

Study

Canadian Individual Annuitant Mortality Experience Policy Years 2005–2006 to 2014–2015

Research Executive Committee –
Experience Studies Research Subcommittee

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MEMORANDUM

To: All Fellows, Affiliates, Associates, and Correspondents of the Canadian Institute of Actuaries

From: Taylor Wasko, Chair
Individual Annuitant Mortality Experience Project Oversight Group

Date: November 10, 2017

Subject: **Canadian Individual Annuitant Mortality Experience – Policy Years 2005–2006 through 2014–2015**

The attached document contains summary results for the Canadian Individual Annuitant Mortality Experience for Policy Years 2005–2006 through 2014–2015. There are a number of tables listed in appendix 2: Additional Data for Study that will be available online at www.cia-ica.ca.

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1. Executive Summary

This report analyzes the mortality experience of Canadian individual payout annuities for the 10-year period from policy year 2005–2006 to policy year 2014–2015.

The following changes were made since the last study:

- The base expected table has been updated from the 1983 Individual Annuity Mortality Basic Table (IAM 1983) to Canadian Insured Payout Mortality Table 2014 (CIP 2014).
- Mortality improvement is now applied to the base expected table to the year of experience.
- Structured settlement policies have been excluded from the results.

Note that results in this report are not adjusted for incurred but not reported (IBNR) factors. However, some statistics on reporting lag are included in appendix 1.

The overall trends are similar to the prior study. The main findings are as follows:

- CIP 2014 is a slightly better fit than IAM 1983 to the mortality experience for males age 70 and older. However, neither CIP 2014 nor IAM 1983 is a particularly good fit for females. Nevertheless, we felt the CIP table is the most natural expected basis because it was developed from recent Canadian individual annuitant data.
- Joint survivor policies experience higher mortality rates than joint both alive policies.
- Actual/expected (A/E) by number is generally higher than A/E by income.
- As annualized income increases, A/E by income decreases.
- Non-registered annuities have lower mortality than registered policies.
- Non-refund mortality experience is lower than refund annuities when measured by annualized income.
- Presumed back-to-backs have significantly lower mortality ratios. This trend is more apparent for single policies than for joint annuities.
- Male joint survivors show significantly higher A/E ratios than joint both alive and single policies, regardless of tax status or annualized income.
- Female joint both alive policies show significantly lower A/E ratios than joint survivor and single policies, regardless of tax status or policy size.

2. Introduction

This study updates the 2002–2003 through 2011–2012 study, published in 2015, with three additional years of data; the information presented here does not require knowledge of the prior study. Seven companies contributed to this study. We acknowledge the assistance of these companies in compiling the data. The results in this report are not adjusted for incurred but not reported (IBNR) factors, but are adjusted using mortality improvement scales. Please see the comments on this topic in section 3.

Because IBNR factors are larger for joint policies than for single policies, the data for single policies are considered more reliable.

The mix of the business has changed slightly over the 10-year period. In general, the proportion of Registered Retirement Savings Plan (RRSP) business has decreased, while the proportion of Non-registered-Unknown Tax Code (NR-UTC) business has increased. The Registered Pension Plan (RPP) business is small in proportion to the other two blocks. Please see section 5. Description of

the Data (figure 2) for details.

NR-UTC policies exhibit different characteristics from RRSP policies. NR-UTC policies tend to have higher average income and lower mortality ratios (see table 6A); they appear to exhibit more selection. The details are in the following pages.

Since subgroups of the data exhibit different characteristics, the reader should use the aggregate mortality ratios carefully. Simpson's paradox suggests that mortality improvement in aggregate is suspect when subgroups exhibit different mortality and mortality improvement.

We have attempted to isolate the experience of back-to-back annuities. The data, although sparse, indicate that there is much lower mortality for this block of business, especially for single policies. (See Section 6. Observations, tables 10A and 10F.)

3. Description of the Study

This study considers the experience of Canadian individual annuities. Most of the policies studied are in payout status, but in some cases, experience is included during the deferred period, provided the policy has no cash value and the policy cannot be changed.

Policy Year/Calendar Year Basis

Four companies contributed data on a calendar year basis, while three contributed on a policy year basis. The study runs between successive policy anniversaries. The "year of experience", as the year under study is known, is referred to by the calendar year in which the policy year ends.

The anniversary is based on the "determination date". This is the day on which the income was determined; it may not be changed, as there is a final disposition of funds on that date. Usually the determination date will be the same as the issue date. In the case of an accumulation type of annuity, the determination date would most likely be the date when the policy changes from accumulation status to payout status.

Select Period

The study uses a 10-year select period. Since there are no published annuitant mortality tables with the 10-year select period, the expected mortality for both the select and ultimate periods has been previously calculated using an aggregate table: the IAM 1983 basic Table, *Transactions of the Society of Actuaries*, Volume XXXIII. For this study, we are using a new aggregate table: Mortality Table: CIP2014 (CIA accession number 215006T).

Mortality Improvement Scale

The study uses the 2010 CIA best-estimate improvement scale (CIA MI, CIA accession number 210065).

Improvement was computed as a fraction raised to the power (PolicyYear - ImproveTableStart), where ImproveTableStart was 1983 for the IAM table and 2014 for the CIP2014 table. This method handles policy years both before and after the ImproveTableStart year in a consistent way.

For a mortality improvement rate (MIR), the expected values of counts and amounts for each age and sex in the aggregate tables are computed as the following:

$$\text{Improved } q_x = q_x * (1 - \text{MIR})^{(\text{PolicyYear} - \text{ImproveTableStart})}$$

For example, for q_x from the IAM table, the *Improved* q_x for policy year 2005–2006 is improved by 23 years using

$$q_x * (1 - MIR)^{(2006-1983)}$$

For the CIP table, the *Improved* q_x for policy year 2014–2015 is improved by one year using

$$q_x * (1 - MIR)^{(2015-2014)}$$

And so, the *Improved* q_x for policy year 2005–2006 is improved by eight years using

$$q_x * (1 - MIR)^{(2006-2014)}$$

To make this explicit, the CIP2014 table shows the following for a 75-year-old male:

$$q_x = 0.02182$$

and the CIA MI scale gives the following:

$$MIR = 0.0100.$$

For policy year 2014–2015, the *Improved* q_x is

$$q_x * (1 - MIR)^{(2015-2014)} = 0.02182 * (1 - 0.0100)^{(1)} = 0.02160.$$

For policy year 2005–2006, the *Improved* q_x is

$$q_x * (1 - MIR)^{(2006-2014)} = 0.02182 * (1 - 0.0100)^{(-8)} = 0.02365.$$

Section 3 compares results using both aggregate tables and the CIA MI improvement scale.

Standard Deviations

This study includes standard deviations of the mortality ratios based on number of lives and income. (“Mortality ratio” means the ratio of the actual mortality to the expected mortality.) The standard deviation measures the degree of confidence that may be placed in the ratios observed. The formulae used to estimate the standard deviations of actual/expected (A/E) are as follows:

$$\text{Standard Deviation of Number of Lives} = \frac{\sqrt{\sum \text{deaths}}}{E}$$

$$\text{Standard Deviation of Income} = \frac{\sqrt{\sum K^2 \times \text{deaths}}}{E}$$

where

- Summation is over each individual;
- The expected sums, both denoted above by E , are based on expected experience; and
- K represents the annualized income of the annuity.

Single and Joint Policies

Data are segregated by single life policies, joint policies in which both annuitants are alive at the

beginning of the study year, and joint policies for which only one annuitant is still alive at the beginning of the year. We have concluded that there are real, measurable differences in mortality by group.

Data Breakdowns Studied

We study RRSP policies, RPP policies, and NR-UTC policies separately.

We also study experience separately by refund and non-refund. A refund policy, also known as a guarantee, is one that provides for the possibility of some payment after the death of the annuitant. The most common refund provision is a continuation of payments for a minimum specified number of years.

We also include a study of single life data by annualized income by sex and by tax type (RRSP, RPP, and NR-UTC).

There are four main income groups: \$0–\$999; \$1,000–\$4,999; \$5,000–\$9,999, and \$10,000 and over. We have also provided a further breakdown of the \$10,000 and over category, although it should be used with caution due to small sample sizes.

Age-Nearest Birthday

All results are computed on the basis of age-nearest birthday. None of the companies are currently submitting data on an age-last birthday basis.

4. Comparisons of Rate Tables and Improvement Scales

We investigated four combinations of aggregate table and improvement scales:

- IAM: IAM 1983 with no improvement (consistent with past studies);
- IAM-MI: IAM 1983 with CIA MI scale;
- CIP: CIP 2014 with no improvement; and
- CIP-MI: CIP 2014 with CIA MI scale.

Since company participation has changed from the previous study, results for policy years 2005–2006 through 2011–2012 using IAM 1983 with no improvement will differ from the prior report.

We compared the results under the four combinations of table and mortality improvement scale to assess their appropriateness relative to the observed experience, with a focus on which combination provides the best fit by attained age. A mortality table with a good fit by attained age has minimal slope for credible ages. All else being equal, the project oversight group preferred to use a more recent and relevant table such as CIP, which was developed using Canadian annuity data from 2000–2011. The IAM 1983 table, by contrast, is based on U.S. data and is over 30 years old.

Table A1. Aggregate Experience for Males and Females, Single Life, A/E by Number

Policy Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	91.9	113.8	116.9	108.7	89.6	110.2	116.4	108.4
2007	92.0	114.6	115.2	108.2	90.6	111.9	116.1	109.3
2008	91.7	114.9	113.3	107.5	90.0	111.7	113.8	108.2
2009	95.8	120.8	116.9	112.0	87.9	109.5	109.7	105.3
2010	91.0	115.4	110.0	106.3	85.1	106.4	105.1	101.8
2011	89.6	114.3	107.2	104.5	87.1	109.2	106.2	103.8
2012	91.4	117.0	108.2	106.4	86.8	108.8	104.5	102.9
2013	84.9	107.5	98.4	97.6	81.5	101.2	96.1	95.5
2014	80.5	102.2	92.8	92.8	80.6	100.1	94.2	94.2
2015	83.1	105.5	95.2	95.9	85.7	106.3	99.3	99.9
Total	89.5	112.9	107.8	104.4	86.5	107.6	106.0	102.9

Table A2. Aggregate Experience for Males and Females, Single Life, A/E by Income

Policy Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	79.8	99.3	105.1	97.5	84.4	104.2	111.4	103.7
2007	82.6	103.5	107.1	100.4	85.8	106.5	111.8	105.1
2008	78.8	99.4	100.9	95.5	83.4	103.9	107.2	101.8
2009	82.7	104.9	104.2	99.6	75.8	95.1	96.6	92.6
2010	77.7	99.1	96.6	93.3	78.1	98.4	98.4	95.2
2011	72.6	93.1	89.2	86.9	78.5	99.3	98.0	95.6
2012	83.1	106.9	100.7	99.0	81.2	103.2	100.5	98.9
2013	82.9	106.4	99.2	98.5	73.3	93.1	89.7	89.0
2014	73.6	95.1	87.9	87.9	74.7	95.1	90.5	90.5
2015	78.2	101.5	93.1	93.9	79.3	101.0	95.3	95.9
Total	79.2	100.9	98.2	95.2	79.3	99.9	99.4	96.6

Tables A1 and A2 show that

- IAM unadjusted has mortality rates that are consistently higher than experience.
- CIP unadjusted underestimates mortality in the early years.
- For IAM A/E by income and CIP A/E by number, mortality improvement leads to experience closer to 100%.
- For CIP-MI A/E by income, the female mortality in the early years is slightly underestimated.

Table B1. Overall Experience for Males and Females, Single Life, A/E by Number, 2005–2015

Income	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
\$0–\$999	91.8	114.4	108.0	104.6	89.1	108.5	105.7	102.8
\$1,000–\$4,999	91.5	115.5	109.8	106.2	87.2	108.7	107.1	104.0
\$5,000–\$9,999	86.7	110.7	107.5	104.1	85.5	107.8	107.5	104.4
\$10,000+	77.5	99.1	97.4	94.5	76.0	96.1	95.9	93.3
Total	89.5	112.9	107.8	104.4	86.5	107.6	106.0	102.9

Table B2. Overall Experience for Males and Females, Single Life, A/E by Income, 2005–2015

Income	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
\$0–\$999	91.6	114.6	108.6	105.1	89.6	109.7	107.1	104.0
\$1,000–\$4,999	91.4	115.5	110.1	106.5	86.8	108.5	107.2	104.0
\$5,000–\$9,999	86.8	110.8	107.8	104.4	85.4	107.8	107.5	104.4
\$10,000+	69.4	88.8	87.5	85.0	69.5	88.2	88.2	85.9
Total	79.2	100.9	98.2	95.2	79.3	99.9	99.4	96.6

Tables B1 and B2 show

- A significant reduction in mortality associated with large annuities. This effect is more pronounced in table B2.
- That aside from this reduction, CIP-MI most closely matches the aggregate experience (i.e., A/E is close to 100%).

