ortality Experience of Workers Entitled to Old-Age Benefits under OASDI 1941-1961

by

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FOREWORD

With the increasing proportion of the population aged 65 and over in the United States that is drawing benefits from the Old-Age, Survivors, and Disability Insurance system, we believe that more accurate estimations of the mortality of our population at the higher ages will be possible. The accuracy of the records of the ages for these beneficiaries is probably one of the best presently available, and it should continue to improve in the future as the time lag between the application for a social security number and the application for social security benefits becomes greater.

This study, therefore, is not only intended as a report on the mortality experience of the retired workers under OASDI, but also as an addition of further data to the analysis of the general mortality trends at the older ages in the United States.

The study is limited to old-age beneficiaries--that is, workers who are entitled to a retirement benefit on their own earnings record. No analysis is made of the mortality of other types of social security beneficiaries, such as widows, widowers, wives, husbands, children, and parents. The observation period covers the 21 calendar years from 1941 to 1961, and the data, as will be seen, are very extensive. These data contain, nevertheless, certain characteristics that are peculiar to the OASDI system and that should be kept in mind when analyzing or using them.

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A. Introduction

There is presented herein the mortality experience of retired workers under the Old-Age, Survivors, and Disability Insurance system for the years 1941 through 1961, inclusive. The long period of observation, the high quality of age determinations under this system, the stability associated with the large exposure volume, and the basic importance of a group including a large majority of individuals who have had any substantial work--all combine to make this experience of interest. In the remainder of this introduction, summary background information on this mortality experience is provided.

The experience covers a steadily increasing proportion of the population age 65 and over. At the beginning of 1941, this was only about 2% for men and 1/2% for women. By the end of the period of this study--January 1, 1962--the corresponding figures had increased to about 75% for men and 30% for women. These large increases are mainly due to maturation of the program, in the sense that those aged 65 and over in 1962 had a larger proportion of their working years covered by OASDI than did those in the 1941 population aged 65 and over. Secondary reasons for these large increases in the proportion of the population on the benefit roll are: the liberalization in the eligibility requirements for old-age benefits, the increased labor force participation of married women, and the general trend for earlier retirement.

A worker is included in the experience analyzed when he becomes "entitled" to old-age benefits. This happens when (1) he is "fully insured", (2) he has attained age 65[1/], and (3) he has filed an application for benefits and is found to meet these conditions. Although conditions (2) and (3) are clear, the concept of "fully insured" is rather technical and needs some explanation.

"Fully insured status" is defined in terms of a certain amount of work done under the OASDI system. The unit used to measure the covered work is the calendar "quarter of coverage". The coverage requirement for fully insured status has changed from time to time. For old-age benefits, starting in 1940, the number of quarters of coverage had to be equal to at least half the calendar quarters elapsed after 1936 (or attainment of age 21, if later) and before the quarter of attainment of age 65. In 1950, the law was amended to change the starting point of calculation from 1936 to 1950. This change was made principally because coverage was being extended in 1951 to a large group of jobs not previously included, and the earlier requirement for eligibility to benefits would have been too strict for the workers that were being brought into the system. In 1960, the proportion of required quarters of coverage was reduced from 1/2 to 1/3, and the end-point was changed to the year of

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1/ This age was lowered to 62, first for females in 1956 and later for males in 1961.

attainment of "retirement age"; this in turn was lowered to 1/4 in 1961. In addition, the end-point of the computation for female workers was lowered in 1956, from age 65 to age 62. Throughout the years there has been a minimum requirement of 6 quarters and a maximum requirement of 40 quarters. Also special requirements, of a transitional nature, were enacted in 1954 and 1956 to permit newly covered groups of people to become insured with fewer quarters than generally required.

From this definition of "fully insured", we can see that many of the institutionalized aged are on the benefit rolls, including many who were unable to work long before they attained retirement age.

An important exclusion from this experience is caused by the "earnings test" (or "retirement test"). Ever since 1940, when monthly benefits were first paid, there has been some earnings standard which, if exceeded, would prevent payment of full (or any) retirement benefits. The effect of this test in the mortality experience is the exclusion of the healthier lives at the younger ages. Many workers past age 65 who would have applied for benefits early did not do so until a later date because of the knowledge that, even if a benefit were awarded to them, monthly payments would not have been made because of the earnings test. On the other hand, the mortality experience includes workers who filed for benefits and became entitled whether or not their benefits were being withheld because of earnings above the allowed limit. A worker is included or excluded from this experience only on the basis of whether or not he had a benefit awarded.

The test has been liberalized several times. In some instances the limits of allowable earnings income were increased, thus creating an incentive for earlier filing of claims and earlier entrance of the workers into the mortality experience. In other instances, the test was made inapplicable beyond certain ages. For example, the test was made inapplicable to beneficiaries age 75 and over in the 1950 Act (effective in 1951) and to beneficiaries aged 72 and over in the 1954 Act (effective in 1955). For years after 1954, we should, therefore, have in the experience almost every person who had the required quarters of coverage and was aged 72 or older.

We shall close this introduction with some remarks about the quality of age determinations. The standards for an acceptable proof of age have stayed about the same since 1940, but the Social Security Administration has continued to study the quality of age determinations, in the belief that changing conditions make it important to review the standards from time to time. A study of 1940 and 1941 awards (based on an experimentally rigid standard of proof) estimated that the average regularly-determined age was about 1/4 years lower than the 'actual' age (i.e., the age determined under an experimentally regid standard). A similar type of study conducted on a group of 1963 awards, the Proof of Age Validation Study for Domestic Born Adults, showed the average regularly-determined age to be about .05 years lower than the actual age. This means that beneficiaries have been claiming to be younger than what the best evidence of age shows, the difference being on the average, about 3 months in the early 1940's and about 18 days in 1963.

Such studies cannot hope to have the precision of results obtained in the physical sciences or in many areas of the social sciences, because the information comes to us from people who sometimes have a personal stake in the results of the age determination, and a proof of age that is of high credibility is not always available. The studies have been sponsored by the Claims Policy Division and have been in evolution, especially in tightening of the concept of "experimentally rigid standard". We believe that the age determinations in the OASDI system, and thus in this mortality study, are of extremely high quality, due to the way in which they are made for claims purposes. The key to this is the requirement that age, as established at the time of the claim, must either agree (in month and year) with a statement of age made at a much earlier date, or full evidence of age must be submitted.

Since self-serving misstatements of age generally take the direction of understatement of age when one is seeking a job, and overstatement of age when one is seeking retirement benefits, the requirement of consistency between the statements of age made in the two situations (otherwise full evidence must be submitted) is stringent. If an incorrect statement of birth date is given both when seeking a job and when applying for retirement benefits, one of these two statements will be against the claimant's interest. Thus we believe that a large proportion of the self-serving age errors are detected and corrected. Further, we believe that errors that are not of a self-serving type show less bias, and therefore affect mortality rates very little.2/

B. Extensiveness of Data

One of the most important aspects of OASDI as a social insurance system is the completeness of its geographical coverage, and the almost universality of its occupational coverage. About 90 percent of all work performed in the United States is covered by the program. A very large proportion of the population is insured or eligible for benefits. For example, about 95% of all children under age 18 would be eligible to receive monthly benefits if the breadwinner should die. Also, about 92% of the population attaining age 65 in 1965 are eligible for monthly benefits.

This extensiveness of coverage permits considerable flexibility and simplification in the estimation of costs for the program. Practically all of the data collected on a nation-wide basis can be used directly in the cost estimation procedures. Most of the statistics published by the Bureau of the Census, by the Bureau of Labor Statistics, by the U.S. Public Health Service, and by other Federal agencies can be used with only minor adjustment. For example, since about 95% of the male population in the

2/ The considerations of this paragraph refer specifically to the mortality experience of this study. An important future departure from this will come when those persons whose first work experience was covered under OASDI (many of them teenagers in 1937 or later) first apply for retirement benefits. For such workers, unlike those included in this study, any earlier self-serving age misstatement would generally be an overstatement.

Table 1

CALCULATED MORTALITY EXPOSURES FOR WORKERS ENTITLED TO OLD-AGE BENEFITS UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM

Year	Age[1/] 66-69	70-74	75-79	80-84	85 and Over
	Exposures--Males (thousands)				
1945	168	212	75	20	4
1950	512	552	313	94	20
1955	1,045	1,184	685	274	74
1959	1,477	1,754	1,103	474	164
1960	1,578	1,831	1,181	521	190
1961	1,664	1,892	1,250	561	218
	Exposures--Females (thousands)				
1945	30	30	8	2	0
1950	108	101	47	10	2
1955	478	394	182	58	11
1959	802	767	386	142	39
1960	874	852	442	170	50
1961	936	931	506	196	63
	Exposures as Percentage of Population--Males				
1945	10	14	8	5	2
1950	27	32	30	17	7
1955	48	58	55	43	20
1959	63	78	78	66	40
1960	67	80	81	71	45
1961	71	81	82	73	50
	Exposures as Percentage of Population--Females				
1945	2	2	1	0	0
1950	5	5	4	1	1
1955	20	17	12	7	2
1959	30	29	22	15	6
1960	32	32	24	17	8
1961	34	34	27	19	9

1/ Age nearest birthday as of the middle of the year.

working ages are insured, the death benefits for the program could be estimated by applying the U.S. Life Table death rates, with little hesitation about their appropriateness. Naturally, the actuary must still evaluate carefully every single statistic before using it, especially with respect to its conceptual structure, but he has an enormous array of relatively recent data to base his calculations upon.

