NEW MORTALITY TABLES FOR RAILROAD DISABILITY ANNUITANTS

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THE purpose of this paper is to present two new mortality tables for railroad disability annuitants which have been developed recently by the actuarial staff of the Railroad Retirement Board (subsequently referred to as RRB or the Board). The first table is similar to previous RRB tables in that it relates to all classes of disability retirements permissible under the provisions of the Railroad Retirement Act (subsequently referred to as RRA) [1, 2, 3]. The second table relates only to the annuitants who meet the disability standards of the Social Security Act as they existed before the 1965 amendments. This is the first time that we have been able to isolate the experience for the latter group in order to construct an appropriate mortality table.

The tables have been designed for use in the actuarial valuation of the railroad retirement plan as of December 31, 1965. They contain certain features which are necessary for the railroad retirement program but which may cast some doubt on their applicability to other retirement plans. An understanding of the problems involved may be gained from the remarks given in the section below.

THE RRA DISABILITY RETIREMENT PROGRAM

Before 1947, an employee had to be totally and permanently disabled in order to qualify for a disability retirement. In addition, there was a thirty-year service requirement for employees under the age of 60 [4].

The present provisions for disability retirement are considerably more liberal and have been in effect since 1947. Two kinds of disability are recognized:

1. Permanent disablement for all gainful employment (total disability) for which there is no service or age requirement other than the general ten-year service requirement for all types of RRA benefits.[1]

2. Permanent disablement for the individual's regular occupation (occupational disability) even though he may not be disabled for all gainful employment. For this type of disability, there is a service requirement of twenty years for employees under the age of 60 and of ten years for older employees. Further-

[1] This requirement does not apply to the residual payment which is a kind of cash-refund feature with respect to the employee's contributions. Finally, individuals with less than ten years of railroad service have their railroad credits transferred to the social security system.

more, the individual needs to have a recent attachment to the railroad industry (current connection) at the time of his retirement.

Since a finding of occupational disability can be made much more quickly and easily than a finding of total disability, the Board had been following the practice of adjudicating cases under the occupational disability provisions whenever possible. This, in turn, had made it impossible to separate the total disabilities from the entire group.

The situation changed in 1959. Current procedures call for a determination in every case of whether the individual is or is not qualified for a "disability freeze" within the meaning of the Social Security Act. Thus, even in a case adjudicated as an occupational disability, there is an indication of whether a disability freeze has been granted or disallowed or whether no decision has yet been made. The need for this additional processing stems from two provisions of the RRA: (1) the allowance of a "freeze" may increase the benefit because of a special guarantee which provides that the employee and his family can receive no less under the railroad retirement system than 110 per cent of the amount or the additional amount that they would have received from social security if railroad earnings had been included as wages under OASDI and (2) the financial co-ordination with the social security system which calls for turning over to the railroad retirement system the savings resulting from the exclusion of railroad employment from social security coverage.

The new procedures calling for a 100 per cent freeze determination were retroactive for all annuitants on the rolls and have been in effect long enough to make possible a separation of railroad disability annuitants into those totally disabled and those occupationally but not totally disabled. This separation enabled us to construct a separate mortality table for the annuitants who retired on account of total disability.

It is impossible to tell whether the date of onset of disability and the beginning date of the annuity coincide. This is particularly true because (a) the annuity beginning date cannot be more than twelve months before an application is filed, (b) cash sickness benefits are available, and (c) an employee can specify the annuity beginning date. However, in the majority of cases, the annuity beginning date and the date of onset of disability are not far apart.

Special problems arose in regard to duration zero because of the availability of cash sickness benefits. As a rule, railroad employees who become either occupationally or totally disabled file for sickness benefits (under the Railroad Unemployment Insurance Act) before they file for a disability annuity. These benefits, running at about $51 a week, are in most

cases higher than the annuity and may be payable for up to twenty-six weeks in a benefit year. If the employee files later for an annuity, the beginning date may be set back as much as one year and may coincide with the beginning date of the sickness benefit. (In this case the employee is not affected, but there is a bookkeeping transaction between the Railroad Retirement Account and the Railroad Unemployment Insurance Account.) However, if the employee dies before he applies for an annuity, he is not recorded as a disability retirement. Such deaths are quite numerous, and all of them are lost in the counts of the actual deaths and of the exposures. This creates quite a distortion in the mortality experience in duration zero after the onset of disability. The net result is that the death rates among disability annuitants in duration zero appear much lighter than they should be by general reasoning.

TABLE 1

SUMMARY OF DATA UNDERLYING THE 1965 RRB MORTALITY
TABLES FOR DISABILITY ANNUITANTS

(Experience in Policy Years 1961–64, by Number of Lives)

DURATION	ALL DISABILITIES COMBINED		TOTAL DISABILITIES ONLY	
	Exposure	Actual Deaths	Exposure	Actual Deaths
0..........	28,534	1,908	18,324	1,769
1..........	27,255	2,061	10,885	1,010
2..........	26,033	1,738	14,687	1,247
3..........	24,982	1,590	12,850	1,072
4..........	22,470	1,470	10,756	892
5 and over..	201,489	16,677	57,870	5,729
Total..	330,763	25,444	125,372	11,719

UNDERLYING DATA

The mortality statistics underlying the two new tables were quite extensive. For the three-year period studied (policy years 1961–64), the total man-years of exposure used was 330,763, and the corresponding actual deaths numbered 25,444. A breakdown of the exposures and deaths by duration and type of disability is given in Table 1.[2]

The records and procedures used in assembling the pertinent mortality statistics were as follows:

[2] More detailed breakdowns of these data, as well as additional information on the study here discussed, may be found in the technical supplement to the report on the tenth actuarial valuation, which is available from the Railroad Retirement Board upon request.

1. The tabulations included all disability annuities in force (payable and withheld) on the anniversary of the accrual date (the first date for which benefits were paid) in 1964 and all death terminations occurring between the anniversaries of the accrual date in 1961 and 1964, respectively. Thus, the latest accrual year included was 1963.

2. The data were obtained from files updated for all activity through December 31, 1965. Because of the considerable time lag between that date and the closing dates of the experience (some time in 1964), there was little likelihood that the data were incomplete to any significant extent.

