Thank you for joining us – the webinar will start shortly

# Longevity 101: *baseline*

February 11th, 2021

11am ET / 4pm GMT

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# Your panel

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# Agenda

1. Introduction
2. Standard tables
3. Factor based models
4. Experience analysis & credibility theory

Today we'll use the language of pension plans,
- techniques apply to any group of lives

# 1 Introduction

# Jargon buster

**Longevity**

How long you are expected to live

**Mortality**

When you are expected to die

**Survival rates p$_x$** - the probability a person aged $x$ will survive the next year

**Mortality rates q$_x$** - the probability a person aged $x$ will die within the next year

$$p_x = (1 - q_x)$$

**Longevity risk** - the risk of people living longer than expected

**Mortality risk** - the risk of people dying sooner than expected

## Life Expectancy

The expectation of the number of years a person will live.

Expressed as either

- “years left” (20 years Life Expectancy for a 65 year old); or
- “total years” (Total Life Expectancy of 85 for a 65 year old)

## Period Life Expectancy

Life expectancy based on mortality rates for one particular period – no allowance for any future changes in mortality rates

## Cohort Life Expectancy

Life expectancy of a person born in a certain year (cohort) allowing for expected future changes (usually improvements/reductions) in mortality rates.

# Two steps to calculate life expectancy


**Baseline**

- Snapshot of current state of longevity
- Objective measure
- Based on past experience