The advantages of this almost universal coverage of OASDI also works in the other direction--i.e., there is a vast array of OASDI statistics that could be regarded as applicable to the entire population. An important example is the mortality experience of the insured workers. The present study may be regarded as an effort to bring a sizable amount of data of relatively high accuracy into the field of mortality studies for our aged population.

Table 1 provides an indication of the volume of the data available for this study of the mortality of Old-Age Insurance Beneficiaries (OAIB). The calculated exposures are shown for selected calendar years by age groups and sex. The table also shows the percentages that these exposures represent of the total population. For males, the ratio reaches a value as high as 82% at ages 75-79 in 1961. For females, the ratios are much lower due to the limited work experience of our currently aged female population. These ratios are expected to increase in the future, reaching values of about 95% for males and possibly 60 to 65% for females before the turn of the century.

C. Effect of the Earnings Test on the Observed Mortality

The benefits paid by the Old-Age, Survivors, and Disability Insurance system are subject to a test that measures the extent to which the worker has retired. This test is applicable to all beneficiaries under age 72[3/] and is based on the amount of the beneficiary's earnings for work performed. The amount of earnings that is allowed before any reduction in benefits has been modified several times in the past. At present, according to the 1961 Act, a beneficiary is allowed earnings of up to $1,200 in a year without any benefit reduction. For earnings between $1,200 and $1,700, there is a $1 reduction for each $2 of earnings. The reduction changes to $1 for $1 for earnings above $1,700. In addition, the law specified that no benefit can be withheld for any month in which wages are $100 or less and in which the individual does not engage in substantial self-employment activities.

In practice, due to the earnings test, there is a tendency for workers to delay the filing of claims for old-age benefits until they are ready to retire (either fully or partially), rather than to file early and have their benefits withheld because of their continuing work. This creates an anomaly in the observed death rates, since presumably those who continue to work and do not file for benefits are in better health than those who had decided to retire.

3/ The test was applicable to all beneficiaries when the program started, but in the 1950 Act, an age-75 limitation was introduced. This was later lowered to age 72 in the 1954 Act.

Table 2

AVERAGE PROPORTION OF THE INSURED WORKERS THAT ARE ENTITLED TO AN OLD-AGE BENEFITS
1959-61 Experience

Age Nearest Birthday	Workers Entitled as Percentage of Workers Insured	
	Males	Females
66	75%	85%
67	82	88
68	86	90
69	88	92
70	90	94
71	93	95
72	96	96
73	99	98
74	99	98
75	99	98
76 and Over	99	98

According to the above discussion, we should then expect our observed mortality to be somewhat high at the early ages relative to the mortality of the total population and gradually to become less so with advancing age until reaching a normal level at about age 72. After this age, the mortality rates should increase with age in the usual way, except for possible statistical fluctuations. In may be noted from Charts A and B that this is the case.

For the period 1959-61, the effect of the earnings test in delaying the filing of claims can be observed in Table 2. Here, we show by age the number of workers entitled to an old-age benefit as a proportion of the insured workers (workers who would become entitled if they filed a claim). The proportion increases for males from 75% at age 66 to 99% at age 73 and remains at that level for the older ages. For females, the proportions are somewhat higher, except that the ultimate level is 98%.

D. Adjustments for Limitation of the Data

The data used in this study were not collected with the specific intention of conducting research into the mortality of the OASDI beneficiaries. These data are instead essentially a by-product of the process of administering the program. As it usually happens in cases like this, it was necessary to adjust the data so that they would conform to suitable mathematical formulas for calculating the mortality rates.

The observed deaths were taken as tabulated--that is, without any adjustment--while the exposures were determined in a manner to conform to the deaths. The tabulated deaths referred to workers who died while entitled to an old-age benefit. This means that once a worker became entitled, he was in the observation group whether or not his benefits were being withheld. The deaths were tabulated by year of occurrence, rather than by year of administrative action, with corrections being made every year according to the latest information.

For the calculation of the exposures, we had two different possible sources. The first source was an annual tabulation of the number of workers who had benefits in force as of the end of the year. These tabulations could not be used directly to compute the exposures for two reasons:

(1) They exclude workers on whose application for benefits no action had been taken before the end of the year.
(2) They include beneficiaries of whose death no information was available at the end of the year.

Of these two possible sources of error, the second one was corrected by using factors derived from later death tabulations. The first one presented more difficulty, especially so for ages under 72. An approximation, based on statistics for a number of recent years, was used to correct for this error. From statistics on awards, it was found that about 16% of the benefits awarded in a given calendar year are due to applications filed in the previous year. The use of the 16% factor constitutes an approximation (as opposed to an exact correction) because it

Table 3

COMPARISON OF ESTIMATED EXPOSURES FOR OLD-AGE BENEFICIARIES, 1959-61

Age Nearest Birthday	Percentage Excess of Exposure from the Entitlement Data over Exposure from the In-Force Data	
	Male	Female
63	--	2.4%
64	--	2.0
65	--	1.9
66	2.0%	1.6
67	1.4	1.2
68	1.1	1.1
69	1.0	1.0
70	.9	.8
71	.8	.8
72	.5	.8
73	.4	.7
74	.4	.2
75	.4	-.2
76	.3	-.4
77	.2	-.2
78	-.1	.0
79	.0	.1
80 and Over	-.2	.0
All ages	.6	.9

is based on all ages and sexes combined and because it is an average for several years. Although there is some small variability by years in this factor, we cannot see any reason for any significant variation by either sex or age. The approximation should, therefore, be regarded as producing values of acceptable accuracy.

Another source for the calculation of the exposures is the tabulations of awards by year of entitlement. These tabulations are updated yearly and, if they are combined with the yearly death tabulation, a good estimate of the number of workers entitled as of the end of each year could be obtained. There is one possible error in such an estimate. This has to do with the retroactivity of the benefit payments. In the OASDI system, a worker can apply for old-age benefits and request that the entitlement be made retroactive for up to 12 months.[4/] In such a case it would not be appropriate to include an individual in the exposure for the period of retroactivity since it is known that he survived the period and could not possibly be among the deaths for the period.

To correct for this error, retroactivity factors were calculated from the award experience by age and sex. These were then coupled with the 16% correction factor discussed earlier, in order to make an adjustment for the period from the determined date of entitlement to the actual date of filing.

The exposures calculated using both methods are compared in Table 3. Clearly the differences are negligible. In the calculation of the monthly rates, we decided to use an exposure that is an average of the exposures calculated by the two different methods. This will tend to reduce the error in the final death rates, since the true exposure should be somewhere between the two estimated values.

E. Completeness of Deaths Recording

Perhaps the most serious source of possible error in a mortality study is the incompleteness in the recording of the deaths. Extreme care should be taken for the complete recording of the deaths occurring in the observation period, but it often happens that advanced planning is not entirely possible because the decision to prepare a mortality study is based on the availability of some mortality data over which the actuary clearly has no control.

In a majority of the cases, the data is a by-product of the general statistical system used in the administration of the program, and it would be costly to try to trace every possible source of inaccuracy in the recording practices followed in the past. Aside from a sample test, which might run into many thousands of dollars just to detect a negligible error, we are left with the alternative of assuming the data to be of acceptable general accuracy (in the absence of any contrary indication). A few tests could, nevertheless, be performed to ascertain the internal consistency of the data and to detect the presence of persistent biases.

4/ There was no allowable retroactivity for old-age benefits at the beginning of the program. This was changed to 3 months in 1946, to 6 months in 1950, and to 12 months in 1954.

