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ORIGINAL ARTICLE

Structured Settlement Annuities, Part 2: Mortality Experience 1967–95 and the Estimation of Life Expectancy in the Presence of Excess Mortality

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Methodology Artical: 005M5

Background.—The mortality experience for structured settlement (SS) annuitants issued both standard (Std) and substandard (SStd) has been reported twice previously by the Society of Actuaries (SOA), but the 1995 mortality described here has not previously been published. We describe in detail the 1995 SS mortality, and we also discuss the methodology of calculating life expectancy (*e*), contrasting three different life-table models.

Results.—With SOA permission, we present in four tables the unpublished results of its 1995 SS mortality experience by Std and SStd issue, sex, and a combination of 8 age and 6 duration groups. Overall results on mortality expected from the 1983a Individual Annuity Table showed a mortality ratio (MR) of about 140% for Std cases and about 650% for all SStd cases.

Life expectancy in a group with excess mortality may be computed by either adding the decimal excess death rate (EDR) to q' for each year of attained age to age 109 or multiplying q' by the decimal MR for each year to age 109. An example is given for men age 60 with localized prostate cancer; annual EDRs from a large published cancer study are used at duration 0–24 years, and the last EDR is assumed constant to age 109. This value of *e* is compared with *e* from constant initial values of EDR or MR after the first year. Interrelations of age, sex, *e*, and EDR and MR are discussed and illustrated with tabular data.

Conclusions.—It is shown that a constant MR for life-table calculation of *e* consistently overestimates projected annual mortality at older attained ages and underestimates *e*. The EDR method, approved for reserve calculations, is also recommended for use in underwriting conversion tables.

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In part 1[1] of this two-part article, we described the development and rapid growth of a market for structured settlement (SS) annuities—single premium annuities with a schedule of lifetime benefit payments designed to meet the future needs of an injured party in a case of tort litigation. The underwriting process for SS applicants was also described, a process that is radically different from the underwriting of applicants for life insurance.

Although only relatively few life insurance companies are engaged in the competitive SS market, the number of SS annuities issued rose substantially after 1980 and the Society of Actuaries (SOA) invited these companies to contribute to an intercompany study of the mortality experience with SS annuitants, both for cases issued on a basis of normal or standard (Std) mortality and for those with excess or substandard (SStd) mortality. The first such study reported the mortality experience through 1989, and the second through 1993. Both of these studies were published as reports in the SOA Transactions.[2,3] A later study of the mortality experience through 1995 was sent, as a report, to the contributing companies but was not published.

1995 STRUCTURED SETTLEMENT MORTALITY STUDY

As described in part 1,[1] very few SS annuities were issued before 1980, but there was an explosive growth from 948 SS annuities issued in 1984 to 77,347 issued in 1995, with a total of 769,507 issued through 1995. Recent growth (1990–95) is at an annual rate of 7.3% per year. Male annuitants outnumber female, and about two thirds of the issues are on a Std basis (Tables 1 through 4). Younger annuitants predominate (Tables 1 through 6): Mean age was 34.6 years for both male and female Std annuitants, but in the SStd annuitants, mean age was 34.2 years for those with smaller age rate-ups (1–20 years) and much lower (only 17.8 years) for those with larger age rate-ups of 21 years or more. The explanation for this lies in the flatness of the mortality curve in children and young adults under age 30. When excess mortality is high, as it is in many of these SStd cases, it becomes necessary to set a rated age far in advance of the actual age to obtain a commensurate reduction in life expectancy. This topic will be discussed later in this article. Compared with life insurance policyholders, SS annuitants have a higher proportion of females and a much higher proportion of children in the total population.

MORTALITY RESULTS

Underwriting for individual life insurance applicants has long been based on intercompany impairment studies with the use of the Select and Ultimate tables for producing standard expected mortality rates. The Select and Ultimate tables provide reliable mortality rates by sex, quinquennial issue age group, and annual durations at durations of 0–15 years; rates are given by single years of attained age for all durations over 15 years combined. The Select and Ultimate tables constitute a tidy and well-established set of expected rates (periodically updated by the SOA) with which to compare both Std and SStd life insurance policy issues for any type of coded impairment.

In contrast, the situation with regard to a standard table of expected mortality for SS annuitants is very different, because no such table exists. The 1983 Individual Annuity Mortality (IAM) Table was developed for annuities not involving an SS, and mortality experience for annuitants under age 50 was very limited. Johansen[4] has reviewed some of these problems and found the 1983 IAM table deficient for current use. Company actuaries use different tables for expected mortality when pricing (ie, setting the cost of) an SS annuity. Some company actuaries use a US population table, such as the 1990 US Life Table, others use the 1983 IAM Table, and still others use tables of their own devising. The committee appointed by the SOA to study the mortality experience of SS annuitants has used three expected mortality tables: the 1983 IAM Table, the 1990 US Population Table, and an updated 1996 US Annuity 2000 Table. As noted above, the SOA committee has published in the SOA Transactions its earlier studies of the SS annuity mortality experience to 1989 and to 1993, but the 1995 experience has only been reported to the contributing companies and has not been published until this article.

Data processing for the SS mortality experience studies has been carried out by Mr Keith Hoffman at the Center for Medico-Actuarial Statistics (CMAS) of MIB under the direction of the SOA committee involved, now the Structured Settlement Experience Committee of the SOA. In previous studies,

Table 1. 1995 Structured Settlement Mortality Experience Male Standard Annuitants by Age and Duration

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	14,340	7	4.0	173	0.5	0.3	0.2
	02-05	17,449	10	6.9	145	0.6	0.4	0.2
	05-10	19,396	32	8.4	379	1.6	0.4	1.2
	10-15	5,697	1	2.9	35	0.2	0.5	-0.3
	15 And Over	122	0	0.1	0	0.0	0.6	-0.6
	Total	57,004	50	22.3	224	0.9	0.4	0.5
15-29	00-02	20,834	22	8.9	247	1.1	0.4	0.6
	02-05	27,290	86	17.0	505	3.2	0.6	2.5
	05-10	32,678	131	23.7	552	4.0	0.7	3.3
	10-15	9,414	34	8.4	404	3.6	0.9	2.7
	15 And Over	263	0	0.3	0	0.0	1.1	-1.1
	Total	90,479	273	58.4	468	3.0	0.6	2.4
30-39	00-02	15,839	31	11.2	276	2.0	0.7	1.2
	02-05	19,961	54	22.3	242	2.7	1.1	1.6
	05-10	21,919	80	35.0	229	3.6	1.6	2.1
	10-15	5,769	31	14.6	212	5.4	2.5	2.8
	15 And Over	97	1	0.4	271	10.3	3.8	6.5
	Total	63,585	197	83.5	236	3.1	1.3	1.8
40-49	00-02	15,257	39	27.1	144	2.6	1.8	0.8
	02-05	18,688	61	56.4	108	3.3	3.0	0.2
	05-10	19,105	175	81.6	215	9.2	4.3	4.9
	10-15	4,265	34	25.5	133	8.0	6.0	2.0
	15 And Over	54	0	0.4	0	0.0	7.6	-7.6
	Total	57,369	309	191.0	162	5.4	3.3	2.1
50-59	00-02	11,800	72	51.3	140	6.1	4.3	1.8
	02-05	14,430	126	99.2	127	8.7	6.9	1.9
	05-10	14,837	236	136.3	173	15.9	9.2	6.7
	10-15	3,724	55	50.1	110	14.8	13.5	1.3
	15 And Over	56	1	1.1	89	17.9	20.1	-2.2
	Total	44,847	490	338.0	145	10.9	7.5	3.4
60-69	00-02	6,641	50	59.1	85	7.5	8.9	-1.4
	02-05	8,158	133	120.0	111	16.3	14.7	1.6
	05-10	8,654	220	185.4	119	25.4	21.4	4.0
	10-15	2,122	86	69.5	124	40.5	32.8	7.8
	15 And Over	37	1	2.1	48	27.0	56.7	-29.6
	Total	25,612	490	436.1	112	19.1	17.0	2.1
70 And Over	00-02	1,895	55	54.8	100	29.0	28.9	0.1
	02-05	1,897	77	83.8	92	40.6	44.2	-3.6
	05-10	1,774	100	102.7	97	56.4	57.9	-1.5
	10-15	348	29	26.6	109	83.3	76.4	7.0
	15 And Over	7	0	0.8	0	0.0	115.7	-115.7
	Total	5,921	261	268.7	97	44.1	45.4	-1.3
Total	00-02	86,606	276	216.5	127	3.2	2.5	0.7
	02-05	107,873	547	405.7	135	5.1	3.8	1.3
	05-10	118,363	974	573.1	170	8.2	4.8	3.4
	10-15	31,339	270	197.6	137	8.6	6.3	2.3
	15 And Over	636	3	5.2	58	4.7	8.1	-3.4
	Total	344,817	2070	1398.1	148	6.0	4.1	1.9

