7th Capacity Building Seminar In Health Insurance

Practical Aspects of Designing Morbidity table

Institute of Actuaries of India

Abhijit Pal

Head of Pricing, Actuarial Research and Innovation
Munich Re India Branch

13th December 2019

Sumit Ramani

Consulting Actuary

Actuaria Consultants

Anshul Mittal

Assistant Vice President-Actuarial

Apollo Munich Health Insurance Co. Ltd

Agenda

- What is Morbidity
- Calculation of Exposed to Risk
- Graduation / Smoothening of Incidence Rates
- Practical Considerations
- Example of a Multifactor Analysis of Incidence Rates

What is Morbidity

Institute of Actuaries of India

- Morbidity is the rate at which disease occurs in a group of people over a given period of time
- In actuarial parlance, it is represented as i(x) which represents the probability of sickness or injury for an individual aged x between time period t and t+1.
- A morbidity table provides morbidity rates that may vary by multiple factors / variates

Morbidity rates may vary by..

- Age
- Gender
- Duration
- Underwriting – Short Form / Long Form; Med / Non-Med
- Geographic location
- Smoker Status
- Product type
- Disease type
- Distribution channel
- Occupation
- Activity of Daily Living or Daily Working
- Waiting period / Survival period
- Rider / Standalone
- Claim triggers (ADL / ADW) etc

Morbidity tables for various products

- Fixed (Defined) Benefit products
  - Critical Illness
  - Hospital Cash Benefit / Surgical Cash Benefit
  - Total and Permanent Disability due to accident and/ or sickness
  - Income Protection
  - Long-Term Care
- Indemnity Products
  - In patient hospitalization
  - Out patient / day care

Today's Exercise…

Is only limited to calculation of crude and smoothed incidence rates / morbidity rates for inpatient hospitalization products

We intend to cover the following aspects:

- Calculation of Exposed to Risk (exposure)
- Calculation of Crude incidence rates
- Smoothening of rates
- Different approaches for graduation
- Univariate / Bivariate analysis of incidence rates
- Multifactor example to unwind the effect of more than one variate

Institute of Actuaries of India

Calculation of Exposed To Risk

&

Derivation of crude and smoothed morbidity rates

Graduation techniques

Some of the graduation techniques

1. Whittaker – Henderson
2. Cubic Spline
3. Heligman Pollard

Whittaker – Henderson

Institute of Actuaries of India

The Whittaker -Henderson method attempts to graduate the crude rates by obtaining a balance between the adherence to data and the smoothness of the rates.

The graduated rates are obtained by minimizing Q below:

$$Q = \sum_{j=0}^{N} w_j (q_{x+j} - \hat{q}_{x+j})^2 + \sum_{j=0}^{N-3} K_j (\Delta^3 q_{x+j})^2$$

Where $w_j = \frac{N.E_x}{\sum E_x}$ are the weights that assign higher weights to ages with higher exposure

And K_j are smoothing coefficients

$\hat{q}_x$ – Crude Rate

q_x – Graduated Rate

Whittaker – Henderson

Institute of Actuaries of India

Ensures that the graduated rates are as close to crude rates as possible

$$Q = \sum_{j=0}^{N} w_j (q_{x+j} - \hat{q}_{x+j})^2 + \sum_{j=0}^{N-3} K_j (\Delta^3 q_{x+j})^2$$

Ensures that the graduated rates are as smooth as possible

Goodness of Fit

Smoothness

This method attempts to balance both these opposing objectives.

Cubic Spline

The Cubic Spline method fits a piecewise curve to the crude rates. It fits a smooth curve between each of the knots, which are predetermined age ranges selected to optimize the graduation process.

The graduated rates are obtained by minimizing Q below:

$$Q = \sum_{j=0}^{N-1} w_{x+j}(q_{x+j} - \hat{q}_{x+j})^2$$

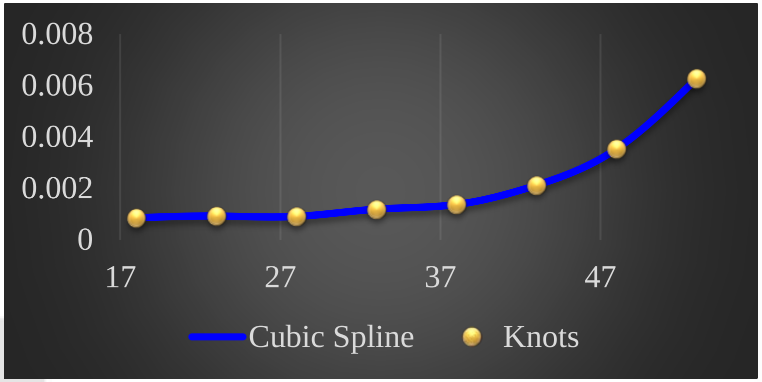
Where $q_x = a_0 + a_1 x + a_2 x^2 + a_3 x^3 + \sum_{i=1}^{n} b_i G_i(x)$ is the cubic equation

