# Practical Analysis of PBR Mortality Credibility for Term Insurance


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With the January 1, 2017, effective date of *VM-20*, we expect that actuarial practice in calculating *VM-20* reserves will evolve over time as companies, actuaries and regulators gain experience in calculating such reserves. The evolving actuarial practice may differ from what is assumed in this research. The methodology and assumptions used in developing *VM-20* reserves within this research are illustrative and should not be viewed as recommendations of Swiss Re or the SOA with respect to the application of *VM-20*.

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## Preface From the Project Oversight Group

The genesis of this project was an experience that a small insurance company had in doing their first detailed research into whether they should implement principle-based reserving (PBR) or use the Companywide Exemption. Mortality was one of the assumptions researched. The company discovered it had very little credibility in its mortality experience. In fact, it had less than 20%, which translates to no credibility according to *VM-20* rules. With no credibility, the resulting deterministic reserve mortality assumption was entirely based on industry tables, with margins added. With this as the mortality assumption for deterministic reserves it appeared that the company couldn't produce reserves that were lower than XXX reserves.

This led to the bigger question about the impact of mortality credibility on companies of various sizes.

This simple idea ended up resulting in an SOA research project. The logical conclusion is that good research can come out of simple ideas, and that anyone could have an idea that results in a meaningful research project.

One of the first steps in making an idea into a research project is to write a Request for Proposal (RFP). Here is an excerpt from the RFP that provides more background on this project:

### RFP Excerpt:

#### *Project: Practical Analysis of PBR Mortality Credibility for Term Insurance*

##### *Background and Purpose*

*In determining principle-based reserves (PBR) for U.S. life insurance, the credibility level of company mortality experience often has a large impact on the level of PBR deterministic reserves for term insurance. Generally the lower the credibility of company experience, the higher the blended mortality rates since industry mortality often is higher than individual company mortality experience. In addition, the mortality margin increases with lower credibility levels of company experience. Other factors impacting the blended mortality rates are a company's own mortality experience and mortality improvement assumptions used to project reserves in future nodes needed for pricing products.*

*The purpose of this study is to provide a resource for actuaries and others to enhance understanding of the impact of VM-20 mortality credibility requirements on life insurers and of the potential solutions for increasing credibility levels.*

##### *Research Objective*

*The Society of Actuaries Smaller Insurance Company Section and other sponsors are seeking researcher(s) to examine the impact of PBR mortality credibility rules for term insurance on a U.S. life insurer. At a minimum, the researcher(s) will compare PBR deterministic reserves (DR) to XXX reserves and discuss findings by size of company. The researcher(s) will:*

1. *Determine minimum levels of deterministic reserve (DR) mortality that would result in DR reserves being lower than reserves calculated using The Valuation of Life Insurance Policies Model Regulation (commonly known as XXX).*
2. *Given the minimum level of DR mortality determined in item 1, estimate at various levels of credibility, the company mortality experience that would be needed to achieve this level of DR mortality.*
3. *Comment on what level of credibility companies of various sizes would have if they used only their own mortality data. Include in this analysis, companies who sell the most term insurance, those who are in the middle of the pack, and also companies who are in the lower part of the range.*
4. *Discuss how reinsurance retention levels impact mortality credibility levels, if any.*
5. *Identify and discuss the ways life insurers may obtain more data to boost credibility levels from a variety of perspectives (e.g., life insurer, reinsurer and data aggregator). Compare and contrast the approaches for increasing credibility levels emphasizing the cost and benefit of each approach.*

*Note that the above list is not meant to be exhaustive but establish minimum expectations for the topics to be included in the study.*

The research objectives in the RFP excerpt above were a starting point and evolved into the research objectives in the paper itself.

# Practical Analysis of PBR Mortality Credibility for Term Insurance

The impact of principle-based reserving (PBR) on aspects such as statutory reserves, product development and financial reinsurance has been well documented. There is, however, limited literature on the impact that mortality credibility—one of the key drivers of the level of reserves—has under a principle-based approach.

In addition, to determine an estimated impact from adopting PBR requires a number of prerequisites to be in place, from cash flow models that have been validated to experience studies and company experience assumptions. Such an assessment is critical for companies with limited resources that want to decide whether or not to defer implementation, or in cases where they qualify for Companywide Exemption, whether to adopt PBR at all. The range of possible outcomes as a result of the level of mortality credibility serves to compound the complexity of any such assessment.

This research paper studies in detail the impact mortality credibility has on principle-based reserves while presenting results using a common yardstick. It does so by providing a practical perspective on the range of possible outcomes that companies may face given representative scenarios.

The key objectives of the research were to do the following:

1. Provide an overview of how mortality credibility may impact a company's decision of when and, in the case of small companies qualifying for the Companywide Exemption, whether to implement PBR.
2. Assist companies to better understand the impact PBR mortality credibility may have on their business and products given their circumstances.
3. Study the impact reinsurance, including retention limits, may have on mortality credibility.
4. Identify and analyze various sources of external data to enhance credibility.

While the primary audience of this report is smaller insurance companies, or companies that may have gone through a significant change to their underwriting, target market(s) and/or distribution channel(s) recently, we find elements of this report to be useful to all. In particular, along with specifying the baseline model assumptions used, Appendix B includes sensitivities that may allow companies to adjust results based on their own experience factors.

## Section 1: Executive Summary

Principle-based reserving (PBR) for life insurance represents a significant shift in statutory reserving in the U.S. from a regime with prescribed assumptions to one where assumptions are derived from company experience with guardrails to ensure conservatism.

The methodology employed to add prudency is one of individual assumptions margins, where each liability assumption gets loaded. This differs from an aggregate margin approach where a singular aggregate margin is applied to the best-estimate liability.

For term insurance, the product in focus in our research, the mortality margin applied to the deterministic reserve is significant. There is an explicit margin based on credibility, which applies a load and determines the speed at which the company experience grades to industry. And there is an implicit margin of not recognizing any future mortality improvement. The *Valuation Manual* does allow for mortality improvement to be reflected once it has been realized, a concept we refer to as dynamic or retrospective mortality improvement.

Mortality credibility can significantly impact reserves to be held for term insurance under PBR. Where there is extremely high credibility, the explicit load can be in the 2–3% range, but upwards of 17–18% where there is limited to no credibility.

Companies falling within the range, and especially smaller ones closer to the upper end of the range, may find it difficult to assess what impact PBR may have on their business, hence the research.

In our research we took a practical view and linked results back to a common yardsick in the form of the 2017 CSO XXX reserves, which defines the reserving standard applicable to term insurance prior to PBR (pre-PBR CRVM). We specifically applied a "match IRR" technique where, to compare two reserve curves, we solved for what mortality load applied to the lower reserve would result in the pricing IRRs under the two reserve curves to be the same. By doing so, we account for both the different shape and level of the reserve and express the results through the lens of mortality experience. This should allow companies to translate their own mortality experience, relative to the one assumed in our model, to approximate outcomes under PBR given their credibility levels.

Through our study, we had the following key observations:

- A 17.5% mortality load applied to our baseline model deterministic reserve, which has all *VM-20* margins *except* the credibility-based explicit mortality loads, results in a similar IRR as under the 2017 CSO XXX reserve. While influenced by the baseline model parameters, this approximately represents the mortality load underlying the 2017 CSO table.
- When we layered on mortality credibility including the sufficient data period, we observed a range of results between an upper bound of the 2017 CSO XXX reserve and a lower bound of the best-estimate liability. While outcomes under limited to no credibility were better than under 2017 CSO XXX reserves, they were only marginally so. The range of pricing IRRs observed on no credibility to very high credibility was 6.3% to 8.0%. These corresponded with an estimated explicit mortality load of 15.5% to 2.5%.
- Future mortality improvement, or lack thereof, represents a significant margin on the modeled reserves. Comparing our baseline model to the best-estimate liability that has future mortality improvement, we estimated the implicit mortality margin to be 7.6%. The load decreases through the projection as dynamic mortality improvement takes hold. Additionally, the load is expected to be larger for products with a longer tail such as permanent insurance.

- The dynamic mortality improvement causes a left-shifting of the deterministic reserve curve compared to the net premium reserve and pre-PBR CRVM where the mortality assumption remains static. This can also cause the net premium reserve to dominate in future projection periods, thereby taking away the focus from modeled reserves.
- Mortality credibility and the sufficient data period have decreasing marginal utility, that is, increasing credibility and sufficient data period while at the lower levels are more meaningful than when those are at a higher level. An 80%+ Limited Fluctuation Method credibility appears to be the "sweet spot."
- In the real world, credibility will be influenced by the size of a company and the relevancy of the underlying claims experience. Significant changes to underwriting, target markets and/or distribution channels influence expected mortality outcomes, relevancy and ultimately credibility. The historical growth rate of the business also influences the credibility and the sufficient data period. We observed a wide range of IRR outcomes when dissecting these characteristics.

We also explored how reinsurance impacts mortality credibility. Both the Limited Fluctuation and Bühlmann Methods, as specified in the *Valuation Manual*, prescribe an amount-based, or severity, credibility measure but do not clarify whether it should be the full amount assured or net of retention.

At the time of publication of this paper, there is still debate regarding whether reflecting retained amounts instead of full face amounts in experience studies and credibility calculations is appropriate. It is advisable to refer to the most current Valuation Manual to assess what approach is permissible. This research paper does not opine on the debate but rather seeks to provide readers with an objective view of the potential implications of reinsurance on experience studies and credibility.

In determining the amount basis to be used in the credibility calculation, the following should be considered:

- The reinsurance type will influence the impact. First dollar quota share reinsurance will typically not influence the credibility measure since the standard deviation of the face amounts relative to the mean will be the same pre- and post-reinsurance.
- For excess reinsurance, a retention limit will act as a cap on the face amounts in an experience study, which reduces the standard deviation of the face amounts relative to the mean. This in turn increases the credibility measure. We have simplistically illustrated this with examples.
- Using amounts net of reinsurance works relatively well under the Limited Fluctuation Method, since the retained amounts can be substituted directly into the formulas. Under the Bühlmann Method, however, careful consideration is needed because the constants in the *VM-20* Bühlmann formula were derived based on a study with full face amounts. As such, substituting retained amounts may not be internally consistent with how the formula was intended to be used.

- Consistency with the rest of the assumption-setting process is important. If amounts net of reinsurance are used in calculating credibility, then a consistent approach should be used when setting the mortality assumption. With excess reinsurance this would decrease the weighting on the larger policies in the study, possibly resulting in a higher company experience mortality assumption.

The final element of our research focused on external sources of data to enhance credibility. A complete analysis of the advantages and disadvantages of three sources—reinsurers, data aggregators and affiliate companies—is summarized in Table 1. The keys to using external data include (1) the relevancy of the experience, (2) restrictions on the data owned by the external sources and (3) how to demonstrate and where the burden of justification lies.

**Table 1**

Cost-Benefit Analysis of External Sources of Data

| Data Source | Benefit | Cost |
|---|---|---|
| **Reinsurer** | 1. **Relationship:** Data submission channel already exists<br>2. **Relevancy:** More industry, business and assumption-setting knowledge to better determine relevancy<br>3. **Ownership of data:** Owns reinsurance data<br>4. **Long-term stability:** Vested interest in underlying data | 1. **Cost (explicit):** Compensation either through reinsurance or fees<br>2. **Cost (implicit):** Ties you to a reinsurer |
| **Data aggregator** | 1. **Relationship:** Data submission channel may already exist<br>2. **Relevancy:** Have granularity and credibility expertise, but not necessarily business knowledge | 1. **Cost (explicit):** Compensation through fees<br>2. **Relationship:** Need to submit data if relationship does not exist<br>3. **Ownership of data:** Do not own data without explicit consent for other uses<br>4. **Long-term stability:** Less skin in the game |
| **Affiliate life insurer** | 1. **Cost (explicit):** Likely none<br>2. **Relevancy:** Relatively straightforward to assess relevancy | 1. **Cost (implicit):** Limited credibility enhancement |

## Section 2: Relevant Principle-Based Reserving Background

Principle-based reserving intends to right-size statutory reserves by moving away from a regime where reserves are based on formulaic calculations with prescribed assumptions to one where assumptions are derived from company experience with necessary guardrails to ensure conservatism.

The document governing PBR is the *Valuation Manual,* and PBR for life insurance is covered under *VM-20*. *Valuation Manual* references and excerpts within this research report come from the January 1, 2018, edition, which has NAIC adoptions through August 9, 2017.

### 2.1 Guardrails Within Principle-Based Reserving

Key guardrails within PBR include the following:

1. A calculation with three components—the net premium reserve (NPR), the deterministic reserve (DR) and the stochastic reserve (SR): The NPR, which is still a formulaic calculation with prescribed assumptions, serves as a floor. The DR and SR are modeled reserves, that is, reserves based on discounting a stream of liability cash flows from a cash flow model using either a deterministic path of interest rates or a set of stochastic interest rate scenarios. Modeled reserves better reflect company experience, underlying product risks, and how a company's reserves are impacted when those are combined.

2. Prudent best-estimate assumptions: The assumptions within the modeled reserves are not pure best-estimate liability and asset return assumptions based on company experience. Rather, they are padded with margins so as to establish prudent best-estimate assumptions and ensure the necessary conservatism within statutory valuation. These are in the form of individual margins for each liability and asset return assumption as opposed to an aggregate margin established on the best-estimate liability.[1]

   The primary focus of this report is the margin to be applied to the modeled reserve mortality assumption. Section 9 of *VM-20* prescribes the methodology a company must follow to establish this margin. The key driver of the level of the margin is the credibility of the underlying mortality experience that is relevant. The concepts of credibility and relevancy will be explored in detail in this research paper.

3. Level of aggregation of mortality for determining credibility: A recent amendment[2] to the *Valuation Manual* adopted at the 2018 NAIC Fall Meeting specifies conditions under which mortality experience may be aggregated for determining credibility and the sufficient data period (SDP).[3] The amendment, including the building blocks of the modeled reserve mortality assumption, is summarized in Section 2.3.