* Basis of expected deaths: 1983a Individual Annuity Mortality Table.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

Table 2. 1995 Structured Settlement Mortality Experience Female Standard Annuitants by Age and Duration

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	12,134	7	1.5	482	0.6	0.1	0.5
	02-05	14,650	9	2.4	379	0.6	0.2	0.5
	05-10	15,838	15	3.0	504	0.9	0.2	0.8
	10-15	4,496	3	1.1	276	0.7	0.2	0.4
	15 And Over	116	0	0.0	0	0.0	0.3	-0.3
	Total	47,234	34	7.9	429	0.7	0.2	0.6
15-29	00-02	15,572	5	3.6	140	0.3	0.2	0.1
	02-05	20,182	17	7.0	241	0.8	0.3	0.5
	05-10	23,893	29	10.1	288	1.2	0.4	0.8
	10-15	7,078	5	3.7	134	0.7	0.5	0.2
	15 And Over	186	0	0.1	0	0.0	0.8	-0.8
	Total	66,911	56	24.6	228	0.8	0.4	0.5
30-39	00-02	12,544	12	5.2	231	1.0	0.4	0.5
	02-05	15,984	23	10.1	228	1.4	0.6	0.8
	05-10	17,820	46	14.7	313	2.6	0.8	1.8
	10-15	4,874	20	5.8	346	4.1	1.2	2.9
	15 And Over	116	0	0.2	0	0.0	1.7	-1.7
	Total	51,338	101	35.9	281	2.0	0.7	1.3
40-49	00-02	10,742	13	8.9	146	1.2	0.8	0.4
	02-05	13,086	27	18.1	149	2.1	1.4	0.7
	05-10	13,581	74	26.6	278	5.4	2.0	3.5
	10-15	3,365	6	9.9	61	1.8	2.9	-1.2
	15 And Over	69	0	0.3	0	0.0	4.2	-4.2
	Total	40,843	120	63.8	188	2.9	1.6	1.4
50-59	00-02	8,332	19	17.5	108	2.3	2.1	0.2
	02-05	10,091	60	35.3	170	5.9	3.5	2.5
	05-10	10,597	106	52.5	202	10.0	5.0	5.0
	10-15	2,875	42	21.3	197	14.6	7.4	7.2
	15 And Over	67	7	0.9	783	104.5	13.3	91.1
	Total	31,962	234	127.5	183	7.3	4.0	3.3
60-69	00-02	4,985	17	25.0	68	3.4	5.0	-1.6
	02-05	6,051	51	50.9	100	8.4	8.4	0.0
	05-10	6,396	103	78.2	132	16.1	12.2	3.9
	10-15	1,590	25	31.0	81	15.7	19.5	-3.8
	15 And Over	32	0	1.0	0	0.0	30.2	-30.2
	Total	19,054	196	186.2	105	10.3	9.8	0.5
70 And Over	00-02	2,423	39	59.1	66	16.1	24.4	-8.3
	02-05	2,580	79	101.1	78	30.6	39.2	-8.6
	05-10	2,212	105	109.9	96	47.5	49.7	-2.2
	10-15	425	21	28.2	75	49.4	66.3	-16.9
	15 And Over	21	1	2.2	45	47.6	106.6	-59.0
	Total	7,661	245	300.5	82	32.0	39.2	-7.2
Total	00-02	66,732	112	120.9	93	1.7	1.8	-0.1
	02-05	82,624	266	224.8	118	3.2	2.7	0.5
	05-10	90,337	478	294.9	162	5.3	3.3	2.0
	10-15	24,703	122	101.0	121	4.9	4.1	0.8
	15 And Over	607	8	4.8	168	13.2	7.9	5.3
	Total	265,003	986	746.5	132	3.7	2.8	0.9

* Basis of expected deaths: 1983a Individual Annuity Mortality Table.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

Table 3. 1995 Structured Settlement Mortality Experience Male Substandard Annuitants by Age and Duration

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	7,398	84	2.1	4066	11.4	0.3	11.1
	02-05	8,687	101	3.3	3056	11.6	0.4	11.2
	05-10	8,085	139	3.3	4150	17.2	0.4	16.8
	10-15	2,106	15	1.0	1507	7.1	0.5	6.7
	15 And Over	49	0	0.0	0	0.0	0.5	-0.5
	Total	26,325	339	9.7	3480	12.9	0.4	12.5
15-29	00-02	8,310	25	3.6	686	3.0	0.4	2.6
	02-05	10,562	65	6.7	965	6.2	0.6	5.5
	05-10	11,273	83	8.4	992	7.4	0.7	6.6
	10-15	3,599	37	3.3	1107	10.3	0.9	9.4
	15 And Over	113	0	0.1	0	0.0	1.2	-1.2
	Total	33,857	210	22.2	945	6.2	0.7	5.5
30-39	00-02	5,368	30	3.8	789	5.6	0.7	4.9
	02-05	6,419	79	7.1	1120	12.3	1.1	11.2
	05-10	6,063	84	9.4	895	13.9	1.5	12.3
	10-15	1,589	17	4.0	430	10.7	2.5	8.2
	15 And Over	37	0	0.1	0	0.0	3.6	-3.6
	Total	19,476	210	24.3	863	10.8	1.2	9.5
40-49	00-02	3,943	39	7.0	561	9.9	1.8	8.1
	02-05	4,600	65	13.9	469	14.1	3.0	11.1
	05-10	3,933	73	16.5	442	18.6	4.2	14.4
	10-15	854	38	5.1	740	44.5	6.0	38.5
	15 And Over	12	1	0.1	1096	83.3	7.6	75.7
	Total	13,342	216	42.6	508	16.2	3.2	13.0
50-59	00-02	3,165	56	13.7	408	17.7	4.3	13.4
	02-05	3,628	105	24.9	421	28.9	6.9	22.1
	05-10	2,964	106	26.6	399	35.8	9.0	26.8
	10-15	579	18	7.5	239	31.1	13.0	18.1
	15 And Over	2	0	0.0	0	0.0	22.8	-22.8
	Total	10,338	285	72.8	391	27.6	7.0	20.5
60-69	00-02	1,408	34	12.1	282	24.1	8.6	15.6
	02-05	1,595	70	22.5	312	43.9	14.1	29.8
	05-10	1,097	60	21.1	284	54.7	19.2	35.5
	10-15	143	4	4.2	95	28.0	29.4	-1.4
	15 And Over	3	0	0.1	0	0.0	46.2	-46.2
	Total	4,246	168	60.0	280	39.6	14.1	25.4
70 And Over	00-02	289	19	7.2	265	65.7	24.8	41.0
	02-05	211	21	9.5	221	99.5	45.0	54.5
	05-10	126	16	7.8	206	127.0	61.7	65.2
	10-15	18	2	1.4	143	111.1	77.6	33.6
	15 And Over	0	0	0.0	0	0.0	0.0	0.0
	Total	644	58	25.8	224	90.1	40.1	49.9
Total	00-02	29,881	287	49.4	581	9.6	1.7	8.0
	02-05	35,702	506	87.8	576	14.2	2.5	11.7
	05-10	33,541	561	93.1	603	16.7	2.8	14.0
	10-15	8,888	131	26.6	493	14.7	3.0	11.8
	15 And Over	216	1	0.6	175	4.6	2.6	2.0
	Total	108,228	1486	257.5	577	13.7	2.4	11.4

* Basis of expected deaths: 1983a Individual Annuity Mortality Table.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

Table 4. 1995 Structured Settlement Mortality Experience Female Substandard Annuitants by Age and Duration

