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The Relationship of Mortality Projections and The Underlying Mortality Tables Used

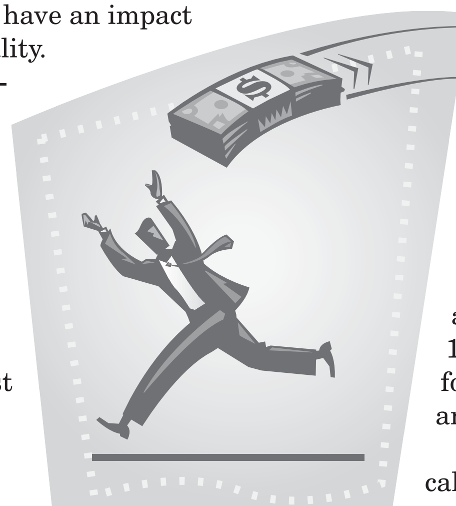
by Larry Warren

Introduction

The 1975-80 Select and Ultimate mortality table has continued to serve the actuarial profession very effectively over the decades. Scaling factors were updated and minor adjustments were made as an attempt to keep this table current. All prototypes, however, need to be re-evaluated from time to time in order to ensure appropriateness and accuracy. Changes in lifestyles, medical advances, new underwriting requirements and risk classifications, etc. can effect mortality patterns and need to be recognized. In this paper it will be shown that the result of using the 1975-80 Select and Ultimate Table as opposed to the more modern 1990-95 Select Ultimate Table can be a significant understatement of future mortality and hence, anticipated profits may prove to be illusory.

Projecting future mortality has been referred to as an art as well as a science. Mortality projections/assumptions are used in many different situations and for many different purposes (from calculating profit margins to demonstrating company solvency). Some examples are pricing new products, cash flow testing, analysis of reinsurance costs (i.e. reinsurance premiums vs. future expected mortality), self-support testing (under the NAIC Model Illustration Regulation, under New York section 4228, etc.), reserve adequacy testing, valuing inforce blocks of business, etc.

The development of mortality projections/assumptions typically takes into consideration company mortality experience, industry mortality experience, or a combination of both. In establishing a mortality assumption for developing new products the pricing actuary often would begin with the mortality experience of recently issued policies of a particular type of product and make some adjustments for possible changes in new underwriting requirements, average face amount, persistency, or any other factor that may have an impact on future mortality.



The appropriate mortality experience, therefore, would be limited to the early durations of newer products, which would have most likely been issued using underwriting guidelines and requirements similar to what is currently being used or will be used in the near future. In performing cash flow testing, reserve adequacy testing, valuing an inforce block of business (possibly for sale or acquisition), etc. the valuation actuary would begin with the mortality experience of policies issued over a longer time frame.

Perhaps issued over a period of 10 to 20 or more years, which would be more representative of the company's entire inforce business. The reinsurance actuary, whether from the ceding company perspective (analyzing reinsurance quotes by comparing them with future expected mortality) or the assuming company perspective (developing a reinsurance quote that properly reflects future expected mortality), would be interested in mortality experience of recently issued policies in reinsuring new business and policies issued "many" years ago in reinsuring inforce business.

General Approach

We started with a simple model using the assumption that $10,000,000 face amount was issued each year for each issue age (25, 35, 45 and 55) and experiencing Linton "B" lapse rates (20%, 12%, 10%, 8.8%, 8%, etc.) We also formed a composite issue age by assuming the distribution of face amount by age was 15%, 35%, 35% and 15% for issue ages 25, 35, 45 and 55 respectively.

We used this model to calculate actual to expected mortality ratios (for each mortality table) for policies in their first three policy years. (Expected mortality was calculated by using a single year of issue, applying lapse rates and multiplying the appropriate qx's to the face amount exposed in durations one through three.) Actual mortality was arbitrarily assumed to equal 80% of the 1990-95 table. This assumption was totally arbitrary and has no impact on this analysis. Next, we calculated the 20-year present value of future claims (for a single year of issue, representing new business) using the qx's of each mortality table separately. That is, the actual to expected mortality ratio obtained by using the 1975-80 mortality table was applied to the 1975-80 mortality table in calculating the 20 year present value of claims, and analogously for the