Table C1. Overall Experience for Males and Females, Joint Life Both Alive, A/E by Number

Policy Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	81.1	101.3	108.6	100.6	74.5	93.3	104.9	97.1
2007	81.2	102.1	107.1	100.2	76.0	95.9	106.2	99.2
2008	80.7	102.2	104.9	99.2	74.0	94.1	102.5	96.8
2009	82.5	105.3	105.8	101.1	73.9	94.7	101.5	96.8
2010	83.3	107.1	105.7	101.9	67.4	87.1	92.0	88.6
2011	81.6	105.6	102.5	99.8	64.7	84.3	87.8	85.3
2012	74.1	96.4	92.1	90.5	70.0	91.9	94.3	92.6
2013	80.9	105.4	99.2	98.4	75.4	98.8	99.8	99.0
2014	80.8	106.0	99.2	99.2	66.2	87.5	87.7	87.7
2015	75.8	99.9	92.7	93.5	54.8	72.7	72.1	72.8
Total	80.4	103.1	102.3	98.7	70.2	90.6	95.7	92.3

Table C2. Overall Experience for Males and Females, Joint Life Both Alive, A/E by Income

Policy Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	79.2	99.0	108.6	100.5	68.5	85.9	97.4	90.1
2007	77.2	97.3	104.4	97.7	66.6	84.3	94.2	88.0
2008	75.8	96.4	101.2	95.7	72.1	92.0	101.2	95.5
2009	81.9	105.0	108.2	103.2	70.1	90.1	97.7	93.1
2010	77.4	100.0	101.1	97.4	60.7	78.7	84.0	80.9
2011	73.7	95.8	95.3	92.8	61.8	80.9	85.1	82.7
2012	70.6	92.5	90.5	88.9	74.3	97.9	101.5	99.6
2013	71.9	94.5	91.0	90.2	70.3	93.0	95.1	94.2
2014	71.1	94.3	89.9	89.9	58.9	78.7	79.6	79.6
2015	72.9	97.2	91.6	92.4	48.8	65.5	65.5	66.1
Total	75.3	97.3	98.3	95.0	65.4	85.0	90.3	87.3

Tables C1 and C2, especially when compared with tables A1 and A2, show the reduction in mortality of joint annuitants compared with single female policyholders. As this reduction holds especially for the early years, it cannot be attributed solely to IBNR. Table C1 for female joint policies shows very stable A/Es for CIP-MI although much lower than for female single policy holders in table A1. The lower CIP-MI A/E for female joint policy holders for 2014 and 2015 in table C1 is due in part to IBNR, which is greater for this group.

Table D1. Overall Experience for Males and Females, Joint Life One Surviving, A/E by Number

Policy Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	108.6	134.0	130.0	121.0	83.6	103.6	110.7	102.8
2007	111.0	137.4	130.1	122.4	86.8	108.1	113.2	106.3
2008	108.3	134.8	124.6	118.4	89.1	111.5	114.4	108.5
2009	106.5	132.8	120.0	115.1	91.5	115.0	115.8	110.9
2010	109.3	136.4	121.0	117.2	88.2	111.2	110.1	106.5
2011	108.2	135.4	118.2	115.5	88.3	111.6	108.7	106.1
2012	103.4	129.6	111.5	109.8	87.5	110.7	106.2	104.5
2013	104.4	130.7	111.2	110.4	87.1	110.0	104.0	103.3
2014	101.1	126.2	106.1	106.1	84.8	107.1	100.1	100.1
2015	100.1	124.7	104.0	104.6	87.1	109.9	101.7	102.4
Total	106.0	132.1	116.9	113.8	87.4	110.0	107.8	105.0

Table D2. Overall Experience for Males and Females, Joint Life One Surviving, A/E by Income

Study Year	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
2006	100.9	124.7	122.3	113.8	79.6	98.9	106.5	98.8
2007	104.8	130.0	124.0	116.6	85.5	106.8	112.5	105.5
2008	111.3	138.6	129.3	122.8	88.6	111.2	114.8	108.8
2009	114.5	142.9	130.5	125.2	89.3	112.7	114.2	109.3
2010	115.7	144.9	130.3	126.2	83.7	106.0	105.7	102.1
2011	108.4	136.0	120.0	117.2	84.1	106.8	104.5	102.0
2012	98.6	124.5	108.4	106.8	84.4	107.4	103.5	101.9
2013	102.6	129.7	111.3	110.5	84.7	107.8	102.5	101.7
2014	95.6	120.8	102.3	102.3	81.6	103.8	97.5	97.5
2015	97.6	123.2	103.3	104.1	80.9	103.0	95.6	96.3
Total	104.9	131.6	117.3	114.2	84.1	106.4	104.7	102.0

A comparison of tables D1 and D2 with tables C1 and C2 shows very large increases in mortality of the joint survivors. The interpretation of these differences is beyond the scope of this report.

Table E1. Overall Experience for Males and Females, Single Life, A/E by Number, Attained Age for Duration 11+, 2005–2015

Attained Age	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
18–59	107.2	142.0	167.5	160.1	167.8	222.6	251.6	240.6
60–64	103.4	135.4	161.1	154.6	166.4	218.1	237.9	228.4
65–69	88.2	115.3	157.2	150.6	109.4	143.5	157.8	151.4
70–74	73.6	96.2	134.1	128.3	100.4	131.3	142.6	136.6
75–79	76.3	99.7	131.4	125.7	87.9	114.8	136.4	130.5
80–84	83.2	108.8	124.7	119.5	81.7	106.6	124.2	118.8
85–89	89.1	116.9	110.1	105.8	86.3	113.1	115.6	111.0
90+	100.5	119.2	97.1	95.0	90.4	106.9	97.8	96.0
Total	91.2	114.7	107.8	104.4	88.2	109.2	106.9	103.9

Table E2. Overall Experience for Males and Females, Single Life, A/E by Income, Attained Age for Duration 11+, 2005–2015

Attained Age	Males				Females			
	IAM	IAM-MI	CIP	CIP-MI	IAM	IAM-MI	CIP	CIP-MI
18–59	117.3	155.6	181.1	173.1	290.3	385.7	436.5	418.1
60–64	100.8	131.8	157.2	150.5	164.7	215.8	235.5	225.9
65–69	99.8	130.7	178.0	170.7	136.2	178.8	196.3	188.8
70–74	61.0	79.8	111.0	106.4	103.7	135.9	147.3	141.3
75–79	70.0	91.6	120.5	115.4	86.6	113.3	134.4	128.8
80–84	77.4	101.5	116.2	111.5	79.5	104.1	121.1	116.1
85–89	84.1	110.6	104.0	100.2	82.7	108.8	110.9	106.8
90+	94.4	112.9	91.5	89.6	90.0	107.2	97.8	96.0
Total	84.9	107.6	102.0	98.9	86.9	108.4	106.3	103.4

Tables E1 and E2 show that, while the aggregate experience matches that of the CIP-MI tables, this agreement does not hold for all ages. A comparison of table E1 to E2 shows that the change in experience by age is due in part to income being strongly associated with mortality; income and age are confounded over the years of the study.

A good mortality table fit is one in which the level of A/E, after accounting for known trends (e.g., excluding the select period), for core ages is approximately level, with no clearly defined upward or downward slope by attained age. Proximity to 100% is ideal but not necessary because a simple scalar could be applied.

While experience for ages < 70 does not appear to fit that well to CIP-MI, we note that more than 98% of the single deaths are for ages > 70. For those ages, the table fit for males is reasonable and

better than IAM-MI. However, neither CIP 2014 nor IAM 1983 is a particularly good fit for females. CIP-MI underestimates female single life mortality, especially for ages 70–89. However, table 4.5 in appendix 2 shows that the CIP-MI table fits the data well for female joint both alive annuitants.

In conclusion, while CIP-MI is not a perfect fit, it is still a reasonable fit to the data and is generally no worse than IAM. CIP-MI is also more recent and is based on Canadian individual payout annuity data, making it the most relevant and giving it a natural expected basis.

5. Description of the Data

Unless indicated otherwise, this report uses single life data only. Substandard and structured settlement policies are not included. Note that structured settlement policies were included in the previous report.

Exposure by Sex

For the single life data, males account for 43% of the exposure by number of policies, 45% of the exposure by income, and 46% of the number of deaths.

Exposure by Refund/Non-Refund

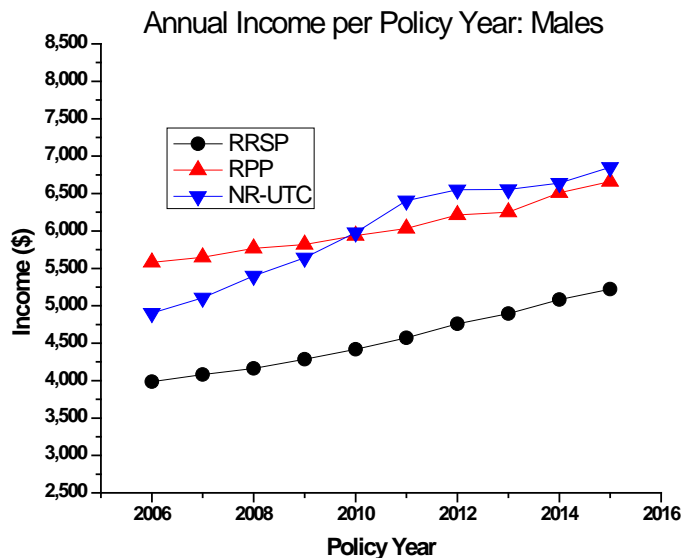
There is less exposure for non-refund policies than for refund policies. Refund business is 74% and 72% of the exposure by policy for male and female single life policies, respectively. Refund business is 67% and 65% of the exposure by income for male and female single life policies, respectively.

Changes in Average Annual Income by Tax Type and Sex

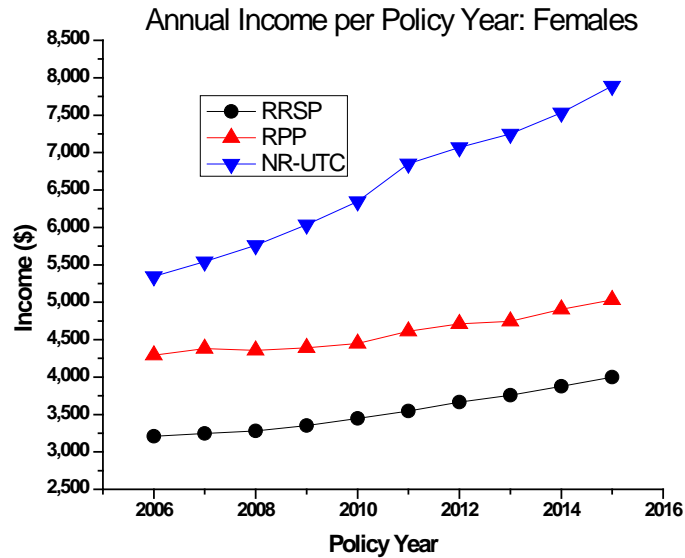
For females, the average annual income per policy for all policies has been growing, with NR-UTC policies increasing the fastest. The same is true for males, but not as dramatically. These observations are shown in figures 1A–B below.

