INJURED WORKER MORTALITY

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I'm *the one that's got to die when it's time for me to die, so let me live my life the way I want to.*

—Jimi Hendrix
If Six Was Nine

Abstract

This paper discusses the NCCI Special Call for Injured Worker Mortality Data and the ensuing analysis of that data. The design of the call and companies' abilities to supply elements of the call are discussed.

The goal was to see if the mortality of pensioned workers differs significantly from that of the general population. It does appear that, at least for ages below 60, the reported injured worker mortality rate is higher than reported on standard U.S. life mortality tables. Between ages 60 and 74, the injured worker mortality rate does not differ appreciably from standard mortality.

The differences in mortality, while significant, do not imply significant redundancy or inadequacy of tabular reserves.

ACKNOWLEDGEMENTS

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Despite the existence of much supposition on the topic, the mortality of injured workers relative to the standard United States Life (USL) Tables has not been well analyzed. Interest in the subject waxes in times of deteriorating results, but then wanes as results improve. As if we needed more proof that the 1980s represented a prolonged period of less-than-satisfactory workers' compensation results, here is one more indication: a study of injured worker mortality has been completed.

1. THE CALL

In 1985, the Actuarial Committee at the National Council on Compensation Insurance (NCCI) resolved to begin such a study with a special call for data. The specifications for the call and committee sanction for its release were completed in 1986. Data elements, as described below, included several parameters of the claims, to be evaluated at two or more sequential year-end dates.

In 1987, the call was submitted to a small group of carriers who agreed to (and did) provide data. In 1988, the call was repeated, but to a larger group of carriers. Submissions were received from nine carriers in all, most in the second year only.

Exhibit 1 shows the record layout of the call. Report ID, carrier code, claim number, and state are used for identification. Injury date and age at injury are essential for the study. Pension date and sex are desirable, but fortunately not essential, as several carriers do not retain this information in the data files used to answer the call. Type of benefit code is a simplification of standard NCCI statistical plan coding. Paid and incurred amounts of indemnity and medical also are not essential, but are desirable for corollary studies and are usually easy to capture on company data files. The reason for closing field requires a choice of only three codes, which may be too simplified: permanent total (PT) claims closed for reasons other than fatality have to be handled carefully.

It probably would be useful to distinguish occupational disease from trauma cases, as allowed in the last entry, but this information is difficult for most companies to provide. In any case, the vast majority of claims reported are traumatic.

The difficulty in identifying certain claim characteristics is not critical, because the study attempts to determine which mortality table should be applied to the reserves for PT cases. If we use the experience of a random cross section of PT cases, we measure the mortality rates of exactly the group we want, whatever the profile of that group happens to be.

Workers who qualify for a life pension constitute a very select cohort. The potential for permanent injury is not usually recognized at the time of a serious accident. Certainly, no pension is established if the worker dies or, better, recovers within a short time. Even if the adjuster were able to recognize such a condition at an early stage, it usually is years before a prudent company will set up a lifetime pension and classify a claim as PT for the purpose of data reporting.

The draft specifications of the Special Call required that the earliest report be at least five years subsequent to the accident date. This requirement was dropped by the time the call was made, so that any claim recognized as PT could be submitted. Even with no maturity requirement, most of the claims submitted are at least four years old; that is, the actual accident occurred more than four years before the evaluation dates in the call. Of course, many claims are much more mature than that. We believe we have an unbiased sample of claims set up for lifetime reserves.

In summary, the call data do not allow the study of mortality rates for all seriously injured workers. Specifically, we are not able to measure the (presumably high) mortality rate of workers who have just been injured. What we can measure is the mortality rate of workers who lived long enough after their serious accidents to enter the elite group of lifetime pensioners.

2. THE DATA

We received information on nearly 13,000 injured workers from nine carriers, covering three calendar periods beginning 12/31/83 and ending 12/31/86. We believe that the data submitted represent an honest attempt to provide an unbiased sample. Minor inconsistencies in coding necessitated the following assumptions.