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[1] Calculation of reserves using best-estimate assumptions without any margins.
[2] See the APF 2018-17 "Life Actuarial (A) Task Force/Health Actuarial Task Force (B)" form at https://www.naic.org/documents/cmte_a_latf_exposure_2018-77.docx (National Association of Insurance Commissioners, 2010).
[3] Defined "as the last policy duration that has 50 or more claims (*VM-20* §9.C.6.b.ii).

4. Level of aggregation of reserves at which level a comparison of the NPR, DR and SR should be carried out to determine the dominant reserve: The *Valuation Manual* specifies three Product Groups—term, ULSG and all other—as levels where such a comparison should be made. As such, a company is not permitted to aggregate, and therefore recognize the risk diversification across all of its business subject to PBR, when comparing the reserve components to determine the greatest reserve.

5. No allowance for the recognition of post-level-term (PLT) period profits but full recognition of PLT losses: For term products with level premium guarantees greater than five years, the PLT cash flows need to be adjusted such that the present value of inflows do not exceed that of outflows (*VM-20* §9.D.6).

The deterministic reserve was the focus of our research given that the scope of the project was limited to term insurance. Term insurance is currently precluded from the deterministic exclusion test (*VM-20* §6.B.1.b) and therefore at a minimum requires the deterministic reserve to be calculated along with the NPR. The deterministic reserve should generally be higher than the NPR for term products and moreover is the only reserve component of the two impacted by mortality credibility. While mortality credibility also impacts the stochastic reserve, term insurance is expected to pass the stochastic exclusion test (*VM-20* §6.A) given the non-interest-sensitive nature of the liabilities.

## 2.2 Key Assumption Difference Between Modeled Reserves Under PBR and 2017 CSO XXX Reserves

A comparison of key assumption differences between the PBR modeled reserves and the 2017 CSO Regulation XXX reserve (2017 CSO XXX), which defines the pre-PBR reserving standard applicable to term insurance, is important. We compare metrics under the deterministic reserve to similar metrics under the 2017 CSO XXX reserve throughout the report.

The key assumption differences include the following:

1. The PBR modeled reserves are based on dynamic prudent best-estimate assumptions, whereas the 2017 CSO XXX reserve has prescribed, locked-in valuation assumptions.

2. The PBR modeled reserves allow for dynamic mortality improvement to be recognized, whereas the prescribed mortality table under the 2017 CSO XXX reserve remains static and locked in.
    a. Dynamic mortality improvement is the ability to recognize incremental mortality improvement as it occurs and has been realized. At time 0, this implies an update to the mortality assumptions to bring them current as of the valuation date. For projecting statutory reserves, this implies assuming incremental years of mortality improvement as the projection moves from one time step to the next.

3. PBR introduces lapsation to be incorporated into statutory valuation
    a. Prior to PBR, and more specifically within the 2017 CSO XXX reserve, statutory valuation required an assumption of zero lapsation of policies.

b. Within PBR, modeled reserves carry prudent best-estimate lapse assumptions. Additionally, the NPR also incorporates lapsation in the form of prescribed assumptions. For term insurance prescribed shock lapse assumptions dependent on the length of the term guarantee and the premium jump at the end of the level-term period are specified.

4. Deterministic and stochastic path(s) of interest
    a. Pre-PBR CRVM assumes a single interest rate to discount liabilities, which is locked in at issue.
    b. The deterministic and stochastic reserves under PBR require the modeling of a deterministic or range of interest rate paths respectively. This not only enables the interest rate curve used to discount liabilities to reflect the returns on a company's asset portfolio and reinvestment strategy, it also allows interest rate mean reversion to be incorporated into the reinvestment through the Economic Scenario Generator.
    c. The interest rate for the net premium reserve is determined in a similar way as pre-PBR CRVM and locked in at issue.

## 2.3 Building Blocks of the Modeled Reserve Mortality Assumption

Much of the research's focus was on the modeled reserve mortality assumption. This takes a building block approach described in detail in *VM-20* §9.C. The summary below reflects a recent substantive amendment to *VM-20* §9.C around the aggregation of mortality segments for the purpose of determining credibility, which was adopted at the NAIC's 2018 Fall National Meeting.

1. A company first determines mortality segments for groups of policies expected to have different mortality experience. For instance, a company may determine that it needs separate prudent best-estimate assumptions at the gender-risk class level.

2. For each mortality segment,
    a. The company determines company experience mortality rates derived from company experience data. If limited or not available, the company may

        i. Use experience data from external sources, such as a reinsurance mortality pool in which policies participate, *if appropriate,* or
        ii. Use an applicable industry table in lieu of company experience.

    An analysis of using external data sources, including key considerations under such an approach, is explored in Section 7 of this report.

    b. The company may determine company experience mortality rates at the following level of granularity:

        i. At the mortality segment level without regard to aggregate experience or
        ii. At an aggregate level then subdivide into the mortality segments using techniques such as conservation of total deaths principle or

iii. At the mortality segment level, then revise as necessary to reflect the aggregate mortality experience.

c. The company determines the applicable industry table for each mortality segment's company experience to grade into. This can be done either by using the Relative Risk Tool[4] (formerly known as the Underwriting Criteria Score Calculator) maintained by the SOA or another actuarially sound method.

d. The company determines the level of credibility of the underlying mortality experience following prescribed methods under *VM-20* §9.C.4 either on a standalone basis or enhanced by external data. Credibility may be computed at an aggregate level if the company experience rates are informed by the aggregate experience.

e. The company determines the prescribed mortality margins for company experience mortality rates based on credibility and for the applicable industry basic tables.

f. The company determines the sufficient data period by identifying the last policy duration which has 50 or more claims. The sufficient data period determines the duration at which, and the speed with which, prudent company experience grades to prudent industry experience. If credibility is computed in aggregate, so can the sufficient data period.

g. Mortality improvement shall not be incorporated beyond the valuation date; however, the company and industry mortality rates may be brought forward to the valuation date by reflecting historical mortality improvement from the central point of the experience study. By extension, mortality improvement may be recognized incrementally within the projection of modeled reserves as it is "realized." This is commonly referred to as dynamic mortality improvement, or retrospective mortality improvement.

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[4] See the Society of Actuaries' Relative Risk Tool at https://www.soa.org/tables-calcs-tools/relativerisktool/.

## Section 3: Baseline Model Assumptions

The underlying product in focus in this research was term insurance. We determined a baseline set of assumptions to create a cash flow model, hereafter referred to as the *Baseline Model*. The assumptions spanned business mix, pricing, mortality, policyholder behavior, expenses, asset modeling and capital and are summarized in this section. We also provide commentary on how we derived these assumptions.

The Baseline Model assumptions highlighted in this section remained fixed in all the model runs unless specified otherwise. Of particular note are the *VM-20* margins, where the lapse, expense and PLT margins were part of the baseline set of assumptions. However, the explicit mortality margins linked to credibility, that is, the credibility-based mortality loads and grading to industry, were not included in the Baseline Model, because the explicit mortality margin is what was studied and therefore varied from one model run to another. The implicit mortality margin of not recognizing future mortality improvement was incorporated into the Baseline Model.

Some of the assumptions within this section also formed the basis of the in-force projection assumptions. For instance the mortality and lapse assumptions without any margins determined the termination rate of the in-force as it moved through the projection.

### Business Mix

Instead of modeling seriatim policies, a hypothetical distribution of policies was set up for both one year and five years of new business. Based on relevant reinsurance data, a portfolio of small companies was studied to derive representative distributions for the following policy characteristics: plan type, gender, risk class, face amount bands, issue age and issue date. Appendix A shows the breakdowns of these characteristics by sum assured.

### Premiums

The 75th percentile of industry-wide fully underwritten term insurance premiums was obtained from an independent source of market data. Seventy-fifth percentile implies that 25% of the data points had higher premiums, whereas 75% had lower premiums. We set premiums such that given the mortality experience and commissions, target loss ratios as specified below were achieved. This ensured internal consistency between assumptions within the cash flow model. The premiums varied by the same characteristics described under the business mix.

### Mortality

The mortality experience assumption was determined at an aggregate level based on how reinsurance experience from a cohort of smaller life insurance companies tracked against the

2015 Valuation Basic Table (VBT) Relative Risk (RR) tables. We assumed an age basis of age-last birthday (ALB) and applied gender-specific rates.

While we studied mortality in aggregate, given the lack of uniformity between nonsmoker and smoker 2015 VBT RR tables, we set an aggregate assumption for nonsmokers separate from smokers. The mortality experience for male and female nonsmokers in aggregate tracked closest to the 2015 VBT RR90 ALB, whereas male and female smokers tracked closest to the 2015 VBT RR100 ALB.

We then subdivided the aggregate nonsmoker and smoker mortality rates to a risk class level while ensuring conservation of total deaths principle held. An initial view of the relative factors was informed by the relationship of the underlying mortality experience between risk classes. This was then adjusted such that the sum of the expected claims at a risk class level was greater than or equal to the expected claims in aggregate. The resulting risk class factors, varied by gender and applied to the 2015 VBT RR90 ALB table for nonsmokers and the 2015 VBT RR100 ALB table for smokers, are presented in Table 2.

**Table 2**

Factors to Subdivide Gender-Smoking Status Mortality Rates to Gender-Risk Class Mortality Rates

| Smoker | Risk Class | Male | Female |
|---|---|---|---|
| Nonsmoker | Residual | 135% | 125% |
| | Preferred | 115% | 105% |
| | Super-preferred | 95% | 85% |
| | Ultra-preferred | 85% | 75% |
| Smoker | Residual | 120% | 115% |
| | Preferred | 80% | 75% |

While grading to applicable industry tables was not part of the Baseline Model, in scenarios where we layered on margins related to mortality credibility, company experience nonsmoker rates graded to the 2015 VBT RR90 ALB and smoker rates graded to the 2015 VBT RR100 ALB.

## Mortality Improvement

The company experience mortality tables were improved from the 2015 Valuation Basic Table date of July 1, 2015, to the valuation date using published SOA mortality improvement factors.[5]

In addition to making the mortality tables current as of the valuation date, the improvement factors were also used to dynamically improve mortality up to future valuation dates in the projection (dynamic or retrospective mortality improvement), that is, the mortality assumption was made current as of each node in the projection to determine future reserve balances. In

[5] See the Society of Actuaries' "Mortality Improvement Rates for AG-38 for Year-End 2017" at https://www.soa.org/experience-studies/2017/mortality-improvement-2017/.

keeping with *Valuation Manual* requirements, the deterministic reserve valued at any given projection date did not reflect future mortality improvement from that point forward.

No future nor retrospective mortality improvement was applied to the mortality tables underlying the net premium reserve, as prescribed by the *Valuation Manual*.

### Lapse

Average lapse assumptions were determined based on market-wide performance by term products for recent years of experience. The assumption varies by level-term period and duration. Differences by issue age, gender, risk class and face amount band were ignored for simplicity. See Appendix A for a breakdown of lapse rates by duration and level-term period.

As a matter of simplification, a 100% shock lapse was applied to address the *Valuation Manual* restriction of not recognizing PLT profits in the deterministic reserve calculation (*VM-20* §9.D.6). This is based on the assumption that term products are typically priced with a modestly profitable PLT period.

### Commission

Based on the research of different agency commission structures, the assumption in Table 3 was applied to the Baseline Model. The structure places most of the weight on the first duration with small amounts of additional commission in renewal years.

**Table 3**
Commissions by Duration

| Duration | 1 | 2–10 | 11+ |
|---|---|---|---|
| Per premium | 100% | 4% | 2% |

### Target Loss Ratio

To ensure internal consistency between premiums, claims and commissions, and a reasonably profitable portfolio of products, the following present value of loss ratios were targeted on a gross premium and a net premium basis:

PV(Death Benefits)/PV(Gross Premiums) = 70%

PV(Death Benefits)/PV(Net Premiums) = 80%

## Expenses

The 2017 Generally Recognized Expense Table (GRET) Factors published by the SOA[6] was the primary source of the expense assumption. The expense factors in Table 4 are on a fully allocated basis and were derived by approximately taking the average of the independent and career agency distribution channels. We also incorporated information on the unit expense seeds and the relative factors between term and permanent insurance found in Appendix B of the SOA report on the 2017 GRET Factors.[6]

**Table 4**
Expense Factors, Split Between Acquisition and Maintenance

| Expense | Acquisition | Maintenance |
|---|---|---|
| Per Policy | $200 | $55 |
| Per premium | 45.0% + 1.5% Premium tax | 1.5% Premium tax |
| Per unit | $0.70 | $0.00 |
| Inflation | 0% | 2% |

## *VM-20* Margins

**Table 5**
*VM-20* Margins for Modeled Reserves

| Assumption | Margin |
|---|---|
| Mortality | No explicit credibility-based margins in the Baseline Model<br>Implicit margin of no future mortality improvement always assumed |
| Lapse | 15%* |
| Expense | 5% |
| Post-level term | 100% shock lapse at the end of the level-term period |

* Determined dynamically within the model such that the margin is always applied in the conservative direction of increasing reserves.

Credibility-based explicit mortality margins were applied to the Baseline Model in subsequent model runs.

## Net Asset Earned Rate (NAER)

The Net Asset Earned Rate was based on a starting asset portfolio mix of 70% A-rated and 30% BBB-rated corporate bonds with *VM-20* prescribed default costs and a reinvestment/new

[6] See the Society of Actuaries' analysis of the 2017 Generally Recognized Expense Table (GRET) at https://www.soa.org/Files/Research/Projects/research-2017-gret-recommendation.pdf.

purchase assumption bound by the guardrail assumption of 50% AA-rated and 50% A-rated corporate bonds (*VM-20* §7.E.1.g). The NAER schedule is included in Appendix A.

### Risk-Based Capital (RBC) and Other Pricing IRR Factors

Table 6 summarizes the RBC and other factors applied in computing pricing IRRs.

