ACTUARIAL SOCIETY OF SOUTH AFRICA

ANNUITANT MORTALITY 2001-2004

REPORT – 26 April 2012

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ABSTRACT
This document sets out the major findings and results of the annuitant mortality investigation conducted by the Continuous Statistical Investigation (CSI) committee. This investigation covered the period 1 January 2001 to 31 December 2004.

KEYWORDS
CSI, Annuity, Standardized Mortality Ratio (SMR), Graduation

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1 Introduction

1.1 Previous investigation

The previous annuitant mortality investigation conducted by the CSI committee covered the period 1996-2000. A set of standard annuitant life tables (SAIML98 and SAIFL98) was produced from this investigation, and a report was published in the South African Actuarial Journal volume 7.

1.2 Scope of current investigation

This investigation covers individual annuities (single and joint lives) for the period 2001 to 2004.

The following data were excluded from the investigation:
- back-to-back annuity arrangements (annuities issued in conjunction with a non-profit life cover product, where a portion of the annuity payment is used to pay the life cover premium);
- deferred, reversionary and contingent annuities;
- living annuities;
- annuities issued in a territory outside the Republic of South Africa; and
- annuities payable in a currency other than the South African Rand.

1.3 Data

Data were obtained in accordance with the data specification sent out by the CSI committee for individual annuities. Old Mutual, Sanlam, Liberty, Metropolitan and Momentum supplied data for all the years 2001-2004. The companies included in the investigation made up the bulk of business sold in the industry. For the 1996-2000 Annuitant mortality investigation, the data of two companies (22 and 25) were excluded from the investigation due to the quality of the data submitted. The current investigation however, includes all the data from all the participating companies.

Details included in the data were:
- age last birthday;
- central exposure to risk;
- sex;
- guaranteed period status;
- compulsory/voluntary purchase;
- annual annuity payment at the end of the year; and
- with-profit annuity or not.

1.4 Exposed-to-Risk Calculation and Rate Interval

The exact exposed-to-risk was calculated for each individual policy in days and converted into years of exposure. The investigation is based on number of policies rather than number of lives.

Since the data are by age last birthday at death or time of exposure, a life year rate interval starting for those classified x, on the x^{th} birthday was used.

2 Data and Statistics

2.1 Disclaimer

The results of this investigation are dependent on the quality of the data and the extent to which we have been able to analyse the experience by different factors. We expect the quality of the data to improve for future investigations as the data collection process is improved, with annual data collection and data cleaning occurring sooner after the data collection.

2.2 Data problems

After submission of the data by the participating companies, a considerable amount of time was spent on cleaning the data, understanding differences in methodology between companies and in some instances obtaining additional information from the participating companies.

Every effort has been made to ensure any major data concerns were addressed with the participating insurers. These included:

- removing duplicate records from all data sets;
- investigating conflicting data records where there were more than one record in the demographic file for a policy; and
- incorporating a compulsory/voluntary-purchase indicator to the data, as this was not requested in the original data request.

2.3 Data characteristics

This section shows some more detail on the data, which is important for understanding the scope of the investigation. Compulsory annuities accounted for about 92% of the total exposure, as shown in Figure 1. Figure 2 shows the split of the exposure between annuities with a guaranteed period, and those with no guaranteed period or an expired guaranteed period.

Figure 1. Proportion of exposure by type of purchase

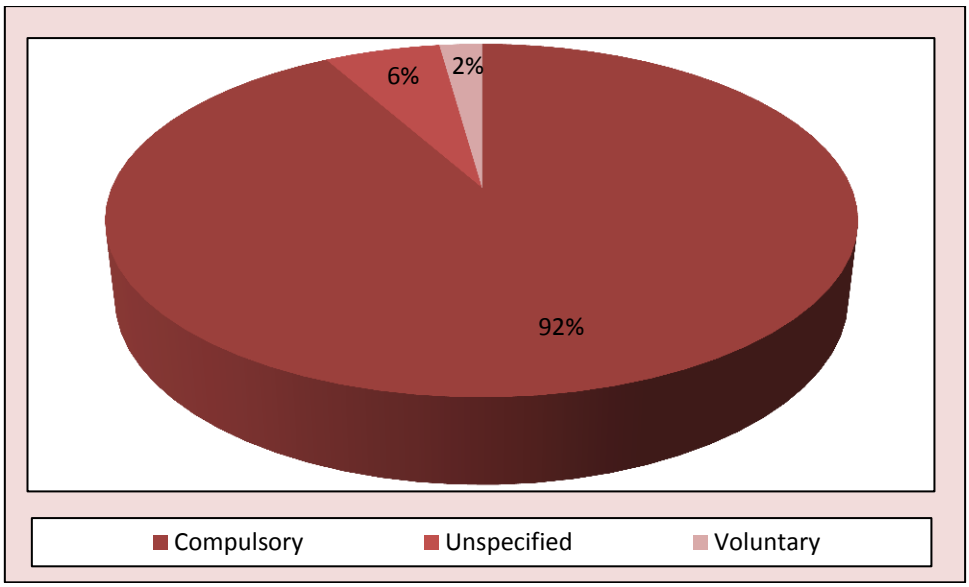


Figure 2. Proportion of exposure by guarantee-type

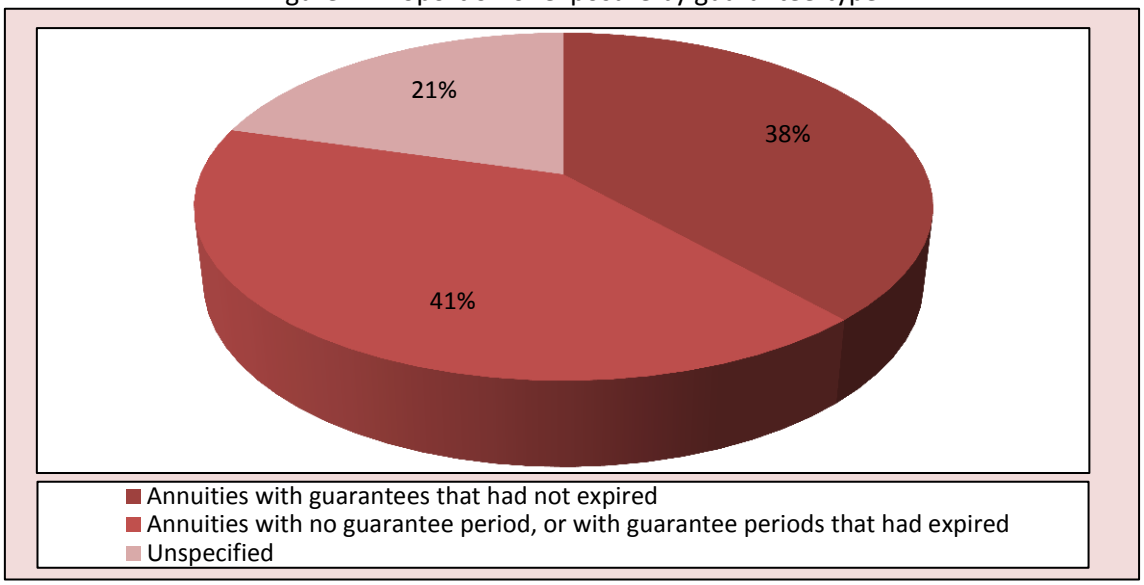


Table 1 contains details on the monthly income from the observed annuities for the current investigation and the 1996-2000 investigation respectively. The increase in income for the current investigation is on average 3% per annum, compared with the average increase of 10% per annum for the 1996-2000 investigation.

For the 2001-2004 investigation, the details on the annual payment for some policies were indicated as unknown in the data sets. In order to overcome this, the annual payment for these policies were taken as the average annual payment for the specific company providing the data, for the particular year in question. The annual amount of annuity payments are surprisingly low. This was however also observed in the 1996-2000 Annuitant mortality investigation.

Table 1. Monthly annuity income for period 1996 to 2004

	Previous investigation			**Current investigation**		
	1996-1998	**1999-2000**	**1996-2000**	**2001-2002**	**2003-2004**	**2001-2004**
Males	6 260	7 603	6 881	8 719	9 047	8 888
Females	4 733	5 834	5 252	6 290	6 426	6 361
Total	5 702	6 942	6 279	7 751	7 981	7 870

2.4 Exposure / deaths statistics

A comparison between the current and previous investigations for the number of years of exposure and number of deaths for lives are shown in Table 2 and for lives aged below 60 and aged 60 and above in Tables 3 and 4. The investigation period for the previous investigation was 5 years, whereas the current investigation period is 4 years. Even though the number of years covered by the current investigation is shorter than the previous investigation, there was an increase in female exposure for ages above 60 in absolute terms. The current investigation has also seen a higher proportion of exposure for ages above 60, for both males and females. Figures 3 and 4 show the exposure for ages 40 and above, for males and females respectively. Whilst, Figures 5 and 6 show the occurrences of deaths for ages 40 and above using quinquennial age bands, for males and females respectively.

Table 2. Exposure and deaths by number of lives for the current and previous investigations

	Previous investigation			Current investigation		
	Male	Female	Total	Male	Female	Total
Deaths	32 107	9 129	41 236	29 986	9 772	39 758
Exposure	967 450	566 388	1 533 838	855 963	577 368	1 433 331

Table 3. Exposure and deaths by number of lives below age 60 and age 60 and above for the current and previous investigations: male

	Previous investigation		Current investigation	
	< 60	60 +	< 60	60 +
Deaths	2 279	29 828	1 291	28 695
Exposure	150 968	816 482	96 529	759 434
% of Total Exposure	16%	84%	11%	89%

Table 4. Exposure and deaths by number of policies below age 60 and age 60 and above for the current and previous investigations: female

	Previous investigation		Current investigation	
	< 60	60 +	< 60	60 +
Deaths	956	8 173	658	9 114
Exposure	173 196	393 191	128 495	448 873
% of Total Exposure	31%	69%	22%	78%

