91	83	117	107
All ages .....	117%	113%	107%	96%	96%	85%	125%	111%
All ages adjusted ..	116%	114%	108%	96%	96%	85%	125%	111%

NOTE.—Mortality ratio in italics where 10-49 contracts terminated by death. N.A. = not available.

In selecting the experience on which to base a new mortality table, the committee reviewed the decisions made relating to the 1971 IAM Table and the reasoning behind those decisions. The committee then evaluated those reasons and decisions as they would apply to the 1971-76 experience and to current conditions generally. As described below, the committee found itself largely in agreement with the conclusions of the Joint ALC-LIAA Actuarial Committee, which constructed the 1971 IAM Table.

TABLE 2-4

COMPARISON OF MORTALITY RATIOS ON INDIVIDUAL IMMEDIATE REFUND  
ANNUITIES—FEMALE LIVES  
EXPERIENCE BETWEEN 1948 AND 1976 ANNIVERSARIES  
EXPECTED DEATHS BASED ON ANNUITY TABLE FOR 1949 ULTIMATE AND  
1971 INDIVIDUAL IMMEDIATE ANNUITY TABLE  
BASED ON AMOUNTS OF ANNUAL INCOME

ATTAINED AGES	<i>a</i> -1949 ULTIMATE						1971 IAM	
	1948-53	1953-58	1958-63	1963-67	1967-71	1971-76	1967-71	1971-76
Contract Years 1-5								
Under 60 .....	<i>92%</i>	<i>92%</i>	<i>113%</i>	<i>72%</i>	<i>137%</i>	<i>192%</i>	N.A.	<i>235%</i>
60-69 .....	135	106	83	107	87	104	118%	141
70-79 .....	93	117	103	73	76	72	108	102
80 and over ...	99	82	92	71	63	71	79	88
All ages .....	103%	101%	96%	78%	73%	77%	96%	101%
All ages adjusted ..	102%	97%	95%	77%	72%	77%	94%	101%
Contract Years 6 and Over								
Under 60 .....	186%	183%	179%	138%	202%	210%	247%	257%
60-69 .....	119	118	118	109	80	102	109	142
70-79 .....	120	112	107	91	86	78	122	110
80 and over ...	106	104	105	98	81	82	101	101
All ages .....	113%	108%	106%	97%	83%	82%	106%	105%
All ages adjusted ..	110%	107%	106%	97%	82%	82%	106%	105%
All Contract Years								
Under 60 .....	160%	164%	157%	96%	162%	199%	199%	244%
60-69 .....	122	115	108	108	84	103	115	141
70-79 .....	116	113	107	84	82	75	115	107
80 and over ...	106	103	104	94	77	80	95	98
All ages .....	112%	107%	105%	92%	80%	81%	103%	104%
All ages adjusted ..	110%	107%	105%	92%	79%	81%	101%	104%

NOTE.—Mortality ratio in italics where 10-49 contracts terminated by death. N.A. = not available.

## SELECTION OF SOURCE DATA

Since the experience in the report "Mortality under Individual Immediate Annuities, Life Income Settlements, and Matured Deferred Annuities between 1971 and 1976 Anniversaries" represents the most recent available on individual annuities, there was no question but that it be used to produce a basic table. Because the 1971-76 experience was approximately centered on 1973 and the committee was aiming for a valuation table appropriate for 1982, the first year in which any new table would likely be effective in a fair number of states, it was necessary to project the 1971-76 experience for about ten years.

The second question to be answered was whether to combine the experience under refund and nonrefund immediate annuities, matured deferred annuities, and settlement options, as was done for the 1971 IAM Table, or to revert to the earlier practice of basing an annuity valuation table on only the experience under immediate nonrefund annuities. The reasoning of the Joint Actuarial Committee was reviewed and is briefly summarized in the following paragraph.

The ALC-LIAA Joint Actuarial Committee's objective was "to develop an annuity mortality table which would be 'safe' . . . for the *valuation* [emphasis added] of all types of individual annuities, including single premium annuities, life income settlements and matured deferred annuities." The table was not intended as a basis for calculating the gross single considerations to be charged for immediate annuities. It was felt that the "combined immediate annuity and settlement option experience, with suitable margins, was an appropriate broad base for developing a mortality table to be used as a minimum valuation standard for all types of individual annuities." There were, however, some misgivings expressed that implicitly adopting the mix of business reflecting the data submitted by the particular companies contributing to the Society of Actuaries studies was, at least, arbitrary.

This latter point was a source of concern also to the current committee. Its concern was even greater because it found that there was such a substantial change in the proportions of business in the various annuity and settlement options categories that it was necessary to adjust the 1971-76 experience to the same proportions as the "1963" experience on which the 1971 IAM Table was based in order to make a valid mortality comparison. Table 3 shows, for ages 60-69, 70-79 and 80 and over, the ratios of the exposures (by amounts of annual income) in the experience used for the 1963 Experience Table to the corresponding exposures in the 1971-76 experience, by kind of contract.

An analysis was made of the individual company contributions to the studies used to derive the 1963 Experience Table and the contributions to the 1971-76 study. The analysis is summarized in Table 4. The portion of the total exposure that represented immediate annuities increased from 22 percent in the data underlying the 1963 Experience Table to 32 percent in the 1971-76 study, a result of a dramatic increase in the experience of four of the five largest contributors to both studies. The fifth large company did not contribute any experience to the settlement options or matured deferred annuity portions. All four companies exhibited similar percentage increases. The other companies, which comprised about 50 percent of the immediate annuity experience in the earlier study, did not exhibit this trend and accounted for only 20 percent of the 1971-76 immediate annuity experience.

The decline in the ratio of nonrefund to total refund and nonrefund annuity business from the 1963-67 study to the 1971-76 study was found to be

TABLE 3

RATIOS OF EXPOSURES IN "1963" EXPERIENCE TO CORRESPONDING EXPOSURES IN 1971-76 EXPERIENCE, BY KIND OF CONTRACT, BY AMOUNT OF ANNUAL INCOME—ALL DURATIONS COMBINED

KIND OF CONTRACT	MALES AT ATTAINED AGES:			FEMALES AT ATTAINED AGES:		
	60-69	70-79	80 and Over	60-69	70-79	80 and Over
Immediate annuities:						
Refund .....	.553	.614	.666	.679	.658	.571
Nonrefund .....	1.098	1.050	1.126	1.175	1.022	.963
Settlement options from death claims:						
Refund:						
Payee election .....	.083	.039	.029	2.609	1.560	.639
Nonpayee .....	.862	.934	.597	1.992	1.165	.586
Nonrefund:						
Payee election .....	.199	.194	.133	.527	.424	.367
Nonpayee .....	.142	.142	.130	.269	.247	.177
Settlement options from maturities, surrenders:						
Refund:						
Nonpension .....	1.795	1.221	.590	1.329	.943	.426
Pension .....	24.920	23.602	2.884	.640	.315	.059
Nonrefund:						
Nonpension .....	.313	.189	.226	.152	.126	.137
Pension .....	.419	.250	.029	.124	.116	.009
Matured deferred annuities:						
Refund:						
Nonpension .....	4.076	1.701	.651	3.362	1.554	.589
Pension .....	3.189	1.360	.396	1.668	.692	.266
Nonrefund:						
Nonpension .....	3.124	1.272	.576	3.209	1.248	.523
Pension .....	2.721	1.190	.414	1.167	.767	.343

TABLE 4

ANALYSIS BY COMPANY OF CHANGES IN RELATIVE WEIGHTS OF EXPERIENCE  
USED FOR 1963 EXPERIENCE TABLE AND CONTRIBUTIONS TO 1971-76 STUDY

COMPANY	RATIO OF IMMEDIATE ANNUITY TO TOTAL IMMEDIATE AND MATURED DEFERRED ANNUITIES AND SETTLEMENT OPTIONS			IMMEDIATE ANNUITIES: RATIO OF NONREFUND CONTRIBUTION TO TOTAL REFUND AND NONREFUND CONTRIBUTION		
	"1963"	1971-76	Change	"1963"	1971-76	Change
A .....	10%	34%	24%	38%	27%	- 11%
B .....	100	100	0	34	25	- 9
C .....	35	47	12	30	25	- 5
D .....	23	43	20	41	25	- 16
E .....	17	43	26	35	24	- 11
All others .....	18	14	- 4	36	31	- 5
All companies	22%	32%	10%	36%	26%	- 10%

consistent with respect to each of the companies contributing to both studies. Evidently this is indicative of a real change in the composition of the immediate annuity business.

The committee examined the adjusted total experience, the unadjusted total experience, and that of immediate annuities as shown in Tables 5 and 6. On the basis of this review, the reasoning behind the construction of the 1971 IAM Table, and the feeling that only a substantial difference could justify reverting to the older method of using only immediate nonrefund

TABLE 5

EFFECT ON MORTALITY OF CHANGES IN RELATIVE WEIGHTS,  
BY KIND OF ANNUITY  
ALL IMMEDIATE AND MATURED DEFERRED  
ANNUITY AND SETTLEMENT OPTION EXPERIENCES  
1971-76 EXPERIENCE, CONTRACT YEARS 1 AND OVER  
(Expected Deaths on 1971 IAM Table )

Age Group	Adjusted to "1963" Exposure Basis	Unadjusted*
Males:		
60-69 .....	109%	109%
70-79 .....	123	118
80 and over ....	108	110
Females:		
60-69 .....	123	123
70-79 .....	110	109
80 and over ....	104	98

\* Excluding pension trust business.

TABLE 6

COMPARISONS OF COMBINATIONS OF IMMEDIATE ANNUITY, MATURED DEFERRED ANNUITY, AND SETTLEMENT OPTION EXPERIENCE OVER THE PERIOD 1971-76 BY AMOUNTS OF ANNUAL INCOME  
(Expected Deaths on 1971 IAM)

AGE GROUP	MALES				FEMALES			
	All Durations		Durations 6 and Over		All Durations		Durations 6 and Over	
	Deaths (Amounts in 1,000s)	Ratio A/E						
Refund Immediate Annuities								
Under 50	\$ 12	316%	\$ 7	518%	\$ 14	476%	\$ 4	295%
50-59	71	183	35	308	64	180	32	236
60-64	155	124	38	157	141	137	44	132
65-69	491	103	149	161	401	134	156	137
70-74	653	112	337	118	569	104	340	115
75-79	869	109	461	108	1,139	105	660	103
80-84	911	101	551	105	1,846	108	1,282	110
85-89	986	109	640	118	1,751	86	1,427	94
90-94	401	92	364	104	1,220	100	1,127	101
95 and over	92	91	88	93	510	112	495	112
All	\$ 4,641	106%	\$ 2,670	113%	\$ 7,655	102%	\$ 5,567	104%
Refund and Nonrefund Immediate Annuities								
Under 50	\$ 13	309%	\$ 9	523%	\$ 17	516%	\$ 7	446%
50-59	76	154	39	268	80	199	46	289
60-64	206	138	55	171	161	134	59	147
65-69	639	113	212	173	494	132	210	144
70-74	956	123	510	133	757	103	477	122
75-79	1,313	113	703	111	1,608	104	983	109
80-84	1,374	98	865	103	2,602	102	1,858	110
85-89	1,477	103	1,047	115	2,489	83	2,057	91
90-94	703	89	657	96	1,722	96	1,597	96
95 and over	190	79	186	80	734	108	718	108
All	\$ 6,947	106%	\$ 4,283	111%	\$ 10,664	98%	\$ 8,012	103%
Immediate Annuities, Matured Deferred Annuities, Settlement Options (Excluding Pension Trust Business)								
Under 50	\$ 24	239%	\$ 17	290%	\$ 45	358%	\$ 30	363%
50-59	165	161	95	217	280	183	169	195
60-64	449	122	155	139	561	127	288	129
65-69	1,819	106	622	132	1,610	122	966	133
70-74	3,239	119	2,329	121	2,859	110	2,336	119
75-79	4,507	118	3,624	117	5,504	108	4,567	110
80-84	4,588	115	3,947	119	7,896	103	6,840	105
85-89	3,630	114	3,122	119	7,124	93	6,554	97
90-94	1,386	96	1,334	100	3,975	97	3,807	97
95 and over	322	83	318	84	1,368	105	1,352	105
All	\$20,129	113%	\$15,563	117%	\$31,222	103%	\$26,909	105%

annuity experience, the committee decided to base the new table on the total experience under immediate refund and nonrefund annuities, matured deferred annuities, and settlement options. However, pension trust issues were excluded because their mortality was higher than that of non-pension trust issues, and it was felt that the proportion of such business could vary widely from company to company. Excluding such business was felt to be compatible with the aim of constructing a safe table for valuation purposes.

The committee found itself in agreement with the Joint Actuarial Committee on the latter's decision to base the annuity valuation table on amounts of income rather than numbers of contracts, since the financial effect of annuitant mortality is measured by the amount of annual income rather than by number of contracts. The variation by amount of annual income that has been observed in mortality must be taken into account in providing sufficient reserves for future payments.

The committee also found no reason to change from the inclusion of all durations in the experience on which the new valuation table would be based. Admittedly, variations in levels of new issues and in the degree of self-selection exercised by applicants for annuities could affect the level of aggregate mortality (see Table 6 for a comparison of mortality ratios for groups of contract years). Nevertheless it was felt that aggregate would be safer than ultimate mortality, and the material contributed to the 1971-76 study was the best available estimate of the mix of select and ultimate business. If, in a particular company, the valuation actuary believes that the proportion of new, select, annuity business is substantially higher than that in the experience used for the new table, he should make suitable adjustments, such as using an age setback. Similar considerations would apply to a company with a very large proportion of nonrefund immediate annuities.

#### THE QUESTION OF SEX-DISTINCT OR UNISEX VALUATION MORTALITY TABLES

The new individual annuity mortality tables are intended for use as valuation tables, that is, to provide a minimum standard for reserves on individual annuities in the aggregate. The committee considered but did not adopt the concept of a single merged gender table as a valuation standard. In making its decision, the committee considered the following points.

If the actual male/female proportions for the annuity business of a particular company are different from those assumed in the construction of a merged gender valuation table, the reserves will be redundant or insufficient depending on whether the actual proportions of male annuitants are greater or smaller.

If a merged gender table were constructed so as to reflect precisely the male/female distribution of a particular company's annuity contracts, then subsequent deviation of male and female mortality from that assumed could make the merged gender table inappropriate at some later time.

#### CONSTRUCTION OF THE 1973 EXPERIENCE TABLE

In order to derive a projected 1983 mortality table, it was first necessary to construct experience tables based on the most recent data available. A special tabulation of the Society of Actuaries 1971-76 annuity mortality study was prepared for the committee. Broken down into five-year age groups, the tabulation summarized the data by numbers of contracts and amounts of annual income for contract durations 1 and over (see Table 6).

Combining the data over all kinds of contracts, ratios of actual to expected deaths on the 1971 IAM Table were calculated by five-year age groups for the total of immediate refund and nonrefund annuities, matured deferred annuities, and all settlement options—from death claims, maturities, and surrenders—for contract durations 1 and over, in all cases excluding pension trust business.

The  $q_x$ 's for each five-year age group were not calculated directly because a test showed that the actual average age of a five-year age group was not always the same as the central age. The test consisted of dividing the expected deaths in each five-year age group by the exposure to obtain the average expected mortality rate. Entering the 1971 IAM Table with the resulting mortality rate showed that the corresponding age was not generally equal to the central age of the five-year age group. Accordingly, to obtain more accurate experience mortality rates at the central ages, the A/E mortality ratio for each five-year age group was applied to the 1971 IAM Table  $q_x$  for the central age of each five-year age group to obtain an experience  $q_x$  at the central age.

The resulting mortality rates, for males and females separately, were graduated and interpolated by a Jenkins fifth-difference osculatory interpolation formula computer program that included a cubic equation to close out the highest ages with  $q_x = 1$  at age 115. (A Whittaker-Henderson graduation of the mortality ratios was also attempted, with varying weights for smoothness, but the results were unsatisfactory.) The experience from the 1971-76 study yielded mortality rates only at ages over 50. In fact, the Jenkins formula yielded usable rates only above age 60. It was necessary to look elsewhere for a source of appropriate mortality rates at the younger ages.

Fairly recent United States population mortality rates were available, but the committee felt that population mortality is not expressive of annuitant

experience, which is affected not only by self-selection but likely also by socioeconomic factors. Experience of insured lives seemed to be an acceptable substitute, and the 1980 CSO Table covered the proper time interval. The committee considered and constructed a version of the 1973 Experience Table by using the mortality rates from the 1980 CSO Basic Table (K Basic Table) at ages 47 and under, with a cubic curve connecting these rates with the graduated 1971-76 combined experience rates at ages 67 and over. However, it appeared to the committee that the resulting mortality rates at the younger ages were somewhat high.

The committee decided to use the 1971 IAM Table mortality rates at ages 47 and under. However, the 1971 IAM Table rates had been loaded for use as a valuation table. If these rates were used without adjustment in the 1973 Experience Table, a second loading would be added in the process of deriving the 1983 Table *a* from the 1983 Basic Table. To avoid this consequence and at the same time provide for a smooth table through all ages, the 1971 IAM Table rates at ages 47 and under were divided by 0.9 to offset exactly the level 10 percent loading adopted by the committee for the 1983 Table *a*. (The rationale for the level 10 percent loading is described later in this report. It should also be noted that the committee developed the 1983 Table *a* at the financially important upper ages before adding the mortality rates at the younger ages.)

A cubic curve was used to connect the unloaded 1971 IAM Table mortality rates to the 1971-76 graduated rates at ages 67 and over. The entire set of rates was then regraduated by the Jenkins fifth-difference modified osculatory graduation formula. The resulting 1973 Experience Table mortality rates appear in Table 7.

The graduated 1973 Experience Table was then applied to the exposures of the 1971-76 combined annuity experience. The results are shown in Table 8, which indicates rather close adherence of the 1973 Experience Table to the 1971-76 experience. Table 15 provides a comparison of the graduated 1973 Experience Table with other annuity tables.

#### MORTALITY IMPROVEMENT, 1973-83

When the committee commenced work on the new individual annuity basis project, it was felt that work could be completed by the end of 1981 in time for consideration by the NAIC at its December, 1981, meeting. Approvals by the various states could begin in 1982. Consequently, the committee decided to project the table to 1983 so that it would, at its inception, be as up to date as possible. The committee suggests that the 1983 Table *a* be reexamined periodically for continuing appropriateness.

As was the case for earlier annuity tables, this committee was hampered

TABLE 7

1973 EXPERIENCE TABLE—1,000 $q_x$ 

Age	Males	Females	Age	Males	Females	Age	Males	Females
5	0.507	0.260	45	3.289	1.538	85	117.907	83.528
6	0.471	0.214	46	3.709	1.682	86	128.241	93.197
7	0.448	0.180	47	4.155	1.850	87	138.957	104.173
8	0.443	0.169	48	4.622	2.046	88	149.996	116.566
9	0.441	0.163	49	5.107	2.268	89	161.439	130.197
10	0.441	0.162	50	5.613	2.515	90	173.403	144.815
11	0.445	0.165	51	6.138	2.787	91	186.006	160.170
12	0.450	0.172	52	6.684	3.083	92	199.363	176.010
13	0.458	0.182	53	7.250	3.401	93	213.588	192.093
14	0.467	0.194	54	7.831	3.736	94	228.778	208.211
15	0.479	0.208	55	8.420	4.084	95	245.025	224.167
16	0.492	0.224	56	9.012	4.440	96	262.420	239.762
17	0.507	0.240	57	9.601	4.801	97	281.058	254.797
18	0.523	0.256	58	10.188	5.167	98	301.088	269.772
19	0.540	0.272	59	10.810	5.568	99	322.661	285.189
20	0.559	0.289	60	11.511	6.040	100	345.926	301.546
21	0.580	0.306	61	12.336	6.618	101	371.033	319.345
22	0.603	0.324	62	13.328	7.340	102	398.133	339.085
23	0.629	0.343	63	14.527	8.227	103	427.376	361.267
24	0.657	0.363	64	15.951	9.248	104	458.910	386.391
25	0.688	0.385	65	17.610	10.357	105	492.838	414.958
26	0.722	0.408	66	19.516	11.511	106	529.457	447.466
27	0.759	0.433	67	21.682	12.664	107	568.770	484.418
28	0.801	0.460	68	24.114	13.793	108	610.974	526.312
29	0.847	0.489	69	26.803	14.964	109	656.222	573.650
30	0.898	0.520	70	29.733	16.264	110	704.661	626.931
31	0.953	0.554	71	32.892	17.779	111	756.444	686.656
32	1.014	0.591	72	36.263	19.596	112	811.719	753.325
33	1.081	0.631	73	39.846	21.790	113	870.636	827.438
34	1.154	0.675	74	43.682	24.380	114	933.347	909.496
35	1.234	0.723	75	47.826	27.370	115	1,000.000	1,000.000
36	1.324	0.775	76	52.334	30.766			
37	1.422	0.832	77	57.261	34.574			
38	1.533	0.895	78	62.661	38.804			
39	1.663	0.963	79	68.592	43.484			
40	1.821	1.038	80	75.113	48.648			
41	2.018	1.119	81	82.282	54.327			
42	2.261	1.208	82	90.157	60.554			
43	2.558	1.305	83	98.770	67.389			
44	2.903	1.414	84	108.052	74.986			

TABLE 8

TEST OF GRADUATION OF 1973 EXPERIENCE TABLE,  
BY AMOUNT OF ANNUAL INCOME

AGE GROUP	MALES				FEMALES			
	All Years		Years 6 and Over		All Years		Years 6 and Over	
	Deaths (in Thousands)	Ratio A/E*	Deaths (in Thousands)	Ratio A/E*	Deaths (in Thousands)	Ratio A/E*	Deaths (in Thousands)	Ratio A/E*
Immediate Refund Annuity; Non-Pension Trust								
Under 50 . . . .	\$ 12	126%	\$ 7	220%	\$ 14	252%	\$ 4	147%
50-59 . . . . .	71	187	35	313	64	177	32	233
60-64 . . . . .	155	129	38	164	141	140	44	135
65-69 . . . . .	491	97	149	149	401	114	156	116
70-74 . . . . .	653	96	337	101	569	93	340	103
75-79 . . . . .	869	93	461	92	1,139	97	660	96
80-84 . . . . .	911	87	551	90	1,846	104	1,282	109
85-89 . . . . .	986	97	640	105	1,751	90	1,427	98
90-94 . . . . .	401	95	364	107	1,220	104	1,127	104
95-99 . . . . .	85	112	81	115	435	109	420	108
100 and over	7	86	7	86	75	93	75	93
All . . . . .	\$4,641	95%	\$2,670	102%	\$7,655	100%	\$5,567	103%
Immediate Nonrefund Annuity; Non-Pension Trust								
Under 50 . . . .	\$ 1	93%	\$ 2	180%	\$ 3	406%	\$ 3	664%
50-59 . . . . .	5	69	4	125	16	343	14	576
60-64 . . . . .	51	218	17	221	20	117	15	220
65-69 . . . . .	148	150	63	191	93	106	54	145
70-74 . . . . .	303	133	173	151	188	88	137	127
75-79 . . . . .	444	103	242	99	469	96	323	116
80-84 . . . . .	463	81	314	87	756	92	576	107
85-89 . . . . .	491	83	407	100	738	81	630	90
90-94 . . . . .	302	89	293	91	502	89	470	88
95-99 . . . . .	84	107	84	108	195	101	195	103
100 and over	14	46	14	46	29	71	28	71
All . . . . .	\$2,306	96%	\$1,613	101%	\$3,009	90%	\$2,445	100%
Total Immediate Refund and Nonrefund; Non-Pension Trust								
Under 50 . . . .	\$ 13	121%	\$ 9	213%	\$ 17	259%	\$ 7	217%
50-59 . . . . .	76	168	39	273	80	196	46	285
60-64 . . . . .	206	143	55	178	161	137	59	149
65-69 . . . . .	639	105	212	160	494	113	210	123
70-74 . . . . .	956	105	510	114	757	92	477	109
75-79 . . . . .	1,313	96	703	94	1,608	97	983	101
80-84 . . . . .	1,374	85	865	89	2,602	100	1,858	108
85-89 . . . . .	1,477	92	1,047	103	2,489	87	2,058	95
90-94 . . . . .	703	92	657	99	1,722	99	1,597	99
95-99 . . . . .	169	109	165	111	630	106	615	106
100 and over	21	53	21	53	104	86	103	86
All . . . . .	\$6,947	95%	\$4,283	102%	\$10,664	97%	\$8,012	102%

\* Expected deaths based on 1973 Experience Table.