3. The study was made on a policy-year basis from tabulations by year of birth. The age at the beginning of a policy year was defined as the corresponding calendar year minus the year of birth. Thus, the rates derived are an approximation of those for an age-nearest-birthday basis. The only exception is with respect to individuals who retired in the calendar year in which their sixty-fifth birthdays fell; they could not have attained age 65 at the time of their retirement. Accordingly, for them the age basis is the age next birthday.

4. A disability freeze determination had been made for the great majority (90 per cent and up) of the cases. There was, however, one sector (namely, duration 1 in policy year 1963–64) of the data for which there were no decisions in nearly half of the terminated cases. In order not to introduce a possible bias in the data, this sector has been omitted from the investigation relating to the experience of totally disabled annuitants.

5. In duration zero there was a special problem. Disability freeze determinations could not be made for employees dying within six months of the date of onset of disability because the waiting period required by the Social Security Act had not been fulfilled. (There is no such waiting period in the Railroad Retirement Act.) We considered it proper to consider all cases of death in duration zero for which no freeze decision had been made as total disability retirements for purposes of our study.

6. No effort was made to account for the deaths which occurred after the onset of total disability but before filing for a disability annuity. This has reference mainly to employees who died while they were receiving sickness benefits. This omission was justified on the grounds that the incidence rates used in the valuations are based only on the number of employees awarded disability annuities and not on the number of those who could have been awarded such annuities had they applied for them at the earliest possible date.

PURPOSE AND RESULTS OF INVESTIGATION

We felt that our 1956 table with the 1959 modification [2, 3] was no longer appropriate, so the need arose for a new table to value the liabilities with respect to disability annuities available under the RRA. The second problem arose because the railroad retirement system is financially co-ordinated with the social security system by means of an arrangement known as the financial interchange, which resembles reinsurance [5, 6]. One of the features of this arrangement is a credit to the railroad retire-

ment system for the additional disability insurance benefits (DIB) that social security would have paid if railroad service had been covered by it since its inception. Obviously, these credits must be determined on the basis of the disability definition of the Social Security Act rather than on that of the Railroad Retirement Act.

Since an estimate of the future progress of the financial interchange is an integral part of the railroad retirement valuations, the need for a mortality table for disability retirements on account of total disability becomes obvious. As stated earlier, the mortality investigation here discussed was the first which furnished data for the construction of such a table. While the new table has a severe limitation in that it does not explicitly recognize the six-month waiting period, it is definitely more suitable as a financial-interchange valuation standard than anything that we had before.

As to the results of the investigation, the most pertinent ones are the age-specific death rates, by type of disability and duration. These rates are shown in Table 2.

Perhaps the most striking feature of these rates is the peculiar flow of rates at duration zero. One would expect these rates to be substantially higher than the duration 1 rates in every sector, but the data do not bear this out. The peculiarity could not be blamed on tabulation errors or time lags—first, because of the great caution exercised in the preparation of the tabulations and, second, because the same relationship had been found to exist in previous mortality studies of railroad disability annuitants. The only explanation that we can offer for this is that the duration zero rates reflect the interrelationship between the disability retirement and the sickness insurance programs which was discussed in the preceding section. We have reason to believe that if the deaths occurring after onset of disability but before application for a disability annuity had been accounted for, the death rates at duration zero would have been considerably higher than those in the next duration.

The death rates shown in Table 2 display certain other characteristics which deserve some comment.

1. Except for the ultimate section, the pattern of the rates within each duration is highly irregular, in that curves connecting them would have numerous bends and inflection points.

2. The duration zero rates for the occupational but not total disabilities are even more peculiar than those for either all types of disability or the total disabilities alone. They just are unbelievably low. The explanation here may be that employees who believe themselves to be less than totally disabled tend to postpone claiming a disability annuity in the

TABLE 2

AGE SPECIFIC DEATH RATES FOR RAILROAD DISABILITY ANNUITANTS
DURING POLICY YEARS 1961–64, BY AGE AND DURATION

ATTAINED AGE	DURATION					
	0	1	2	3	4	5 and Over
All Disabilities Combined						
40–44.......	0.06768	0.05946	0.04884	0.03436	*	0.05305
45–49.......	.07079	.06677	.04682	.03810	0.03854	.04948
50–54.......	.07090	.07419	.06342	.05227	.04649	.04330
55–59.......	.06740	.08439	.07156	.06540	.06069	.05476
60–64.......	.06372	.07307	.06610	.06400	.06658	.06100
65–69.......	0.08626	0.07957	0.06972	0.06767	0.07125	.06987
70–74.......	....	....	....	....	....	.08631
75–79.......	....	....	....	....	....	.10941
80–84.......	....	....	....	....	....	.14771
85–89†.....	....	....	....	....	....	.19885
90 and over†.	....	....	....	....	....	0.30201
Total Disabilities Only						
40–44.......	0.09165	0.06667	0.05178	*	*	0.05050
45–49.......	.10531	.08491	.05790	0.04952	0.03217	.05363
50–54.......	.10278	.09185	.07089	.06737	.06250	.05497
55–59.......	.09822	.10172	.09406	.08753	.06828	.07055
60–64.......	.09279	.09233	.08807	.08565	.09035	.08429
65–69.......	0.11504	0.09482	0.08746	0.08997	0.09457	.09775
70–74.......	....	....	....	....	....	.11627
75–79.......	....	....	....	....	....	.13982
80 and over..	....	....	....	....	....	0.16400
Occupational but Not Total Disabilities						
40–44.......	*	0.05263	*	*	*	0.06195
45–49.......	*	.05384	*	*	*	.03642
50–54.......	0.01380	.06194	0.05176	0.02991	0.02103	.02992
55–59.......	.01441	.07255	.04159	.04063	.05286	.04219
60–64.......	.01372	.06140	.04221	.04423	.04629	.04779
65–69.......	0.02508	0.06848	0.04611	0.04569	0.05300	.05688
70–74.......	....	....	....	....	....	.07733
75–79.......	....	....	....	....	....	.10229
80–84.......	....	....	....	....	....	.14468
85–89.......	....	....	....	....	....	.19963
90 and over..	....	....	....	....	....	0.30201

* Less than 10 actual deaths.
† Pertains to individuals who could have retired only under a total disability clause, as in the Social Security Act before the 1965 amendments.

expectation of returning to work. This, in turn, results in a loss to the annuitant mortality statistics of many deaths which occur before a claim for an annuity is filed. The more severe cases, with little or no expectation to return to work, will generally tend to file for an annuity earlier. This is true even though in neither case is there any financial loss to the employee, because he is receiving sickness benefits in amounts higher than what his annuity would have been. Furthermore, late filing for a disability annuity will not hurt the employee in any event, because the annuity beginning date may be set back as much as twelve months and any excess of the annuity over the sickness benefit will be payable to the employee.