Figure 3. Male exposure for ages 40 and above

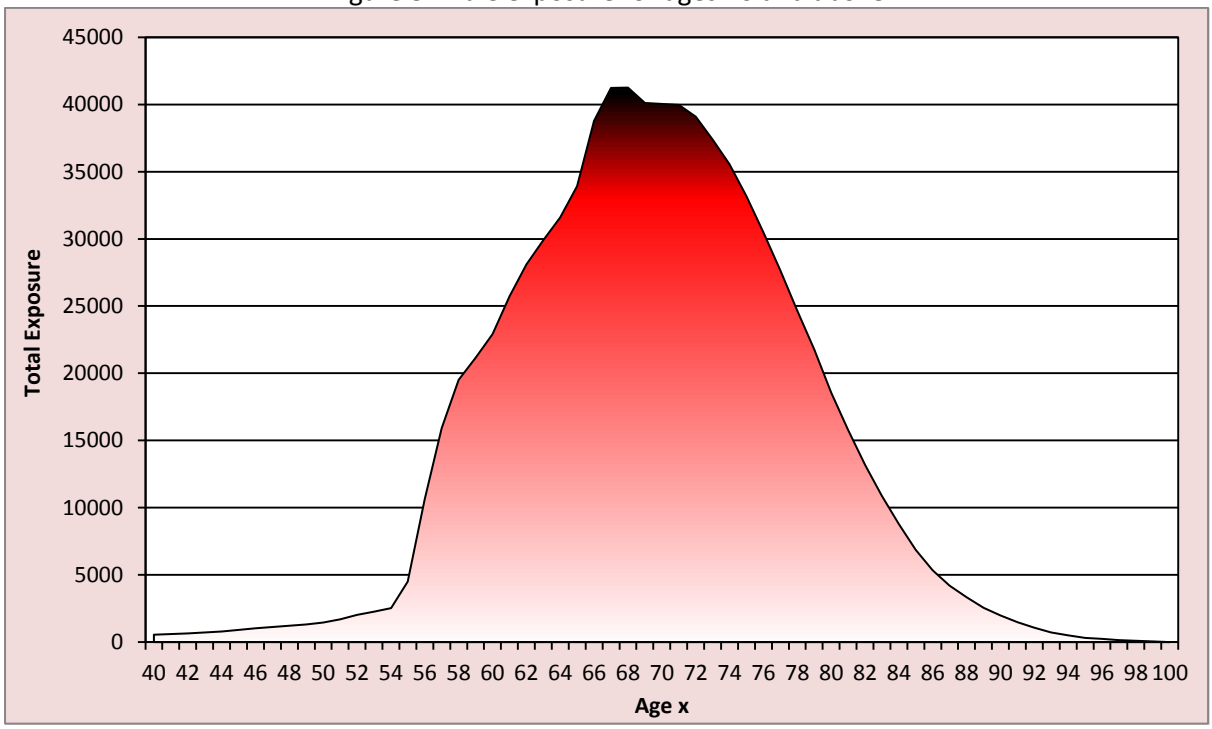


Figure 4. Female exposure for ages 40 and above

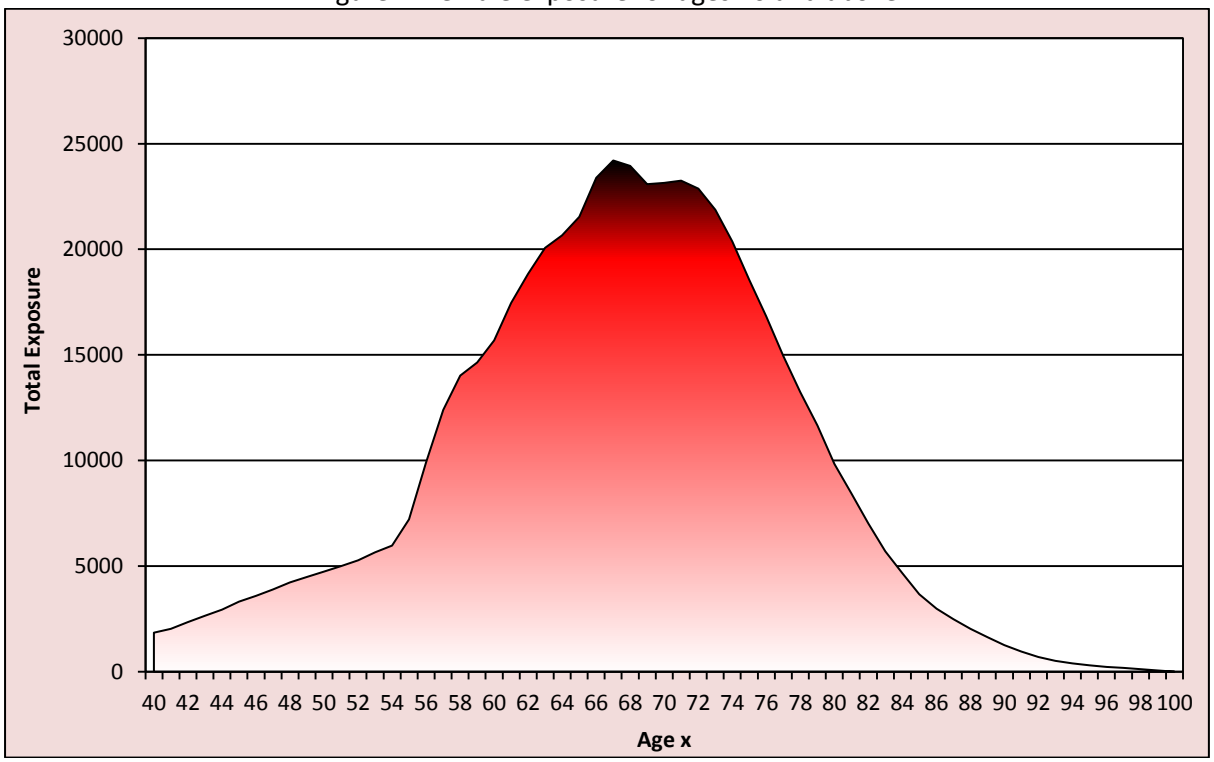


Figure 5. Number of male deaths per age group

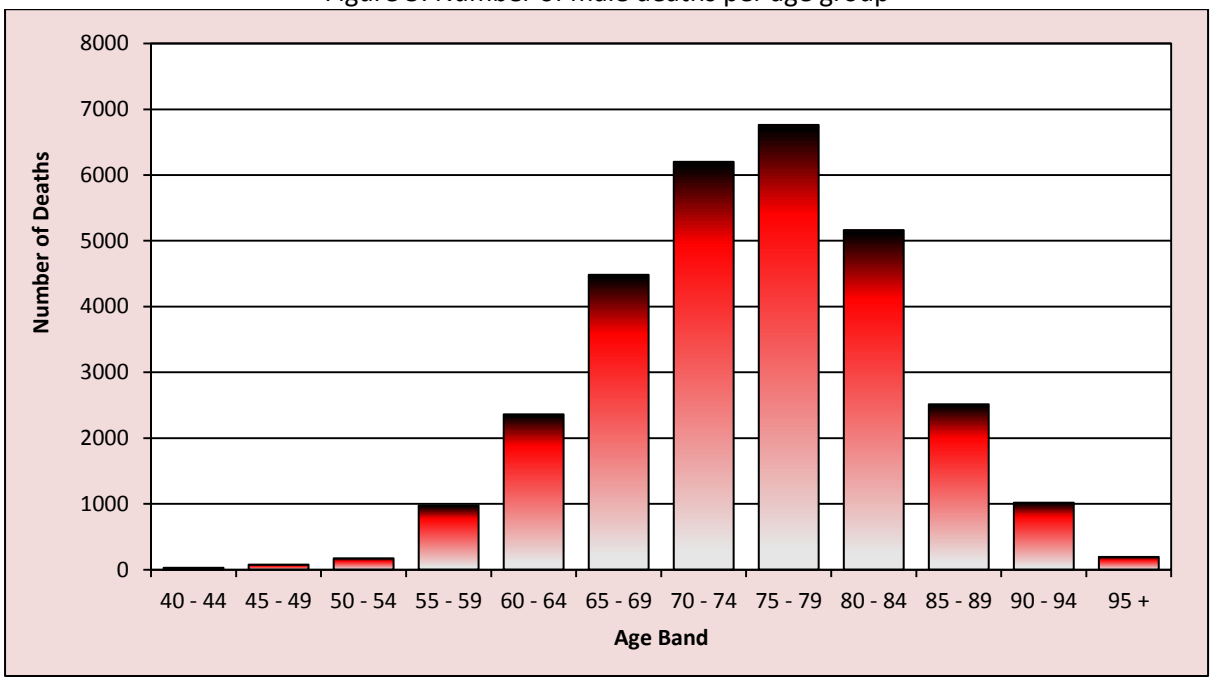
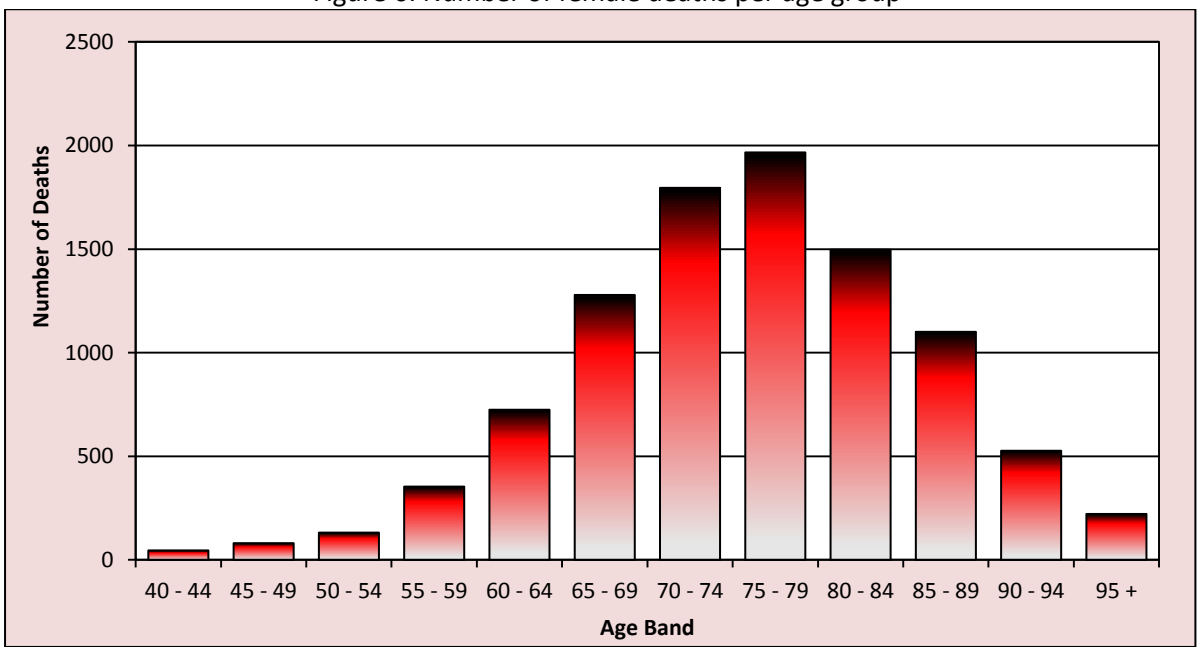


Figure 6. Number of female deaths per age group



3 Analyses

3.1 By Sex

The total exposure and deaths for ages 60 and older is given in Table 5 and the total deaths and exposures for ages 40 and above in quinquennial age bands is given in Table 6.

Table 5. Total exposure and deaths for ages 60 and older with the overall crude mortality rate by sex

	Exposure	% of Total	Deaths	% of Total	Crude mortality rate
Male	759 434	63%	28 695	76%	0.037785
Female	448 873	37%	9 114	24%	0.020304
Total	1 208 308	100%	37 809	100%	0.031291

Table 6. Observed mortality rates by sex

	Males			Females		
Age Band	**Deaths**	**Exposure**	**Crude rates**	**Deaths**	**Exposure**	**Crude rates**
40 - 44	28	3 318	0.00844	46	11 810	0.00389
45 - 49	76	5 564	0.01366	81	19 521	0.00415
50 - 54	172	9 951	0.01728	132	26 633	0.00496
55 - 59	978	71 707	0.01364	354	58 175	0.00609
60 - 64	2 361	138 247	0.01708	725	92 699	0.00782
65 - 69	4 483	195 262	0.02296	1 279	116 178	0.01101
70 - 74	6 201	192 011	0.03230	1 796	111 497	0.01611
75 - 79	6 762	137 727	0.04910	1 967	75 248	0.02614
80 - 84	5 163	67 184	0.07685	1 497	35 671	0.04197
85 - 89	2 514	22 310	0.11269	1 101	12 806	0.08598
90+	1 211	6 693	0.18092	749	4 776	0.15684

Figure 7 shows the observed crude mortality rates for males and females respectively. The size of the exposure is also shown, to put the observed rates into context. Figure 8 shows the relative proportion of the male and female rates as a proportion of the male rates. As expected, female annuitant mortality is significantly lower than male annuitant mortality, expecially for ages below 80 years.