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	4,995	51	0.6	8299	10.2	0.1	10.1
	02-05	5,841	72	0.9	7827	12.3	0.2	12.2
	05-10	5,344	63	0.9	6835	11.8	0.2	11.6
	10-15	1,324	7	0.3	2356	5.3	0.2	5.1
	15 And Over	69	1	0.0	5411	14.5	0.3	14.2
	Total	17,573	194	2.8	6999	11.0	0.2	10.9
15-29	00-02	3,427	15	0.8	1926	4.4	0.2	4.1
	02-05	4,185	22	1.4	1534	5.3	0.3	4.9
	05-10	4,051	22	1.7	1314	5.4	0.4	5.0
	10-15	1,121	7	0.6	1208	6.2	0.5	5.7
	15 And Over	33	0	0.0	0	0.0	0.6	-0.6
	Total	12,817	66	4.5	1470	5.1	0.4	4.8
30-39	00-02	2,150	22	0.9	2504	10.2	0.4	9.8
	02-05	2,529	33	1.6	2090	13.0	0.6	12.4
	05-10	2,308	23	1.8	1255	10.0	0.8	9.2
	10-15	549	4	0.6	658	7.3	1.1	6.2
	15 And Over	16	1	0.0	4116	62.5	1.5	61.0
	Total	7,552	83	4.9	1686	11.0	0.7	10.3
40-49	00-02	1,893	31	1.6	1950	16.4	0.8	15.5
	02-05	2,018	25	2.8	895	12.4	1.4	11.0
	05-10	1,665	22	3.2	685	13.2	1.9	11.3
	10-15	358	6	1.0	575	16.8	2.9	13.8
	15 And Over	9	0	0.0	0	0.0	4.7	-4.7
	Total	5,943	84	8.7	968	14.1	1.5	12.7
50-59	00-02	1,335	21	2.8	743	15.7	2.1	13.6
	02-05	1,486	37	5.2	716	24.9	3.5	21.4
	05-10	1,199	41	5.8	710	34.2	4.8	29.4
	10-15	237	6	1.7	355	25.3	7.1	18.2
	15 And Over	8	0	0.1	0	0.0	11.1	-11.1
	Total	4,265	105	15.5	675	24.6	3.6	21.0
60-69	00-02	801	24	4.0	602	30.0	5.0	25.0
	02-05	878	44	7.2	610	50.1	8.2	41.9
	05-10	660	37	7.7	483	56.1	11.6	44.5
	10-15	78	7	1.3	546	89.7	16.4	73.3
	15 And Over	0	0	0.0	0	0.0	0.0	0.0
	Total	2,417	112	20.1	556	46.3	8.3	38.0
70 And Over	00-02	316	20	7.1	281	63.3	22.5	40.8
	02-05	335	28	12.6	222	83.6	37.6	45.9
	05-10	246	21	13.7	153	85.4	55.8	29.6
	10-15	23	3	1.6	189	130.4	68.9	61.5
	15 And Over	0	0	0.0	0	0.0	0.0	0.0
	Total	920	72	35.0	206	78.3	38.1	40.2
Total	00-02	14,917	184	17.8	1035	12.3	1.2	11.1
	02-05	17,272	261	31.7	823	15.1	1.8	13.3
	05-10	15,473	229	34.8	658	14.8	2.2	12.6
	10-15	3,690	40	7.1	564	10.8	1.9	8.9
	15 And Over	135	2	0.2	1027	14.8	1.4	13.4
	Total	51,487	716	91.6	782	13.9	1.8	12.1

* Basis of expected deaths: 1983a Individual Annuity Mortality Table.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

Table 5. 1995 Structured Settlement Mortality Experience Male and Female Substandard Annuitants by Age and Duration Experience for Age Rateups of 1–20 Years

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	4,548	4	1.4	278	0.9	0.3	0.6
	02-05	5,122	6	2.4	254	1.2	0.5	0.7
	05-10	4,659	3	2.5	120	0.6	0.5	0.1
	10-15	1,197	1	0.8	127	0.8	0.7	0.2
	15 And Over	17	0	0.0	0	0.0	0.9	-0.9
	Total	15,543	14	7.1	197	0.9	0.5	0.4
15-29	00-02	7,882	11	5.4	203	1.4	0.7	0.7
	02-05	9,757	28	10.8	260	2.9	1.1	1.8
	05-10	9,781	43	15.2	282	4.4	1.6	2.8
	10-15	2,611	29	6.6	441	11.1	2.5	8.6
	15 And Over	58	0	0.2	0	0.0	4.0	-4.0
	Total	30,089	111	38.2	290	3.7	1.3	2.4
30-39	00-02	5,946	17	10.4	163	2.9	1.8	1.1
	02-05	6,990	58	20.0	290	8.3	2.9	5.4
	05-10	6,274	61	24.3	251	9.7	3.9	5.8
	10-15	1,513	12	8.4	142	7.9	5.6	2.4
	15 And Over	24	1	0.2	487	41.7	8.5	33.1
	Total	20,747	149	63.4	235	7.2	3.1	4.1
40-49	00-02	4,995	32	18.7	171	6.4	3.8	2.7
	02-05	5,659	65	34.8	187	11.5	6.1	5.3
	05-10	4,659	52	38.2	136	11.2	8.2	3.0
	10-15	961	29	10.7	270	30.2	11.2	19.0
	15 And Over	9	1	0.1	849	111.1	13.1	98.0
	Total	16,283	179	102.6	174	11.0	6.3	4.7
50-59	00-02	3,983	49	37.8	129	12.3	9.5	2.8
	02-05	4,518	103	72.8	141	22.8	16.1	6.7
	05-10	3,576	116	84.0	138	32.4	23.5	9.0
	10-15	670	21	23.0	91	31.3	34.3	-2.9
	15 And Over	9	0	0.3	0	0.0	29.6	-29.6
	Total	12,756	289	217.8	133	22.7	17.1	5.6
60-69	00-02	2,072	53	46.2	115	25.6	22.3	3.3
	02-05	2,311	104	85.1	122	45.0	36.8	8.2
	05-10	1,607	92	82.0	112	57.2	51.0	6.2
	10-15	191	10	13.4	75	52.4	70.0	-17.7
	15 And Over	3	0	0.2	0	0.0	63.4	-63.4
	Total	6,184	259	226.8	114	41.9	36.7	5.2
70 And Over	00-02	599	39	30.2	129	65.1	50.5	14.6
	02-05	539	49	45.6	107	90.9	84.6	6.3
	05-10	367	36	40.8	88	98.1	111.1	-13.0
	10-15	41	5	5.6	89	122.0	137.1	-15.2
	Total	1,546	129	122.2	106	83.4	79.0	4.4
Total	00-02	30,025	205	150.3	136	6.8	5.0	1.8
	02-05	34,896	413	271.3	152	11.8	7.8	4.1
	05-10	30,923	403	287.0	140	13.0	9.3	3.8
	10-15	7,184	107	68.5	156	14.9	9.5	5.4
	15 And Over	120	2	1.0	195	16.7	8.6	8.1
	Total	103,148	1130	778.2	145	11.0	7.5	3.4

* Basis of expected deaths: 1983a Individual Annuity Mortality Table Rates, with increases based on age rateups of 1–20 years.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

Table 6. 1995 Structured Settlement Mortality Experience Male and Female Substandard Annuitants by Age and Duration Experience for Age Rateups of 21 Years and Up