A further peculiarity with respect to these rates at duration zero is that, while rates go up somewhat with advancing age initially, they actually decrease with advancing age from about age 50 to age 65. For all disabilities combined, this phenomenon is probably caused by the gradually increasing proportion of the experience which is made up of employees who are occupationally but not totally disabled. It is also possible that more weight is given to nonmedical factors in granting a disability annuity at the higher ages than at the younger ages.

THE NEW MORTALITY TABLES

Graduation.—It is well known that the construction of select and ultimate mortality tables for disabled lives involves graduation problems of a complex nature. This was particularly true in the case of our tables, where the underlying experience showed highly irregular trends. These irregularities could be removed only at the expense of badly damaging the fit, and this did not appear to be a wise course of action. We therefore decided to sacrifice some smoothness in favor of fit.

A preliminary plotting of the crude data indicated that graduation by mathematical formula could be attempted only for the ultimate experience. The select portions of the tables were graduated primarily by graphic means with only minor subsequent adjustments for the flow of second differences. More specifically, the method by which the graduated death rates appearing in Tables 3 and 4, respectively, were obtained is described in the following paragraphs.

1. Central age values for the ultimate part of the tables for exposures and actual deaths, respectively, were obtained at quinquennial age intervals by means of King's formula:

$$u_x = 0.2w_x - 0.008(w_{x-5} - 2w_x + w_{x+5}) .$$

From these, central age death rates were computed.

TABLE 3

1965 RRB DISABLED ANNUITANTS MORTALITY TABLE
RATES OF MORTALITY—1,000 $q^i_{[x]+n}$ AND 1,000 q^i_x

AGE AT ENTRY* [x]	1,000 $q^i_{[x]+n}$ FOR n EQUAL TO:					AGE† x	1,000 q^i_x	AGE† x	1,000 q^i_x
	0	1	2	3	4				
30....	65.50	57.37	50.00	46.55	44.66	35....	44.06	71...	78.30
31....	65.78	57.45	50.09	46.61	44.74	36....	44.07	72...	82.10
32....	66.19	57.55	50.19	46.68	44.85	37....	44.08	73...	86.19
33....	66.73	57.68	50.31	46.76	44.99	38....	44.09	74...	90.58
34....	67.40	57.86	50.45	46.85	45.16	39....	44.10	75...	95.46
35....	68.20	58.13	50.61	46.95	45.36	40....	44.12	76...	100.94
36....	68.52	58.48	50.79	47.07	45.59	41....	44.14	77...	107.07
37....	68.71	58.89	50.99	47.21	45.85	42....	44.16	78...	114.03
38....	68.85	59.33	51.22	47.37	46.14	43....	44.22	79...	121.62
39....	68.94	59.79	51.48	47.55	46.46	44....	44.29	80...	129.80
40....	68.97	60.26	51.77	47.75	46.81	45....	44.38	81...	138.43
41....	68.94	60.74	52.10	47.98	47.19	46....	44.49	82...	147.25
42....	68.90	61.23	52.48	48.25	47.60	47....	44.63	83...	156.37
43....	68.85	61.73	52.92	48.57	48.04	48....	44.80	84...	165.77
44....	68.78	62.24	53.44	48.96	48.51	49....	45.01	85...	174.79
45....	68.70	62.76	54.06	49.45	49.01	50....	45.30	86...	186.65
46....	68.61	63.29	54.81	50.06	49.54	51....	45.71	87...	198.41
47....	68.51	63.83	55.71	50.80	50.11	52....	46.17	88...	211.42
48....	68.40	64.38	56.76	51.66	50.72	53....	46.68	89...	225.38
49....	68.28	64.94	57.94	52.62	51.38	54....	47.22	90...	240.24
50....	68.15	65.50	59.20	53.67	52.09	55....	47.83	91...	255.81
51....	68.01	66.06	60.45	54.80	52.85	56....	48.82	92...	271.71
52....	67.85	66.62	61.60	56.00	53.66	57....	49.84	93...	288.04
53....	67.67	67.18	62.56	57.25	54.53	58....	50.94	94...	304.46
54....	67.47	67.74	63.36	58.51	55.46	59....	52.08	95...	321.12
55....	67.25	68.30	64.03	59.72	56.45	60....	53.30	96...	337.96
56....	67.00	68.86	64.59	60.81	57.49	61....	54.63	97...	355.00
57....	66.79	69.42	65.06	61.75	58.58	62....	56.02	98...	371.73
58....	66.43	69.97	65.48	62.54	59.72	63....	57.56	99...	388.44
59....	65.97	70.51	65.88	63.22	60.91	64....	59.22	100...	405.24
60....	65.39	71.04	66.26	63.86	62.15	65....	61.10	101...	422.22
61....	64.69	71.54	66.62	64.54	63.45	66....	63.24	102...	439.44
62....	63.94	71.98	66.97	65.33	64.84	67....	65.76	103...	456.46
63....	63.24	72.33	67.31	66.30	66.38	68....	68.36	104...	474.47
64....	62.74	72.56	67.64	67.52	68.47	69....	71.38		
								105...	492.49
65....	62.59	72.62	67.96	69.09	71.45	70....	74.70		

* Age nearest birthday on date of accrual of disability annuity.

† Age nearest birthday.