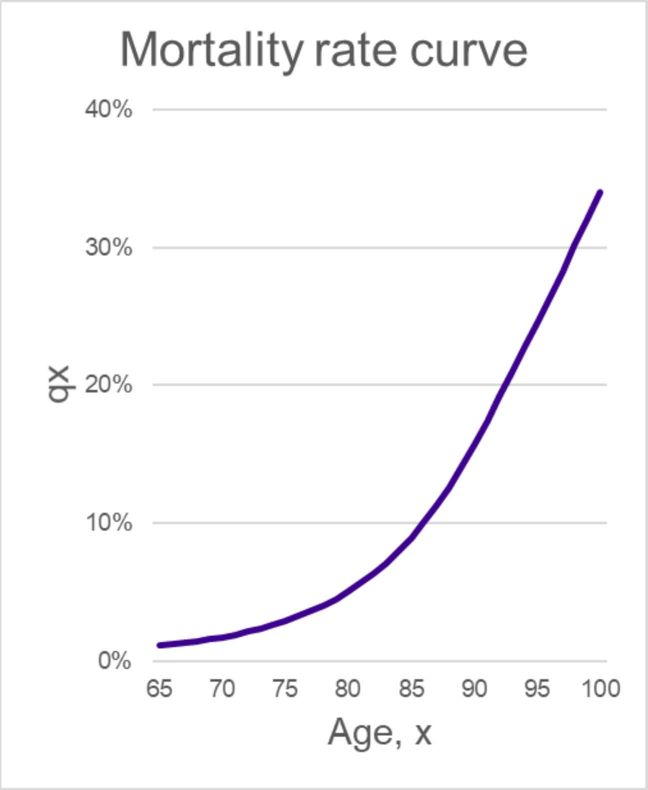


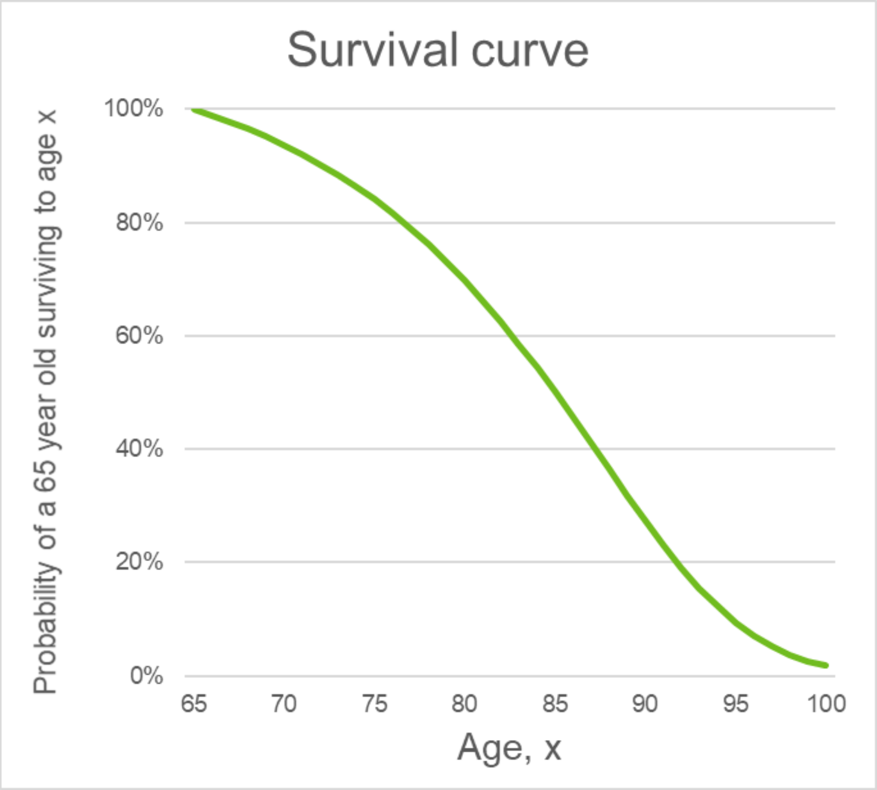

**Future trends**

- How longevity will change in the future
- More subjective measure
- Recent experience a good starting point, but how and when will it change?

# What does a baseline assumption look like

| Age ($x$) | $q_x$ |
|---|---|
| … | … |
| 57 | 0.724% |
| 58 | 0.767% |
| 59 | 0.808% |
| 60 | 0.845% |
| … | … |
| 89 | 14.079% |
| 90 | 15.694% |
| 91 | 17.391% |
| … | … |
| 120 | 100% |



# Different approaches

**Collect large amounts of data from similar pension plans**

***"Top Down" approach***

Average out experience and apply to your plan

**Your assumption**

***"Bottom Up" approach***

Combine assumptions for the individuals within your plan

**Calculate longevity for different individuals based on their characteristics**

# 2 Standard tables

# What are standard tables?

- Mortality base tables published by national agencies or actuarial bodies
- Constructed using a large portfolio, based on the expectation that they will be widely used across the industry.
- Separate tables are published for common risk classes
- "Top down" approach