Age at Issue of Contract	Duration After Issue**	Exposure Person Yrs. E	No. of Deaths Observed d	No. of Deaths Expected d'*	Mortality Ratio 100d/d'	Mean Ann. Mort. Rate/1000 Observed q	Mean Ann. Mort. Rate/1000 Expected q'	Mean Ann. Mort. Rate/1000 Excess (q-q')
00-14	00-02	7,845	131	46.2	284	16.7	5.9	10.8
	02-05	9,406	167	88.5	189	17.8	9.4	8.3
	05-10	8,770	199	107.8	185	22.7	12.3	10.4
	10-15	2,233	21	29.4	71	9.4	13.2	-3.8
	15 And Over	101	1	1.6	62	9.9	15.9	-6.0
	Total	28,355	519	273.6	190	18.3	9.6	8.7
15-29	00-02	3,855	29	27.8	104	7.5	7.2	0.3
	02-05	4,990	59	55.8	106	11.8	11.2	0.6
	05-10	5,543	62	85.5	72	11.2	15.4	-4.2
	10-15	2,109	15	46.5	32	7.1	22.0	-14.9
	15 And Over	88	0	2.2	0	0.0	24.6	-24.6
	Total	16,585	165	217.8	76	9.9	13.1	-3.2
30-39	00-02	1,572	35	18.8	186	22.3	12.0	10.3
	02-05	1,958	54	36.8	147	27.6	18.8	8.8
	05-10	2,097	46	56.6	81	21.9	27.0	-5.1
	10-15	625	9	26.2	34	14.4	42.0	-27.6
	15 And Over	29	0	1.3	0	0.0	43.8	-43.8
	Total	6,281	144	139.8	103	22.9	22.3	0.7
40-49	00-02	841	38	18.1	210	45.2	21.6	23.6
	02-05	959	25	32.3	77	26.1	33.7	-7.7
	05-10	939	43	44.7	96	45.8	47.6	-1.8
	10-15	251	15	17.7	85	59.8	70.5	-10.7
	15 And Over	12	0	1.1	0	0.0	95.7	-95.7
	Total	3,002	121	114.1	106	40.3	38.0	2.3
50-59	00-02	517	28	19.6	143	54.2	38.0	16.2
	02-05	596	39	36.8	106	65.4	61.7	3.8
	05-10	587	31	49.2	63	52.8	83.8	-31.0
	10-15	146	3	18.6	16	20.5	127.5	-106.9
	15 And Over	1	0	0.1	0	0.0	114.0	-114.0
	Total	1,847	101	124.3	81	54.7	67.3	-12.6
60-69	00-02	137	5	8.2	61	36.5	60.2	-23.7
	02-05	162	10	16.6	60	61.7	102.2	-40.5
	05-10	150	5	20.7	24	33.3	137.8	-104.5
	10-15	30	1	5.9	17	33.3	197.7	-164.4
	Total	479	21	51.4	41	43.8	107.3	-63.5
70 And Over	00-02	6	0	0.8	0	0.0	141.3	-141.3
	02-05	7	0	1.3	0	0.0	186.7	-186.7
	05-10	5	1	1.1	88	200.0	227.2	-27.2
	Total	18	1	3.3	30	55.6	182.8	-127.3
Total	00-02	14,773	266	139.7	190	18.0	9.5	8.6
	02-05	18,078	354	268.1	132	19.6	14.8	4.8
	05-10	18,091	387	365.7	106	21.4	20.2	1.2
	10-15	5,394	64	144.4	44	11.9	26.8	-14.9
	15 And Over	231	1	6.3	16	4.3	27.3	-23.0
	Total	56,567	1072	924.2	116	19.0	16.3	2.6

* Basis of expected deaths: 1983a Individual Annuity Mortality Table Rates, with increases based on age rateups of 21 years and up.

** Duration is based on calendar year of issue and of followup. Average duration of exposure in year of issue is only 0.5 years. Duration times should be adjusted accordingly (00–02 = 00–1.5, 02–05 = 1.5–4.5, etc).

the results were presented only for observed and expected deaths (d and d') and the mortality ratio (MR). However, in the tables here, we have shown additional results for the exposures (e in person-years) and annual mortality rates per 1000 (observed, q; expected, q'; and excess, EDR $= q - q'$). Tables 1 through 4 cover the experience for male and female Std and SStd cases, all ratings and all impairments combined. In the absence of actuarial agreement, we have elected to use the 1983 IAM Table for our standard expected mortality.

The coding of SS cases by impairment has begun only recently, and no such data were available in the 1995 or preceding studies. However, mortality was analyzed by rating in the 1995 study for male and female cases combined. Data for d, d', and MR were shown in separate tables for true issue age and for a grouping of ''age rate-up,'' quinquennial from 0–5 to 26–30 years, and decennial from 31–40 to 71 years up. The age rate-up was generally reported by contributing companies as the difference between the rated age assigned and the issue age, as the measure of excess mortality. As explained in part 1,[1] the rated age is obtained from an actuarial table, which shows the rated age (or the corresponding life expectancy) for the sex, the issue age, and the estimated initial MR, which is assumed to be constant up to age 109 in the construction of the table. The problem raised by the assumption of a constant MR in calculating life expectancy will be described later in this article. For display in this article, we have used the SStd experience, male and female combined, by the same combination of issue age and duration, with two sets of expected rates: the 1983 IAM rates adjusted upward for the rate-ups corresponding to 1–20 years (Table 5) and the same rates adjusted upward at rate-ups of 21 years or more (Table 6).

Tables 1 and 2 contain the mortality experience by age and duration for the male and female SS annuitants, respectively, issued on a Std basis. Up to age 60, mortality in the Std cases was much higher than mortality in the 1983 IAM Table. The highest MR in males was 468% at issue ages 15–29 years, but in females the highest MR of 429% was found in the youngest age group (less than 15 years). For issues at age 60–69, observed mortality was a little above that expected from the 1983 IAM Table, and for the oldest age group, 70 and up, the MR was slightly less than 100%. Mortality trends by duration varied somewhat by age group, and there was virtually no experience beyond 15 years. For all ages combined, the highest MR values in both sexes was at duration 5–10 years. Overall MR values, all ages and durations combined, were 148% for males and 132% for females. The overall excess death rate (EDR) of 1.9 per 1000 in males was higher than the EDR of 0.9 per 1000 in females. These results demonstrate the unsuitability of the 1983 IAM Table as a table of expected rates for SS annuitants when issue was on a Std basis. In our view, the Std experience is sufficient in volume, with nearly 610,000 person-years of exposure and 3056 deaths, to utilize as the basis for an expected SS annuitant mortality table that would be far more accurate than the 1983 IAM Table.

Excess mortality for the SStd experience was at an overall level of about 12 per 1000 for both male and female SS annuitants (Tables 3 and 4). The trend of EDR with age was similar in both sexes: an initial high value of over 10 per 1000 in children, about half this in young adults, then an increase with issue age to a maximum of about 40 per 1000 in annuitants age 70 and up. There did not appear to be a definite trend with duration. Because of the much lower expected mortality in females, there were pronounced sex differences in MR, with very high values in children (3480% in males and nearly 7000% in females). The usual trend for MR was for it to decrease with advancing age. In annuitants age 70 and up, the MR fell to 224% in men and to 206% in women. These, of course, are aggregate results, reflecting the combination of all levels of excess risk and of rating. SS annuity applicants are known to include cases with very high levels of excess mortality, far above the limits for declination in applicants for life insurance. The proportion of high risks appears to be particularly large in children. We interpret this to be the reason for the higher EDR in children as compared with young adults, age 15–29. As noted in part 1, there is a high prevalence of head injuries and other disabling injuries at all ages, but this is more significant in children and young adults. Birth injuries and cerebral palsy are important conditions in infants and young children. The general level of excess mortality in these SStd annuitants approximates the level found in Pension Trust mortality experience for working adults in the highest risk category of SD (substandard declined, with a limited graded death benefit).[5]

The SStd mortality experience for SS annuitants has also been analyzed with expected mortality based on the rated age, expressed as the age rate-up, or difference between the rated age and actual issue age. This method of rating is detailed in part 1.[1] In essence, the rated age is based on the use of an appropriate MR applied as a decimal to the mortality rate, q', for the issue age. This rated expected q' is used to enter the table of expected rates, and the age at which it is found is the rated age. The difference between the rated and issue ages is designated as the age rate-up. The relation between MR and age rate-up is complex, because the curve of expected mortality rates is very flat at the younger ages; but the rate increases from age 35 to 85 at a nearly constant rate of about 10% per year, a rate of increase that gradually slows above age 85. If an EDR of 10 per 1000 prevails in a group of boys age 10, the age rate-up would have to be 63 − 10, or 53 years to achieve the necessary increase in q'. However, the same EDR in a group of men age 60 would involve an age rate-up of only 8 years (68 − 60). This is the reason for the high prevalence of children and young adults in Table 6, the experience for age rate-ups of 21 years or more, in comparison to the prevalence in Table 5, which displays the experience for cases with smaller age rate-ups of 1–20 years. Exposures at duration 0–2 years number in the thousands in age groups 40–69 years in Table 5 but are only in the hundreds in Table 6, where the age rate-up exceeds 20 years. As we will explain later, use of a constant initial MR to express excess mortality overestimates mortality projected into higher attained ages, but this overestimate is less evident in the 1995 experience than it would be in a more mature experience, such as that for life insurance policyholders, because the maximum follow-up duration is about 15 years. An overestimate of future mortality, of course, implies an underestimate of life expectancy.