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TABLE 3A

1965 RRB DISABLED ANNUITANTS MORTALITY TABLE
ANNUITY VALUES—$a^{i(12)}_{[x]+n}$ AND $a^{i(12)}_x$ AT $3\frac{3}{4}$ PER CENT

AGE AT ENTRY* [x]	$a^{i(12)}_{[x]+n}$ FOR n EQUAL TO:					AGE† x	$a^{i(12)}_x$	AGE† x	$a^{i(12)}_x$
	0	1	2	3	4				
30....	11.3603	11.5620	11.6795	11.7130	11.7051	35..	11.6724	71..	6.6167
31....	11.3268	11.5284	11.6435	11.6750	11.6644	36..	11.6292	72..	6.3907
32....	11.2889	11.4915	11.6043	11.6333	11.6201	37..	11.5824	73..	6.1633
33....	11.2462	11.4511	11.5614	11.5880	11.5719	38..	11.5318	74..	5.9360
34....	11.2083	11.4066	11.5148	11.5388	11.5194	39..	11.4769	75..	5.7073
35....	11.1449	11.3572	11.4638	11.4851	11.4623	40..	11.4174	76..	5.4788
36....	11.0926	11.3029	11.4085	11.4271	11.4005	41..	11.3532	77..	5.2518
37....	11.0375	11.2440	11.3487	11.3641	11.3337	42..	11.2838	78..	5.0279
38....	10.9784	11.1800	11.2837	11.2959	11.2614	43..	11.2087	79..	4.8093
39....	10.9157	11.1112	11.2134	11.2225	11.1836	44..	11.1280	80..	4.5966
40....	10.8490	11.0373	11.1379	11.1432	11.0998	45..	11.0411	81..	4.3918
41....	10.7784	10.9582	11.0563	11.0581	11.0100	46..	10.9479	82..	4.1958
42....	10.7027	10.8734	10.9687	10.9669	10.9137	47..	10.8480	83..	4.0043
43....	10.6219	10.7827	10.8746	10.8691	10.8109	48..	10.7411	84..	3.8186
44....	10.5355	10.6857	10.7733	10.7643	10.7012	49..	10.6272	85..	3.6375
45....	10.4429	10.5815	10.6643	10.6521	10.5847	50..	10.5057	86..	3.4561
46....	10.3437	10.4700	10.5472	10.5326	10.4610	51..	10.3771	87..	3.2809
47....	10.2384	10.3515	10.4224	10.4059	10.3313	52..	10.2418	88..	3.1116
48....	10.1272	10.2263	10.2899	10.2724	10.1951	53..	10.1000	89..	2.9486
49....	10.0099	10.0943	10.1502	10.1320	10.0523	54..	9.9514	90..	2.7946
50....	9.8876	9.9567	10.0036	9.9849	9.9028	55..	9.7954	91..	2.6486
51....	9.7610	9.8143	9.8516	9.8309	9.7462	56..	9.6322	92..	2.5119
52....	9.6325	9.6694	9.6970	9.6728	9.5853	57..	9.4645	93..	2.3835
53....	9.5031	9.5234	9.5408	9.5103	9.4200	58..	9.2923	94..	2.2629
54....	9.3728	9.3762	9.3830	9.3441	9.2502	59..	9.1154	95..	2.1513
55....	9.2412	9.2276	9.2234	9.1743	9.0754	60..	8.9336	96..	2.0448
56....	9.1091	9.0780	9.0624	9.0015	8.8959	61..	8.7464	97..	1.9447
57....	8.9755	8.9275	8.9004	8.8262	8.7113	62..	8.5539	98..	1.8491
58....	8.8415	8.7748	8.7359	8.6481	8.5222	63..	8.3559	99..	1.7561
59....	8.7068	8.6207	8.5690	8.4670	8.3281	64..	8.1528	100..	1.6594
60....	8.5706	8.4638	8.3992	8.2815	8.1288	65..	7.9436	101..	1.5538
61....	8.4333	8.3044	8.2260	8.0923	7.9249	66..	7.7297	102..	1.4247
62....	8.2933	8.1422	8.0485	7.8984	7.7172	67..	7.5115	103..	1.2475
63....	8.1512	7.9786	7.8687	7.7015	7.5071	68..	7.2914	104..	0.9647
64....	8.0038	7.8105	7.6833	7.4978	7.2905	69..	7.0679		
65....	7.8479	7.6372	7.4897	7.2854	7.0670	70..	6.8427		

* Age nearest birthday on date of accrual of disability annuity.
† Age nearest birthday.