1) *Wrong Benefit Type*
   Benefit types 0, 5, 6, 7, 8, or 9 appear on more than 3,000 claims. We assume these are regular statistical plan codes for non-serious losses and do not include them in the study. (Interestingly, inclusion of these claims in the study would increase the sample mortality rate slightly.)

2) *Reason for Closing Omitted*
   There are 1,151 reports with the reason for closing field left blank. We assume they are open claims.

3) *Multiple Deaths and Life After Death*
   A few claims that were closed due to death reappear, usually closed, but occasionally open. We exclude such subsequent reports.

4) *Reopened Claims*
   Of the PT claims closed for reasons other than death (code 3), there are 222 that sometimes appear later as open. These claims are taken to be open the whole time.

5) *Disappearing Claims*
   There are 801 claims appearing as open in one report that fail to appear in any subsequent report. These are treated as closed for reasons other than death (code 3) in the first subsequent report.

6) *Holes*
   286 claims reported as open in one evaluation disappear the next, but reappear later. These claims are assumed to be open for the missing evaluation. (One claim skipped over two evaluations, and this gap was filled.)

7) *Contradictory Age Reports*
   For example, a claimant may be reported at 12/31/84 to be 52 and to be 54 at 12/31/85. We use the lower of the two ages. There are 956 such reports.

Because of these inconsistencies and the resulting assumptions, we do not have strong confidence in the actual mortality rates by age in the study. Nevertheless, the patterns that emerge are believable, and the derived table is certainly better than one based on anecdotal information. The assumptions, either individually or in total, do not have much impact on the statistics derived from the sample.

3. MORTALITY RATES

The data are used to produce empirical mortality rates by age as follows:

1) As of the beginning of each year (previous year-end), there is some number of open PT cases for each age of claimant. Date of injury and age of claimant at injury are used to determine the age of a pensioner as of the evaluation date. We assume that the last birthday was six months before the accident. For each age, then, there is a sample of claimants who are followed through the calendar year to the next evaluation.

2) Claims missing or listed as closed for reasons other than fatality at the next year-end evaluation do not represent full lives. Since the exact date of closure is not coded in the call (and apparently difficult to obtain on company files), it is reasonable to assume an average mid-year closing. Using this logic, every claim closed for reasons other than fatality is counted as one-half of a life in the denominator of the mortality rate sample and zero fatalities in the numerator. This is a standard life actuarial technique.

3) The total of claims open for a year or closed due to death, plus half of the claims closed for other reasons, is denoted l_x, the lives at age x.

4) For age group x, we denote the number of deaths as d_x. For a given calendar year, the sample mortality rate, q_x, is the

number of deaths in that group during the year divided by the number of lives in the same group, so $q_x = d_x/l_x$.

5) The call spans more than a single calendar year; respondents to the call report claims evaluated at 12/31/83, 12/31/84, 12/31/85, and 12/31/86 (or some subset of those years, depending on available company data). As such, several calendar years' data can be compiled to evaluate empirical mortality rates. It should be apparent that a single claimant reported as living through several year-end evaluations would be part of the exposure for age x in the first evaluation, $x + 1$ in the second, and so on. The first evaluation of a claim does not have to be 12/83, but can be 12/84 or 12/85.

Exhibit 2 shows the data and mortality rates based on this procedure. In the fitting described below, we use only the ages with more than 30 lives, which are ages 23 to 87.

4. THE FORCE OF MORTALITY

A smoothing procedure facilitates the comparison of the sample mortality rates by age to standard. Life actuaries have found that a Makeham curve of the form $M_x = A + BC^x$, where M_x is the force of mortality at age x, provides a good fit to empirical fatality statistics. We fit a Makeham curve to the injured worker mortality data, using maximum likelihood.