TABLE 8—Continued

AGE GROUP	MALES				FEMALES			
	All Years		Years 6 and Over		All Years		Years 6 and Over	
	Deaths (in Thousands)	Ratio A/E*						
Total Matured Deferred; Non-Pension Trust								
Under 50 . . . .	\$ 0	0%	\$ 0	0%	\$ 1	13%	\$ 1	89%
50-59 . . . . .	2	43	2	101	7	216	2	119
60-64 . . . . .	38	168	14	141	43	151	12	149
65-69 . . . . .	219	97	70	108	188	92	117	100
70-74 . . . . .	623	93	477	94	444	94	403	98
75-79 . . . . .	1,208	99	1,171	99	1,004	105	992	104
80-84 . . . . .	1,399	105	1,377	104	1,485	108	1,475	108
85-89 . . . . .	1,053	108	1,049	108	1,312	106	1,312	108
90-94 . . . . .	364	106	364	106	703	105	703	105
95-99 . . . . .	84	121	84	121	185	100	185	106
100 and over	2	63	2	63	14	91	14	91
All . . . . .	\$4,992	102%	\$4,610	103%	\$ 5,386	105%	\$5,216	105%
Total Settlement Options; Non-Pension Trust								
Under 50 . . . .	\$ 11	212%	\$ 8	221%	\$ 27	353%	\$ 22	440%
50-59 . . . . .	87	177	54	211	193	181	121	181
60-64 . . . . .	205	111	86	132	357	127	217	129
65-69 . . . . .	961	97	340	110	928	103	639	114
70-74 . . . . .	1,660	104	1,342	104	1,658	104	1,456	108
75-79 . . . . .	1,986	104	1,750	102	2,892	101	2,592	102
80-84 . . . . .	1,815	108	1,705	109	3,809	100	3,507	100
85-89 . . . . .	1,100	110	1,026	108	3,323	103	3,185	104
90-94 . . . . .	319	106	313	107	1,550	100	1,507	100
95-99 . . . . .	41	87	41	93	385	98	385	98
100 and over	5	85	5	85	50	79	50	80
All . . . . .	\$ 8,190	105%	\$ 6,670	106%	\$15,172	103%	\$13,681	104%
Total Immediate, Matured Deferred, Settlement Options; Non-Pension Trust								
Under 50 . . . .	\$ 24	150%	\$ 17	217%	\$ 45	254%	\$ 30	344%
50-59 . . . . .	165	165	95	226	280	186	169	199
60-64 . . . . .	449	128	155	147	561	131	288	133
65-69 . . . . .	1,819	99	622	123	1,610	104	966	114
70-74 . . . . .	3,239	102	2,329	103	2,859	99	2,336	107
75-79 . . . . .	4,507	100	3,624	100	5,504	101	4,567	103
80-84 . . . . .	4,588	99	3,947	102	7,896	101	6,840	104
85-89 . . . . .	3,630	101	3,122	106	7,124	97	6,554	102
90-94 . . . . .	1,386	98	1,334	103	3,975	100	3,807	100
95-99 . . . . .	294	109	290	111	1,200	103	1,185	104
100 and over	28	58	28	58	168	84	167	84
All . . . . .	\$20,129	101%	\$15,563	104%	\$31,222	101%	\$26,909	104%

\* Expected deaths based on 1973 Experience Table.

by a lack of recent, suitable data from which to project mortality improvement rates, since the most recent individual annuity experience was centered around 1973. Published United States population mortality rates through 1978 indicated that mortality at the higher ages had shown much higher rates of improvement in the mid- and later 1970s than in previous years. The committee was given an advance copy of John C. Wilkin's paper "Recent Trends in the Mortality of the Aged," published in this volume of the *Transactions*. The paper, which reported on the mortality of persons covered under medicare where deaths were matched to exposures and ages were felt to be more accurately reported than in census data, corroborated the higher improvement rates. Annual improvement rates from several different sources are shown in Table 9.

In deriving the 1971 IAM Table, the Joint Actuarial Committee based its choice of mortality improvement rates for the period from 1963-71 on the immediate annuity experience from 1958-63 to 1963-67 and the "settlement annuity" experience from 1955-60 to 1960-65. Annual improvement rates were developed from the combined experience for ages 79 and under (1.6 percent) and ages 80 and over (1.1 percent). The same rates were used for males and females.

There can be no doubt that there has been a substantial drop in mortality since 1968, following a marked slowdown in the rate of improvement over the period from the 1950s into the 1960s. Further, whereas the improvement in mortality prior to the 1950s reflected mostly progress against the infectious, acute diseases and benefited mainly the younger ages, the more recent improvements occurred among the chronic ailments of the older ages— ischemic heart disease, in particular. While it is hard to find complete agreement among epidemiologists as to the cause of the decrease, they agree that the decrease is a fact. They also agree that the decrease in heart-related deaths is real and not a result of changes in diagnostic techniques or coding of cause of death.

Reasons given for the recent improvement range from changes in smoking habits to greater recognition of hypertension and more effective means of treatment and better emergency and post-heart attack care. One writer suggests that the increase in deaths from heart-related disease after 1920 followed the rapid spread of smoking after World War I, while the recent decrease reflects a reduction in smoking.

There has been a decrease in deaths from other causes as well, even from cancer, if lung cancer is excluded.

In view of the continued drop in mortality since 1968, especially at the very high ages, the use of improvement rates based on prior annuity experience did not seem appropriate for use over the period from 1973 to 1983.

TABLE 9  
COMPARISON OF ANNUAL IMPROVEMENT RATES IN MORTALITY  
FROM VARIOUS SOURCES

AGE	"1963" EXPERIENCE TO 1971-76 "ADJUSTED" EXPERIENCE (SEE TEXT)	U.S. WHITE POPULATION		U.S. MEDICARE 1973-77	INTER- COMPANY INSURED LIVES 1970-75 TO 1976-79	PROJEC- TION B† (INTER- POLATED)	ASSUMED IMPROVE- MENT FACTORS 1973-83
		1961-65 to 1971-76	1971-76 to 1977-79*				
Males							
7			} 2.05%				2.00%
12					3.17%		0
17			} .39		-.01		0
22					.85	1.25%	0
27			} .26		1.20	1.25	0
32					2.00	1.25	1.00
37			} 3.32		3.15	1.25	2.25
42					4.28	1.25	2.25
47			} 2.66		3.69	1.25	2.25
52		.77%		2.40%	3.34	1.24	2.25
57		.74	3.24	2.23	4.61	1.22	2.25
62	} 1.52%	.41	2.21	1.97	2.85	1.16	2.25
67		.72	2.41	2.75	3.54	1.04	2.25
72		.22	2.14	2.15	2.07	.87	2.25
77	} .26	-.19	1.57	2.15	3.35	.65	2.00
82		.44	1.12	1.59	1.81	.40	1.75
87		.11	2.17		2.42	.15	1.50
92	} 1.08				-.05		1.50
97							1.50
Females							
7			} 3.24%				2.00%
12					2.44%		0
17			} .78		-1.68		0
22					.77	1.25%	0
27			} 2.72		4.58	1.25	0
32					3.07	1.25	1.00
37			} 4.10		2.40	1.25	2.25
42					2.77	1.25	2.25
47			} 2.10		1.80	1.25	2.25
52		.43%		2.35%	3.47	1.24	2.25
57		.20	2.22	3.44	3.58	1.22	2.25
62	} .35%	.58	1.15	3.78	.07	1.16	2.25
67		1.53	1.83	3.53	2.59	1.04	2.25
72		1.30	2.67	3.54	3.66	.87	2.25
77	} 1.46	1.01	2.45	2.71	3.74	.65	2.00
82		1.73	1.99	1.02	2.80	.40	1.75
87		2.15	2.85		4.97	.15	1.50
92	} 1.43				-.23		1.50
97							1.50

\* The 1979 experience was based on a 10 percent sample of deaths.

† W. A. Jenkins and E. A. Lew, "A New Mortality Basis for Annuities," TSA, I (1949), 369.

Unfortunately, there was no suitable annuity experience available, subsequent to the 1971-76 study. A review of one large company's recent annuity experience showed inconsistencies and anomalies, probably arising from the effects of class selection in a competitive marketplace, which could have a proportionately greater effect on a single company's experience than on that of several companies combined. The Society's ordinary life insurance experience was not deemed entirely appropriate because of the probable effects of changes in underwriting rules caused by inflation and competitive considerations. This left United States population mortality and medicare experience as likely sources.

The committee considered both United States population data and the medicare data reported in the Wilkin paper, which ably analyzed the data at length and compared the data with United States population experience. The committee found that the improvement rates of the United States white population (males and females separately) for the period 1961-65 to 1971-76 tended to parallel the improvement rate of the total annuity and settlement option experience from the period covered by the 1963 Experience Table data to the 1971-76 study and were of about the same magnitude.

The use of population data to project annuity mortality can be objected to for a number of reasons. There is no self-selection. There are likely to be wide differences in average income levels, occupations, and geographic distributions between the two sets of individuals. Mortality improvement among the population may be largely the result of improvement in average socioeconomic status (mortality is considered a "social indicator"<sup>2</sup>). Finally, there may be errors in counting or age reporting in the deaths and exposures.

Since the mortality improvement factors measure the change in the mortality of the population, not the mortality itself, they are not likely to be unduly sensitive to differences in composition of the two groups except to the extent that the factors causing the change in mortality reflect changes affecting one socioeconomic group more than another.

While changes in the socioeconomic area may have had some effect, it is believed that over the periods studied, other factors were much more important, particularly at the ages that are financially important in an annuity table. These other factors were evident in the increased rate of improvement observed during the period subsequent to 1971-76.

Improvement rates in the medicare experience at the higher ages were examined, but, since they were available only for white and nonwhite lives combined, it was felt that these rates might be influenced too much by changes in socioeconomic status of the nonwhite population. In fact, a

<sup>2</sup> See panel discussion "Social Indicators: Update of a New and Developing Field," *RSA*, VI, 1517.

comparison of the improvement rates in Table 9 will show that the mortality improvement rates in the female medicare experience from 1973 to 1977 are markedly higher than in any other experience.

After reviewing all the available data, the committee developed a set of improvement rates based largely on the United States white population experience, with some effect given to the medicare experience and the relationship of annuitant to the United States white population improvement rates during the period 1961-65 to 1971-76. The committee also felt that the use of separate male and female improvement rates was not warranted by the available experience for use over the period of projection from 1973 to 1983. A further consideration was the desire of the committee to create a table that, while it would be a safe table to use for valuation when interest rate margins were likely to be thin, would not be so conservative as to cause undue surplus strain on new issues. The final 1973-83 annual improvement factors appear in Table 9.

A distinction by sex will be made in the derivation of projection factors beyond 1983, since they may be in use over a longer period and should reflect past experience over a longer period. The factors used to derive the 1983 Experience Table were based on observed rates that covered half of the period—in fact, the committee also looked at rates through 1977-79, although the 1979 experience was based on only a 10 percent sample of United States population deaths.

For comparison purposes, the Projection B improvement rates have been included in Table 9; the shift by age is apparent. As compared with Projection B, the 1973-83 annual projection rates are higher at ages over 32 and persist into the 90s, where the Projection B factors grade down to zero. The chosen improvement factors were intended to project recent experience, which, however, may not be indicative of the period beyond 1983.

A discussion on changes in selection by annuitants since 1945 appears in Appendix B.

#### THE 1983 BASIC TABLE

Applying the final 1973-83 improvement factors to the 1973 Experience Table produced the 1983 Basic Table (Table 10). For pivotal ages (those ending in 2 and 7) the ten-year (actually 9.5 years) improvement factors were calculated as

$$\left(1 - \frac{\text{annual improvement rate percent}}{100}\right)^{9.5}.$$

The factors were applied to the 1973 Experience Table values at pivotal ages, and then the resulting 1983 pivotal values were graduated and interpolated by the Jenkins modified osculatory interpolation formula with, as

TABLE 10

1983 BASIC TABLE—1,000 $q_x$ 

Age	Males	Females	Age	Males	Females	Age	Males	Females
5	.419	.215	45	2.657	1.242	85	101.261	72.368
6	.389	.178	46	2.988	1.362	86	110.424	81.137
7	.370	.149	47	3.343	1.500	87	119.894	90.907
8	.391	.149	48	3.718	1.658	88	129.609	101.721
9	.409	.151	49	4.110	1.837	89	139.643	113.454
10	.424	.156	50	4.518	2.033	90	150.099	125.936
11	.438	.163	51	4.938	2.246	91	161.082	138.997
12	.450	.172	52	5.370	2.474	92	172.699	152.469
13	.461	.183	53	5.811	2.716	93	185.049	166.187
14	.472	.195	54	6.260	2.971	94	198.219	180.008
15	.483	.209	55	6.718	3.242	95	212.291	193.795
16	.495	.224	56	7.184	3.528	96	227.346	207.411
17	.508	.239	57	7.658	3.832	97	243.467	220.718
18	.523	.255	58	8.146	4.155	98	260.903	234.236
19	.540	.271	59	8.671	4.515	99	279.903	248.485
20	.559	.288	60	9.266	4.927	100	300.716	263.985
21	.581	.306	61	9.961	5.411	101	323.592	281.255
22	.605	.325	62	10.787	5.983	102	348.780	300.815
23	.632	.345	63	11.769	6.656	103	376.529	323.185
24	.661	.366	64	12.920	7.416	104	407.088	348.885
25	.692	.388	65	14.248	8.241	105	440.707	378.434
26	.724	.410	66	15.761	9.114	106	477.634	412.352
27	.756	.431	67	17.467	10.012	107	518.120	451.160
28	.788	.452	68	19.373	10.931	108	562.412	495.376
29	.819	.473	69	21.486	11.916	109	610.761	545.521
30	.850	.493	70	23.810	13.027	110	663.417	602.115
31	.881	.513	71	26.353	14.326	111	720.626	665.676
32	.913	.534	72	29.120	15.872	112	782.640	736.725
33	.945	.555	73	32.123	17.717	113	849.708	815.782
34	.980	.578	74	35.398	19.883	114	922.077	903.367
35	1.023	.605	75	38.986	22.383	115	1,000.000	1,000.000
36	1.077	.636	76	42.930	25.228			
37	1.146	.673	77	47.272	28.433			
38	1.232	.717	78	52.054	32.017			
39	1.341	.769	79	57.325	36.029			
40	1.476	.827	80	63.132	40.525			
41	1.641	.894	81	69.523	45.561			
42	1.842	.967	82	76.547	51.194			
43	2.079	1.048	83	84.229	57.483			
44	2.352	1.139	84	92.498	64.512			

before, a cubic curve to finish off the table at the extreme ages. Table 14 shows the calculation of the mortality rates at ages 5 and 6 for the 1973 Experience Table, the 1983 Basic Table, and 1983 Table *a*. The 1983 Basic Table is compared with recent nonannuity mortality rates in Table 11, and with other annuity mortality rates in Table 15.

COMPARISON OF 1983 BASIC TABLE WITH RECENT  
NONANNUITY MORTALITY

Table 11 compares the 1983 Basic Table with the 1980 CSO Basic Table, recent intercompany ordinary life insurance mortality experience, and recent group life insurance experience. The group figures made available to the committee were not yet final.

As compared with ordinary life insurance experience, the 1983 Basic Table has rather comfortable margins at the older male ages and the midrange

TABLE 11  
COMPARISON OF 1983 BASIC TABLE WITH  
RECENT NONANNUITY MORTALITY

AGE	1983 BASIC TABLE 1,000 $q_x$	1980 CSO BASIC TABLE		INTERCOMPANY ORDINARY LIFE INSURANCE MEDICAL AND NONMEDICAL 1976-79 EXPERIENCE DURATIONS 6 AND OVER		TOTAL GROUP LIFE WAIVER OF PREMIUM CONTRACTS 1975-79 EXPERIENCE TOTAL CLAIMS*	
		1,000 $q_x$	Ratio to 1983 Basic	1,000 $q_x$	Ratio to 1983 Basic	1,000 $q_x$	Ratio to 1983 Basic
Males							
12 .....	.450	.31	69%	.377	84%	.....	.....
22 .....	.605	1.25	207	1.199	198	1.60	264%
32 .....	.913	.99	108	.894	98	1.29	141
42 .....	1.842	2.35	128	1.888	102	2.88	156
52 .....	5.370	6.08	113	5.050	94	8.34	155
62 .....	10.787	15.95	148	13.615	126	15.62	145
72 .....	29.120	41.38	142	36.581	126	45.43	156
82 .....	76.547	103.61	135	92.508	121	92.03	120
92 .....	172.699	219.77	127	203.236	118	.....	.....
Females							
12 .....	.172	.22	128%	.213	124%	.....	.....
22 .....	.325	.50	154	.481	148	.44	135%
32 .....	.534	.69	129	.627	117	.72	135
42 .....	.967	1.81	187	1.587	164	1.32	137
52 .....	2.474	4.11	166	3.422	138	3.73	151
62 .....	5.983	8.33	139	8.105	135	6.36	106
72 .....	15.872	21.89	138	17.822	112	21.01	132
82 .....	51.194	71.11	139	60.564	118	.....	.....
92 .....	152.469	197.20	129	170.785	112	.....	.....

\* Includes 75 percent of disability waiver claims.

of female ages, with somewhat lesser margins at the older and younger female ages and very thin margins at the younger male ages and at male ages 50-54.

As compared with group life insurance experience, the margins in the 1983 Basic Table are ample at all ages. However, examination of the death rates excluding disability claims indicates that the experience at ages in the 50s is heavily affected by disability claims.

The mortality rates in the 1983 Basic Table are comfortably below those of the 1971 IAM Table except for male ages in the 70s and 80s (see Table 15). Since the committee was aiming for a valuation table that would be adequate but not overly conservative, these results are in line with expectations. It might be noted, too, that new tax laws that favor increased investment for retirement may make annuities more popular and act to decrease the effect of self-selection in the future.

Subsequent to the selection by the committee of the United States white population mortality improvement rates as the basis for projecting the 1983 Basic Table from the 1973 Experience Table, an error in the underlying United States population estimates was announced by the National Center for Health Statistics (United States Department of Health and Human Services). For years between the 1970 and the 1980 census, NCHS had computed exposures using the prior year's figures, adding births and estimates of net migration and subtracting deaths. The intercensal estimates are routinely checked against census counts every ten years and have been, in the past, fairly close to the actual.

It has now been reported that the estimated 1980 population was less than the census count by almost five million lives. As of this writing, few details are available except that the largest error affects males in the age range 15-34. It is most likely that the error increased with years elapsed since 1970. Under this hypothesis, the annual improvement rates are probably understated by some small amount. Since birth and death records are almost complete, the error must stem from one or more of the following: underestimating net immigration, a very large undercount in 1970, or a much more complete count in 1980. The committee believes that the underestimate would not have had any material effect on the committee's choice of improvement factors, even though they were in large part based on the population data. A rough recalculation on the basis of total population indicates that any resulting understatement of improvement factors is of the order of two-hundredths of 1 percent. Table 12, an exhibit prepared by the Statistical Bureau of the Metropolitan Life Insurance Company, is of interest. It shows several sets of improvement rates and their effects projected to 1985, 1990, 1995, and 2000.

