Mortality Trends
The Good, the Bad and the Future

Tom Rhodes, FSA, MAAA, FCA
Vice President & Actuarial Director
MIB

trhodes@mib.com
Life Industry Results

- Individually Underwritten Life Insurance
  - Issue Ages 18+
  - Attained Ages 60+
- Past and Present
  - Individual Year Mortality Results
  - Individual Company Variability
- Evaluating the Future
  - Linear Regression
  - Time-Series Analysis
  - Predictive Model
Individually Underwritten Life Insurance
Issue Ages 18+; Attained Ages 60+
(SOA 2003-2008; SOA +PBR 2009; PBR 2010-2013)

### A/E Ratios by Face Amount
Expected Based on 2015 VBT

<table>
<thead>
<tr>
<th>Observation Year</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>111.1%</td>
<td>120.2%</td>
<td>117.5%</td>
</tr>
<tr>
<td>2005</td>
<td>100.8%</td>
<td>112.0%</td>
<td>108.8%</td>
</tr>
<tr>
<td>2007</td>
<td>106.1%</td>
<td>108.0%</td>
<td>107.4%</td>
</tr>
<tr>
<td>2009</td>
<td>100.8%</td>
<td>100.7%</td>
<td>100.8%</td>
</tr>
<tr>
<td>2011</td>
<td>104.1%</td>
<td>97.5%</td>
<td>99.6%</td>
</tr>
<tr>
<td>2013</td>
<td>96.4%</td>
<td>94.9%</td>
<td>95.3%</td>
</tr>
</tbody>
</table>
Life Industry Results

Industry Average A/E Ratios: Horizontal Line

Individual Company
Dots are A/E Ratios
Vertical Lines are 95% Confidence Intervals
Evaluating the Future Linear Regression

- The underlying data is for attained ages 60+ for the years 2003 – 2013.

- The Observation Years (2003 – 2013) are plotted on the X-axis of the graph.

- The A/E ratio by Amount using the 2015 VBT is plotted on the Y-axis of the graph.

- The dotted line is the simple linear regression line passing through the actual A/E ratios from the underlying data.

- A negative slope for the linear regression indicates a mortality improvement among the group.

- A positive slope for the linear regression indicates a worsening mortality among the group.
**Gender**

- The slope for both genders is negative.
- The slope for males is steeper than that for females.
- Indicates a higher mortality improvement rate among males than females.

![Graph showing A/E ratio by Amount using the 2015VBT for Female and Male over Observation Years.](image)

**Female**

- Linear (Female): $y = -0.013x + 1.1108$

**Male**

- Linear (Male): $y = -0.0246x + 1.2059$
Smoker Status

- The slope for Non-Smokers is steeper than that for Smokers.
- Indicates a higher mortality improvement rate among Non-Smokers than Smokers.
- Smokers have a low mortality improvement rate.

**Non-smoker**

\[ y = -0.0224x + 1.1808 \]

**Smoker**

\[ y = -0.0056x + 1.0848 \]
Female - Smoker Class

- Female Smoker – Standard Class has positive slope indicating increasing mortality.

- Female – Smoker – Preferred Class has mortality improvement but variability skews results of linear regression.

**Female - Smoker - Standard Class**

\[ y = 0.0098x + 0.99 \]

**Female - Smoker - Preferred Class**

\[ y = -0.0368x + 1.1906 \]
Evaluating the Future
Time-Series Analysis Requires 30 Years of Data

- As Chief Actuary of Veterans Administration – 1980
  - National Service Life Insurance (NSLI)
  - World War Two Male Soldiers
  - About 30 years of Post WW2 NSLI mortality

- Social Security Administration Data
  - Older Age Mortality

- Successful: Time-Series Analysis Applied to NSLI Mortality
  - Consistent Results with Male Social Security Mortality at Older Ages

- Time-Series Analysis Holds Promise in Future for Industry Data
Evaluating the Future - Predictive Model
Older Age Mortality (OAM) Model

- 2009 – 2013 Data
- PBR VM-51 Data
- Additional SOA 2009 and 2010 Data
- Attained Age 60+ and Issue Age 18+
- Total of 3,626,553 observations
Older Age Mortality Model - Methods

- Programming language: R

- Generalized Linear Model – Zero Inflated Poisson
  - More interpretable than machine learning methods
  - Very good predictive power for low-dimensional data
  - Zero-Inflated Poisson in two stages
    - Binomial determine ‘true’ zeros
    - Poisson concerns a random event containing zero count data
OAM Model - Zero-Inflated Poisson (ZIP)

- The number of deaths for a small group of policies is often 0.
- ZIP distinguishes between ‘true’ zeroes and ‘excess’ zeroes.

*Sparse Data: Are lack of deaths in groupings ‘true’ zeroes or due to low exposure?*

- An actuarial student did not ‘Pass an Exam’: ‘true’ or ‘excess’ zero?
OAM Model – Interpretation of Poisson Parameters

- Poisson part of ZIP regression uses Log link function

\[
\log \left( \frac{Number\ of\ death}{Exposure} \right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots
\]

- The exponentiated parameters \( e^{\beta} \) are interpreted as multiplicative effects on the rate for the groups of policies that are not excess zeroes.

- For a given coefficient pertaining to a unit change in a variable (for example, Issue Age):
  - exponentiated values greater than 1 raise the mortality rate
  - exponentiated values less than 1 lower the rate
OAM Model – Zero Inflated Poisson Results

- **Binomial Logistical Regression**
  - Removes Excess Zeros
  - Most variables are statistically significant results

- **Poisson Regression**
  - Includes True Zeros
  - Statistically significant results for all variables
    - Gender
    - Issue Age
    - Attained Age
    - Face Amount
    - Class Distinction Variable
OAM Model - Class Distinction Variable

VM-51 fields were replaced with the new **Class Distinction** variable in order to decrease the number of variables in the model.
OAM Model Validation

10 fold Cross Validation Method
(where the data is partitioned into 10 subsamples and 10 validations performed, with each subsample used as validation data)

**Evaluation metric 1:**
Root Mean Square Error – measures standard deviation of the residuals.

\[
RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (y_{Actual} - y_{Predicted})^2}
\]

Our model’s CV - RMSE = 0.874

**Evaluation metric 2:**

\[
AE \ Ratio = \frac{\sum \text{Actual Number of Deaths}}{\sum \text{Predicted Number of Deaths}}
\]

Our Model’s CV to AE ratio = 100.1%
2009-2013 Data - A/E Ratios
OAM ZIP Model – Actual/Predicted Ratio

By Attained Age Group

© 2017 MIB Group, Inc. All rights reserved. Use of this information without prior MIB approval is strictly prohibited.
Conclusion

- SOA Individual Life Studies Show Mortality Improvement
- Linear Regression
  - More improvement for Males than Females
  - Improvement concentrated in Nonsmokers
  - Female Smoker Standard shows increase in mortality
- Zero Inflated Poisson Model
  - Two step process – Binomial then Poisson
  - Statistically significant results for all variables
    - Gender
    - Issue Age
    - Attained Age
    - Face Amount
    - Class Distinction Variable
Questions?

Tom Rhodes FSA, MAAA, FCA
Vice President & Actuarial Director
MIB

trhodes@mib.com
781-751-6460