1) The Makeham force of mortality must first be restated as a mortality rate by age. This is done as follows:

$$Q_x = 1 - e^{-\int_x^{x+1} M_t \, dt}$$

$$= 1 - e^{-\int_x^{x+1} A + BC^t \, dt}$$

$$= 1 - e^{-[A + \frac{B(C-1) \cdot C^x}{\ln C}]}\,.$$

2) We use ages 23 to 87, which each have at least 30 lives. For the whole sample, the likelihood is

$$\Lambda = \prod_{x=23}^{87} \binom{l_x}{d_x} Q_x^{d_x} (1 - Q_x)^{(l_x - d_x)},$$

which is a function of independent variables A, B, and C.

It is usually easier to work with a sum, rather than a product, so we take the natural logarithm of the likelihood. The SAS function PROC NLIN is used to minimize the negative log likelihood of the sample in terms of A, B, and C.

5. THE FIT

The fit results in $A = 5.691 \times 10^{-3}$, $B = 1.156 \times 10^{-5}$, and $C = 1.115$, with a log likelihood of -136.84. Figure 1 compares the empirical and fitted injured worker mortality rates to USL rates. Figure 1 compares the graph of the mortality rates implied by the fitted curve with the data points.

The standard USL table based on 1979-1981 census data yields an excellent fit to a Makeham curve with parameters $A = 7.447 \times 10^{-4}$, $B = 5.728 \times 10^{-5}$, and $C = 1.093$. For this fit, we minimize an unweighted sum of squared differences. Figure 2 compares the empirical USL data with its fitted curve.

FIGURE 1
MAKEHAM FIT OF INJURED WORKER MORTALITY

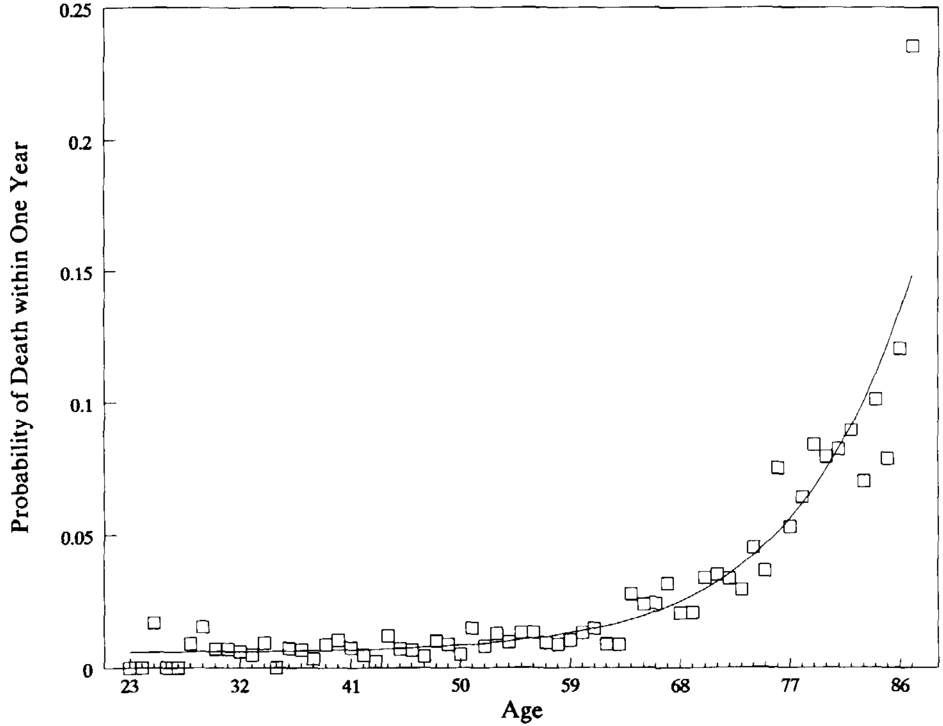
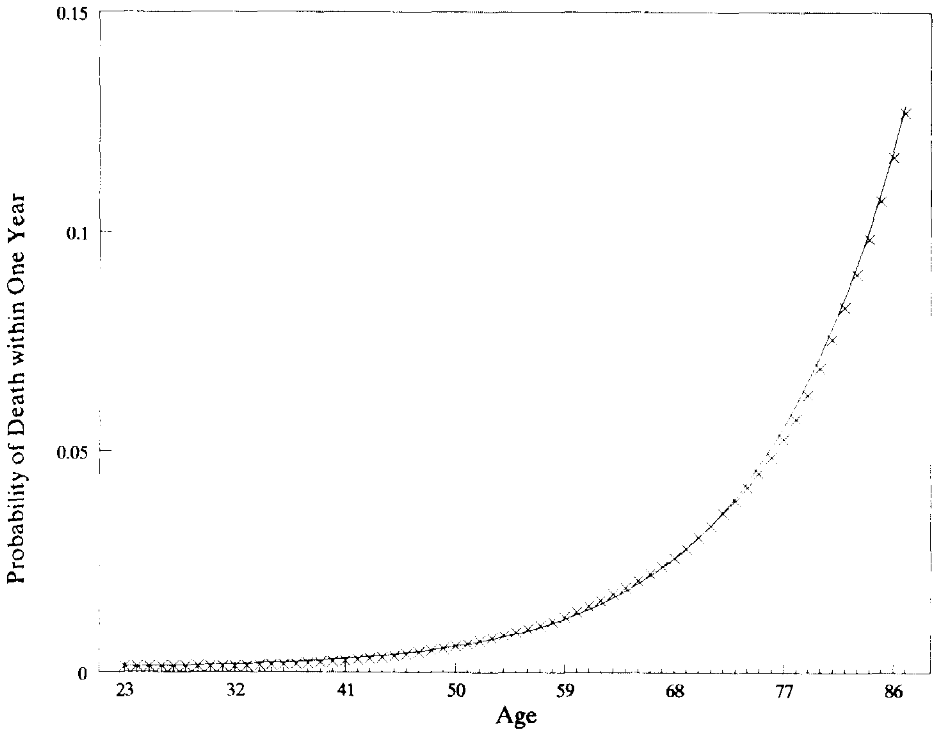