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1990-95 mortality table. We then repeated this process using the first five policy years to see if the results would differ significantly. (Table 1) We also used this model to calculate actual to expected mortality ratios (for each mortality table) for inforce blocks represented by policies in later durations. We then similarly calculated the 20-year present value of future claims. (Table 2)

Results

It was shown that where the actual to expected mortality ratios were based on mortality experience of the first three policy years that using the 1975-80 Select and Ultimate Mortality Table produces a present value of future claims (male composite) that are 13% lower than what would be obtained by using the 1990-95 select/ultimate mortality table. This reduction varies significantly by issue age: 32% lower at issue age 25, and becomes 14% lower, 22% lower, and 2% lower for issue ages 35, 45, and 55 respectively.

The results for females were similar but not as extreme. The present value of future claims (female composite) are 10 % lower when using the 1975-80 table as opposed to using the more recent 1990-95 table.

Surprisingly enough, our analysis showed that even if the actual to expected mortality ratios were based on the mortality experience of the first five policy years, the above relationships would be similar. It was also shown for inforce blocks that this relationship still holds but is less dramatic.

It became clear that the 1975-80 table generally produced mortality projections considerably lower than the more recent 1990-95 table. To gain insights into the significance of the mortality differentials between these tables we developed a simple model to calculate the reduction in the present value of future claims over 20 years based on a single year of issue (assuming Linton B lapses and a discount rate of 6%) resulting from annual mortality improvement (reduction) factors for all 20 years. This analysis was done for ages 25 and 55, male and female, and both mortality tables (1975-80 and 1990-95). The results were that a 1.0%

Table 1

RELATIONSHIP OF MORTALITY PROJECTIONS AND THE UNDERLYING MORTALITY TABLES

FOR A SINGLE YEAR OF ISSUE

SCENARIO 1

PRESENT VALUE OF FUTURE CLAIMS *
(based on the mortality experience of the first 3 policy years)

	males			
issue age	based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 27,337	$ 40,456	67.6%	32.4%
35	54,334	63,082	86.1%	13.9%
45	123,820	158,473	78.1%	21.9%
55	370,761	377,786	98.1%	1.9%
composite**	$ 122,069	$ 140,281	87.0%	**13.0%**

PRESENT VALUE OF FUTURE CLAIMS *
(based on the mortality experience of the first 3 policy years)

	females			
issue age	based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 16,493	$ 22,222	74.2%	25.8%
35	37,547	44,728	83.9%	16.1%
45	91,718	118,935	77.1%	22.9%
55	292,919	272,221	107.6%	-7.6%
composite**	$ 91,655	$ 101,449	90.3%	**9.7%**

SCENARIO 2

PRESENT VALUE OF FUTURE CLAIMS *
(based on the mortality experience of the first 5 policy years)

	males			
issue age	based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 31,784	$ 40,456	78.6%	21.4%
35	56,328	63,082	89.3%	10.7%
45	124,051	158,473	78.3%	21.7%
55	372,220	377,786	98.5%	1.5%
composite**	$ 123,733	$ 140,281	88.2%	**11.8%**

PRESENT VALUE OF FUTURE CLAIMS *
(based on the mortality experience of the first 5 policy years)

	females			
issue age	based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 17,735	$ 22,222	79.8%	20.2%
35	38,904	44,728	87.0%	13.0%
45	99,959	118,935	84.0%	16.0%
55	290,298	272,221	106.6%	-6.6%
composite**	$ 94,807	$ 101,449	93.5%	**6.5%**

* Based on a **single year of issue of $10 million face** amount for each age assuming Linton B lapses at 6% discount rate over a 20 year period.
** Using the distribution of 15%,35%,35%,15% for ages 25,35,45,55 respectively.

note: The mortality experience underlying this analysis was arbitrarily chosen to equal 80% of the 90-95 Table. All ratios shown however, are independent of this assumption.