**Collect large amounts of data from similar pension plans**

Average out experience and apply to your plan

**Your assumption**

# Using standard tables

## When they are useful

- Plan-specific characteristics are “similar” to composite data in standard tables
- Small plan/limited experience - not sufficiently credible

## Limitations

- May not accurately reflect plan-specific characteristics
- Limited risk factors available for investigation
- Assessing sub-populations for risk transfer purposes

Reference population is rarely exactly appropriate to an individual plan’s needs, so standard tables are often adjusted by applying an age rating or scaling factor.

# Data collection and segmentation

**Age**

**Gender**

**Collar Type**

Blue/White

**Sector Type**

Public/Private

**Pensioner Type**

Pensioner/Survivor

**Retirement-Health**

Normal/Ill-Health

**Pension Amount**

# Data collection and segmentation

Men

- Men Low Pension
- Men High Pension

Women

- Women Low Pension
- Women High Pension

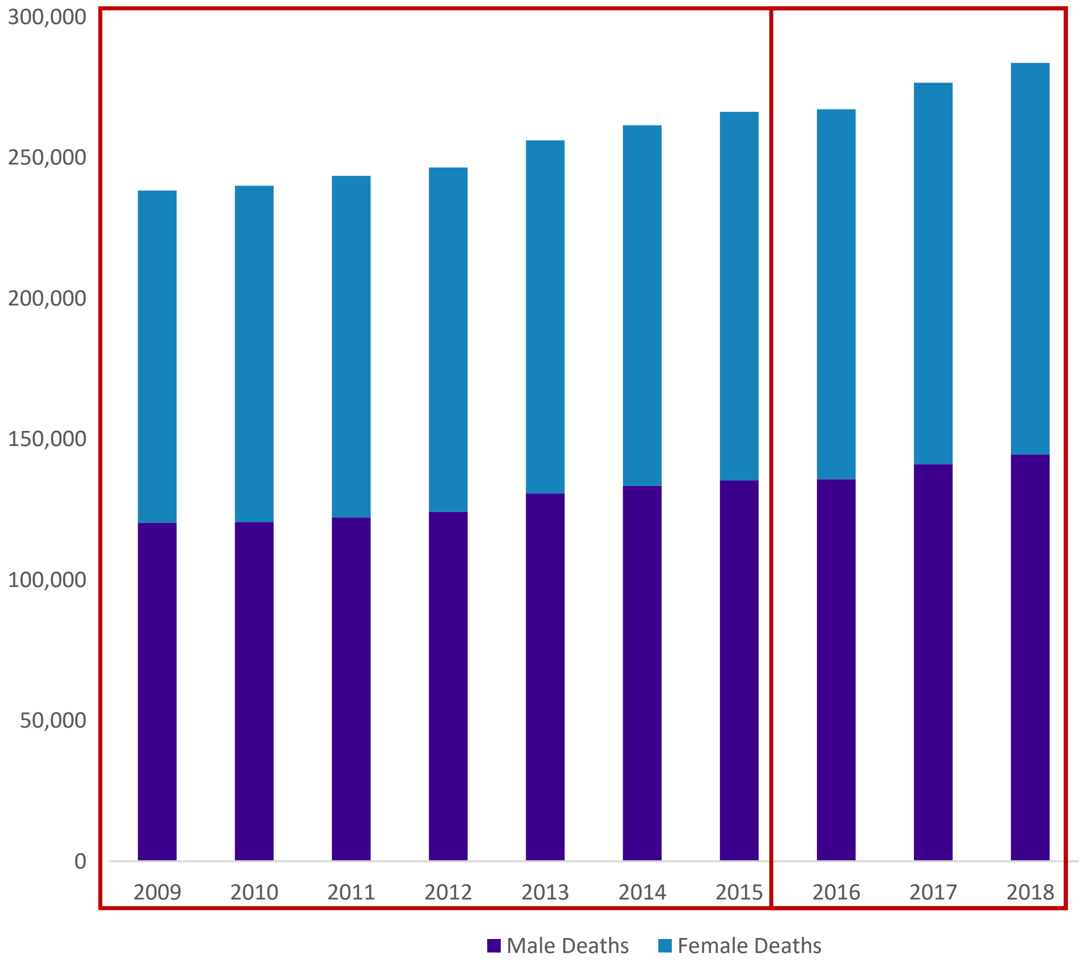
**Experience data is collected from a variety of pension plans, actuarial consulting firms and/or annuity providers**