Figure 1. Annual Income per Policy Year

A. Males without structured settlement policies

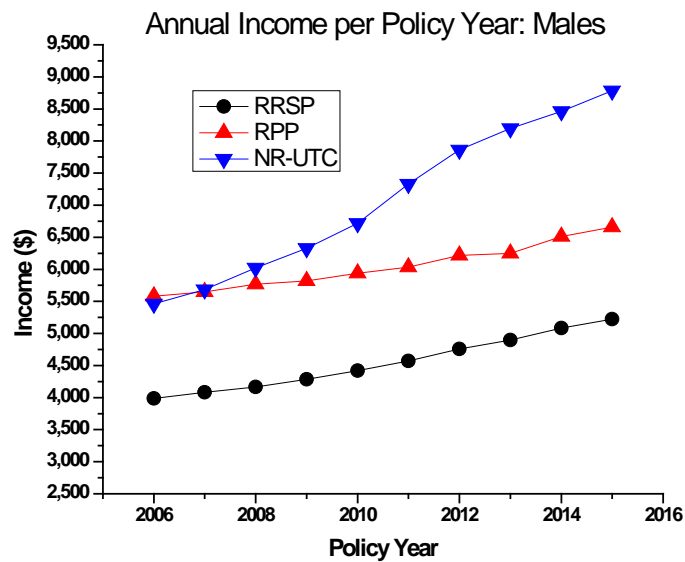


B. Females without structured settlement policies

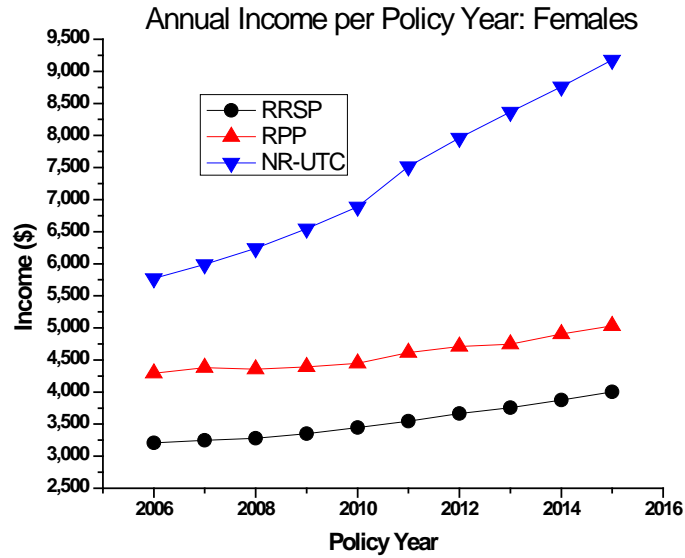


Figures 1A–B show the average income of RRSP and RPP policies increasing over time but still consistently lower for females than for males. The difference between males and females for NR-UTC is explained partly by the tendency of the largest male NR-UTC policies to be structured settlements and hence not included in this report. Had we included structured settlements, the results would have appeared as in figures 1C–D below.

C. Males with structured settlement policies



D. Females with structured settlement policies

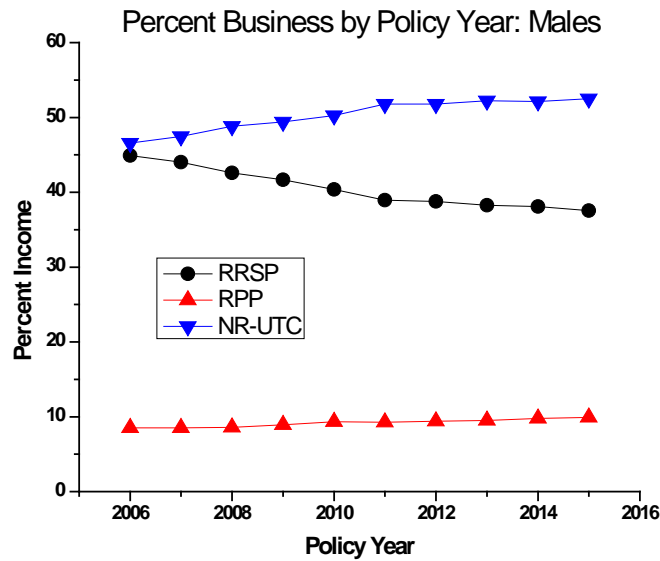


Changes in Business Mix

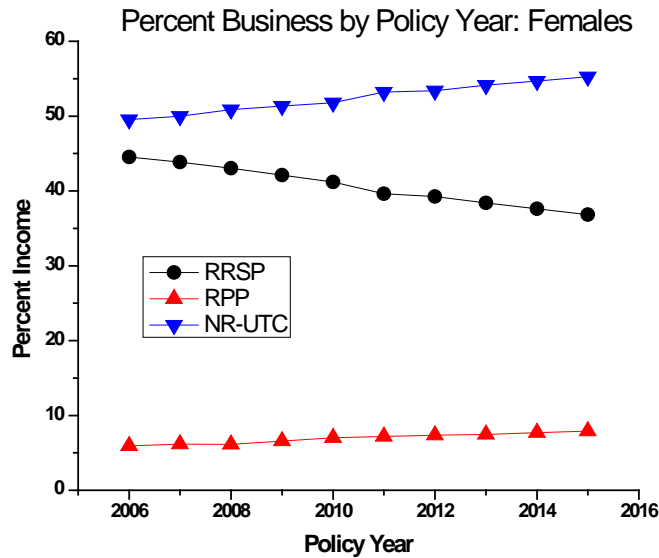
Over time, the NR-UTC portion of the business has increased, while the RRSP portion has decreased, as seen in figure 2 below.

Figure 2. Business Mix by Policy Year

A. Males



B. Females



6. Observations

The rest of this report is based on the CIP-MI rates only.

General Observations

The following tables give overviews of the data by year of experience. The totals in the # Exposed columns for the individual study years represent the data included in this year’s report. The totals will not be consistent with previous years’ reports, as some of the previous data have been updated to include late-reported deaths and the collection of companies participating has changed. Note that the # Deaths columns are counts of deaths reported, unadjusted for IBNR.

During the study period, the A/E ratios by number of policies are greater than the A/E ratios by annualized income for single life data. For joint life data, the A/E ratios for joint survivors are greater than the A/E ratios for joint life (both annuitants alive) by number of policies and by annualized income. Note that the A/E ratios for joint life (both annuitants alive) are less than those for joint survivors or for single life.

Table 1. Single Life Data

Study Year	# Exposed	# Deaths	A/E by Number	A/E by Income
2006	192,215	12,385	108.6	100.6
2007	182,488	12,351	108.8	102.8
2008	171,539	12,038	107.9	98.7
2009	163,253	11,964	108.4	96.1
2010	156,147	11,284	103.8	94.3
2011	148,842	11,080	104.1	91.4
2012	140,835	10,830	104.5	99.0
2013	134,424	10,333	96.4	93.6
2014	126,908	9,660	93.6	89.3
2015	120,009	9,769	98.2	95.0
Total	1,536,658	111,694	103.6	95.9

Table 2. Joint Life Data (Both Annuitants Alive at Beginning of Study Year)

Study Year	# Exposed	# Deaths	A/E by Number	A/E by Income
2006	104,058	4,631	99.4	97.0
2007	96,797	4,501	99.9	94.4
2008	89,877	4,270	98.4	95.6
2009	84,751	4,208	99.6	99.7
2010	80,869	3,992	97.3	91.7
2011	76,475	3,713	94.8	89.3
2012	72,228	3,421	91.2	92.6
2013	67,891	3,611	98.6	91.6
2014	62,929	3,156	95.2	86.4
2015	59,139	2,668	86.3	83.5
Total	795,014	38,171	96.5	92.4

Table 3. Joint Survivor Data (Only One Annuitant Alive at Beginning of Study Year)

Study Year	# Exposed	# Deaths	A/E by Number	A/E by Income
2006	43,193	3,083	109.0	104.1
2007	44,687	3,487	111.7	109.4
2008	46,331	3,840	111.8	113.6
2009	46,393	4,105	112.3	114.7
2010	46,216	4,215	110.0	110.3
2011	45,552	4,322	109.0	106.9
2012	44,466	4,300	106.1	103.4
2013	43,791	4,444	105.4	104.4
2014	42,375	4,331	101.9	99.0
2015	40,724	4,370	103.0	98.6
Total	443,728	40,497	107.7	106.0

Male/Female Observations

Table 4A summarizes aggregate male and female mortality ratios for single life data only. The differences between the overall male and female A/E ratios vary by study year. IBNR adjustments have not been made to the data tabulated. If IBNR adjustments were included, the ratios in the last three years would be increased.

Table 4A. Aggregate Experience for Males and Females, Single Life

Study Year	A/E by Number		A/E by Income	
	Male	Female	Male	Female
2006	108.7	108.4	97.5	103.7
2007	108.2	109.3	100.4	105.1
2008	107.5	108.2	95.5	101.8
2009	112.0	105.3	99.6	92.6
2010	106.3	101.8	93.3	95.2
2011	104.5	103.8	86.9	95.6
2012	106.4	102.9	99.0	98.9
2013	97.6	95.5	98.5	89.0
2014	92.8	94.2	87.9	90.5
2015	95.9	99.9	93.9	95.9
Total	104.4	102.9	95.2	96.6

As shown in tables 4B and 4C below, there is a distinct difference in mortality experience between RRSP and NR-UTC business for both males and females. We note again that the ratios in recent years would be slightly increased by an IBNR adjustment. Mortality ratios by income are generally higher for RRSP than for NR-UTC policies. Mortality ratios by number are higher for NR-UTC business than for RRSP in the first five years of the study but generally lower in the second five years.

Table 4B. Male Experience, Single Life

Study Year	A/E by Number		A/E by Income	
	RRSP	NR-UTC	RRSP	NR-UTC
2006	106.0	111.9	103.1	87.9
2007	104.9	111.8	104.3	94.3
2008	100.3	118.0	94.9	92.2
2009	105.3	120.9	100.8	97.0
2010	104.7	106.1	100.1	81.3
2011	107.4	96.8	100.6	70.6
2012	108.1	102.3	106.5	90.7
2013	106.9	84.6	105.8	90.2
2014	101.4	80.8	103.7	72.9
2015	106.3	82.3	98.3	89.6
Total	105.1	101.4	101.8	86.4

Table 4C. Female Experience, Single Life

Study Year	A/E by Number		A/E by Income	
	RRSP	NR-UTC	RRSP	NR-UTC
2006	102.8	117.6	103.2	104.0
2007	102.9	118.7	101.4	106.2
2008	102.2	117.1	97.8	105.8
2009	99.1	113.9	98.1	85.1
2010	97.7	107.5	97.9	92.7
2011	105.1	99.2	103.6	86.0
2012	101.5	104.8	100.8	95.9
2013	102.8	83.3	101.1	76.6
2014	100.0	85.1	96.5	83.4
2015	108.9	85.9	102.0	90.3
Total	102.2	102.9	100.2	92.0

Figure 3 shows the trends over time of mortality ratios (based on the mortality table as modified by the improvement scale) measured by income. The circles in the plots represent the ratios of actual to expected deaths. The dashes represent 95% confidence intervals. The trend lines shown are exponential regression lines of the ratios of actual to expected deaths.

An exponential trend line is more appropriate than a linear regression line for determining the rate of improvement implied by the data. When the mortality ratios are similar to each other, there is little difference between the two methods, but as the mortality ratios vary more, the exponential improvement rate more reasonably models the dependence. (For example, the trend line cannot go negative.)

The exponential trend line is represented by the following formula, where “*a*”, or more precisely e^a , measures the proportional annual rate of change in mortality:

$$Y = b \times e^{ax}$$

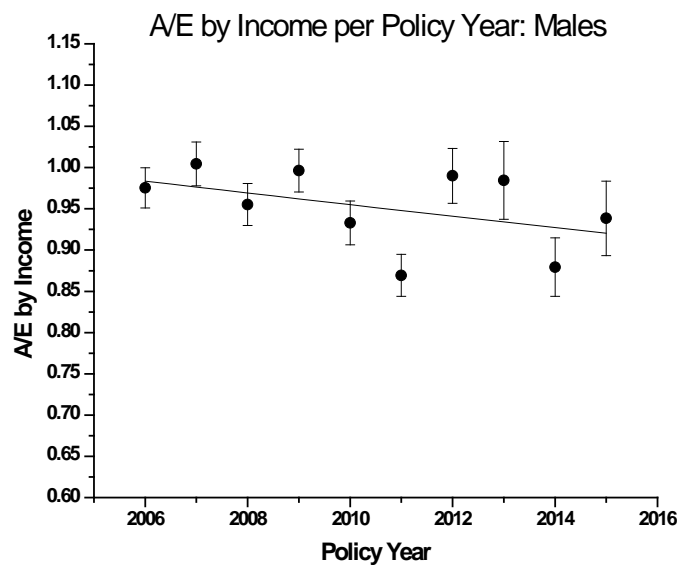
The *P*-values give the probabilities that the apparent trends are due to chance. *P*-values less than 0.05 are commonly considered significant.