**Table 6**
RBC and Pricing IRR Factors

| Factor | Value |
|---|---|
| RBC C1 | 0.85% |
| RBC C2 | 1.125 |
| RBC C3 | 0.0052 |
| Investment income rate | 4.5% |
| Corporate tax rate | 21.0% |

## Section 4: Research Methodology

Mortality credibility is the mechanism through which the necessary level of prudency is added to the company experience mortality assumption. While the determination of the appropriateness of the mortality margin and the overall prudency within the PBR reserve should be assessed against the best-estimate liability,[7] we recognize that any such comparison will vary considerably from one company to another.

Within our research therefore, we compared the deterministic reserve under various scenarios to the 2017 CSO XXX reserve. Along with providing a common yardstick, a comparison to pre-PBR CRVM is most appropriate for companies not far enough along the PBR implementation journey to get an indication of what their PBR reserves may look like.

More specifically, we carried out comparisons of reserve projections using the following techniques:

1. **Matching reserve peaks.** Applies a flat load to the mortality assumption such that the peaks of two reserve projections are equal. This methodology has the advantage of simplicity, being well understood, and often colloquially quoted as an impact measure. For example, one may express that the 2017 CSO XXX reserve is approximately 65% of the 2001 CSO XXX reserve (at its peak).

   The main drawback of such a comparison is that it does not take the shape of the reserve curve into account. While the 2017 CSO XXX and 2001 CSO XXX will likely have a similar shape, that shape is different from the PBR reserve curve because of the key assumption differences highlighted in Section 2.

2. **Matching pricing IRRs.** Applies a flat load to the mortality assumption such that the pricing IRR under two reserve projections are equal. While this methodology adds complexities in the form of the interest rate curve to discount cash flows and the incorporation of Risk-Based Capital (RBC) calculations, it has a significant advantage over the matching reserve peaks technique since it incorporates both the different level and shape of the reserve curves.

We primarily used the matching pricing IRR technique as a means to compare results within the research.

We ran the various sensitivities and scenarios in two ways:

1. **New business approach**. Runs a single year of policy issues through the model. This could be viewed as a pricing run where typically a single year of issues is modeled. Under this approach, policies were assumed to be issued at various points during 2018. The

[7] Calculation of reserves using best-estimate assumptions without any margins.

deterministic reserve mortality assumption was improved to a year-end 2018 valuation date but exhibits show reserves from year-end 2017 (time 0).

2. **In force block approach**. Runs five years of layered policy issues through the model. Reserve patterns are smoother, and this approach provides a medium-term view of how business under PBR will look. Policies were assumed to be issued at various points during the five years 2018—2022 with a 3% annual growth in the number of policies. Under this approach, the deterministic reserve mortality assumption was improved to a year-end 2022 valuation date, but exhibits show reserves from year-end 2017 (time 0 for the first year of policy issues).

When matching pricing IRRs, policy cash flows were included from the issue date through to the end of the level-term period regardless of the valuation dates specified above; that is, the valuation dates were set to be after all policies were issued, but cash flows occurring before the valuation date were still included in the IRR calculation. This allowed first year expenses to be included, resulting in a more realistic IRRs.

## Section 5: Impact of Mortality Credibility on Modeled Reserves

Our modeling exploration into mortality credibility began with a comparison and analysis of the PBR reserve to the pre-PBR CRVM reserve to understand the fundamental differences between the two. We then layered on credibility margins to study its impact on the modeled reserve. Finally, we derived sample credibility values that may be observed in real life within companies fitting various profiles.

### 5.1 Comparison of Modeled Reserves to Pre-PBR CRVM

As a starting point, we compared what reserves look like under 2017 CSO XXX versus PBR in the Baseline Model.

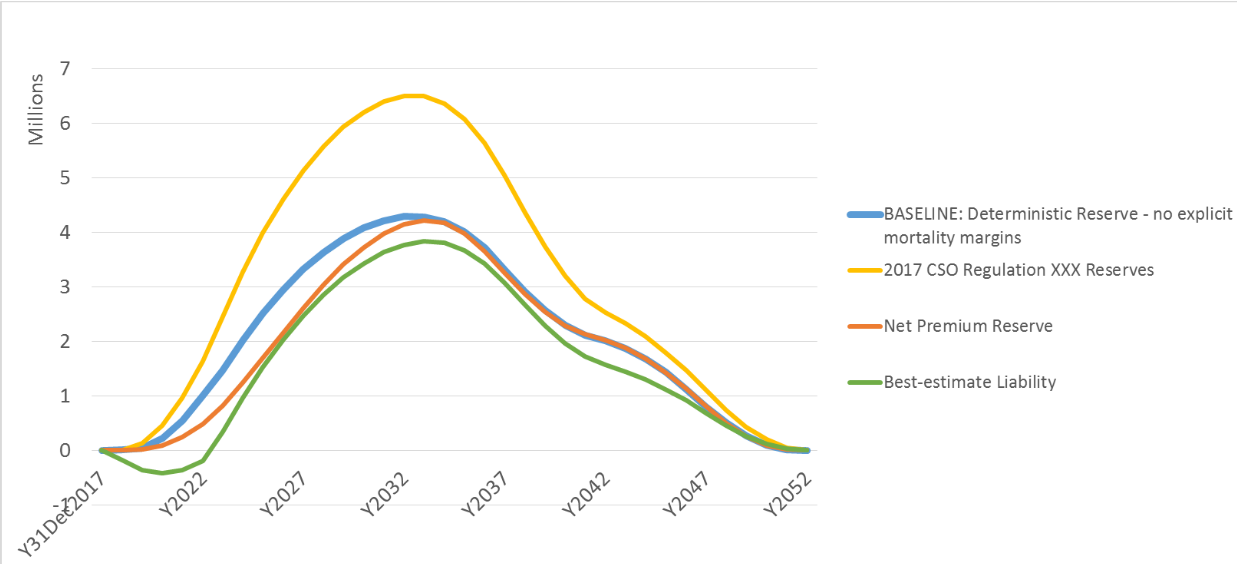
For the 2017 CSO XXX reserve, the Baseline Model simply provides the business mix characteristics as the rest of the assumptions and methodology is prescribed.

For the purposes of PBR, as described in Section 3, the Baseline Model provides a cash flow model for the deterministic reserve, *but without incorporating any explicit mortality margins*. Therefore the mortality assumption applied in the reserving is simply the company experience assumption without any *VM-20* credibility-based mortality loads nor any grading to industry tables. An implicit mortality margin of not recognizing future mortality improvement is included in the Baseline Model; however, mortality improvement is dynamically recognized in the projection of the deterministic reserve as it is realized.

We consider the deterministic reserve under the Baseline Model as a "no-credibility-margin deterministic reserve," which provides a baseline to then experiment with credibility-based loads.

The purpose of this comparison is to demonstrate, at a high level, but through the lens of mortality experience, how the 2017 CSO XXX compares to the deterministic reserve under the Baseline Model. Figure 1 is based on the in-force block approach where multiple years of policy issues were modeled.

**Figure 1**
2017 CSO XXX versus Baseline Model PBR




The Baseline Model deterministic reserve is higher than the best-estimate liability given the remainder of the *VM-20* margins but significantly lower than the 2017 CSO XXX reserve.

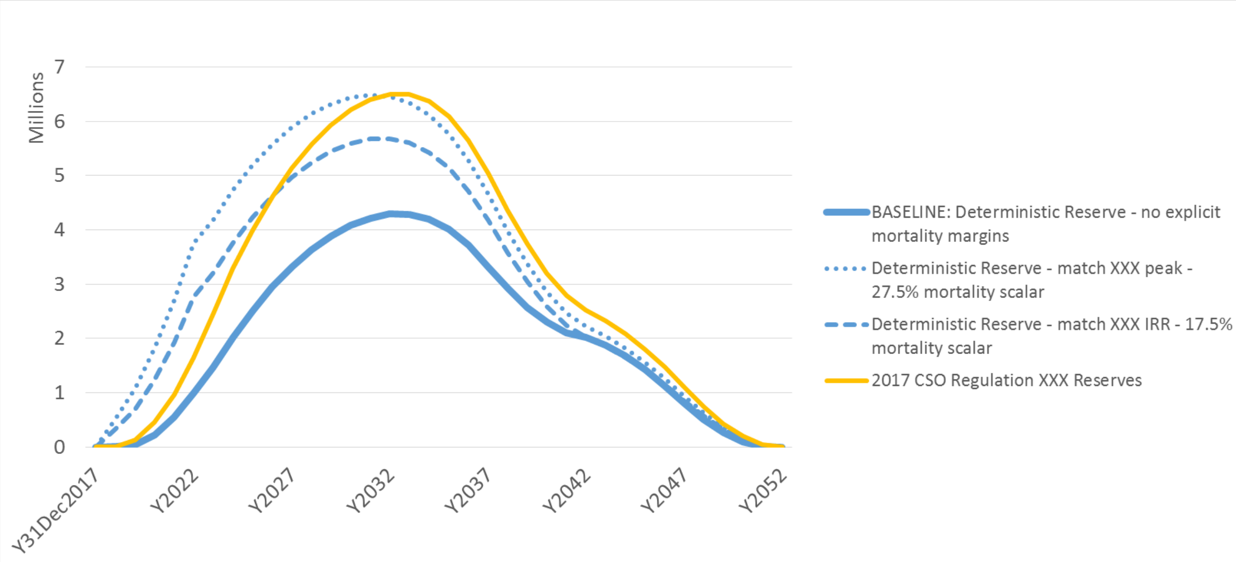
It is noteworthy that the deterministic reserve is already higher than the NPR even without an explicit mortality margin on the DR. However, we draw attention to the fact that there are numerous variables that impact the comparison of the NPR and the DR, mortality credibility being one, and that the relative comparison will vary from one company to another.

Furthermore, the DR curve is left-shifted compared to both the 2017 CSO XXX reserve and the NPR because of the continuous incremental improvement of the mortality in the projection from the application of the dynamic mortality improvement. The 2017 CSO XXX reserve and the NPR on the other hand have mortality assumptions that remain static throughout the projection. While not the case here, a key implication is how the NPR may dominate further out in the projection and move the focus away from the principles-based modeled reserves.

It should be noted though that the *Valuation Manual* allows for the NPR mortality assumption to potentially be unlocked, unlike in pre-PBR CRVM. However, this would occur in the future when an updated industry valuation table is available. The *Valuation Manual* in its guidance note under *VM-20* §3.C.1 recognizes the various implications of such a change and mentions that the details of unlocking the NPR mortality table will need to be addressed in the future. An in-depth discussion of the NPR is beyond the scope of this paper.

Having explored the no-credibility-margin deterministic reserve, we investigated the level of mortality experience that would result in the Baseline Model deterministic reserve to equate to the 2017 CSO XXX reserve. Figure 2 shows the results both under the match peak and the match IRR method under the in-force block approach.

**Figure 2**
2017 CSO XXX versus Baseline Model PBR: Mortality Scalars




The dotted and the dashed blue lines indicate the mortality loads necessary—27.5% under the match peak and 17.5% under the match IRR method—to equate the Baseline Model deterministic reserve with no explicit mortality margins to the 2017 CSO XXX reserve.

Figure 2 demonstrates why we find the match IRR method to be superior. The match peak method does not account for the different shape, in particular the left-shifting, of the DR curve relative to the 2017 CSO XXX reserve. As such it overestimates the load. One way to interpret the 17.5% mortality load determined under the match IRR method is as an average load between the industry basic table, used in the deterministic reserve, and the industry valuation table, used in the 2017 CSO XXX reserve. It should be noted that the load is influenced by the Baseline Model assumptions and therefore while indicative, it should not be misconstrued as a universal load.

## 5.2 Attribution Analysis of Modeled Reserves to Pre-PBR CRVM

To better understand the modeled reserve under PBR compared to the 2017 CSO XXX reserve, we carried out an attribution analysis of the key assumption differences highlighted in Section 2. The attribution analysis included the following sensitivity runs under the in-force block approach:

1. Remove dynamic mortality improvement: Relative to the Baseline Model, this run removes the recognition of mortality improvement in the projection as it is realized. This further heightens the implicit mortality load in the deterministic reserve and is akin to the base mortality table being static as is the case in pre-PBR CRVM.

2. Remove lapse assumption in the Baseline Model: Quantifies the impact that the lapse assumption has on the modeled reserve compared to pre-PBR CRVM where lapsation is prescribed to be zero.

3. Replace the Net Asset Earned Rate curve with a flat 3.5% discount rate in the Baseline Model: Quantifies the impact of discounting liabilities based on the returns from

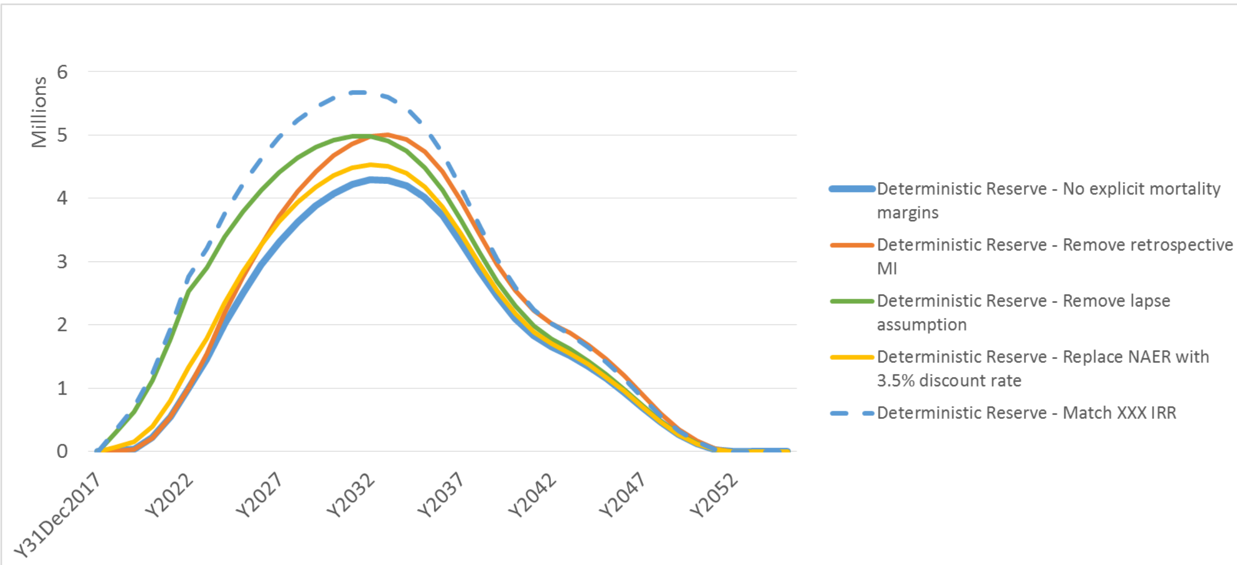
invested assets, including starting and reinvestment assets, to pre-PBR CRVM where a flat interest rate that is locked in is assumed.