**Data is summarized and *segmented* into risk factors with a standard table being produced for each subgroup**

# Selecting the study period

***Longer period***

- Increases data volume
- Smooths out year over year volatility




***Shorter period***

- More appropriate picture of current rates of mortality
- Better separation between baseline mortality rates and trend

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# Calculating qxs

| | |
|---|---|
| $q_x$ | The mortality rate for age $x$ - calculated as the number of deaths for exact age $x$ divided by exposure for exact age $x$. |
| **Deaths** | Number of people who died receiving a pension |
| **Exposure** | Measures the number of people receiving a pension who are “at risk” of dying |

$$\frac{\text{Deaths}}{\text{Exposure}} \leftarrow \boxed{\text{Crude/Observed Mortality Rate}}$$

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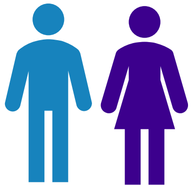
# Lives-weighted vs amounts-weighted qx

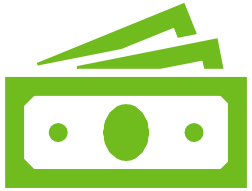
**Lives-weighted or Headcount $q_x$**



$$= \frac{\text{Total Deaths}}{\text{Total Lives Exposed to Risk}}$$

Equal weight for each life

**Amounts-weighted $q_x$**



$$= \frac{\text{Total Pension Amounts for Deceased Lives}}{\text{Total Pension Amounts for Exposed Lives}}$$