Figure 7. Comparison of the crude mortality rates and total exposure by sex

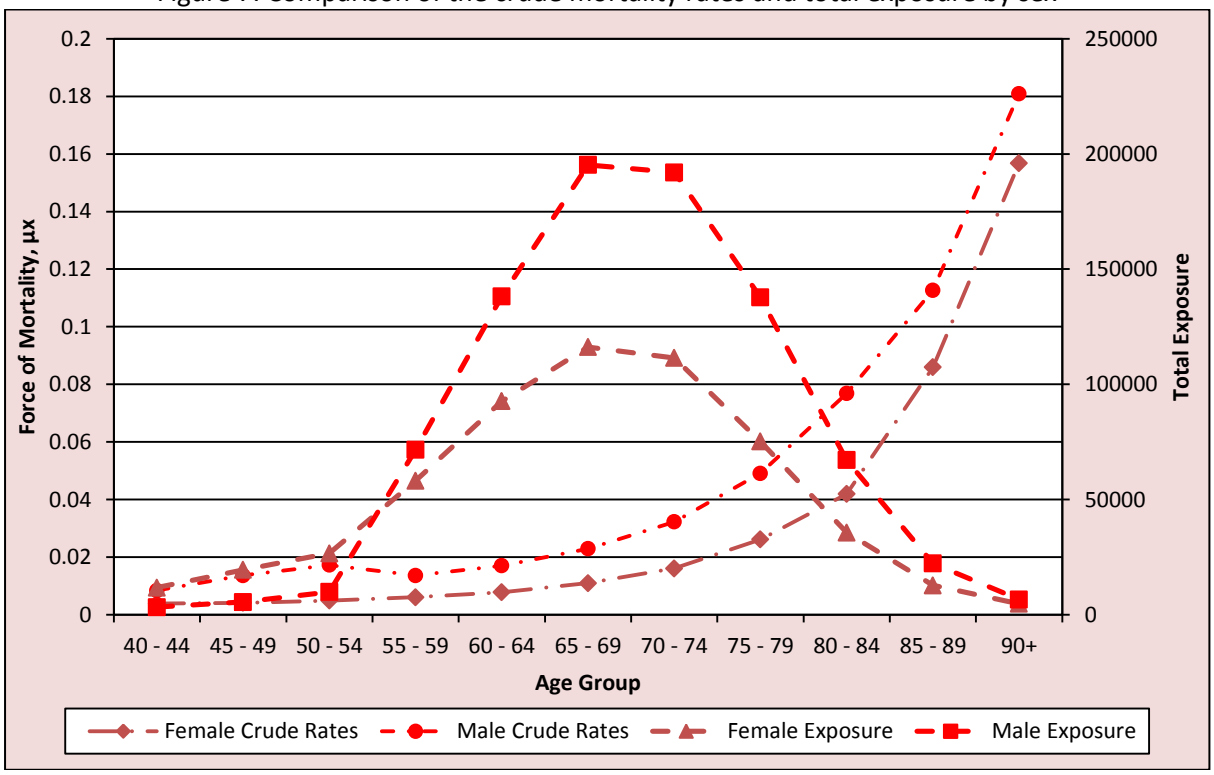
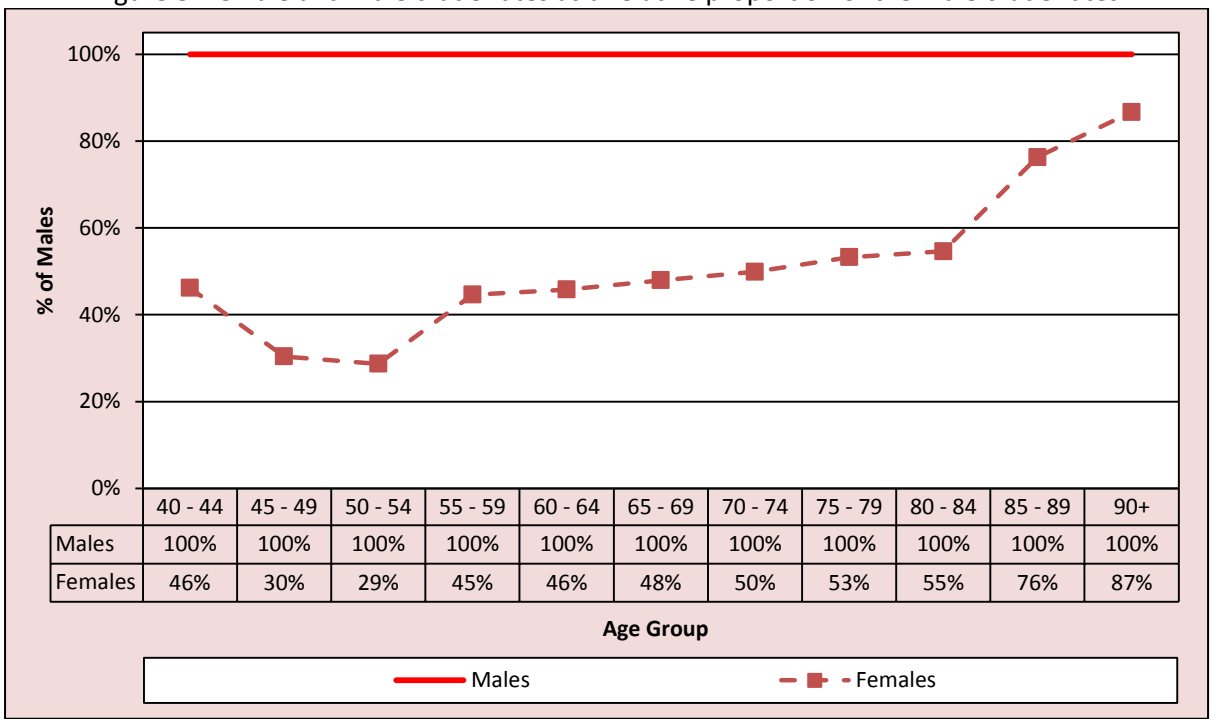


Figure 8. Female and male crude rates as a relative proportion of the male crude rates



	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90+
Males	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Females	46%	30%	29%	45%	46%	48%	50%	53%	55%	76%	87%

3.2 By compulsory/voluntary purchase

Tables 7 and 8 consider the total exposure and total deaths by purchase type for males and females respectively. For both males and females, the exposure for voluntary annuities is too low compared to that for compulsory annuities in order to observe a clear difference in mortality rates, therefore the rates were combined in order to make a comparison between voluntary and compulsory purchase-type, these results are shown in Table 9 and graphically in Figures 9 and 10. One would expect the crude rates for voluntary annuities to be lower than for compulsory annuities, but the converse is observed. Lower mortality rates for voluntary annuities compared to compulsory annuities, was also observed during the previous annuitant mortality investigation. By including the age band, it can be noted that the crude rates for voluntary annuities is lower than for compulsory annuities (as would be expected) for ages between 45 and 80.

Table 7. Total exposure, total deaths and overall crude rates by purchase-type: male

	Exposure	% of Total	Deaths	% of Total	Crude rate
Compulsory	796 655	98%	26 006	98%	0.03264
Voluntary	14 565	2%	656	2%	0.04504
Total	811 220	149%	26 662	314%	0.03287

Table 8. Total exposure, total deaths and overall crude rates by purchase-type: female

	Exposure	% of Total	Deaths	% of Total	Crude rate
Compulsory	526 009	96%	7 666	90%	0.01457
Voluntary	19 095	4%	834	10%	0.04368
Total	545 104	100%	8 500	100%	0.01559

Table 9. Overall crude rates, deaths and exposure by purchase type

	Compulsory			Voluntary		
Age Band	**Deaths**	**Exposure**	**Crude rates**	**Deaths**	**Exposure**	**Crude rates**
40 - 44	47	13 187	0.00356	2	428	0.00467
45 - 49	125	22 190	0.00563	2	665	0.00301
50 - 54	244	32 057	0.00761	6	1 112	0.00539
55 - 59	1 132	121 030	0.00935	20	2 304	0.00868
60 - 64	2 659	217 321	0.01224	38	3 446	0.01103
65 - 69	5 053	293 362	0.01722	61	4 712	0.01295
70 - 74	7 064	284 042	0.02487	105	5 251	0.02000
75 - 79	7 665	196 980	0.03891	157	4 793	0.03275
80 - 84	5 703	92 034	0.06197	257	4 084	0.06293
85 - 89	2 677	27 977	0.09569	454	3 675	0.12354
90+	1 634	10 049	0.16261	387	2 158	0.17932

Figure 9. Overall crude rates and exposure by purchase-type

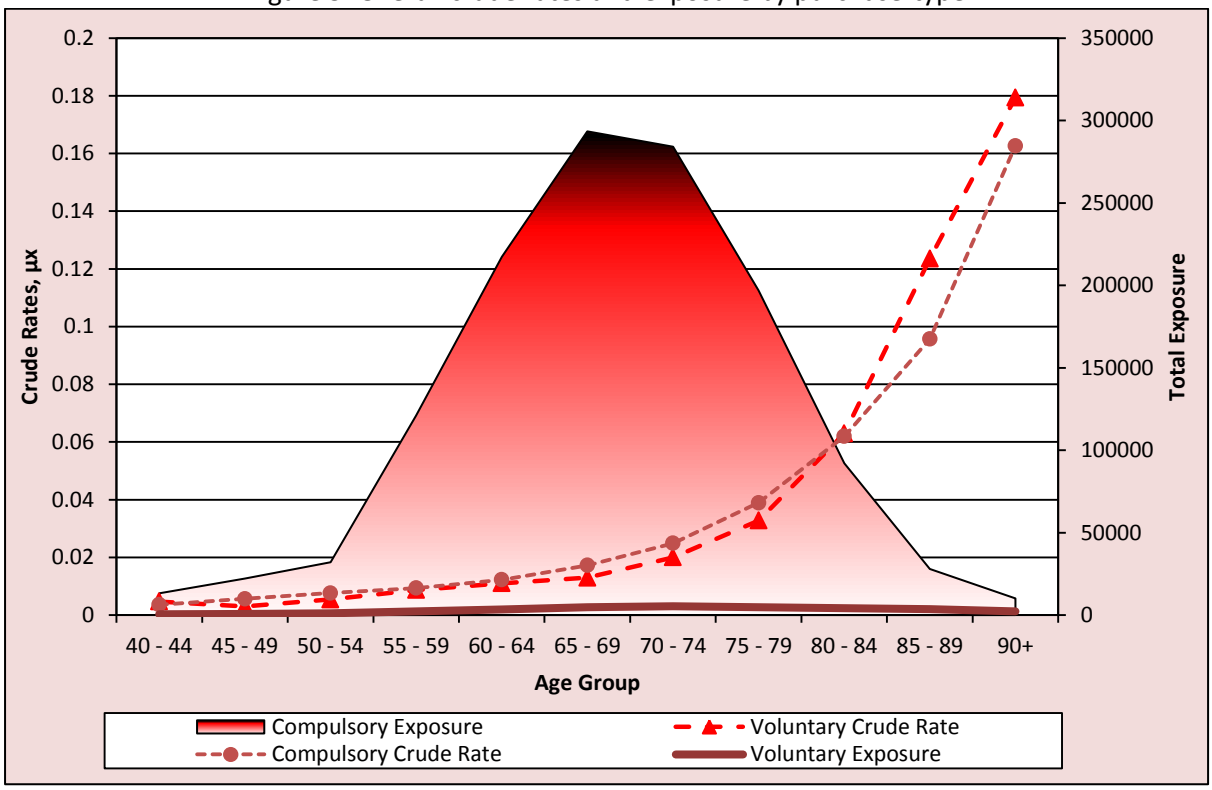
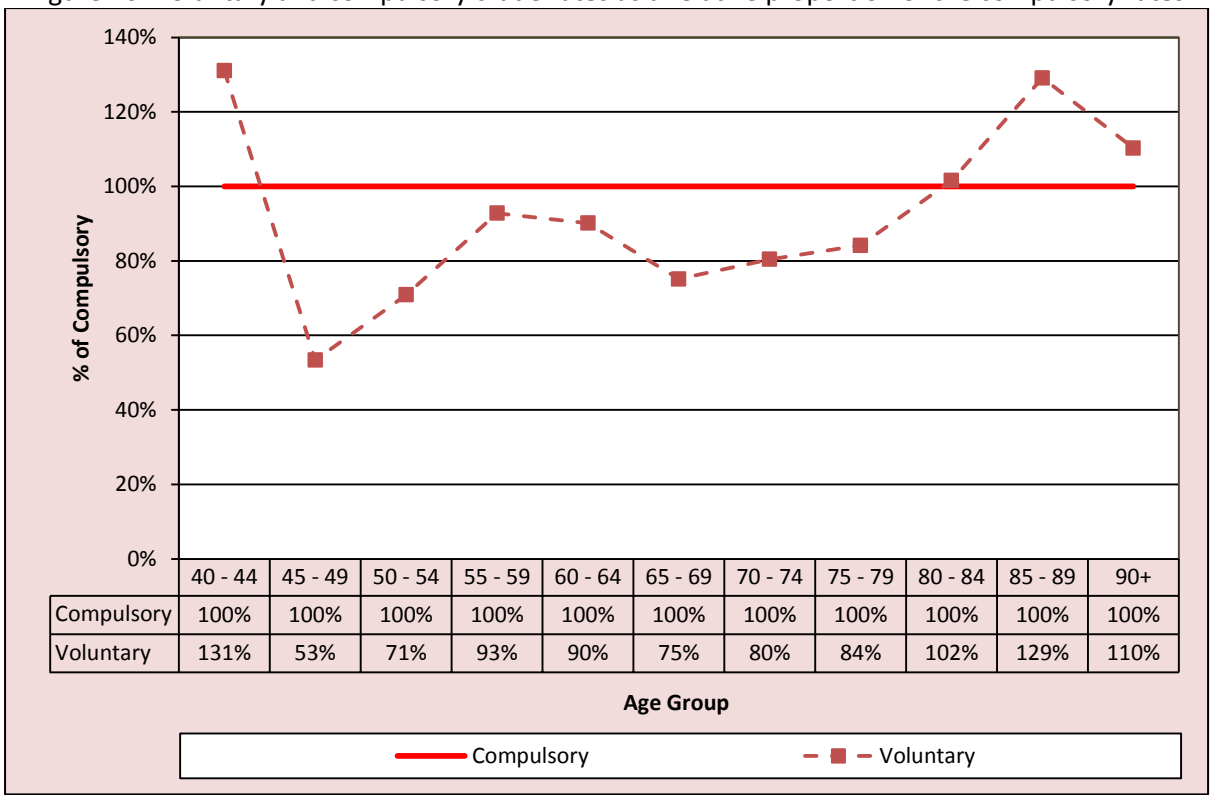