In Table 5, where SStd rates are compared with adjusted expected rates when age rate-ups are less than 21 years, MR values exceed 100% in all age groups and all duration groups. The aggregate MR was 145%, with a range of 290%–106%. The overall EDR was 3.4 per 1000. Because the age rate-up method of using a constant MR tends to overestimate expected deaths as high attained ages, these results suggest that underwriting has produced a safe margin with respect to excess mortality and reduced life expectancy, a duration of at least up to 15 years, when the 1983 IAM Table has been used for expected mortality.

Excess mortality above the rated expected level was much less consistent in SStd cases with age rate-ups of 21 years or more (Table 6). In children younger than 15 years, the largest age group, the MR, all durations combined, was 190% and the EDR was 9.7 per 1000. However, the trend by duration was downward, with mortality less than the rated expected at longer durations, a trend noted in all age groups. In contrast, the overall MR was only 76% in young adults age 15–29 years, and 103%, 106%, and 81%, respectively, in age groups 30–39, 40–49, and 50–59 years. Experience was very limited at age 60 years and up. In all of these age groups, except the 15–29 group, the MR was initially elevated at 143% or higher but then fell to levels below 100%. Initial EDR values were correspondingly high at duration 0–2 but dropped below 0 when the MR fell below 100%. Remember, when observed deaths exceed rated expected deaths, this represents conservative underwriting for annuitants, life expectancy is smaller than anticipated, and reserves are adequate. On this basis, results for high-risk cases in Table 6 are conservative only for the early durations in the age groups under 60 years. In annuitants age 60 years and older and at the later durations in younger cases, MR is less than 100%, excess mortality has apparently been overestimated, life expectancy underestimated, and mortality-dependent reserves are inadequate. It is, however, very difficult to be certain of the interpretation of comparative mortality in Tables 5 and 6, because of the calculation problem involved in the age rate-up method.

In another approach to assessing how appropriate the assigned ratings were, we estimated the age-specific MR values as averaged in Tables 5 and 6. This was accomplished by dividing the rated q' in Tables 5 and 6 (both sexes combined) by the corresponding age-specific standard q', approximately weighted by sex as given in Tables 1 and 2. The range of risk ratio (RR) in Table 5 (the table with smaller age rate-ups) was 1.67–3.10, with little or no discernible age trend. In Table 6, with larger age rate-ups, the RR decreased from 32 in the youngest age group to 4.4 in the oldest. The resulting risk ratios (RR = MR/100) were multiplied by the corresponding observed age-specific Std q values from Tables 1 and 2, again approximately weighted by sex to obtain approximate age-specific rated expected rates based on the Std SS mortality experience. The Std SS experience shows higher rates than in the 1983 IAM Table, particularly below age 60. Tables similar to Tables 1 through 4 were constructed for the two rate-up groupings of Tables 5 and 6, both sexes and all durations combined. The MR was less than 100% in all age groups in both tables, except for a single value of 104%. MR values tended to be lower at the older ages, as compared with the younger ages. The overall MR was 62% in the group with rate-ups of 1–20 years and only 46% in the group with age rate-ups of 21 years or more. If our approximation method is valid, the aggregate rate-up applied was excessive, particularly for the higher rate-ups. This means, in turn, that the long-term mortality provided for was overestimated, life expectancy was underestimated, and the mortality portions of the reserves would be inadequate if the rating is considered relative to the observed Std SS mortality experience. The problem of overestimating mortality is compounded by the limitation of duration to only 15 years; the overestimate might be even higher at longer durations. The above must be qualified by the uncertainties regarding the best expected SS table to use, and the error inherent in the customary actuarial table used to convert a constant initial MR value into a life expectancy or age rate-up (see later discussion). The medical underwriter of SS applications deserves better help in both of these areas.

EXCESS MORTALITY AND THE CALCULATION OF LIFE EXPECTANCY

Logically the most accurate method of calculating life expectancy for a group at increased mortality risk is to use annual life-table methodology and results from a detailed mortality follow-up study that is specific for the medical condition, its severity, age group, sex, race, and annual duration. Such studies are made for groups drawn from various population samples with differing expected mortality rates (eg, select insurance, group insurance, and US population rates). It has been shown that the best method of translating excess mortality results between groups with differing expected mortality rates is to use the EDR values as the data of excess mortality and to add these to the appropriate q' values for the new group, in this case SS annuitants.[6] Accordingly we present in Table 7 an illustrative calculation of life expectancy of this sort. Annual EDR values to a duration of 24 years have been used from detailed results of the 1976 Cancer Surveillance, Epidemiology, and End-Results (SEER) Program (Report No. 5) on cancer-patient survival.[7] These are not from the published report but from additional detailed ta-

Table 7. Life Expectancy of Men Age 55–64 Years with Localized Prostate Cancer, SEER Results 1950–75, With Excess Death Rates Added to 1989–91 US Population Rates

Age x	Exp. q′	dec EDR	Proj. q	Cohort	d	L	T	e	P′
60	0.01503	0.058	0.0730	1000.0	73.0	963.5	11207.2	11.2	0.985
61	0.01641	0.050	0.0664	927.0	61.6	896.2	10243.7	11.1	0.969
62	0.01788	0.061	0.0789	865.4	68.3	831.3	9347.5	10.8	0.951
63	0.01947	0.056	0.0755	797.1	60.2	767.1	8516.3	10.7	0.933
64	0.02118	0.061	0.0822	737.0	60.6	706.7	7749.2	10.5	0.913
65	0.02297	0.058	0.0810	676.4	54.8	649.0	7042.5	10.4	0.892
66	0.02483	0.040	0.0648	621.7	40.3	601.5	6393.5	10.3	0.870
67	0.02689	0.047	0.0739	581.3	43.0	559.9	5792.0	10.0	0.847
68	0.02926	0.050	0.0793	538.4	42.7	517.1	5232.1	9.7	0.822
69	0.03200	0.042	0.0740	495.7	36.7	477.4	4715.0	9.5	0.796
70	0.03509	0.051	0.0861	459.0	39.5	439.3	4237.7	9.2	0.768
71	0.03848	0.031	0.0695	419.5	29.1	404.9	3798.4	9.1	0.738
72	0.04215	0.037	0.0792	390.4	30.9	374.9	3393.4	8.7	0.707
73	0.04598	0.035	0.0810	359.5	29.1	344.9	3018.5	8.4	0.675
74	0.04993	0.073	0.1229	330.4	40.6	310.1	2673.6	8.1	0.641
75	0.05414	0.032	0.0861	289.8	25.0	277.3	2363.5	8.2	0.606
76	0.05875	0.032	0.0908	264.8	24.0	252.8	2086.3	7.9	0.571
77	0.06372	0.032	0.0957	240.8	23.0	229.2	1833.5	7.6	0.534
78	0.06920	0.032	0.1012	217.7	22.0	206.7	1604.2	7.4	0.497
79	0.07533	0.032	0.1073	195.7	21.0	185.2	1397.5	7.1	0.460
80	0.08246	0.004	0.0865	174.7	15.1	167.1	1212.4	6.9	0.422
81	0.09049	0.004	0.0945	159.6	15.1	152.0	1045.2	6.6	0.384
82	0.09891	0.004	0.1029	144.5	14.9	137.1	893.2	6.2	0.346
83	0.10715	0.004	0.1112	129.6	14.4	122.4	756.1	5.8	0.309
84	0.11519	0.004	0.1192	115.2	13.7	108.4	633.7	5.5	0.273
85	0.12436	0.004	0.1284	101.5	13.0	95.0	525.4	5.2	0.239
86	0.13522	0.004	0.1392	88.5	12.3	82.3	430.4	4.9	0.207
87	0.14695	0.004	0.1510	76.1	11.5	70.4	348.1	4.6	0.176
88	0.15927	0.004	0.1633	64.7	10.6	59.4	277.7	4.3	0.148
89	0.17219	0.004	0.1762	54.1	9.5	49.3	218.3	4.0	0.123
90	0.18617	0.004	0.1902	44.6	8.5	40.3	169.0	3.8	0.100
91	0.20159	0.004	0.2056	36.1	7.4	32.4	128.7	3.6	0.080
92	0.21773	0.004	0.2217	28.7	6.4	25.5	96.3	3.4	0.062
93	0.23376	0.004	0.2378	22.3	5.3	19.7	70.8	3.2	0.048
94	0.24893	0.004	0.2529	17.0	4.3	14.9	51.1	3.0	0.036
95	0.26329	0.004	0.2673	12.7	3.4	11.0	36.3	2.9	0.026
96	0.27914	0.004	0.2831	9.3	2.6	8.0	25.3	2.7	0.019
97	0.28299	0.004	0.2870	6.7	1.9	5.7	17.3	2.6	0.014
98	0.30869	0.004	0.3127	4.8	1.5	4.0	11.5	2.4	0.009
99	0.32413	0.004	0.3281	3.3	1.1	2.7	7.5	2.3	0.006
100	0.34033	0.004	0.3443	2.2	0.8	1.8	4.8	2.2	0.004
101	0.35735	0.004	0.3614	1.4	0.5	1.2	3.0	2.1	0.003
102	0.37522	0.004	0.3792	0.9	0.3	0.7	1.8	2.0	0.002
103	0.39398	0.004	0.3980	0.6	0.2	0.5	1.1	1.8	0.001
104	0.41368	0.004	0.4177	0.3	0.1	0.3	0.6	1.7	0.001
105	0.43436	0.004	0.4384	0.2	0.1	0.2	0.3	1.6	0.000
106	0.45608	0.004	0.4601	0.1	0.1	0.1	0.2	1.5	0.000