TABLE 12\*  
MORTALITY PROJECTIONS OF THE GENERAL WHITE POPULATION OF THE UNITED STATES  
MALES

AGE GROUP	DEATH RATES PER 100,000					ANNUAL IMPROVEMENT RATES FOR PERIOD SHOWN				
	1968	1973	1975	1978	1980†	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	2,267.0	1,776.5	1,594.4	1,359.6	1,388.3	.050	.048	.052	.035	.027
1-4 .....	83.6	79.8	71.3	71.7	63.5	.105	.009	.021	.032	.023
5-14 .....	48.5	47.0	41.5	39.2	46.4	.021	.006	.036	.002	-.023
15-24 .....	169.0	176.2	165.9	168.5	185.2	-.000	-.008	.009	-.007	-.022
25-34 .....	174.4	177.6	169.1	166.7	176.6	.005	-.004	.013	.001	-.009
35-44 .....	345.8	324.4	295.8	268.1	269.6	.025	.013	.037	.026	.018
45-54 .....	907.6	839.7	790.2	733.8	748.9	.021	.015	.027	.016	.011
55-64 .....	2,269.6	2,118.2	1,954.5	1,819.2	1,803.7	.022	.014	.030	.023	.016
65-74 .....	5,029.7	4,653.9	4,355.8	4,135.6	4,043.9	.019	.015	.023	.020	.015
75-84 .....	10,004.2	10,214.3	9,608.1	9,420.5	8,803.1	.006	-.004	.016	.021	.017
85 and over .....	21,560.6	20,436.1	18,257.9	18,100.3	18,076.3	.017	.011	.024	.017	.002

\* Prepared by the Metropolitan Life Insurance Company, Actuarial Corporate: Statistical Bureau, August 27, 1981.

† Provisional.

TABLE 12—MALES—Continued  
PROJECTED DEATH RATES PER 100,000

AGE GROUP	1985—BASED ON:					1990—BASED ON:				
	1968-78	1968-73	1973-78	1973-80	1975-80	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	1,075.1	1,087.9	1,062.5	1,164.1	1,208.8	832.6	852.5	813.2	976.1	1,052.6
1-4 .....	58.8	60.6	57.1	53.9	56.6	54.5	57.9	51.3	45.8	50.4
5-14 .....	41.7	45.0	38.7	46.0	51.9	37.5	43.6	32.3	46.6	58.0
15-24 .....	189.9	193.1	177.1	191.9	206.7	184.7	201.3	169.4	198.9	230.8
25-34 .....	172.7	179.8	165.8	175.9	184.4	168.8	183.1	155.6	175.2	192.6
35-44 .....	237.4	252.9	222.8	236.2	245.7	209.0	237.3	184.1	207.0	224.0
45-54 .....	673.4	692.9	654.5	690.1	709.8	605.5	641.0	571.9	635.9	672.7
55-64 .....	1,614.8	1,683.4	1,549.1	1,608.1	1,664.5	1,445.8	1,571.1	1,330.4	1,433.7	1,536.1
65-74 .....	3,666.9	3,741.8	3,593.5	3,657.8	3,754.3	3,325.0	3,462.2	3,193.3	3,308.5	3,485.5
75-84 .....	8,542.4	8,988.0	8,119.0	7,916.1	8,065.5	8,289.5	9,176.7	7,488.0	7,118.5	7,389.8
85 and over .....	16,562.3	17,133.5	16,010.2	16,559.5	17,896.5	15,175.2	16,239.9	14,180.3	15,169.9	17,718.5

AGE GROUP	1995—BASED ON:					2000—BASED ON:				
	1968-78	1968-73	1973-78	1973-80	1975-80	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	644.8	668.1	622.3	818.5	916.5	499.3	523.5	476.3	686.3	798.0
1-4 .....	50.4	55.2	46.1	38.9	44.9	46.7	52.7	41.4	33.1	39.9
5-14 .....	33.7	42.2	26.9	45.1	64.9	30.3	40.9	22.5	44.7	72.5
15-24 .....	184.4	209.9	162.0	206.1	257.6	184.1	218.8	154.9	213.5	287.6
25-34 .....	165.0	186.5	146.0	174.5	201.2	161.3	189.9	137.1	173.8	210.1
35-44 .....	184.0	222.6	152.2	181.4	204.1	162.1	208.8	125.8	158.9	186.0
45-54 .....	544.4	593.1	499.8	586.0	637.5	489.5	548.7	436.8	540.0	604.2
55-64 .....	1,294.4	1,466.3	1,142.6	1,278.2	1,417.6	1,158.8	1,368.5	981.3	1,139.5	1,308.2
65-74 .....	3,015.1	3,203.5	2,837.7	2,992.6	3,235.9	2,734.0	2,964.1	2,521.7	2,706.9	3,004.2
75-84 .....	8,044.0	9,369.5	6,906.1	6,401.2	6,770.6	7,805.8	9,566.2	6,369.3	5,756.2	6,203.3
85 and over .....	13,904.2	15,392.9	12,559.5	13,896.9	17,542.2	12,739.7	14,590.1	11,124.0	12,730.8	17,367.7

TABLE 12—Continued  
 MORTALITY PROJECTIONS OF THE GENERAL WHITE POPULATION OF THE UNITED STATES  
 FEMALES

AGE GROUP	DEATH RATES PER 100,000					ANNUAL IMPROVEMENT RATES FOR PERIOD SHOWN				
	1968	1973	1975	1978	1980†	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	1,683.6	1,342.8	1,222.3	1,069.7	1,044.9	.044	.044	.044	.035	.031
1-4 .....	68.7	62.5	57.1	53.3	56.9	.025	.019	.031	.013	.001
5-14 .....	31.0	30.2	25.8	25.0	26.0	.021	.005	.037	.021	-.002
15-24 .....	60.8	60.0	56.0	58.1	56.9	.005	.003	.006	.008	-.003
25-34 .....	82.7	79.3	73.3	69.3	67.6	.018	.008	.027	.023	.016
35-44 .....	198.1	181.8	164.6	145.8	148.1	.030	.017	.043	.029	.021
45-54 .....	467.3	439.9	414.8	393.9	408.4	.017	.012	.022	.011	.003
55-64 .....	1,038.1	1,000.7	944.6	914.0	898.9	.013	.007	.018	.015	.010
65-74 .....	2,622.8	2,324.7	2,152.8	2,063.8	2,080.9	.024	.024	.024	.016	.007
75-84 .....	6,887.5	6,582.2	6,034.7	5,810.2	5,455.6	.017	.009	.025	.026	.020
85 and over .....	20,012.9	16,685.8	14,494.1	14,079.0	14,234.3	.035	.036	.033	.022	.004

† Provisional.

TABLE 12—FEMALES—Continued  
PROJECTED DEATH RATES PER 100,000

AGE GROUP	1985 BASED ON:					1990 BASED ON:				
	1968-78	1968-73	1973-78	1973-80	1975-80	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	832.9	833.4	832.4	873.5	893.2	663.9	664.7	663.1	730.2	763.6
1-4 .....	50.1	51.8	48.5	53.2	56.7	44.1	47.1	41.4	49.8	56.5
5-14 .....	23.3	25.3	21.5	23.4	26.2	21.0	24.7	17.8	21.0	26.4
15-24 .....	55.6	56.2	55.1	54.8	57.8	54.4	55.4	53.4	52.7	58.7
25-34 .....	61.9	64.8	59.1	60.3	62.3	56.6	62.2	51.6	53.8	57.5
35-44 .....	127.1	135.9	118.8	127.9	133.3	109.0	124.7	95.3	110.5	119.9
45-54 .....	375.0	384.5	365.7	387.9	402.1	344.2	361.9	327.5	367.3	395.9
55-64 .....	843.5	866.5	821.0	832.6	855.4	791.4	835.3	749.9	771.2	814.0
65-74 .....	1,845.1	1,843.6	1,846.6	1,921.1	2,009.7	1,636.7	1,634.1	1,639.3	1,774.4	1,941.7
75-84 .....	5,010.8	5,213.8	4,815.7	4,771.0	4,932.1	4,602.2	4,982.6	4,250.9	4,172.3	4,458.8
85 and over .....	11,939.0	11,867.9	12,010.5	12,707.0	13,979.1	10,013.8	9,894.9	10,134.1	11,343.5	13,728.6

AGE GROUP	1995 BASED ON:					2000 BASED ON:				
	1968-78	1968-73	1973-78	1973-80	1975-80	1968-78	1968-73	1973-78	1973-80	1975-80
Under 1 .....	529.2	530.1	528.2	610.4	652.8	421.8	422.8	420.8	510.3	558.0
1-4 .....	38.9	42.8	35.3	46.5	56.3	34.2	39.0	30.1	43.5	56.1
5-14 .....	18.8	24.0	14.7	18.9	26.6	16.9	23.4	12.2	16.9	26.8
15-24 .....	53.2	54.7	51.7	50.8	59.7	52.0	54.0	50.0	48.9	60.6
25-34 .....	51.9	59.6	45.1	48.0	53.0	47.5	57.2	39.4	42.8	48.9
35-44 .....	93.5	114.5	76.4	95.4	107.9	80.2	105.0	61.3	82.4	97.1
45-54 .....	316.1	340.7	293.2	348.3	389.8	290.2	320.7	262.5	330.3	383.8
55-64 .....	742.6	805.2	684.9	714.3	774.6	696.8	776.2	625.6	661.6	737.2
65-74 .....	1,451.8	1,448.3	1,455.3	1,638.9	1,876.0	1,287.9	1,283.7	1,292.0	1,513.7	1,812.6
75-84 .....	4,227.0	4,761.8	3,752.3	3,648.7	4,030.9	3,882.4	4,550.7	3,312.2	3,190.8	3,644.1
85 and over .....	8,399.0	8,249.9	8,550.8	10,126.4	13,482.5	7,044.6	6,878.3	7,214.9	9,039.8	13,240.8

DERIVING THE VALUATION MORTALITY TABLE—1983 TABLE *a*

To provide a safe mortality table for valuation purposes, it is necessary to provide a margin over the experience rates. The purpose of the margin may be defined variously as providing for variations in mortality levels by company, variations between different types of contracts (e.g., refund versus nonrefund immediate annuities) and different levels of mortality because of variations in a company's mix of business, fluctuations in mortality from year to year, and, to some extent, a future decrease in mortality of annuitants, although the preferred method would be to recognize this improvement directly through the use of mortality improvement factors.

In its deliberations on the form and amount of the loading, the committee considered the use of a nonlevel loading formula that would vary by age. In particular, the committee considered the use of a loading formula that would decrease the percentage loading at the ages above, say, age 70. Nonlevel loading formulas considered were of the form  $0.10e_x/e_{70}$  at ages over 70, or a linear function of age providing for a reduction in the loading at the higher ages. It was felt that the  $0.10e_x/e_{70}$  function would provide too rapid a falloff in loading, while the linear function would be more gradual. It was also noted that in the process of applying a flat loading to the experience table and regraduating, the loading would diminish toward the very end of the table as a result of the graduation process.

In order to test the adequacy and appropriateness of a flat 10 percent loading, an approximate test was made for the companies that contributed to the 1971-76 annuity mortality study.

The total nonpension experience for males and females combined produced a mortality ratio of 107 percent of the 1971 IAM Table. A 10 percent safety margin lowers the ratio to 96 percent of the 1971 IAM Table. Table 13 shows the mortality ratios of ten companies that contributed data to the 1971-76 annuity mortality study. The experience of all but companies C, E, and J is covered by the loaded experience, and only Company C falls very far under the 96 percent limit.

The committee finally rejected any variation by age, noting that the primary reason for the loading was to cover variations in mortality between companies. A secondary purpose of the loading is to provide for variations in mortality from year to year, and the committee felt that there was a greater chance of fluctuation at the highest ages where the number of lives would be fewer and less confidence could be placed in the mortality experience. The committee also felt that weight should be given to the choice of a 10 percent level loading in the 1971 IAM. The committee noted that, on the basis of the 1971-76 combined immediate annuity experience, a 10

TABLE 13

TEST OF ADEQUACY OF 10 PERCENT MARGIN  
 VARIATION IN MORTALITY LEVEL BY COMPANY,  
 BY AMOUNT OF ANNUAL INCOME  
 (MALE AND FEMALE, REFUND AND NONREFUND COMBINED)  
 (1971-76 Experience)

Company	Actual Deaths (\$1,000s)	Expected Deaths on 1971 IAM Table (\$1,000s)	Mortality Ratio
A .....	\$ 564	\$ 477	118%
B .....	209	188	111
C .....	292	407	72
D .....	1,178	946	125
E .....	291	319	91
F .....	377	258	146
G .....	740	616	120
H .....	3,152	3,154	100
I .....	3,946	3,658	108
J .....	3,116	3,266	95
Total* .....	\$13,865	\$13,287	104%

\* Ten companies.

percent loading factor would have provided a safe table for most of the companies contributing to the 1971-76 Society of Actuaries mortality study. Basing its judgment on the foregoing considerations, the committee agreed that a level 10 percent loading was the preferred approach.

#### HIGH AGE MORTALITY

##### *Tabular Mortality Rates at the Very High Ages*

As is customary in ending a valuation mortality table, the 1983 Table *a* mortality rates at ages above 97 were obtained by fitting a cubic curve from age 97 to age 115, with the value of  $q_x$  at age 115 taken as 1.000. This method is satisfactory in that it provides for graded mortality rates at the extreme ages where the precise values have little effect on monetary values at the important ages under 100.

It is suggested, however, that in the construction of future mortality tables this procedure be replaced by the use of more accurate experience mortality rates that will likely be available from sources such as medicare and special follow-up studies. A private communication received by the chairman shows that mortality apparently does not continue to increase at ages over 100 but rather tends to level off at about 30 percent. Unfortunately, these data are not yet sufficiently substantiated that the committee could make use of the rates developed. Otherwise the 1983 Table *a* could have been terminated

by using 300 deaths per thousand for males at ages 102 and higher and at ages 104 and higher for females, in each case terminating at age 115 with  $q_x$  set at 1.000. The table below shows the effect on values of  $a_x$  at ages 65, 75, 85, and 95.

VALUES OF  $a_x$  AT 7 PERCENT INTEREST

AGE	1983 TABLE <i>a</i> UNADJUSTED VALUE OF $a_x$		1983 TABLE <i>a</i> USING 0.300 AS UPPER LIMIT ON $q_x$			
	(1)		Value of $a_x$		Ratio to Unadjusted [(2) ÷ (1)]	
			(2)		(3)	
	Males	Females	Males	Females	Males	Females
65 .....	9.265	10.246	9.266	10.247	1.0001	1.0001
75 .....	6.867	7.868	6.869	7.869	1.0003	1.0001
85 .....	4.450	5.041	4.454	5.045	1.0009	1.0008
95 .....	2.598	2.845	2.632	2.867	1.0131	1.0077

FINAL GRADUATION OF THE 1983 TABLE *a*

The 10 percent loading was subtracted from the 1983 Basic Table at pivotal ages. The resulting rates were then graduated by the Jenkins modified oscillatory fifth-difference interpolation formula. The calculation of mortality rates at ages 5 and 6 is shown in Table 14. The table was closed off at the high ages by means of a cubic curve with  $q_{115} = 1.000$ . The 1983 Table *a* mortality rates appear in Table 16; a comparison with other annuity mortality

TABLE 14

EXTENSION OF 1973 EXPERIENCE TABLE, 1983 BASIC TABLE,  
1983 TABLE *a* TO AGE 5

Age $x$	1971 IAM Table $1,000q_x$	1973 Experience Table $1,000q_x$ Ages 5, 6: (1) × (3) <sub>7</sub> (2)	Ratio at Age 7 (3) <sub>7</sub> = (2) <sub>7</sub> ÷ (1) <sub>7</sub> (3)	1983 Basic Table $1,000q_x$ Ages 5, 6: (1) × (5) <sub>7</sub> (4)	Ratio at Age 7 (5) <sub>7</sub> = (4) <sub>7</sub> ÷ (1) <sub>7</sub> (5)	1983 Table <i>a</i> $1,000q_x$ Ages 5, 6: (1) × (7) <sub>7</sub> (6)	Ratio at Age 7 (7) <sub>7</sub> = (6) <sub>7</sub> ÷ (1) <sub>7</sub> (7)
<b>Males:</b>							
7 ....	.403	.448	1.11166	.370	.91811	.333	.82630
6 ....	.424	.471		.389		.350	
5 ....	.456	.507		.419		.377	
<b>Females:</b>							
7 ....	.162	.180	1.11111	.149	.91975	.134	.82716
6 ....	.193	.214		.178		.160	
5 ....	.234	.260		.215		.194	

rates appears in Table 15. Graphs comparing the 1983 Table *a* with the 1971 IAM Table and the 1980 CSO Basic Table appear in Figures 1 and 2.

At its June, 1981, meeting, the NAIC (C4) Life, Accident, and Health Insurance Technical Subcommittee expressed a desire that the 1983 Table *a* be expressible by a mathematical formula, noting that the 1980 CSO tables had been expressed as a 20-term formula. If a formula had to be found for the 1983 Table *a*, the best time to do so would be before its final adoption, when minor variations would be acceptable in view of the ability to use a fairly simple formula.

TABLE 15

COMPARISON OF VALUES OF  $1,000q_x$  ON VARIOUS ANNUITY MORTALITY TABLES

AGE <i>x</i>	1971 IAM $1,000q_x$	1973 EXPERIENCE TABLE		1983 BASIC TABLE		1983 TABLE <i>a</i>		ANNUITY TABLE FOR 1979*	
		$1,000q_x$	Ratio to 1971 IAM	$1,000q_x$	Ratio to 1971 IAM	$1,000q_x$	Ratio to 1971 IAM	$1,000q_x$	Ratio to 1971 IAM
Males									
42 .....	2.000	2.261	113%	1.842	92	1.673	84%	1.701	85%
47 .....	3.754	4.155	111	3.343	89	3.009	80	3.193	85
52 .....	6.461	6.684	103	5.370	83	4.812	74	5.511	85
57 .....	9.850	9.601	97	7.658	78	6.839	69	8.543	87
62 .....	14.073	13.328	95	10.787	77	9.740	69	12.678	90
67 .....	20.290	21.682	107	17.467	86	15.717	77	19.880	98
72 .....	30.933	36.263	117	29.120	94	26.131	84	32.413	105
77 .....	48.715	57.261	118	47.272	97	42.587	87	54.058	111
82 .....	77.668	90.157	116	76.547	99	69.081	89	90.941	117
87 .....	123.048	138.957	113	119.894	97	107.577	87	152.327	124
92 .....	208.457	199.363	96	172.699	83	155.429	75	246.328	118
97 .....	340.214	281.058	83	243.467	72	219.120	64	370.973	109
Females									
42 .....	1.094	1.208	110%	.967	88%	.867	79%	1.085	99%
47 .....	1.654	1.850	112	1.500	91	1.356	82	1.639	99
52 .....	2.641	3.083	117	2.474	94	2.215	84	2.497	95
57 .....	4.826	4.801	99	3.832	79	3.432	71	3.867	80
62 .....	7.773	7.340	94	5.983	77	5.413	70	6.394	82
67 .....	10.622	12.664	119	10.012	94	8.888	84	11.190	105
72 .....	17.548	19.596	112	15.872	90	14.319	82	20.160	115
77 .....	32.050	34.574	108	28.433	89	25.509	80	36.836	115
82 .....	59.409	60.554	102	51.194	86	46.121	78	67.481	114
87 .....	109.338	104.173	95	90.907	83	82.318	75	122.582	112
92 .....	181.776	176.010	97	152.469	84	137.222	75	214.397	118
97 .....	242.211	254.797	105	220.718	91	198.646	82	346.674	143

\* W. A. Jenkins and E. A. Lew, "A New Mortality Basis for Annuities," *TSA*, I, 446, 447.

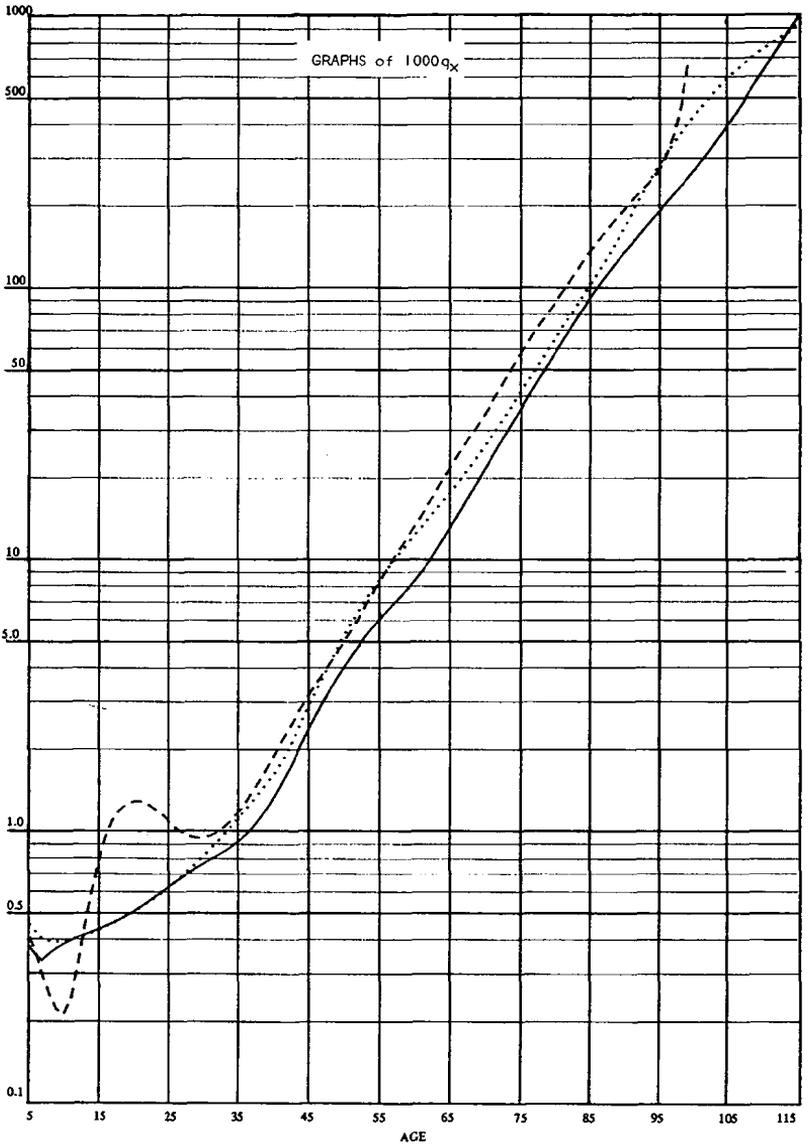


FIG. 1.— Comparison of 1983 Table *a* with 1971 IAM Table and 1980 CSO Basic Table (males). *Solid line*: 1983 Table *a*; *dotted line*: 1971 IAM Table; *dashed line*: 1980 CSO Basic Table.