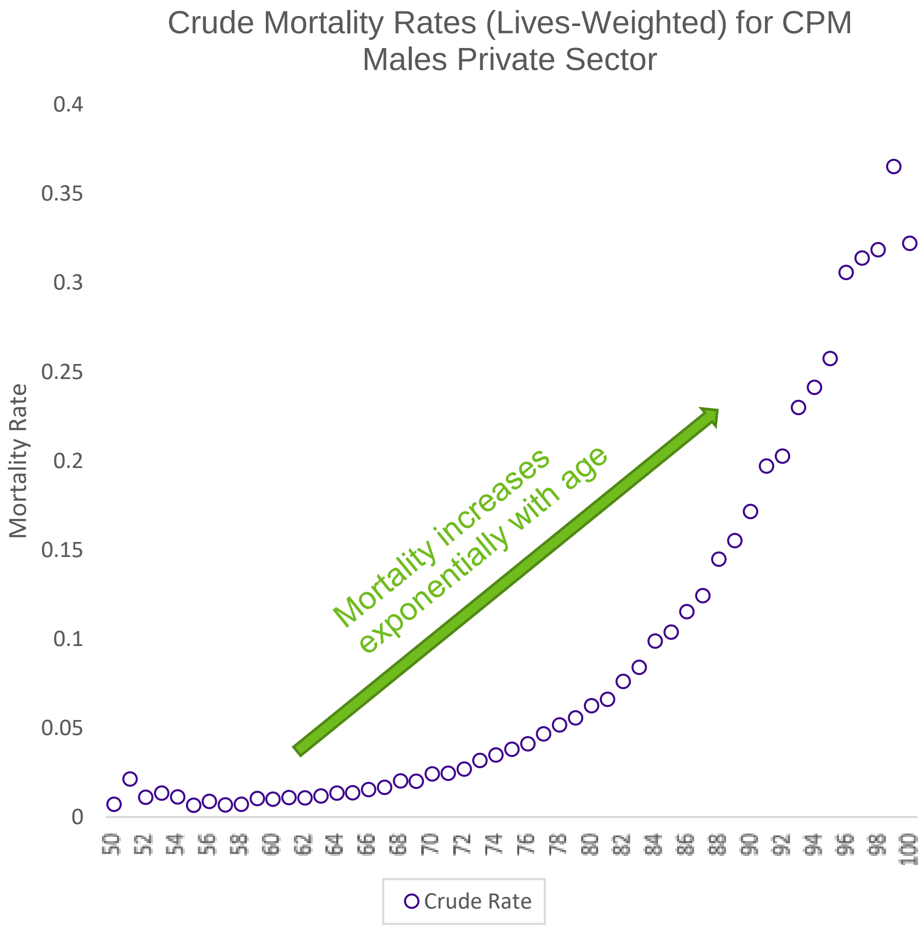
Weighted by pension amount

Amounts-weighted qxs are lighter than lives-weighted qxs hence they are more appropriate for valuing pension plan liabilities.

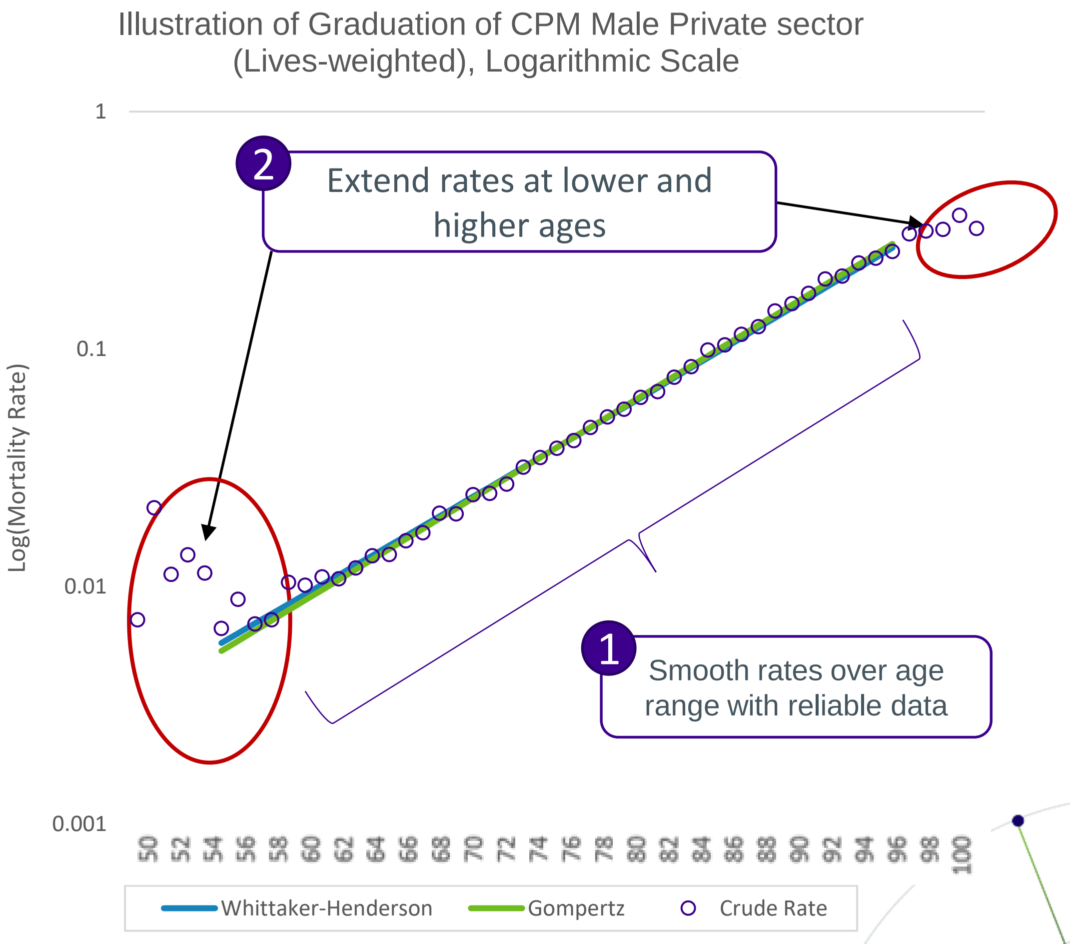
# Graduating tables

**Graduation** is the mathematical process of ironing out bumps in observed mortality rates at individual ages to produce rates that progress smoothly between ages.