bles supplied by Dr Myers, tables providing annual observed data and derived observed, expected, and relative survival rates. The extensive SEER survival results from Report No. 5 were recomputed to comparative mortality in the cancer tables of the 1990 Medical Risks monograph.[8] Table 514A in that report (for prostate cancer) provides these data for men age 55–64 with localized prostate cancer, but condensed into a smaller number of intervals. The annual EDR values are used in Table 7 to 15 years, then averages for 15–19 years and 20–24 years.

Table 7 is very different in format from the preceding tables used to provide comparative mortality results for the SS annuitant experience. Its design is derived from the format of the US Decennial Life Tables, and the expected mortality rate, q', is taken from the 1989–91 Decennial US Life Table for the white male population.[9] Instead of duration, attained age is used, starting with age 60, the central age of the age group of the prostate cancer patients, and extending to attained age 105 (data for ages 106 to 109, the maximum age shown in the Decennial Tables, have been omitted). This design is used in a spreadsheet program to calculate life expectancy, designated e in Table 7.[10] The arrangement of the columns and their interrelation as components of the life table are discussed in the methodology article, the fundamental relation being $q' + \text{EDR} = q$.[10] A description of the life-table arrangement is also given in the preliminary text of the US Life Tables.[9]

Table 3 of the methodology article[10] (not shown here) gives the SEER results from which EDR was obtained in the customary format of Tables 1–6 in this article. The number of entrants for the prostate cancer cases was 2364, with 212 observed and 63.2 expected deaths in the first year. Expected deaths were derived from contemporary population rates during the observation period 1950–75. We have substituted the lower mortality rates of the most recent Decennial US Life Tables in Table 7. The trend in EDR was one of gradual decrease with duration. The 5-year average EDR values were 57 per 1000 for duration 0–5 years, 49 for 5–10 years, 44 for 10–15 years, and 32 for 15–20 years. The EDR dropped to only 4 per 1000 at duration 20–24 years. This was based on only 7 deaths in a total exposure of 63.0 patient-years. However, as the EDR of longest available duration, it is not only used at attained ages 80–84 but is also assumed to remain constant for all future attained ages to 109 years. This lack of EDR data from even the longest follow-up studies produces an inevitable uncertainty in the precise calculation of life expectancy. However, at this age and this high level of EDR, there were only about 101 survivors at age 85. The T value at this age was 525.4 person-years, less than 5% of the T value at age 60, 11,207.2 years. The annual L contributions to the initial T value are therefore as accurate as can be for the first 95% of the initial T value or the initial life expectancy. The residual uncertainty due to lack of long-term data above attained age 85 years in this group must be less than 5%. The residual uncertainty must be much higher when the initial age is a young one, especially in children.

Next, we examined the effect of relying on a constant initial measure of excess mortality, either a decimal EDR or an RR (RR = MR/100). To compare with the 11.2 years in Table 7, we utilized the EDR and RR values found in the first year and held these constant from age 60 to 109, in this life-table program. The initial EDR was 0.058 and the initial RR (not given in the table) was q/q', or 0.073/0.015, or 4.87. In this model of the life table, subsequent mortality rates were calculated as $q = 4.87q'$. Use of the higher initial EDR of 0.58 as a constant in the first 20 years of duration and thereafter produced a decreased life expectancy of 10.2 years, a reduction of 9% below the 11.2 years calculated above. The EDR model is shown in Table 8. When the model was changed to one of a constant RR of 4.87 (Table 9), the life expectancy fell even lower, to 7.6 years, a reduction of 25% below the life expectancy for the constant EDR model and 32% below the most accurate value in Table 7, the life table in which all of EDR results to a duration of 24 years are used. These life-

Table 8. Life Expectancy of White Men Age 55–64 Years With Localized Prostate Cancer: Constant Excess Death Rate of 0.058 Added to Annual Rates in the 1989–91 US Population Tables