Table 2

EXHIBIT 2

RELATIONSHIP OF MORTALITY PROJECTIONS AND THE UNDERLYING MORTALITY TABLES

FOR INFORCE BUSINESS

SCENARIO 1

PRESENT VALUE OF FUTURE CLAIMS *
(based on an inforce containing 5 years of new business)

issue age	males based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 161,618	$ 230,208	70.2%	29.8%
35	351,082	409,330	85.8%	14.2%
45	799,844	1,066,309	75.0%	25.0%
55	2,496,462	2,505,651	99.6%	0.4%
composite**	$ 801,536	$ 926,853	86.5%	**13.5%**

PRESENT VALUE OF FUTURE CLAIMS *
(based on an inforce containing 5 years of new business)

issue age	females based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 102,082	$ 134,721	75.8%	24.2%
35	242,197	299,178	81.0%	19.0%
45	624,419	791,014	78.9%	21.1%
55	1,939,427	1,796,045	108.0%	-8.0%
composite**	$ 609,542	$ 671,182	90.8%	**9.2%**

SCENARIO 2

PRESENT VALUE OF FUTURE CLAIMS *
(based on an inforce containing 10 years of new business)

issue age	males based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 400,171	$ 477,958	83.7%	16.3%
35	823,528	924,597	89.1%	10.9%
45	2,126,564	2,445,817	86.9%	13.1%
55	6,184,557	5,800,633	106.6%	-6.6%
composite**	$ 2,020,241	$ 2,121,433	95.2%	**4.8%**

PRESENT VALUE OF FUTURE CLAIMS *
(based on an inforce containing 10 years of new business)

issue age	females based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 273,811	$ 295,742	92.6%	7.4%
35	524,719	687,496	76.3%	23.7%
45	1,490,873	1,786,448	83.5%	16.5%
55	4,128,255	4,080,374	101.2%	-1.2%
composite**	$ 1,365,767	$ 1,522,298	89.7%	**10.3%**

SCENARIO 3

PRESENT VALUE OF FUTURE CLAIMS *

issue age	males based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 716,328	$ 776,097	92.3%	7.7%
35	1,485,217	1,606,312	92.5%	7.5%
45	3,978,370	4,296,823	92.6%	7.4%
55	10,810,050	10,295,890	105.0%	-5.0%
composite**	$ 3,641,212	$ 3,726,895	97.7%	**2.3%**

PRESENT VALUE OF FUTURE CLAIMS *
(based on an inforce containing 15 years of new business)

issue age	females based on 75-80 table	based on 90-95 table	ratio	% decrease
25	$ 495,919	$ 498,967	99.4%	0.6%
35	964,740	1,209,215	79.8%	20.2%
45	2,688,225	3,076,162	87.4%	12.6%
55	7,546,308	7,155,640	105.5%	-5.5%
composite**	$ 2,484,872	$ 2,648,073	93.8%	**6.2%**

These inforce blocks were developed from 5,10,and 15 years of new business of $10 million face amount for each age.

Using the distribution of 15%,35%,35%,15% for ages 25,35,45,55 respectively.

note: The mortality experience underlying this analysis was arbitrarily chosen to equal 80% of the 90-95 Table.
All ratios shown however, are independent of this assumption.

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Table 3

EFFECT OF MORTALITY IMPROVEMENT FACTORS ON MORTALITY PROJECTIONS (20 YEARS)

75-80 mortality table

mortality improvement factor *	male age 25 % decrease**
0.00%	0.0%
0.50%	3.6%
1.00%	6.9%
1.50%	10.1%

90-95 mortality table

mortality improvement factor *	male age 25 % decrease**
0.00%	0.0%
0.50%	4.1%
1.00%	8.0%
1.50%	11.6%

75-80 mortality table

mortality improvement factor *	female age 25 % decrease**
0.00%	0.0%
0.50%	4.2%
1.00%	8.2%
1.50%	11.9%

90-95 mortality table

mortality improvement factor *	female age 25 % decrease**
0.00%	0.0%
0.50%	4.4%
1.00%	8.6%
1.50%	12.5%

75-80 mortality table

mortality improvement factor *	male age 55 % decrease**
0.00%	0.0%
0.50%	5.1%
1.00%	9.8%
1.50%	14.3%

90-95 mortality table

mortality improvement factor *	male age 55 % decrease**
0.00%	0.0%
0.50%	5.0%
1.00%	9.6%
1.50%	14.0%

75-80 mortality table

mortality improvement factor *	female age 55 % decrease**
0.00%	0.0%
0.50%	4.9%
1.00%	9.5%
1.50%	13.9%

90-95 mortality table

mortality improvement factor *	female age 55 % decrease**
0.00%	0.0%
0.50%	4.9%
1.00%	9.5%
1.50%	13.8%

* Compounded each year for years 1-20.