While not displayed as an attribution analysis run, as demonstrated in Section 5.1, the match XXX IRR run is both (1) a proxy for the 2017 CSO XXX reserve in a cash flow model and (2) an estimate of the overall prudency in the industry valuation mortality table (2017 CSO) relative to the industry basic mortality table (2015 VBT) from which the industry valuation mortality table is built.

The attribution analysis is illustrated in Figure 3 where each reserve curve demonstrates a noncumulative impact of a key assumption difference against the Baseline Model.

**Figure 3**

Attribution Analysis of Key Assumption Differences Between 2017 CSO XXX and DR




The following are some noteworthy observations.

1. Sensitivity of margins: The reserve is most sensitive to the mortality margins followed by the lapse margin and then finally the discount rate.

   The difference between the dashed blue and bold blue curves may be read as the impact of the explicit mortality margin underlying the 2017 CSO XXX reserve and the static nature of the base mortality rates therein. It does not reflect the impact of the implicit mortality load of no future mortality improvement because that load is incorporated in the bold blue curve. We explore the impact of the implicit mortality load within the deterministic reserve relative to the best-estimate liability in the next section.

2. The directional impact of the Net Asset Earned Rate compared to a flat, locked-in interest rate is dependent on the current interest rate environment. If, for instance, we are in a high interest-rate environment, the yellow curve would be expected to be lower than the bold blue curve due to the mean reversion of interest rates within the economic scenario generator that builds the NAER interest rate path.

3. The left-shifting of the deterministic reserve due to the dynamic mortality improvement is more observable in Figure 3 when comparing the orange curve to the bold blue curve.

## 5.3 Varying Mortality Credibility Within the Modeled Reserves

So what does all of this mean for a company trying to get a feel for what their PBR reserve will look like? Or one that is grasping with questions around relevancy and aggregation of mortality for the purposes of determining credibility? Or one that is debating whether adopting PBR is even worth the effort if it qualifies for the Companywide Exemption?

To expound on these questions, we layered on mortality credibility to the Baseline Model. We initially did so purely on a sensitivity basis, that is, identified different levels of credibility and sufficient data period to study impacts. Later in the paper, we will explore ranges of credibility likely to be observed in real life for companies that have different business profiles.

Table 7 summarizes the sensitivity runs and the results thereof. We draw the reader's attention to the fact that with mortality credibility layered on, we are now building a true PBR deterministic reserve that has all components of prudency, including specifically the credibility-based explicit mortality margins and grade to industry tables. *VM-20* margins for different levels of credibility and the table specifying the grade to industry determination are included in Appendix C.

**Table 7**
IRR, Mortality Loads to Match 2017 CSO XXX IRR and Approximate Credibility-Based Mortality Margin for Various Credibility and SDP Sensitivities

| A: Limited Fluctuation Credibility (%) | B: Sufficient Data Period (Years) | C: IRR (%) | D: Mortality Load to Match 2017 CSO XXX IRR (%) | E: Approximate Credibility-Based Mortality Margin (%) |
|---|---|---:|---:|---:|
| 2017 CSO XXX reserve | | 6.2 | N/A | N/A |
| 10 | 0 | 6.3 | 2.0 | 15.5 |
| 30 | 2 | 6.3 | 2.0 | 15.5 |
| 50 | 6 | 6.5 | 4.0 | 13.5 |
| 50 | 12 | 6.7 | 7.0 | 10.5 |
| 70 | 12 | 7.1 | 10.0 | 7.5 |
| 90 | 12 | 7.6 | 12.5 | 5.0 |
| 90 | 16 | 7.7 | 13.5 | 4.0 |
| 99+ (Bühlmann) | 16 | 8.0 | 15.0 | 2.5 |
| Baseline Model DR | | 8.7 | 17.5 | — |

The following are some observations on the results of the credibility and SDP sensitivities:

1. The results of the 2017 CSO XXX reserve and Baseline Model determinsitic reserve are reiterated here. These demonstrate the two extremes in the range of results. A 17.5% mortality load applied to the Baseline Model, which has all the necessary *VM-20* margins

except for the credibility-based explicit mortality margin, equates the Baseline Model deterministic reserve to the 2017 CSO XXX reserve.

2. The range of pricing IRRs of [6.3%–8.0%] under various DR mortality credibility sensitivities is greater than the pricing IRR under the 2017 CSO XXX of 6.2%; however, the lower end of the range is only marginally so. This is to be expected given the prescribed *VM-20* mortality margins where there is very little to no credibility (less than or equal to 12% under the Limited Fluctuation Method, or less than or equal to 22% under the Bühlmann Method) is similar to the loads applied to the 2015 VBT to get to the 2017 CSO mortality tables.[8]

3. One way to read the mortality loads identified in column D is to interpret them as the level of company mortality experience relative to the Baseline Model that would result in a similar pricing IRR as under the 2017 CSO XXX. The company mortality experience underlying the Baseline Model is the 2015 VBT RR90 ALB for nonsmokers and 2015 VBT RR100 ALB for smokers.

   For instance, the 4% match IRR mortality load in row 4 of the table implies that for a company having Limited Fluctuation credibility of 50% and a sufficient data period of six years, if their company mortality experience is tracking at 104% of the company experience underlying the Baseline Model, then their pricing IRR will be similar under PBR as under pre-PBR CRVM.

   As would therefore be expected, the higher the credibility and sufficient data period a company has, the worse their company experience can be relative to the Baseline Model while still having higher product profitability by implementing PBR.

4. Another way to interpret the results in column D is to take the difference between the mortality load under each sensitivity run against the mortality load of 17.5% identified for the Baseline Model, as shown in column E. The delta is an approximate explicit mortality load embedded within the PBR deterministic reserve.

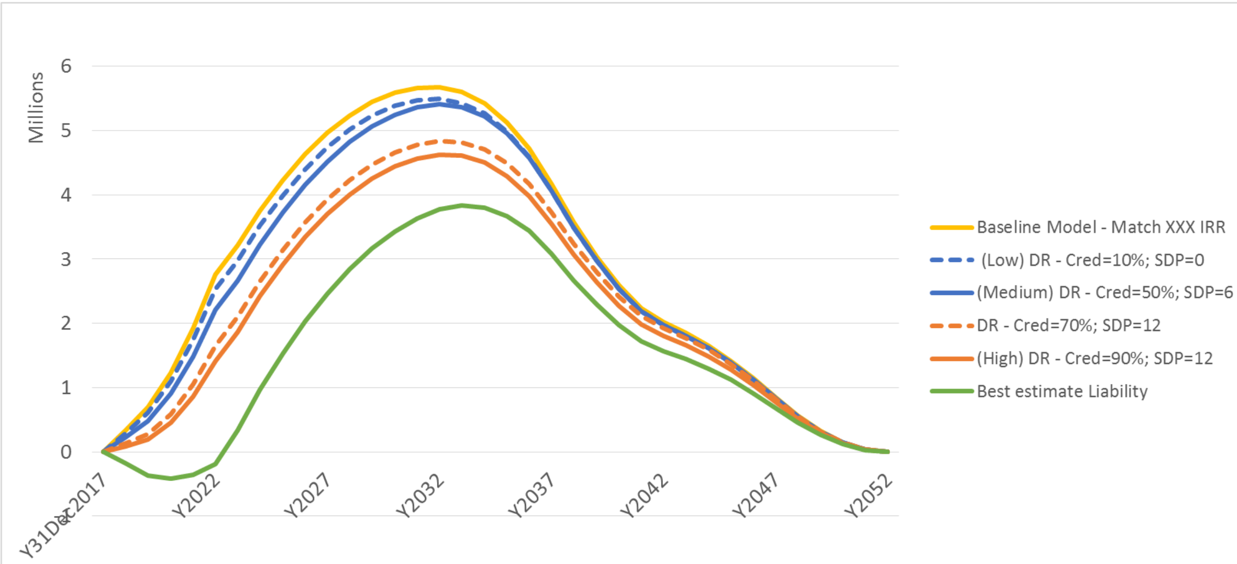
5. What isn't included in the calculation in column E is the implicit mortality load within the deterministic reserve of not recognizing any future mortality improvement. To approximately determine in a single value what this load is we compared the IRR under the Baseline Model deterministic reserve to IRR under the best-estimate liability. Since the best-estimate liability has full future mortality improvement reflected, and therefore has a lower reserve projection, we then identified what mortality load needs to be applied to the best-estimate liability such that the pricing IRR is similar to the Baseline Model. We determined this to be 7.6%. As such, under the Baseline Model parameters, the impact at time 0 of not reflecting future mortality improvement is tantamount to a

[8] See the Society of Actuaries' 2017 Commissioners Standard Ordinary (CSO) Tables at https://www.soa.org/resources/experience-studies/2015/2017-cso-tables/.

7.6% implicit mortality load on the best-estimate liability. This load decreases through the projection as retrospective mortality improvement is recognized.

Figure 4 illustrates graphically the impact that mortality credibility has on the reserve projection for select sensitivities.

**Figure 4**
Impact of Mortality Credibility on the Deterministic Reserve




Rapid and significant improvement occurs when increasing credibility from the lower levels, as illustrated by the distance between the blue and orange lines; however, the marginal utility decreases as companies get to higher levels of credibility, as illustrated by the distance between the solid and dashed orange lines.

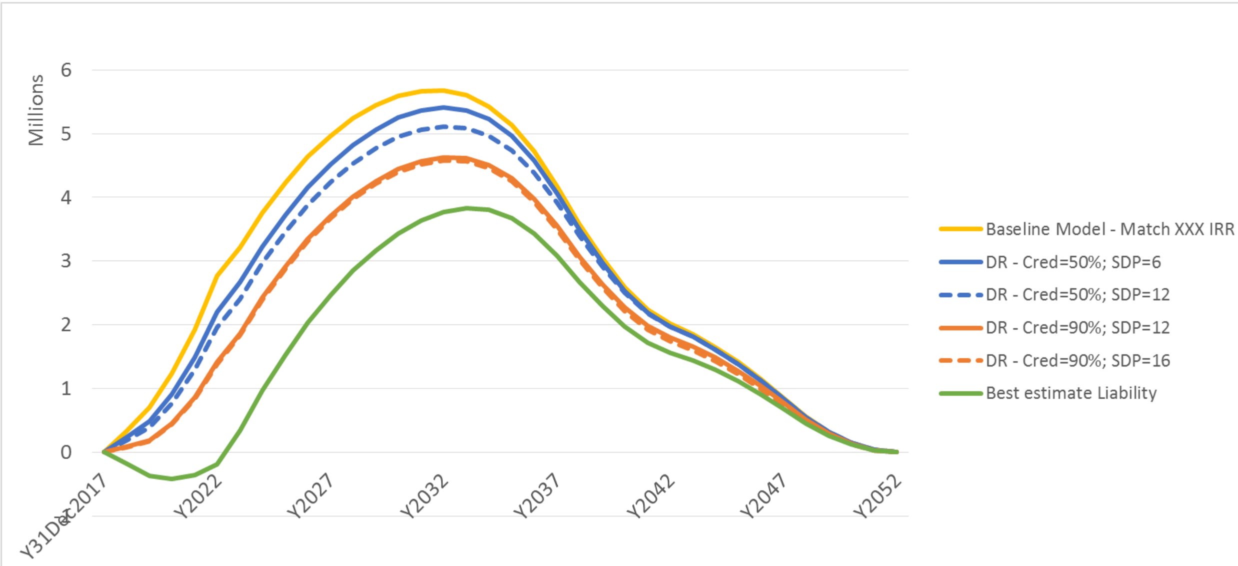
We believe that the “sweet spot” for credibility is around 80% and above.

## 5.4 Impact of the Sufficient Data Period on the Modeled Reserves

Figure 5 illustrates the impact that the sufficient data period has on the reserve projection for select sensitivities.

**Figure 5**

Impact of the Sufficient Data Period on the Deterministic Reserve




Similar conclusions may be drawn here as under Figure 4. At lower levels of SDP, there is a higher marginal benefit for each incremental year of SDP, as illustrated by the distance between the solid and dashed blue lines, which decreases as the SDP increases, as illustrated by the distance between the solid and dashed orange lines.

The sufficient data period is a more material and sensitive aspect of the mortality margin the longer the tail of the liability. Therefore, while for term insurance the credibility-based *VM-20* margin is more impactful than the grade to industry tables driven by the sufficient data period, for permanent insurance, the sufficient data period is as, and is likely more, material than the credibility-based *VM-20* margin.

## 5.5 Estimated Levels of Credibility and SDP for Various Profiles

To put the credibility sensitivities into perspective, we created company profiles that exist in the life insurance industry across characteristics that would impact the mortality credibility and the sufficient data period. The primary characteristic considered was company size; however, we layered on the following nuances which would impact the mortality credibility and the sufficient data period:

1. Whether a company has undergone a recent significant change to their underwriting methodology, target market, and/or distribution channel, such that business they are writing today is not relevant in terms of mortality expectations to business written prior to the change.