FIGURE 2
MAKEHAM FIT OF U.S. LIFE MORTALITY



6. A HYPOTHESIS TEST

To see if the sample data exhibits a mortality rate that differs from the USL rate, we use a simple likelihood ratio test. It is known that the following expression, Ω, is asymptotic chi-square, with degrees of freedom equal to the number of independent parameters, in this case three.

$$\Omega = -2 \ln \left[\frac{\Lambda_{USL}}{\Lambda_{MLE}} \right].$$

The likelihood Λ_{MLE} is that using the parameters A, B, and C estimated by maximum likelihood. The sample also has a likelihood under the USL parameters, Λ_{USL}, which is of course lower than that under the fit. In this case, we calculate $\ln \Lambda_{USL} = -152.57$.

So

$$\Omega = -2(-152.57 + 136.84)$$
$$= 31.46\,.$$

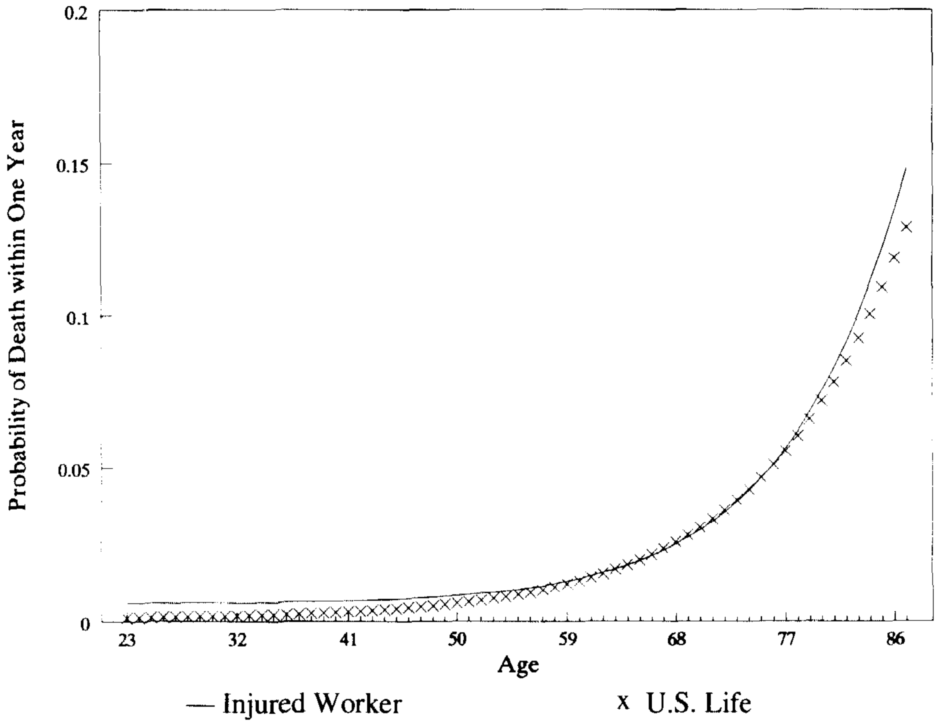
This value says that we can reject the hypothesis that the mortality rate of the sample population is USL, with a degree of confidence so large it is generally not on the table.