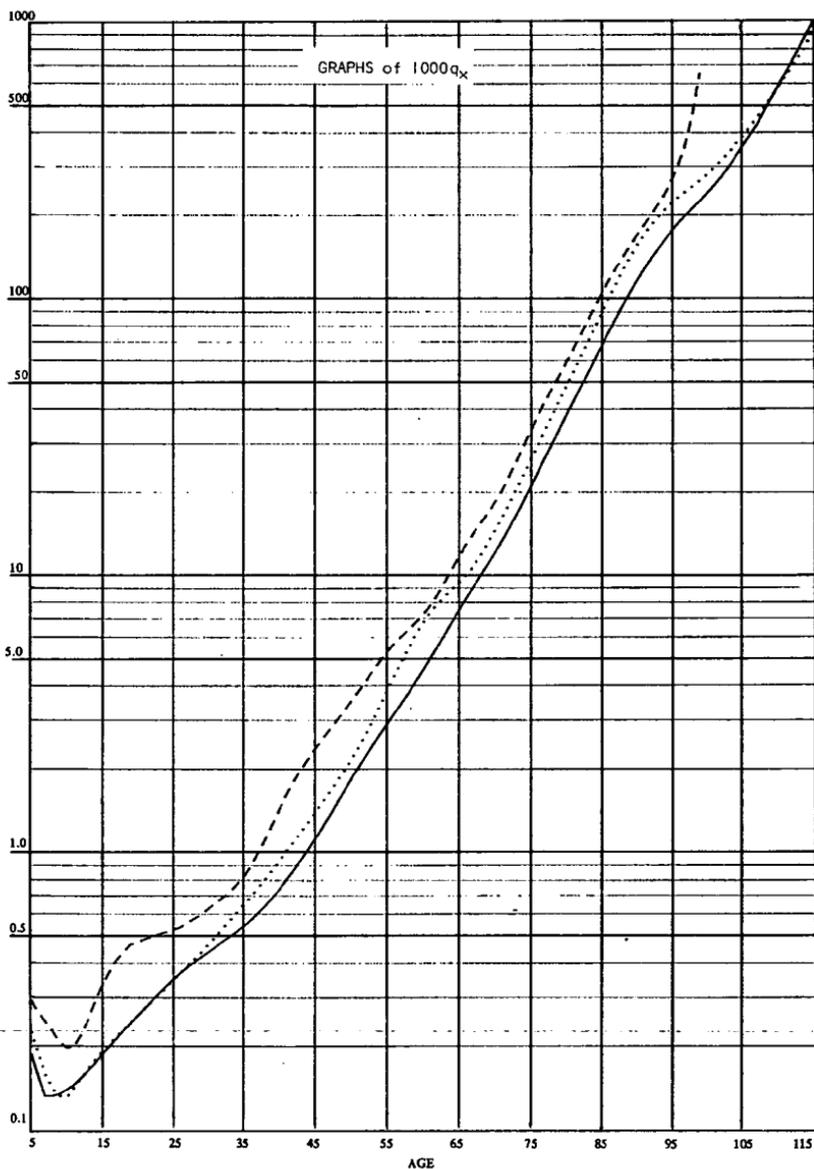


FIG. 2.—Comparison of 1983 Table *a* with 1971 IAM Table and 1980 CSO Basic Table (females). *Solid line*: 1983 Table *a*; *dotted line*: 1971 IAM Table; *dashed line*: 1980 CSO Basic Table.

TABLE 16  
1983 TABLE *a*—1,000*q<sub>x</sub>*

Age	Males	Females	Age	Males	Females	Age	Males	Females
5	.377	.194	45	2.399	1.122	85	90.987	65.518
6	.350	.160	46	2.693	1.231	86	99.122	73.493
7	.333	.134	47	3.009	1.356	87	107.577	82.318
8	.352	.134	48	3.343	1.499	88	116.316	92.017
9	.368	.136	49	3.694	1.657	89	125.394	102.491
10	.382	.141	50	4.057	1.830	90	134.887	113.605
11	.394	.147	51	4.431	2.016	91	144.873	125.227
12	.405	.155	52	4.812	2.215	92	155.429	137.222
13	.415	.165	53	5.198	2.426	93	166.629	149.462
14	.425	.175	54	5.591	2.650	94	178.537	161.834
15	.435	.188	55	5.994	2.891	95	191.214	174.228
16	.446	.201	56	6.409	3.151	96	204.721	186.535
17	.458	.214	57	6.839	3.432	97	219.120	198.646
18	.472	.229	58	7.290	3.739	98	234.735	211.102
19	.488	.244	59	7.782	4.081	99	251.889	224.445
20	.505	.260	60	8.338	4.467	100	270.906	239.215
21	.525	.276	61	8.983	4.908	101	292.111	255.953
22	.546	.293	62	9.740	5.413	102	315.826	275.201
23	.570	.311	63	10.630	5.990	103	342.377	297.500
24	.596	.330	64	11.664	6.633	104	372.086	323.390
25	.622	.349	65	12.851	7.336	105	405.278	353.414
26	.650	.368	66	14.199	8.090	106	442.277	388.111
27	.677	.387	67	15.717	8.888	107	483.406	428.023
28	.704	.405	68	17.414	9.731	108	528.989	473.692
29	.731	.423	69	19.296	10.653	109	579.351	525.658
30	.759	.441	70	21.371	11.697	110	634.814	584.462
31	.786	.460	71	23.647	12.905	111	695.704	650.646
32	.814	.479	72	26.131	14.319	112	762.343	724.750
33	.843	.499	73	28.835	15.980	113	835.056	807.316
34	.876	.521	74	31.794	17.909	114	914.167	898.885
35	.917	.545	75	35.046	20.127	115	1,000.000	1,000.000
36	.968	.574	76	38.631	22.654			
37	1.032	.607	77	42.587	25.509			
38	1.114	.646	78	46.951	28.717			
39	1.216	.691	79	51.755	32.328			
40	1.341	.742	80	57.026	36.395			
41	2.492	.801	81	62.791	40.975			
42	2.673	.867	82	69.081	46.121			
43	1.886	.942	83	75.908	51.889			
44	2.129	1.026	84	83.230	58.336			

The committee attempted to use a formula of the kind described by L. Heligman and J. H. Pollard in "The Age Pattern of Mortality."<sup>3</sup> The authors were able to fit the formula

$$q_x/p_x = A^{(\alpha+B)x} + D \exp [-E(\ln x - \ln F)^2] + GH^x$$

rather closely to Australian population mortality rates. The three parts of the Heligman-Pollard formula consist of (1) a Gompertz function for the high ages, (2) a lognormal function to cover the accident hazard at the young adult ages, and (3) a sharply reducing exponential function for the childhood ages.

The form of the equation is unchanged whether the function graduated is  $q_x/p_x$  or  $\text{colog } p_x$ . The committee attempted to fit a comparable formula to the 1983 Table *a* values, first to values of  $q_x/p_x$ , and then to  $\text{colog } p_x$ .

At the higher ages, the Heligman-Pollard formula rates are provided mainly by the Gompertz function,  $GH^x$ , to represent  $\text{colog } p_x$ . A least-squares method was used first to derive the values of  $GH^x$ . When these had been obtained, the lognormal segment was then estimated, and finally the first term of the formula (omitting the *B* term) was fitted to the values for ages 5 and 6.

While it was possible to achieve a close fit at the younger ages, especially on a relative basis ( $\Delta/q_x$ ), it was not possible to obtain a satisfactory fit ( $\pm 2.5$  percent) for the Gompertz function at the important ages 60-92. This may be attributed in part to the use of the discontinuously varying "improvement factors" (described above) to reflect improvements in mortality over the period 1973-83. The original raw data followed an exponential more closely.

When graphed on semilog paper, the 1983 Table *a* mortality rates fell below a least-squares straight line at the lower and upper age ranges of 60 through the 90s. In an attempt to correct for this, a function of the form  $x^{1/n}/K$  was applied to  $GH^x$ , where *n* was arbitrary and *K* was chosen so that  $x^{1/n}/K$  was equal to unity at some pivotal age where no correction was desired. Values for *n* of 2, 4, 6, and 8 were tried, and different pivotal ages were used, but it appeared that no such simple expedient could improve one segment of the Gompertz function without worsening another. The attempt to define the new mortality table in terms of a reasonable mathematical formula was reluctantly abandoned.

Life table values and commutation columns at 5, 7, and 9 percent interest appear in Appendix A.

<sup>3</sup> *JIA*, CVII, Part I, 49.

COMPARISON OF ANNUITY VALUES 1983 TABLE *a*  
VERSUS 1971 IAM TABLE

Values of (1) life annuities, (2) annuities for ten years certain and life and (3) twenty years certain and life at 5, 7, and 9 percent on the 1983 Table *a* and the 1971 IAM Table are shown in Table 17. Ratios of 1983 Table *a* values to 1971 IAM Table values are shown to indicate how much reserves will increase under the new table. (A model office comparison is described in the following section.) Values are shown for every fifth age from 60 to 95.

As might be expected, the percentage increases are greater when interest is at 5 percent than at 7 percent and 9 percent. The percentage differences also increase with age for life annuities, a result of the improvement factors at the older ages. For annuities with ten years certain the percentage differences decrease with age as the effect of the certain annuity outweighs the contribution of the deferred annuity. This effect is more pronounced for annuities with twenty years certain and at the higher interest rates.

At 5 percent interest, 1983 Table *a* life annuity values are about 5–7 percent higher than those on the 1971 IAM Table for males at ages 60–75, and 5–10 percent higher for females at ages 60–75. The percentage increases are greatest at the very high ages, where they exceed 20 percent. At male age 95, there is a 50 percent increase in the life annuity value at all three interest rates. The reserve, however, increases only from about 1½ times the annual payment to about 2½ times the annual payment.

To test the effect of carrying reserves at a lower interest rate on the 1971 IAM Table rather than on the 1983 Table *a* at an interest rate closer to the earned rate, ratios of 7 percent IAM Table annuity values to 9 percent 1983 Table *a* values were calculated. These ratios have been interpreted in Table 17A to show as a percentage of the 9 percent 1983 Table *a* values how much the 7 percent 1971 IAM Table values fall short of (–) or exceed (+) the 1983 Table *a* values. Table 17A indicates that an interest differential of somewhat less than 2 percent would be sufficient for life annuities. For annuities with ten years certain and twenty years certain, it is evident that the *n*-year certain annuity portion outweighs the deferred life annuity portion.

## MODEL OFFICE RESERVE TEST

In order to show the aggregate effect on reserves of valuing on the 1983 Table *a* rather than on the 1971 IAM Table, a model office was constructed and reserves on both tables were calculated at 5, 7, and 9 percent. The results of the model office analysis appear in Table 18.

TABLE 17

## COMPARISON OF ANNUITY RESERVES: 1983 TABLE A VERSUS 1971 IAM TABLE

SEX AND AGE	5% INTEREST			7% INTEREST			9% INTEREST		
	1971 IAM Table	1983 Table A	Ratio 1983A/ 1971	1971 IAM Table	1983 Table A	Ratio 1983A/ 1971	1971 IAM Table	1983 Table A	Ratio 1983A/ 1971
Immediate Life Annuity									
Male:									
60 ...	11.702	12.355	1.056	9.809	10.279	1.048	8.387	8.736	1.042
65 ...	10.332	10.918	1.057	8.832	9.265	1.049	7.670	7.999	1.043
70 ...	8.831	9.362	1.060	7.704	8.106	1.052	6.803	7.115	1.046
75 ...	7.261	7.775	1.071	6.465	6.867	1.062	5.809	6.130	1.055
80 ...	5.706	6.237	1.093	5.184	5.613	1.083	4.740	5.092	1.074
85 ...	4.238	4.861	1.147	3.925	4.450	1.134	3.651	4.097	1.122
90 ...	2.871	3.722	1.296	2.706	3.459	1.278	2.559	3.228	1.261
95 ...	1.776	2.757	1.552	1.698	2.598	1.530	1.627	2.455	1.509
Female:									
60 ...	13.000	13.613	1.047	10.742	11.148	1.038	9.077	9.356	1.031
65 ...	11.625	12.262	1.055	9.809	10.246	1.045	8.425	8.734	1.037
70 ...	10.002	10.728	1.073	8.629	9.158	1.061	7.547	7.941	1.052
75 ...	8.203	9.016	1.099	7.239	7.868	1.087	6.453	6.948	1.077
80 ...	6.374	7.239	1.136	5.749	6.455	1.123	5.223	5.807	1.112
85 ...	4.679	5.543	1.185	4.302	5.041	1.172	3.977	4.615	1.160
90 ...	3.344	4.100	1.226	3.121	3.793	1.215	2.924	3.525	1.206
95 ...	2.522	3.033	1.203	2.380	2.845	1.195	2.252	2.677	1.189
Life Annuity with 10 Years Certain									
Male:									
60 ...	12.275	12.770	1.040	10.313	10.643	1.032	8.831	9.057	1.026
65 ...	11.152	11.577	1.038	9.553	9.843	1.030	8.306	8.509	1.024
70 ...	10.045	10.411	1.036	8.771	9.028	1.029	7.745	7.928	1.024
75 ...	9.067	9.391	1.036	8.056	8.289	1.029	7.215	7.386	1.024
80 ...	8.324	8.621	1.036	7.494	7.716	1.030	6.787	6.954	1.025
85 ...	7.893	8.131	1.030	7.159	7.343	1.026	6.525	6.668	1.022
90 ...	7.746	7.865	1.015	7.043	7.137	1.013	6.433	6.508	1.012
95 ...	7.723	7.751	1.004	7.025	7.047	1.003	6.419	6.436	1.003
Female:									
60 ...	13.316	13.848	1.040	11.020	11.354	1.030	9.322	9.538	1.023
65 ...	12.081	12.640	1.046	10.209	10.577	1.036	8.777	9.025	1.028
70 ...	10.752	11.344	1.055	9.287	9.698	1.044	8.126	8.417	1.036
75 ...	9.505	10.071	1.060	8.382	8.793	1.049	7.461	7.763	1.040
80 ...	8.559	9.004	1.052	7.671	8.006	1.044	6.921	7.176	1.037
85 ...	8.039	8.297	1.032	7.272	7.470	1.027	6.612	6.767	1.023
90 ...	7.828	7.933	1.013	7.108	7.190	1.012	6.484	6.549	1.010
95 ...	7.750	7.774	1.003	7.046	7.066	1.003	6.435	6.451	1.002
Life Annuity with 20 Years Certain									
Male:									
60 ...	13.659	13.912	1.019	11.340	11.489	1.013	9.599	9.689	1.009
65 ...	13.097	13.290	1.015	10.998	11.114	1.001	9.388	9.459	1.008
70 ...	12.707	12.850	1.011	10.752	10.841	1.008	9.232	9.288	1.006
75 ...	12.516	12.603	1.007	10.630	10.685	1.005	9.152	9.188	1.004
80 ...	12.467	12.497	1.002	10.597	10.617	1.002	9.131	9.144	1.001
85 ...	12.462	12.466	1.000	10.594	10.597	1.000	9.129	9.130	1.000
Female:									
60 ...	14.157	14.531	1.026	11.642	11.859	1.019	9.786	9.914	1.013
65 ...	13.410	13.743	1.025	11.191	11.393	1.018	9.510	9.634	1.013
70 ...	12.860	13.104	1.019	10.849	11.001	1.014	9.293	9.390	1.010
75 ...	12.583	12.706	1.010	10.672	10.751	1.007	9.180	9.230	1.005
80 ...	12.489	12.528	1.003	10.611	10.637	1.002	9.140	9.157	1.002
85 ...	12.465	12.472	1.001	10.596	10.601	1.000	9.130	9.133	1.000

TABLE 17A

PERCENTAGE DEFICIENCY (-) OR EXCESS (+) OF 1971 IAM ANNUITY VALUES AT 7 PERCENT COMPARED WITH 1983 TABLE *a* ANNUITY VALUES AT 9 PERCENT

AGE	LIFE ANNUITY		10 YEARS CERTAIN AND LIFE		20 YEARS CERTAIN AND LIFE	
	Males	Females	Males	Females	Males	Females
60 .....	+12%	+15%	+14%	+16%	+17%	+17%
65 .....	+10	+12	+12	+13	+16	+16
70 .....	+ 8	+ 9	+11	+10	+16	+16
75 .....	+ 5	+ 4	+ 9	+ 8	+16	+16
80 .....	+ 2	- 1	+ 8	+ 7	+16	+16
85 .....	- 4	- 7	+ 7	+ 7	+16	+16
90 .....	-16	-11	+ 8	+ 9	.....	.....
95 .....	-31	-11	+ 9	+ 9	.....	.....

As a basis for the model office, the exposures from the 1971-76 study (contract years 1-5) were used as the first-year in-force of a typical company. Values of  ${}_5p_x$  at the central age of each five-year age group from the 1983 Basic Table were used to age the in-force over a period of twenty years. A computer program was written to apply reserve values to the in-forces at each five-year interval. Annuity values for ten years certain and life thereafter were used for all refund annuities. Simpson's rule was used to obtain a sum over the entire period. The results, as percentages of 1983 Table *a* reserves over 1971 IAM Table reserves, are shown for each kind of annuity business and for all combined. Admittedly certain liberties were taken with the calculation of the aggregate reserves—for example, the use of an eleven-year period and a twenty-one-year period—to simplify the calculations. The results should, of course, be regarded as illustrative only.

At 5 percent interest, the 1983 Table *a* aggregate reserves were about 8 percentage points higher than those on the 1971 IAM Table over eleven years, and 10 percentage points higher over twenty-one years. The 1983 Table *a* female reserves as compared with 1971 IAM Table female reserves were about 2 percentage points higher than for male reserves.

At 7 percent interest, the 1983 Table *a* reserves as compared with the 1971 IAM Table reserves were about 7 percentage points higher over eleven years, and 9-10 percentage points higher over twenty-one years. The ratios were generally about 1 percentage point lower than those for 5 percent. Similarly, the ratios for 9 percent reserves were about 1 percentage point lower than those for 7 percent reserves and about 2 percentage points below those for 5 percent reserves.

TABLE 18

MODEL OFFICE ANALYSIS OF 1983 TABLE *a* VERSUS 1971 IAM TABLE  
 RATIO OF MODEL OFFICE TOTAL RESERVES OVER 11 YEARS ON 1983 TABLE *a* TO  
 1971 IAM TABLE AT 5, 7, AND 9 PERCENT INTEREST

	IMMEDIATE ANNUITIES			MATURED DEFERRED			SETTLEMENT OPTIONS			GRAND TOTAL
	Refund	Non- refund	Total	Refund	Non- refund	Total	Refund	Non- refund	Total	
5% Interest										
Males .....	106.7%	109.8%	107.2%	106.5%	107.7%	106.7%	106.4%	107.9%	106.5%	106.8%
Females .....	108.8	113.4	109.7	108.1	108.7	108.2	107.8	108.9	107.8	108.7
Total .....	108.0	112.1	108.7	107.3	108.3	107.5	107.2	108.3	107.3	108.0
7% Interest										
Males .....	105.9%	109.0%	106.4%	105.6%	106.9%	105.8%	105.6%	107.0%	105.7%	106.0%
Females .....	107.9	112.4	108.8	107.0	107.6	107.1	106.8	108.0	106.8	107.8
Total .....	107.1	111.2	107.8	106.3	107.3	106.5	106.3	107.4	106.3	107.1
9% Interest										
Males .....	105.3%	108.3%	105.8%	105.0%	106.3%	105.2%	105.0%	106.4%	105.0%	105.4%
Females .....	107.1	111.6	108.0	106.1	106.7	106.2	106.0	107.3	106.0	107.0
Total .....	106.4	110.4	107.1	105.6	106.5	105.7	105.6	106.8	105.6	106.3

RATIO OF MODEL OFFICE TOTAL RESERVES OVER 21 YEARS ON 1983 TABLE *a* TO 1971  
 IAM TABLE AT 5, 7, AND 9 PERCENT INTEREST

	IMMEDIATE ANNUITIES			MATURED DEFERRED			SETTLEMENT OPTIONS			GRAND TOTAL
	Refund	Non- refund	Total	Refund	Non- refund	Total	Refund	Non- refund	Total	
5% Interest										
Males .....	108.7%	111.6%	109.2%	108.6%	109.5%	108.7%	108.4%	109.5%	108.4%	108.8%
Females .....	111.6	116.2	112.5	111.4	111.7	111.4	110.4	111.1	110.4	111.5
Total .....	110.5	114.6	111.2	110.1	110.9	110.3	109.7	110.2	109.7	110.4
7% Interest										
Males .....	107.9%	110.8%	108.4%	107.7%	108.7%	107.9%	107.6%	108.7%	107.6%	108.0%
Females .....	110.7	115.2	111.6	110.3	110.7	110.4	109.5	110.2	109.5	110.5
Total .....	109.6	113.7	110.3	109.2	110.0	109.3	108.8	109.3	108.8	109.5
9% Interest										
Males .....	107.3%	110.1%	107.7%	107.1%	108.0%	107.2%	106.9%	108.0%	106.9%	107.3%
Females .....	110.0	114.5	110.9	109.5	109.8	109.5	108.7	109.5	108.8	109.8
Total .....	108.9	112.9	109.6	108.4	109.2	108.5	108.0	108.6	108.1	108.8

## FUTURE MORTALITY IMPROVEMENT—SOME GENERAL CONSIDERATIONS

Dr. James M. Fries, in his article "Aging, Natural Death and the Compression of Morbidity,"<sup>4</sup> comments on the interaction between two sets of observations—first, that the length of life is fixed (or may increase at the rate of one month per century) and, second, that chronic disease may be postponed, thus decreasing the period by which one falls short of the expected length of life, which he estimates at around 85. He points out that if one assumes a normal distribution of deaths around such an age, there would be some survivals beyond age 100, but not many would exceed that age. Most of the improvement in survival, Fries points out, has been at the neonatal and younger ages, with relatively little improvement at the older ages, where the chronic diseases are important.