CHART A

MORTALITY OF WORKERS ENTITLED TO OLD-AGE BENEFITS, 1959–61

DEATH RATES BY SINGLE YEARS

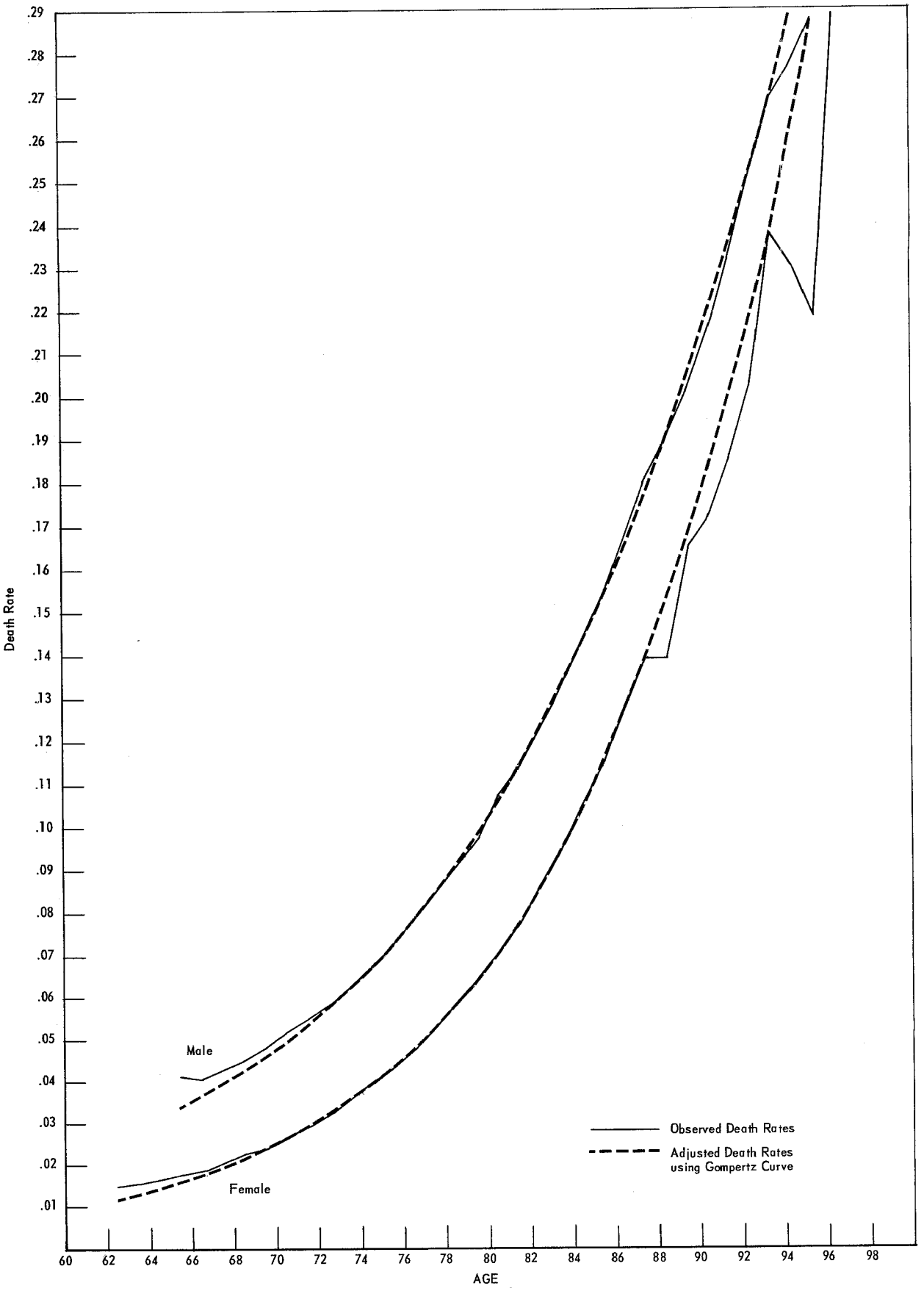


CHART B

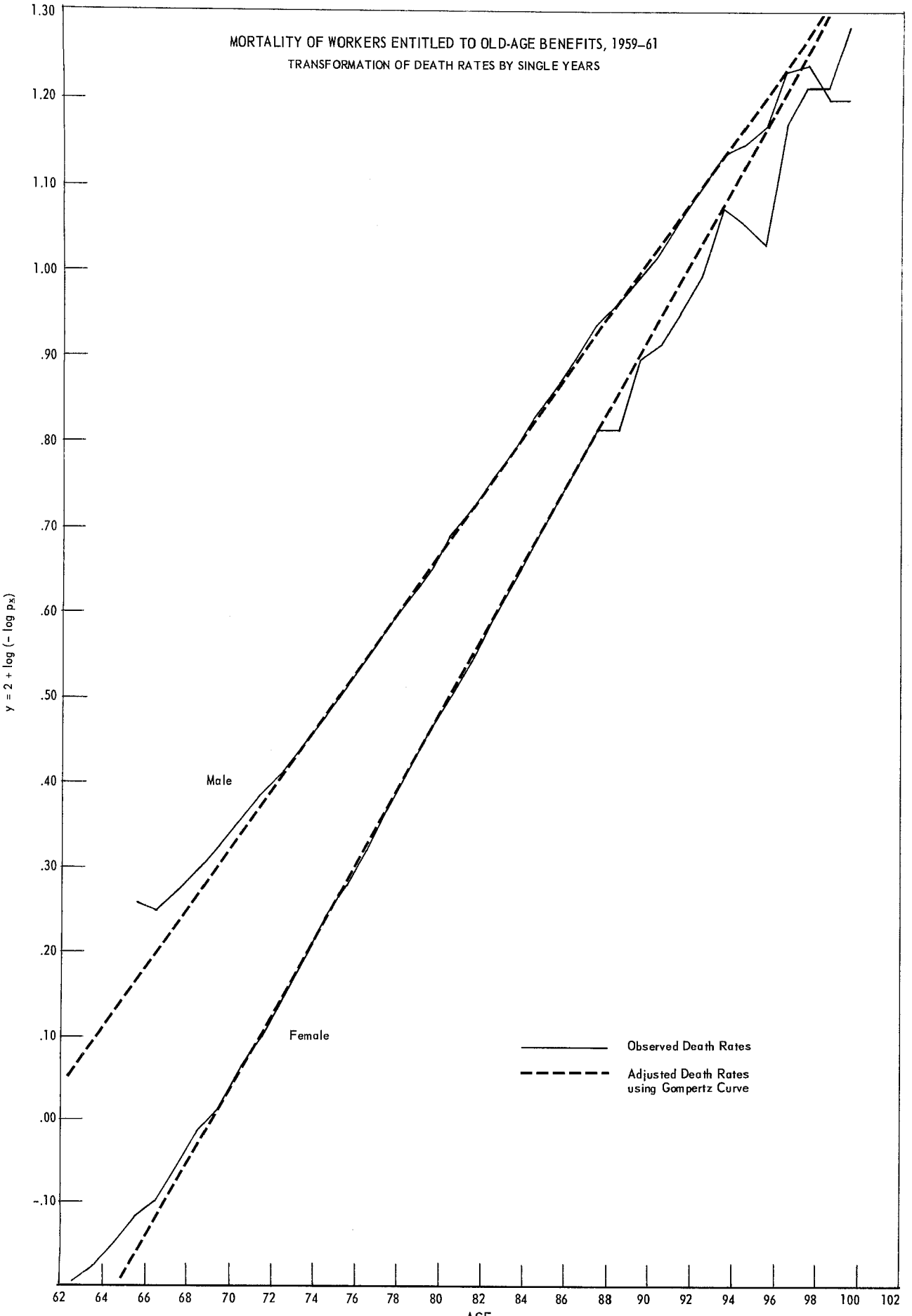

MORTALITY OF WORKERS ENTITLED TO OLD-AGE BENEFITS, 1959–61
TRANSFORMATION OF DEATH RATES BY SINGLE YEARS
y = 2 + log (− log px)
1.30
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.00
-.10
Male
Female
Observed Death Rates
Adjusted Death Rates using Gompertz Curve
62
64
66
68
70
72
74
76
78
80
82
84
86
88
90
92
94
96
98
100
102
AGE

Table 4

PERCENTAGE EXCESS OF DEATHS RECORDED AFTER THE END OF THE YEAR FOLLOWING THE YEAR OF DEATH

Up to the End of Year	Year of Occurrence of Death								
	1952	1953	1954	1955	1956	1957	1958	1959	1960
Males									
1954	.07								
1955	.15	.11							
1956	.17	.13	.04						
1957	.18	.14	.07	.04					
1958	.18	.15	.08	.06	.05				
1959	.20	.17	.09	.08	.08	.06			
1960	.21	.18	.10	.09	.10	.09	.05		
1961	.22	.19	.11	.10	.11	.10	.06	.03	
1962	.22	.20	.12	.11	.13	.12	.08	.05	.04
Females									
1954	.07								
1955	.11	.09							
1956	.13	.12	.06						
1957	.14	.13	.09	.07					
1958	.15	.13	.10	.10	.07				
1959	.16	.16	.11	.12	.10	.12			
1960	.17	.18	.12	.13	.11	.14	.08		
1961	.18	.18	.13	.13	.13	.15	.10	.08	
1962	.18	.20	.14	.14	.14	.18	.12	.12	.05

Note: As an example to aid in the interpretation, we have that the .12 in the 1954 column for males of the 1962 line means that of the male deaths occurring in 1954 by the end of 1962 there were .12 percent more deaths recorded than had been recorded by the end of 1955. That is the deaths recorded up to 1962 represent about 100.12 percent of the deaths recorded up to 1955.

In the OASDI program, one important source of bias in the number of deaths recorded is the result of the time lag between the occurrence of the death and its corresponding recording. The lag is due to late reporting of death by the beneficiary's survivors and to the time it takes to get the information to the payment centers, where the reports enter the statistical system. In the particular case of the death of workers eligible for old-age benefits, we have found that if the recording period is extended one year beyond the end of the observation period, this is sufficient (for actuarial purposes) to eliminate the lag bias. To show the factual basis for this "one additional year of recording" rule, see Table 4. For deaths after 1951, the size of the understatement in the general mortality that would result from recording deaths through the end of the year after the year of death is measured in terms of the excess percentages of the data available at the end of each successive year. From this, it appears that the ultimate error will be less than 0.2% for deaths of 1961. Naturally, in the estimation of the death rates for the present study we used the latest available data--i.e., all deaths recorded through the end of 1962. If a correction were to be applied for noncompletion of death recordings, it would have to be less than 0.2% for 1961 and increasingly smaller values for earlier years. No correction would have to be made for years before 1952.

It could happen that the error, although small for the total number of deaths, was concentrated at a few particular ages and in this way could significantly distort part of the mortality curve. We have not found this to be the case, but the bias seems to be smaller for ages over 72. We estimate that for such ages the largest error for non-completion of death recording would be at a level of less than 0.1% for 1961. The errors would, naturally, be much smaller for earlier years in the observation period. We believe that the higher completeness for ages 72 and over could be due to the fact that, since all of the workers entitled at those ages are drawing benefits, we would then know more rapidly about their death because of the return of their uncashed checks than would be the case for workers under age 72; many of the latter are not drawing benefits due to the earnings test, and thus it could conceivably take longer to learn about their deaths.