2. Whether a company has been a recent entrant into the term insurance or life insurance space and has seen strong growth.

To identify the mortality credibility and the sufficient data period that may be expected for such companies, we looked at the reinsurance claims experience of a range of companies and adjusted observations as necessary to account for reinsurance structures, pools and aggregation of mortality business.

The company profiles we derived along with an estimate of the mortality credibility (expressed and the sufficient data period were as specified in Table 8. While we identify singular values for the mortality credibility and the sufficient data period, we note that there is a range around these. Such a range is wider for smaller and midsized companies compared to ones with a larger relevant in-force and claims experience.

**Table 8**

Company Profiles with Estimates of Mortality Credibility, Sufficient Data Period and Resulting IRR

| Company Profile | Bühlmann Credibility | Sufficient Data Period | IRR |
|---|---|---|---|
| **Large established company** | 98% | 20 | 7.8% |
| **Large established company with recent significant change to underwriting/target market/distribution channel** | 90% | 10 | 6.9% |
| **Midsize established company** | 85% | 14 | 7.0% |
| **Recent entrant with focus/strong growth on term-only business** | 75% | 8 | 6.6% |
| **Small company** | 30% | 2 | 6.3% |
| **FinTech/start-up insurance company** | 0% | 0 | 6.3% |

## Section 6: Impact of Reinsurance on Mortality Credibility

*VM-20* §9.C.4 makes it clear that credibility, whether calculated using the Limited Fluctuation Method or the Bühlmann Empirical Bayesian Method, must be calculated on a by-amount, or severity, basis. It is stated in several places, and it appears in the prescribed credibility formulas. However, as of the writing of this paper *VM-20* does not prescribe the amount basis to be used in the credibility calculations.

If an insurance company has reinsurance agreements in place that alter the amount that the company is insuring, there may be alternatives to using the full face amount in the credibility calculations worthy of consideration, such as the retained portion of the face amount.

It would be plausible for a company setting assumptions for future claims they will pay to base their work on the portion of the claim amount that they expect to pay, while the reinsurers would handle the ceded amounts using their own PBR assumptions. If the mortality assumption is consistent with and appropriate to the retained portion, then it would logically follow that credibility should be calculated based on the same retained amounts.

At the time of publication of this paper, there is still debate regarding whether reflecting retained amounts instead of full face amounts in experience studies and credibility calculations is appropriate. It is advisable to refer to the most current Valuation Manual to assess what approach is permissible. This section does not opine on the debate but rather seeks to provide readers with an objective view of the potential implications of reinsurance on experience studies and credibility.

The impact that reflecting the net effect of a reinsurance program has on the credibility calculations depends in large part on what kind of reinsurance is in place.

For first dollar quota share reinsurance, the standard deviation of the face amounts relative to the average amount will be the same, since both the numerator and denominator of the relative standard deviation calculation (standard deviation divided by the mean) change based on the same multiple. The result of the credibility calculation when reflecting first dollar quota share reinsurance on the amounts remains the same as it was when reflecting the full face amounts. This is assuming the same quota share percentage across the entire block, since using different percentages for different subsets of the portfolio could result in each subset being weighted into the calculation differently when considering the retained portion.

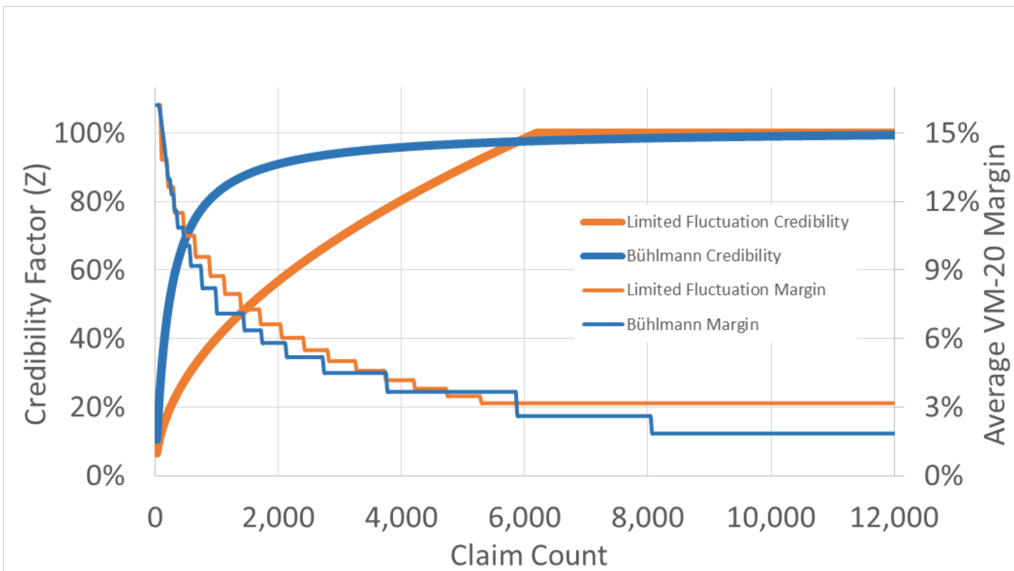
For excess reinsurance, any application of a retention limit will act as a cap on the face amounts in an experience study, which reduces the relative standard deviation. This in turn increases the calculated credibility, which can lead to lower mortality margins. Some examples are illustrated in the figures below.

Each of these figures is based on a hypothetical block of life insurance policies. They illustrate the relationship between the amount of experience, using claim count as a proxy, and both credibility and the explicit credibility-based *VM-20* mortality margin. The thicker lines represent the credibility calculations using both the Limited Fluctuation Method and the Bühlmann Empirical Bayesian Method, while the thinner lines represent an average explicit mortality margin and are based on the scale on the right-hand side.

Figure 6 illustrates these relationships when the full face amount is used as the amount basis in the credibility calculations, ignoring any reinsurance. Figures 7 and 8 illustrate the same relationships but are based on amounts that reflect the impact of excess reinsurance under different retention limit scenarios.

An example could be helpful in understanding these figures. Suppose experience for a block of business has 2,000 claims. For this block the credibility factor is 57% using the Limited Fluctuation Method and 91% using the Bühlmann Empirical Bayesian Method. The average explicit mortality margin is approximately in the 5.8%–6.6% range for both.

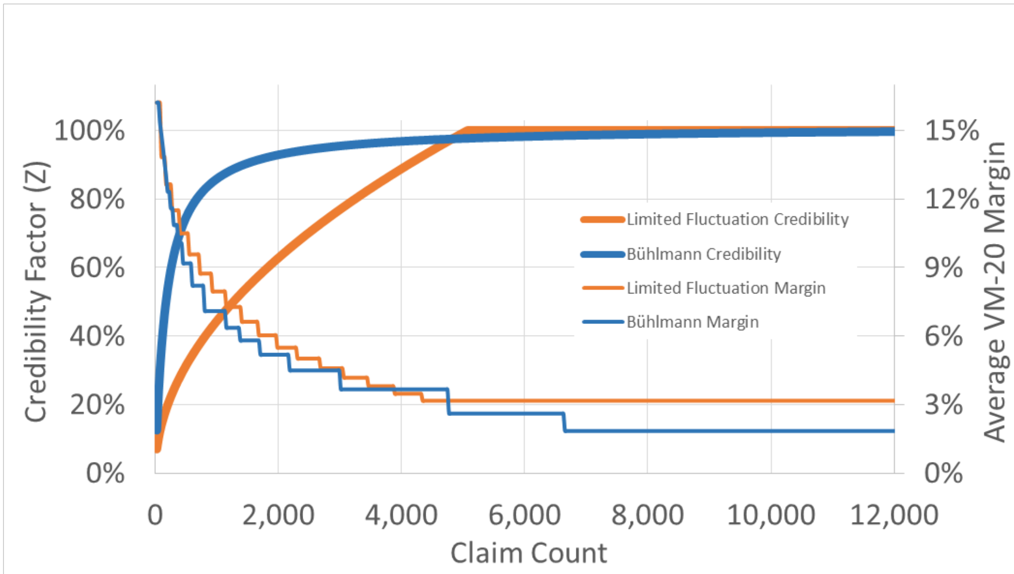
**Figure 6**
Credibility Factors and Margins Based on Full Face Amount




In Figure 7, the face amounts are effectively capped at $2 million as excess reinsurance with a $2 million retention limit is reflected in the retained amounts. In the example with 2,000 claims, the credibility factor is 63% (up from 57%) using the Limited Fluctuation Method and 93% (up from 91%) using the Bühlmann Empirical Bayesian Method. The average *VM-20* required margin has dropped slightly to the 5.2%–5.5% range.

**Figure 7**

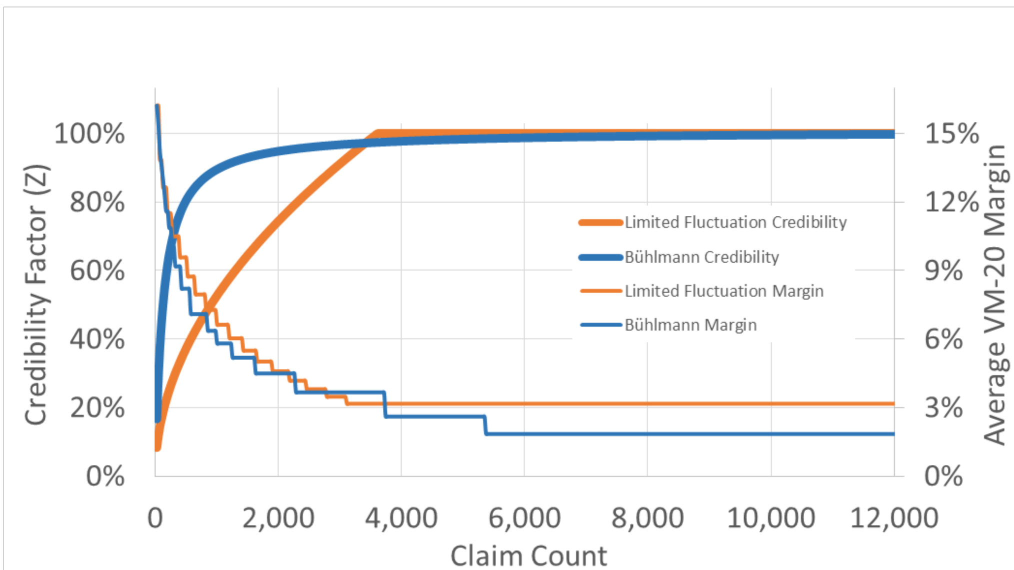
Credibility Factors and Margins Based on Excess Reinsurance: $2 Million Retention Limit




In Figure 8, the face amounts are capped at $500,000 to reflect excess reinsurance with a $500,000 retention limit. In the example with 2,000 claims, the credibility factor is 75% (up from 57%) using the Limited Fluctuation Method and 95% (up from 91%) using the Bühlmann Empirical Bayesian Method. The average *VM-20* required margin has dropped to the 4.5%—4.6% range.

**Figure 8**

Credibility Factors and Margins Based on Excess Reinsurance: $500,000 Retention Limit



As reinsurance is reflected in the retained amounts and the retention limit decreases, credibility increases and the explicit mortality margins decrease.

The change from using full face amounts to using retained amounts net of reinsurance works well for the credibility calculation formulas under the Limited Fluctuation Method, since the retained amounts can be simply inserted into the formulas and used in the calculations the same way that full face amounts could have been used.

However, for credibility calculations using the Bühlmann Method, more careful consideration is needed because of the way the calculation formulas prescribed in *VM-20* work. In particular, the constants in the *VM-20* Bühlmann formula, in other words, the 0.019604, 109% and 120.4% that are multiplied by the A, B and C terms, respectively, were derived based on the full face amounts of policies in the study underlying the 2015 Valuation Basic Table. Therefore, simply dropping retained amounts into the formulas may not be appropriate if they are not consistent with the way the prescribed *VM-20* Bühlmann formula was intended to be used.

If a company chooses to use Bühlmann credibility in PBR going forward, some sensitivity testing probably needs to be done to become more comfortable with that approach, to see if they would arrive at similar margins if they were to use Limited Fluctuation Method, and probably both on a gross face amount basis and net of reinsurance in order to see the full impact of each calculation change.

Another consideration when deciding whether to use full face amounts or retained amounts in *VM-20* credibility calculations is the consistency with the rest of the assumption-setting process. If amounts net of reinsurance are used in calculating credibility, then a consistent approach should be used when setting the mortality assumption, which would require the use of the retained amounts as the amount basis in any experience studies. For first dollar quota share reinsurance, there should not be a significant difference unless there is a difference in quota share percentages that could introduce a bias. When dealing with excess reinsurance, however, there will be less weight on the larger policies in the study. The larger policies will generally have lower mortality relative to smaller policies because more underwriting tests have been done for larger face amounts, so the mortality assumption may be slightly higher on the retained portion, which may partially or wholly offset the small amount of margin reduction obtained by calculating credibility based on retained amounts. It will be up to each company to make the judgment for their own blocks of business.

As with many aspects of PBR, the actuary must decide what amount basis is the most appropriate in their application.

## Section 7: External Sources of Data to Enhance Mortality Credibility

The *Valuation Manual* contains a very detailed description for setting the mortality assumption. *VM-20* §9.A.6.a mentions using relevant company experience, industry experience data, tables and other applicable data to set mortality assumptions.

> For risk factors (such as mortality) to which statistical credibility theory may be appropriately applied, the company shall establish anticipated experience assumptions for the risk factor by combining relevant company experience with industry experience data, tables, *or other applicable data (emphasis added)* in a manner that is consistent with credibility theory and accepted actuarial practice.