Figure 10. Voluntary and compulsory crude rates as a relative proportion of the compulsory rates



	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90+
Compulsory	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Voluntary	131%	53%	71%	93%	90%	75%	80%	84%	102%	129%	110%

3.3 By Guarantee-type

This section analyses the differences between annuities with guarantees and annuities with no guarantees or where the guarantees had expired at the census date. The years of exposure, number of deaths and overall crude rate for annuities with guarantees and with no guarantees is given in Tables 10 and 11, for males and females respectively. Tables 12 and 13 compare the crude rates for annuities with guarantees and with no guarantees and these are displayed graphically in Figures 11 to 14, for males and females respectively.

Overall, the crude rates (for both males and females) for annuities with guaranteed periods which had not expired, was lower than for annuities with no or expired guaranteed periods. This was also observed for the previous annuitant mortality investigation and is different from the expectation that annuities with guaranteed periods would show higher mortality rates. However, Figures 11 to 14 shows that for both males and females, for ages between 50 and 80 the crude rates for annuities within a guaranteed period is lower than the crude rates for annuities with no or expired guaranteed periods. For ages above 80, the converse is observed.

Table 10. Total exposure, total deaths and overall crude rates by guarantee-type: male

	Exposure	% of Total	Deaths	% of	Crude rate
With Guarantees*	345 317	50%	9 184	37%	0.02660
No Guarantees**	349 546	50%	15 807	63%	0.04522
Total	694 863	100%	24 991	100%	0.03597

* Annuities with a guarantee which has not expired

** Annuities with no guarantees or where the guarantee has expired

Table 11. Total exposure, total deaths and overall crude rates by guarantee-type: female

	Exposure	% of Total	Deaths	% of Total	Crude rate
With Guarantees	208 390	46%	2 880	36%	0.01382
No Guarantees	244 726	54%	5 103	64%	0.02085
Total	453 117	100%	7 983	100%	0.01762

Table 12. Overall crude rates, deaths and exposure by guarantee-type: male

	With Guarantees			No Guarantees		
Age Band	**Deaths**	**Exposure**	**Crude rates**	**Deaths**	**Exposure**	**Crude rates**
40 - 44	15	1 274	0.01177	8	1 296	0.00617
45 - 49	21	2 016	0.01042	26	2 124	0.01224
50 - 54	59	3 649	0.01617	54	4 065	0.01328
55 - 59	551	42 224	0.01305	216	15 761	0.01370
60 - 64	1 144	74 626	0.01533	545	30 924	0.01762
65 - 69	1 839	89 228	0.02061	1 608	63 489	0.02533
70 - 74	1 899	72 249	0.02628	2 786	78 694	0.03540
75 - 79	1 590	36 989	0.04299	3 948	78 033	0.05059
80 - 84	1 129	13 883	0.08132	3 817	51 265	0.07446
85 - 89	611	5 251	0.11635	1 894	16 992	0.11146
90+	1 212	6 666	0.18181	898	5 025	0.17871

Table 13. Overall crude rates, deaths and exposure by guarantee-type: female

	With Guarantees			No Guarantees		
Age Band	**Deaths**	**Exposure**	**Crude rates**	**Deaths**	**Exposure**	**Crude rates**
40 - 44	24	4 793	0.00501	13	4 877	0.00267
45 - 49	28	7 154	0.00391	38	8 699	0.00437
50 - 54	51	9 848	0.00518	61	12 173	0.00501
55 - 59	146	27 277	0.00535	124	19 212	0.00645
60 - 64	283	42 620	0.00664	221	26 130	0.00846
65 - 69	480	46 536	0.01031	413	38 452	0.01074
70 - 74	473	34 765	0.01361	795	48 740	0.01631
75 - 79	368	17 154	0.02145	1 184	43 663	0.02712
80 - 84	313	6 970	0.04491	1 090	27 119	0.04019
85 - 89	429	3 773	0.11371	668	8 950	0.07463
90+	743	4 728	0.15714	477	3 263	0.14617