Figures 3A–C show the trends of male single life mortality ratios by income by policy year. Figure 3A shows all male data, while figures 3B and 3C show RRSP-only and NR-UTC-only business, respectively. Figures 3D–F show A/E results for female single life policies.

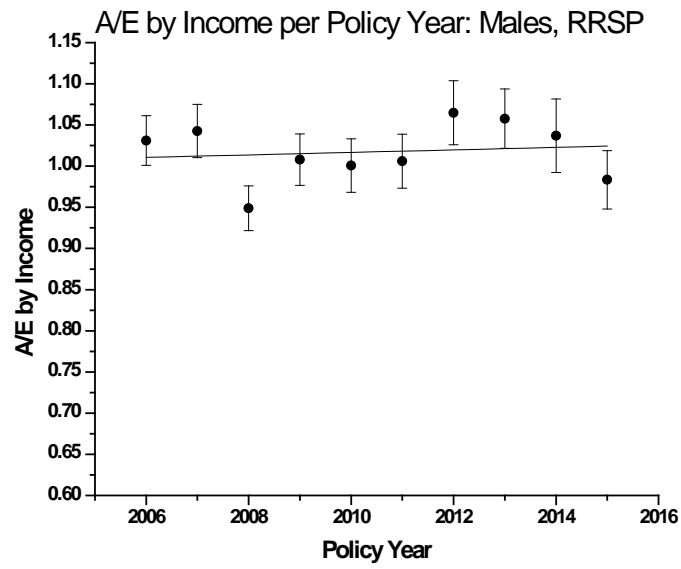
For both sexes, the overall and NR-UTC summaries below have negative “*a*” factors, indicating a general decrease in mortality ratios over time greater than the adopted mortality improvement scale. For female overall and NR-UTC business, the sample sizes are large enough, and the variability over time small enough, that the measured trends are statistically significant, suggesting that the improvement is not due to chance.

Figure 3. A/E by Income per Policy Year

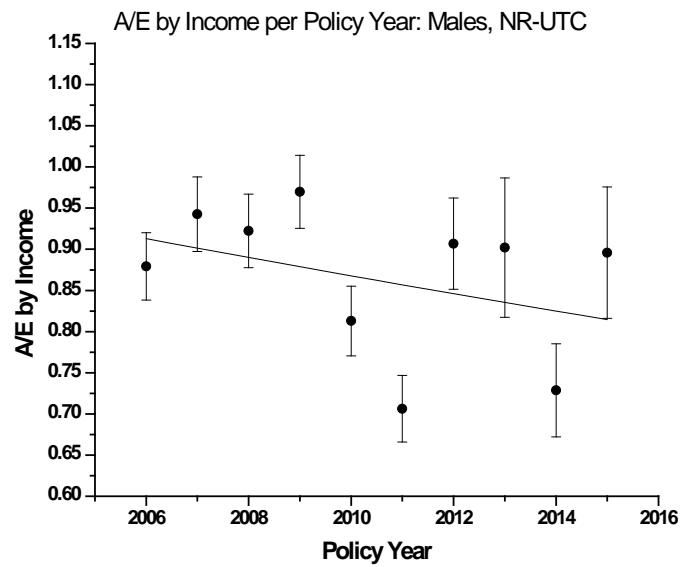
A. Males ($a = -0.0074$; $P = 0.2055$)



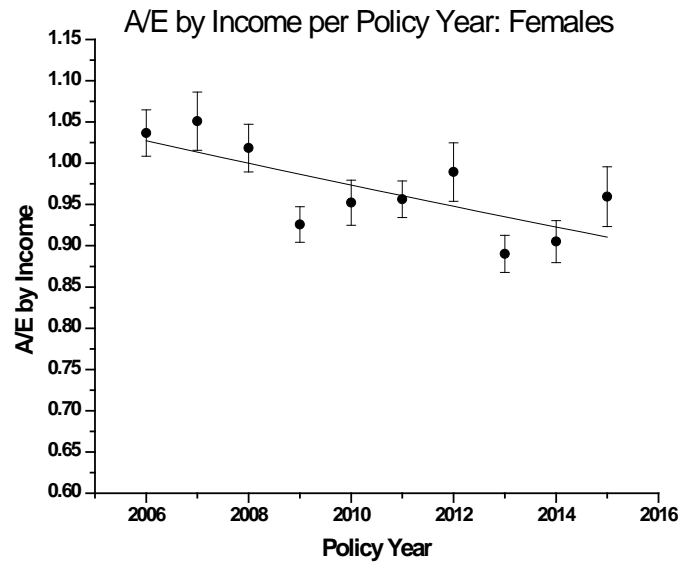
B. Males, RRSP ($\alpha = 0.0015$; $P = 0.7233$)



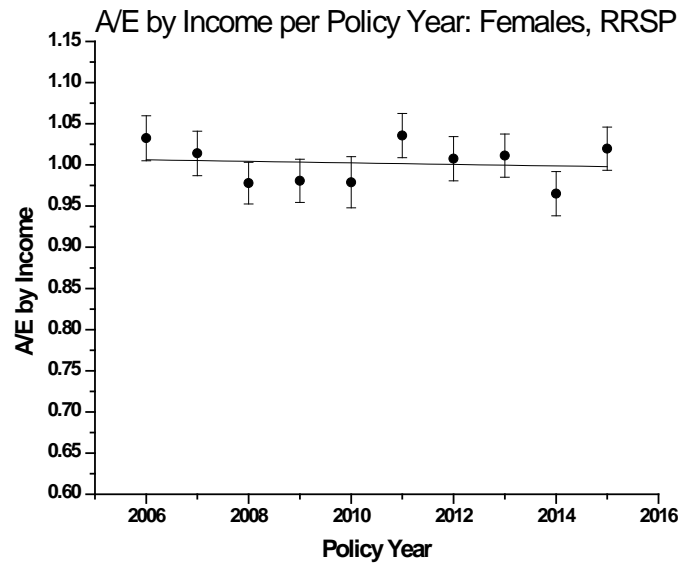
C. Males, NR-UTC ($\alpha = -0.0126$; $P = 0.3131$)



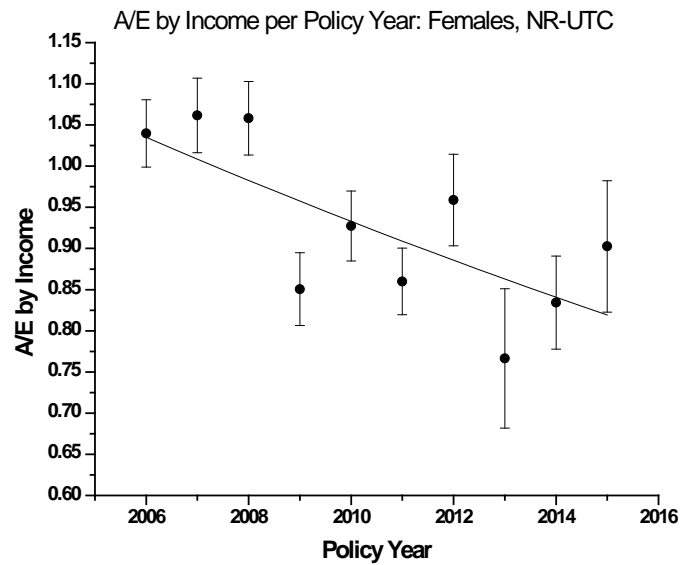
D. Females ($\alpha = -0.0134$; $P = 0.0187$)



E. Females, RRSP ($\alpha = -0.0009$; $P = 0.7562$)



F. Females, NR-UTC ($\alpha = -0.0260$; $P = 0.0217$)



The plots above show for RRSP business that observed mortality improvement is similar to the CIA scale resulting in a flat result by calendar year.

Income Study Observations (Single Life Data Only)

The study by amount of income explores in greater detail the previous observations about the relationship between income and mortality ratios. Mortality ratios are lowest for the largest policy incomes for both males and females. This pattern is more pronounced for NR-UTC business.

The pattern of decrease in mortality ratios with increase in policy size is observed in all categories. By splitting the male/female \$10,000+ band into sub-bands, we observe that the decreasing trend continues (table 5C). Actuaries dealing with valuation or pricing of annuities with very high income should be careful in selecting mortality assumptions. (Note also that as income has been growing over time, the A/E ratios at higher incomes are more heavily influenced by recent data, i.e., the years most affected by IBNR.)

Tables 5A–E provide overviews of results by income level.

Table 5A. Overall Results by Income Level, 2005–2015

Income	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	337,528	203,169,347	28,047	16,636,886	103.6	104.5	0.6	0.7
\$1,000–\$4,999	793,654	1,908,725,182	59,630	139,827,224	105.0	105.1	0.4	0.5
\$5,000–\$9,999	242,199	1,682,249,134	15,319	105,628,961	104.3	104.4	0.8	0.9
\$10,000+	163,277	3,778,800,662	8,698	179,937,772	93.9	85.4	1.0	1.4
Total	1,536,658	7,572,944,325	111,694	442,030,843	103.6	95.9	0.3	0.7

Table 5B. Overall Results by Income Level with Male/Female Split, 2005–2015

Income	Males				Females			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	104.6	105.1	0.9	1.0	102.8	104.0	0.8	0.9
\$1,000–\$4,999	106.2	106.5	0.7	0.7	104.0	104.0	0.6	0.6
\$5,000–\$9,999	104.1	104.4	1.2	1.3	104.4	104.4	1.1	1.2
\$10,000+	94.5	85.0	1.4	2.0	93.3	85.9	1.4	2.0
Total	104.4	95.2	0.5	1.0	102.9	96.6	0.4	0.9

Table 5C. Overall Results by High Income Level with Male/Female Split, 2005–2015

Income	Males				Females			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$10,000–\$19,999	98.9	98.4	1.8	1.8	96.2	95.8	1.7	1.7
\$20,000–\$49,999	88.0	87.0	2.6	2.7	86.5	84.7	2.8	2.8
\$50,000+	75.4	65.2	5.1	5.6	82.8	69.7	6.4	6.8
Total	94.5	85.0	1.4	2.0	93.3	85.9	1.4	2.0

Table 5D. Overall Results for RRSP with Male/Female Split, 2005–2015

Income	Males				Females			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	106.2	106.2	1.3	1.5	103.8	103.8	1.1	1.2
\$1,000–\$4,999	105.6	105.4	0.8	0.9	102.1	102.2	0.7	0.8
\$5,000–\$9,999	104.9	105.0	1.6	1.7	102.4	102.5	1.5	1.6
\$10,000+	98.1	95.5	2.2	2.6	94.6	93.1	2.4	2.8
Total	105.1	101.8	0.6	1.1	102.2	100.2	0.5	0.9

Table 5E. Overall Results for NR-UTC Policies with Male/Female Split, 2005–2015

Income	Males				Females			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	102.1	103.1	1.3	1.4	100.9	103.7	1.4	1.6
\$1,000–\$4,999	104.8	105.8	1.1	1.2	106.3	106.3	1.0	1.1
\$5,000–\$9,999	100.5	101.0	2.0	2.1	104.8	104.6	1.8	1.8
\$10,000+	87.5	76.1	2.0	2.9	91.2	82.0	1.8	2.7
Total	101.4	86.4	0.7	1.8	102.9	92.0	0.7	1.6

Tax Observations

Since this study reports results for individual life policies rather than group policies, there is a relatively small amount of RPP business compared to RRSP and NR-UTC business. One would expect A/E ratios to be the highest for RPP and lowest for NR-UTC policies, because RPP annuitants typically have minimal options other than annuitization. Tables 6A–B below show summaries of single life data by tax type.

Table 6A. Overall Results by Tax Type, 2005–2015

Tax Type	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
RRSP	795,298	3,081,670,891	63,317	210,571,978	103.5	101.0	0.4	0.7
RPP	114,640	600,591,090	5,925	27,526,617	116.4	114.5	1.5	2.8
NR-UTC	626,721	3,890,682,343	42,452	203,932,248	102.2	89.4	0.5	1.2
Total	1,536,658	7,572,944,325	111,694	442,030,843	103.6	95.9	0.3	0.7

It is possible that what we are seeing is a result of heterogeneity in the data. Disregarding RPP, note that the average annual income for RRSP is \$3,875 and for NR-UTC is \$6,208. Since experience improves with increasing size, it is possible that the difference due to RRSP and NR-UTC is really one associated with policy size.