# Graduating tables




Transform to log scale so that rates are broadly linear with age



# Examples of different standard tables

| | UK | Canada | US | |
|---|---|---|---|---|
| Published by | Continuous Mortality Investigation (CMI) | Canadian Institute of Actuaries (CIA) | Society of Actuaries (SOA) | |
| Table Name | "S3" Series | CPM2014 | Pri-2012 | Pub-2010 |
| Underlying population | Self-administered pension schemes (SAPS) | Canadian registered pension plans | US private-sector retirement plans | US public-sector retirement plans |
| Risk Factors | Gender<br>Pensioner Type<br>Retirement Type<br>Pension Bands | Gender<br>Sector Type<br>*Pension Size Adjustment Factors* | Gender<br>Pensioner Type<br>Collar Type<br>Top/Bottom Benefit Quartile | Gender<br>Pensioner Type<br>Retirement Type<br>Employment Type<br>Above/Below Median Income |
| Mortality Experience | 2009-2016 | 1999-2008 | 2009-2014 | 2008-2013 |
| Effective Date/Base Year | 1 January 2013 | 1 January 2014 | 1 January 2012 | 1 July 2010 |

"Weighted mid-point of the standard table" or date the mortality rates are said to be applied

# 3 Factor based models

# Factor based models

- ‘Bottom up’ approach
- Consider factors which influence longevity
- Which should be modelled?
- Construct model to reflect those factors
- Allocate individuals based on their characteristics
- Overall assumption based on aggregating across individuals

**Your assumption**

Combine assumptions for the individuals within your plan

**Calculate longevity for different individuals based on their characteristics**

# What affects how long people live?

- Age
- Gender
- Affluence
- Lifestyle
- Health
- Occupation
- Location
- Smoker?
- Married?
- Genetics

# Data collection

- Age ✓
- Gender ✓
- Pension / salary
- Postcode / ZIP code
- Disability / ill health?
- Manual / Non-manual
- Location
- Smoker? ✗
- Pension form
- Genetics ✗