Figure 11. Overall crude rates and exposure by guarantee –type: male

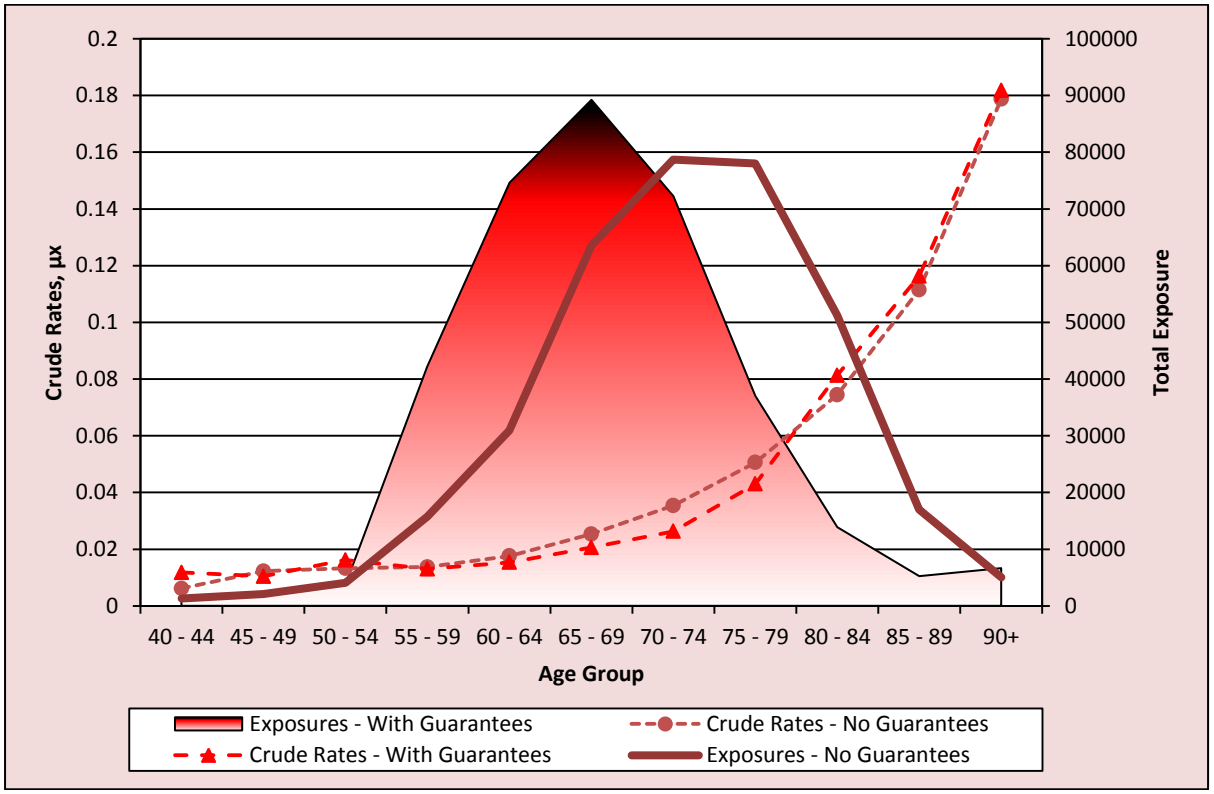


Figure 12. Overall crude rates and exposure by guarantee –type: female

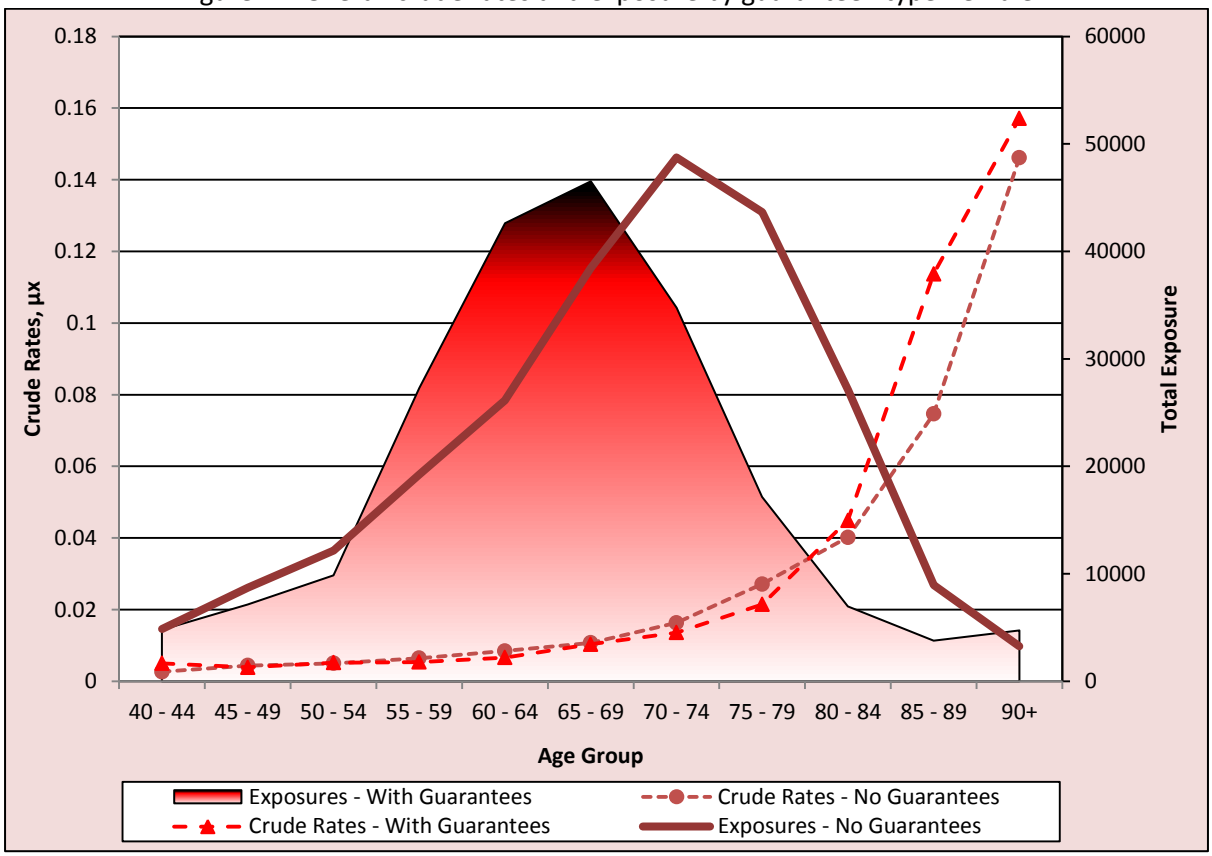
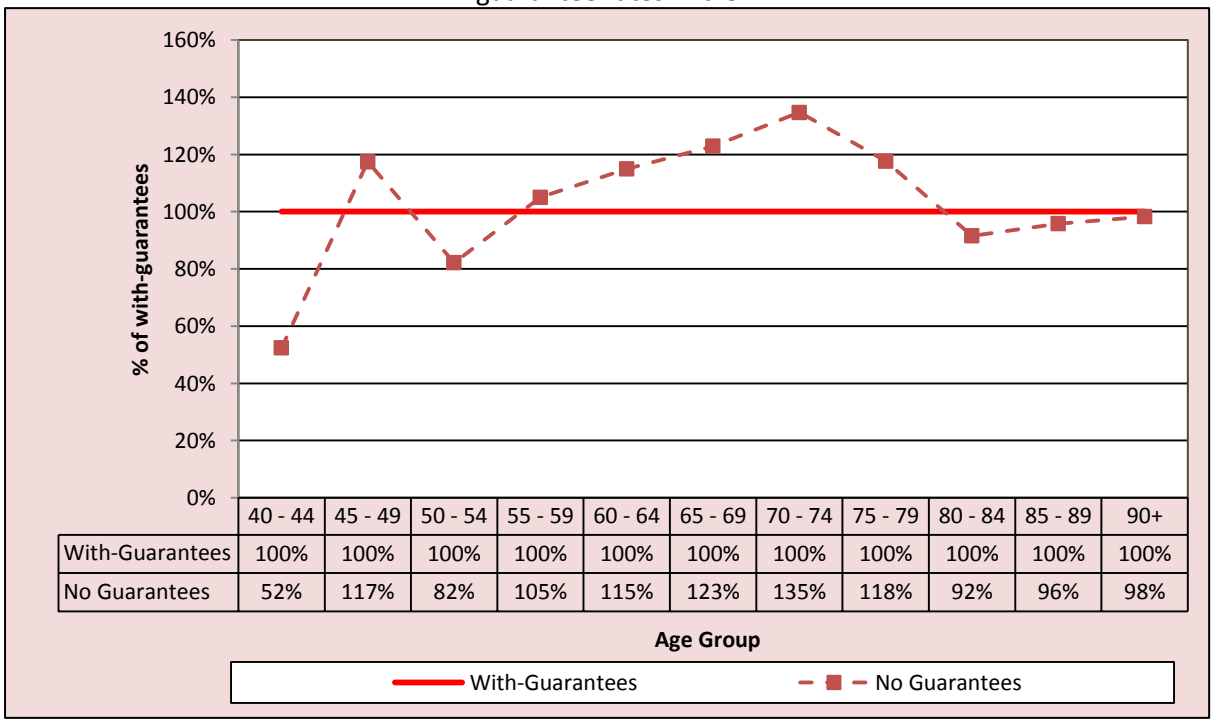
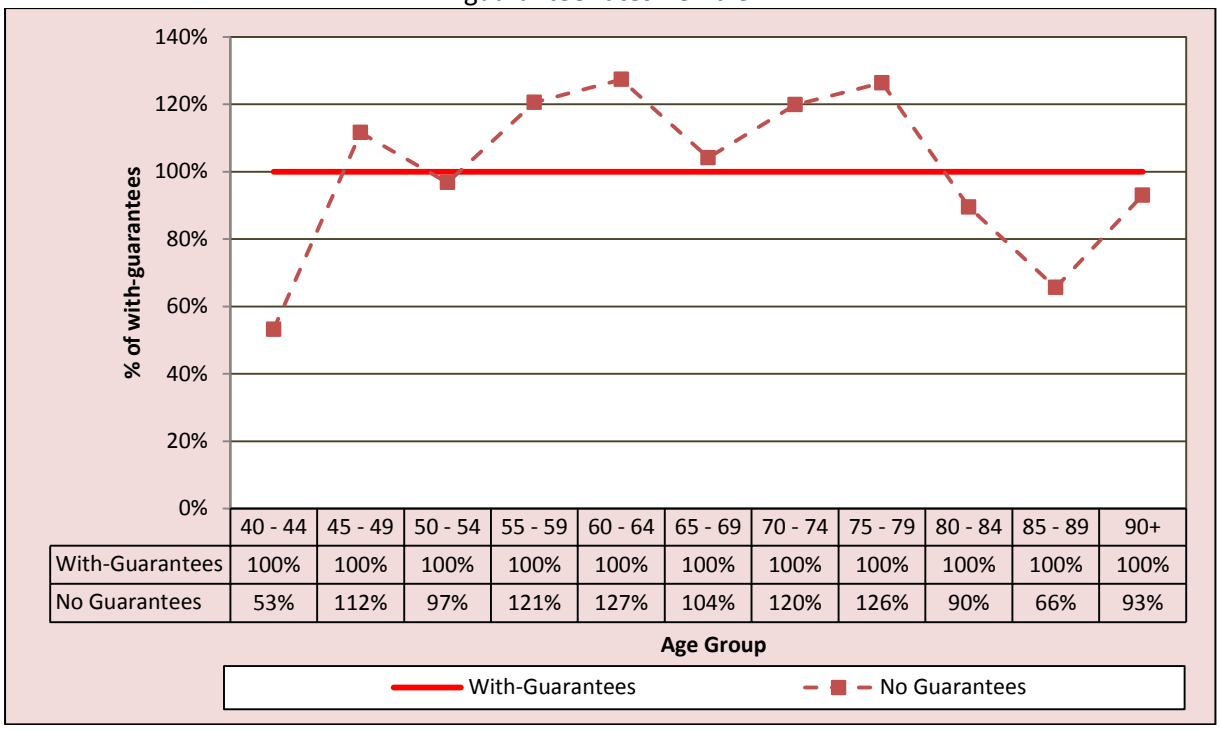


Figure 13. With-guarantee and no guarantees crude rates as a relative proportion of the with-guarantee rates: male



	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	65 - 69	70 - 74	75 - 79	80 - 84	85 - 89	90+
With-Guarantees	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
No Guarantees	52%	117%	82%	105%	115%	123%	135%	118%	92%	96%	98%

Figure 14. With-guarantee and no guarantees crude rates as a relative proportion of the with-guarantee rates: female



3.4 Impact of size of annuity

The data regarding annuity amounts were not considered to be sufficient and reliable in order to perform an amounts-based mortality investigation (where exposure and deaths are weighted by the annuity amount). The 1996-2000 investigation suggested that the amounts-based rates were not significantly different from the person-weighted rates.

4 Graduation

The data collected by the CSI Committee cover ages 0 to 110. Table 14 shows the age ranges for which there are sufficient data to facilitate the production of statistically reliable rates. However, as pointed out by Dorrington and Tootla (2007), the data below age 60 are of limited usefulness due to the influence of ill-health retirements. In addition, due to the sparseness of the data above age 95, extrapolation methods will need to be used in determining the mortality rates at the advanced ages.

Table 14. Ages with significant data

Sex	Total	Exposure ≥ 100	Deaths ≥ 10
Male	0-110	21-98	44-99
Female	0-107	22-97	46-99

Tables 15 and 16 show the standardised mortality ratios using the mortality rates from the SA85-90 ultimate rates for assured lives as standard and also the mortality rates from SAIML98 or SAIFL98 rates for immediate annuitants as standard. The crude mortality rates with 95% confidence intervals around the force of mortality, $\mu_{x+0.5}$, are compared with the SA85-90 ultimate rates for assured lives and SAIML98/SAIFL98 mortality rates for immediate annuitants in Figures 15 and 16. From these we note that the relationship above age 60 is as expected, the rates for assured lives being higher than

those for annuitants, and there is some evidence of a possible decline in annuitant mortality, with mortality rates being lower than those expected from SAIML98 or SAIFL98 mortality rates for immediate annuitants. However, below age 60, the current mortality rates are higher than those for assured lives and SAIML98/SAIFL98 mortality rates for immediate annuitants. Also, the SAIML98/SAIFL98 mortality rates for immediate annuitants were constructed by extrapolating the graduated curves below age 65 using the SA85-90 rates which were the last South African assured lives experience for which AIDS related deaths had a negligible impact. We have decided not to graduate or extrapolate the 2000-2004 immediate annuitant experience below age 60.

Table 15. Observed vs. expected deaths by age band using SA85-90 and SAIML98 as standards: male

Age Band	Actual Deaths	Using SAIML98 as standard		Using SA85-90 as standard	
		Expected Deaths	SMR	Expected Deaths	SMR
40 - 44	28	11	2.5326	12	2.3560
45 - 49	76	28	2.7577	30	2.5276
50 - 54	172	77	2.2246	85	2.0345
55 - 59	978	896	1.0918	981	0.9967
60 - 64	2 361	2 611	0.9042	2 897	0.8149
65 - 69	4 483	5 401	0.8301	6 464	0.6935
70 - 74	6 201	7 446	0.8328	9 823	0.6312
75 - 79	6 762	7 778	0.8693	10 760	0.6285
80 - 84	5 163	5 868	0.8799	8 091	0.6381
85 - 89	2 514	3 137	0.8014	4 193	0.5996
90 - 94	1 018	1 282	0.7939	1 686	0.6040
95 - 99	185	289	0.6403	383	0.4829
100 +	7	28	0.2490	39	0.1815
All	29948	34852	0.8593	45444	0.6590

Table 16. Observed vs. expected deaths by age band using SAIFL98 as standard: female

Age Band	Actual Deaths	Expected Deaths	SMR
40 - 44	46	18	2.5888
45 - 49	81	43	1.8667
50 - 54	132	92	1.4359
55 - 59	354	320	1.1067
60 - 64	725	795	0.9122
65 - 69	1 279	1 572	0.8137
70 - 74	1 796	2 371	0.7574
75 - 79	1 967	2 626	0.7489
80 - 84	1 497	2 149	0.6967
85 - 89	1 101	1 374	0.8015
90 - 94	527	684	0.7699
95 - 99	203	253	0.8020
100 +	17	33	0.5148
All	9 725	12 330	0.7887

Figure 15. Observed male mortality rates with 95% confidence intervals vs. SA85-90 and SAIML98