Table 6B. Results by Tax Type for Males and Females, 2005–2015

Tax Type	Males				Females			
	A/E #	A/E \$	S.D. #	S.D. \$	A/E	A/E	S.D. #	S.D. \$
RRSP	105.1	101.8	0.6	1.1	102.2	100.2	0.5	0.9
RPP	118.9	113.6	2.1	3.7	113.5	116.0	2.2	4.1
NR-UTC	101.4	86.4	0.7	1.8	102.9	92.0	0.7	1.6
Total	104.4	95.2	0.5	1.0	102.9	96.6	0.4	0.9

Select/Ultimate Observations

Tables 7A–B give overviews of the select and ultimate single life mortality ratios in this study. The difference in experience between the select and ultimate policies has been used as a measure of selection. This measure depends heavily on the mortality table used for expected deaths. Its use as a measure of selection is tempered by tables E1 and E2 and table 1 in appendix 2 which show that experience decreases with age even for ultimate policies. Age, duration, and policy year are algebraically confounded. Their separate effects cannot be determined easily without the use of more advanced statistical techniques. Since age increases with duration, the differences between select and ultimate experience are due in part to differences in age. Below, with this caveat, the tables suggest the following observations:

- There is self-selection;
- The self-selection is mainly present during a select period of approximately 10 years; and
- Within the first 10 years following the policy issuance, self-selection is greatest in the early years, and steadily declines over time.

Table 7A. Overall Ultimate – Select Mortality Experience (10-year Select Period), 2005–2015

Duration	Mortality Ratios				Ultimate minus Select			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
1	65.3	45.3	3.5	3.9	38.8	55.8	3.5	4.0
2	76.1	57.7	3.5	5.3	28.0	43.4	3.5	5.4
3	93.5	74.9	3.6	6.1	10.7	26.3	3.6	6.2
4	100.3	77.6	3.6	5.5	3.8	23.6	3.6	5.5
5	98.7	79.1	3.5	5.2	5.4	22.1	3.5	5.2
6	99.2	107.3	3.4	9.9	5.0	-6.1	3.5	9.9
7	98.1	68.2	3.4	5.1	6.0	32.9	3.4	5.1
8	98.8	73.4	3.3	6.7	5.3	27.7	3.3	6.7
9	107.1	79.2	3.2	6.9	-3.0	22.0	3.2	7.0
10	109.9	80.8	3.1	4.6	-5.8	20.4	3.1	4.6
Ultimate	104.1	101.2	0.3	0.7	--	--	--	--
Total	103.6	95.9	0.3	0.7	--	--	--	--

Table 7B. Overall Ultimate – Select Mortality Experience (25-year Select Period), 2005–2015

Duration	Mortality Ratios				Ultimate minus Select			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
1–5	88.7	68.5	1.6	2.4	8.9	28.1	1.7	2.6
6–10	103.2	81.7	1.5	3.1	-5.6	14.9	1.5	3.2
11–15	112.6	96.0	1.2	2.7	-15.0	0.6	1.3	2.8
16–20	113.2	107.5	0.8	1.7	-15.5	-10.9	1.0	1.9
21–25	107.0	104.8	0.6	1.1	-9.3	-8.2	0.8	1.4
Ultimate	97.7	96.6	0.5	0.9	--	--	--	--
Total	103.6	95.9	0.3	0.7	--	--	--	--

Further splitting by income band shows a clear relationship between self-selection and income band. This supports the notion that individuals investing a larger amount of money in annuity products are better informed of their health, and/or have invested so that they can maintain good health, thus increasing the impact of self-selection. Table 7C uses a select period of 10 years.

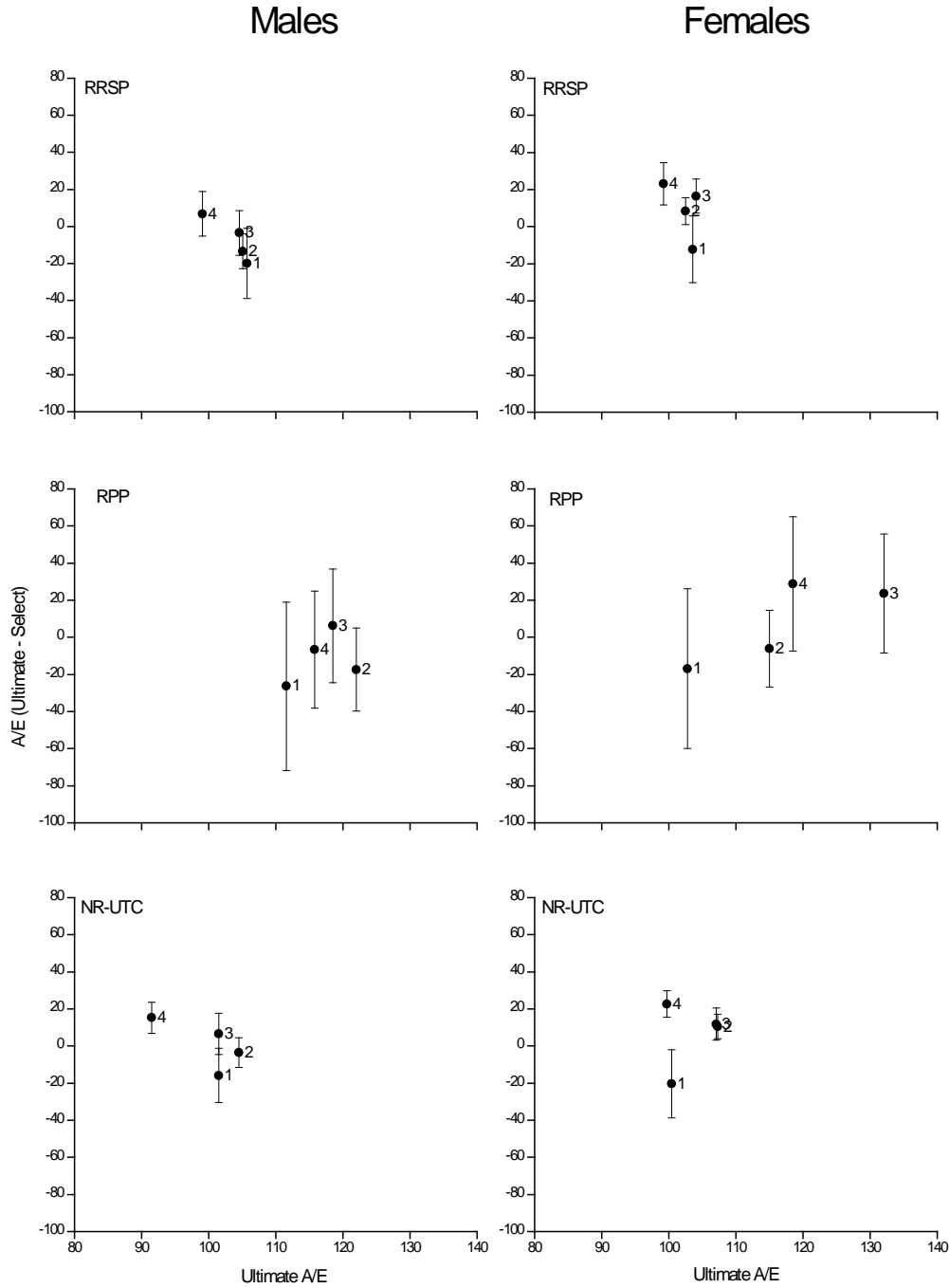
Table 7C. Ultimate – Select Mortality Experience by Income Band (10-year Select Period), 2005–2015

Income	Ultimate minus Select			
	A/E		S.D.	
	#	\$	#	\$
\$0–\$999	-17.1	-13.6	4.2	4.3
\$1,000–\$4,999	0.1	1.4	1.8	2.0
\$5,000–\$9,999	9.0	9.1	2.4	2.5
\$10,000+	18.7	26.7	2.2	3.1
Total	6.9	25.6	1.1	2.1

The above tables indicate that experience, as measured by A/E, depends in important ways on duration, sex, tax type, and income. The following displays are based on grouping single life policies by sex, income, and tax type.

Figure 4A. A/E by Number of Policies (Ultimate – Select) as a Function of Ultimate A/E

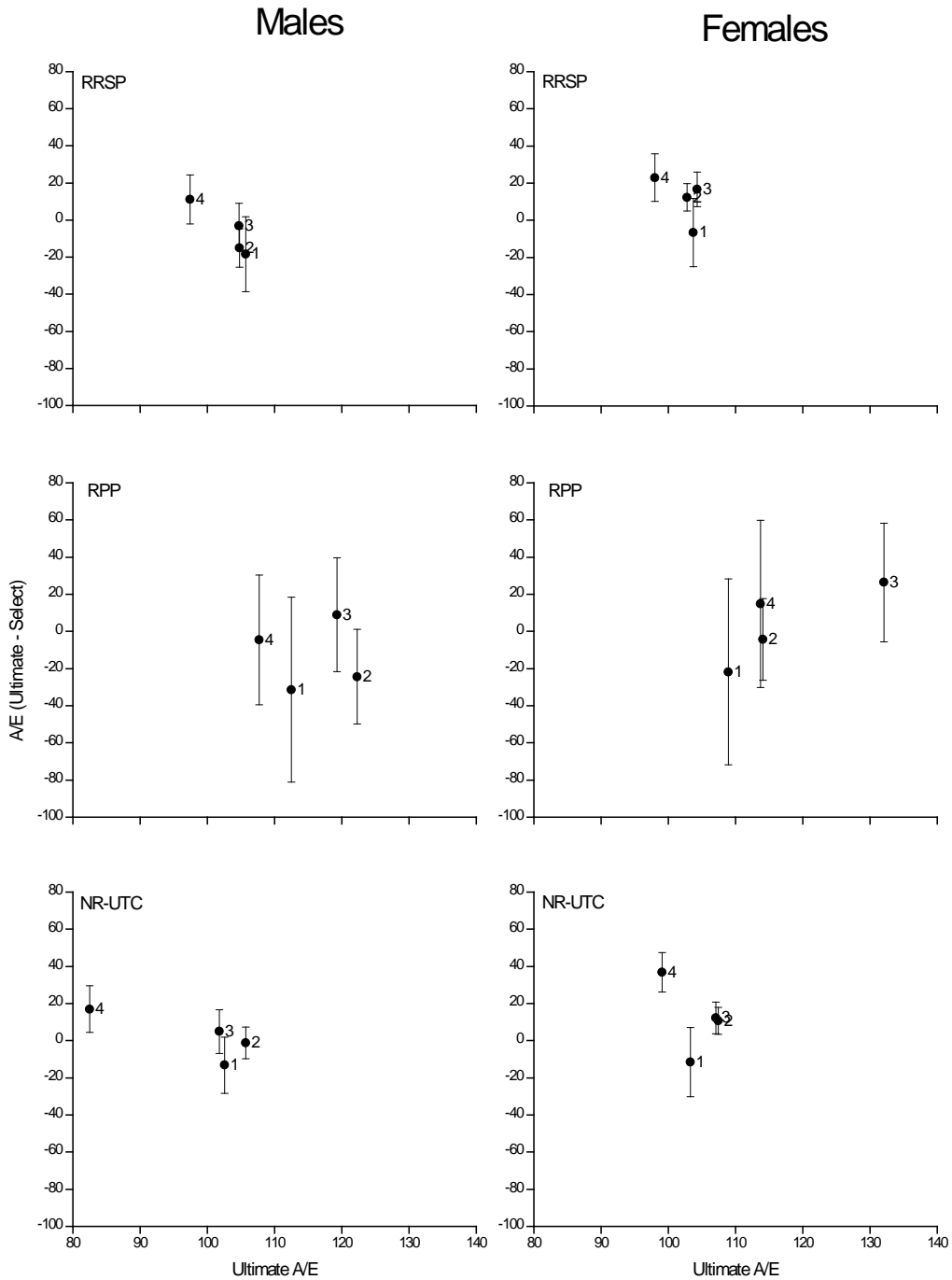
Plots are shown for males, females, three tax types, and four income bands. Income band: 1 = \$0–\$999; 2 = \$1,000–\$4,999; 3 = \$5,000–\$9,999; 4 = \$10,000+. We show 95% confidence intervals.



The above displays show small differences in A/E (Ultimate – Select).