TABLE 4

1965 RRB TOTALLY DISABLED ANNUITANTS MORTALITY TABLE
RATES OF MORTALITY—1,000 $q^i_{[x]+n}$ AND 1,000 q^i_x

AGE AT ENTRY* [x]	1,000 $q^i_{[x]+n}$ FOR n EQUAL TO:					AGE† x	1,000 q^i_x	AGE† x	1,000 q^i_x
	0	1	2	3	4				
30....	65.50	57.37	50.00	46.55	44.66	35....	44.06	71...	107.74
31....	65.78	57.45	50.09	46.61	44.74	36....	44.07	72...	112.02
32....	66.19	57.55	50.19	46.68	44.85	37....	44.08	73...	116.55
33....	66.73	57.68	50.31	46.76	44.99	38....	44.09	74...	121.34
34....	67.40	57.86	50.45	46.85	45.16	39....	44.10	75...	126.34
35....	68.20	58.13	50.62	46.95	45.36	40....	44.12	76...	131.55
36....	69.13	58.56	50.83	47.07	45.60	41....	44.14	77...	136.95
37....	70.18	59.24	51.09	47.23	45.89	42....	44.16	78...	142.54
38....	72.08	60.25	51.41	47.45	46.24	43....	44.28	79...	148.32
39....	75.21	61.62	51.80	47.75	46.66	44....	44.49	80...	154.28
40....	79.06	63.37	52.27	48.15	47.16	45....	44.81	81...	160.43
41....	83.19	65.51	52.83	48.67	47.75	46....	45.26	82...	167.51
42....	86.47	68.00	53.49	49.33	48.44	47....	45.82	83...	174.99
43....	88.50	70.79	54.26	50.15	49.24	48....	46.56	84...	182.48
44....	89.99	73.78	55.16	51.15	50.16	49....	47.48	85...	190.05
45....	91.22	76.82	56.22	52.35	51.21	50....	48.64	86...	198.73
46....	92.28	79.76	57.49	53.77	52.40	51....	50.08	87...	208.51
47....	93.18	82.40	59.01	55.43	53.74	52....	51.78	88...	218.60
48....	93.93	84.44	60.83	57.38	55.24	53....	53.84	89...	229.42
49....	94.54	85.84	63.01	59.72	56.91	54....	56.14	90...	241.50
50....	95.01	86.66	65.60	62.60	58.76	55....	59.23	91...	255.81
51....	95.34	87.18	68.66	65.94	60.80	56....	61.37	92...	271.71
52....	95.53	87.55	72.21	69.51	63.04	57....	64.11	93...	288.04
53....	95.58	87.84	76.07	72.97	65.49	58....	66.91	94...	304.46
54....	95.49	88.10	79.78	75.93	68.14	59....	69.69	95...	321.12
55....	95.26	88.36	82.74	78.10	70.96	60....	72.52	96...	337.96
56....	94.87	88.62	84.57	79.70	73.91	61....	75.36	97...	355.00
57....	94.30	88.90	85.50	81.05	76.95	62....	78.14	98...	371.73
58....	93.55	89.23	86.18	82.33	80.04	63....	80.97	99...	388.44
59....	92.62	89.64	86.86	83.61	83.02	64....	83.78	100...	405.24
60....	91.51	90.15	87.65	84.95	85.73	65....	86.70	101...	422.22
61....	90.24	90.76	88.53	86.52	88.17	66....	89.74	102...	439.44
62....	88.87	91.47	89.77	88.60	90.56	67....	92.84	103...	456.46
63....	87.50	92.28	91.32	91.28	93.25	68....	96.21	104...	474.47
64....	86.33	93.19	93.24	94.71	96.64	69....	99.79		
65....	85.66	94.20	95.61	98.84	100.93	70....	103.63		

* Age nearest birthday on date of accrual of disability annuity.

† Age nearest birthday.

TABLE 4A

1965 RRB TOTALLY DISABLED ANNUITANTS MORTALITY TABLE
ANNUITY VALUES—$a_{[x]+n}^{i(12)}$ AND $a_x^{i(12)}$ AT $3\frac{3}{4}$ PER CENT

AGE AT ENTRY* [x]	$a_{[x]+n}^{i(12)}$ FOR n EQUAL TO:					AGE† x	$a_x^{i(12)}$	AGE† x	$a_x^{i(12)}$
	0	1	2	3	4				
30....	11.1301	11.3064	11.3982	11.4057	11.3708	35..	11.3093	71..	5.6073
31....	11.0771	11.2511	11.3383	11.3416	11.3016	36..	11.2352	72..	5.4456
32....	11.0181	11.1907	11.2731	11.2715	11.2264	37..	11.1548	73..	5.2853
33....	10.9526	11.1247	11.2021	11.1955	11.1446	38..	11.0676	74..	5.1276
34....	10.8803	11.0526	11.1249	11.1129	11.0557	39..	10.9731	75..	4.9722
35....	10.8000	10.9732	11.0407	11.0230	10.9591	40..	10.8706	76..	4.8190
36....	10.7109	10.8853	10.9493	10.9256	10.8546	41..	10.7597	77..	4.6672
37....	10.6115	10.7873	10.8494	10.8195	10.7409	42..	10.6396	78..	4.5182
38....	10.4923	10.6772	10.7401	10.7037	10.6174	43..	10.5095	79..	4.3706
39....	10.3494	10.5549	10.6214	10.5785	10.4845	44..	10.3697	80..	4.2236
40....	10.1885	10.4200	10.4929	10.4433	10.3419	45..	10.2201	81..	4.0807
41....	10.0149	10.2730	10.3549	10.2988	10.1902	46..	10.0614	82..	3.9345
42....	9.8411	10.1143	10.2074	10.1446	10.0294	47..	9.8937	83..	3.7888
43....	9.6714	9.9450	10.0505	9.9813	9.8599	48..	9.7176	84..	3.6458
44....	9.4998	9.7666	9.8849	9.8092	9.6827	49..	9.5341	85..	3.5056
45....	9.3248	9.5807	9.7103	9.6291	9.4986	50..	9.3438	86..	3.3610
46....	9.1477	9.3901	9.5281	9.4423	9.3088	51..	9.1484	87..	3.2171
47....	8.9706	9.1972	9.3391	9.2500	9.1149	52..	8.9496	88..	3.0742
48....	8.7961	9.0055	9.1439	9.0533	8.9185	53..	8.7491	89..	2.9321
49....	8.6253	8.8163	8.9439	8.8542	8.7222	54..	8.5495	90..	2.7889
50....	8.4569	8.6281	8.7386	8.6522	8.5271	55..	8.3523	91..	2.6486
51....	8.2922	8.4425	8.5331	8.4536	8.3390	56..	8.1639	92..	2.5119
52....	8.1272	8.2552	8.3237	8.2539	8.1504	57..	7.9756	93..	2.3835
53....	7.9663	8.0710	8.1172	8.0587	7.9644	58..	7.7916	94..	2.2629
54....	7.8148	7.8965	7.9208	7.8719	7.7821	59..	7.6124	95..	2.1513
55....	7.6767	7.7360	7.7407	7.6953	7.6027	60..	7.4368	96..	2.0448
56....	7.5528	7.5902	7.5772	7.5264	7.4264	61..	7.2647	97..	1.9447
57....	7.4389	7.4546	7.4253	7.3623	7.2530	62..	7.0954	98..	1.8491
58....	7.3294	7.3228	7.2782	7.2012	7.0817	63..	6.9281	99..	1.7561
59....	7.2234	7.1936	7.1343	7.0434	6.9134	64..	6.7619	100..	1.6594
60....	7.1192	7.0650	6.9920	6.8881	6.7486	65..	6.5965	101..	1.5538
61....	7.0158	6.9367	6.8505	6.7343	6.5863	66..	6.4314	102..	1.4247
62....	6.9097	6.8043	6.7052	6.5788	6.4258	67..	6.2663	103..	1.2475
63....	6.7985	6.6671	6.5545	6.4190	6.2636	68..	6.1010	104..	0.9647
64....	6.6793	6.5224	6.3962	6.2524	6.0985	69..	5.9359		
65....	6.5491	6.3696	6.2292	6.0783	5.9287	70..	5.7710		

* Age nearest birthday on date of accrual of disability annuity.