F. Mortality Trend

When the period of observation in a mortality study is long, one can be faced with the problem of either discarding some valuable information or having to combine into a single group of data several periods that clearly had different mortality experience. One possible solution to this problem is to analyze the trend of the mortality for broad groups of ages or years and at the same time to study in detail the mortality for a short period of time that is known to have reasonably homogeneous experience.

Chart C and Table 5 show the ratio of the actual number of deaths observed in each year to the expected number of deaths calculated, by single years of age, on the basis of the ungraduated death rates obtained for the whole period of observation. Some standard mortality table could

Table 5

MORTALITY TREND FOR WORKERS ENTITLED TO OLD-AGE BENEFITS UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM

Calendar Year	Actual Deaths[1]		Expected Deaths[2]		Ratio Actual to Expected	
	Male	Female	Male	Female	Male	Female
1941	10,311	657	8,380	492	1.230	1.335
1942	15,985	1,151	13,130	843	1.217	1.365
1943	21,675	1,692	17,224	1,192	1.258	1.419
1944	26,471	2,123	21,478	1,555	1.232	1.365
1945	33,653	2,780	28,248	2,035	1.191	1.366
1946	43,706	3,554	38,777	2,744	1.127	1.295
1947	56,180	4,682	50,533	3,681	1.112	1.272
1948	67,775	5,755	62,142	4,792	1.091	1.201
1949	78,080	7,122	74,520	6,081	1.048	1.171
1950	93,478	8,991	92,577	8,402	1.010	1.070
1951	125,058	14,148	116,473	12,387	1.074	1.142
1952	141,174	18,063	138,226	17,024	1.021	1.061
1953	164,675	23,466	159,574	22,276	1.032	1.053
1954	181,197	28,688	184,557	28,643	.982	1.002
1955	209,881	35,719	211,128	35,871	.994	.996
1956	235,093	43,240	239,154	43,936	.983	.984
1957	270,861	52,832	272,340	52,987	.995	.997
1958	298,743	62,193	307,326	63,374	.972	.981
1959	320,267	71,086	333,831	73,445	.959	.968
1960	349,695	81,114	358,905	83,709	.974	.969
1961	365,988	90,612	381,426	94,194	.960	.962
1941-61	3,109,946	559,668	3,109,949	559,663	1.000	1.000

1/ Data as of the end of 1962.

2/ Calculated by single years of age according to the mortality for the entire period.

Note: Includes only data for workers who were age 65 or over at the beginning of the year.

CHART C
RATIO OF ACTUAL DEATHS TO EXPECTED DEATHS
FOR ALL WORKERS ENTITLED TO OLD-AGE BENEFITS

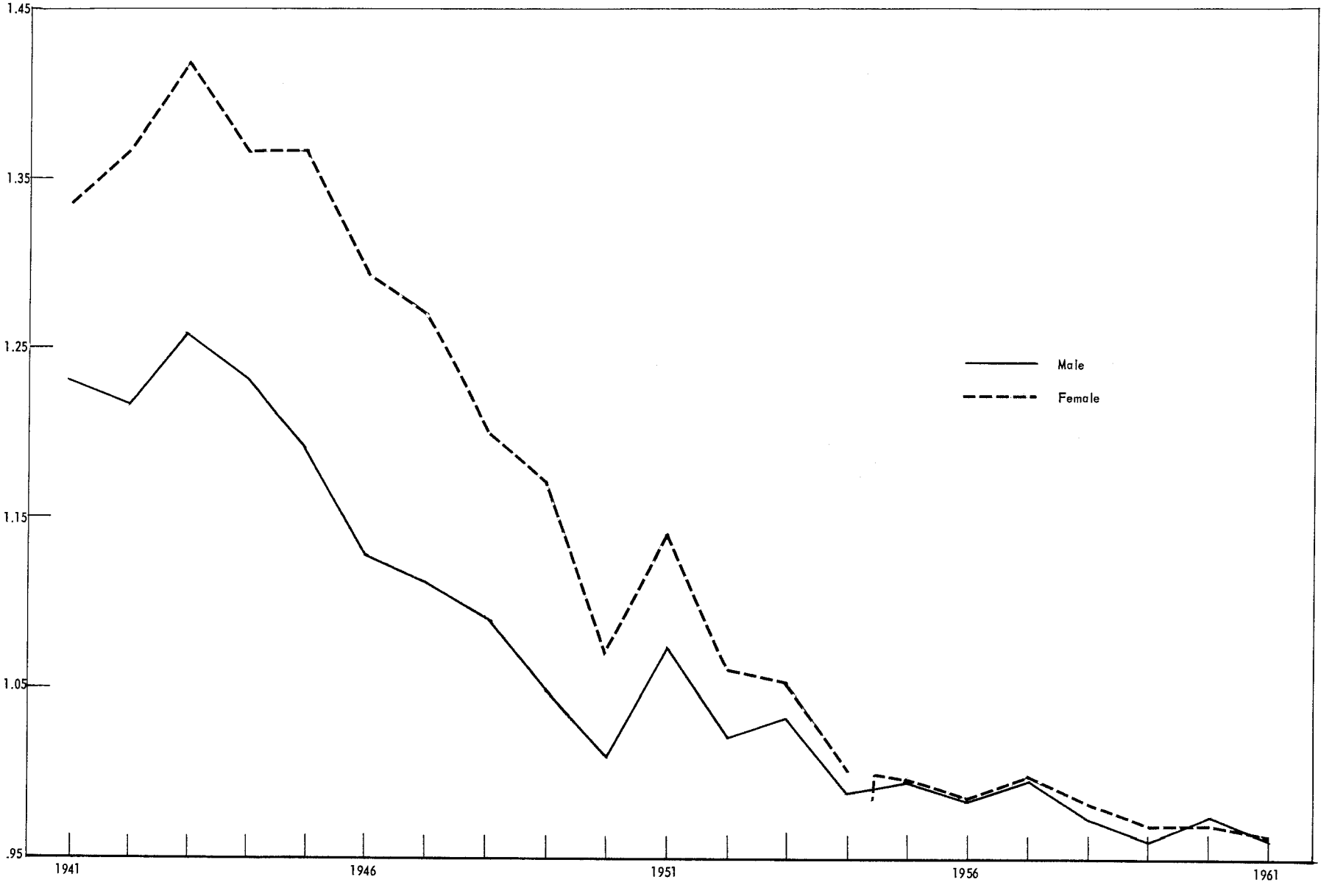


Table 6

MORTALITY TREND FOR WORKERS ENTITLED TO OLD-AGE BENEFITS UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM

Ratio of Actual Deaths to Expected Deaths

Period	Age Nearest Birthday					
	66-69	70-74	75-79	80-84	85 and Over	66 and Over
			Males			
1941-43	1.244	1.267	1.229	1.098	1.065	1.238
1944-46	1.278	1.159	1.130	1.035	1.010	1.173
1947-49	1.120	1.088	1.061	1.019	.993	1.079
1950-52	1.061	1.052	1.014	1.003	.984	1.036
1953-55	1.018	1.006	.994	.984	.972	1.001
1956-58	.969	.971	.990	1.003	1.009	.983
1959-61	.913	.952	.982	1.000	1.005	.964
			Females			
1941-43	1.420	1.140	1.277	1.071	.700	1.385
1944-46	1.443	1.308	1.280	1.220	1.076	1.335
1947-49	1.286	1.212	1.170	1.090	1.063	1.206
1950-52	1.121	1.099	1.062	1.048	1.021	1.090
1953-55	1.022	1.022	.999	1.003	.969	1.012
1956-58	.983	.986	.983	.998	1.013	.987
1959-61	.933	.952	.986	.991	.998	.966

Note: All data as of the end of 1962. The expected deaths were calculated according to the mortality for the entire period.

have been used instead for this purpose, but we believe that an analysis of higher acceptability would result if no outside information were introduced. The downward trend of the mortality is clear from the chart. The ratio for males goes from 1.23 in 1941 to .96 in 1961, which means that the overall mortality of the beneficiaries decreased by about 22% in the 20-year period.

A closer look at the data shows that the rapid reduction experienced in the late 1940's was somewhat slowed down in the early 1950's and that a state of almost level mortality was reached beginning with 1954. In our opinion, although the mortality for the period 1954-61 is almost level, there is a slight tendency for it to decrease.

For females, there is practically the same trend as for men, except that the reduction in mortality for the 20-year period is somewhat larger (28%, as compared to 22% for males) and that there is a clearer tendency for the mortality to decrease during the period 1954-61.

The jump in the ratio for the year 1951 is probably principally due to a major liberalization in the eligibility requirements that was enacted in the 1950 Amendments. These made it possible for workers with limited OASDI coverage to qualify for old-age benefits. For example, an individual attaining age 65 at the beginning of 1951 had his quarters-of-coverage requirement reduced from 28 to 6.