# Should we split the data?

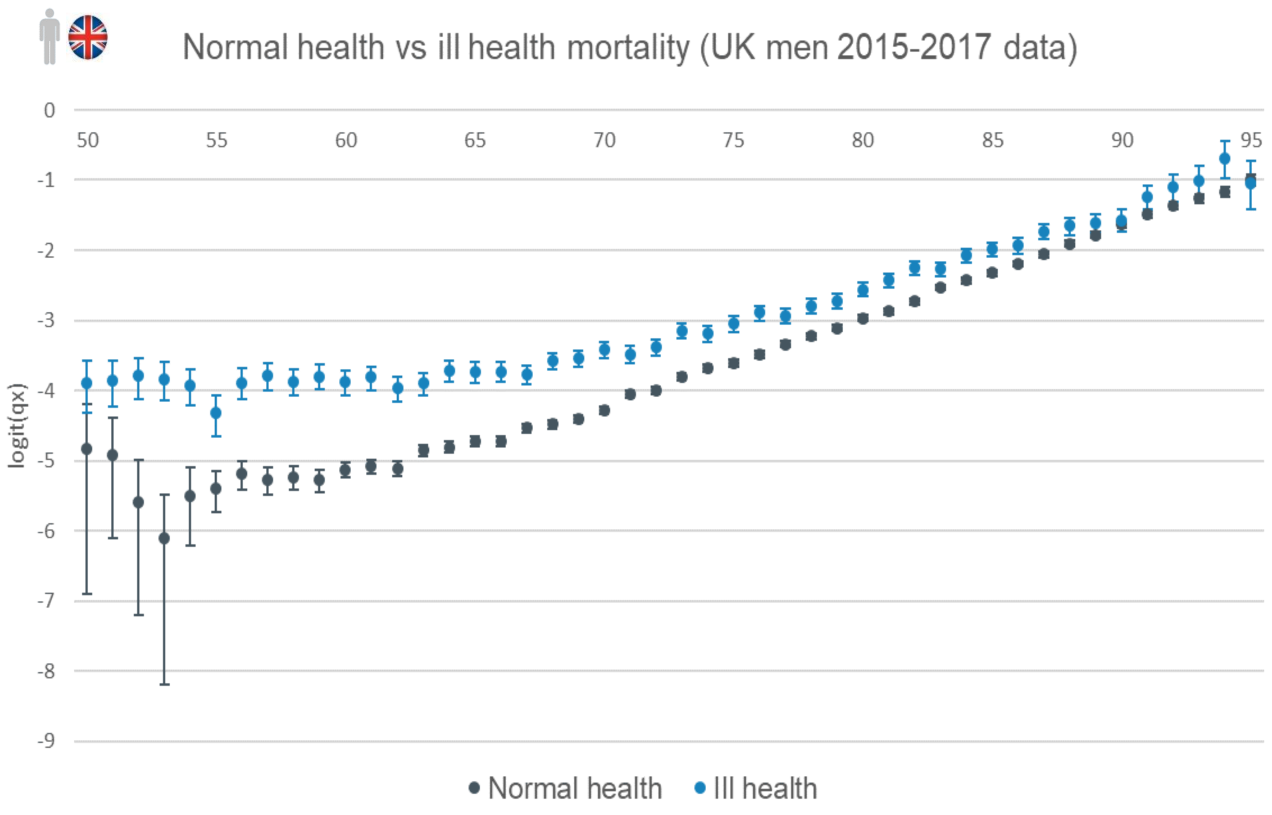
Factor

| Split | Don't split |
| --- | --- |
| Split data into groups | Allow for interactions |
| Model groups independently | Model simultaneously |
| Reflects fundamental differences between groups | Maximises data used to inform model |

# Splitting the data

Reasons to split the data (stratify):

1. **Differences in shape**
   (e.g. normal versus ill health)
2. **Difference in meaning**
   (e.g. pension amount for pensioners versus dependants)
3. **Different age ranges**
   (e.g. dependants older than pensioners)




Source: Crude mortality rates with 95% confidence intervals, 2015-2017 Club Vita (UK) data

# Assigning variables

**Which** factors to use?

- How much ‘extra’ does each additional factor add?
- Does it justify extra complexity?

Simplicity

Predictiveness

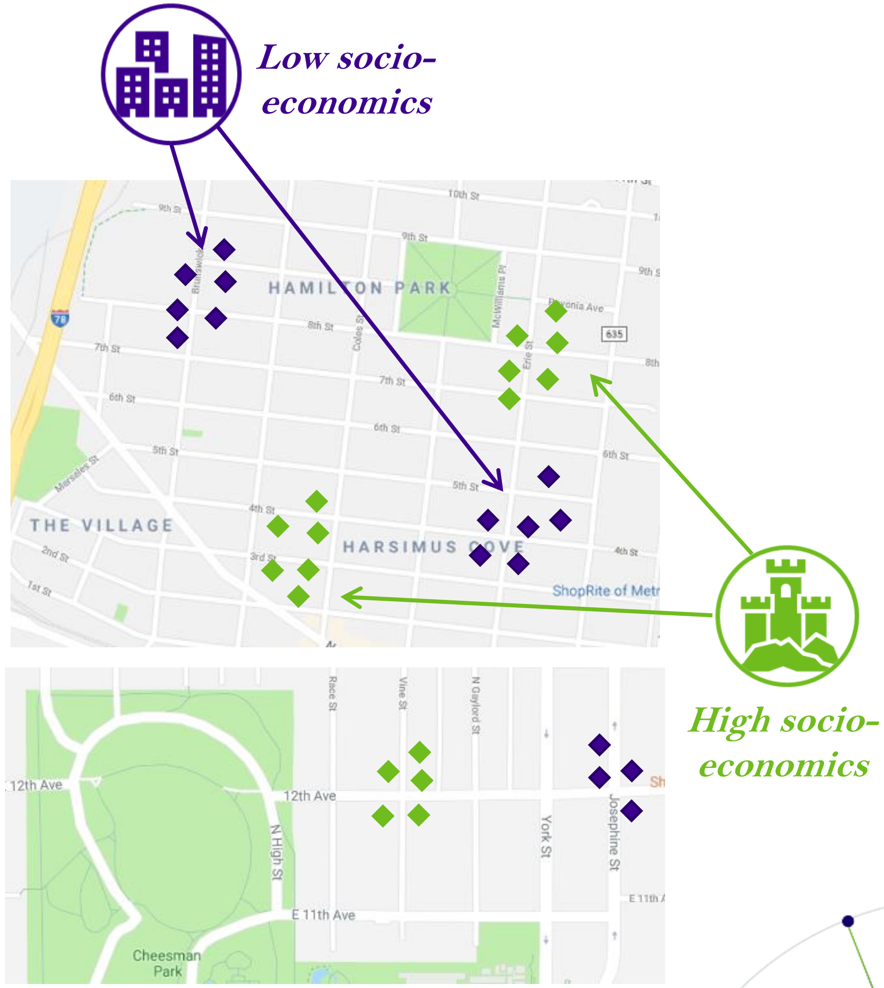
How to **assign** variables?