*VM-20* §9.C.2 requires the use of experience data for setting mortality assumptions. Here we are given several options, ranging from a very narrow focus on just the product in question, to a wider range of business being aggregated for the purpose of assumption setting. Some companies may have the potential to significantly increase the credibility associated with their mortality assumption if they look to outside sources for additional experience data. Examples of these additional sources could include available experience data from other companies under the same parent company, data provided by a data aggregator or, as referenced in *VM-20* §9.C.2, data from a reinsurance pool. The increased credibility comes with the burden of additional documentation to justify the use of that data. A company must be able to show that the additional experience being used is relevant to their own block. *VM-20* §9.C.2.b.iii states:

> Experience data from other sources, if available and appropriate, such as *actual experience data of one or more mortality pools in which the policies participate under the term of a reinsurance agreement (emphasis added).* Data from other sources is appropriate if the source has *underwriting and expected mortality experience characteristics that are similar to policies in the mortality segment (emphasis added).*

Next are some key things to consider when deciding what experience to use to set a *VM-20* mortality assumption. It is important to consider how relevant the experience data is to the block of business for which one is setting assumptions.

In the context of using experience from a reinsurer, there are several questions one must ask when determining how relevant that experience is. For one, were the policies in that pool subject to similar underwriting criteria? The underwriting criteria of course will not match exactly, since each company does not use the same underwriting, but it should have enough similarities that a reasonable actuary would expect similar levels of mortality.

The second consideration is the policyholder demographics compared to the referent block. For example, experience is limited in relevance if the age distribution is significantly younger or older than your own block due to differences in age trends over time relative to the VBT. This would also include things like gender distribution and face amount distribution, among other things.

Finally, does the additional experience have a similar target market and distribution channel to your block? An extreme (and completely made-up) example would be a company with captive agents that targets smokers using data to set assumptions from companies who use independent agents and advertise to nurses. The not-so-extreme examples and everything else in between will require a lot of thought, documentation and probably some testing to get comfortable.

There is also the question of the reinsurance structure reflected in the experience shared by a reinsurer. If there is a lot of excess reinsurance, there might be an inherent skewness toward larger policies that may need to be assessed.

Every opportunity has its own unique set of costs and benefits to consider. Table 9 summarizes three different sources of external data to enhance credibility and the costs and benefits associated with each.

**Table 9**
Cost-Benefit Analysis of External Sources of Data

| Data Source | Benefit | Cost |
|---|---|---|
| Reinsurer | 1. **Relationship:** Data submission channel already exists<br>2. **Relevancy:** More industry, business and assumption-setting knowledge to better determine relevancy<br>3. **Ownership of data:** Owns reinsurance data<br>4. **Long-term stability:** Vested interest in underlying data | 1. **Cost (explicit):** Compensation either through reinsurance or fees<br>2. **Cost (implicit):** Ties you to a reinsurer |
| Data aggregator | 1. **Relationship:** Data submission channel may already exist<br>2. **Relevancy:** Have granularity and credibility expertise, but not necessarily business knowledge | 1. **Cost (explicit):** Compensation through fees<br>2. **Relationship:** Need to submit data if relationship does not exist<br>3. **Ownership of data:** Do not own data without explicit consent for other uses<br>4. **Long-term stability:** Less skin in the game |
| Affiliate life insurer | 1. **Cost (explicit):** Likely none<br>2. **Relevancy:** Relatively straightforward to assess relevancy | 1. **Cost (implicit):** Limited credibility enhancement |

Each company likely has several options for sources of experience data that can potentially be used to help set a *VM-20* mortality assumption. For each of these sources, there may be a question of whether they are willing or even able to share experience externally.

For example, if there is a nondisclosure agreement in place between a reinsurer and one of its clients that precludes the reinsurer from using the experience on that block for any purpose not explicitly stated, they may not be able to reflect that experience in what they share.

Other factors may revolve around reinsurers putting a high value on their intellectual property and asking to put restrictions or agreements in place regarding future new business to compensate them for the work involved.

Data aggregators on the other hand are likely bound by restrictions on the data they have in terms of what it can be used for. They may also not have the market and business knowledge necessary to assess the relevancy of the experience data.

Finally, while assessing relevancy with an affiliate life insurance company may be relatively straightforward, any such experience data likely has limited upside in enhancing the credibility of the assumption.

In order to use more than one's own company experience when setting the *VM-20* mortality assumption, one will need to provide evidence of the relevancy and appropriateness of the external experience data to the block of business for which one is setting assumptions.

It is ultimately up to each company's Qualified Actuar(ies) and Appointed Actuary to provide this evidence, but they can do so using reliance statements, as noted in *VM-20*. Any reinsurer or data aggregator providing experience should be prepared to provide sufficient documentation on which an Appointed Actuary can rely.

*VM-20* §9.B.2 and *VM-20* §9.C.5.d include lists of items that may prompt actuaries to increase their margin. If using external data where the experience is not entirely relevant, it may be appropriate to set an additional margin on the *VM-20* mortality assumption. Data may be of "poor quality" if incomplete, internally inconsistent or not current. If this is the case, the margin may need to similarly be increased. The conclusion is that although margins are already included based on credibility, various factors may necessitate the setting of an additional margin.

## Appendix A: Baseline Model Assumption Details

Table A.1 is provided as supplemental information to Section 3. Distribution breakdowns are provided as a percent of total policy face amount.

**Table A.1**
Distribution by Face Amount

| Gender | Distribution |
|---|---|
| Female | 40% |
| Male | 60% |

| Smoker | Risk Class | Distribution |
|---|---|---|
| Nonsmoker | Residual | 30% |
| | Preferred | 20% |
| | Super preferred | 25% |
| | Ultra-preferred | 20% |
| Smoker | Residual | 3% |
| | Preferred | 2% |

| Face Amount Band | Distribution |
|---|---|
| 0—99,999 | 1% |
| 100,000 - 249,999 | 19% |
| 250,000—499,999 | 25% |
| 500-000—999,999 | 40% |
| 1,000,000+ | 15% |

| Issue Age | Distribution |
|---|---|
| 20–29 | 10% |
| 30–39 | 40% |
| 40–49 | 30% |
| 50–59 | 15% |
| 60–69 | 5% |

| Issue Date | Distribution |
|---|---|
| Feb. 15th | 25% |
| May 15th | 25% |
| Aug. 15th | 25% |
| Nov. 15th | 25% |

Lapse rates were assumed by duration and level-term period (see table A.2).

**Table A.2**
Lapse Rates by Duration and Level-Term Period

| Duration | 1–2 | 3–5 | 6–7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|
| T10 | 8% | 7% | 6% | 7% | 8% | 100% |

| Duration | 1 | 2–3 | 4–6 | 7–11 | 12–16 | 17–19 | 20 |
|---|---|---|---|---|---|---|---|
| T20 | 6% | 5% | 4% | 3% | 2% | 3% | 100% |

| Duration | 1 | 2 | 3 | 4–5 | 6–8 | 9–28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|
| T30 | 8% | 6% | 5% | 4% | 3% | 2% | 3% | 100% |

## Appendix B: Baseline Model Sensitivities

We ran the following sensitivities on the Baseline Model:

1. 95% multiplier applied to premiums
2. 90% multiplier applied to the lapse assumption
3. Expense sensitivities:
    a. 75% multiplier applied to acquisition expenses
    b. 75% multiplier applied to maintenance expenses
4. Increase to the Net Asset Earned Rate (NAER) assumption by 50 basis points (0.50%)

The IRR impacts from the assumption sensitivities is shown in Table B.1.

**Table B.1**
Impacts to IRR from Baseline Model Sensitivities

| Sensitivity | IRR (%) |
|---|---|
| 2017 CSO XXX reserves | 6.2 |
| Baseline Model | 8.7 |
| 95% premium | 8.0 |
| 90% lapse | 9.6 |
| 75% acquisition expense | 8.7 |
| 75% maintenance expense | 9.6 |
| 50 bps NAER increase | 7.5 |

Figure B.1 demonstrates the impact of a 5% decrease in premiums to the deterministic reserve. There is a greater impact in the first half of the projection. This is seen through the initial increase in the projection curve that diverges to the baseline as the present value of premiums decreases as in-force decreases.

**Figure B.1**
95% Premium Scalar Sensitivity

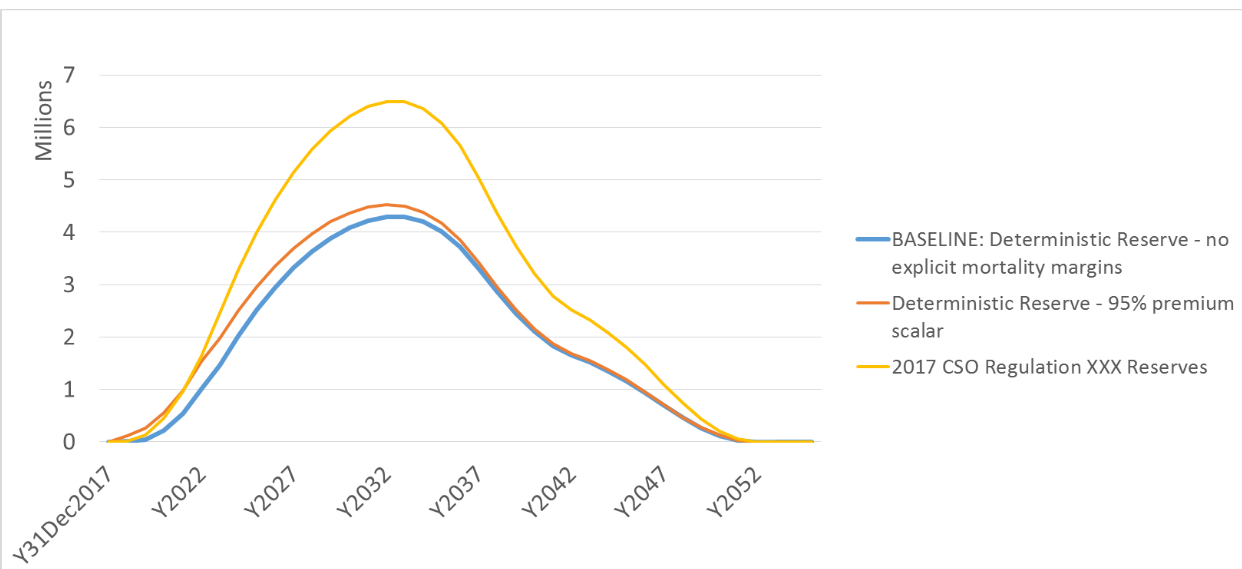


Figure B.2 illustrates the impact of applying a 90% multiplier to the inner and outer loop lapse assumption. Decreasing the lapse decrement increases the projection curve.

**Figure B.2**

90% Lapse Scalar Sensitivity

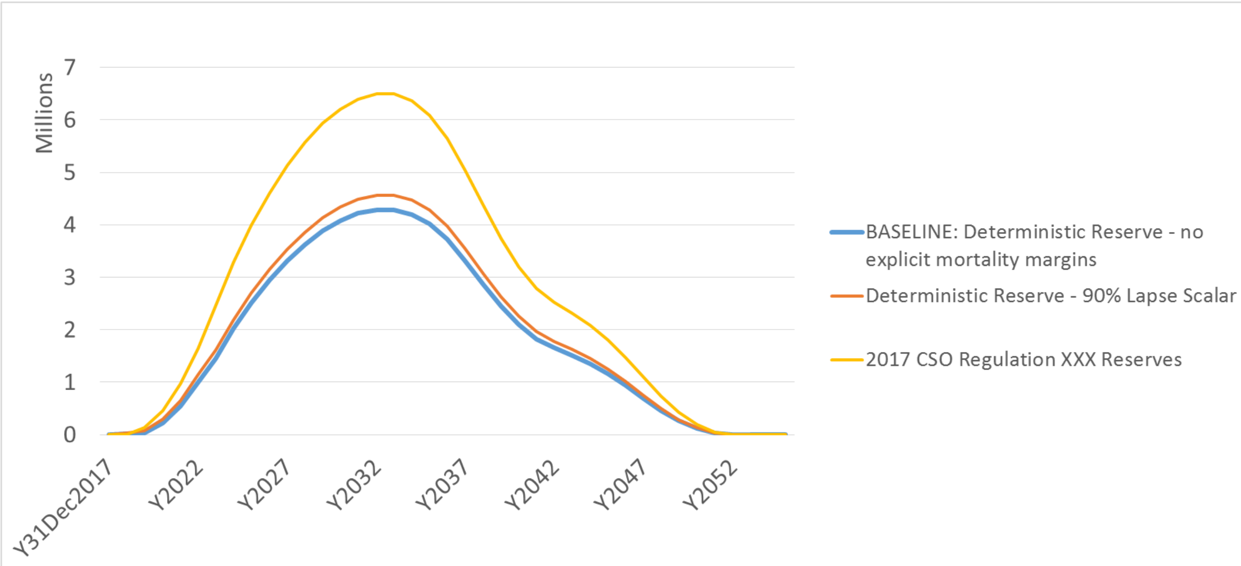



Figure B.3 shows the impact of a 75% multiplier applied to the expense assumption. Two different sensitivities were run: one to the acquisition expense and one to the maintenance expense assumption, both of which are detailed in Section 6. Modifying the acquisition expense did not move the projection curve. However, the impact is seen through a 0.9% increase in the IRR.