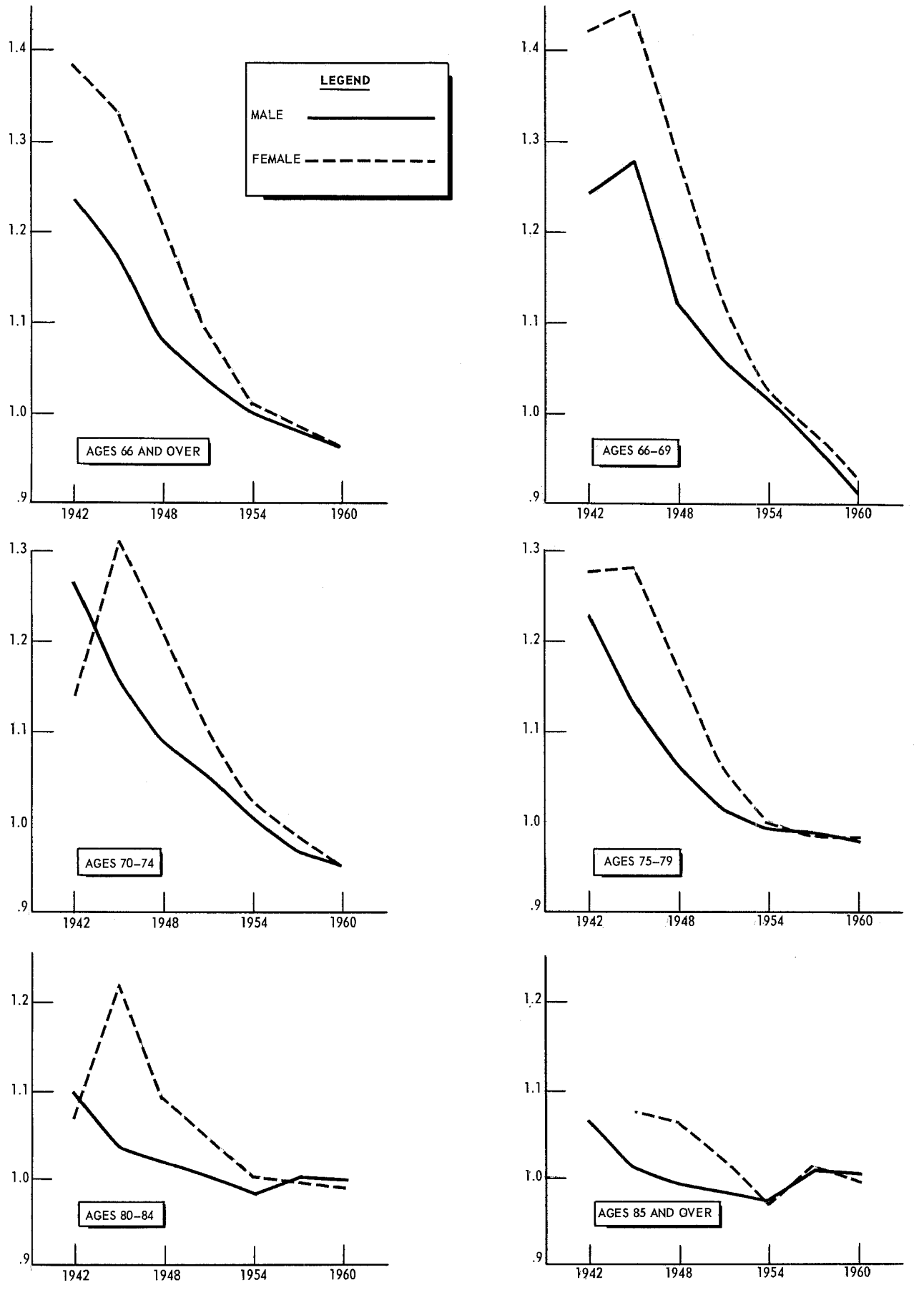
Many who applied for benefits shortly after the enactment of the 1950 Amendments were persons (some of them relatively old) who had not been working recently and who could be presumed to be in poorer health than workers who met the stricter coverage requirements of the previous law. Other liberalizations in eligibility requirements were enacted in 1954, 1956, 1960, and 1961, but we believe that they had little effect on the overall mortality of the beneficiary group.

A somewhat different picture in the mortality trend is obtained if the analysis is done by age groups. For male workers, there is definite decreasing trend in all years for age groups 66-69, 70-74, and 75-79 (see Chart D and Table 6); the rate of decline is highest for the youngest, and lowest for the oldest, of these three age groups. For ages 80-84, male mortality seems to have leveled off after 1949; at ages 85 and over, however, there is a clear indication of a reversal in the mortality trend at the end of the period. For female workers, practically the same observations can be made, although the relative decline in mortality for the whole period was greater than for males.

If these trends are compared with those for the United States population[5/], similar trends are observed for ages 75 and over for both males and females. For ages under 75, the trends would be similar for females, but different for males. The mortality of the younger male old-age beneficiaries under the OASDI system continues to decline, but the mortality for males aged 65-74 in the United States population shows signs of being

5/ See "The Change in the Mortality Trends in the United States", Series 3, No. 1; National Center for Health Statistics, Public Health Service, Department of Health, Education, and Welfare.

CHART D
MORTALITY TREND FOR WORKERS ENTITLED TO OLD-AGE BENEFITS
RATIO OF ACTUAL DEATHS TO EXPECTED DEATHS



on the increase. We do not have an explanation for this difference in trend, but it is entirely possible that it may be due to the trend toward earlier retirement that has been experienced. Under these circumstances a larger proportion of people are retiring at a relatively younger age, when they are healthy, than was the case earlier, and so the beneficiaries aged 65-71 more nearly consist of an "average spread" of lives insofar as mortality is concerned, rather than containing an undue number of higher-than-average-mortality persons. This would tend to produce a decline in the observed mortality of the retired workers, even though the mortality of the general populations may have remained stable or might even have been increasing.

G. Graduation of the Data

In the great majority of studies on mortality, a need for graduation arises because of the presence of what is believed to be irregularities in the observed mortality. Naturally, there is no standard rule that will indicate what constitutes an irregularity, and accordingly the persons conducting the study must use their judgment in order to arrive at a series of death rates that could acceptably be regarded as the mortality underlying the observed data. Usually the analyst can be guided by the general trend by age of the mortality rates and by prior knowledge of possible biases in his decisions as to what specific points or sections of the curve fall out of line and should be graduated.

Of all the many possible graduating procedures that could be used in this case, it was decided, after careful study of the data, to fit a Gompertz curve to only the middle section of the observations. As was discussed in an earlier section, the mortality at the younger ages is affected by the operations of the earnings test provision and should be expected to be off line from the observed rates at the older ages (see Charts A and B). For this reason, the data for ages below 70 for females and 73 for males were not used in the calculation of the specific Gompertz curve to be fitted.

We believe that by extrapolating the fitted curve back to the early ages, mortality rates could be obtained that are representative of the entire insured population, although clearly they would not be representative of the beneficiaries. It should also be noted that the trend toward earlier entitlement, caused by either the liberalization of the earnings test or by an underlying early-retirement trend (or even by an administrative encouragement to file early) tends to produce decreases from year to year in the observed mortality and thus to blur the true picture of the mortality trend of our population at the ages immediately following age 65. The extrapolated rates would probably produce a clearer picture.

At the other end of the mortality curve, at ages over 90 or 95, we find that the observed mortality is much lower than what could be projected from the middle section (see Charts A and B). It is entirely possible that the true rate of mortality at these very high ages has a tendency to become level or at least to slow down in its accelerated increase, but until future experience shows this to be the case, it is more reasonable to question the accuracy of the tabulated age data.

In our case, the beneficiaries who are involved in the experience at ages above 94 became entitled to benefits at an average age of about 83. Certainly none of them could have become entitled to benefits before age 75, because that was the youngest possible age that an individual aged 95 in 1961 could have been to receive benefits when the program started paying monthly

benefits (since he could not have qualified until 1941). Evidently, these are people who were well past age 65 when they filed for benefits, and it would be most unreasonable to assume that as great an effort was made to determine their exact age as was done for the younger workers. It would be difficult to conceive of a case in which a worker claims to be 83 years old and can acceptably show that he is at least 78, and yet the program administrators insist on spending some time and money, and also causing some inconveniences to the worker, just to get a better age data for statistical tabulations.

The above argument of unreliability at the very old ages could very well be applied to each successive younger age. Naturally, the younger the age the less applicable the argument would be and the more credible would be the data. Since there is no clear-cut age breaking point before which the data are fully reliable and beyond which they are completely unreliable, a sliding scale of reliability would then be the most reasonable assumption. In the absence of any knowlege as to such a sliding scale, it was decided to select arbitrarily the breaking points for the calculation of the Gompertz curve. The points were chosen solely on the basis of what was believed would be a good fit on a graphical basis by using Chart B.

It should be emphasized that the selection of a Gompertz curve is basically subjective and that whether or not it is valid at the very high ages will have to be established during the next decade or two as the age data become more and more reliable.

For those readers not familiar with the problem of age accuracy at the older ages, the situation is not one of the beneficiary misstating his age in order to draw OASDI benefits. Rather, it is one of the beneficiary not really knowing how old he is. Possibly it could also be a situation of the beneficiary "aging" more than one year for each year that elapses--for the mere prestige of being older--but clearly there is no financial incentive present for such overstatement when a beneficiary is at the very high ages.

H. Fit of Gompertz Curve

It was pointed out earlier that a Gompertz curve was fitted to the middle section of the data. Charts A and B give a visual idea of how well this type of curve fits the data.

According to the Gompertz law, the force of mortality--that is, the instantaneous rate of mortality--increases geometrically with age. This force of mortality, μ, is usually represented by the formula:

$$\mu_x = Bc^x$$

where x is the exact age, and where B and c are constants that characterize a particular curve.