7. SOME CONCLUSIONS

The comparison of the injured worker mortality curve with the USL mortality value in Figure 3 is much more illuminating than a comparison of the sample data points with standard tables. The graph shows a mortality rate for injured workers that is slightly higher than standard at ages less than 60, but very slightly lower for ages 61 to 72.

Is it possible that injured worker mortality is so near standard? We think that it is possible, but it is important to remember the characteristics of the cohort in the study. An injured worker has been healthy enough to have worked in the first place. Such a person has demonstrated an ability to survive an accident long enough to be put on a

FIGURE 3
COMPARISON OF MORTALITIES



pension, which, as mentioned above, takes several years. By definition, the pensioner enjoys an annuity sufficient for lifetime support. The unfortunate worker whose workplace injury results in an immediate death, or one soon enough to preclude the need for a life pension, should not and does not enter the study.

A member of this sample population would presumably be resigned to his/her status and under relatively low stress, with the trauma of the original injury well behind him or her. It is also quite probable that older workers may qualify for permanent disability with an injury less severe than that necessary to disable a younger worker. This may account, in part, for the relatively favorable mortality of injured workers around the age of retirement.

8. THE ISSUE OF RESERVING

One of the motivations for this study was to test the propriety of using standard USL tables to reserve PT cases. We observed—and rationalized—slight differences in mortality rates by age between injured workers and the general population. The mortality found in the study implies that the average life pension on injured workers should be 1.6% lower than on standard. This finding is nominally supported by a weighted average of life pensions using sample distributions of permanently injured workers by age and wage level. The analysis is based on data from the call for detailed claim information, and may be seen in Exhibit 4.

Should action be taken on the possible 1.6% overstatement of reserves for injured workers? Perhaps, but the issue is more complicated than a simple argument about mortality rates. Pensions for permanently injured workers are subject to multiple decrements. Besides fatality, there may be other reasons for change in claim status. Such claims often change to permanent partial if the worker can resume employment in some other capacity. In fact, the worker may recover completely and be taken off the pension rolls. In some states, benefits terminate after a specified period or maximum amount. In most cases, pensions will terminate, or at least be reduced, when the claimant is eligible for Social Security. All of these things may reduce the need for a full lifetime reserve.

It should be noted that the death of the injured worker may result in a change of claim status to a benefit for the surviving spouse. This is a significant upward force on the required reserve for the permanently injured worker.

Weighing these considerations to decide whether to reduce reserves is unnecessary. The loss development analysis done in regular ratemaking almost always indicates upward reserve development. It would not be appropriate to lower reserves.

The existence of multiple decrements may indicate a need for further study of the denouement of PT claims. Certainly, the process is far more complicated than that contemplated by simple mortality tables. This study is complete, however, in that the mortality rate of pensioned workers has been reasonably determined.