Age x	Exp. q'	dec EDR	Proj. q	Cohort	d	L	T	e	P'
60	0.01503	0.0580	0.0730	1000.0	73.0	963.5	10200.7	10.2	0.985
61	0.01641	0.0580	0.0744	927.0	69.0	892.5	9237.2	10.0	0.969
62	0.01788	0.0580	0.0759	858.0	65.1	825.4	8344.7	9.7	0.951
63	0.01947	0.0580	0.0775	792.9	61.4	762.2	7519.2	9.5	0.933
64	0.02118	0.0580	0.0792	731.5	57.9	702.5	6757.1	9.2	0.913
65	0.02297	0.0580	0.0810	673.5	54.5	646.3	6054.6	9.0	0.892
66	0.02483	0.0580	0.0828	619.0	51.3	593.4	5408.3	8.7	0.870
67	0.02689	0.0580	0.0849	567.7	48.2	543.6	4814.9	8.5	0.847
68	0.02926	0.0580	0.0873	519.5	45.3	496.9	4271.3	8.2	0.822
69	0.03200	0.0580	0.0900	474.2	42.7	452.9	3774.4	8.0	0.796
70	0.03509	0.0580	0.0931	431.5	40.2	411.4	3321.5	7.7	0.768
71	0.03848	0.0580	0.0965	391.4	37.8	372.5	2910.1	7.4	0.738
72	0.04215	0.0580	0.1002	353.6	35.4	335.9	2537.6	7.2	0.707
73	0.04598	0.0580	0.1040	318.2	33.1	301.6	2201.7	6.9	0.675
74	0.04993	0.0580	0.1079	285.1	30.8	269.7	1900.1	6.7	0.641
75	0.05414	0.0580	0.1121	254.3	28.5	240.1	1630.4	6.4	0.606
76	0.05875	0.0580	0.1168	225.8	26.4	212.6	1390.3	6.2	0.571
77	0.06372	0.0580	0.1217	199.4	24.3	187.3	1177.7	5.9	0.534
78	0.06920	0.0580	0.1272	175.2	22.3	164.0	990.3	5.7	0.497
79	0.07533	0.0580	0.1333	152.9	20.4	142.7	826.3	5.4	0.460
80	0.08246	0.0580	0.1405	132.5	18.6	123.2	683.6	5.2	0.422
81	0.09049	0.0580	0.1485	113.9	16.9	105.4	560.4	4.9	0.384
82	0.09891	0.0580	0.1569	97.0	15.2	89.4	455.0	4.7	0.346
83	0.10715	0.0580	0.1652	81.8	13.5	75.0	365.6	4.5	0.309
84	0.11519	0.0580	0.1732	68.3	11.8	62.3	290.6	4.3	0.273
85	0.12436	0.0580	0.1824	56.4	10.3	51.3	228.3	4.0	0.239
86	0.13522	0.0580	0.1932	46.1	8.9	41.7	177.0	3.8	0.207
87	0.14695	0.0580	0.2050	37.2	7.6	33.4	135.3	3.6	0.176
88	0.15927	0.0580	0.2173	29.6	6.4	26.4	101.9	3.4	0.148
89	0.17219	0.0580	0.2302	23.2	5.3	20.5	75.5	3.3	0.123
90	0.18617	0.0580	0.2442	17.8	4.4	15.7	55.0	3.1	0.100
91	0.20159	0.0580	0.2596	13.5	3.5	11.7	39.3	2.9	0.080
92	0.21773	0.0580	0.2757	10.0	2.8	8.6	27.6	2.8	0.062
93	0.23376	0.0580	0.2918	7.2	2.1	6.2	19.0	2.6	0.048
94	0.24893	0.0580	0.3069	5.1	1.6	4.3	12.8	2.5	0.036
95	0.26329	0.0580	0.3213	3.5	1.1	3.0	8.5	2.4	0.026
96	0.27914	0.0580	0.3371	2.4	0.8	2.0	5.5	2.3	0.019
97	0.28299	0.0580	0.3410	1.6	0.5	1.3	3.5	2.2	0.014
98	0.30869	0.0580	0.3667	1.1	0.4	0.9	2.2	2.1	0.009
99	0.32413	0.0580	0.3821	0.7	0.3	0.5	1.3	2.0	0.006
100	0.34033	0.0580	0.3983	0.4	0.2	0.3	0.8	1.9	0.004
101	0.35735	0.0580	0.4154	0.2	0.1	0.2	0.4	1.8	0.003
102	0.37522	0.0580	0.4332	0.1	0.1	0.1	0.2	1.7	0.002
103	0.39398	0.0580	0.4520	0.1	0.0	0.1	0.1	1.6	0.001
104	0.41368	0.0580	0.4717	0.0	0.0	0.0	0.1	1.5	0.001
105	0.43436	0.0580	0.4924	0.0	0.0	0.0	0.0	1.4	0.000
106	0.45608	0.0580	0.5141	0.0	0.0	0.0	0.0	1.3	0.000
107	0.47888	0.0580	0.5369	0.0	0.0	0.0	0.0	1.2	0.000
108	0.50282	0.0580	0.5608	0.0	0.0	0.0	0.0	1.0	0.000
109	0.52797	0.0580	0.5860	0.0	0.0	0.0	0.0	0.7	0.000

Table 9. Life Expectancy of White Men Age 55–64 Years With Localized Prostate Cancer: Constant Risk Ratio of 4.87 Multiplied by Annual Rates in the 1989–91 US Population Rates

Age x	Exp. q'	dec MR	Proj. q	Cohort	d	L	T	e	P'
60	0.01503	4.87	0.0732	1000.0	73.2	963.4	7631.0	7.6	0.985
61	0.01641	4.87	0.0799	926.8	74.1	889.8	6667.6	7.2	0.969
62	0.01788	4.87	0.0871	852.7	74.3	815.6	5777.8	6.8	0.951
63	0.01947	4.87	0.0948	778.5	73.8	741.6	4962.2	6.4	0.933
64	0.02118	4.87	0.1031	704.7	72.7	668.3	4220.6	6.0	0.913
65	0.02297	4.87	0.1119	632.0	70.7	596.6	3552.3	5.6	0.892
66	0.02483	4.87	0.1209	561.3	67.9	527.4	2955.7	5.3	0.870
67	0.02689	4.87	0.1310	493.4	64.6	461.1	2428.3	4.9	0.847
68	0.02926	4.87	0.1425	428.8	61.1	398.3	1967.2	4.6	0.822
69	0.03200	4.87	0.1558	367.7	57.3	339.0	1569.0	4.3	0.796
70	0.03509	4.87	0.1709	310.4	53.0	283.9	1229.9	4.0	0.768
71	0.03848	4.87	0.1874	257.4	48.2	233.2	946.0	3.7	0.738
72	0.04215	4.87	0.2053	209.1	42.9	187.7	712.8	3.4	0.707
73	0.04598	4.87	0.2239	166.2	37.2	147.6	525.1	3.2	0.675
74	0.04993	4.87	0.2432	129.0	31.4	113.3	377.5	2.9	0.641
75	0.05414	4.87	0.2637	97.6	25.7	84.8	264.2	2.7	0.606
76	0.05875	4.87	0.2861	71.9	20.6	61.6	179.5	2.5	0.571
77	0.06372	4.87	0.3103	51.3	15.9	43.4	117.9	2.3	0.534
78	0.06920	4.87	0.3370	35.4	11.9	29.4	74.5	2.1	0.497
79	0.07533	4.87	0.3669	23.5	8.6	19.2	45.1	1.9	0.460
80	0.08246	4.87	0.4016	14.9	6.0	11.9	26.0	1.7	0.422
81	0.09049	4.87	0.4407	8.9	3.9	6.9	14.1	1.6	0.384
82	0.09891	4.87	0.4817	5.0	2.4	3.8	7.1	1.4	0.346
83	0.10715	4.87	0.5218	2.6	1.3	1.9	3.4	1.3	0.309
84	0.11519	4.87	0.5610	1.2	0.7	0.9	1.5	1.2	0.273
85	0.12436	4.87	0.6056	0.5	0.3	0.4	0.6	1.1	0.239
86	0.13522	4.87	0.6585	0.2	0.1	0.1	0.2	1.0	0.207
87	0.14695	4.87	0.7156	0.1	0.1	0.0	0.1	0.9	0.176
88	0.15927	4.87	0.7756	0.0	0.0	0.0	0.0	0.8	0.148
89	0.17219	4.87	0.8386	0.0	0.0	0.0	0.0	0.7	0.123
90	0.18617	4.87	0.9066	0.0	0.0	0.0	0.0	0.6	0.100
91	0.20159	4.87	0.9817	0.0	0.0	0.0	0.0	0.5	0.080
92	0.21773	4.87	1.0603	0.0	0.0	0.0	0.0	0.4	0.062
93	0.23376	4.87	1.1384	-0.0	-0.0	-0.0	-0.0	0.4	0.048
94	0.24893	4.87	1.2123	0.0	0.0	0.0	0.0	0.3	0.036
95	0.26329	4.87	1.2822	-0.0	-0.0	-0.0	-0.0	0.3	0.026
96	0.27914	4.87	1.3594	0.0	0.0	0.0	0.0	0.2	0.019
97	0.28299	4.87	1.3782	-0.0	-0.0	-0.0	-0.0	0.2	0.014
98	0.30869	4.87	1.5033	0.0	0.0	0.0	0.0	0.2	0.009
99	0.32413	4.87	1.5785	-0.0	-0.0	-0.0	-0.0	0.0	0.006
100	0.34033	4.87	1.6574	0.0	0.0	0.0	0.0	0.3	0.004
101	0.35735	4.87	1.7403	-0.0	-0.0	-0.0	0.0	-0.2	0.003
102	0.37522	4.87	1.8273	0.0	0.0	0.0	0.0	0.4	0.002
103	0.39398	4.87	1.9187	-0.0	-0.0	-0.0	0.0	-0.4	0.001
104	0.41368	4.87	2.0146	0.0	0.0	-0.0	0.0	0.5	0.001
105	0.43436	4.87	2.1153	-0.0	-0.0	0.0	0.0	-0.5	0.000
106	0.45608	4.87	2.2211	0.0	0.0	-0.0	0.0	0.4	0.000
107	0.47888	4.87	2.3321	-0.0	-0.0	0.0	0.0	-0.4	0.000
108	0.50282	4.87	2.4487	0.0	0.0	-0.0	0.0	0.2	0.000
109	0.52797	4.87	2.5712	-0.0	-0.0	0.0	0.0	-0.3	0.000

Table 10. Life Expectancies (e_x) by Age, Sex, and Excess Death Rate per 1000, Based on 1989–91 US Life Tables for the White Population