Fries justifies his view of a limit on the length of life mainly on the grounds of loss of organ reserve with increasing age and the consequent inability of the body to restore itself after some threat to its continued health. However, he states that the chronic diseases can be postponed so that not only premature death (i.e., death prior to the expected age) will be prevented or postponed, but also chronic morbidity will be postponed and its duration until death shortened. The reasons, he asserts, lie in effective treatment of hypertension, exercise as an answer to arthritis and heart disease, a decrease in smoking causing a postponement in chronic obstructive pulmonary disorders, and a changing way of life stressing personal choice, all helping to postpone the onset of disabling disease.

According to the Fries viewpoint, we may look to decreases in mortality that will continue but will lessen with increase in age. This concept would favor a set of projection factors much like Projection B. However, this conclusion must be contrasted with the recent decreases in mortality in the United States white population and in the medicare experience.

Further refutation of the idea of little improvement in mortality of the extreme aged appears in Ira Rosenwaike, Nurit Yaffe, and Philip C. Sagi, "The Recent Decline in Mortality of the Extreme Aged: An Analysis of Statistical Data."<sup>5</sup> (Since this article relies on intercensal estimates of the United States population during the 1970s, it should be kept in mind that the populations were understated as noted earlier in this report and consequently the improvement rates during the 1970s may be slightly understated, although probably by a negligible amount at these very high ages.) The authors also make use of medicare data to develop their analyses. According to their analysis of medicare as compared with Census Bureau

<sup>4</sup> *New England Journal of Medicine*, CCCIII, No. 3 (July 17, 1980), 130.

<sup>5</sup> *American Journal of Public Health*, LXX, No. 10 (October, 1980), 1074.

estimates of population, some, but certainly not the greater part, of the substantial drop from 1966 to 1977 among those 85 and over is probably due to age misstatements and other errors. This is illustrated in Table 19, which compares (1) mortality rates and (2) percentage changes in mortality rates, by cause of death, for the United States white population using Census Bureau and medicare data in the denominators of the mortality rates.

Over the period 1968-77, the same cause-of-death coding instructions were in effect, so coding of cause of death would have had no material effect on the decreases noted above. Because diseases of the heart and cerebrovascular disease are together such an important part of the total death rate at these advanced ages, any appreciable improvement in the death rate from these causes would have considerable impact. Rosenwaike et al. attribute to Stamler and others the opinion that the sharp downturn in cardiovascular disease mortality is due to "progress in controlling such risk factors as high saturated fat and cholesterol diets, cigarette smoking and hypertension," which prevents or postpones cardiovascular disease, plus, on the other hand, more effective "emergency, acute and long term care for patients with coronary heart disease and stroke."

Another writer, however, concludes that there is no single cause or combination of causes that accounts for the recent decline in ischemic heart disease. Analyzing the rise in the death rate from 1920 to the 1950s and the sharp decline in the 1970s, Reuel A. Stallones<sup>6</sup> can find nothing to account for the rise and fall, with the possible exception of cigarette smoking, which increased and decreased over the same period. He does not believe that increased exercise, diet control, treatment of hypertension, or better emer-

TABLE 19

1977 DEATH RATES PER 1,000 POPULATION AND ANNUAL PERCENTAGE CHANGE IN DEATH RATE FROM 1968 TO 1977 AMONG PERSONS AGED 85 AND OVER BY MAJOR CAUSE OF DEATH

CAUSE OF DEATH	BASED ON CENSUS BUREAU ESTIMATES				BASED ON MEDICARE DATA			
	White Male		White Female		White Male		White Female	
	Rate	Percent Change	Rate	Percent Change	Rate	Percent Change	Rate	Percent Change
All causes .....	180.4	-2.0%	140.4	-2.8%	183.9	-1.7%	139.8	-2.5%
Diseases of heart ..	84.7	-2.0	69.2	-2.6	86.4	-1.7	68.9	-2.2
Cerebrovascular disease .....	25.1	-3.6	25.3	-3.7	25.6	-3.3	25.2	-3.3
Cancer (all) .....	21.8	+1.0	11.8	-0.8	22.0	+1.3	11.8	-0.4

<sup>6</sup> "The Rise and Fall of Ischemic Heart Disease," *Scientific American*, XXIV, No. 3 (November, 1980), 53.

gency care could have had the widespread effects needed to explain the decline. Even though Stallones cannot cite a logical cause for the decline, he nevertheless believes that the decline is real and not an artifact.

Stallones does, however, note that "the decrease in the risk of death from acute myocardial infarction for women is sharply at odds with the popular supposition that the redefinition of women's roles in American society (in particular their appearance in large numbers in executive offices around the country) will result in redistribution in their pattern of illness. Increases in peptic ulcer and in myocardial infarction are projected and sometimes cited. Since the mortality from peptic ulcer is decreasing as steeply as the mortality from myocardial infarction, the thesis appears to be contradicted by the observations."

In October, 1978, a Conference on the Decline in Coronary Heart Disease Mortality<sup>7</sup> was held to analyze the drop in mortality from various heart-related causes. Some of this analysis is particularly pertinent to the projection of mortality improvement rates after 1983 and will be summarized below.

Harry M. Rosenberg and A. Joan Klebba, in "Trends in Cardiovascular Mortality, with a Focus on Ischemic Heart Disease: United States, 1950-76,"<sup>8</sup> comment that for the total United States population over the period 1968-76 almost every cause of death in the category major cardiovascular diseases "showed substantial reductions in mortality" on an age-adjusted basis. The percentage reductions ranged from 21 percent for ischemic heart disease to 50 percent for hypertensive heart disease and almost as much for hypertension. Only the residual group showed an increase. Table 20 illustrates recent annual changes in mortality for two important

TABLE 20

## ANNUAL CHANGE—UNITED STATES WHITE POPULATION, 1968-76

AGE GROUP	ACUTE MYOCARDIAL INFARCTION		CHRONIC ISCHEMIC HEART DISEASE	
	Male	Female	Male	Female
25-34 .....	-5.0%	-7.7%	+2.2%	+2.8%
35-44 .....	-5.0	-5.6	+ .4	- .3
45-54 .....	-4.3	-3.8	+1.0	- .4
55-64 .....	-3.8	-3.5	- .5	-1.4
65-74 .....	-3.5	-4.2	-1.5	-3.3
75-84 .....	-2.5	-3.0	- .8	-1.9
85 and over .....	-3.9	-4.2	-1.4	-2.2

<sup>7</sup> *Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality*, NIH Publication No. 79-1610 (U.S. Department of Health, Education, and Welfare, May, 1979).

<sup>8</sup> *Ibid.*, p. 11.

categories of heart disease. The importance of Table 20 in future projections of mortality lies in the fact that these two causes account for two-thirds of the total cardiovascular deaths and one-third of the deaths from all causes. It should also be noted that, while the female improvement rates are somewhat greater than male at the older ages for acute myocardial infarction, they are about double for chronic ischemic heart disease, which is the more important of the two at these older ages. At ages under 75, mortality from acute myocardial infarction is much the more important of the two.

Finally, Dr. Nemat O. Borhani, in his discussion "Mortality Trend in Hypertension, United States, 1950-1976,"<sup>9</sup> as another part of the Conference on the Decline in Coronary Heart Disease Mortality, comments that "mortality from hypertension and hypertensive heart disease has declined steadily and dramatically since 1950" and that mortality from the latter cause has dropped during this period by 81 percent; the largest percentage decline was observed among white females, which he claims may be due to higher percentage changes in awareness and control of hypertension among women.

In any case, Dr. Borhani attributes the reduction in mortality not to a decrease in prevalence rates but rather to a much increased public awareness of hypertension and an increase in the percentage of persons with hypertension who were being adequately treated. While the awareness and treatment percentage increase was greatest among white women, there were increases also among the other race/sex groups. Dr. Borhani attributes about 40-48 percent of the decline in mortality to these changes in public awareness, changes in physicians' attitudes, and efficacy of treatment.

If, in fact, the reduction in cardiovascular mortality does reflect improved awareness of and effective treatment for hypertension, then there is a good possibility for further reduction in the death rate, with perhaps, however, a greater effect among race/sex groups other than white females, where the percentages of awareness and treatment are already quite high.

Cancer, in all its forms, presents a less hopeful picture for considerable future improvement, but at the more advanced ages it is not nearly as important as the cardiovascular group of causes of death. In the absence of a breakthrough of some kind, it appears unlikely that there will be any sharp downward shift in mortality from cancer. If smoking declines in the future or if the use and/or effectiveness of low tar/low nicotine cigarettes increases proportionately among those who continue to smoke, there may be future declines in lung cancer, which, when combined with the decline in other cancer mortality, will lead to lower cancer mortality overall. Cer-

<sup>9</sup> *Ibid.*, p. 218.

tainly at the older ages, no significant contribution to any overall reduction in mortality can be expected from the causes grouped under cancer (all forms).

#### MORTALITY PROJECTION BEYOND 1983

The close relationship between the annual improvement rates from the "1963" annuity experience to the 1971-76 annuity experience and that of the corresponding United States white population was noted in the discussion leading to the decision to base the 1973-83 improvement factors mainly on the population experience. In going beyond 1983, recent population experience will be relied upon largely, although other sources will also be referred to in selecting likely improvement rates—for example, recent ordinary insurance experience and the 1980 Social Security Administration projections.

The preceding section discussed at length recent expert opinion on trends in mortality from cardiovascular disease and also included a few comments on changes in cancer death rates, notably on the decrease in mortality from cancer excluding lung cancer. The Statistical Bureau of the Metropolitan Life Insurance Company prepared an analysis of the changes in mortality rates among the United States white population during the period 1968-78 for major causes of death. These analyses corroborated the opinions on heart and circulatory deaths and on cancer deaths. The analyses show substantial decreases with respect to several other important cause-of-death groups.

According to the Statistical Bureau analyses, there were decreases of generally 25-35 percent and more in the death rate from diabetes with higher decreases in the influenza and pneumonia death rates and deaths from bronchitis, emphysema, and asthma. Deaths from accidents decreased about 20-35 percent at ages over 39 and at the childhood ages. The mortality of young adults either worsened or did not show appreciable change during the period. The suicide death rate increased considerably at the young adult and teen years. Homicides were up substantially over a wide range of ages.

It would appear likely that the distribution by cause of death for annuitants would be quite different from that of the United States population. Just the difference in average socioeconomic level between the two groups could have an effect. Unfortunately, no cause-of-death analysis is available for annuitants, and consequently any projection for the future will have to be on the basis of a judicious weighing of the relation of change in mortality by cause to total change in the mortality of annuitants. In any case the reasonableness of the set of future mortality improvement factors must rest

on their relationship to changes by cause of death. A projection of future United States mortality using cause-of-death analyses was used in the 1980 projection of United States social security populations.<sup>10</sup> The result of using this method was computed by the committee and appears in Table 21.

Admittedly, a change in the average socioeconomic status of annuitants could have a significant effect on the future mortality experienced under annuities, as could a lessening of self-selection in the purchase of an annuity or in the decision to take the value of a matured deferred annuity or settlement option in the form of a refund or nonrefund annuity. While it is not possible to estimate changes of this type, it seems reasonable to assume that under the newly adopted tax laws in the United States there may well be additional incentives for the use of annuities as retirement savings vehicles. Certainly there would appear to be no reason to assume increasing annuitant selection in purchasing annuities. Accordingly, the prime forces affecting annuitant mortality would seem to be those influences that affect the mortality of the population as a whole.

TABLE 21

PROJECTED UNITED STATES POPULATION MORTALITY RATES DERIVED FROM  
IMPROVEMENT FACTORS BY CAUSE  
USED IN SSA ACTUARIAL STUDY NO. 82 PROJECTIONS (ALTERNATIVE II)

AGE	1977 MORTALITY RATE/ 100,000		MORTALITY RATE/ 100,000 PROJECTED 10 YEARS		IMPLIED ANNUAL IMPROVEMENT RATE	
	Male	Female	Male	Female	Male	Female
0 .....	1,659.0	1,303.5	1,299.2	1,013.4	2.42%	2.49%
1-4 .....	76.5	60.8	62.3	47.9	2.03	2.36
5-9 .....	40.6	27.1	33.1	21.1	2.02	2.47
10-14 .....	44.4	25.5	37.1	19.8	1.78	2.50
15-19 .....	145.7	56.4	128.7	47.0	1.23	1.81
20-24 .....	201.9	65.3	179.7	53.7	1.16	1.94
25-29 .....	193.9	71.4	167.9	55.5	1.43	2.49
30-34 .....	193.2	90.0	160.0	67.9	1.87	2.78
35-39 .....	259.5	134.8	205.7	100.4	2.30	2.90
40-44 .....	393.3	220.6	304.1	167.8	2.54	2.70
45-49 .....	625.8	345.8	484.5	274.8	2.53	2.27
50-54 .....	998.7	528.7	787.5	433.2	2.35	1.97
55-59 .....	1,524.3	785.1	1,230.3	661.3	2.12	1.70
60-64 .....	2,431.1	1,216.5	2,018.1	1,033.1	1.84	1.62
65-69 .....	3,473.5	1,691.2	2,968.2	1,433.3	1.56	1.64
70-74 .....	5,319.9	2,766.7	4,681.3	2,313.3	1.27	1.77
75-79 .....	8,153.1	4,739.7	7,356.5	3,899.5	1.02	1.93
80-84 .....	11,363.7	7,393.6	10,456.6	5,972.2	.83	2.11

<sup>10</sup> *United States Population Projections for OASDI Cost Estimates, 1980*, Actuarial Study No. 82, SSA Publication No. 11-11529 (U.S. Department of Health and Human Services, June, 1980).

PROPOSED MORTALITY IMPROVEMENT FACTORS  
BEYOND 1983

From the foregoing discussions, it is reasonable to state that, for the foreseeable future, mortality at most ages will continue to improve. While nothing in the way of a "breakthrough" in the treatment of cancer or heart and circulatory diseases is indicated or assumed, continuation of and improvement in current detection and treatment methods will almost certainly result in continued decreases in death rates from these diseases, although probably not at the levels of the 1970s. There are indications of continued progress in prevention and treatment of other diseases also.

Mortality in the teen years and in the twenties largely reflects life-style, and there is nothing to indicate any great change from current levels. At the childhood ages, some future improvement should be expected, but probably not at a rate as high as in the 1970s.

As the United States population mortality experience of 1980 (see Table 12) indicates, there will also be periods of somewhat increased mortality, especially in years of influenza epidemics. Any set of future improvement rates must take into consideration that there will be periods of retrogression and no improvement in addition to periods of greater than average improvement.

The discussion relative to Table 4 indicated not only a trend toward increased immediate annuity in-forces but also a trend toward a greater proportion of refund annuities. The latter trend and the recent United States tax legislation portend the probability of less self-selection by annuitants (but see Appendix B). If this continues, it could act to reduce the rate of improvement in overall annuitant mortality. The set of improvement factors identified as Projection Scale G in Table 22 is intended to reflect probable average improvement rates through the next decade or so. Table 22 also shows some other improvement rates for comparison purposes.

The Projection Scale G factors are generally somewhat lower than those used to obtain the 1983 Basic Table from the 1973 Experience Table, except that some small improvement is anticipated in the teens and young adult years. Improvement rates for males are somewhat lower than those for females. (The projection factors used to obtain the 1983 Basic Table were the same for males and females. As noted earlier in this report, this was because the committee, in reviewing a set of improvement rates that were different for males and females, felt that the differences were not significant considering the nature of the underlying data and were not sufficient to justify separate improvement rates over a relatively short period.)

The Projection Scale G improvement rates continue to ages in the 90s at rates of 1.25 percent for females and 1.00 percent for males; increase slightly

down to the 40s, where the rates are 2.25 percent and 2.00 percent for females and males, respectively; and then decrease rapidly to very low rates in the teen years for males. The rates have been set at a level that should keep the 1983 Table *a* (with projection) reasonably up to date during the remainder of the century but not cause it to become unduly conservative.

TABLE 22

COMPARISON OF ANNUAL MORTALITY IMPROVEMENT RATES

Age	Improvement Factors Used to Derive 1983 Table <i>a</i>	Derived Factors from SSA Actuarial Study No. 82 (Alternative II)	U.S. White Population 1973-80 (Metropolitan Life Statistical Bureau)	Projection G beyond 1983
Males				
7 .....	2.00%	2.02%	} .2%	1.50
12 .....	0	1.78		} .7
17 .....	0	1.23	} .1	
22 .....	0	1.16		} 2.6
27 .....	0	1.43	} 1.6	
32 .....	1.00	1.87		} 2.0
37 .....	2.25	2.30	} 2.3	
42 .....	2.25	2.54		} 2.0
47 .....	2.25	2.53	} 2.1	
52 .....	2.25	2.35		} 2.1
57 .....	2.25	2.12	} 2.0	
62 .....	2.25	1.84		} 2.0
67 .....	2.25	1.56	} 2.1	
72 .....	2.25	1.27		} 2.1
77 .....	2.00	1.02	} 2.1	
82 .....	1.75	.83		} 2.1
87 .....	1.50	.....	} 2.1	
92 .....	1.50	.....		} 2.1
97 .....	1.50	.....	} 2.1	
Females				
7 .....	2.00%	2.47%	} 2.1%	1.50
12 .....	0	2.50		} .8
17 .....	0	1.81	} 2.3	
22 .....	0	1.94		} 2.9
27 .....	0	2.49	} 2.9	
32 .....	1.00	2.78		} 1.1
37 .....	2.25	2.90	} 1.5	
42 .....	2.25	2.70		} 1.6
47 .....	2.25	2.27	} 1.6	
52 .....	2.25	1.97		} 2.6
57 .....	2.25	1.70	} 2.6	
62 .....	2.25	1.62		} 2.6
67 .....	2.25	1.64	} 2.6	
72 .....	2.25	1.77		} 2.6
77 .....	2.00	1.93	} 2.6	
82 .....	1.75	2.11		} 2.6
87 .....	1.50	.....	} 2.6	
92 .....	1.50	.....		} 2.6
97 .....	1.50	.....	} 2.6	

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## APPENDIX A

TABLE A1

1983 TABLE A: ELEMENTARY VALUES

MALE LIVES

Age x	$l_x$	$d_x$	Age x	$l_x$	$d_x$
5	10,000.0000	3.7700	61	8,938.6298	80.2957
6	9,996.2300	3.4987	62	8,858.3341	86.2802
7	9,992.7313	3.3276	63	8,772.0539	93.2469
8	9,989.4037	3.5163	64	8,678.8070	101.2296
9	9,985.8874	3.6748	65	8,577.5774	110.2304
10	9,982.2126	3.8132	66	8,467.3470	120.2279
11	9,978.3994	3.9315	67	8,347.1191	131.1917
12	9,974.4679	4.0397	68	8,215.9274	143.0722
13	9,970.4282	4.1377	69	8,072.8552	155.7738
14	9,966.2905	4.2357	70	7,917.0814	169.1959
15	9,962.0548	4.3335	71	7,747.8855	183.2142
16	9,957.7213	4.4411	72	7,564.6713	197.6724
17	9,953.2802	4.5586	73	7,366.9989	212.4274
18	9,948.7216	4.6958	74	7,154.5715	227.4724
19	9,944.0258	4.8527	75	6,927.0991	242.7671
20	9,939.1731	5.0193	76	6,684.3320	258.2224
21	9,934.1538	5.2154	77	6,426.1096	273.6687
22	9,928.9384	5.4212	78	6,152.4409	288.8633
23	9,923.5172	5.6564	79	5,863.5776	303.4695
24	9,917.8608	5.9110	80	5,560.1081	317.0707
25	9,911.9498	6.1652	81	5,243.0374	329.2156
26	9,905.7846	6.4388	82	4,913.8218	339.4517
27	9,899.3458	6.7019	83	4,574.3701	347.2313
28	9,892.6439	6.9644	84	4,227.1388	351.8248
29	9,885.6795	7.2264	85	3,875.3140	352.6032
30	9,878.4531	7.4977	86	3,522.7108	349.1781
31	9,870.9554	7.7586	87	3,173.5327	341.3991
32	9,863.1968	8.0286	88	2,832.1336	329.4225
33	9,855.1682	8.3079	89	2,502.7111	313.8250
34	9,846.8603	8.6258	90	2,188.8861	295.2523
35	9,838.2345	9.0217	91	1,893.6338	274.3364
36	9,829.2128	9.5147	92	1,619.2974	251.6858
37	9,819.6981	10.1339	93	1,367.6116	227.8838
38	9,809.5642	10.9279	94	1,139.7278	203.4836
39	9,798.6363	11.9151	95	936.24420	179.02300
40	9,786.7212	13.1240	96	757.22120	155.01908
41	9,773.5972	14.5822	97	602.20212	131.95453
42	9,759.0150	16.3268	98	470.24759	110.38357
43	9,742.6882	18.3747	99	359.86402	90.64579
44	9,724.3135	20.7031	100	269.21823	72.93283
45	9,703.6104	23.2790	101	196.28540	57.33712
46	9,680.3314	26.0691	102	138.94828	43.88348
47	9,654.2623	29.0497	103	95.064800	32.548001
48	9,625.2126	32.1771	104	62.516799	23.261626
49	9,593.0355	35.4367	105	39.255173	15.909258
50	9,557.5988	38.7752	106	23.345915	10.325361
51	9,518.8236	42.1779	107	13.020554	6.294214
52	9,476.6457	45.6016	108	6.7263400	3.5581599
53	9,431.0441	49.0226	109	3.1681801	1.8354883
54	9,382.0215	52.4549	110	1.3326918	.8460114
55	9,329.5666	55.9214	111	.48668040	.33858550
56	9,273.6452	59.4348	112	.14809490	.11289910
57	9,214.2104	63.0160	113	.035195800	.029390464
58	9,151.1944	66.7122	114	.005805336	.005307047
59	9,084.4822	70.6954	115	.000498289	.000498289
60	9,013.7868	75.1570			