Figure 4B. A/E by Annualized Income (Ultimate – Select) as a Function of Ultimate A/E

Plots are shown for males, females, three tax types, and four income bands. Income band: 1 = \$0–\$999; 2 = \$1,000–\$4,999; 3 = \$5,000–\$9,999; 4 = \$10,000+. We show 95% confidence intervals.



The largest difference in A/E (Ultimate – Select) is for female NR-UTC business between the highest income band and incomes less than \$10,000. For male NR-UTC, the Ultimate – Select difference is only slightly larger for the largest income band, but the ultimate A/E is much lower than incomes less than \$10,000.

Table 8 below presents the A/E ratios for all groups of policies.

Table 8. A/E Ratios for Males and Females with Four Income Bands and Three Tax Types (Income Bands as for Figure 4), 2005–2015

			A/E						S.D. of Difference	
			Select		Ultimate		Ultimate – Select		By #	By \$
Sex	Income Band	Tax Type	By #	By \$	By #	By \$	By #	By \$		
Males	1	RRSP	125.7	124.1	105.7	105.7	-20.0	-18.3	9.5	10.1
Males	1	RPP	137.9	143.9	111.6	112.5	-26.4	-31.4	22.7	24.9
Males	1	NR-UTC	117.4	115.8	101.5	102.6	-15.9	-13.2	7.3	7.6
Males	2	RRSP	118.5	119.7	105.1	104.8	-13.4	-15.0	4.7	5.2
Males	2	RPP	139.4	146.6	122.0	122.3	-17.4	-24.4	11.2	12.7
Males	2	NR-UTC	107.9	106.9	104.5	105.7	-3.5	-1.2	4.0	4.3
Males	3	RRSP	108.1	107.9	104.6	104.7	-3.5	-3.1	6.0	6.1
Males	3	RPP	112.3	110.3	118.5	119.3	6.2	9.0	15.3	15.3
Males	3	NR-UTC	94.8	96.9	101.5	101.8	6.6	4.9	5.6	5.9
Males	4	RRSP	92.4	86.3	99.1	97.4	6.8	11.0	6.0	6.6
Males	4	RPP	122.5	112.3	115.8	107.7	-6.7	-4.6	15.8	17.5
Males	4	NR-UTC	76.1	65.5	91.5	82.5	15.3	17.0	4.2	6.3
Females	1	RRSP	115.8	110.4	103.6	103.7	-12.2	-6.7	9.0	9.2
Females	1	RPP	119.6	130.7	102.8	108.9	-16.9	-21.8	21.5	25.0
Females	1	NR-UTC	120.8	114.9	100.4	103.3	-20.4	-11.6	9.2	9.3
Females	2	RRSP	94.0	90.5	102.5	102.8	8.4	12.3	3.6	3.7
Females	2	RPP	121.1	118.5	115.0	114.1	-6.1	-4.4	10.3	11.0
Females	2	NR-UTC	96.8	96.7	107.3	107.4	10.5	10.7	3.3	3.6
Females	3	RRSP	87.7	87.8	104.1	104.3	16.4	16.6	4.6	4.7
Females	3	RPP	108.5	105.7	132.1	132.1	23.6	26.4	16.0	16.0
Females	3	NR-UTC	95.4	94.9	107.1	107.1	11.8	12.2	4.3	4.3
Females	4	RRSP	76.0	75.1	99.2	98.0	23.2	22.9	5.7	6.4
Females	4	RPP	89.6	98.9	118.5	113.7	28.8	14.8	18.1	22.5
Females	4	NR-UTC	77.0	62.4	99.7	99.1	22.7	36.8	3.6	5.3

Non-refund/Refund Observations

There are several difficulties when comparing refund and non-refund business:

- There is much less non-refund business than refund business, although the percentage of non-refund business has been increasing in the last few study years;
- The length of the certain period on refund business is not homogeneous; and
- Some companies have difficulties classifying refund business correctly after the certain period has expired.

Table 9 shows both mortality ratios and standard deviations for single life policies. As can be seen by the standard deviations for the non-refund ratios, there is less precision with this experience.

Despite this imprecision and the above concerns, we can make some interesting observations. For single life policies (both male and female), the non-refund mortality ratios are lower than the refund mortality ratios when measured by annualized income. That does not seem to be the case when measured by number of policies.

The non-refund mortality ratios by income are lower than the refund mortality ratios for all three tax types and for the three highest income bands. These results certainly warrant investigation in pricing non-refund annuities.

One possible explanation for the difference observed based on refund status is that the annuitants may have additional information on their health status, such as under back-to-back policies, and they then choose the appropriate type of annuity. Thus, one would expect that annuitants who choose non-refund policies believe that they have good health status and are willing to receive a higher annuity income at the risk of receiving nothing at time of death.

Table 9. Mortality Experience by Refund Type, 2005–2015

Experience	Refund	Exposed		Deaths		A/E		S.D.	
		#	\$	#	\$	#	\$	#	\$
Total	No	422,971	2,566,157,507	39,162	173,780,009	107.9	91.4	0.5	1.2
Total	Yes	1,113,687	5,006,786,818	72,532	268,250,834	101.4	99.1	0.4	0.8
Males	No	171,849	1,130,546,099	16,594	78,885,068	107.3	87.7	0.8	1.8
Males	Yes	482,477	2,291,998,701	34,445	134,932,577	103.1	100.3	0.6	1.3
Females	No	251,122	1,435,611,408	22,568	94,894,941	108.4	94.8	0.7	1.6
Females	Yes	631,210	2,714,788,117	38,087	133,318,257	99.9	97.9	0.5	1.0
RRSP	No	196,903	787,524,080	19,771	66,938,297	104.2	100.5	0.7	1.2
RRSP	Yes	598,395	2,294,146,811	43,546	143,633,681	103.1	101.2	0.5	0.8
RPP	No	33,670	185,592,061	2,329	11,369,499	113.9	111.6	2.4	4.5
RPP	Yes	80,969	414,999,029	3,596	16,157,118	118.1	116.6	2.0	3.6
NR-UTC	No	192,397	1,593,041,366	17,062	95,472,213	111.6	84.3	0.9	1.8
NR-UTC	Yes	434,323	2,297,640,977	25,390	108,460,035	96.7	94.4	0.6	1.6
\$0–\$999	No	91,151	52,799,463	9,939	5,676,127	109.2	110.9	1.1	1.2
\$0–\$999	Yes	246,377	150,369,884	18,108	10,960,759	100.8	101.5	0.7	0.8
\$1,000–\$4,999	No	207,921	506,687,004	20,102	47,749,028	111.9	111.3	0.8	0.9
\$1,000–\$4,999	Yes	585,734	1,402,038,178	39,528	92,078,196	101.8	102.2	0.5	0.6
\$5,000–\$9,999	No	67,236	465,423,163	5,488	37,800,483	106.2	106.3	1.4	1.5
\$5,000–\$9,999	Yes	174,963	1,216,825,971	9,831	67,828,478	103.2	103.3	1.0	1.1
\$10,000–\$19,999	No	35,388	479,995,723	2,466	33,375,093	94.8	94.2	1.9	1.9
\$10,000–\$19,999	Yes	76,084	1,023,525,299	3,770	50,276,157	99.4	99.1	1.6	1.6
\$20,000–\$49,999	No	16,566	474,291,511	946	26,672,136	81.6	79.7	2.7	2.7
\$20,000–\$49,999	Yes	25,980	723,072,974	1,128	31,466,144	92.9	92.1	2.8	2.8
\$50,000+	No	4,710	586,960,643	221	22,507,142	72.9	59.9	4.9	5.0
\$50,000+	Yes	4,549	490,954,512	167	15,641,100	87.3	81.1	6.8	8.0
Select (10)	No	55,148	863,524,183	1,709	21,808,218	88.2	57.6	2.1	2.9
Select (10)	Yes	255,644	1,850,241,550	6,332	49,243,311	99.9	87.7	1.3	2.7
Ultimate	No	367,823	1,702,633,324	37,453	151,971,791	109.0	99.8	0.6	1.3
Ultimate	Yes	858,043	3,156,545,268	66,200	219,007,523	101.5	102.1	0.4	0.7

Back-to-Back Policy Observations

The project oversight group isolated the experience of back-to-back annuities. In this study, we assume that the non-refund and NR-UTC policies with higher income bands are back-to-back annuities. Table 10A compares the non-refund and NR-UTC policies by income bands.

Although the data for non-refund and NR-UTC policies are sparse, they indicate that single life policies have monotonically decreasing mortality ratios (except for the smallest policies) when measured by number of deaths or by income. The pattern is similar for joint, both alive (except for the largest policies, by income).

Table 10A. Single, Non-refund and NR-UTC Experience Only, 2005–2015

Experience	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	45,049	25,007,419	4,690	2,562,106	114.4	118.3	1.7	1.9
\$1,000–\$4,999	80,443	195,657,458	7,648	18,106,438	122.6	121.8	1.4	1.5
\$5,000–\$9,999	31,157	217,370,060	2,511	17,440,829	108.1	107.9	2.2	2.2
\$10,000–\$19,999	19,925	273,252,053	1,376	18,922,035	90.8	90.5	2.4	2.5
\$20,000–\$49,999	11,664	337,347,707	651	18,477,709	76.2	74.2	3.0	3.0
\$50,000+	4,159	544,406,668	186	19,963,096	71.8	58.2	5.3	5.3
Total	192,397	1,593,041,366	17,062	95,472,213	111.6	84.3	0.9	1.8

Table 10B. Joint (Both Alive), Non-refund and NR-UTC Experience Only, 2005–2015

Experience	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	5,969	3,713,078	301	183,428	78.0	76.1	4.5	4.7
\$1,000–\$4,999	23,271	56,111,190	1,044	2,638,779	87.0	89.0	2.7	3.0
\$5,000–\$9,999	8,363	59,309,675	389	2,679,372	83.7	82.0	4.2	4.2
\$10,000–\$19,999	5,547	77,305,732	203	2,851,638	73.2	74.8	5.1	5.4
\$20,000–\$49,999	2,950	85,713,163	104	2,928,188	73.4	72.6	7.2	7.4
\$50,000+	1,088	149,434,816	29	6,319,746	56.2	86.3	10.4	25.3
Total	47,188	431,587,653	2,070	17,601,151	82.1	81.3	1.8	8.7

Table 10C. Joint (One Survivor), Non-refund and NR-UTC Experience Only, 2005–2015

Experience	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	5,087	3,114,454	515	301,823	94.4	93.1	4.2	4.5
\$1,000–\$4,999	13,844	33,408,467	1,290	3,126,118	99.5	100.2	2.8	3.1
\$5,000–\$9,999	3,968	27,446,668	405	2,758,140	106.4	106.3	5.3	5.4
\$10,000–\$19,999	2,027	27,198,377	198	2,560,326	104.3	101.8	7.4	7.4
\$20,000–\$49,999	833	22,909,971	73	1,912,368	96.5	92.1	11.3	11.0
\$50,000+	132	11,139,392	14	1,880,247	104.1	185.2	27.8	102.4
Total	25,892	125,217,330	2,495	12,539,022	99.7	107.7	2.0	9.4

By splitting the single back-to-back business by male and female, we observe that the mortality ratios show the same pattern. (See tables 10D and 10E.)

Table 10D. Single, Male, Non-refund and NR-UTC Experience Only, 2005–2015

Experience	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	23,388	13,624,686	2,208	1,258,788	117.5	118.1	2.5	2.7
\$1,000–\$4,999	34,500	80,455,430	3,277	7,585,912	120.9	120.6	2.1	2.3
\$5,000–\$9,999	12,433	86,891,032	984	6,908,825	103.4	103.4	3.3	3.4
\$10,000–\$19,999	7,878	108,597,824	581	8,037,554	90.6	90.1	3.8	3.8
\$20,000–\$49,999	5,015	145,394,437	303	8,806,011	72.1	71.2	4.1	4.2
\$50,000+	1,897	261,266,390	95	9,902,336	72.3	54.4	7.4	6.9
Total	85,112	696,229,798	7,448	42,499,426	110.6	79.4	1.3	2.7

Table 10E. Single, Female, Non-refund and NR-UTC Experience Only, 2005–2015

Experience	Exposed		Deaths		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	21,660	11,382,733	2,482	1,303,318	111.8	118.4	2.2	2.6
\$1,000–\$4,999	45,943	115,202,028	4,371	10,520,526	124.0	122.7	1.9	2.0
\$5,000–\$9,999	18,724	130,479,029	1,527	10,532,004	111.4	111.0	2.9	2.9
\$10,000–\$19,999	12,047	164,654,229	795	10,884,481	91.0	90.7	3.2	3.3
\$20,000–\$49,999	6,648	191,953,270	348	9,671,698	80.1	77.1	4.3	4.3
\$50,000+	2,262	283,140,278	91	10,060,760	71.3	62.5	7.5	8.2
Total	107,285	896,811,567	9,614	52,972,787	112.4	88.6	1.1	2.5

Tables 10F–J show the results for back-to-back policies vs. non-back-to-back policies. To exhibit the known decreasing trend in A/E by income, these tables compare back-to-back business with all other business.