The contention that the mortality rate of injured workers is higher than standard is often used in rate hearings as an argument against the need for rate increases: don't redundant reserves on pensions of short-lived injured workers overstate losses and hence the need for rate relief? Actuaries know that any systematic aggregate reserve redundancy or deficiency will result in measurable patterns of loss development, which, in turn, will be compensated for in standard methods used to project future ultimate loss levels. In that sense, then, the argument is already fallacious. Now there is direct evidence that the higher mortality in these cases does not make current reserves significantly redundant.

EXHIBIT 1

Injured Worker Mortality Study
Record Layout

Field Name	Width	Column(s)	Description
Report ID	2	1–2	Calendar year of report
Carrier Code	5	3–7	Five-digit insurer code number
Claim #	18	8–25	Alphanumeric code uniquely defining a claim
State	2	26–27	State of jurisdiction determining benefits
Injury Date	6	28–33	Date injury occurred (in MMDDYY format)
Pension Date	6	34–39	Date identified as a pension case (in MMDDYY format)
Age at Injury	2	40–41	Age on date of injury
Sex	1	42	M = male F = female U = unknown
Type of Benefit	1	43	1 = Death 2 = Permanent total 3 = Permanent partial 4 = Temporary total
Medical Paid	7	44–50	Medical benefits paid (whole dollars) as of report date
Medical Incurred	7	51–57	Medical benefits incurred (whole dollars) as of report date
Indemnity Paid	7	58–64	Indemnity benefits paid (whole dollars) as of report date
Indemnity Incurred	7	65–71	Indemnity benefits incurred (whole dollars) as of report date
Reason for Closing	1	72	1 = Open claim 2 = Death of claimant 3 = Other
OD/Trauma Code	1	73	1 = Occupational disease 2 = Traumatic

EXHIBIT 2
Part 1

Injured Worker Mortality Table

Age (x)	Lives (l_x)	Deaths (d_x)	Mortality (q_x)
All	29,586.5	575	0.01943
23	36.5	0	0.00000
24	45.5	0	0.00000
25	59.0	1	0.01695
26	71.0	0	0.00000
27	81.5	0	0.00000
28	112.5	1	0.00889
29	131.0	2	0.01527
30	143.5	1	0.00697
31	143.0	1	0.00699
32	167.5	1	0.00597
33	205.0	1	0.00488
34	214.0	2	0.00935
35	257.0	0	0.00000
36	282.5	2	0.00708
37	303.5	2	0.00659
38	310.5	1	0.00322
39	347.0	3	0.00865
40	387.5	4	0.01032
41	403.0	3	0.00744
42	422.5	2	0.00473
43	421.0	1	0.00238
44	415.5	5	0.01203
45	431.5	3	0.00695
46	464.5	3	0.00646
47	480.5	2	0.00416
48	510.0	5	0.00980
49	582.5	5	0.00858
50	598.0	3	0.00502
51	604.5	9	0.01489
52	631.0	5	0.00792
53	710.0	9	0.01268
54	735.0	7	0.00952

EXHIBIT 2
Part 2

INJURED WORKER MORTALITY TABLE

Age (x)	Lives (l_x)	Deaths (d_x)	Mortality (q_x)
55	764.5	10	0.01308
56	828.0	11	0.01329
57	848.5	8	0.00943
58	923.0	8	0.00867
59	982.0	10	0.01018
60	1,001.5	13	0.01298
61	1,017.5	15	0.01474
62	1,025.5	9	0.00878
63	1,036.0	9	0.00869
64	1,006.5	28	0.02782
65	961.5	23	0.02392
66	902.0	22	0.02439
67	849.5	27	0.03178
68	820.0	17	0.02073
69	766.0	16	0.02089
70	708.5	24	0.03387
71	624.0	22	0.03526
72	564.5	19	0.03366
73	511.5	15	0.02933
74	442.0	20	0.04525
75	383.5	14	0.03651
76	305.0	23	0.07541
77	263.5	14	0.05313
78	248.5	16	0.06439
79	202.5	17	0.08395
80	201.0	16	0.07960
81	170.0	14	0.08235
82	156.5	14	0.08946
83	128.0	9	0.07031
84	99.0	10	0.10101
85	63.5	5	0.07874
86	41.5	5	0.12048
87	34.0	8	0.23529