TABLE A1—Continued

## FEMALE LIVES

Age $x$	$l_x$	$d_x$	Age $x$	$l_x$	$d_x$
5	10,000.0000	1.9400	61	9,458.3686	46.4217
6	9,998.0600	1.5997	62	9,411.9469	50.9469
7	9,996.4603	1.3395	63	9,361.0000	56.0724
8	9,995.1208	1.3393	64	9,304.9276	61.7196
9	9,993.7815	1.3592	65	9,243.2080	67.8082
10	9,992.4223	1.4089	66	9,175.3998	74.2290
11	9,991.0134	1.4687	67	9,101.1708	80.8912
12	9,989.5447	1.5484	68	9,020.2796	87.7763
13	9,987.9963	1.6480	69	8,932.5033	95.1580
14	9,986.3483	1.7476	70	8,837.3453	103.3704
15	9,984.6007	1.8771	71	8,733.9749	112.7119
16	9,982.7236	2.0065	72	8,621.2630	123.4479
17	9,980.7171	2.1359	73	8,497.8151	135.7951
18	9,978.5812	2.2851	74	8,362.0200	149.7554
19	9,976.2961	2.4342	75	8,212.2646	165.2882
20	9,973.8619	2.5932	76	8,046.9764	182.2962
21	9,971.2687	2.7521	77	7,864.6802	200.6201
22	9,968.5166	2.9208	78	7,664.0601	220.0888
23	9,965.5958	3.0993	79	7,443.9713	240.6487
24	9,962.4965	3.2876	80	7,203.3226	262.1649
25	9,959.2089	3.4758	81	6,941.1577	284.4139
26	9,955.7331	3.6637	82	6,656.7438	307.0157
27	9,952.0694	3.8515	83	6,349.7281	329.4810
28	9,948.2179	4.0290	84	6,020.2471	351.1971
29	9,944.1889	4.2064	85	5,669.0500	371.4248
30	9,939.9825	4.3835	86	5,297.6252	389.3384
31	9,935.5990	4.5704	87	4,908.2868	404.0404
32	9,931.0286	4.7570	88	4,504.2464	414.4672
33	9,926.2716	4.9532	89	4,089.7792	419.1656
34	9,921.3184	5.1690	90	3,670.6136	417.0001
35	9,916.1494	5.4043	91	3,253.6135	407.4403
36	9,910.7451	5.6888	92	2,846.1732	390.5576
37	9,905.0563	6.0124	93	2,455.6156	367.0212
38	9,899.0439	6.3948	94	2,088.5944	338.0056
39	9,892.6491	6.8358	95	1,750.5888	305.0016
40	9,885.8133	7.3353	96	1,445.5872	269.6526
41	9,878.4780	7.9127	97	1,175.9346	233.5947
42	9,870.5653	8.5578	98	942.33990	198.92984
43	9,862.0075	9.2900	99	743.41006	166.85467
44	9,852.7175	10.1089	100	576.55539	137.92070
45	9,842.6086	11.0434	101	438.63469	112.26986
46	9,831.5652	12.1027	102	326.36483	89.81593
47	9,819.4625	13.3152	103	236.54890	70.37330
48	9,806.1473	14.6994	104	166.17560	53.73953
49	9,791.4479	16.2244	105	112.43607	39.73648
50	9,775.2235	17.8887	106	72.699590	28.215511
51	9,757.3348	19.6708	107	44.484079	19.040209
52	9,737.6640	21.5689	108	25.443870	12.052558
53	9,716.0951	23.5712	109	13.391312	7.039250
54	9,692.5239	25.6852	110	6.3520620	3.7125389
55	9,666.8387	27.9468	111	2.6395231	1.7173951
56	9,638.8919	30.3721	112	.92212800	.66831227
57	9,608.5198	32.9764	113	.25381573	.20490950
58	9,575.5434	35.8030	114	.048906230	.043961077
59	9,539.7404	38.9317	115	.004945153	.004945153
60	9,500.8087	42.4401			

TABLE A2

1983 TABLE A: STANDARD COMMUTATION COLUMNS  
MALE LIVES—5 PERCENT INTEREST

Age $x$	$D_x$	$N_x$	Age $x$	$D_x$	$N_x$
5	7,835.2617	158,217.5113	61	455.74688	5,961.92871
6	7,459.3407	150,382.2496	62	430.14563	5,506.18183
7	7,101.6476	142,922.9089	63	405.67239	5,076.03620
8	6,761.2216	135,821.2613	64	382.24771	4,670.36381
9	6,436.9921	129,060.0397	65	359.79921	4,288.11610
10	6,128.2126	122,623.0476	66	338.26232	3,928.31689
11	5,834.1635	116,494.8350	67	317.58031	3,590.05457
12	5,554.1570	110,660.6715	68	297.70372	3,272.47426
13	5,287.5309	105,106.5145	69	278.59000	2,974.77054
14	5,033.6539	99,818.9836	70	260.20412	2,696.18054
15	4,791.9187	94,785.3297	71	242.51743	2,435.97642
16	4,561.7469	89,993.4110	72	225.50726	2,193.45899
17	4,342.5832	85,431.6641	73	209.15670	1,967.95173
18	4,133.8993	81,089.0809	74	193.45301	1,758.79503
19	3,935.1887	76,955.1816	75	178.38321	1,565.34202
20	3,745.9698	73,019.9929	76	163.93485	1,386.95881
21	3,565.7887	69,274.0231	77	150.09703	1,223.02396
22	3,394.2063	65,708.2344	78	136.86176	1,072.92693
23	3,230.8125	62,314.0281	79	124.22473	936.06517
24	3,075.2104	59,083.2156	80	112.18617	811.84044
25	2,927.0262	56,008.0052	81	100.75108	699.65427
26	2,785.9101	53,080.9790	82	89.928403	598.903187
27	2,651.5231	50,295.0689	83	79.729580	508.974784
28	2,523.5505	47,643.5458	84	70.169016	429.245204
29	2,401.6895	45,119.9953	85	61.265570	359.076188
30	2,285.6513	42,718.3058	86	53.039237	297.810618
31	2,175.1585	40,432.6545	87	45.506555	244.771381
32	2,069.9513	38,257.4960	88	38.677235	199.264826
33	1,969.7775	36,187.5447	89	32.550908	160.587591
34	1,874.3971	34,217.7672	90	27.113541	128.036683
35	1,783.5763	32,343.3701	91	22.339311	100.923142
36	1,697.0865	30,559.7938	92	18.193284	78.583831
37	1,614.7083	28,862.7073	93	14.633829	60.390547
38	1,536.2304	27,247.9990	94	11.614674	45.756718
39	1,461.4467	25,711.7686	95	9.0866903	34.1420445
40	1,390.1615	24,250.3219	96	6.9992266	25.0553542
41	1,322.1879	22,860.1604	97	5.3012742	18.0561276
42	1,257.3478	21,537.9725	98	3.9425324	12.7548534
43	1,195.4707	20,280.6247	99	2.8734115	8.8123210
44	1,136.3963	19,085.1540	100	2.0472673	5.9389095
45	1,079.9780	17,948.7577	101	1.4215718	3.8916422
46	1,026.0829	16,868.7797	102	.95839529	2.47007037
47	974.59020	15,842.69681	103	.62448489	1.51167508
48	925.38824	14,868.10661	104	.39111964	887.19019
49	878.37587	13,942.71837	105	.23389476	.49607055
50	833.45824	13,064.34250	106	.13247844	.26217579
51	790.54942	12,230.88426	107	.070367879	.129697346
52	749.56809	11,440.33484	108	.034620594	.059329467
53	710.43921	10,690.76675	109	.015530172	.024708873
54	673.09176	9,980.32754	110	.006221668	.009178701
55	637.45572	9,307.23578	111	.002163872	.002957033
56	603.46172	8,669.78006	112	.000627103	.000793161
57	571.04203	8,066.31834	113	.000141938	.000166058
58	540.13017	7,495.27631	114	.000022297	.000024120
59	510.65964	6,955.14614	115	.000001823	.000001823
60	482.55779	6,444.48650			

TABLE A2—Continued

## FEMALE LIVES—5 PERCENT INTEREST

Age $x$	$D_x$	$N_x$	Age $x$	$D_x$	$N_x$
5	7,835.2617	159,980.1174	61	482.24640	6,924.10777
6	7,460.7063	152,144.8557	62	457.02812	6,441.86137
7	7,104.2977	144,684.1494	63	432.90879	5,984.83325
8	6,765.0912	137,579.8517	64	409.82444	5,551.92446
9	6,442.0807	130,814.7605	65	387.72007	5,142.10002
10	6,134.4805	124,372.6798	66	366.54834	4,754.37995
11	5,841.5386	118,238.1993	67	346.26949	4,387.83161
12	5,562.5523	112,396.6607	68	326.84938	4,041.56212
13	5,296.8477	106,834.1084	69	308.25601	3,714.71274
14	5,043.7845	101,537.2607	70	290.44967	3,406.45673
15	4,802.7637	96,493.4762	71	273.38313	3,116.00706
16	4,573.2007	91,690.7125	72	257.00487	2,842.62393
17	4,354.5538	87,117.5118	73	241.26173	2,585.61906
18	4,146.3066	82,762.9580	74	226.10131	2,344.35733
19	3,947.9591	78,616.6514	75	211.47815	2,118.25602
20	3,759.0437	74,668.6923	76	197.35403	1,906.77787
21	3,579.1108	70,909.6486	77	183.69826	1,709.42384
22	3,407.7361	67,330.5378	78	170.48791	1,525.72558
23	3,244.5120	63,922.8017	79	157.70667	1,355.23767
24	3,089.0505	60,678.2897	80	145.34127	1,197.53100
25	2,940.9820	57,589.2392	81	133.38245	1,052.18973
26	2,799.9577	54,648.2572	82	121.82581	918.80728
27	2,665.6451	51,848.2995	83	110.67341	796.98147
28	2,537.7271	49,182.6544	84	99.933983	686.308064
29	2,415.9041	46,644.9273	85	89.623080	586.374081
30	2,299.8878	44,229.0232	86	79.763005	496.751001
31	2,189.4034	41,929.1354	87	70.381888	416.987996
32	2,084.1869	39,739.7320	88	61.512563	346.606108
33	1,983.9891	37,655.5451	89	53.192726	285.093545
34	1,888.5706	35,671.5560	90	45.467571	231.900819
35	1,797.7016	33,782.9854	91	38.383073	186.433248
36	1,711.1636	31,985.2838	92	31.977596	148.050175
37	1,628.7442	30,274.1202	93	26.275777	116.072579
38	1,550.2434	28,645.3760	94	21.284331	89.796802
39	1,475.4685	27,095.1326	95	16.990288	68.512471
40	1,404.2371	25,619.6641	96	13.362004	51.522183
41	1,336.3763	24,215.4270	97	10.351926	38.160179
42	1,271.7199	22,879.0507	98	7.9005308	27.8082528
43	1,210.1117	21,607.3308	99	5.9359171	19.9077220
44	1,151.4017	20,397.2191	100	4.3844097	13.9718049
45	1,095.4480	19,245.8174	101	3.1767553	9.5873952
46	1,042.1132	18,150.3694	102	2.2511003	6.4106399
47	991.26703	17,108.25620	103	1.5539002	4.1595396
48	942.78368	16,116.98917	104	1.0396332	2.6056394
49	896.54329	15,174.20549	105	.66992974	1.56600618
50	852.43592	14,277.66220	106	.41254019	.89607644
51	810.35806	13,425.22628	107	.24040838	.48353625
52	770.21369	12,614.86822	108	.13096006	.24312787
53	731.91207	11,844.65453	109	.065643168	.112167806
54	695.36805	11,112.74246	110	.029654584	.046524638
55	660.50031	10,417.37441	111	.011735815	.016870054
56	627.22934	9,756.87410	112	.003904718	.005134239
57	595.47899	9,129.64476	113	.001023594	.001229521
58	565.17648	8,534.16577	114	.000187838	.000205927
59	536.25075	7,968.98929	115	.000018089	.000018089
60	508.63077	7,432.73854			

TABLE A3

1983 TABLE A: STANDARD COMMUTATION COLUMNS  
MALE LIVES—7 PERCENT INTEREST

Age <i>x</i>	<i>D<sub>x</sub></i>	<i>N<sub>x</sub></i>	Age <i>x</i>	<i>D<sub>x</sub></i>	<i>N<sub>x</sub></i>
5	7,129.8618	107,335.0733	61	144.16522	1,598.89706
6	6,660.9101	100,205.2115	62	133.52354	1,454.73184
7	6,222.9708	93,544.3014	63	123.57292	1,321.20830
8	5,813.9239	87,321.3306	64	114.26106	1,197.63538
9	5,431.6611	81,507.4067	65	105.54049	1,083.37432
10	5,074.4507	76,075.7456	66	97.368399	977.833829
11	4,740.6657	71,001.2949	67	89.706416	880.465430
12	4,428.7830	66,260.6292	68	82.520093	790.759014
13	4,137.3732	61,831.8462	69	75.778587	708.238921
14	3,865.0993	57,694.4730	70	69.454545	632.460334
15	3,610.7071	53,829.3737	71	63.523582	563.005789
16	3,373.0247	50,218.6666	72	57.963963	499.482207
17	3,150.9536	46,845.6419	73	52.756361	441.518244
18	2,943.4677	43,694.6883	74	47.883301	388.761883
19	2,749.6060	40,751.2206	75	43.327943	340.878582
20	2,568.4712	38,001.6146	76	39.074273	297.550639
21	2,399.2281	35,433.1434	77	35.107285	258.476366
22	2,241.0921	33,033.9153	78	31.413244	223.369081
23	2,093.3350	30,792.8232	79	27.979776	191.955837
24	1,955.2727	28,699.4882	80	24.795965	163.976061
25	1,826.2686	26,744.2155	81	21.852290	139.180096
26	1,705.7315	24,917.9469	82	19.140339	117.327806
27	1,593.1054	23,212.2154	83	16.652435	98.187467
28	1,487.8755	21,619.1100	84	14.381665	81.535032
29	1,389.5589	20,131.2345	85	12.322130	67.153367
30	1,297.7039	18,741.6756	86	10.468202	54.831237
31	1,211.8869	17,443.9717	87	8.8136199	44.3630346
32	1,131.7143	16,232.0848	88	7.3509133	35.5494147
33	1,056.8160	15,100.3705	89	6.0709199	28.1985014
34	986.84589	14,043.55452	90	4.9623018	22.1275815
35	921.47796	13,056.70863	91	4.0121044	17.1652797
36	860.40463	12,135.23067	92	3.2064101	13.1531753
37	803.33809	11,274.82604	93	2.5308794	9.9467652
38	750.00846	10,471.48795	94	1.9711789	7.4158858
39	700.16163	9,721.47949	95	1.5133182	5.4447069
40	653.56097	9,021.31786	96	1.1438791	3.9313887
41	609.98556	8,367.75689	97	.85018971	2.78750964
42	569.22940	7,757.77133	98	.62046368	1.93731993
43	531.10008	7,188.54193	99	.44375620	1.31685625
44	495.41909	6,657.44185	100	.31026065	.87310005
45	462.02274	6,162.02276	101	.21141045	.56283940
46	430.76107	5,700.00002	102	.13986461	.35142895
47	401.49630	5,269.23895	103	.089431525	.211564336
48	374.10111	4,867.74265	104	.054964699	.122132811
49	348.45841	4,493.64154	105	.032255237	.067168112
50	324.45906	4,145.18313	106	.017927943	.034912875
51	302.00255	3,820.72406	107	.009344698	.016984932
52	280.99475	3,518.72152	108	.004511602	.007640234
53	261.34823	3,237.72677	109	.001985995	.003128632
54	242.98106	2,976.37854	110	.000780754	.00142637
55	225.81547	2,733.39748	111	.000266468	.000361883
56	209.77751	2,507.58201	112	.000075780	.000095415
57	194.79724	2,297.80450	113	.000016832	.000019635
58	180.80843	2,103.00726	114	.000002595	.000002803
59	167.74798	1,922.19883	115	.000000208	.000000208
60	155.55380	1,754.45085			

TABLE A3—Continued

## FEMALE LIVES—7 PERCENT INTEREST

Age x	$D_x$	$N_x$	Age x	$D_x$	$N_x$
5	7,129.8618	107,967.7216	61	152.54775	1,827.80655
6	6,662.1295	100,837.8598	62	141.86826	1,675.25880
7	6,225.2931	94,175.7303	63	131.86947	1,533.39054
8	5,817.2513	87,950.4372	64	122.50427	1,401.52107
9	5,435.9550	82,133.1859	65	113.73056	1,279.01680
10	5,079.6408	76,697.2309	66	105.51050	1,165.28624
11	4,746.6585	71,617.5901	67	97.810203	1,059.775745
12	4,435.4773	66,870.9316	68	90.598940	961.965542
13	4,144.6634	62,435.4543	69	83.847965	871.366602
14	3,872.8780	58,290.7909	70	77.527787	787.518637
15	3,618.8788	54,417.9129	71	71.608359	709.990850
16	3,381.4939	50,799.0341	72	66.060050	638.382491
17	3,159.6394	47,417.5402	73	60.854333	572.322441
18	2,952.3021	44,257.9008	74	55.964374	511.468108
19	2,758.5290	41,305.5987	75	51.366457	455.503734
20	2,577.4354	38,547.0697	76	47.039817	404.137277
21	2,408.1919	35,969.6343	77	42.966521	357.097460
22	2,250.0254	33,561.4424	78	39.131297	314.130939
23	2,102.2114	31,311.4170	79	35.521087	274.999642
24	1,964.0725	29,209.2056	80	32.124076	239.478555
25	1,834.9760	27,245.1331	81	28.929832	207.354479
26	1,714.3324	25,410.1571	82	25.929376	178.424647
27	1,601.5902	23,695.8247	83	23.115409	152.495271
28	1,496.2340	22,094.2345	84	20.482218	129.379862
29	1,397.7832	20,598.0005	85	18.025577	108.897644
30	1,305.7868	19,200.2173	86	15.742596	90.872067
31	1,219.8234	17,894.4305	87	13.631425	75.129471
32	1,139.4974	16,674.6071	88	11.690947	61.498046
33	1,064.4407	15,535.1097	89	9.9207304	49.8070987
34	994.30803	14,470.66900	90	8.3214437	39.8863683
35	928.77570	13,476.36097	91	6.8935383	31.5649246
36	867.54160	12,547.58527	92	5.6357767	24.6713863
37	810.32115	11,680.04367	93	4.5443216	19.0356096
38	756.84980	10,869.72252	94	3.6122600	14.4912880
39	706.87932	10,112.87272	95	2.8296014	10.8790280
40	660.17838	9,405.99340	96	2.1837436	8.0494266
41	616.53133	8,745.81502	97	1.6601859	5.8656830
42	575.73597	8,129.28369	98	1.2433614	4.2054971
43	537.60449	7,553.54772	99	.91671522	2.96213570
44	501.96081	7,015.94323	100	.66445147	2.04542048
45	468.64093	6,513.98242	101	.47243431	1.38096901
46	437.49077	6,045.34149	102	.32851714	.90853470
47	408.36655	5,607.85072	103	.22253167	.58001756
48	381.13347	5,199.48417	104	.14610140	.35748589
49	355.66556	4,818.35070	105	.092386603	.211384491
50	331.84694	4,462.68514	106	.055827930	.118997888
51	309.56977	4,130.83820	107	.031925697	.063169958
52	288.73428	3,821.26843	108	.017066135	.031244261
53	269.24741	3,532.53415	109	.008394433	.014178126
54	251.02264	3,263.28674	110	.003721339	.005783693
55	233.97890	3,012.26410	111	.001445194	.002062354
56	218.03969	2,778.28520	112	.000471855	.000617160
57	203.13332	2,560.24551	113	.000121381	.000145305
58	189.19268	2,357.11219	114	.000021858	.000023924
59	176.15447	2,167.91951	115	.000002066	.000002066
60	163.95849	1,991.76504			

TABLE A4

1983 TABLE A: STANDARD COMMUTATION COLUMNS:  
MALE LIVES—9 PERCENT INTEREST

Age $x$	$D_x$	$N_x$	Age $x$	$D_x$	$N_x$
5	6,499.3139	78,104.1672	61	46.585909	447.348154
6	5,960.4253	71,604.8533	62	42.355439	400.762245
7	5,466.3662	65,644.4280	63	38.479722	358.406806
8	5,013.3449	60,178.0618	64	34.927231	319.927084
9	4,597.7800	55,164.7169	65	31.669578	284.999853
10	4,216.5945	50,566.9369	66	28.681278	253.330275
11	3,866.9576	46,350.3424	67	25.939479	224.648997
12	3,546.2697	42,483.3848	68	23.423659	198.709518
13	3,252.1408	38,937.1151	69	21.115375	175.285859
14	2,982.3772	35,684.9743	70	18.998104	154.170484
15	2,734.9630	32,702.5971	71	17.056968	135.172380
16	2,508.0489	29,967.6341	72	15.278552	118.115412
17	2,299.9361	27,459.5852	73	13.650742	102.836860
18	2,109.0667	25,159.6491	74	12.162498	89.186118
19	1,934.0103	23,050.5824	75	10.803490	77.023620
20	1,773.4555	21,116.5721	76	9.5641013	66.2201303
21	1,626.2017	19,343.1166	77	8.4354409	56.6560290
22	1,491.1449	17,716.9149	78	7.4093585	48.2205881
23	1,367.2759	16,225.7700	79	6.4784236	40.8112296
24	1,253.6666	14,858.4941	80	5.6359016	34.3328060
25	1,149.4674	13,604.8275	81	4.8756960	28.6969044
26	1,053.9013	12,455.3601	82	4.1922442	23.8212084
27	966.25343	11,401.45882	83	3.5804035	19.6289642
28	885.87090	10,435.20539	84	3.0354332	16.0485607
29	812.15344	9,549.33449	85	2.5530221	13.0131275
30	744.55023	8,737.18105	86	2.1291103	10.4601054
31	682.55516	7,992.63082	87	1.7596960	8.3309951
32	625.70520	7,310.07566	88	1.4407277	6.5712991
33	573.57420	6,684.37046	89	1.1680257	5.1305714
34	525.77126	6,110.79626	90	.93721310	3.96254570
35	481.93641	5,585.02500	91	.74384883	3.02533260
36	441.73805	5,103.08859	92	.58356442	2.28148377
37	404.87197	4,661.35054	93	.45216659	1.69791935
38	371.05885	4,256.47857	94	.34570872	1.24575276
39	340.04173	3,885.41972	95	.26053846	.90004404
40	311.58554	3,545.37799	96	.19332097	.63950558
41	285.47496	3,233.79245	97	.14104964	.44618461
42	261.51287	2,948.31749	98	.10104848	.30513497
43	239.51868	2,686.80462	99	.070943912	.204086494
44	219.32748	2,447.28594	100	.048691670	.133142582
45	200.78947	2,227.95846	101	.032569546	.084450912
46	183.76861	2,027.16899	102	.021151949	.051881366
47	168.14103	1,843.40038	103	.013276709	.030729417
48	153.79366	1,675.25935	104	.008010156	.017452708
49	140.62342	1,521.46569	105	.004614393	.009442552
50	128.53574	1,380.84227	106	.002517689	.004828159
51	117.44428	1,252.30653	107	.001288232	.002310470
52	107.26962	1,134.86225	108	.000610544	.001022238
53	97.938937	1,027.592630	109	.000263828	.000411694
54	89.385183	929.653693	110	.000101816	.000147866
55	81.546267	840.268510	111	.000034112	.000046050
56	74.364659	758.722243	112	.000009523	.000011938
57	67.787207	684.357584	113	.000002076	.000002415
58	61.764780	616.570377	114	.000000314	.000000339
59	56.251849	554.805597	115	.000000025	.000000025
60	51.205594	498.553748			