† Age nearest birthday.

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2. A margin for contingencies was introduced into the crude central age rates by means of the formula:

$$q'_x = (1 - k_x)q_x,$$

where the reduction factor k_x was as follows: (a) 0.05 for all ages in the select periods of both groups (all disabilities and total disabilities, respectively), (b) 0.006 $\overset{\circ}{e}^i_x$ for the ultimate rates of all disabilities, and (c) 0.005 $\overset{\circ}{e}^i_x$ for the ultimate rates of the total disabilities.

The procedure for adjusting the ultimate rates was based on the general premise that the margins inserted in the death rates should be directly proportional to the corresponding life expectancies. The latter were taken from the mortality table previously used for all railroad disability annuitants. The coefficients attached to the $\overset{\circ}{e}^i_x$ values were computed from the equation

$$\sum_x (1 - c\, \overset{\circ}{e}^i_x) \cdot {}_5\Theta_{x-2} = 1.05 \sum_x {}_5\Theta_{x-2},$$

where c stands for the coefficient to be computed and ${}_5\Theta_{x-2}$ stands for the actual deaths in the quinquennial age group $x - 2$ to $x + 2$. It will be noted that ${}_5\Theta_{x-2}$ is an approximation to ${}_5E_{x-2} \cdot q_x$ and that the 1.05 appearing in the above equation was a predetermined factor designed to produce an over-all ratio of actual to expected deaths of approximately 105 per cent.

3. The single age rates for the ultimate sections were obtained by means of Jenkins' fifth difference modified osculatory interpolation formula, with the special formulas for the end values as shown in Boyer [7]. At the upper end of the table, we used for pivotal points the graduated death rates derived from the most recent RRB experience on age annuities. These were 0.26583 for age 92, 0.34935 for age 97, 0.43944 for age 102, and 0.52953 for age 107. The ultimate sections were further adjusted so as to merge with our rates for nondisability annuities at age 102.
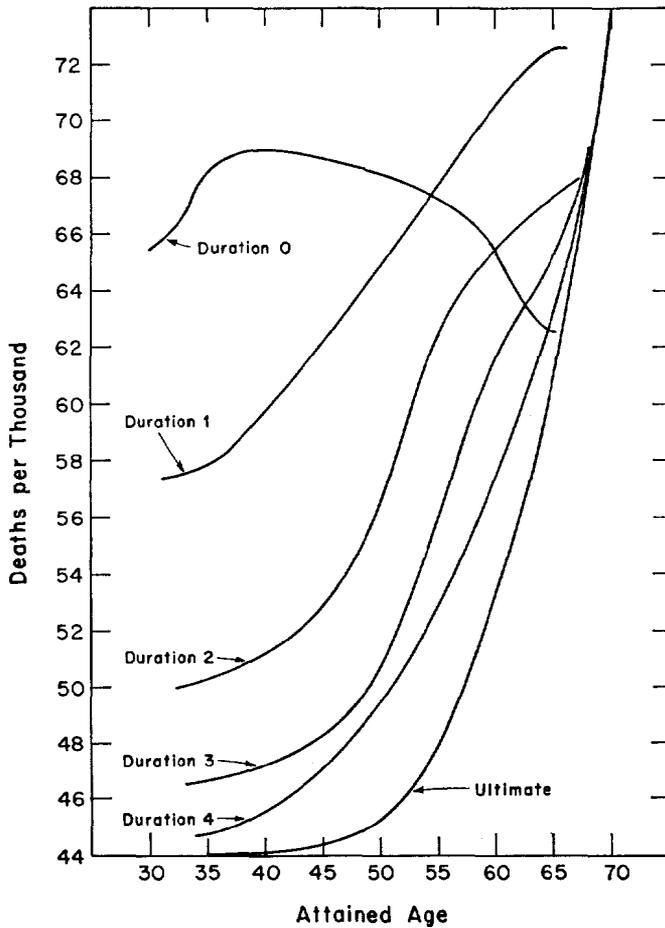
4. The single age rates for the select portions were obtained by graphic graduation with a minimum amount of smoothing. The flow of these graduated rates together with the curves for the ultimate rates are shown in Charts I and II.

Fit.—The fit of the new tables is reasonably good, as can be seen from the ratios of actual to expected deaths appearing in Table 5. Particular attention was paid to the fit at the older ages (55 and up), where the experience was the heaviest. Because of the rather crude method of graduation, no tests were applied in regard to magnitudes and signs of the differences between actual and expected deaths at single ages.

Limited presentation.—In order to conserve space, we are showing in this paper only the graduated death rates (Tables 3 and 4) and the annuity values at 3¾ per cent (Tables 3A and 4A) by age attained in the policy year. This is approximately the exact age with the exception noted in item 3 of the preceding section. The complete tables have been published in the technical supplement to the tenth actuarial valuation of the railroad retirement system.

Applicability to other plans.—In deciding whether the tables here dis-

CHART I

1965 RRB DISABLED ANNUITANTS MORTALITY TABLE

(GRADUATED MORTALITY RATES)

cussed can be used to value disability annuities under another plan, the prospective user should keep in mind the following points:

1. There is no waiting period for disability annuities under the RRA.
2. The duration zero death rates are in all likelihood badly understated for the reasons which were discussed earlier in this paper (availability of sickness benefits).
3. The duration is measured from the date of accrual of the annuity and not from the date of the actual onset of disability.

CHART II

1965 RRB TOTALLY DISABLED ANNUITANTS MORTALITY TABLE
(GRADUATED MORTALITY RATES)

4. The tables are based on experience which was about 95 per cent male.
5. There is a twenty-year service requirement for occupational disabilities under the age of 60 but only a ten-year service requirement for total disabilities.