Table 7

MORTALITY OF MALE WORKERS ENTITLED TO OLD-AGE BENEFITS UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM, 1959-61

Age[1]	Observed Deaths	Exposures	Observed Death Rate	Adjusted Death Rate[2]
66	42,872	1,051,508	.04077	.03323
67	48,722	1,215,875	.04007	.03594
68	52,122	1,233,908	.04224	.03886
69	54,434	1,217,962	.04469	.04201
70	55,890	1,174,711	.04758	.04541
71	59,454	1,160,964	.05121	.04908
72	60,568	1,114,845	.05433	.05304
73	61,331	1,062,645	.05772	.05731
74	59,641	964,298	.06185	.06191
75	59,617	897,677	.06641	.06686
76	57,718	800,960	.07206	.07220
77	55,292	709,740	.07790	.07794
78	50,835	604,214	.08413	.08412
79	46,999	521,759	.09008	.09077
80	42,111	435,197	.09676	.09791
81	39,196	366,509	.10694	.10558
82	34,330	301,990	.11368	.11381
83	30,761	249,372	.12335	.12264
84	26,580	201,722	.13177	.13210
85	22,890	159,410	.14359	.14223
86	18,638	121,481	.15342	.15307
87	15,216	91,488	.16632	.16465
88	11,726	64,966	.18049	.17702
89	8,742	45,965	.19019	.19020
90	6,272	31,155	.20132	.20423
91	4,639	21,592	.21485	.21916
92	3,232	13,902	.23248	.23501
93	2,264	9,009	.25130	.25180
94	1,488	5,532	.26898	.26957
95	932	3,366	.27689	.28835
96	562	1,953	.28776	.30813
97	368	1,131	.32538	.32893
98	219	662	.33082	.35076
99	124	405	.30617	.37359
100	73	238	.30672	.39741

1/ Age next birthday at the beginning of the year of exposure.

2/ These rates were obtained by adjusting a Gompertz' curve to the data for ages 73 to 94.

Table 8

MORTALITY OF FEMALE WORKERS ENTITLED TO OLD-AGE BENEFITS UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM, 1959-61

Age[1]	Observed Deaths	Exposures	Observed Death Rate	Adjusted Death Rate[2]
63	5,041	347,474	.01451	.01156
64	6,585	435,946	.01511	.01279
65	8,882	548,805	.01618	.01416
66	11,143	639,130	.01743	.01567
67	12,247	673,430	.01819	.01734
68	13,315	664,432	.02004	.01919
69	14,038	634,894	.02211	.02123
70	14,028	595,797	.02354	.02349
71	14,774	562,968	.02624	.02598
72	14,789	517,708	.02857	.02874
73	14,755	467,982	.03153	.03178
74	14,268	406,050	.03514	.03513
75	14,169	359,035	.03946	.03884
76	13,104	307,972	.04255	.04293
77	12,420	264,409	.04697	.04743
78	11,507	219,474	.05243	.05240
79	10,676	183,768	.05809	.05787
80	9,625	150,078	.06413	.06389
81	8,612	122,892	.07008	.07051
82	7,466	97,120	.07687	.07779
83	6,690	77,634	.08617	.08579
84	5,747	60,767	.09457	.09457
85	4,913	46,824	.10492	.10419
86	3,880	33,937	.11433	.11473
87	3,086	24,237	.12733	.12626
88	2,273	16,354	.13899	.13885
89	1,562	11,221	.13920	.15258
90	1,235	7,471	.16531	.16754
91	850	4,948	.17179	.18380
92	574	3,098	.18582	.20144
93	378	1,862	.20301	.22053
94	273	1,146	.23822	.24114
95	155	674	.22997	.26334
96	88	402	.21891	.28715
97	68	236	.28814	.31263
98	44	140	.31429	.33980
99	28	89	.31461	.36863
100	17	48	.35417	.39910

1/ Age next birthday at the beginning of the year of exposure.

2/ These rates were obtained by adjusting a Gompertz' curve to the data for ages 70 to 88.

It can be shown that when the Gompertz law of mortality is applicable,

$$\log \operatorname{colog}(1-q_x) = Ex + F,$$

where q_x is the probability that a person age x dies before reaching age x + 1, and where E and F are constants defined as follows:

$$F = \log \frac{B(c-1)}{\log c}$$

$$E = \log c.$$

This implies that, if the observed mortality follows the Gompertz law, then the transform, log colog $(1-q_x)$ is linear (see Chart B), and the constants E and F could be readily evaluated using the least squares principle.

In this study, the constants for females were evaluated from the data for ages 70 to 88, while the data for ages 73 to 94 were used in the case of males. Since the exposure decreased rapidly with age, a weighted least squares line was fitted. An equal-weight least squares fit would have overemphasized the observations at the higher ages. The weights we used were calculated using the formula,

$$W_x = \sqrt{\frac{D_x}{1-q_x}}$$

where D_x is the number of observed deaths at age x. This formula was derived on the assumption of weights being equal to the reciprocal of the relative standard deviation of the number of deaths. Even after using these weights, there is probably unmerited emphasis placed on the data at the very high ages (about twice as much at age 94 as seems desirable) due to the fact that the linear fit is made on the transform and not on the observations themselves, but it is believed that the resulting distortion would not be significant.

The curves finally adopted were as follows:

Females:

$$q_x = 1-(10)^{-(10)^{.044366x-5.069637}}$$

Males:

$$q_x = 1-(10)^{-(10)^{.0345795x-4.098288}}$$

Tables 7 and 8 contain the data on observed deaths, exposure, and death rates and on the adjusted death rates computed from the adopted curves.

Table 9

WORKERS ENTITLED TO OLD-AGE INSURANCE BENEFITS, 1959-61: FEMALE DEATH RATE AS PERCENTAGE OF MALE DEATH RATE

Age[1/]	Observed Rates	Adjusted Rates
66	43	47
67	45	48
68	47	49
69	49	51
70	49	52
71	51	53
72	53	54
73	55	55
74	57	57
75	59	58
76	59	59
77	60	61
78	62	62
79	64	64
80	66	65
81	66	67
82	68	68
83	70	70
84	72	72
85	73	73
86	75	75
87	77	77
88	77	78
89	73	80
90	82	82
91	80	84
92	80	86
93	81	88
94	89	89
95	83	91

1/ Age next birthday at the beginning of the year of exposure.

No test for smoothness was made on the adjusted values, since the mathematical curve guarantees the smoothness of the resulting rates. For the closeness of fit, three measurements were used.

The first measure was the correlation coefficient between age and the transform of the death rate. The coefficients were found to be .9999 for females and .9998 for males.

The second measure was the average relative differences in the observed and adjusted q_x's. This was found to be 0.6% for both males and females--that is, the observed values were on the average at a distance of 0.6% of the adjusted value. When the signs of the relative difference were considered, the average error was found to be less than 0.01%.

The third measure was the ratio of the total observed deaths to the total expected deaths. This was found to be equal to 100.01% for both males and females. All three of the measures of fit are well within acceptable limits.

I. Male vs. Female Mortality

As can be seen from Table 9 and Chart A, the mortality of the female beneficiaries is lower than that of the male beneficiaries. This differential in mortality has been found in practically all modern mortality investigations. In this study, the female rates are about 45% to 50% of the male rates at the early old ages. This percentage increases slowly and steadily, reaching levels of about 80% at age 90 and about 90% at age 95.

If the adjusted rates were projected at the higher ages, the differential would disappear at about age 100. For ages over 100, the differential would be reversed, and female mortality would become higher than male mortality. It is possible that this reversal really exists, but further experience will be needed to establish its validity.

In the United States Life Tables for 1959-61, it was found that the observed mortality had this reversal. The ratio of the observed female central death rate to the male central death rate changed from under 100% to over 100% at ages 95-99 for nonwhites and at ages 100 and over for whites and for the total population. Since the tables were artificially closed by using the experience at these extreme ages for Union Civil War Veterans, the reversal was not contained in the published rates.

Although there is considerable likelihood that the reversal does exist, its true occurrence has not been categorically established. The population data used in the United States Life tables are not regarded as accurate at the oldest ages, and the observation for OASDI beneficiaries is based on a projection of the adjusted rate. In both cases, there are valid reasons for rejecting the reversal argument.

Table 10

COMPARISON OF GRADUATED DEATH RATES FOR FEMALES

Age[1]	(1) OASDI 1959-61	(2) U.S. Population 1959-61[2]	(3) CSR Ultimate 1958-62[3]	(4) As a Ratio of Col. (1) Col. (2)	(5) Col. (3)
62	.01099	.01451	.0096	1.32	.87
63	.01216	.01578	.0106	1.30	.87
64	.01346	.01711	.0117	1.27	.87
65	.01489	.01854	.0131	1.25	.88
66	.01649	.02014	.0145	1.22	.88
67	.01824	.02199	.0162	1.20	.89
68	.02018	.02415	.0178	1.20	.88
69	.02233	.02661	.0197	1.19	.88
70	.02470	.02929	.0219	1.19	.89
71	.02732	.03219	.0243	1.18	.89
72	.03022	.03546	.0270	1.17	.89
73	.03342	.03914	.0297	1.17	.89
74	.03694	.04327	.0327	1.17	.89
75	.04083	.04767	.0362	1.17	.89
76	.04512	.05246	.0402	1.16	.89
77	.04985	.05804	.0445	1.16	.89
78	.05507	.06469	.0488	1.17	.89
79	.06081	.07240	.0537	1.19	.88
80	.06712	.08144	.0593	1.21	.88
81	.07407	.09143	.0656	1.23	.89
82	.08170	.10154	.0725	1.24	.89
83	.09008	.11096	.0794	1.23	.88
84	.09927	.11975	.0872	1.21	.88
85	.10934	.13423	.0961	1.23	.88
86	.12037	.15009	.1060	1.25	.88
87	.13242	.16689	.1169	1.26	.88
88	.14557	.18478	.1278	1.27	.88
89	.15991	.20364	.1402	1.27	.88
90	.17550	.22329	.1541	1.27	.88
91	.19242	.24327	.1695	1.26	.88
92	.21078	.26302	.1864	1.25	.88
93	.23064	.28181	.2033	1.22	.88
94	.25203	.29903	.2226	1.19	.88
95	.27503	.31416	.2440	1.14	.89

1/ Exact age at the beginning of the year of exposure.