EXHIBIT 3

Part 1

COMPARISON OF INJURED WORKER AND U.S. LIFE MORTALITIES

Age (x)	Injured Worker Mortality: Actual (q_x)	Fitted (Q_x)	U.S. Life Mortality
all	0.01943	0.01944	0.01787
23	0.00000	0.00548	0.00134
24	0.00000	0.00550	0.00133
25	0.01695	0.00552	0.00132
26	0.00000	0.00554	0.00131
27	0.00000	0.00557	0.00130
28	0.00889	0.00560	0.00130
29	0.01527	0.00563	0.00131
30	0.00697	0.00567	0.00133
31	0.00699	0.00571	0.00134
32	0.00597	0.00575	0.00137
33	0.00488	0.00580	0.00142
34	0.00935	0.00586	0.00150
35	0.00000	0.00592	0.00159
36	0.00708	0.00599	0.00170
37	0.00659	0.00607	0.00183
38	0.00322	0.00615	0.00197
39	0.00865	0.00625	0.00213
40	0.01032	0.00636	0.00232
41	0.00744	0.00647	0.00254
42	0.00473	0.00660	0.00279
43	0.00238	0.00675	0.00306
44	0.01203	0.00691	0.00335
45	0.00695	0.00709	0.00366
46	0.00646	0.00729	0.00401
47	0.00416	0.00751	0.00442
48	0.00980	0.00775	0.00488
49	0.00858	0.00802	0.00538
50	0.00502	0.00833	0.00589
51	0.01489	0.00866	0.00642
52	0.00792	0.00904	0.00699
53	0.01268	0.00945	0.00761
54	0.00952	0.00991	0.00830

EXHIBIT 3
Part 2
COMPARISON OF INJURED WORKER AND U.S. LIFE MORTALITIES

Age	Injured Worker Mortality		U.S. Life
(x)	Actual (q_x)	Fitted (Q_x)	Mortality
55	0.01308	0.01042	0.00902
56	0.01329	0.01099	0.00978
57	0.00943	0.01162	0.01059
58	0.00867	0.01232	0.01151
59	0.01018	0.01310	0.01254
60	0.01298	0.01396	0.01368
61	0.01474	0.01492	0.01493
62	0.00878	0.01599	0.01628
63	0.00869	0.01717	0.01767
64	0.02782	0.01848	0.01911
65	0.02392	0.01993	0.02059
66	0.02439	0.02155	0.02216
67	0.03178	0.02334	0.02389
68	0.02073	0.02532	0.02585
69	0.02089	0.02752	0.02806
70	0.03387	0.02996	0.03052
71	0.03526	0.03267	0.03315
72	0.03366	0.03567	0.03593
73	0.02933	0.03898	0.03882
74	0.04525	0.04266	0.04184
75	0.03651	0.04673	0.04507
76	0.07541	0.05122	0.04867
77	0.05313	0.05620	0.05274
78	0.06439	0.06170	0.05742
79	0.08395	0.06777	0.06277
80	0.07960	0.07447	0.06882
81	0.08235	0.08185	0.07552
82	0.08946	0.09000	0.08278
83	0.07031	0.09896	0.09041
84	0.10101	0.10881	0.09842
85	0.07874	0.11964	0.10725
86	0.12048	0.13151	0.11712
87	0.23529	0.14452	0.12717

EXHIBIT 4
Part 1
RESERVES REQUIRED BY U.S. LIFE AND INJURED WORKER MORTALITIES FOR A SAMPLE OF PENSIONED INJURED WORKERS
(INTEREST RATE = 6.0%)