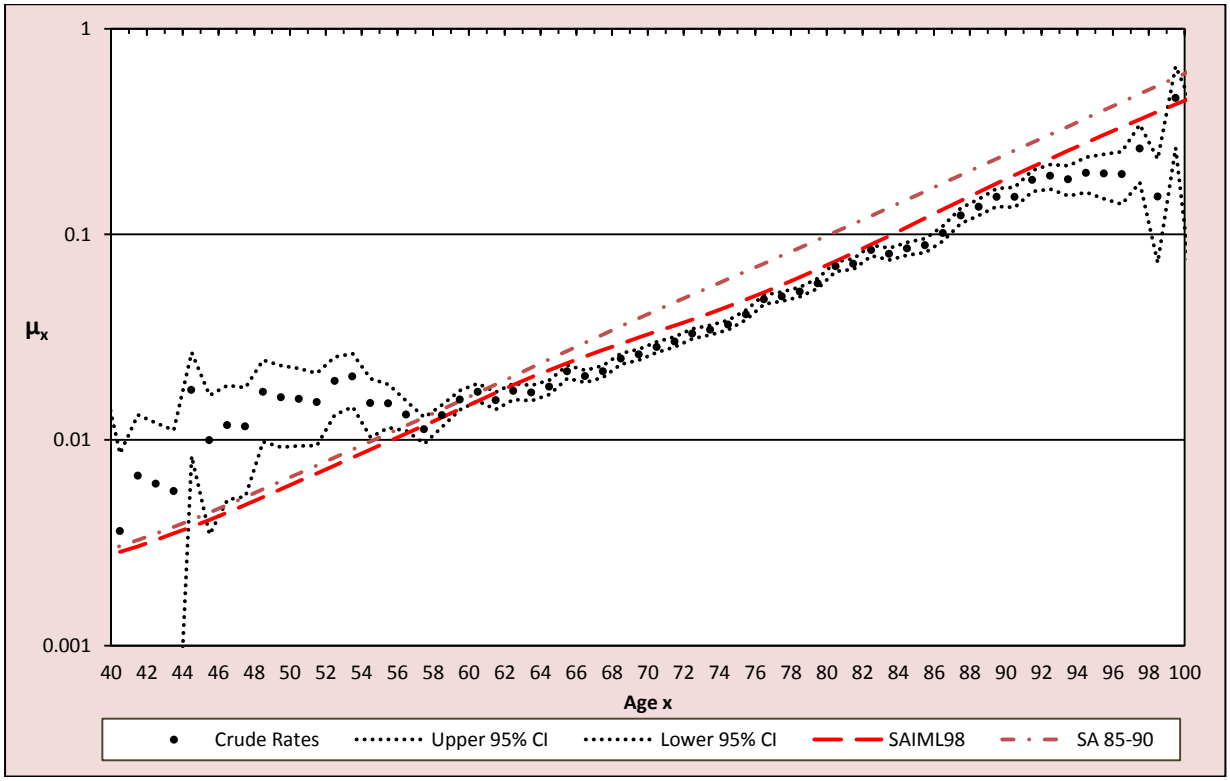
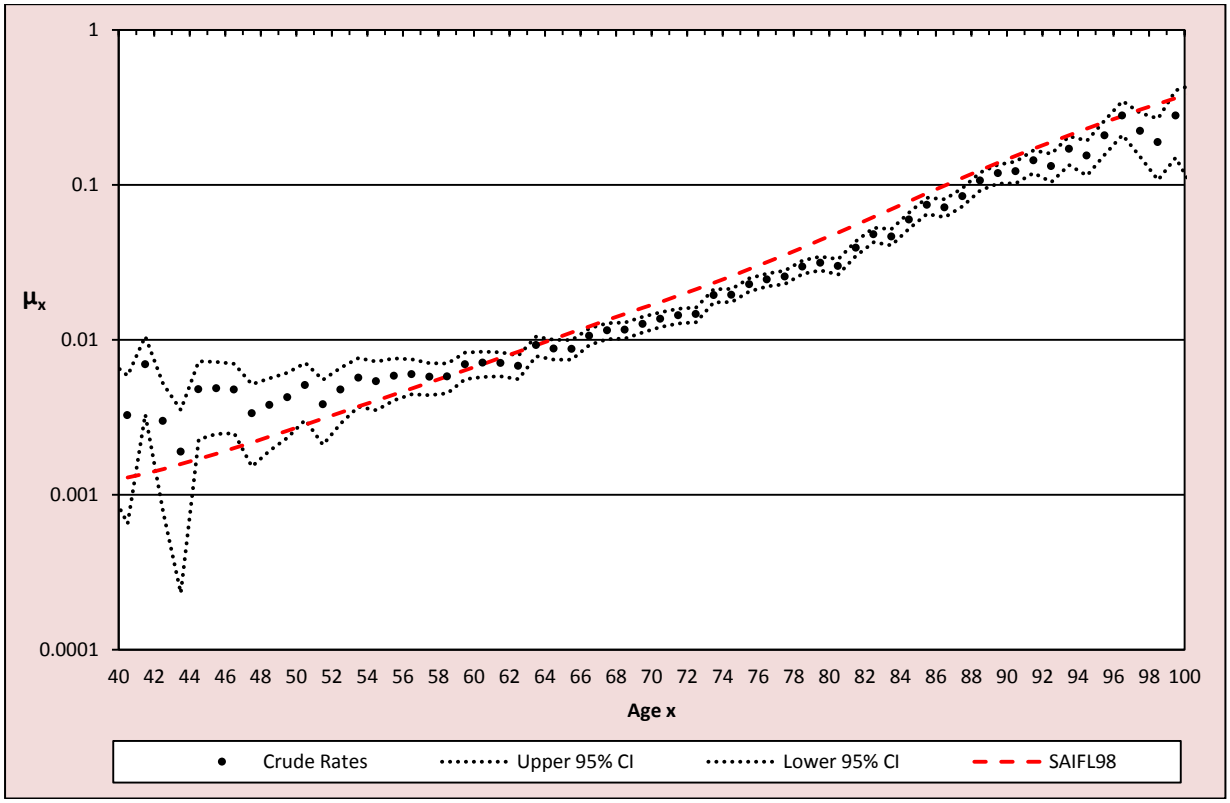


Figure 16. Observed female mortality rates with 95% confidence intervals vs. SAIFL98



Examination of the crude mortality rates with 95% confidence intervals in Figures Figure 15 and Figure 16 led to the identification of two issues with the data which require further investigation. Firstly, the narrowness of the confidence intervals suggests that the lack of smoothness is more than random fluctuations (this is particularly relevant for males between ages 76 and 88) and secondly, the levelling off of mortality rates at ages over 90 suggests that deaths are going unrecorded. Due to the levelling off of the rates at ages over 90, it was decided to graduate only the crude mortality rates over the age range 60 to 90 and then extrapolated to 110.

The crude mortality rates, between ages 60 and 90, were graduated using the parametric family $GM_x(r,s)$ proposed by Forfar, McCutcheon and Wilkie (1988), where the $GM_x(r,s)$ equation is defined by

$$\mu_x = GM_x(r,s) = \sum_{i=1}^{r} \alpha_i \, x^{i-1} + \exp\left(\sum_{j=r+1}^{r+s} \alpha_i \, x^{i-r-1} \right).$$

This family of models was chosen primarily because they were used to graduate the SAIML98/SAIFL98 mortality rates for immediate annuitants, but also because they can handle a wide range of parametric equations and produce smooth results.

The results from these graduations are shown graphically in Figures 17 and 18 and the results from the chi-squared goodness of fit test, together with the critical value at the 5% level of significance, are presented in Table 17. As expected, increasing the number of parameters in the model improves the fit and the model with the most parameters has the lowest chi-squared statistic. All the male graduations are statistically significantly different from the observed rates, whilst only five of the female graduations are statistically significantly different from the observed rates. For the male graduations this is not surprising given the lack of smoothness in the underlying rates between ages 76 and 88.

Table 17. Chi-squared values vs. critical value at the 5% level of significance (in brackets) for various graduations over the age range 60 to 90

GM(R,S)	Males		Females	
	chi-squared value		chi-squared value	
GM(0,3)	78.92	(41.34)	39.95	(41.34)
GM(0,4)	66.45	(40.11)	38.92	(40.11)
GM(0,5)	63.95	(38.89)	38.88	(38.89)
GM(1,2)	72.14	(41.34)	44.68	(41.34)
GM(1,3)	66.07	(40.11)	39.95	(40.11)
GM(1,4)	63.97	(38.89)	38.92	(38.89)
GM(1,5)	63.58	(37.65)	38.05	(37.65)
GM(2,2)	64.76	(40.11)	39.05	(40.11)
GM(2,3)	64.18	(38.89)	38.64	(38.89)
GM(2,4)	63.62	(37.65)	38.11	(37.65)
GM(2,5)	63.03	(36.42)	38.04	(36.42)

Figure 17. Observed vs. graduated rates: male

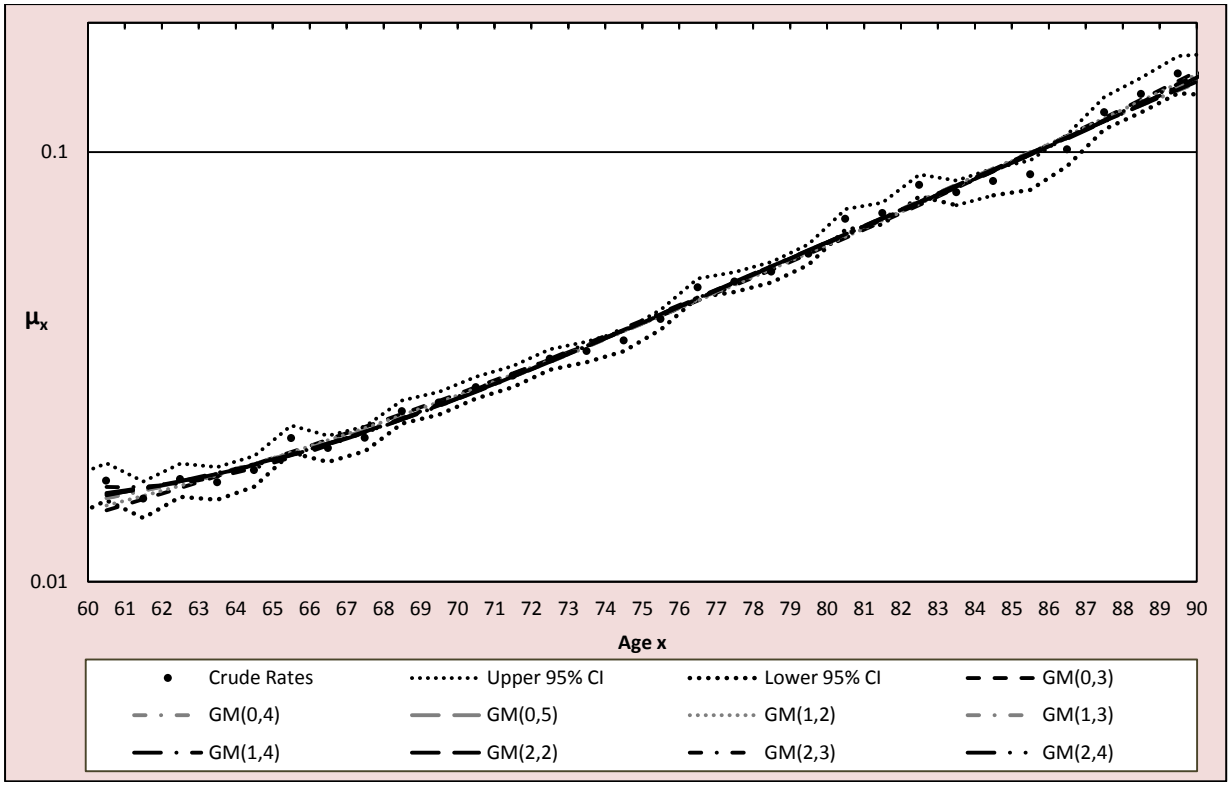
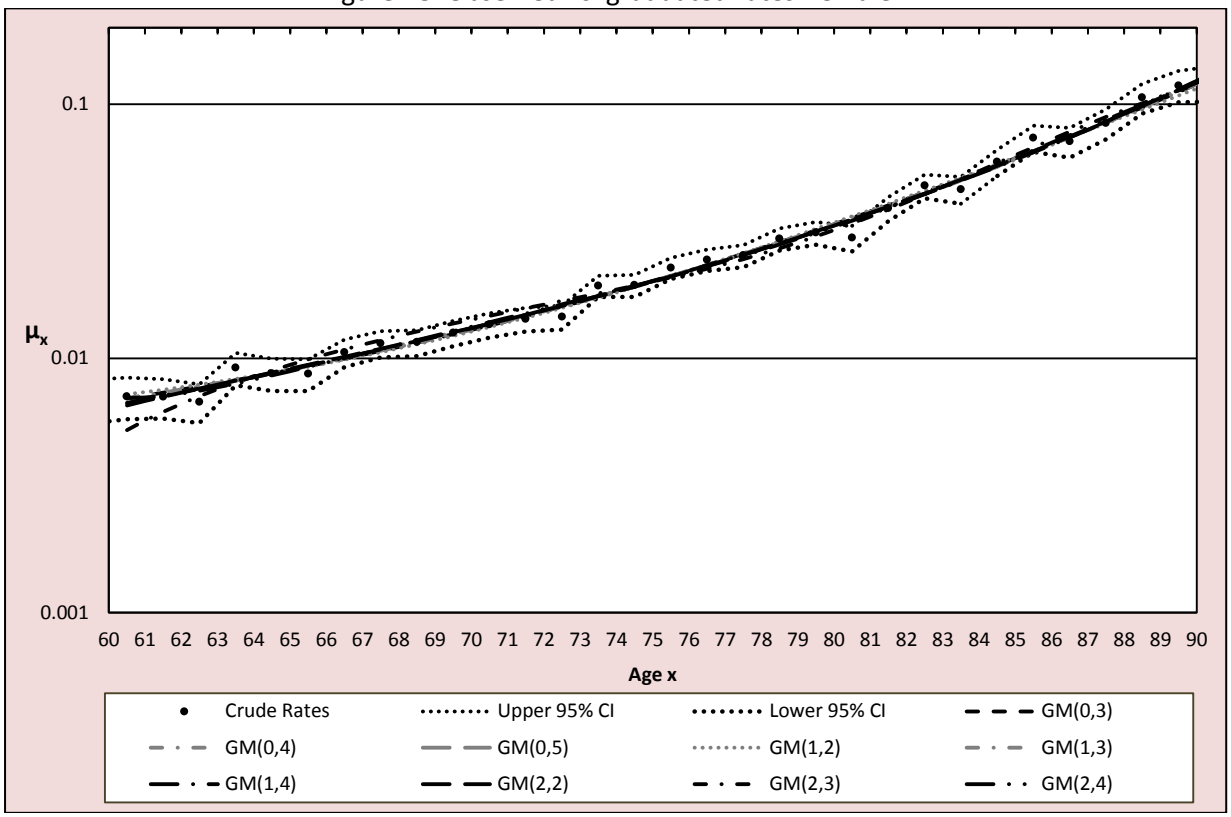


Figure 18. Observed vs. graduated rates: female



The fits were subjected to further statistical tests, including the standard deviations, cumulative deviations, serial correlations, signs, grouping of signs and serial correlations test. These statistical tests were used along with information criteria to select the final model. The final models selected were *GM*(*2,3*) for the male graduation and *GM*(*0,3*) for the female graduation, which were the models that most satisfied all the statistical tests and minimized the AIC and BIC values. The results from the statistical tests for these graduations are given in Table 18.

