

## This is an excerpt from the full handout file for sample purposes

### **Experience Study Calculations**

#### Basic Terminology and Mortality Concepts

#### Annual Exposure Method

Reflecting Withdrawal (Lapse) Rates Individual Exposure Calculation (Cohort Study) Multi-Year Studies Period Study Examples Review of Individual Exposure Period Studies Visualizing the Grouped Exposure (No Decrements) Grouped Exposure Formulas with Decrements Grouped Exposure Example Amount-Weighted Studies Individual Amount-Weighted Example Withdrawal Studies Actual To Expected (A/E) Analysis Uses of A/E Analysis

#### Utilization Studies

Practical Considerations

**Product-Related Considerations** 

Experience Study Calculations

### Reflecting Withdrawal (Lapse) Rates

If lives can withdraw due to lapse, etc.:

$$\ell_{x+1} = \ell_x - d_x - w_x$$

Using the **Balducci Hypothesis**, we can calculate  $q_x = d_x/E_x$ 

$$E_x = \begin{cases} \ell_x - \sum_{i=1}^{w_x} (1 - t_i) = (\ell_x - w_x) + \sum_{i=1}^{w_x} t_i & \text{for individual calculations} \\ \ell_x - \frac{1}{2}w_x & \text{for grouped calculations} \end{cases}$$

 $t_i$  = fraction of the year when each withdrawal *i* occurs

Balducci assumes mortality decreases over the course of the year

• Not realistic, but not a problem if  $w_x$ 's are small

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# Individual Exposure Calculation (Cohort Study)

Assume a 4-year LY study on 3 lives

		Exposure for age <i>x</i>			
Life	Situation	65	66	67	68
А	Survives to 69th birthday	1.0000	1.0000	1.0000	1.0000
В	Dies between 66th and 67th birthdays	1.0000	1.0000		
С	Lapses 110 days after 67th birthday	1.0000	1.0000	0.3014	
	Annual Exposure $(E_x)$	3.0000	3.0000	1.3014	1.0000

- Deaths get a full year of exposure (Life B)
- Withdrawal exposure for Life C in year of age 66 = 110/365
- Annual exposure by year:

 $\ell_{65} = \ell_{66} = 3 = E_{65} = E_{66}$  since no *d*'s or *w*'s  $\ell_{67} = 3 - 1 - 0 = 2$  since 1 death occurred  $E_{67} = \ell_{67} - 1(1 - 0.3014) = 2 - 0.6986 = 1.3014$  $\ell_{68} = 2 - 0 - 1 = 1 = E_{68}$  since no other decrements



### Multi-Year Studies

Exposure-weighted average mortality rate over an *N*-year period starting at age *x*:

$$q = \frac{\sum_{t=0}^{N} E_{x+t} q_{x+t}}{\sum_{t=0}^{N} E_{x+t}} = \frac{\sum_{t=0}^{N} d_{x+t}}{\sum_{t=0}^{N} E_{x+t}}$$

From the previous slide, the probability of someone age 65 dying before age 69:

$$_4q_{65} = \frac{1}{3+3+1.3014+1} = 12\%$$

Not very credible since we only had 3 lives!

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# Period Study: Individual Exposure Example 1

Assume the following:

- Study runs from 1/1/2010 to 12/31/2013
- ► Minimum age = 65
- ▶ Policyholder turns 65 on  $10/1/2010 \approx 75\%$  into 2010
- Policyholder survives entire study



#### Total life years exposed = 3.25

Experience Study Calculations

# Period Study: Individual Exposure Example 2



- Study runs from 1/1/2010 to 12/31/2013
- ► Minimum age = 65
- Policyholder turned 65 on  $4/1/2009 \approx 25\%$  into 2009
- Policyholder survives entire study



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# Period Study: Individual Exposure Example 3

Assume Example 2 except that the policyholder lapses on 10/1/2012



If the policyholder had <u>died</u> on 10/1/2012,  $E_{68} = 1$  (always give a full year)

# Review of Individual Exposure Period Studies

- Exposure depends on when the min age is met (before or after study start)
- First or last year will have partial exposures for each life
  - Exceptions: January 1 birthdays or deaths in final partial year
- Deaths and withdrawals are treated the same as a cohort study
- Aggregate mortality rate is calculated the same as before

$$q = \frac{\sum_{t=0}^{N} d_{x+t}}{\sum_{t=0}^{N} E_{x+t}}$$

Experience Study Calculations

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