**Figure B.3**

75% Expense Scalar Sensitivity

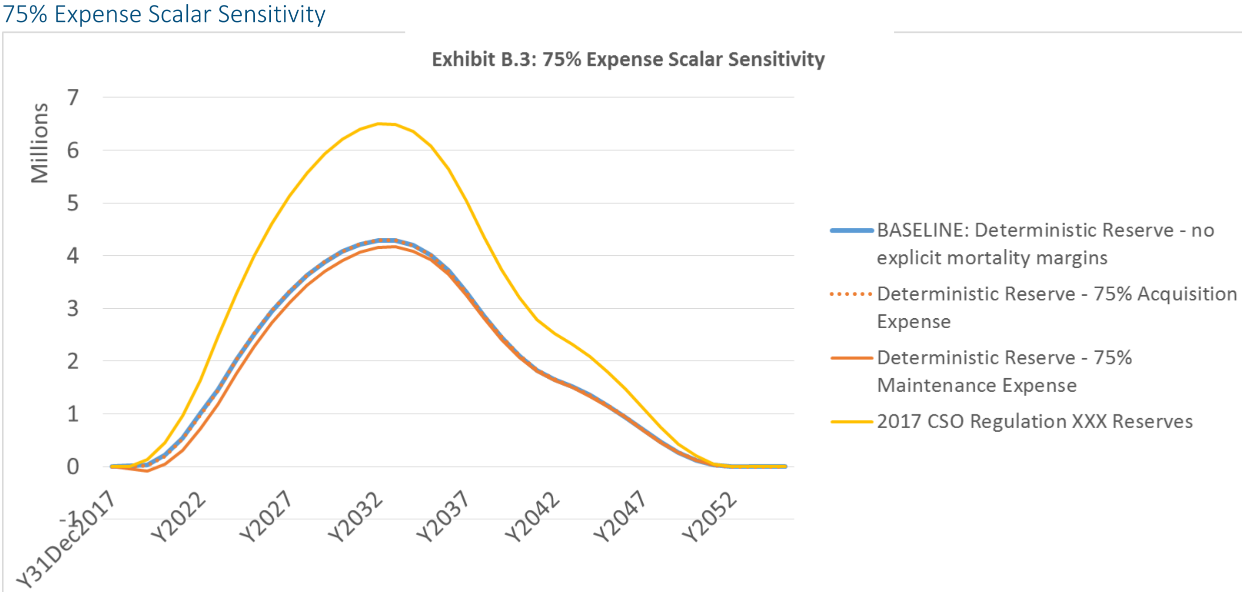
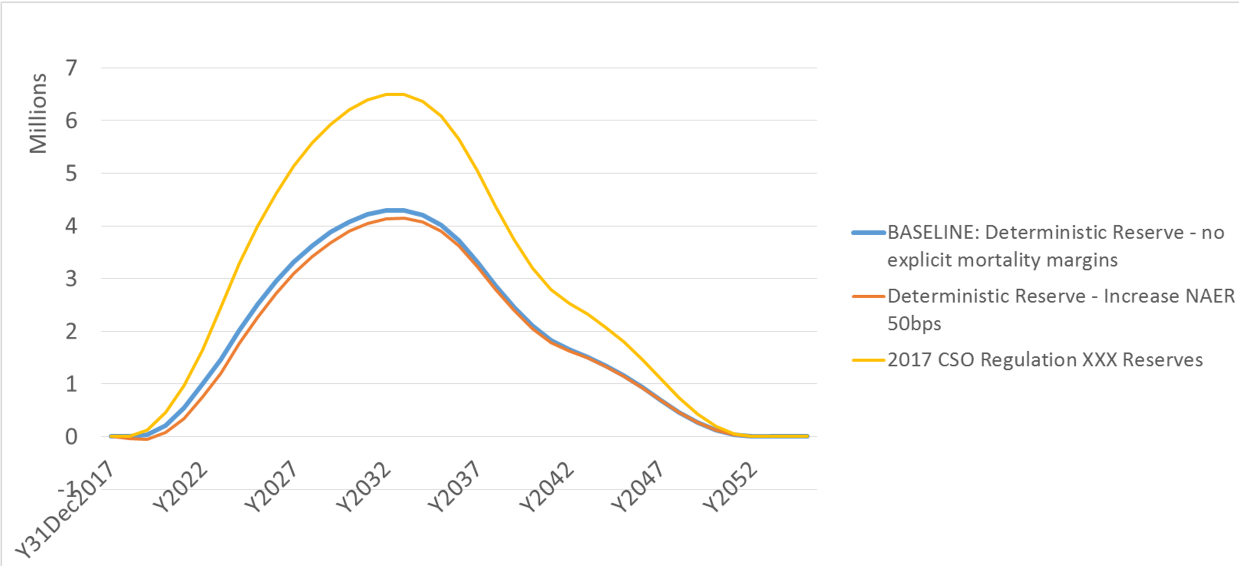


Figure B.4 illustrates the change caused by increasing the deterministic reserve's net asset earned rate (NAER) assumption by 50 basis points.

**Figure B.4**

Effect of Increase of NAER by 50 bps



## Appendix C: *VM-20* Credibility-Based Mortality Margin Tables

**Table C.1**

*VM-20* §9.C.5.b.iii: Credibility-Based Limited Fluctuation Margins (%)

| **Limited Fluctuation Margins** | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Credibility Level (%) | | | | | | | | | | | | | | | | | | | |
| Attained Age | 0–7% | 8–12% | 13–17% | 18–22% | 23–27% | 28–32% | 33–37% | 38–42% | 43–47% | 48–52% | 53–57% | 58–62% | 63–67% | 68–72% | 73–77% | 78–82% | 83–87% | 88–92% | 93–100% |
| <46 | 20.4 | 20.4 | 17.4 | 15.9 | 14.5 | 13.2 | 12.1 | 11.0 | 10.0 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 |
| 46–47 | 20.2 | 20.2 | 17.4 | 15.9 | 14.5 | 13.2 | 12.1 | 11.0 | 10.0 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 |
| 48–49 | 20.0 | 20.0 | 17.2 | 15.7 | 14.3 | 13.0 | 11.9 | 10.8 | 9.9 | 9.0 | 8.2 | 7.5 | 6.8 | 6.2 | 5.7 | 5.2 | 4.7 | 4.3 | 3.9 |
| 50–51 | 19.8 | 19.8 | 17.0 | 15.5 | 14.1 | 12.9 | 11.7 | 10.7 | 9.7 | 8.9 | 8.1 | 7.4 | 6.7 | 6.1 | 5.6 | 5.1 | 4.7 | 4.2 | 3.9 |
| 52–53 | 19.6 | 19.6 | 16.7 | 15.2 | 13.9 | 12.7 | 11.5 | 10.5 | 9.6 | 8.7 | 8.0 | 7.3 | 6.6 | 6.0 | 5.5 | 5.0 | 4.6 | 4.2 | 3.8 |
| 54–55 | 19.2 | 19.2 | 16.4 | 15.0 | 13.6 | 12.4 | 11.3 | 10.3 | 9.4 | 8.6 | 7.8 | 7.2 | 6.5 | 5.9 | 5.4 | 4.9 | 4.5 | 4.1 | 3.8 |
| 56–57 | 18.9 | 18.9 | 16.1 | 14.7 | 13.4 | 12.2 | 11.1 | 10.2 | 9.3 | 8.5 | 7.7 | 7.0 | 6.4 | 5.8 | 5.3 | 4.9 | 4.4 | 4.0 | 3.7 |
| 58–59 | 18.5 | 18.5 | 15.8 | 14.4 | 13.1 | 12.0 | 10.9 | 10.0 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.7 | 5.2 | 4.8 | 4.3 | 4.0 | 3.6 |
| 60–61 | 18.2 | 18.2 | 15.5 | 14.1 | 12.9 | 11.7 | 10.7 | 9.8 | 8.9 | 8.1 | 7.4 | 6.8 | 6.2 | 5.6 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 |
| 62–63 | 17.8 | 17.8 | 15.2 | 13.8 | 12.6 | 11.5 | 10.5 | 9.6 | 8.7 | 8.0 | 7.2 | 6.6 | 6.0 | 5.5 | 5.0 | 4.6 | 4.2 | 3.8 | 3.5 |
| 64–65 | 17.4 | 17.4 | 14.8 | 13.5 | 12.3 | 11.2 | 10.2 | 9.3 | 8.5 | 7.8 | 7.1 | 6.5 | 5.9 | 5.4 | 4.9 | 4.5 | 4.1 | 3.7 | 3.4 |
| 66–67 | 16.9 | 16.9 | 14.5 | 13.2 | 12.0 | 11.0 | 10.0 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.7 | 5.2 | 4.8 | 4.4 | 4.0 | 3.6 | 3.3 |
| 68–69 | 16.5 | 16.5 | 14.1 | 12.8 | 11.7 | 10.7 | 9.7 | 8.9 | 8.1 | 7.4 | 6.7 | 6.1 | 5.6 | 5.1 | 4.7 | 4.2 | 3.9 | 3.5 | 3.2 |
| 70–71 | 16.1 | 16.1 | 13.7 | 12.5 | 11.4 | 10.4 | 9.5 | 8.6 | 7.9 | 7.2 | 6.6 | 6.0 | 5.4 | 5.0 | 4.5 | 4.1 | 3.8 | 3.4 | 3.1 |
| 72–73 | 15.6 | 15.6 | 13.3 | 12.1 | 11.1 | 10.1 | 9.2 | 8.4 | 7.7 | 7.0 | 6.4 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 | 3.7 | 3.3 | 3.0 |
| 74–75 | 15.1 | 15.1 | 12.9 | 11.8 | 10.7 | 9.8 | 8.9 | 8.1 | 7.4 | 6.8 | 6.2 | 5.6 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 | 3.2 | 2.9 |
| 76–77 | 14.6 | 14.6 | 12.5 | 11.4 | 10.4 | 9.5 | 8.6 | 7.9 | 7.2 | 6.5 | 6.0 | 5.4 | 5.0 | 4.5 | 4.1 | 3.8 | 3.4 | 3.1 | 2.9 |
| 78–79 | 14.1 | 14.1 | 12.0 | 11.0 | 10.0 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.8 | 5.2 | 4.8 | 4.4 | 4.0 | 3.6 | 3.3 | 3.0 | 2.8 |
| 80–81 | 13.6 | 13.6 | 11.6 | 10.6 | 9.6 | 8.8 | 8.0 | 7.3 | 6.7 | 6.1 | 5.5 | 5.0 | 4.6 | 4.2 | 3.8 | 3.5 | 3.2 | 2.9 | 2.6 |
| 82–83 | 13.0 | 13.0 | 11.1 | 10.1 | 9.2 | 8.4 | 7.7 | 7.0 | 6.4 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 | 3.7 | 3.4 | 3.1 | 2.8 | 2.5 |
| 84–85 | 12.5 | 12.5 | 10.6 | 9.7 | 8.8 | 8.1 | 7.4 | 6.7 | 6.1 | 5.6 | 5.1 | 4.6 | 4.2 | 3.9 | 3.5 | 3.2 | 2.9 | 2.7 | 2.4 |
| 86–87 | 11.9 | 11.9 | 10.1 | 9.2 | 8.4 | 7.7 | 7.0 | 6.4 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 | 3.7 | 3.4 | 3.1 | 2.8 | 2.5 | 2.3 |
| 88–89 | 11.3 | 11.3 | 9.6 | 8.8 | 8.0 | 7.3 | 6.7 | 6.1 | 5.5 | 5.1 | 4.6 | 4.2 | 3.8 | 3.5 | 3.2 | 2.9 | 2.6 | 2.4 | 2.2 |
| 90–91 | 10.7 | 10.7 | 9.1 | 8.3 | 7.6 | 6.9 | 6.3 | 5.7 | 5.2 | 4.8 | 4.4 | 4.0 | 3.6 | 3.3 | 3.0 | 2.7 | 2.5 | 2.3 | 2.1 |
| 92–93 | 10.1 | 10.1 | 8.6 | 7.8 | 7.1 | 6.5 | 5.9 | 5.4 | 4.9 | 4.5 | 4.1 | 3.7 | 3.4 | 3.1 | 2.8 | 2.6 | 2.4 | 2.2 | 2.0 |
| 94–95 | 9.4 | 9.4 | 8.0 | 7.3 | 6.7 | 6.1 | 5.6 | 5.1 | 4.6 | 4.2 | 3.8 | 3.5 | 3.2 | 2.9 | 2.7 | 2.4 | 2.2 | 2.0 | 1.8 |
| 96–97 | 8.8 | 8.8 | 7.5 | 6.8 | 6.2 | 5.7 | 5.2 | 4.7 | 4.3 | 3.9 | 3.6 | 3.3 | 3.0 | 2.7 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 |
| 98–99 | 8.1 | 8.1 | 6.9 | 6.3 | 5.7 | 5.2 | 4.8 | 4.4 | 4.0 | 3.6 | 3.3 | 3.0 | 2.7 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 | 1.6 |
| 100–101 | 7.4 | 7.4 | 6.3 | 5.8 | 5.3 | 4.8 | 4.4 | 4.0 | 3.6 | 3.3 | 3.0 | 2.8 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 | 1.6 | 1.4 |
| 102–103 | 6.7 | 6.7 | 5.7 | 5.2 | 4.8 | 4.3 | 4.0 | 3.6 | 3.3 | 3.0 | 2.7 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 | 1.6 | 1.4 | 1.3 |
| 104–105 | 6.0 | 6.0 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 | 3.2 | 2.9 | 2.7 | 2.4 | 2.2 | 2.0 | 1.9 | 1.7 | 1.5 | 1.4 | 1.3 | 1.2 |
| >105 | 5.3 | 5.3 | 4.5 | 4.1 | 3.7 | 3.4 | 3.1 | 2.8 | 2.6 | 2.4 | 2.1 | 2.0 | 1.8 | 1.6 | 1.5 | 1.4 | 1.2 | 1.1 | 1.0 |

**Table C.2**

*VM-20* §9.C.5.b.ii: Credibility-Based Bühlmann Margins (%)