2/ From United States Life Tables: 1959-61, Public Health Service, Department of Health, Education, and Welfare.

3/ From the Forty-third Annual Report of the Board of Actuaries of the Civil Service Retirement System.

Table 11

COMPARISON OF GRADUATED DEATH RATES FOR MALES

Age[1]	(1) OASDI 1959-61	(2) U.S. Population 1959-61[2]	(3) CSR Ultimate 1958-62[3]	(4) As a Ratio of Col. (1) Col. (2)	(5) As a Ratio of Col. (1) Col. (3)
62	.02525	.02769	.0237	1.10	.94
63	.02732	.02992	.0255	1.10	.93
64	.02955	.03226	.0276	1.09	.93
65	.03196	.03474	.0298	1.09	.93
66	.03456	.03739	.0323	1.08	.93
67	.03737	.04017	.0349	1.07	.93
68	.04040	.04307	.0375	1.07	.93
69	.04367	.04612	.0405	1.06	.93
70	.04721	.04936	.0437	1.05	.93
71	.05102	.05285	.0473	1.04	.93
72	.05513	.05665	.0511	1.03	.93
73	.05956	.06083	.0550	1.02	.92
74	.06434	.06541	.0593	1.02	.92
75	.06948	.07035	.0640	1.01	.92
76	.07501	.07571	.0692	1.01	.92
77	.08097	.08176	.0748	1.01	.92
78	.08738	.08870	.0805	1.02	.92
79	.09427	.09661	.0868	1.02	.92
80	.10167	.10598	.0937	1.04	.92
81	.10962	.11654	.1012	1.06	.92
82	.11815	.12732	.1094	1.08	.93
83	.12729	.13728	.1176	1.08	.92
84	.13708	.14623	.1267	1.07	.92
85	.14756	.15768	.1368	1.07	.93
86	.15877	.17002	.1477	1.07	.93
87	.17074	.18343	.1596	1.07	.93
88	.18351	.19868	.1716	1.08	.94
89	.19711	.21564	.1849	1.09	.94
90	.21159	.23320	.1995	1.10	.94
91	.22679	.25056	.2154	1.10	.95
92	.24329	.26792	.2326	1.10	.96
93	.26057	.28481	.2500	1.09	.96
94	.27884	.30050	.2692	1.08	.97
95	.29811	.31416	.2904	1.05	.97

1/ Exact age at the beginning of the year of exposure.

2/ From United States Life Tables: 1959-61, Public Health Service, Department of Health, Education, and Welfare.

3/ From the Forty-third Annual Report of the Board of Actuaries of the Civil Service Retirement System.

J. Comparison with Other Mortality Experience

Tables 10 and 11 compare the adjusted death rates of the old-age beneficiaries with the graduated rates of the latest decennial life tables for the United States population and also with the graduated ultimate rates of the United States Civil Service Retirement system. All three observation periods are centered about 1960, and therefore the rates are comparable as to time of observation.

OASDI mortality falls between the general population mortality and that of the Civil Service Retirement system. This is something to be expected, since the civil service annuitants are, generally speaking, probably healthier than either the OASDI beneficiaries or the general population. On the other hand, the OASDI group is made up of people who worked in covered employment long enough to qualify for a benefit and who would, therefore, be healthier than the general population.

For males, the general population has a mortality that ranges from about 1% to 10% (an average of about 5-6%) higher than that for OASDI beneficiaries, while the CSR mortality is lower by 3% to 8% (an average of about 7%). For females, the differentials are larger with averages of about 20-22% for the general population and 11-12% for CSR.

In Table 12, a comparison is made of the observed ungraduated rates for the male annuitants of the Railroad Retirement system and the OASDI beneficiaries. The comparison is made for ages 80 and over, and it shows Railroad Retirement mortality to be about 10-11% higher than OASDI mortality. There is no explanation for this higher mortality of Railroad Retirement annuitants.

K. Life Table and Actuarial Values

This final section presents life table values and actuarial values based on the adjusted mortality of the workers entitled to old-age benefits under OASDI for 1959-61.

In Table 13, values of l_x, L_x, T_x, and $\overset{o}{e}_x$ are given for ages 62 to 90. Comparable values of q_x for single years of age were given previously in Tables 10 and 11. It should be noted that the death rates in Tables 7 and 8 are for exact ages which are $\frac{1}{2}$ year younger than the tabulated ages, while in Table 12, the values are for exact ages which are $\frac{1}{2}$ year older than those tabulated.

The actuarial functions, D_x, N_x, and $\bar{a}_x$, were computed for the graduated mortality rates, using interest rates of 3%, 3-1/2%, and 4%. The values are presented in Tables 14, 15, and 16.

The user should not compute actuarial reduction factors for early retirement based on these tables, unless he feels that the mortality which has been extrapolated back from age 72 is applicable. As discussed previously, the mortality of the early retirees is generally higher than the mortality of the total eligible workers.

Table 12

COMPARISON OF UNGRADUATED DEATH RATES FOR MALES

Age[1]	(1) OASDI 1959-61	(2) RRB 1958-62[2]	Col. (2) As a Ratio of Col. (1)
80	.10694	.11608	1.09
81	.11368	.12455	1.10
82	.12335	.13436	1.09
83	.13177	.14709	1.12
84	.14359	.15859	1.10
85	.15342	.16715	1.09
86	.16632	.18007	1.08
87	.18049	.19775	1.10
88	.19019	.21066	1.11
89	.20132	.22473	1.12
90	.21485	.24315	1.13
91	.23248	.26330	1.13
92	.25130	.28938	1.15
93	.26898	.30717	1.14
94	.27689	.32329	1.17
95	.28776	.33594	1.17

1/ Age last birthday at beginning of year of exposure.

2/ Transactions, Society of Actuaries, Vol. XVI, part I, page 456.

Table 13

LIFE TABLE VALUES FOR OLD-AGE BENEFICIARIES UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM: 1959-61

Exact Age x	FEMALE				MALE			
	l_x	L_x	T_x	$\mathring{e}_x$	l_x	L_x	T_x	e_x
62	1,000,000	994,505	19,513,419	19.51	1,000,000	987,375	15,132,455	15.13
63	989,010	982,997	18,518,914	18.72	974,750	961,435	14,145,080	14.51
64	976,984	970,408	17,535,917	17.95	948,120	934,112	13,183,645	13.90
65	963,834	956,658	16,565,509	17.19	920,103	905,400	12,249,533	13.31
66	949,483	941,654	15,608,851	16.44	890,697	875,306	11,344,133	12.74
67	933,826	925,310	14,667,197	15.71	859,915	843,848	10,468,827	12.17
68	916,793	907,542	13,741,887	14.99	827,780	811,059	9,624,979	11.63
69	898,292	888,262	12,834,345	14.29	794,338	777,014	8,813,920	11.10
70	878,233	867,387	11,946,083	13.60	759,689	741,757	8,036,906	10.58
71	856,541	844,840	11,078,696	12.93	723,824	705,360	7,295,149	10.08
72	833,140	820,552	10,233,856	12.28	686,894	667,960	6,589,789	9.59
73	807,963	794,462	9,413,304	11.65	649,026	629,698	5,921,829	9.12
74	780,961	766,536	8,618,842	11.04	610,370	590,734	5,292,131	8.67
75	752,112	736,758	7,852,306	10.44	571,099	551,259	4,701,397	8.23
76	721,403	705,128	7,115,548	9.86	531,419	511,488	4,150,138	7.81
77	688,853	671,684	6,410,420	9.31	491,557	471,656	3,638,650	7.40
78	654,514	636,492	5,738,736	8.77	451,756	432,019	3,166,994	7.01
79	618,470	599,668	5,102,244	8.25	412,282	392,849	2,734,975	6.63
80	580,867	561,373	4,502,576	7.75	373,416	354,434	2,342,126	6.27
81	541,879	521,810	3,941,203	7.27	335,451	317,065	1,987,692	5.93
82	501,742	481,246	3,419,393	6.82	298,679	281,034	1,670,627	5.59
83	460,750	439,998	2,938,147	6.38	263,390	246,626	1,389,593	5.28
84	419,246	398,436	2,498,149	5.96	229,863	214,108	1,142,967	4.97
85	377,627	356,982	2,099,713	5.56	198,353	183,718	928,859	4.68
86	336,337	316,094	1,742,731	5.18	169,084	155,662	745,141	4.41
87	295,852	276,264	1,426,637	4.82	142,239	130,096	589,479	4.14
88	256,675	237,993	1,150,373	4.48	117,953	107,130	459,383	3.89
89	219,311	201,776	912,380	4.16	96,307	86,816	352,253	3.66
90	184,241	168,074	710,604	3.86	77,324	69,144	265,437	3.43