TABLE A4—Continued

## FEMALE LIVES—9 PERCENT INTEREST

Age x	$D_x$	$N_x$	Age x	$D_x$	$N_x$
5	6,499.3139	78,385.1417	61	49.294658	504.984617
6	5,961.5165	71,885.8278	62	45.002495	455.689959
7	5,468.4061	65,924.3113	63	41.063208	410.687464
8	5,016.2141	60,455.9052	64	37.447009	369.624256
9	4,601.4146	55,439.6911	65	34.127177	332.177247
10	4,220.9072	50,838.2765	66	31.079651	298.050070
11	3,871.8459	46,617.3693	67	28.282767	266.970419
12	3,551.6300	42,745.5234	68	25.716872	238.687652
13	3,257.8711	39,193.8934	69	23.363872	212.970780
14	2,988.3794	35,936.0223	70	21.206401	189.606908
15	2,741.1527	32,947.6429	71	19.227844	168.400507
16	2,514.3462	30,206.4902	72	17.412577	149.172663
17	2,306.2760	27,692.1440	73	15.746097	131.760086
18	2,115.3967	25,385.8680	74	14.215114	116.013989
19	1,940.2865	23,270.4713	75	12.807831	101.798875
20	1,779.6451	21,330.1848	76	11.513805	88.991044
21	1,632.2774	19,550.5397	77	10.323827	77.477239
22	1,497.0889	17,918.2623	78	9.2297952	67.1534118
23	1,373.0736	16,421.1734	79	8.2245350	57.9236166
24	1,259.3088	15,048.0998	80	7.3015158	49.6990816
25	1,154.9479	13,788.7910	81	6.4548414	42.3975658
26	1,059.2154	12,633.8431	82	5.6792242	35.9427244
27	971.39967	11,574.62776	83	4.9699933	30.2635002
28	890.84746	10,603.22809	84	4.3230324	25.2935069
29	816.96025	9,712.38063	85	3.7347193	20.9704745
30	749.18777	8,895.42038	86	3.2018605	17.2357552
31	687.02512	8,146.23261	87	2.7216020	14.0338947
32	630.00834	7,459.20749	88	2.2913441	11.3122927
33	577.71244	6,829.19915	89	1.9087170	9.0209486
34	529.74694	6,251.48671	90	1.5716428	7.1122316
35	485.75316	5,721.73977	91	1.2780700	5.5405888
36	445.40222	5,235.98661	92	1.0257075	4.2625188
37	408.39134	4,790.58439	93	.81188791	3.23681128
38	374.44353	4,382.19305	94	.63352434	2.42492337
39	343.30425	4,007.74952	95	.48715464	1.79139903
40	314.74040	3,664.44527	96	.36906299	1.30424439
41	288.53840	3,349.70487	97	.27543103	.93518140
42	264.50209	3,061.16647	98	.20249336	.65975037
43	242.45208	2,796.66438	99	.14655652	.45725701
44	222.22357	2,554.21230	100	.10427765	.31070049
45	203.66566	2,331.98873	101	.072782452	.206422845
46	186.63958	2,128.32307	102	.049682171	.133640393
47	171.01819	1,941.68349	103	.033036319	.083958222
48	156.68467	1,770.66530	104	.021291755	.050921903
49	143.53193	1,613.98063	105	.013216710	.029630148
50	131.46247	1,470.44870	106	.007840128	.016413438
51	120.38706	1,338.98623	107	.004401182	.008573310
52	110.22418	1,218.59917	108	.002309518	.004172128
53	100.89912	1,108.37499	109	.001115154	.001862610
54	92.343428	1,007.475877	110	.000485288	.000747456
55	84.494236	915.132449	111	.000185005	.000262168
56	77.293545	830.638213	112	.000059296	.000077163
57	70.688067	753.344668	113	.000014974	.000017867
58	64.628868	682.656601	114	.000002647	.000002893
59	59.070844	618.027733	115	.000000246	.000000246
60	53.972272	558.956889			

## APPENDIX B

## EFFECTS OF SELECTION

Self-selection by prospective annuitants can have an important effect on annuitant mortality experience. It is evident in the overall mortality of annuitants as a class, in the relatively lower mortality under (1) nonrefund contracts as compared with refund contracts and (2) payee elections on settlement options as opposed to nonpayee elections. Selection is evident, too, in the early durations under annuity contracts.

Select mortality in the early contract years affects aggregate mortality if there has been a considerable increase in new issues or if there is an increase in the selectivity exercised by annuitants. Since the effect of selection could be important as to whether an annuity mortality table will be suitable for valuation in the future, an attempt was made to measure changes in selection over an extended period.

Using data published in the report "Mortality under Individual Immediate Annuities, Life Income Settlements, and Matured Deferred Annuities" (TSA, 1979 Reports), ratios of the mortality ratios (on the *a*-1949 Table) in the first five contract years to those of contract years 6 and over were computed for each study period from 1945 to 1976. These ratios appear in Tables B1, B2, and B3. Since long-term trends were not readily apparent from these results, averages of the first three periods and the last three periods were calculated.

From these averages it appears that there has been some increase in selection under refund annuities—slight under immediate annuities and for females under settlement options and somewhat greater under matured deferred annuities. Selection also increased somewhat for females under nonrefund immediate annuities. Selection was less for males under nonrefund immediate annuities and for both males and females under nonrefund matured deferred annuities.

On an overall basis, the amount of selection is still not great under the refund experience generally, but it bears watching for any continuation of the trend. The trend of selection can be regarded as mixed under the nonrefund experience, where the effect of selection is of much greater magnitude.

To the extent that the 1973–83 improvement factors were based mainly on improvement experienced by the United States white population, the factors could be understated if there were an appreciable increase in selection by annuitants. The results of the above analysis, however, indicate that over the ten-year period it is not likely that a change in selection exercised by annuitants would, in the aggregate, have exercised much greater influ-

ence on the improvement in annuitant mortality than the improvement in the general population death rate, which, in the earlier periods, matched rather well with that of aggregate annuitant mortality.

Table B4 illustrates the effect on immediate annuity values of 90 percent assumed select mortality over the first five and the first ten years after issue.

TABLE B1  
TRENDS IN SELECTION  
BASED ON RATIOS OF MORTALITY IN CONTRACT YEARS 1-5 TO MORTALITY  
IN CONTRACT YEARS 6 AND OVER  
EXPERIENCE BETWEEN ANNIVERSARIES IN INDICATED YEARS  
(BASED ON AMOUNTS OF ANNUAL INCOME)

ATTAINED AGES	1948-53	1953-58	1958-63	1963-67	1967-71	1971-76	AVERAGES	
							1948-63	1963-76
Immediate Nonrefund Annuities (Excluding Pension Trust Issues)								
Males:								
Under 60 .....	<i>134%</i>	<i>126%</i>	*	<i>103%</i>	*	*	.....	.....
60-69 .....	122	71	57%	78	77%	82%	83%	79%
70-79 .....	65	80	70	93	89	92	72	91
80-and over .....	82	90	50	89	79	69	74	79
All ages (adjusted)	83%	85%	59%	88%	90%	85%	76%	88%
Females:								
Under 60 .....	<i>84%</i>	<i>110%</i>	<i>157%</i>	<i>321%</i>	<i>153%</i>	*	.....	.....
60-69 .....	85	98	46	69	64	53%	76%	62%
70-79 .....	67	86	64	72	49	59	72	60
80 and over .....	62	67	76	73	72	68	68	71
All ages (adjusted)	68%	76%	72%	72%	65%	65%	72%	67%
Immediate Refund Annuities (Excluding Pension Trust Issues)								
Males:								
Under 60 .....	140%	<i>135%</i>	<i>102%</i>	70%	<i>273%</i>	50%	126%	131%
60-69 .....	101	85	74	73	99	64	87	79
70-79 .....	86	94	85	83	86	89	88	86
80 and over .....	109	86	83	73	68	93	93	78
All ages (adjusted)	106%	95%	87%	81%	86%	88%	96%	85%
Females:								
Under 60 .....	49%	<i>50%</i>	<i>63%</i>	<i>52%</i>	<i>68%</i>	<i>91%</i>	54%	78%
60-69 .....	113	90	70	98	109	102	91	103
70-79 .....	78	104	96	80	88	92	93	87
80 and over .....	93	79	88	72	78	87	87	79
All ages (adjusted)	93%	91%	90%	79%	88%	94%	91%	87%

NOTE.—Ratio in italics where 10-49 contracts terminated by death in numerator, denominator, or both.

\* Fewer than 10 contracts terminated by death in numerator or denominator.

TABLE B2

TRENDS IN SELECTION  
 BASED ON RATIOS OF MORTALITY IN CONTRACT YEARS 1-5 TO MORTALITY IN  
 CONTRACT YEARS 6 AND OVER  
 EXPERIENCE BETWEEN ANNIVERSARIES IN INDICATED YEARS  
 (BASED ON AMOUNTS OF ANNUAL INCOME)  
 ALL REFUND LIFE SETTLEMENTS—PAYEE ELECTIONS  
 (EXCLUDING PENSION TRUST ISSUES)

ATTAINED AGES	1945-50	1950-55	1955-60	1960-65	1965-70	1971-76	AVERAGES	
							1945-60	1960-76
<b>Males:</b>								
Under 60 .....	88%	80%	81%	112%	53%	82%	83%	82%
60-69 .....	107	89	89	100	102	84	95	95
70 and over .....	73	98	94	89	104	108	88	100
All ages .....	92%	90%	90%	96%	99%	93%	91%	96%
<b>Females:</b>								
Under 60 .....	75%	75%	60%	81%	61%	71%	70%	71%
60-69 .....	91	86	87	77	81	82	88	80
70 and over .....	85	84	91	79	78	77	87	78
All ages .....	91%	87%	88%	81%	83%	83%	89%	82%

NOTE.—Ratio in italics where 10-49 contracts terminated by death in numerator, denominator, or both.

**TABLE B3**  
**TRENDS IN SELECTION**  
**BASED ON RATIOS OF MORTALITY IN CONTRACT YEARS 1-5 TO MORTALITY IN**  
**CONTRACT YEARS 6 AND OVER**  
**EXPERIENCE BETWEEN ANNIVERSARIES IN INDICATED YEARS**  
**(BASED ON AMOUNTS OF ANNUAL INCOME)**  
**MATURED DEFERRED ANNUITIES**  
**(EXCLUDING PENSION TRUST ISSUES)**

ATTAINED AGES	1945-50	1950-55	1955-60	1960-65	1965-70	1971-76	AVERAGES	
							1945-60	1960-76
<b>Nonrefund</b>								
<b>Males:</b>								
Under 60 .....	*	*	*	*	*	*	.....	.....
60-69 .....	39%	124%	71%	86%	54%	96%	78%	79%
70 and over .....	82	48	98	137	78	*	.....	.....
All ages .....	69%	59%	85%	109%	80%	59%	71%	83%
<b>Females:</b>								
Under 60 .....	*	*	40%	*	*	*	.....	.....
60-69 .....	79%	78%	77	67%	96%	82	78%	82%
70 and over .....	75	119	78	70	49	115	91	78
All ages .....	80%	87%	71%	71%	86%	93%	79%	83%
<b>Refund</b>								
<b>Males:</b>								
Under 60 .....	103%	96%	92%	218%	*	*	.....	.....
60-69 .....	97	114	102	82	132%	90%	104%	101%
70 and over .....	87	95	81	108	80	102	88	97
All ages .....	103%	111%	94%	98%	97%	97%	103%	97%
<b>Females:</b>								
Under 60 .....	87%	64%	131%	135%	*	*	.....	.....
60-69 .....	94	115	81	101	105%	94%	97%	100%
70 and over .....	104	129	85	78	99	65	106	81
All ages .....	102%	119%	91%	95%	103%	84%	104%	94%

NOTE.—Ratio in italics where 10-49 contracts terminated by death in numerator, denominator, or both.

\* Fewer than 10 contracts terminated by death in numerator or denominator.

TABLE B4

TEST OF EFFECT OF SELECTION ON ANNUITY VALUES  
 SELECT MORTALITY ASSUMED EQUAL TO 90 PERCENT OF 1983 TABLE *a*  
 5 PERCENT INTEREST

AGE AT ISSUE	$a_x$ ON 1983 TABLE <i>a</i> (1)	5-YEAR SELECT PERIOD		10-YEAR SELECT PERIOD	
		$a_{[x]}$ (2)	(2) ÷ (1) (3)	$a_{[x]}$ (4)	(4) ÷ (1) (5)
<b>Males:</b>					
65 .....	10.918	10.991	100.7%	11.065	101.3%
70 .....	9.362	9.463	101.1	9.557	102.1
75 .....	7.775	7.910	101.7	8.019	103.1
80 .....	6.237	6.406	102.7	.....	.....
<b>Females:</b>					
65 .....	12.262	12.309	100.4	12.358	100.8
70 .....	10.728	10.793	100.6	10.862	101.2
75 .....	9.106	9.111	101.1	9.204	102.1
80 .....	7.239	7.372	101.8	.....	.....



## DISCUSSION OF PRECEDING PAPER

JOHN H. COOK:

Mr. Johansen and the members of his committee are to be commended for their excellent work in developing the mortality table which they identify as the 1983 Table *a* for Individual Annuity Valuation. I am impressed with the careful consideration that they devoted to the mortality rates in that table for young adult ages. It is not typical for actuaries to have great concern about the level of mortality rates in an annuity table for ages under 50. It is usually felt that the impact of a change in mortality rates at those ages is insignificant. In spite of this, I know that the committee members devoted a great deal of energy to the consideration of the mortality curve for their table in the young adult age range.

It is also a common interpretation that minor variations in mortality rates at ages over 80 have little financial impact on life insurance functions and annuity functions in the upper middle age range. Premium rates for life insurance at age 50 are affected very little by mortality rates after age 80. Reserve liability for annuity benefits under age 60 are influenced very little by variations in mortality levels after age 80. Unit life insurance reserves at ages over 80, especially on paid-up benefits, can be greatly influenced by the mortality rates in the valuation table. In spite of this, aggregate life reserves are very little affected, since the bulk of the valuation in-force for life benefits is for ages under 80.

In the case of annuity benefits at ages over 80, the valuation reserve is highly sensitive to the mortality rates. In this case, the aggregate annuity reserve is also sensitive, although to a lesser degree, to these same mortality rates. I know that Mr. Johansen and his committee gave careful consideration to the mortality level in the 1983 Table *a* for the ages over 80. It has been traditional to assume a terminal age for a mortality table and to develop a table of mortality rates in the latter part of the age range that represent nothing more than a graduation between the last "reliable" value and the value at the terminal age. There is a wide degree of variation concerning the age that is interpreted to represent the oldest-age "reliable" value.

In recent years there has been use of expressions such as the "squaring off of the mortality curve." This implies that improvements in mortality continue through the ages up to retirement and for some years thereafter.

As we approach the end of the table (according to the theory), mortality rates rapidly approach unity. The result of this is an increase in the expectation of life but no increase in the maximum life span.

More recently the theory has been expressed that there is a flattening of the mortality curve at the advanced ages. This theory suggests that mortality rates continue to increase until they reach a level of about 300 per thousand, and then the curve flattens out and the rate does not increase much beyond that. Here we have not only an increase in the expectation of life but also an increase in the maximum life span, although the probability of survival for ten years at that mortality rate is less than 3 percent.

The difference between the two theories is relatively unimportant in life insurance reserve valuation. It is very important in annuity reserve valuation. The report of Mr. Johansen's committee was considered in public forum at the annual meeting of the Society of Actuaries in Atlanta on October 19, 1981. One week before I left the office to attend that meeting, I did not have any particular opinion or concern about the level of mortality at the advanced ages for the 1983 Table *a*. Two or three days before I left the office for that meeting, I learned by chance of some insured life mortality experience that caused me to take a much keener interest in the mortality rates for annuity valuation at the advanced ages.

The mortality experience that became available to me was limited in volume and, accordingly, is subject to the error of statistical fluctuation. The phenomenon that I stumbled across was that the experience rate of mortality in my own company, for certain blocks of business between anniversaries in 1975 and 1980, has been essentially no higher for attained ages 80 and over than for attained ages 75-79. Both of these experience rates are low, and they are significantly below the male rate for age 80 in the 1983 Table *a*.

What I wish to emphasize is that the experience that I report was insured life mortality. It was not annuitant mortality. Furthermore, it was insured life mortality in the ultimate period, excluding the first fifteen durations. I have subsequently examined the experience at durations 11-15 for the same experience period at the same attained ages. That analysis expands the volume of exposure, but of course it reflects the influence of selection standards to a much greater degree. The increased volume of exposure continues to exhibit the trend to lower levels of mortality at the advanced ages than are customarily anticipated.

When I make a statement such as this, it suggests certain obvious questions. One such question is why the 1965-70 Basic Table has such high rates of mortality for the ultimate period at these ages, if the experience of my own company is so much more favorable. Another similar question is, why

does the annual standard ordinary intercompany mortality report of ultimate experience at these ages show a higher level of mortality than I referred to? Another question is, why does the 1980 CSO Table list a higher mortality level at these ages?

Each of these questions is quite appropriate to ask under the circumstances. I have a partial response to each one of these questions, although I do not have a complete and satisfactory understanding of the relationships involving the various mortality experiences. In the first place, the 1965-70 Basic Table reflects intercompany experience for a period ten years prior to the period for which I am reporting. There has been substantial mortality improvement during these ten years. I have examined the intercompany ultimate experience for ages over 75 covering the period between anniversaries in 1975 and 1979. The intercompany experience up to anniversaries in 1980 has not yet been assembled. The four-year period of intercompany experience reflects mortality trends that are consistent with traditional expectations. The difference between this experience and the observed data in my own company I interpret to result from the nature of the business I was analyzing.

The intercompany study includes all contributions for business at durations 16 and over, and it is highly influenced by the experience of business issued more than twenty-five or thirty years ago. My own company data in this instance were limited to policies issued in 1960 and later. This meant that all the business that I was analyzing had been issued at ages 60 and over. Additionally, it was drawn from a block of business that was subject to different and somewhat more stringent selection criteria than what we had applied in 1959 and earlier. The combination of these two facts resulted in more favorable mortality experience than the average. The class of business from which the experience was drawn exhibits generally more favorable mortality than our other blocks of business. The selection standards at the advanced ages at issue are of necessity more severe.

In this connection it is interesting to note that the percentage of insurance applications submitted at ages 60 and over and acceptable at standard rates is low. According to industry data, an all-ages average indicates that about 92 percent of applicants are acceptable at standard rates. This percentage, however, is highly sensitive to age. I do not know what the statistics are for other companies, but in my own company the rate of standard acceptances at age 60 is approximately one-third of the rate at age 20. Above age 60 the acceptance rate drops rapidly and is only one-half as much at age 65 as it is at age 60. I have been told that this is a demonstration that our selection standards are too severe at the advanced ages. I defend our selection standards, however, because I believe it is necessary, in order to be

both equitable and financially secure, that a block of business issued at the same rates must consist essentially of a homogeneous set of insured lives. It is impossible to establish selection standards at ages above 60 that will admit anything like 50 percent of applicants without having an excessive mortality differential between the best and the worst accepted risk.

Evidence of this variation is readily apparent when one examines the select mortality rates in the intercompany basic table. The mortality for policy year one at ages over 65 is only about 30 percent of ultimate mortality at the same attained age. It is less than 60 percent of the mortality at the same attained age for business issued five years younger. The only explanation for this is that a large percentage of those lives meeting selection standards at the advanced ages become impaired and subject to mortality in excess of the ultimate rate within a short period of time after issue. In fact, I have reason to believe that more than 10 percent of those qualifying for standard insurance at age 60 are unable to meet selection standards one year later.

Why does the 1980 CSO Table contain mortality rates that increase in geometric fashion for ages over 75? That table is based on the intercompany experience between anniversaries in 1970 and 1975. This includes all durations, omitting only the first five. The resultant table does not appear to be representative of the high-attained-age mortality on more recently underwritten business in my own company.

These statistics that I report are facts. The analyses I submit are perhaps no better than subjective determinations. The significance that I attach to these determinations is that companies should be prepared to observe some typical twists in mortality at the advanced ages in the future. The impact of this is not likely to be significant in terms of the financial analysis of life insurance business. It is possible that it will have far greater significance in the financial analysis of annuity business.

JAMES L. COWEN:

The report of the Committee to Recommend a New Mortality Basis for Individual Annuity Valuation is an excellent piece of work and should serve the purposes for which the new table is intended.

It is unfortunate that the actual experience for 1971-76 on which the table is based is not as current as would be desirable. This is especially true since all or practically all mortality experience studies made through the 1970s have shown continuing improvement in mortality rates, especially at the older ages. However, the procedures used to project the mortality improvement from the 1971-76 experience appear to be reasonable, so there should be little problem with respect to the mortality improvement projection.