Age	Injured Workers	Average Annual Benefit	U.S. Life Annuity	Injured Worker Annuity
21	2	9,641	15.9250	15.0456
22	1	9,360	15.8719	15.0110
23	9	9,363	15.8161	14.9743
24	14	9,516	15.7575	14.9354
25	24	9,219	15.6961	14.8942
26	34	9,147	15.6316	14.8506
27	35	9,792	15.5640	14.8044
28	64	10,117	15.4932	14.7555
29	65	10,561	15.4190	14.7038
30	64	10,327	15.3413	14.6490
31	77	10,365	15.2600	14.5912
32	89	10,648	15.1749	14.5301
33	116	11,098	15.0859	14.4655
34	106	11,635	14.9929	14.3972
35	136	11,503	14.8957	14.3253
36	156	11,649	14.7943	14.2493
37	152	11,767	14.6885	14.1692
38	148	11,932	14.5781	14.0848
39	171	12,156	14.4631	13.9959
40	189	12,862	14.3434	13.9023
41	197	12,611	14.2187	13.8038
42	199	12,582	14.0890	13.7002
43	189	13,045	13.9543	13.5914
44	194	13,306	13.8143	13.4772
45	216	13,139	13.6690	13.3573
46	229	13,571	13.5184	13.2316
47	222	13,467	13.3623	13.1000
48	268	13,366	13.2007	12.9622
49	290	13,785	13.0336	12.8180
50	258	13,496	12.8609	12.6674
51	286	13,367	12.6825	12.5103
52	296	13,419	12.4986	12.3463

EXHIBIT 4
Part 2
RESERVES REQUIRED BY U.S. LIFE AND INJURED WORKER MORTALITIES FOR A SAMPLE OF PENSIONED INJURED WORKERS (INTEREST RATE = 6.0%)

Age	Injured Workers	Average Annual Benefit	U.S. Life Annuity	Injured Worker Annuity
53	336	13,607	12.3091	12.1756
54	337	13,694	12.1139	11.9979
55	356	13,631	11.9133	11.8132
56	387	13,669	11.7072	11.6214
57	369	13,439	11.4958	11.4226
58	449	13,426	11.2792	11.2168
59	449	13,459	11.0574	11.0039
60	432	13,546	10.8307	10.7841
61	444	13,433	10.5992	10.5574
62	464	13,465	10.3633	10.3241
63	449	13,127	10.1230	10.0842
64	429	13,078	9.8787	9.8381
65	384	12,930	9.6307	9.5860
66	358	12,597	9.3792	9.3282
67	342	12,347	9.1247	9.0652
68	351	12,319	8.8675	8.7972
69	288	11,778	8.6079	8.5247
70	261	11,768	8.3464	8.2484
71	233	11,406	8.0835	7.9686
72	201	11,178	7.8195	7.6860
73	188	10,738	7.5549	7.4013
74	155	10,464	7.2903	7.1151
75	126	10,141	7.0260	6.8280
76	104	10,063	6.7626	6.5408
77	100	9,678	6.5006	6.2543
78	95	9,351	6.2405	5.9692
79	70	9,400	5.9827	5.6862
80	78	8,634	5.7278	5.4062
81	59	8,256	5.4762	5.1298
82	58	8,465	5.2285	4.8578
83	40	7,869	4.9849	4.5909
84	21	7,691	4.7461	4.3298

EXHIBIT 4
Part 3

RESERVES REQUIRED BY U.S. LIFE AND INJURED WORKER MORTALITIES FOR A SAMPLE OF PENSIONED INJURED WORKERS (INTEREST RATE = 6.0%)

Age	Injured Workers	Average Annual Benefit	U.S. Life Annuity	Injured Worker Annuity
85	16	7,275	4.5123	4.0752
86	11	6,804	4.2840	3.8276
87	14	7,481	4.0615	3.5875
88	9	6,333	3.8451	3.3555
89	3	7,041	3.6351	3.1320
90	3	6,881	3.4317	2.9173
91	4	7,043	3.2352	2.7117
92	4	6,555	3.0457	2.5155
93	1	6,803	2.8633	2.3287
95	2	5,914	2.5204	1.9839
96	2	4,994	2.3600	1.8257
97	1	5,481	2.2068	1.6770
99	1	5,406	1.9223	1.4070
100	1	5,323	1.7907	1.2853
	12,981		11.3258	11.1417

Relative Difference = (Average Injured Worker/Average US Life)−1 = −1.6%