** Reduction in present value of future claims based on a single year of issue assuming Linton B lapses at a 6% discount rate over 20 years.

annual improvement factor over all 20 years (a somewhat aggressive assumption) produces a decrease in the present value of future claims ranging from 7% to 10%, while using a 1.5% annual improvement factor over all 20 years (a very aggressive assumption) produces a decrease ranging from 10% to 14%. (Table 3) It now becomes quite apparent that for many issue ages the decrease in the present value of future claims resulting from using the 1975-80 Select and Ultimate Table as opposed to the 1990-95 Select and Ultimate Table, is often greater than the decrease in the present value of future claims resulting from using aggressive mortality improvement factors.

Observations and Conclusions

The relationship of mortality projections and the underlying mortality tables turns out to be quite significant. The majority of companies continue to use the 1975-80 Select and Ultimate Mortality Table. ***The actuary in making the decision to utilize the 1975-80 Select and Ultimate mortality table (as opposed to the 1990-95 Select and Ultimate mortality table) may unwittingly be taking an aggressive posture when it comes to projecting future claims.*** The significant decrease in the present value of future claims resulting from using the 1975-80 Select and Ultimate Table as opposed to the 1990-95 Select and Ultimate Table results from the fact that the slope of the 1990-95 table is higher than that of the 1975-80 table (i.e. in the early years the ratio of the qx's of the 1990-95 table to the 1975-80 table are lower than they are in the later years). Each of these tables was based on the SOA Inter-company Mortality Study on Standard Ordinary Issues in the USA. The 1990-95 table, in addition to being a much more recent table, was based on data where the total dollar amount of exposure was $4.1 trillion for males, and $1.6 trillion for females (more than double that of the earlier 1975-80 table and hence should have greater credibility). It should be noted that the 1990-95 table was developed with selection factors for 25 years with an emphasis of fit over smoothness, while the 1975-80 table was developed with selection factors for 15 years with an emphasis of smoothness over fit.

Companies with relatively low average issue ages (e.g., issue ages 25 - 45) that are still using the 1975-80 Select and Ultimate Mortality Table, should be especially careful in setting their mortality assumptions. If actual mortality turns out to be better reflected by the 1990-95 table (which is very likely), they run the risk of significantly understating future claims.

Certain state regulations dealing with self-support testing and Valuation (e.g. Regulation XXX) prohibit the use of mortality improvement factors prospectively. Since we have shown that using the 1975-80 mortality table is often similar (in slope) to using the 1990-95 table with aggressive mortality improvement factors, it is not unlikely that State Regulators may soon consider the need to require the use of the 1990-95 mortality table or a modification thereof—perhaps the 2001 VBT table.

Based on a recent survey conducted by Tillinghast-Towers Perrin (The 2000 Pricing Survey of Individual Life and Annuity Products) covering 22 mutual companies and 38 stock companies, very few companies include future mortality improvement when calculating expected mortality in product pricing. Therefore, since companies in general believe it prudent not to reflect future mortality improvement it is especially important that they fully analyze their choice in selecting the underlying mortality table used in their profit studies and mortality projections. In addition, adjustments and modifications to existing tables may be necessary (e.g. there is an AIDS "hump" in young male middle duration mortality reflected in the 1990-95 mortality table, which is probably inappropriate in today's climate of fluid-tested underwriting).

Many companies (direct writers as well as reinsurers), in order to meet competition, have reduced profit margins. Some may have even liberalized (lowered) their mortality assumptions to offset this reduction to profit margin. This increases the likelihood of adverse mortality deviations. In this business environment, the additional vulnerability caused by using a possibly inappropriate mortality table becomes untenable.

Mortality studies are becoming less and less rigorous because it is more difficult to get credible experience. This results from the fact that over recent years, new underwriting requirements and many differentiated risk classifications have emerged (preferred, super-preferred, preferred-plus, etc). In addition this paper suggests the selection of the proper mortality table is yet another variable requiring judgment. In this climate greater emphasis must therefore be placed on subjective judgment rather than stringent statistical techniques, thereby substantiating our earlier comment that projecting mortality is clearly an art, as well as a science.

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