Subject to the above qualifications, Table 3 may be said to apply to a liberal definition of disability which recognizes occupational and total disablement, while Table 4 relates to a definition which recognizes total disability only. Of course, adjustments may be needed to compensate for

TABLE 5

FIT OF 1965 RRB MORTALITY TABLES FOR DISABILITY ANNUITANTS

(Ratios of Actual to Expected Deaths for Experience in
Policy Years 1961–64, by Number of Lives)

ATTAINED AGE	DURATION					
	0	1	2	3	4	5 and Over
All Disabilities Combined						
Under 45....	95.1%	83.3%	93.1%	100.0%	66.7%	110.3%
45–49.......	103.5	104.9	85.7	77.8	80.0	110.7
50–54.......	104.5	111.8	106.2	98.9	91.3	93.2
55–59.......	101.2	122.2	111.8	111.4	110.3	108.9
60–64.......	102.1	102.1	99.6	100.9	110.5	107.9
65–69.......	....	109.8	103.2	101.4	107.5	105.2
70–74.......	....	....	....	....	....	105.8
75–79.......	....	....	....	....	....	103.7
80–84.......	....	....	....	....	....	102.6
85–89.......	....	....	....	....	....	103.8
90 and over..	....	....	....	....	....	102.9
Total...	102.0%	108.2%	102.8%	102.1%	107.1%	105.1%
Total Disabilities Only						
Under 45....	95.2%	81.5%	92.0%	105.9%	*	104.2%
45–49.......	105.7	107.1	102.8	96.3	63.2%	115.9
50–54.......	112.7	105.0	105.6	111.1	110.6	104.3
55–59.......	107.6	114.8	114.3	114.9	102.7	108.3
60–64.......	106.5	101.4	100.0	101.9	111.7	107.0
65–69.......	....	101.3	94.2	97.3	102.0	104.5
70–74.......	....	....	....	....	....	104.9
75–79.......	....	....	....	....	....	103.5
80 and over..	....	....	....	....	....	100.9
Total...	105.2%	104.4%	101.5%	102.7%	104.2%	105.1%

* Less than 10 actual deaths.

the differences between the particular disability retirement plan under consideration and the plan operated by the Railroad Retirement Board. In general, it appears to us that the peculiar features of the railroad plan which have been accounted for in our tables would tend to make these tables somewhat conservative for purposes of certain other plans.

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DISCUSSION OF PRECEDING PAPER

JOHN E. HEARST:

The mortality experience of disability annuitants in other retirement systems may be of interest even though the experience is meager in comparison to that of the Railroad Retirement Board. The latest experience at my disposal includes six retirement systems covering schoolteachers, school employees, and denominational employees observed from 1961 through 1965. Most of the denominational employees are ministers, although lay workers are included in some plans. Although the data are

TABLE 1

MORTALITY OF DISABILITY ANNUITANTS BY NUMBER OF LIVES

OCCUPATION	EXPOSURE	ACTUAL DEATHS	EXPECTED DEATHS	RATIO A/E
	Males			
School employees..............	711	39	36.1	108%
Denominational employees.......	1,695	104	113.6	92
Schoolteachers.................	2,440	189	146.5	129
Total.....................	4,846	332	296.2	112%
	Females			
School employees..............	475	26	24.6	106%
Denominational employees.......	266	9	18.0	50
Schoolteachers.................	4,990	246	277.0	89
Total.....................	5,731	281	319.6	88%

not select and the definition of disability differs from plan to plan, the experience is separate by sex and the occupations are generally homogeneous within each plan. In Table 1, where the data are summarized by occupations, expected deaths are calculated according to the ultimate rates for the 1965 RRB Disabled Annuitants Mortality Table.

The experience for the denominational employees is significantly lighter than the total, which is consistent with the mortality experience of active and retired ministers. The female mortality was consistently lighter than that for males. Expected mortality for females was also calculated using a five-year set-back in age in the mortality rates. This

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adjustment decreased the total expected deaths to 286.7 and increased the ratio of actual to expected deaths to 98 per cent.

The experience for all occupations combined is shown in Table 2 according to the attained age of the disability annuitant.

There is a bias by age in this experience which also appears in each of the plans. It would be reduced if select mortality rates were used under attained age 65, but it would not be eliminated because the mortality at these ages generally exceeds that at duration zero in both the disabled and the totally disabled annuitant tables.

TABLE 2

DISABILITY ANNUITANT EXPERIENCE BY NUMBER OF LIVES

ATTAINED AGES	ACTUAL DEATHS	EXPECTED DEATHS	RATIO A/E	ACTUAL DEATHS	EXPECTED DEATHS	RATIO A/E
	Males			Females		
Under 45....	16	10.2	157%	18	9.6	188%
45–49.......	19	11.4	167	23	13.2	174
50–54.......	38	25.2	151	57	38.7	147
55–59.......	74	48.4	153	79	84.7	93
60–64.......	77	66.8	115	57	79.0	72
65–69.......	51	57.3	89	27	55.6	49
70–74.......	34	38.4	89	12	27.2	44
75–79.......	15	23.9	63	4	7.3	55
80–84.......	7	10.0	70	2	2.5	80
85–89.......	1	3.4	30	2	1.8	111
90 and over..	0	1.2	0	0	0	0
Total...	332	296.2	112%	281	319.6	88%

Since disability annuitant data are often sparse, the modification of a published table might be appropriate in the valuation of some pension plans. For example, the a-1949 mortality rates loaded forty deaths per thousand are nearly equal to the ultimate mortality rates of the 1965 RRB Disabled Annuitants Mortality Table (see Table 3).

A modification of a published table, if it fits the experience, is appealing because of its simplicity. It has the added advantage of numerically describing the extra mortality of disabled lives.

ROBERT J. MYERS:

The actuaries of the Railroad Retirement Board should once again be thanked by the members of the Society for their presentation and analyses of significant operating data of their system. This material should be very useful to many consulting actuaries. The authors have pointed out well

the various unique features of these experience data, so that the user will be cautious in the handling of the data. This is necessary because there are many differences in disability experiences, depending upon such matters as the definition of disability, the qualifying conditions, the general nature of the covered workers, and the administrative procedures and regulations.