Table 10F. Single, Back-to-back vs. Non-back-to-back Experience, 2005–2015

Experience	Non-refund NR-UTC				Everything Else			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	114.4	118.3	1.7	1.9	101.7	102.4	0.7	0.7
\$1,000–\$4,999	122.6	121.8	1.4	1.5	102.8	103.0	0.5	0.5
\$5,000–\$9,999	108.1	107.9	2.2	2.2	103.5	103.7	0.9	0.9
\$10,000–\$19,999	90.8	90.5	2.4	2.5	99.6	99.2	1.4	1.5
\$20,000–\$49,999	76.2	74.2	3.0	3.0	93.6	92.8	2.5	2.5
\$50,000+	71.8	58.2	5.3	5.3	85.8	80.6	6.0	7.2
Total	111.6	84.3	0.9	1.8	102.3	99.7	0.3	0.7

Table 10G. Joint (Both Alive), Back-to-back vs. Non-back-to-back Experience, 2005–2015

Experience	Non-refund NR-UTC				Everything Else			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	78.0	76.1	4.5	4.7	101.6	99.7	1.4	1.5
\$1,000–\$4,999	87.0	89.0	2.7	3.0	98.4	98.5	0.7	0.8
\$5,000–\$9,999	83.7	82.0	4.2	4.2	95.7	95.5	1.1	1.2
\$10,000–\$19,999	73.2	74.8	5.1	5.4	92.6	92.3	1.7	1.7
\$20,000–\$49,999	73.4	72.6	7.2	7.4	88.7	89.1	2.8	2.9
\$50,000+	56.2	86.3	10.4	25.3	87.2	80.5	7.6	7.7
Total	82.1	81.3	1.8	8.7	97.4	93.6	0.5	0.9

Table 10H. Joint (One Survivor), Back-to-back vs. Non-back-to-back Experience, 2005–2015

Experience	Non-refund NR-UTC				Everything Else			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	94.4	93.1	4.2	4.5	111.6	111.7	1.4	1.5
\$1,000–\$4,999	99.5	100.2	2.8	3.1	108.9	109.3	0.7	0.8
\$5,000–\$9,999	106.4	106.3	5.3	5.4	105.8	105.8	1.3	1.3
\$10,000–\$19,999	104.3	101.8	7.4	7.4	103.9	103.3	2.1	2.1
\$20,000–\$49,999	96.5	92.1	11.3	11.0	101.7	102.4	4.0	4.1
\$50,000+	104.1	185.2	27.8	102.4	91.7	93.8	12.5	13.4
Total	99.7	107.7	2.0	9.4	108.3	105.8	0.6	0.9

Table 10I. Single, Male, Back-to-back vs. Non-back-to-back Experience, 2005–2015

Experience	Non-refund NR-UTC				Everything Else			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	117.5	118.1	2.5	2.7	102.3	103.0	1.0	1.1
\$1,000–\$4,999	120.9	120.6	2.1	2.3	104.4	104.8	0.7	0.8
\$5,000–\$9,999	103.4	103.4	3.3	3.4	104.3	104.6	1.3	1.4
\$10,000–\$19,999	90.6	90.1	3.8	3.8	101.0	100.6	2.0	2.0
\$20,000–\$49,999	72.1	71.2	4.1	4.2	95.7	94.8	3.3	3.4
\$50,000+	72.3	54.4	7.4	6.9	78.0	78.7	7.0	9.0
Total	110.6	79.4	1.3	2.7	103.4	100.2	0.5	1.1

Table 10J. Single Female, Back-to-back vs. Non-back-to-back Experience, 2005–2015

Experience	Non-refund NR-UTC				Everything Else			
	A/E		S.D.		A/E		S.D.	
	#	\$	#	\$	#	\$	#	\$
\$0–\$999	111.8	118.4	2.2	2.6	101.1	101.9	0.9	1.0
\$1,000–\$4,999	124.0	122.7	1.9	2.0	101.5	101.6	0.6	0.7
\$5,000–\$9,999	111.4	111.0	2.9	2.9	102.9	103.0	1.2	1.3
\$10,000–\$19,999	91.0	90.7	3.2	3.3	98.1	97.7	2.0	2.1
\$20,000–\$49,999	80.1	77.1	4.3	4.3	90.8	90.0	3.7	3.8
\$50,000+	71.3	62.5	7.5	8.2	101.7	84.0	11.4	11.9
Total	112.4	88.6	1.1	2.5	101.3	99.3	0.4	0.9

A/E by income for single male and female back-to-back policies decreases much more as policy size increases than it does for non-back-to-back policies. However, this is not true for joint policies. Although the overall A/E by income for joint (both alive) annuitants is lower for back-to-back policies, the decreasing pattern with increasing policy size is apparent only for A/E by number.

Joint and Survivor Policy Observations

Figure 5A illustrates the male aggregate mortality ratios by income for single life, joint life (both alive), and joint survivor policies. The data clearly indicate significantly higher ratios for joint survivor policies than for joint life policies (both alive) or single life policies. Ratios for joint (both alive) and single policies do not show a marked difference.

Figure 5. A/E by Income per Policy Year for Three Annuitant Types

A. Males

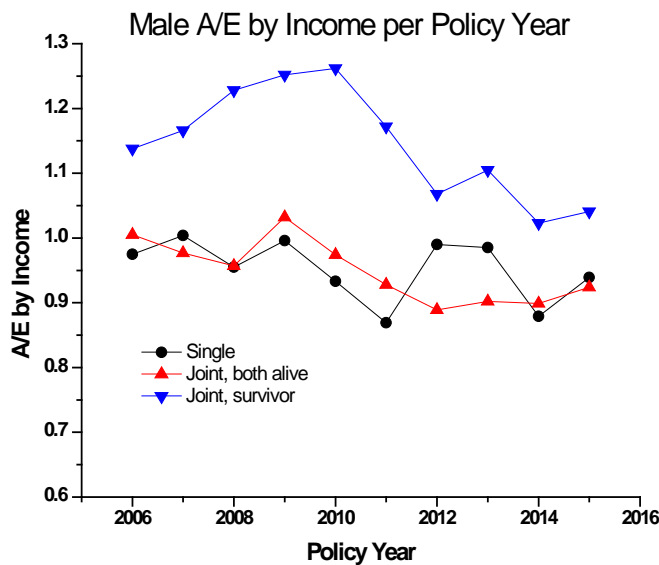
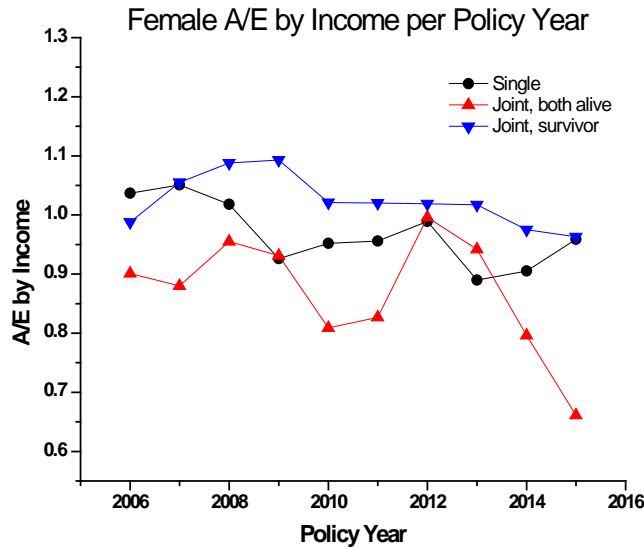


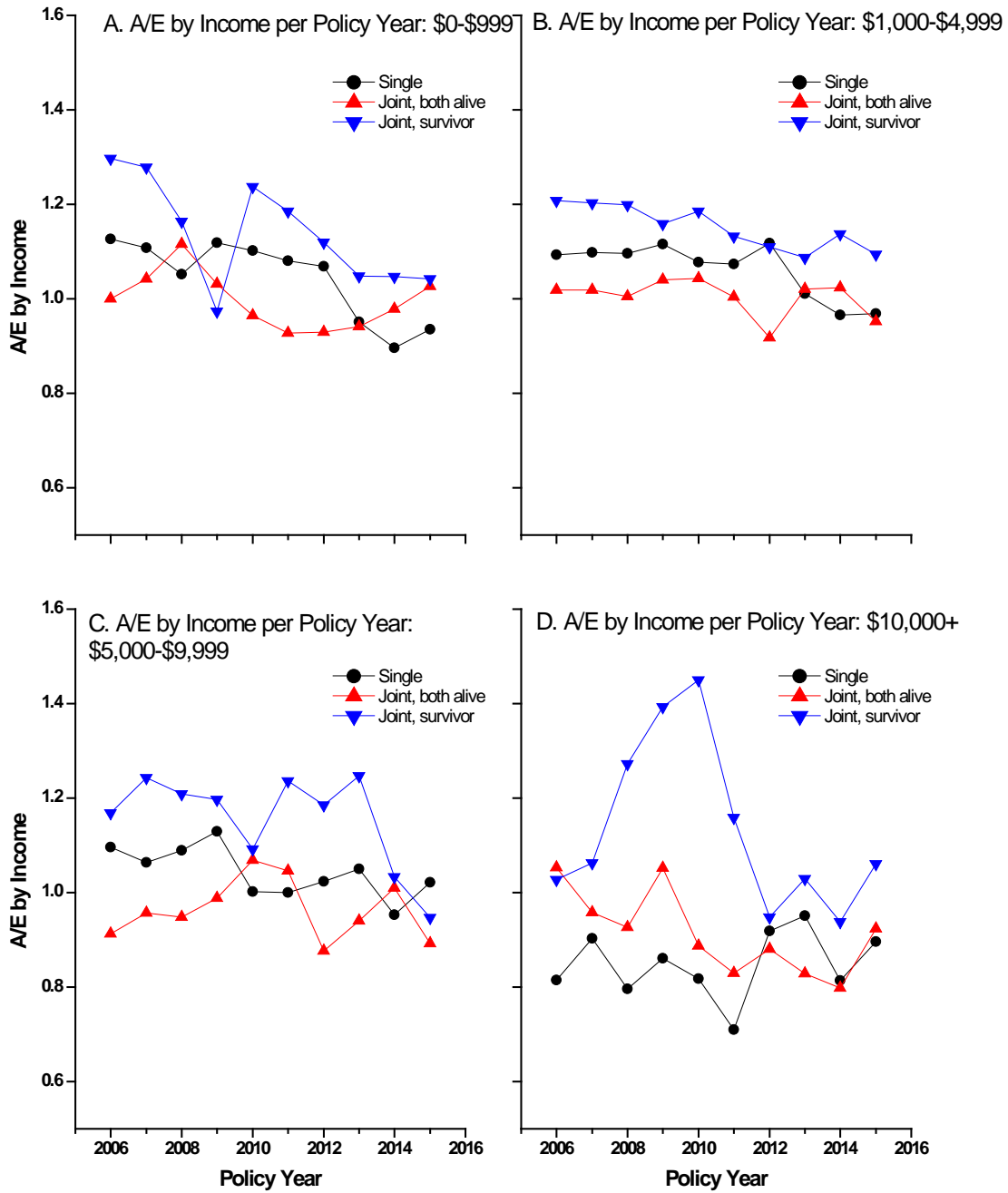
Figure 5B illustrates the corresponding aggregate mortality ratios for female lives. In this case, the data indicate a somewhat higher mortality for joint survivor policies compared with joint, both alive. For males, joint, both alive and single mortality are similar, with joint survivor mortality much higher; for females, joint survivor mortality is somewhat higher than single mortality, and both are generally higher than joint, both alive. The apparent drop in female A/E in recent years for joint policies may be attributed to deaths not being reported or being reported late, as evidenced by the higher IBNR factors for joint female annuitants (see appendix 1).