	Excess Death Rates Per 1000								
Age	0	1	2	5	10	20	50	100	200
White Males									
0	72.7	70.0	67.4	60.4	50.7	37.2	18.6	9.4	4.5
10	63.6	61.5	59.4	53.9	46.2	34.9	18.3	9.4	4.5
20	54.0	52.4	50.9	46.8	40.6	31.9	17.7	9.3	4.5
30	44.7	43.6	42.6	39.6	35.3	28.5	16.8	9.1	4.4
40	35.6	34.9	34.2	32.2	29.3	24.5	15.5	8.9	4.4
50	26.7	26.3	25.9	24.7	22.9	19.8	13.5	8.3	4.3
60	18.7	18.5	18.3	17.6	16.5	14.9	11.0	7.3	4.0
70	12.1	12.0	11.9	11.6	11.1	10.2	8.1	5.9	3.6
80	7.1	7.1	7.0	6.9	6.7	6.3	5.4	4.2	2.8
90	3.8	3.8	3.8	3.8	3.7	3.6	3.2	2.7	2.0
100	2.2	2.2	2.2	2.2	2.1	2.1	1.9	1.7	1.3
White Females									
0	79.4	76.3	73.2	65.1	54.1	38.9	18.9	9.4	4.5
10	70.2	67.7	65.3	58.8	49.8	36.0	18.7	9.4	4.5
20	60.4	58.5	56.7	51.7	44.7	34.2	18.3	9.4	4.5
30	50.6	49.3	48.0	44.4	39.1	31.0	17.6	9.3	4.5
40	41.0	40.1	39.2	36.7	33.0	27.1	16.4	9.1	4.4
50	31.7	31.1	30.6	29.0	26.6	22.6	14.8	8.7	4.4
60	23.1	22.8	22.5	21.5	20.1	17.7	12.6	7.9	4.2
70	15.5	15.3	15.1	14.7	14.0	12.7	9.8	6.8	3.9
80	9.1	9.1	9.0	8.8	8.5	8.0	6.6	5.0	3.2
90	4.7	4.7	4.6	4.6	4.5	4.3	3.8	3.1	2.2
100	2.5	2.5	2.5	2.4	2.4	2.3	2.1	1.9	1.4

table computations of *e* demonstrate the serious underestimate of life expectancy when the constant RR model is used and a modest underestimate when the initial EDR is used if EDR decreases with duration, as it often does in chronic conditions such as the follow-up after cancer surgery. We regard this comparison as strong evidence for the desirability of converting MR to EDR in the underwriting process and using an actuarial table of EDR to obtain life expectancy (or rated age) by age and sex, based on the expected mortality table.

We continue our description of the estimation of life expectancy with a more general view of its relation to sex, age, EDR, and the interrelation of EDR and MR. Table 10 shows life expectancy computed by the life-table method for constant values of EDR. The expected mortality rates are those from the US Decennial Life Tables for 1989–91 (white population), and the life expectancies in these tables are shown in the column headed 0. The columns to the right give life expectancies computed for a set of EDR values ranging from 1 to 200 per 1000 per year. In each life table, the EDR value has been held constant from age 0 to 109, the maximum age in the Decennial Tables for which data are given. At low levels of EDR, life expectancy is minimally reduced, especially at the older ages. The highest levels of EDR in Table 10 produce little age variation in the much-reduced life expectancy until the older ages are reached. This table can be used to estimate an approximate life expectancy by interpolation for a given EDR and age, and it can be used in place of similar tables that show MR in place of EDR, if the medical director and actuary agree on the substitution of an EDR table for the traditional MR table. If some other table is preferred for the expected rates, the actuary can develop the needed EDR table from the description of the spreadsheet program used.[10]

Table 11 shows for each EDR level the corresponding MR at various ages from 10 to 100 years for both males and females. To the left of the MR values is given the annual mortality rate, q', in the 1989–91 US Decennial Life Tables, expressed as deaths per 1000 per year (the denominator of the MR). In children age 10, MR values are extremely high, even at the lowest EDR of 2 per 1000, because q' is so small at this age. On the other hand, when q' is high, as it is at the oldest ages, MR is only 101% at the lowest EDR level in the table, and even when EDR is 100 per 1000, the MR is well under 200% at ages 90 and 100. Table 11 emphasizes the limitations of MR as a measure of excess mortality for both sexes and over a lifetime age span and should prove to be a convenient reference table to accompany Table 10.

CONCLUSION

Johansen[4] has been critical of standard annuitant mortality tables, but it seems to us

Table 11. Mortality Ratios Corresponding to Excess Death Rates per 1000 by Attained Age and Sex, Based on the 1989–91 US Life Tables for the White Population

Age (y) x	Sex (M or F)	Mortality Rate Per 1000* q'	Excess Death Rate Per 1000: 2	5	10	20	50	100
			Mortality Ratios (%)					
			Younger Ages					
10	M	0.16	1350	3200	6400	12,600	31,000	63,000
	F	0.14	1530	3700	7200	14,400	36,000	72,000
20	M	1.4	245	470	835	1530	3800	7500
	F	0.5	510	1120	2100	4200	10,300	21,000
30	M	1.8	215	380	650	1190	2900	5800
	F	0.6	420	905	1710	3300	8200	16,200
			Middle Ages					
40	M	2.7	174	285	470	840	1940	3800
	F	1.2	265	515	925	1750	4200	8400
50	M	5.6	135	189	275	455	985	1870
	F	3.2	162	255	410	660	1660	3200
60	M	15.0	113	133	167	235	430	765
	F	8.4	124	160	220	320	695	1290
			Older Ages					
70	M	35.1	106	114	128	157	240	385
	F	19.7	110	125	151	200	355	660
80	M	82.0	102	106	112	124	161	220
	F	51.0	104	110	120	140	199	300
90	M	186.0	101	103	105	111	127	154
	F	140.0	101	104	107	114	136	171
100	M	340.0	101	102	103	106	115	129
	F	300.0	101	102	103	107	117	133

* Basis of annual mortality rates per 1000: 1989–91 Decennial US Life Tables for the white population.

that the volume of the 1995 Std experience for SS annuitants in Tables 1 and 2 is sufficient to provide a firm basis for development of standard tables for this special type of annuity. With male and female annuitants combined, the standard experience comprises over 600,000 person-years of exposure, with 3056 deaths. There is virtually no experience beyond 15 years, but Tables 1 and 2 provide a detailed breakdown of the Std experience by a combination of sex, age, and duration up to 15 years. These tables are similar in scope to the life insurance select tables. If the actuaries desire similar tables for SS annuitants, the data are already at hand for graduation and as a basis for valuation tables. The preponderance of young SS annuitants compensates for the low mortality rates at younger ages.

The need for accurate Std tables for SS annuitants is increased by the high proportion of high-risk SStd annuities issued (see Tables 3 through 6). There is also a need for SStd mortality experience by individual impairment, and the SOA plans to request such data from the companies contributing to overall SS mortality.

When SStd mortality in SS annuitants is compared with expected rates approximated from the Std mortality, MRs are well under 100%, indicating overly aggressive underwriting, excessively high ratings, and an underestimate of life expectancy. The magnitude of this discrepancy may be larger than found in our analysis, because the mortality experience is limited to duration 0–15 years.

Table 7 illustrates the life-table methodology for the most accurate possible estimation of life expectancy in men age 55–64 years with localized prostate cancer. Data from SEER Report No. 5 are used up to a maximum duration of 24 years; these data provide 95% of the exposure needed for calculation of a life expectancy of 11.2 years, thus reducing the uncertainty of assuming mortality rates at attained ages 85 years and up. When an initial excess mortality is utilized as a constant in the life table, we have found that the life expectancy is modestly underestimated at 10.2 years with a constant EDR but seriously underestimated at 7.6 years if a constant initial MR is used. Both EDR and MR from the initial age 60 years were taken from Table 7 in these life-table calculations. We have emphasized the intrinsic danger of underestimating life expectancy by using a constant MR in the life-table model, because this invariably overestimates the projected mortality at older attained ages in a group at high excess mortality risk. With high MR values, impossibly high mortality rates in excess of 1.000 per year are derived at the older ages and interfere with the sequential life-table calculations.

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