and $G_i(x) = (x - x_i)^3 \; for\; x \geq x_i$

$= 0 \qquad for\; x < x_i$

$\hat{q}_x$ – Crude Rate

q_x – Graduated Rate



Heligman Pollard

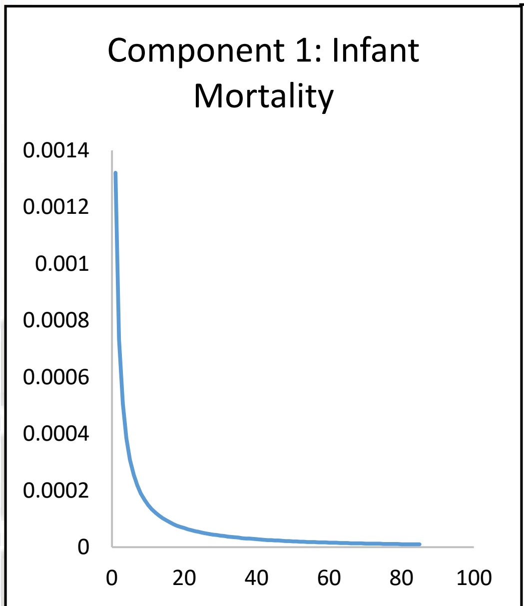
The mortality law suggested by Heligman and Pollard is:

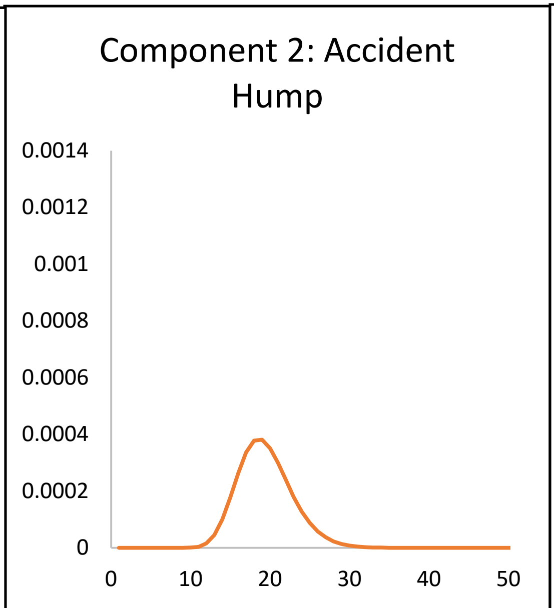
$$\frac{q_x}{p_x} = A^{(x+B)^C} + De^{-E(lnx - lnF)^2} + GH^x$$

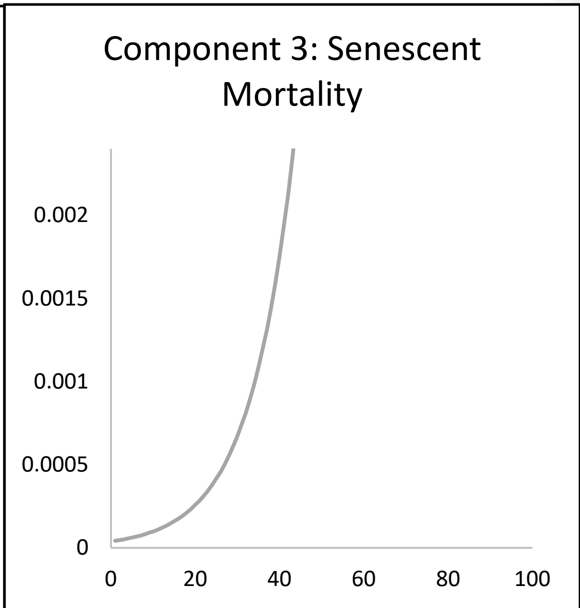
Where q_x is the probability of dying within 1 year for a person aged x exactly and

$p_x = 1 - q_x$

Each component represents a distinct component of mortality:







Test of Graduated rates

Institute of Actuaries of India

Test	Purpose	Working	Criteria
Standardized Deviations Test	Testing Overall Goodness of Fit	Checks for normality of Standardized deviations	$z_x = \frac{(Actual - Expected)}{sqrt(Expected)}$ We expected z_x's to follow Standard Normal Distribution
Chi-Squared Test	Testing Overall Goodness of Fit	Calculates sum of squares of differences between excepted and actual deaths	We expect $\sum {z_x}^2$ to follow χ^2 distribution (Degrees of freedom depend on the method of graduation)
Sign Test	Detecting Overall Bias	Calculates number of positive deviations of the graduated rate from the crude rates	$P = Count\ of\ Positive\ z_x\ values$ We expect P to follow Binomial distribution with parameters (n,0.5) where n is the number of observations
Grouping of Signs Test	Detecting Runs and Clumps	Calculates groups of positive deviations throughout the graduation	$G = Groups\ of\ Positive\ z_x$ We expect neither too many nor too few groups
Cumulative Deviations Test	Testing for Over graduation	Calculates overall deviation	Test statistic= $\frac{\sum(Actual - Expected)^2}{\sum Expected}$
Serial Correlation Test	Testing for Over graduation	Calculates correlation between successive standardized deviations	Calculate correlation between successive z_x values. It is expected to follow $N(0, 1/m)$
Third Differences Test	Test for smoothness	Calculates the third order difference of the graduated rates	Find third difference ($\Delta^3 q_x$) of the graduated rates. They are expected to be small and to move gradually.

Univariate / Bivariate Analysis of Morbidity Rates

First principle approach to unwind the effects of more than one variate

Thank you !!