B. Females



Figures 6A–D illustrate the aggregate mortality ratios for males, for each of the four income bands, for single life, joint life (both alive), and joint survivor policies. The joint (both alive) policies generally have lower A/E ratios than single and survivor policies at lower income levels; joint survivor A/E ratios are highest for all income bands.

Figure 6A–D. Males—A/E by Income per Policy Year for Three Annuitant Types and Four Income Bands



Similarly, figures 6E–H illustrate the aggregate mortality ratios for females. Generally, the joint (both alive) policies have lower A/E ratios than single and survivor policies. Unlike the males, joint survivor A/E ratios are similar to the single A/E ratios, except at the highest income band.

Figure 6E–H. Females—A/E by Income per Policy Year for Three Annuitant Types and Four Income Bands

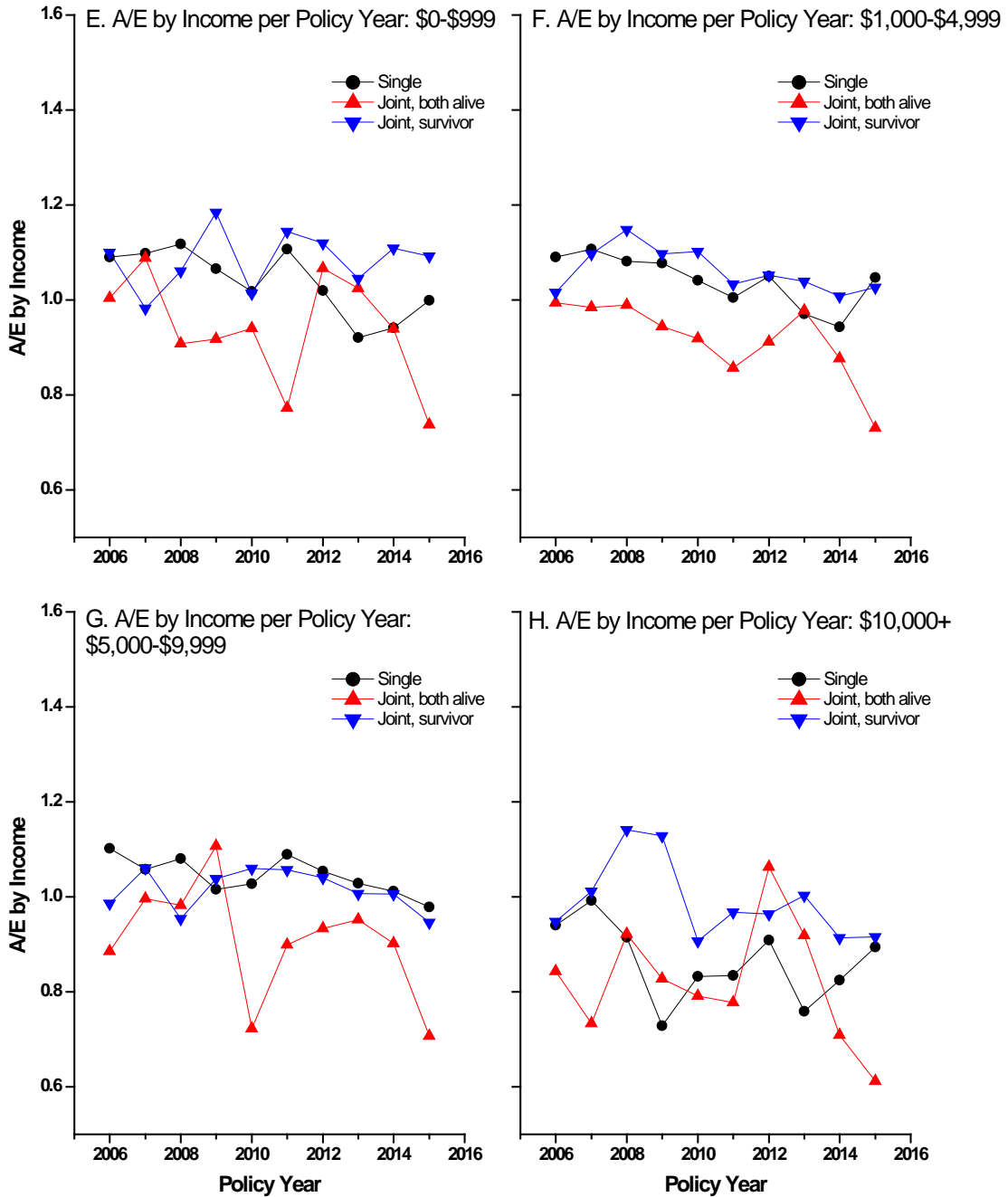
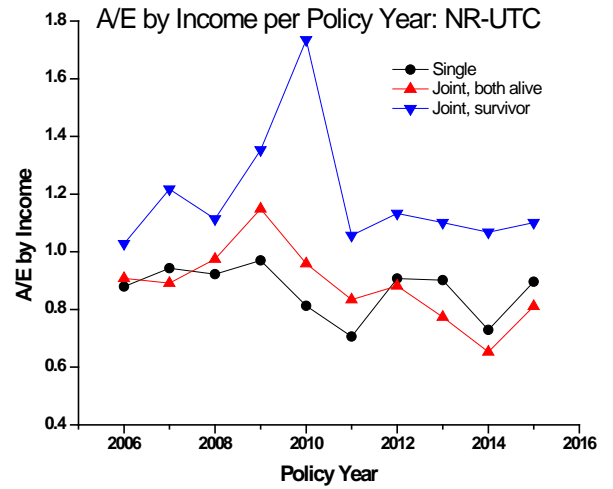
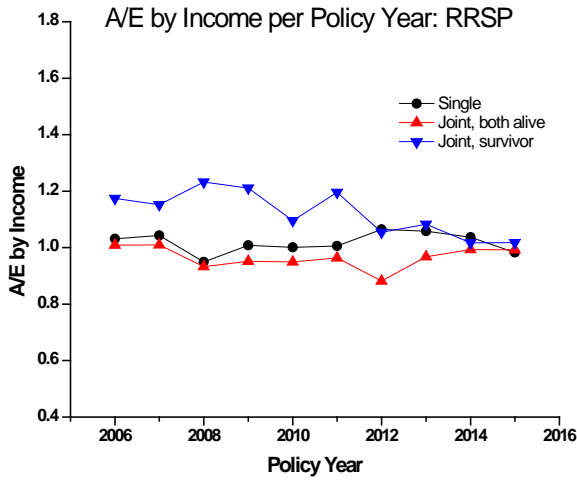


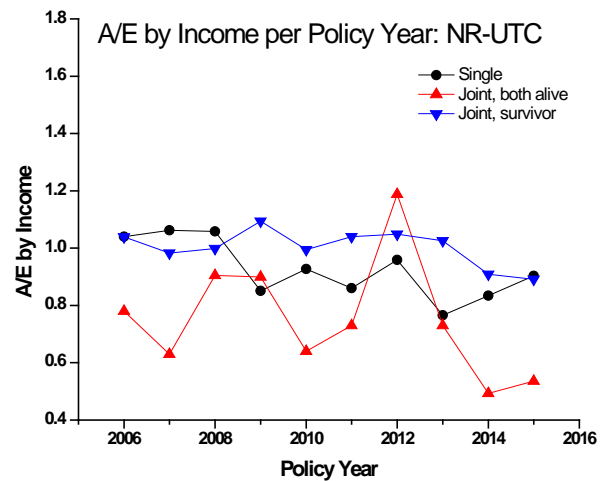
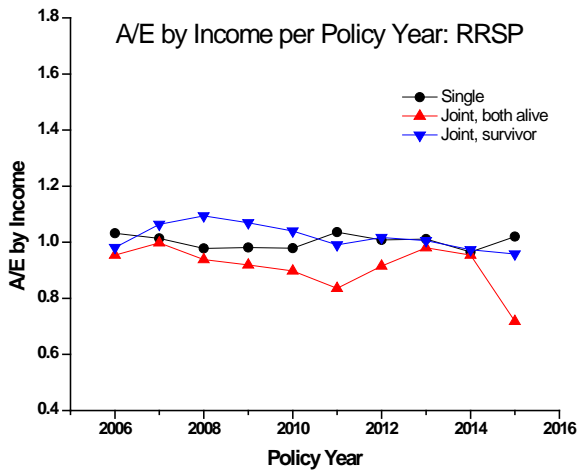
Figure 7 illustrates the ratios by tax status. For males, the NR-UTC mortality ratios tend to be much higher for joint survivors than for joint (both alive) or single life policies.

Figure 7. A/E by Income per Policy Year for Three Annuitant Types and Two Tax Types

A. Males



B. Females



7. Contributing Companies

Table 11 shows, for each of the contributing companies, the proportion of deaths on single life policies submitted for 2005–2015.

Table 11. Contributions of Companies

Company	2005–2014	2014–2015
Canada Life	18.6%	17.6%
Co-operators	1.3%	1.8%
Great-West	6.0%	3.6%
Industrial	6.6%	6.4%
Manulife	27.7%	27.2%
Standard Life	9.7%	10.2%
Sun Life	30.3%	33.3%

8. Individual Annuitant Mortality Experience Project Oversight Group Members

This report was approved by the CIA Research Executive Committee and the members of the Individual Annuitant Mortality Experience Project Oversight Group: Taylor Wasko (Chair), Greg Bacon, Louis-Olivier Buteau, Nicolas Genois, and Jacob Reid.

This report was prepared by Barbara Thomson of Thomson Data Analysis (TDA) in collaboration with David Andrews of TDA and various project oversight group members.

June 2017

Toronto, ON

Appendix 1: IBNR (Incurred But Not Reported)

The incidence of late-reported deaths varies by company, year, annuitant type, and sex. Due to limitations of the data received, estimating IBNR cannot be done as precisely as desired. However, the data do provide some indication of these rates.

For each company that reported annually and for each year of submission, we computed the number of deaths for that year and each succeeding submission year. We then computed the percent of total deaths for each year and each company for the year of submission and for the first, second, third, etc. years following.

The deaths that were reported with lags of one, two, and three years were summed separately. The deaths reported in the year of submission were summed for the years 2005–2014, 2005–2013, and 2005–2012, as those were the ranges of years that could have had deaths reported with lags one, two, and three. For example, only deaths that occurred in 2005–2013 could have been reported by 2015 with a lag of two years.

The percentages were computed by dividing the second set of totals by the first. These are the percentages of deaths that are reported with lags of one, two, and three years. For example, the percent of deaths reported with a lag of two years was the sum of all the deaths reported with a lag of two policy years divided by the sum of the deaths reported for the years 2005–2013. Note that the years in the above discussion refer to policy years.

Table A1 presents the summary results by annuitant type and sex.

Table A1. Percentages of Deaths Reported Late for Males, Females, and Three Annuitant Types

Annuitant Type	Sex	% 1-year lag	% 2-year lag	% 3-year lag
Single	Male	2.1	0.6	0.4
Single	Female	2.0	0.5	0.5
Joint	Male	4.2	1.4	1.0
Joint	Female	10.0	4.9	3.5
Survivor	Male	2.3	1.8	1.2
Survivor	Female	2.3	1.2	0.9

The table suggests that deaths for single policies are under-reported for lags one, two, and three by approximately 2.0%, 0.5%, and 0.5%, respectively. These values suggest the following IBNR multipliers of A/E: 1.005, 1.010 [$1 + 0.005 + 0.005$], and 1.030 [$1 + 0.005 + 0.005 + 0.020$], for the years 2013, 2014, and 2015, respectively, since these years are missing reported deaths lagged by three years, two plus three years, and one plus two plus three years, respectively.

These rates may be useful in the interpretation of trends over the years as the experience in the most recent three years is slightly under-reported. This modest adjustment for single and surviving annuitants is often smaller than the standard deviation of the individual results. However, the joint, both alive results are higher (especially for females) and readers of this report may want to consider normalizing the calendar year A/E ratios to account for these lags.

Appendix 2: Additional Data for Study

This study includes more detailed tables summarizing the data. Table A2 is a table of contents for the combined 10 years of experience 2005–2015. Note that table 8.1 includes summaries by policy year.

Table A2. Table of Contents for Detailed Tables Available from the CIA Website

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