Perhaps the most interesting feature of the results presented is the availability of mortality rates for two distinctly different categories of disability—one that might be called "permanent disability" and the other that might be called "occupational disability." The very significant

TABLE 3

COMPARISON OF MORTALITY RATES
a-1949 MORTALITY TABLE (MALES)
AND 1965 RRB DISABLED ANNUI-
TANTS MORTALITY TABLE

Attained Age x	1,000 q_x 1965 RRB Ultimate	1,000 q_x+40 *a*-1949 Males
37........	44	42
42........	44	42
47........	45	45
52........	46	48
57........	50	52
62........	56	58
67........	66	67
72........	82	82
77........	107	104
82........	147	141
87........	198	198
92........	272	284

difference between the two categories is shown by comparing the ungraduated age-specific death rates in Table 2 for the age and duration categories that are most meaningful, namely, durations 1 and over for ages 50–64. The death rates for the occupational definition generally run about 30–55 per cent lower. Or, to look at it another way, by comparing the graduated death rates at ages over 50 for all disabilities in Table 3 with those for permanent disabilities in Table 4, the mortality rates for the latter are generally 25–40 per cent higher, with this differential extending even up to age 80. These are very significant, and in some ways very surprising, differences.

Very frequently, in disability experiences when the incidence rate is high, the termination rates are also high, and vice versa. In this railroad

retirement experience that considers only mortality, the reverse is the case, since the less stringent definition of disability has the lower termination rates. Often a large proportion of disability terminations is due to recoveries, but the railroad retirement termination experience apparently has relatively few of these. In the social security experience, in which the definition of disability is the same as the railroad retirement total and permanent definition, there are many terminations on account of recovery. For example, in 1965 the terminations for recovery represented 23 per cent of the terminations because of death (deaths after age 65 are not counted as terminations, because the individual is shifted over to the old-age-benefit roll upon attainment of that age).

I cannot close without expressing my deep embarrassment that we in the Social Security Administration have not yet been able to present termination rates for disability benefits on the proper select-and-ultimate basis. We have developed disability incidence rates and have presented them from time to time in our *Actuarial Notes*. Difficulties have been encountered in regard to termination rates, because we have had to go back and build up (and correct) the necessary data. We expect to have this matter rectified in the near future and to make our extensive experience available to the actuarial profession. When this is done, it will be interesting to compare the results with the experience for railroad retirement workers under the same definition of disability. Of special significance would be the verification of the existence of points of inflection in the curves for durations 1–4. At the present time, I do not know what could cause the rate of increment in mortality to slow down around ages 50–65.

(AUTHORS' REVIEW OF DISCUSSION)

JAMES L. COWEN AND ABRAHAM M. NIESSEN:

The discussions of our paper by Messrs. Hearst and Myers contributed additional valuable information on the problem of mortality of disability annuitants.

Mr. Hearst makes the interesting observation that the ultimate rates of our table for all disability annuitants combined are approximately the same as those of the *a*-1949 Mortality Table loaded by forty deaths per thousand. That this should be so for the younger ages could be expected, because our rates at those ages are approximately flat and the mortality rates of the *a*-1949 table are very small. What is remarkable, however, is that this relationship also holds for the older ages.

We have no full explanation for this phenomenon, although we might suggest that this is due to certain unique features of our experience and

particularly to the admixture of two types of disability on which our table
is based. Be that as it may, it is not likely that the relationship brought
out by Mr. Hearst will hold for other groups of disabled lives retiring
under a single definition of disability. In this connection, it should be
observed that a nearly constant differential of forty deaths per thousand
in the ultimate rates does not hold for ages over 50 in our table for totally
disabled lives. This is clearly shown in the comparison given in the ac-
companying tabulation.

Mr. Myers' comments on the unique features of the experience under
the railroad retirement program are very pertinent and should be kept in
mind by anyone who contemplates using our tables in connection with

Attained Age x	1,000 q_x from 1965 RRB Tables		1,000 q_x+40 a-1949 Males
	Totally Disabled	All Disabled	
37........	44	44	42
42........	44	44	42
47........	46	45	45
52........	52	46	48
57........	64	50	52
62........	78	56	58
67........	93	66	67
72........	112	82	82
77........	137	107	104
82........	168	147	141
87........	209	198	198
92........	272	272	284

another retirement plan. These unique features are (1) the availability of
cash sickness benefits for some six months prior to retirement; (2) the
existence of two definitions of disability, each with different service re-
quirements; and (3) the low incidence of formal recovery from disability.
As we pointed out in our paper, the availability of cash sickness benefits
is in all likelihood the major reason for the unusually low death rates at
duration zero. It stands to reason that the experience under another plan
which is not co-ordinated with temporary sickness benefits would be
quite different in this area. However, we think that it should be possible
to extrapolate our rates backward to duration zero so as to obtain a dis-
ability mortality table which would follow a more typical pattern.

With regard to the low incidence of formal recovery from disability
under the railroad program, it should be kept in mind that such recovery
will be relatively less frequent under an occupational provision than under
a total provision, especially when we deal with an industrial rather than

a clerical group. As a practical matter, a determination of recovery from occupational disability cannot be made unless there is a strong possibility that the individual in question will return to his previous job. This matter is largely within the control of the employer, not of the agency which administers the disability program.

Another point to keep in mind in this connection is that a large proportion of annuitants found by the Board to be totally disabled would qualify for benefits even if they were only occupationally disabled. Thus, even for total disabilities, a determination of recovery from disability would not necessarily remove the individual from the Board's benefit rolls. Under these circumstances. determinations of recovery would be a superfluous action without effect on the experience under the program. It might be added that the railroad program does take into consideration partial or permanent recovery from disability, but this is done most frequently in the form of annuity suspension (when the annuitant earns more than $1,200 per year) rather than annuity termination.

We are always interested in comparing the railroad retirement experience with that of social security. Our experience for totally disabled annuitants should be comparable to that under the disability insurance (DI) provisions of the Social Security Act. But even there, there would be differences, mainly because social security has a six-month waiting period while railroad retirement does not have a comparable requirement. However, we are looking forward to the publication of data on mortality and recovery rates under the DI program which Mr. Myers is now developing.