Table 18. Graduation and statistical test for male GM(2,2) and female GM(0,3)

Statistic	**Male GM(2,3)**	**Female GM(0,3)**
Chi-squared test statistic (TS)	64.18	39.95
Critical value (CV) (at 5% significance)	38.89	41.34
Standard Deviations TS	4.42	0.94
CV (at 5 % Significance)	11.07	11.07
Signs TS	14	17
(lower bound, upper bound)	(10,21)	(10,21)
Grouping of Signs TS	7	8
CV (at 5 % Significance)	6	6
|Cumulative Deviations TS|	0.05	0.45
Critical value (CV) (at 5% significance)	1.96	1.96
Serial Correlations TS	1.07	-0.43
Critical value (CV) (at 5% significance)	1.64	1.64

The mortality rates were extrapolated using the same methodology as was used for the SAIML98 or SAIFL98 mortality rates for immediate annuitants, namely by using the method proposed by Coale and Kisker (1990), such that

$$m_x = b \times \exp\left(\sum_{y=85}^{x} [k_{85} + (y-85)s]\right)$$

where

$$k_{85} = \frac{\ln(m_{88}) - \ln(m_{81})}{7}, b = \frac{m_{82}+m_{83}+m_{84}+m_{85}+m_{86}}{5}$$

and

$$s = -\frac{1}{325}\left\{\ln\left(\frac{b}{m_{110}}\right) + 26k_{85}\right\}.$$

There is evidence that the mortality rates are lower than those of SAIML98 or SAIFL98 for immediate annuitants and to avoid the situation of possible over estimating mortality, rather than using the values of m_{110} = 1 for males and m_{110} = 0.8 for females, as was done for SAIML98 or SAIFL98, the effect of using different values for m_{110} was considered as shown graphically in Figures 19 and 20.

From these we note that there is very little difference between rates for ages 85 to 95, but there is above ages 95.

Figure 19. Comparison of alternative m_{110} values for extending the tables to age 110: male

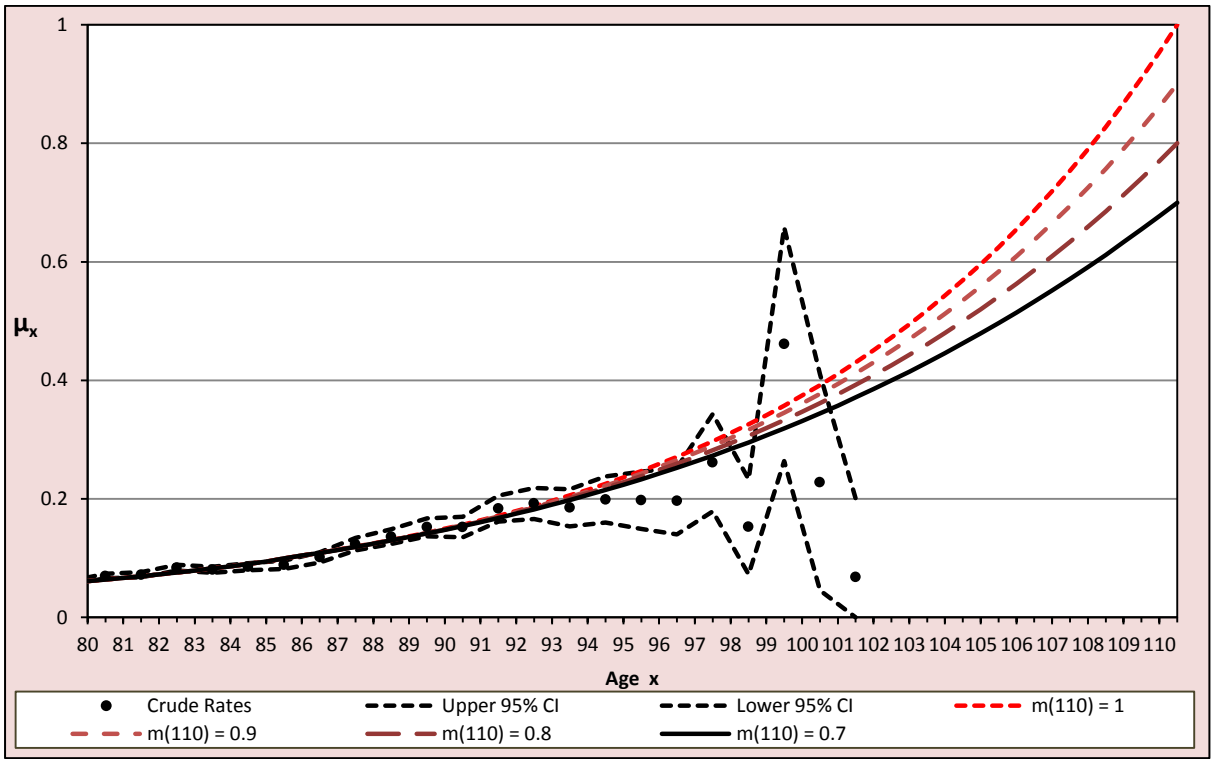
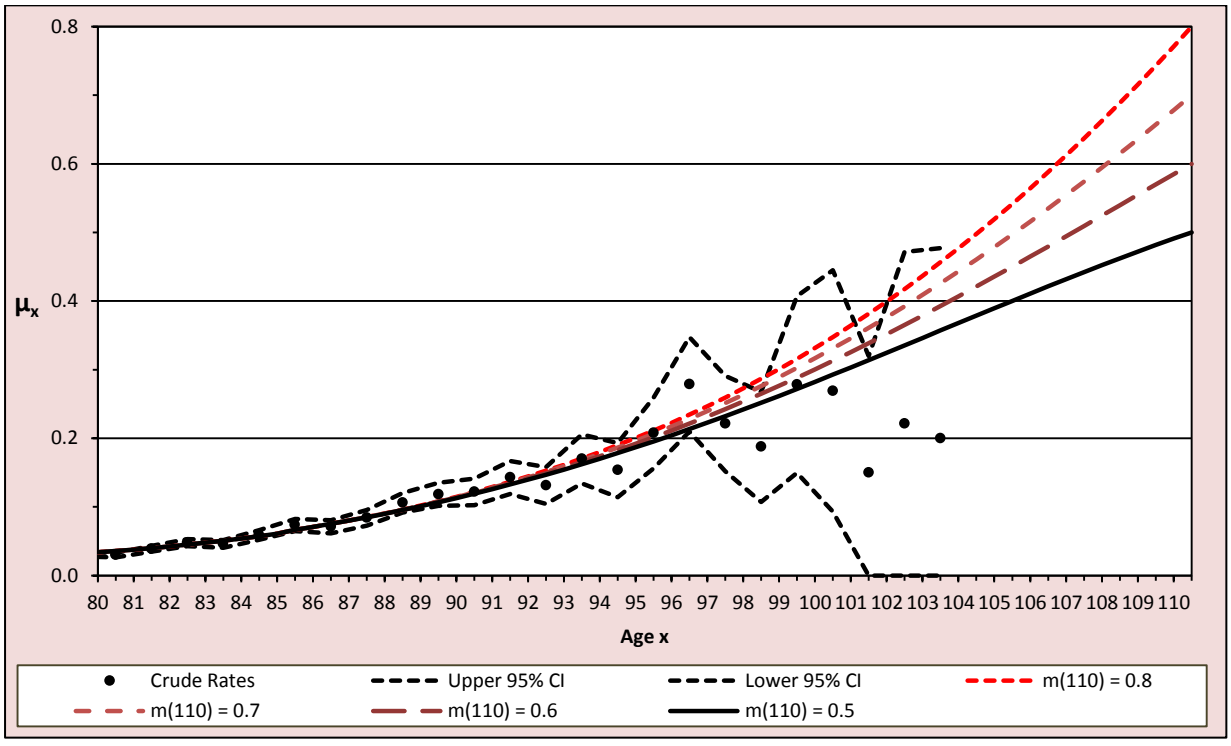


Figure 20. Comparison of alternative m_{110} values for extending the tables to age 110: female



Given that there is an element in subjectivity in choosing the value for m_{110}, as there are no data available to estimate it directly, a decision was taken to use values calculated by multiplying the values used for SAIML98 and SAIML98 at age 110 by the standardised mortality ratio (SMR) calculated using SAIML98 and SAIML98 as the standard (i.e. the SMR over all ages given in Tables 15 and 16), namely $m_{110} = 0.8593$ for males and $m_{110} = 0.63096$ for females.

The final graduated rates are compared to the SAIML98 or SAIFL98 mortality rates in Figures 21 and 22 and are given in Appendix A along with values for q_x which were derived by using the formula

$$q_x = 1 - \exp\left(-\int_0^1 \mu_{x+t}dt\right)$$

where the integral is approximated by

$$\int_0^1 \mu_{x+t}dt \approx \frac{7\mu_x + 32\mu_{x+0.25} + 12\mu_{x+0.5} + 32\mu_{x+0.75} + 7\mu_{x+1}}{90}.$$