Table 14

ACTUARIAL VALUES AT 3% INTEREST FOR OLD-AGE BENEFICIARIES UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM: 1959-61

Exact Age x	Female			Male		
	D_x	N_x	$\bar{a}_x$	D_x	N_x	$\bar{a}_x$
62	1,000,000	14,660,273	14.16	1,000,000	12,014,721	11.51
63	960,204	13,660,273	13.73	946,359	11,014,721	11.13
64	920,901	12,700,069	13.29	893,694	10,068,362	10.77
65	882,045	11,779,168	12.85	842,025	9,174,668	10.40
66	843,603	10,897,123	12.41	791,373	8,332,643	10.03
67	805,527	10,053,520	11.98	741,770	7,541,270	9.67
68	767,799	9,247,993	11.54	693,253	6,799,500	9.30
69	730,394	8,480,194	11.11	645,870	6,106,247	8.95
70	693,285	7,749,800	10.68	599,705	5,460,377	8.61
71	656,468	7,056,515	10.25	554,751	4,860,672	8.26
72	619,934	6,400,047	9.82	511,114	4,305,921	7.92
73	583,689	5,780,113	9.40	468,870	3,794,807	7.59
74	547,750	5,196,424	8.99	428,101	3,325,937	7.27
75	512,151	4,648,674	8.58	388,890	2,897,836	6.95
76	476,933	4,136,523	8.17	351,331	2,508,946	6.64
77	442,149	3,659,590	7.78	315,512	2,157,615	6.34
78	407,872	3,217,441	7.39	281,519	1,842,103	6.04
79	374,184	2,809,569	7.01	249,437	1,560,584	5.76
80	341,198	2,435,385	6.64	219,343	1,311,147	5.48
81	309,026	2,094,187	6.28	191,303	1,091,804	5.21
82	277,803	1,785,161	5.93	165,371	900,501	4.95
83	247,676	1,507,358	5.59	141,585	735,130	4.69
84	218,801	1,259,682	5.26	119,964	593,545	4.45
85	191,341	1,040,881	4.94	100,504	473,581	4.21
86	165,456	849,540	4.63	83,178	373,077	3.99
87	141,301	684,084	4.34	67,934	289,899	3.77
88	119,019	542,783	4.06	54,694	221,965	3.56
89	98,732	423,764	3.79	43,356	167,271	3.36
90	80,528	325,032	3.54	33,797	123,915	3.17

Table 15

ACTUARIAL VALUES AT 3½% INTEREST FOR OLD-AGE BENEFICIARIES UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM: 1959-61

Exact Age x	Female			Male		
	D_x	N_x	$\bar{a}_x$	D_x	N_x	$\bar{a}_x$
62	1,000,000	14,001,366	13.50	1,000,000	11,554,061	11.05
63	955,566	13,001,366	13.11	941,788	10,554,061	10.71
64	912,025	12,045,800	12.71	885,080	9,612,273	10.36
65	869,323	11,133,775	12.31	829,880	8,727,193	10.02
66	827,419	10,264,452	11.91	776,191	7,897,313	9.67
67	786,256	9,437,033	11.50	724,025	7,121,122	9.34
68	745,812	8,650,777	11.10	673,400	6,397,097	9.00
69	706,049	7,904,965	10.70	624,343	5,723,697	8.67
70	666,941	7,198,916	10.29	576,917	5,099,354	8.34
71	628,471	6,531,975	9.89	531,092	4,522,437	8.02
72	590,629	5,903,504	9.50	486,952	3,991,345	7.70
73	553,411	5,312,875	9.10	444,548	3,504,393	7.38
74	516,827	4,759,464	8.71	403,932	3,059,845	7.08
75	480,903	4,242,637	8.32	365,163	2,655,913	6.77
76	445,670	3,761,734	7.94	328,301	2,290,750	6.48
77	411,170	3,316,064	7.56	293,406	1,962,449	6.19
78	377,462	2,904,894	7.20	260,530	1,669,043	5.91
79	344,614	2,527,432	6.83	229,725	1,408,513	5.63
80	312,716	2,182,818	6.48	201,033	1,178,788	5.36
81	281,862	1,870,102	6.13	174,487	977,755	5.10
82	252,158	1,588,240	5.80	150,106	803,268	4.85
83	223,727	1,336,082	5.47	127,895	653,162	4.61
84	196,690	1,112,355	5.16	107,840	525,267	4.37
85	171,173	915,665	4.85	89,911	417,427	4.14
86	147,301	744,492	4.55	74,052	327,516	3.92
87	125,189	597,191	4.27	60,188	253,464	3.71
88	104,938	472,002	4.00	48,224	193,276	3.51
89	86,630	367,064	3.74	38,042	145,052	3.31
90	70,316	280,434	3.49	29,511	107,010	3.13

Table 16

ACTUARIAL VALUES AT 4% INTEREST FOR OLD-AGE BENEFICIARIES UNDER THE OLD-AGE, SURVIVORS, AND DISABILITY INSURANCE SYSTEM: 1959-61

Exact Age x	Female			Male		
	D_x	N_x	$\bar{a}_x$	D_x	N_x	$\bar{a}_x$
62	1,000,000	13,392,371	12.89	1,000,000	11,124,677	10.62
63	950,971	12,392,371	12.53	937,259	10,124,677	10.30
64	903,276	11,441,400	12.17	876,590	9,187,418	9.98
65	856,845	10,538,124	11.80	817,968	8,310,828	9.66
66	811,622	9,681,279	11.43	761,371	7,492,860	9.34
67	767,537	8,869,657	11.06	706,787	6,731,489	9.02
68	724,555	8,102,120	10.68	654,207	6,024,702	8.71
69	682,628	7,377,565	10.31	603,632	5,370,495	8.40
70	641,716	6,694,937	9.93	555,097	4,766,863	8.09
71	601,795	6,053,221	9.56	508,549	4,211,766	7.78
72	562,839	5,451,426	9.19	464,041	3,703,217	7.48
73	524,837	4,888,587	8.81	421,595	3,239,176	7.18
74	487,786	4,363,750	8.45	381,235	2,817,581	6.89
75	451,699	3,875,964	8.08	342,987	2,436,346	6.60
76	416,592	3,424,265	7.72	306,881	2,093,359	6.32
77	382,495	3,007,673	7.36	272,944	1,786,478	6.05
78	349,450	2,625,178	7.01	241,196	1,513,534	5.78
79	317,506	2,275,728	6.67	211,654	1,272,338	5.51
80	286,732	1,958,222	6.33	184,329	1,060,684	5.25
81	257,199	1,671,490	6.00	159,219	876,355	5.00
82	228,989	1,414,291	5.68	136,313	717,136	4.76
83	202,193	1,185,302	5.36	115,584	580,823	4.53
84	176,903	983,109	5.06	96,992	465,239	4.30
85	153,213	806,206	4.76	80,477	368,247	4.08
86	131,212	652,993	4.48	65,963	287,770	3.86
87	110,979	521,781	4.20	53,356	221,807	3.66
88	92,580	410,802	3.94	42,544	168,451	3.46
89	76,061	318,222	3.68	33,401	125,907	3.27
90	61,440	242,161	3.44	25,786	92,506	3.09

Actuarial Studies Available from the Division of the Actuary*

40. The Financial Principle of Self-Support in the OASI System--April 1955.

41. Analysis of Benefits, OASI Program, 1954 Amendments--May 1955.

43. Estimated Amount of Life Insurance in Force as Survivor Benefits under OASI--1955--September 1955.

44. Analysis of 157 Group Annuity Plans Amended in 1950-54--July 1956.

45. Present Values of OASI Benefits in Current Payment Status 1940-56--May 1957.

46. Illustrative United States Population Projections--May 1957.

47. Estimated Amount of Life Insurance in Force as Survivor Benefits under OASI--1957--July 1958.

48. Long-Range Cost Estimates for Old-Age, Survivors, and Disability Insurance under 1956 Amendments--August 1958.

49. Methodology Involved in Developing Long-Range Cost Estimates for the Old-Age, Survivors, and Disability Insurance System--May 1959.

50. Analysis of Benefits, OASDI Program, 1960 Amendments--December 1960.

51. Present Values of OASI Benefits in Current Payment Status, 1960--February 1961.

52. Actuarial Cost Estimates for Health Insurance Benefits Bill--July 1961.

53. Medium-Range Cost Estimates for Old-Age, Survivors, and Disability Insurance and Increasing-Earnings Assumption--August 1961.

54. Estimated Amount of Life Insurance in Force as Survivor Benefits under OASI 1959-60--October 1961.

55. Remarriage Tables Based on Experience under OASDI and U.S. Employees' Compensation Systems--December 1962.

56. Analysis of Benefits under 26 Selected Private Pension Plans--January 1963.

57. Actuarial Cost Estimates for Hospital Insurance Bill--July 1963.

58. Long-Range Cost Estimates for Old-Age, Survivors, and Disability Insurance System, 1963--January 1964.

59. Actuarial Cost Estimates for Hospital Insurance Act of 1965 and Social Security Amendments of 1965--January 1965.

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*Numbers not listed are out of print.