Another question, however, is whether the distribution between types of annuities (immediate annuities, matured deferred annuities, and life income settlement options) that existed in the period 1971-76 is going to continue. I have a feeling that matured deferred annuities may become a more important part of this experience in the future. Under the Employee Retirement Income Security Act of 1974 (ERISA) when a pension plan terminates, among other options, the plan sponsor can let the Pension Benefit Guaranty Corporation (PBGC) take over the payment of guaranteed benefits, or he can purchase deferred annuities from an insurance company. In 1980 I was involved with the termination of two pension plans totaling about 1,200 active lives for which both immediate and deferred annuities were purchased depending on whether employees met the eligibility conditions for retirement. Little, if any, of this type of deferred annuity would be represented in the 1971-76 experience, since ERISA was not enacted until September 1974. It is also probable that this type of annuity purchase will not show the same degree of antiselection shown by other annuities.

The report states that there are many theories about what is causing the mortality improvement at the older ages, and I would like to express mine. Simply put, I feel that the major cause of the mortality improvement has been the inception of medicare and medicaid. The first benefits under medicare were paid in July, 1966, and the mortality improvement began with the 1968 experience.

The advent of medicare has made medical treatment more readily available to the elderly and made them more aware of their medical problems. This goes along with Dr. Borhani's theory of increased public awareness, quoted in the report. Improved health due to better medical treatment also would make the elderly more active, which would complete the circle, since activity helps keep people healthy. Both the increased longevity and improved health have made communities aware of the need to provide activities for the elderly.

If my theory is correct, there should be a lag correlation between improving mortality and medicare utilization. This is a study that someone in the Health Care Financing Administration of the Department of Health and Human Resources should institute.

EDWARD A. LEW:

In my judgment, this report sets a new standard for papers on annuitant mortality. I assume it will be published in the *Transactions*, so that together with the discussion it will serve as a source of ready reference on the subject for many years to come and also as a model for future studies of annuitant mortality. Periodic investigations of the experience among annuitants of

various kinds, and in the general population, will be needed if the downward trend in mortality continues.

The report relies in large part for its conclusions concerning the appropriate level of death rates for valuation purposes on information other than annuitant experience. It leans heavily on the paper "Recent Trends in the Mortality of the Aged" by John C. Wilkin (published in this issue of the *Transactions*, p. 11), which provides the most accurate data currently available on recent population death rates past age 65 and particularly past age 85.

The private communication referred to in the report came from me. It spoke of the findings of an American Cancer Society study of some 50,000 men and women who were in their late eighties in 1959 and were traced to the end of 1979. The ages of these subjects were repeatedly examined, so that the death rates derived for ages 95 and older in this study are probably more accurate than those in the medicare experience. These death rates also corroborate John Wilkin's point that population mortality flattens out in the late 90s; at age 95-105 the death rates in the American Cancer Society study ranged from 0.3 to 0.4.

There is considerable difference of opinion regarding the reasons for the sharp reduction in death rates past age 65, and especially past age 85. Hence, there are also different views on the likelihood of further decreases in mortality in the near future. I believe that the decline in death rates since the mid-1960s reflects primarily such factors as rising living standards, the influence of medicare, greater general understanding of health hazards and more salutary life styles, as well as some specific improvements in medical treatment, notably that of hypertension. Death rates among Mormons and Seventh-Day Adventists and the studies conducted by the Human Laboratory group in Alameda County, California, illustrate well the potent effects of healthful habits.

If my appraisal of the influences affecting death rates during the last fifteen years is correct, then mortality should continue on a downward trend in the years immediately ahead.

The obvious merit of projecting mortality decreases into the future is exemplified by the table at the top of page 743, which compares values at 5 percent on the Annuity Table for 1979 and the 1983 Table *a*.

In 1949, W. A. Jenkins and I developed the Annuity Table for 1979 (*TSA*, I, 369) to represent the approximate level of annuitant mortality in 1979 on reasonable assumptions as to future declines in mortality. In my judgment, any reasonable assumptions would have produced sensible values. However, the recent sharp reductions in death rates at the older ages suggest different projections for the years ahead.

	ANNUITY TABLE FOR 1979		1983 TABLE <i>a</i>		PERCENT VALUES ON THE ANNUITY TABLE FOR 1979 TO THOSE ON 1983 TABLE <i>a</i>	
	Males	Females	Males	Females	Males	Females
35 .....	17.176	17.745	17.134	17.793	100.2%	99.7%
45 .....	15.570	16.438	15.620	16.569	99.7	99.2
55 .....	13.353	14.465	13.610	14.772	98.2	97.9
65 .....	10.874	11.625	10.918	12.262	99.6	94.8
75 .....	7.681	8.019	7.775	9.016	98.8	88.9

## JOHN O. MONTGOMERY:

The 1983 Table *a* will be presented to the NAIC at its December, 1981, meeting for disclosure and will be presented for adoption by the NAIC, along with guidelines for implementing its promulgation by the various states, at the June, 1982, meeting of the NAIC. This disclosure period conforms with established NAIC procedures for adopting experience tables. At that time all states which will have passed the new 1980 amendments to the valuation and nonforfeiture laws will be able to incorporate this table by regulation. To date, seventeen states have enacted these laws. We expect that by 1982 another seventeen to twenty states will have enacted these laws. Therefore a majority of the states will be able to use this table next year.

The question I have is whether or not you attempted to use the so-called log-linear method that was used in the construction of the new disability tables. This method has the capability of translating almost any table of experience values into a relatively simple mathematical formula. I do not think it likely that you have, since the report of the committee to construct the disability tables has yet to be published. At some future time it may be worthwhile to see whether the annuity tables can be so transformed using the log-linear method that was used in the disability tables.

## COMMITTEE'S REVIEW OF DISCUSSION:

The exposure draft of the report of the committee was mailed to members shortly before the Society's 1981 annual meeting, and the draft was presented and discussed at that meeting. A covering letter from President Leckie invited comments from the membership to be sent to the committee chairman by November 6, 1981. Recognizing the short period for review, the committee considered comments received after that date, as well. All comments are discussed in this review whether or not they have been published as discussions. It should be noted that the final published report has, in several places, been changed from the exposure draft as a result of suggestions in the discussions.

Mr. Edward A. Lew's remarks were most kind and gracious. The committee wishes to express its gratitude and appreciation to Mr. Lew for his comments, especially considering that his landmark paper with Wilmer A. Jenkins, "A New Mortality Basis for Annuities" (*TSA*, I, 369), set a scholarly standard for future authors to aim at. Additionally, his discussion of mortality at the extreme old ages and his review of reasons for the recent and continuing reduction in mortality rates add considerably to the value of the report and to a better understanding of the committee's conclusions. We shall look forward to Mr. Lew's presentation of the high-age mortality experience when he feels it can be published, a date we hope is earlier rather than later.

The committee is also grateful to Mr. John C. Wilkin who, in the oral presentation of his paper, "Recent Trends in the Mortality of the Aged," at the 1981 annual meeting, stated, in part, "We concur with (the) committee's recommendation that at this time we need to project significantly higher rates of improvement in mortality, particularly at the older ages." We also noted with some satisfaction Professor William H. Wetterstrand's comment in a letter to the committee that his "analyses of medicare data lend considerable support to the use of 1.5-2 percent projection factors in an annuity table for ages 30-90," using the methods described in his paper.

Mr. John Tomlinson questioned the committee's use of a single set of improvement factors for the period from 1973 to 1983, while for the period beyond 1983, separate male and female improvement factors were suggested. The reasons given in the paper for deciding on only a single set of factors for the period 1973-83 do, in fact, describe the basis for the committee's decision. The reasoning of the committee was somewhat as follows.

Preliminary sets of 1973-1983 improvement factors had been prepared for males and females separately for ages over 30. These two sets appear in Table 1 of this discussion. The improvement rate for males aged 30-34 through 40-45 was then reduced from 2.5 to 2.25 percent. The committee also felt that improvement factors in excess of 2.5 percent were unduly high for females. After these changes were taken into account, the differences between the separate male and female factors would have been rather small, too small in the opinion of the committee, considering the variation in improvement rates from various sources, to warrant two separate scales.

In addition, the period from 1973 to 1983 was relatively short, and it was felt that enough of the 1973-83 period had already transpired that it was unlikely that there would be any marked changes in the years remaining. For the longer-range period, beyond 1983, it seemed appropriate to recognize the historically greater improvement rates among females, a rec-

TABLE I  
MORTALITY IMPROVEMENT RATES

AGE	PRELIMINARY			MODIFIED FEMALE IMPROVEMENT RATES	FINAL IMPROVEMENT RATES
	Male	Female	Excess (F - M)		
32 .....	2.5 %	2.0 %	-0.5	2.0 %	1.00%
37 .....	2.5	2.25	-0.25	2.25	2.25
42 .....	2.5	2.5	0	2.5	2.25
47 .....	2.25	2.75	0.5	2.5	2.25
52 .....	2.25	3.0	0.75	2.5	2.25
57 .....	2.25	3.0	0.75	2.5	2.25
62 .....	2.25	3.0	0.75	2.5	2.25
67 .....	2.25	3.0	0.75	2.5	2.25
72 .....	2.25	2.75	0.5	2.5	2.25
77 .....	2.0	2.50	0.5	2.5	2.00
82 .....	1.75	2.25	0.5	2.25	1.75
87 .....	1.5	2.0	0.5	2.0	1.50
92 .....	1.5	1.75	0.25	1.75	1.50
97 .....	1.5	1.5	0	1.5	1.50

ognition which was consistent with the commentaries that had been reviewed and summarized in the report and on which Projection Scale G was largely based.

Mr. Tomlinson also provided the committee with an extensive and detailed set of editorial changes, questions pertaining to clarity and suggestions of areas for improvement in presentation. The committee appreciates his painstaking work and has adopted or acted on most of his suggestions. We think that the final version of the paper has been considerably improved over the exposure draft in readability and clarity because of his efforts.

Mr. John H. Cook's extensive discussion of mortality at ages 85 and over adds considerable value to the committee's report. As he and Mr. Wilkin noted, the greater numbers of people surviving to these advanced ages will make the financial effects of lower mortality more important to both annuity valuation and social security costs. The comparisons in Table 11 of the report were intended to indicate that the 1983 Table *a* mortality rates were not markedly low when compared to recent experience. To learn that projected aggregate annuity mortality is higher than some actual insured life ultimate experience is somewhat disturbing. However, not only was the ultimate experience restricted to issues of 1960 and later, but the strict underwriting mentioned by Mr. Cook was indeed very restrictive, and the policies involved were those in the higher-amount second and third tiers of a three-tier classification system. All three of these factors would assure a more select group. The experience should perhaps be viewed as an indi-

cation of the possible effect of annuitant selection on mortality at very high ages. The committee thanks Mr. Cook for his contribution and suggests that Mr. Lew, Mr. Wilkin, Mr. Cook, and others pursue further study of mortality levels and changes at high ages.

A possible counterbalancing force affecting future changes in annuitant mortality has been cited in Mr. James Cowen's discussion. Certainly inclusion of terminated pension plans in the experiences on immediate annuities and on matured deferred annuities should tend to offset the lower mortality of individual purchasers of annuities. The magnitude of the effect will, of course, depend on the relative size of the terminated pension business. It would be interesting and useful to check for this effect in the next inter-company annuity mortality study.

Mr. Cowen's theory on the cause of improved mortality at the high ages is very likely true. There appears to have been a synergistic effect of the combination of efficacy and availability of diagnosis and treatment, interest on the part of both patients and the medical profession, and the funds to pay the costs.

In a letter to the committee, Mr. Paul H. Jackson took issue with the committee's rejection of a merged-gender valuation table in favor of separate male and female valuation tables. Stating that the "conclusions reached cannot be justified on technical actuarial grounds," Mr. Jackson, referring to the committee's discussion on this point as originally presented in the exposure draft, wrote as follows:

The entire discussion relates to the extent to which a merged-gender table might develop inadequate reserves if the proportion of females to males should be greater than that assumed in the basic table. I can agree that a merged-gender table that is appropriate at issue might, due to subsequent deviation of percentage female from that assumed, become inappropriate or even unsafe. . . . My problem . . . is that I view the difference between male and female mortality in this area of setting reserves for annuities as far less significant than the matter of interest rates, and all of your arguments apply equally to the rate of return on invested assets initially and on into the future.

The report of the committee sets out male and female commutation functions at 5, 7, and 9 percent interest. Taking the 7 percent interest values as the middle rate, the variation in female annuity value to male annuity value runs about 103¼ percent at 40, 107¾ percent at 60, and 112¾ percent at 80. Taking an average mix of business and assuming a 50/50 unisex table for reserve purposes, the worst that could happen would be that the group could shift to 100 percent female, and this would involve about a 4½ percent increase in actual reserve liability over that developed by the unisex table. On the other hand, if the reserves were based on a 7 percent basis, a 4½ percent variation in the reserve liability on the sex-distinct table would result whenever the assets shifted in such a way as to develop an interest yield ½ percent

different from the 7 percent assumed rate. There is no doubt in my mind but that the likelihood of a swing in the sex content of a company's annuity business from 50/50 to 0/100 or 100/0 is far less than that of a swing in interest yields from 7 percent to 6½ or 7½ percent. Accordingly, from a purely scientific point of view, I believe that if you are going to raise hypothetical questions about the problems raised prospectively when the mix of business deviates from that assumed in the original unisex table, then in fairness you should make the similar argument about what happens to the adequacy of reserves when the asset mix shifts so that the prospective yield varies from the single rate used in the reserve table.

Finally, the basic argument that you have set out here is that an actuary, for reserve purposes, should not average male and female experience and use an overall average unisex valuation mortality table. On the other hand, you apparently condone, without comment, the fact that the actuary in 1981 who uses even a 9 percent valuation rate of interest for a block of new business could not possibly be suggesting that the money would be invested so as to yield only 9 percent next year. Many of the insurance companies that are issuing these annuity contracts and that will use the table for valuation purposes are currently offering guaranteed investment contracts with yields in the general neighborhood of 15 percent. This suggests that those actuaries are assuming a high rate of return in the early years and a lower rate of return in the later years, working out to some overall average single rate of return such as 5, 7, or 9 percent, and that average rate is deemed to be appropriate for reserve purposes.

If a company bases reserves on an average rate of 7 percent, which has been selected so as to reflect real-world yields of 15 percent in 1982 grading down to 5 percent in 10 or 15 years, then that company's block of reserves will develop experience gains in the early years which must be held as reserves to offset the experience losses of later years arising out of interest rates that are ultimately less than the 7 percent level. With select and ultimate interest as the basis for reserves, these amounts would indeed be included in the reserves. With a single interest rate as the basis for reserves, the additional interest in early years would show up as added surplus. Surely, on theoretical grounds this practice is no more to be condoned than the practice of approximating mortality rates by a unisex table.

My recommendation, quite simply, would be to delete the statement that "use of a merged-gender table for valuation is not recommended." Second, in the last paragraph, the statement that "the committee does not advocate use of a merged gender mortality table for valuation" should also be deleted. The committee should not be advocating anything.

I do recognize the difficulty that you have had in developing tables for valuation, and I certainly have no objection to your setting out separate male and female tables as the standard approach. I do strongly object, however, to your characterization of the unisex mortality table as unsound, when in fact you are clearly advocating another practice (the use of single interest rates) which is demonstrably even more unsound. There should be a substantial muting of the crusading tone in this section of your report. It is one thing to prefer to employ sex-distinct valuation mortality tables, but it is a far different matter to contend, as this section appears to, that the actuary

using a merged-gender table is somehow running tremendous risks. I believe that any actuary reviewing the figures dispassionately would conclude that the likelihood of having the percentage female rise from say, 50 percent to 60 percent is very much smaller than the likelihood of having the actual rate of return vary from the assumed rate by one-tenth of 1 percent, and yet the financial risk in these two situations is about the same.

Ms. Daphne D. Bartlett also wrote to the committee on this subject to "second Paul Jackson's request that some modification be made . . . in the section on sex-distinct tables." She distinguished the actuary's right to *price* according to sex or other risk factors from the use of sex-distinct valuation tables. She also expressed concern that the committee's wording in the section on merged-gender tables implied that "use of this valuation table in combination with 'appropriate' interest rates will provide *sufficient* reserves" (emphasis Ms. Bartlett's). Her primary concern appeared to be more with the language used in the committee's reasoning than with the committee's decision, as she pointed out that "minimum valuation reserves are necessary but may not be sufficient."

On the other hand, Mr. James Bagshaw, in a letter to the committee, strongly supported the "committee's decision not to advocate the use of merged-gender mortality tables for valuation purposes." Noting that "pressures that have been placed on our profession by the nondiscrimination laws of this country should not cloud our judgment as to the proper methods for determining the present value of future benefits to decidedly different classes of mortality risk," Mr. Bagshaw said that a merged-gender table for valuation would work only for certain types of groups over relatively short periods of time.

With respect to Mr. Jackson's comments, the committee wishes to make clear that it was not implying or stating any conclusion or recommendation as to a choice of interest rates or the conviction that the proposed 1983 Table *a* would provide sufficient reserves at some interest rate. In reviewing the reasons for constructing a new valuation mortality table, the committee cited "the concept of dynamic interest rates for valuation" as further eroding "interest rate margins available to cover inadequate or negative mortality margins." The committee suggested later in the report that a valuation actuary who believes that his company's "proportion of new, select annuity business is substantially higher than that in the experience used for the new table should make suitable adjustments." Similar action is suggested where a company has a high proportion of nonrefund immediate annuity business. Further, the committee provided values at various interest rates to permit comparison of the effect of changes in interest rates and mortality tables. In effect, the committee was careful to make no comment as to a choice

of an interest rate or the sufficiency of reserves on any table in any particular case. In fact, in the section discussing the 10 percent margin, the text notes that the 10 percent margin is not sufficient for all companies.

The committee disagrees with Mr. Jackson's contention that because of the considerable effect of different interest levels on reserves, a smaller error in reserves because of mortality is of no consequence. Rather, the committee, in recommending a new valuation table, recognizes the need to minimize variations to the extent that this can be done.

Both Mr. Jackson and Ms. Bartlett suggested that their arguments were more concerned with the way the case against a merged-gender table was presented than with the decision itself. Accordingly, the committee reviewed the exposure draft text and made extensive revisions, inserted a discussion of the inability of any single merged-gender table to be applicable to a variety of companies with differing proportions of males and females, and shortened the discussion on later effects of changes in the proportions of males and females as a block of business ages. The committee also made it clear in the revised text that the discussion and recommendation referred to the use of a merged-gender table as a valuation standard.

The committee is indebted to Ms. Bartlett and Messrs. Jackson and Bagshaw for their letters and their questioning of the committee's handling of this question. The values of their contributions can be seen in the substantially revised text in this section of the final report.

Mr. John Montgomery asked whether the committee had considered a log-linear formula approach of deriving a mathematical formula for the 1983 Table *a*. Since the Heligman-Pollard method seemed to offer considerable promise, the committee concentrated its efforts on adapting to that form. It did not consider any other approach, since the Heligman-Pollard approach also included the Makeham and Gompertz formulas, the heretofore standard formulas for mortality rates.

Mr. James Bagshaw and Mr. Albert Christians both objected to the exposure draft's format of the commutation columns, in which the number of significant figures was far exceeded and the number of decimal places at the younger ages became unwieldy. The committee had intended to follow the format of the commutation columns in Harold Cherry's paper on the 1971 IAM Table (*TSA*, XXIII, 475). However, the programmer was unable to solve the problem of proper rounding in time to meet necessary deadlines. The commutation columns in the final report are more amenable to calculation.

Mr. Christians raised the question of the definition of "attained age" in the 1971-76 annuity experience, that is, was it age nearest birthday, last birthday, or what? In *TSA, 1973 Reports*, page 61, the statement was made

that "the study is on an attained-age basis, where attained age equals age at issue plus contract year less one. The age at issue was taken as the age nearest birthday on the issue date of the contract, or some reasonable approximation to that age." Mr. Christians also asked that the committee include in Table 8 a tabulation of the 1971-76 experience showing exposures and deaths by five-year age groups, or preferably by single year of age, for both amounts of annual income and numbers of contracts. The committee believes it would not be cost effective for it to produce the data by single age or even in five-year age groups. The basic data appear in *TSA, 1979 Reports*, although the age grouping is by ten years of age.

The committee is most grateful to all who submitted discussions or letters on the exposure draft. It should be obvious from the foregoing that these discussions and letters played an important part in modifying the report and that they have unquestionably contributed considerably to its improvement.

REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON DYNAMIC  
INTEREST AND RELATED MATTERS

To: The NAIC Actuarial Advisory Group

Subject: Annuity Valuation Mortality Tables

Date: December 12, 1981

The Technical Advisory Committee has reviewed the Exposure Draft on "Derivation of the 1983 Table *a* for Individual Annuity Valuation" prepared by the Society of Actuaries Committee to Recommend a New Mortality Basis for Individual Annuity Valuation, chaired by Robert Johansen. It is the consensus of the Technical Advisory Committee that the Johansen Committee has done a superb job in the development of 1983 Table *a* and preparation of this exposure draft, and we strongly endorse the recommendations set forth in the draft.

Specifically, we recommend that the NAIC adopt 1983 Table *a* as a mortality table suitable for the valuation of annuity benefits under individual annuities and supplementary contracts issued in 1983 and subsequent years. Moreover, we recommend that this table be adopted by the NAIC as the minimum valuation standard mortality table for the valuation of such annuity benefits.

In particular, the Technical Advisory Committee supports the recommendations in the exposure draft as to the propriety of gender-distinct mortality rates for the valuation of annuity benefits and in any minimum valuation standard mortality table.

We recognize that while the 1983 Table *a* mortality rates have margins that appear sufficient to provide for future mortality improvement affecting annuities issued in 1983 and even during the several years beyond 1983, we would expect that continuing improvements in mortality will make it necessary to replace the 1983 Table *a* by a more conservative table in perhaps five years, applicable to annuities and supplementary contracts issued thereafter. At that time, the NAIC may choose to adopt as a new minimum valuation standard mortality table the 1983 Table *a* with five years' projection using the exposure draft's Projection Scale G, or it may choose to adopt another table if warranted by actual mortality experience during the intervening years.

Again, the Technical Advisory Committee welcomes this opportunity to comment on the proposed individual annuity valuation mortality table. We want to commend the Johansen Committee on the outstanding work done by that group in developing the 1983 Table *a*, and on the excellent exposure draft.

Submitted for the Technical Advisory Committee

Charles Greeley, F.S.A., M.A.A.A.  
*Chairman*