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bühlmann Margins** | | | | | | | | | | | | | | | | | | | | | | | |
| Credibility Level (%) | | | | | | | | | | | | | | | | | | | | | | | |
| Attained Age | 0–7% | 8–12% | 13–17% | 18–22% | 23–27% | 28–32% | 33–37% | 38–42% | 43–47% | 48–52% | 53–57% | 58–62% | 63–67% | 68–72% | 73–77% | 78–82% | 83–87% | 88–89% | 90–91% | 92–93% | 94–95% | 96–97% | 98% | 99% + |
| <46 | 20.4 | 20.4 | 20.4 | 20.4 | 20.0 | 19.3 | 18.6 | 17.9 | 17.1 | 16.3 | 15.5 | 14.6 | 13.7 | 12.7 | 11.6 | 10.3 | 8.9 | 8.0 | 7.3 | 6.5 | 5.7 | 4.6 | 3.3 | 2.3 |
| 46–47 | 20.2 | 20.2 | 20.2 | 20.2 | 20.0 | 19.3 | 18.6 | 17.9 | 17.1 | 16.3 | 15.5 | 14.6 | 13.7 | 12.7 | 11.6 | 10.3 | 8.9 | 8.0 | 7.3 | 6.5 | 5.7 | 4.6 | 3.3 | 2.3 |
| 48–49 | 20.0 | 20.0 | 20.0 | 20.0 | 19.7 | 19.1 | 18.4 | 17.6 | 16.9 | 16.1 | 15.3 | 14.4 | 13.5 | 12.5 | 11.4 | 10.2 | 8.8 | 7.9 | 7.2 | 6.4 | 5.6 | 4.6 | 3.2 | 2.3 |
| 50–51 | 19.8 | 19.8 | 19.8 | 19.8 | 19.4 | 18.8 | 18.1 | 17.4 | 16.7 | 15.9 | 15.1 | 14.2 | 13.3 | 12.3 | 11.2 | 10.0 | 8.7 | 7.8 | 7.1 | 6.4 | 5.5 | 4.5 | 3.2 | 2.2 |
| 52–53 | 19.6 | 19.6 | 19.6 | 19.6 | 19.1 | 18.5 | 17.8 | 17.1 | 16.4 | 15.6 | 14.8 | 14.0 | 13.1 | 12.1 | 11.1 | 9.9 | 8.6 | 7.7 | 7.0 | 6.3 | 5.4 | 4.4 | 3.1 | 2.2 |
| 54–55 | 19.2 | 19.2 | 19.2 | 19.2 | 18.8 | 18.2 | 17.5 | 16.8 | 16.1 | 15.4 | 14.6 | 13.7 | 12.9 | 11.9 | 10.9 | 9.7 | 8.4 | 7.5 | 6.9 | 6.1 | 5.3 | 4.3 | 3.1 | 2.2 |
| 56–57 | 18.9 | 18.9 | 18.9 | 18.9 | 18.5 | 17.9 | 17.2 | 16.5 | 15.8 | 15.1 | 14.3 | 13.5 | 12.6 | 11.7 | 10.7 | 9.5 | 8.3 | 7.4 | 6.8 | 6.0 | 5.2 | 4.3 | 3.0 | 2.1 |
| 58–59 | 18.5 | 18.5 | 18.5 | 18.5 | 18.1 | 17.5 | 16.9 | 16.2 | 15.5 | 14.8 | 14.1 | 13.2 | 12.4 | 11.5 | 10.5 | 9.4 | 8.1 | 7.3 | 6.6 | 5.9 | 5.1 | 4.2 | 3.0 | 2.1 |
| 60–61 | 18.2 | 18.2 | 18.2 | 18.2 | 17.8 | 17.2 | 16.5 | 15.9 | 15.2 | 14.5 | 13.8 | 13.0 | 12.1 | 11.2 | 10.3 | 9.2 | 7.9 | 7.1 | 6.5 | 5.8 | 5.0 | 4.1 | 2.9 | 2.1 |
| 62–63 | 17.8 | 17.8 | 17.8 | 17.8 | 17.4 | 16.8 | 16.2 | 15.6 | 14.9 | 14.2 | 13.5 | 12.7 | 11.9 | 11.0 | 10.0 | 9.0 | 7.8 | 7.0 | 6.4 | 5.7 | 4.9 | 4.0 | 2.8 | 2.0 |
| 64–65 | 17.4 | 17.4 | 17.4 | 17.4 | 17.0 | 16.4 | 15.8 | 15.2 | 14.6 | 13.9 | 13.2 | 12.4 | 11.6 | 10.8 | 9.8 | 8.8 | 7.6 | 6.8 | 6.2 | 5.6 | 4.8 | 3.9 | 2.8 | 2.0 |
| 66–67 | 16.9 | 16.9 | 16.9 | 16.9 | 16.6 | 16.0 | 15.4 | 14.8 | 14.2 | 13.5 | 12.8 | 12.1 | 11.3 | 10.5 | 9.6 | 8.6 | 7.4 | 6.6 | 6.1 | 5.4 | 4.7 | 3.8 | 2.7 | 1.9 |
| 68–69 | 16.5 | 16.5 | 16.5 | 16.5 | 16.2 | 15.6 | 15.0 | 14.5 | 13.8 | 13.2 | 12.5 | 11.8 | 11.0 | 10.2 | 9.3 | 8.3 | 7.2 | 6.5 | 5.9 | 5.3 | 4.6 | 3.7 | 2.6 | 1.9 |
| 70–71 | 16.1 | 16.1 | 16.1 | 16.1 | 15.7 | 15.2 | 14.6 | 14.1 | 13.5 | 12.8 | 12.2 | 11.5 | 10.7 | 9.9 | 9.1 | 8.1 | 7.0 | 6.3 | 5.7 | 5.1 | 4.4 | 3.6 | 2.6 | 1.8 |
| 72–73 | 15.6 | 15.6 | 15.6 | 15.6 | 15.3 | 14.7 | 14.2 | 13.7 | 13.1 | 12.5 | 11.8 | 11.1 | 10.4 | 9.7 | 8.8 | 7.9 | 6.8 | 6.1 | 5.6 | 5.0 | 4.3 | 3.5 | 2.5 | 1.8 |
| 74–75 | 15.1 | 15.1 | 15.1 | 15.1 | 14.8 | 14.3 | 13.8 | 13.2 | 12.7 | 12.1 | 11.5 | 10.8 | 10.1 | 9.4 | 8.5 | 7.6 | 6.6 | 5.9 | 5.4 | 4.8 | 4.2 | 3.4 | 2.4 | 1.7 |
| 76–77 | 14.6 | 14.6 | 14.6 | 14.6 | 14.3 | 13.8 | 13.3 | 12.8 | 12.2 | 11.7 | 11.1 | 10.4 | 9.8 | 9.0 | 8.3 | 7.4 | 6.4 | 5.7 | 5.2 | 4.7 | 4.0 | 3.3 | 2.3 | 1.7 |
| 78–79 | 14.1 | 14.1 | 14.1 | 14.1 | 13.8 | 13.3 | 12.8 | 12.3 | 11.8 | 11.3 | 10.7 | 10.1 | 9.4 | 8.7 | 8.0 | 7.1 | 6.2 | 5.5 | 5.0 | 4.5 | 3.9 | 3.2 | 2.3 | 1.6 |
| 80–81 | 13.6 | 13.6 | 13.6 | 13.6 | 13.3 | 12.8 | 12.4 | 11.9 | 11.4 | 10.8 | 10.3 | 9.7 | 9.1 | 8.4 | 7.7 | 6.9 | 5.9 | 5.3 | 4.9 | 4.3 | 3.8 | 3.1 | 2.2 | 1.5 |
| 82–83 | 13.0 | 13.0 | 13.0 | 13.0 | 12.7 | 12.3 | 11.9 | 11.4 | 10.9 | 10.4 | 9.9 | 9.3 | 8.7 | 8.1 | 7.4 | 6.6 | 5.7 | 5.1 | 4.7 | 4.2 | 3.6 | 2.9 | 2.1 | 1.5 |
| 84–85 | 12.5 | 12.5 | 12.5 | 12.5 | 12.2 | 11.8 | 11.4 | 10.9 | 10.4 | 10.0 | 9.4 | 8.9 | 8.3 | 7.7 | 7.0 | 6.3 | 5.5 | 4.9 | 4.5 | 4.0 | 3.5 | 2.8 | 2.0 | 1.4 |
| 86–87 | 11.9 | 11.9 | 11.9 | 11.9 | 11.6 | 11.2 | 10.8 | 10.4 | 10.0 | 9.5 | 9.0 | 8.5 | 7.9 | 7.4 | 6.7 | 6.0 | 5.2 | 4.7 | 4.2 | 3.8 | 3.3 | 2.7 | 1.9 | 1.3 |
| 88–89 | 11.3 | 11.3 | 11.3 | 11.3 | 11.1 | 10.7 | 10.3 | 9.9 | 9.5 | 9.0 | 8.6 | 8.1 | 7.6 | 7.0 | 6.4 | 5.7 | 4.9 | 4.4 | 4.0 | 3.6 | 3.1 | 2.6 | 1.8 | 1.3 |
| 90–91 | 10.7 | 10.7 | 10.7 | 10.7 | 10.5 | 10.1 | 9.7 | 9.4 | 9.0 | 8.5 | 8.1 | 7.6 | 7.1 | 6.6 | 6.0 | 5.4 | 4.7 | 4.2 | 3.8 | 3.4 | 3.0 | 2.4 | 1.7 | 1.2 |
| 92–93 | 10.1 | 10.1 | 10.1 | 10.1 | 9.8 | 9.5 | 9.2 | 8.8 | 8.4 | 8.0 | 7.6 | 7.2 | 6.7 | 6.2 | 5.7 | 5.1 | 4.4 | 3.9 | 3.6 | 3.2 | 2.8 | 2.3 | 1.6 | 1.1 |
| 94–95 | 9.4 | 9.4 | 9.4 | 9.4 | 9.2 | 8.9 | 8.6 | 8.3 | 7.9 | 7.5 | 7.1 | 6.7 | 6.3 | 5.8 | 5.3 | 4.8 | 4.1 | 3.7 | 3.4 | 3.0 | 2.6 | 2.1 | 1.5 | 1.1 |
| 96–97 | 8.8 | 8.8 | 8.8 | 8.8 | 8.6 | 8.3 | 8.0 | 7.7 | 7.4 | 7.0 | 6.6 | 6.3 | 5.9 | 5.4 | 5.0 | 4.4 | 3.8 | 3.4 | 3.1 | 2.8 | 2.4 | 2.0 | 1.4 | 1.0 |
| 98–99 | 8.1 | 8.1 | 8.1 | 8.1 | 7.9 | 7.7 | 7.4 | 7.1 | 6.8 | 6.5 | 6.1 | 5.8 | 5.4 | 5.0 | 4.6 | 4.1 | 3.5 | 3.2 | 2.9 | 2.6 | 2.2 | 1.8 | 1.3 | 0.9 |
| 100–101 | 7.4 | 7.4 | 7.4 | 7.4 | 7.3 | 7.0 | 6.8 | 6.5 | 6.2 | 5.9 | 5.6 | 5.3 | 5.0 | 4.6 | 4.2 | 3.7 | 3.2 | 2.9 | 2.6 | 2.4 | 2.1 | 1.7 | 1.2 | 0.8 |
| 102–103 | 6.7 | 6.7 | 6.7 | 6.7 | 6.6 | 6.3 | 6.1 | 5.9 | 5.6 | 5.4 | 5.1 | 4.8 | 4.5 | 4.2 | 3.8 | 3.4 | 2.9 | 2.6 | 2.4 | 2.1 | 1.9 | 1.5 | 1.1 | 0.8 |
| 104–105 | 6.0 | 6.0 | 6.0 | 6.0 | 5.9 | 5.7 | 5.5 | 5.2 | 5.0 | 4.8 | 4.5 | 4.3 | 4.0 | 3.7 | 3.4 | 3.0 | 2.6 | 2.3 | 2.1 | 1.9 | 1.7 | 1.4 | 1.0 | 0.7 |
| >105 | 5.3 | 5.3 | 5.3 | 5.3 | 5.1 | 5.0 | 4.8 | 4.6 | 4.4 | 4.2 | 4.0 | 3.8 | 3.5 | 3.3 | 3.0 | 2.7 | 2.3 | 2.1 | 1.9 | 1.7 | 1.5 | 1.2 | 0.8 | 0.6 |

**Table C.3**

*VM-20* §9.C.5.c.ii: Prescribed Margins for Industry Tables

| Mortality Margin (Loading) for Industry Table | | | |
|---|---|---|---|
| **Attained Age** | **Load** | **Attained Age** | **Load** |
| 0–45 | 20.4% | 76–77 | 14.6% |
| 46–47 | 20.2% | 78–79 | 14.1% |
| 48–49 | 20.0% | 80–81 | 13.6% |
| 50–51 | 19.8% | 82–83 | 13.0% |
| 52–53 | 19.6% | 84–85 | 12.5% |
| 54–55 | 19.2% | 86–87 | 11.9% |
| 56–57 | 18.9% | 88–89 | 11.3% |
| 58–59 | 18.5% | 90–91 | 10.7% |
| 60–61 | 18.2% | 92–93 | 10.1% |
| 62–63 | 17.8% | 94–95 | 9.4% |
| 64–65 | 17.4% | 96–97 | 8.8% |
| 66–67 | 16.9% | 98–99 | 8.1% |
| 68–69 | 16.5% | 100–101 | 7.4% |
| 70–71 | 16.1% | 102–103 | 6.7% |
| 72–73 | 15.6% | 104–105 | 6.0% |
| 74–75 | 15.1% | 106 and over | 5.3% |

**Table C.4**

*VM-20* §9.C.6.b: Credibility, Sufficient Data Period and Grading to Industry Tables

| Credibility of company data (as defined in Section 9.C.4 above) rounded to nearest % (1) | Maximum # of years for data to be considered sufficient (2) | Maximum # of years in which to begin grading after sufficient data no longer exists (3) | Maximum # of years in which the assumption must grade to 100% of an applicable industry table (from the duration where sufficient data no longer exists)* (4) |
|---|---|---|---|
| 20%–39% | 10 | 2 | 8* |
| 40%–59% | 20 | 4 | 12* |
| 60%–79% | 35 | 7 | 17* |
| 80%–100% | 50 | 10 | 25* |

*The maximum # of years in which the assumption must grade to 100% of an applicable industry table shall be the lesser of (a) the appropriate number of years stated in the chart above and (b) the number of years of sufficient data + 15 times the credibility percentage applicable to column (1) in the chart above. This maximum # of years figure shall be rounded to the nearest whole number.

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