Figure 21. Male graduated vs. SAIML98

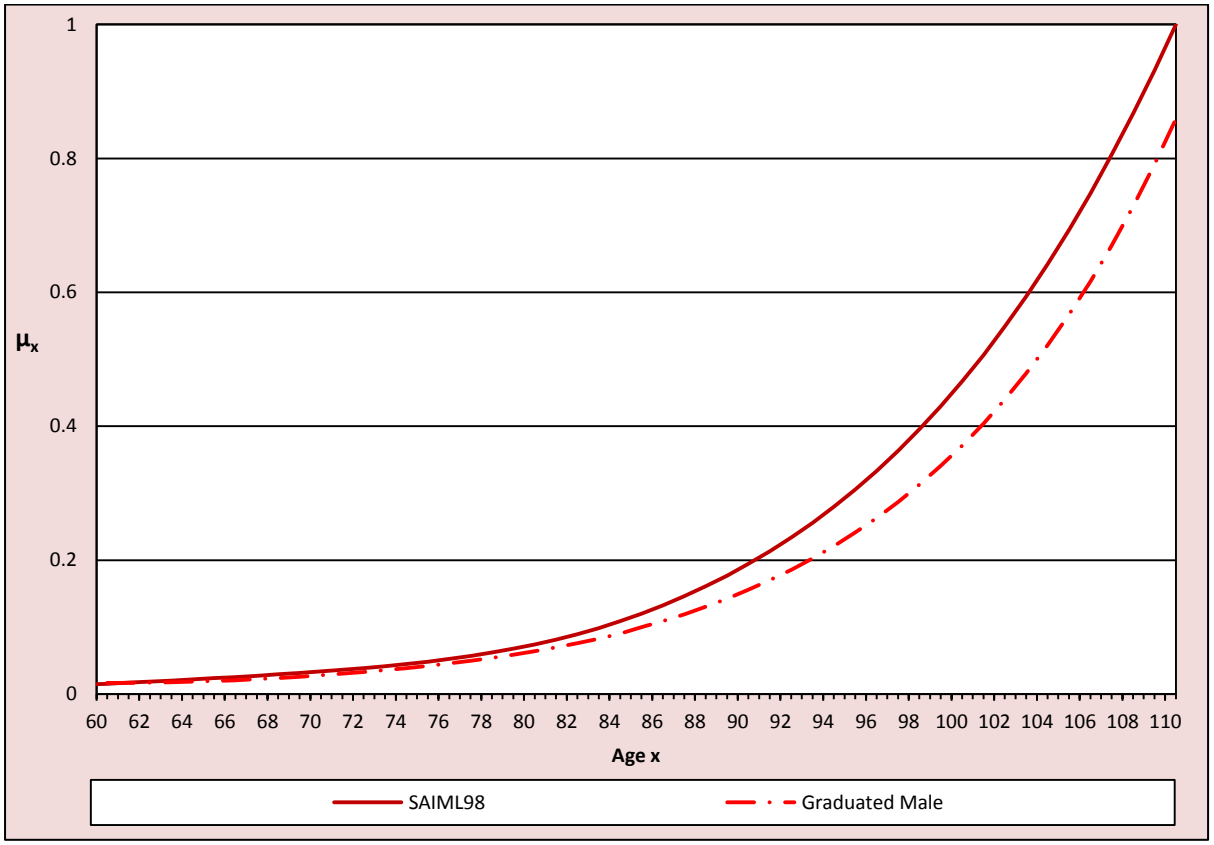
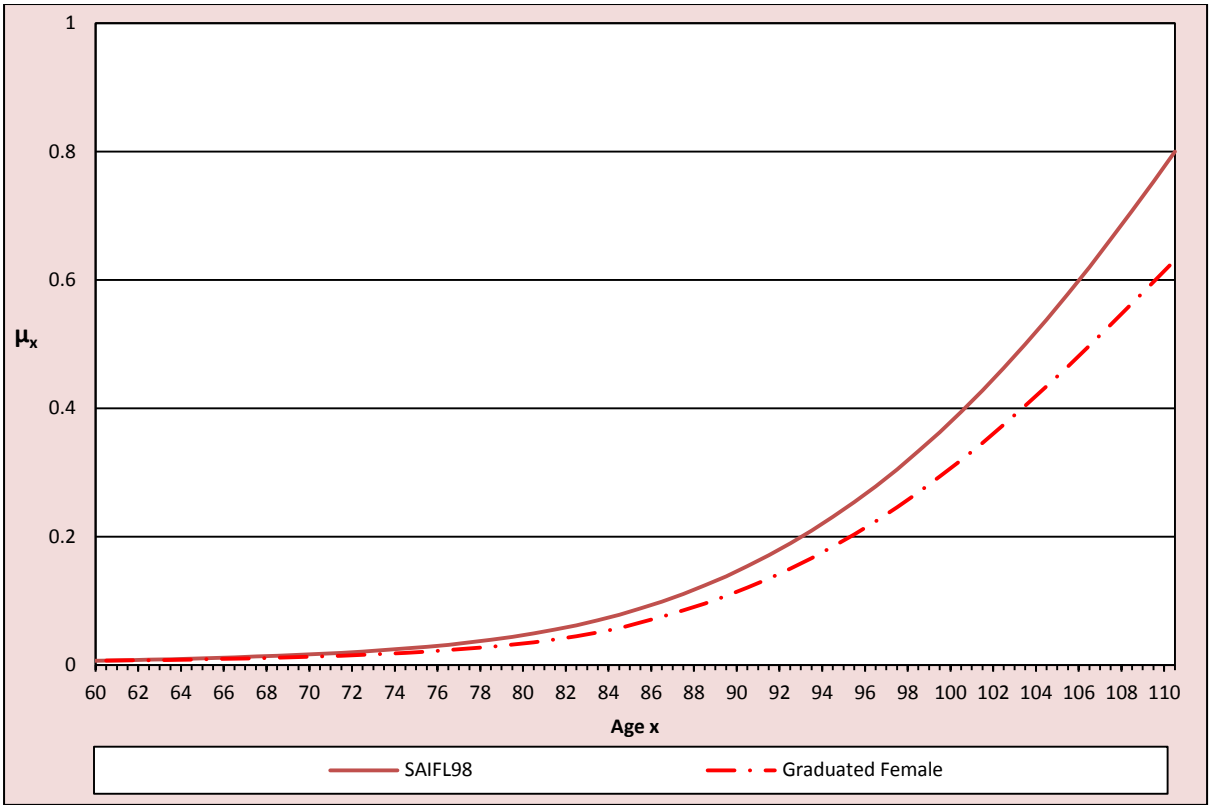


Figure 22. Female graduated vs. SAIFL98



5 Trend

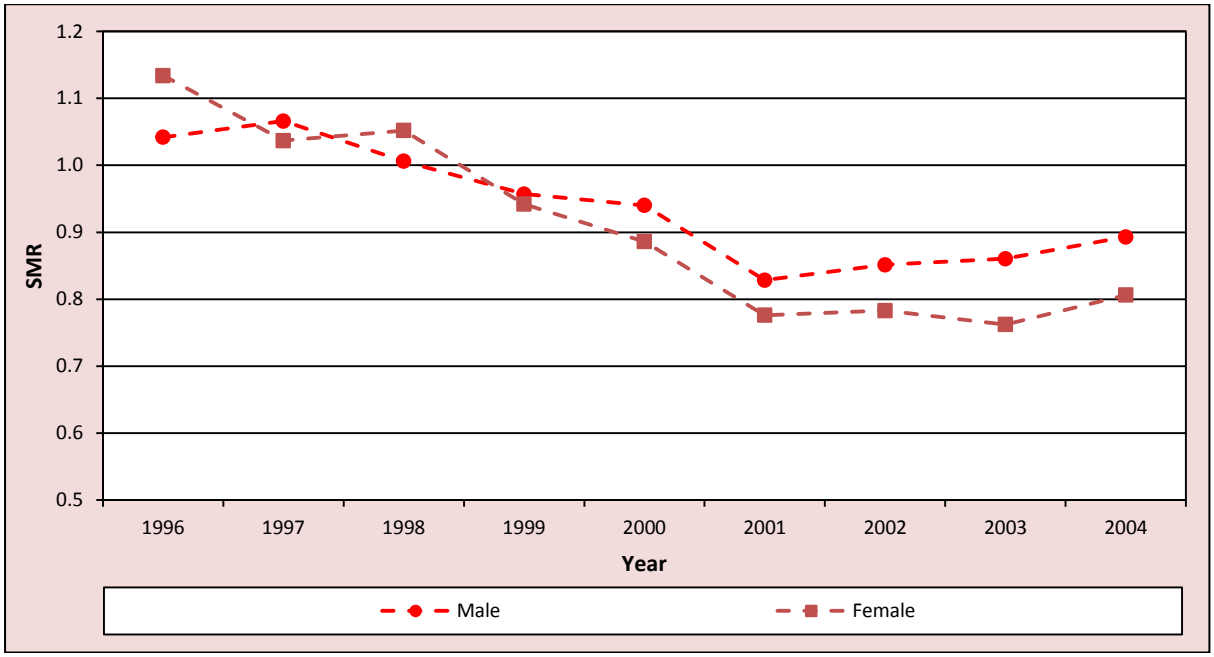
Table 19 shows the SMRs by year over the age range 40 to 100, where the standard was taken as 2001-2004 combined results for males and females respectively. For both males and females the mortality rates observed for each year are higher than that for the previous year. When the next annuitant mortality investigation is conducted, it should be investigated whether this increase in rates is a continuing trend.

Table 19. Standardised mortality ratio by year using all years combined as standard

Sex	2001-2002	2003-2004	2001	2002	2003	2004
Male	0.976	1.022	0.961	0.989	1.002	1.041
Female	0.991	1.008	0.989	0.992	0.977	1.037

In order to make a comparison between the previous and current investigation, Figure 23 compares the SMRs over time over the age range 50 to 94, using the 1996-2000 mortality rates as standard. It is evident that the observed for the 2001-2004 mortality investigation are lower than that for the 1996-2000 investigation. There is decreasing trend in the SMRs between 1996 and 2001, followed by a slight upward trend between 2001 and 2004. Whilst this does suggest a reduction in the observed mortality rates between the two investigations, there is not enough evidence to conclude an improvement in mortality. Further investigations need to be carried out in order to identify the company specific effects on the underlying rates and an analysis should be conducted by combining the data from the previous and current investigations.

Figure 23. Standardised mortality ratio by year using 1996-2000 mortality rates as standard



6 Summary and Conclusions

The 2001-2004 annuitant mortality investigation has seen increased participation from insurers in terms of the volume of data submitted, which is an encouraging trend which will make future investigations easier. The data from all companies were of sufficient quality to include in the report.

There is evidence of a reduction in the observed mortality rates for both males and females between the 1996-2000 investigation and the 2001-2004 investigation. The differences in participating companies (and data submitted) between the 1996-2000 investigation and the 2001-2004 investigation was such, that the extent of the mortality improvement could not be quantified without including an element of data differences between the two investigations.

The graduated results from this investigation are included in Appendix A.

7 Acknowledgements

Without the commitment and participation of the contributing companies, this investigation would also not have been possible.

8 References

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APPENDIX A: Final Graduated Rates

Age x	Female		Male	
	$\mu_{x+0.5}$	q_x	$\mu_{x+0.5}$	q_x
60	0.0069679	0.0069453	0.0166133	0.0164891
61	0.0073402	0.0073152	0.0166407	0.0165149
62	0.0077566	0.0077286	0.0169590	0.0168270
63	0.0082221	0.0081907	0.0175452	0.0174024
64	0.0087428	0.0087073	0.0183810	0.0182227
65	0.0093256	0.0092851	0.0194518	0.0192730
66	0.0099782	0.0099318	0.0207466	0.0205417
67	0.0107098	0.0106564	0.0222578	0.0220206
68	0.0115311	0.0114690	0.0239809	0.0237042
69	0.0124540	0.0123815	0.0259145	0.0255902
70	0.0134929	0.0134077	0.0280601	0.0276788
71	0.0146640	0.0145632	0.0304221	0.0299731
72	0.0159866	0.0158666	0.0330084	0.0324791
73	0.0174829	0.0173391	0.0358299	0.0352056
74	0.0191790	0.0190056	0.0389012	0.0381650
75	0.0211053	0.0208950	0.0422408	0.0413727
76	0.0232977	0.0230409	0.0458716	0.0448481
77	0.0257981	0.0254826	0.0498217	0.0486149
78	0.0286561	0.0282662	0.0541245	0.0527013
79	0.0319301	0.0314453	0.0588204	0.0571412
80	0.0356893	0.0350827	0.0639571	0.0619742
81	0.0400157	0.0392522	0.0695916	0.0672473
82	0.0450067	0.0440399	0.0757914	0.0730153
83	0.0507783	0.0495469	0.0826364	0.0793425
84	0.0574689	0.0558914	0.0902217	0.0863039
85	0.0664833	0.0638643	0.0996465	0.0944942
86	0.0753406	0.0726085	0.1089996	0.1033007
87	0.0851289	0.0816441	0.1191955	0.1123996
88	0.0959083	0.0914925	0.1303067	0.1222101
89	0.1077375	0.1021781	0.1424117	0.1327748
90	0.1206725	0.1137186	0.1555953	0.1441362
91	0.1347663	0.1261238	0.1699493	0.1563371
92	0.1500671	0.1393946	0.1855729	0.1694193
93	0.1666175	0.1535221	0.2025730	0.1834239
94	0.1844537	0.1684871	0.2210654	0.1983897
95	0.2036035	0.1842595	0.2411748	0.2143530
96	0.2240857	0.2007981	0.2630360	0.2313465
97	0.2459091	0.2180503	0.2867942	0.2493980
98	0.2690705	0.2359528	0.3126063	0.2685298
99	0.2935546	0.2544317	0.3406411	0.2887571

100	0.3193324	0.2734039	0.3710808	0.3100865
101	0.3463604	0.2927776	0.4041214	0.3325151
102	0.3745802	0.3124542	0.4399743	0.3560286
103	0.4039174	0.3323293	0.4788670	0.3805998
104	0.4342818	0.3522952	0.5210441	0.4061876
105	0.4655666	0.3722416	0.5667690	0.4327349
106	0.4976493	0.3920586	0.6163249	0.4601679
107	0.5303910	0.4116375	0.6700164	0.4883949
108	0.5636378	0.4308731	0.7281707	0.5173054
109	0.5972214	0.4496649	0.7911393	0.5467700
110	0.6309600	0.4679192	0.8593000	0.5765416