- Number of ‘buckets’ to use
- Thresholds for each bucket

# Grouping ZIP/postcodes

- Postal code is a proxy for lifestyle etc
- Residents in similar areas have similar characteristics
- Areas can be categorised by typical residents
- Similar areas exist in different parts of a country
- People with similar characteristics have similar longevity
- Postal code can be assigned to small number of groupings

- See our 'Zooming in on ZIP codes' paper for more details

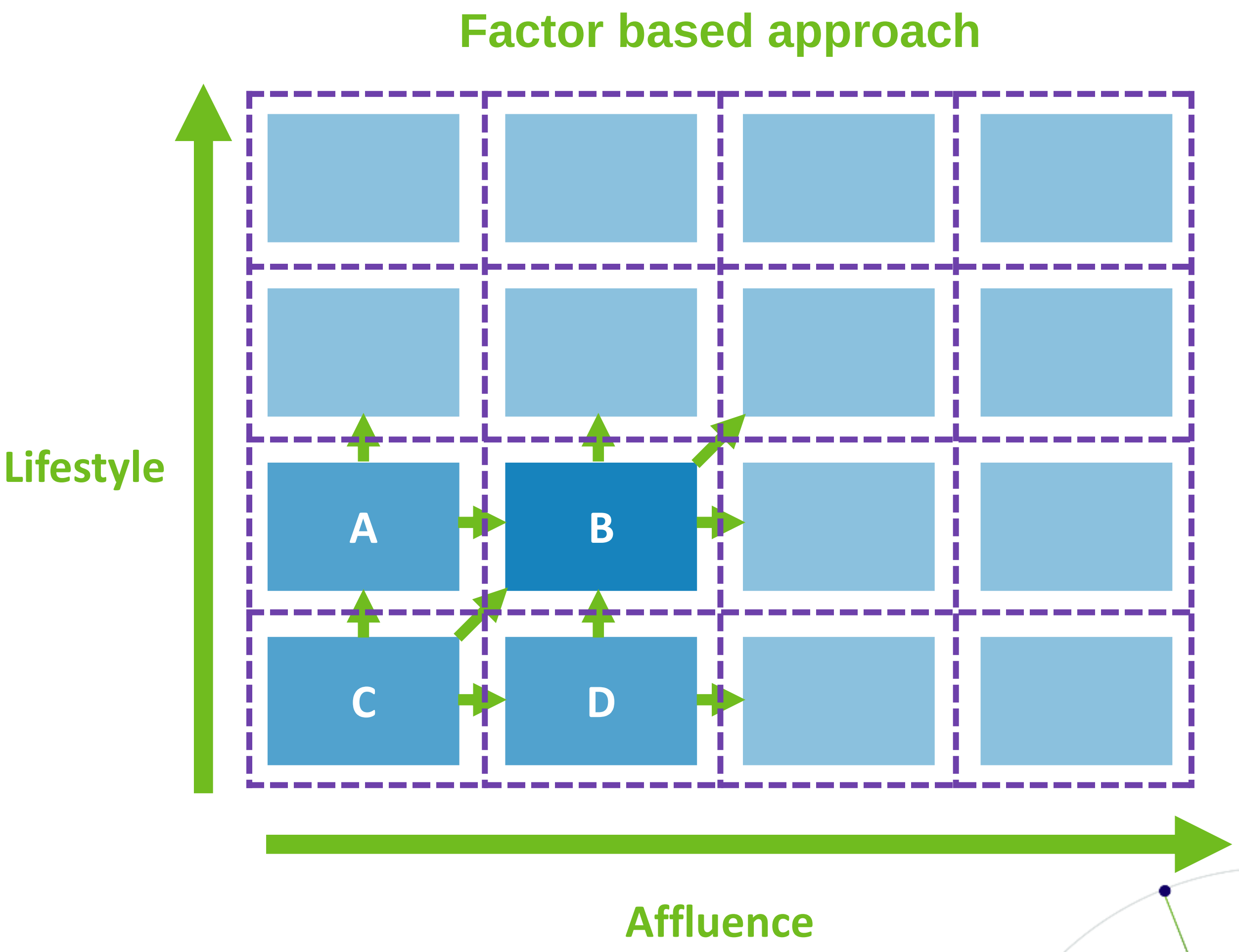



*Neighbourhood characteristics for illustration only

https://www.clubvita.us/collaborative-research/zooming-in-on-zipcodes-whitepaper

# Fitting the model

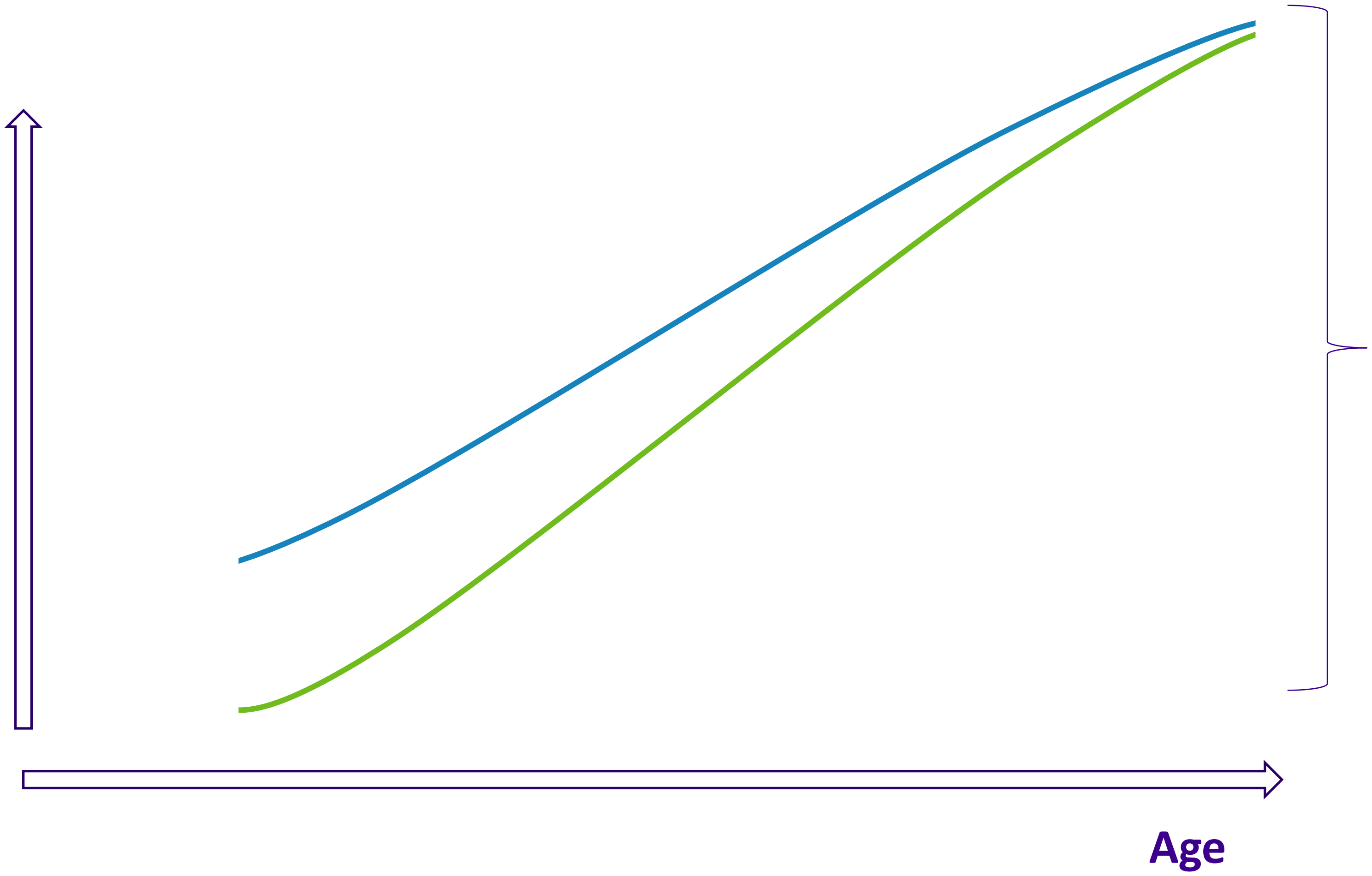
- Consider interaction of two factors
- Standard table approach:
  - each combination treated separately
  - very small ‘buckets’
- Factors based models:
  - allows for interactions between factors
  - maximises data used to inform fit



# Fitting the model

**Chance of dying over next year**

*Transformed onto a "log" or "logistic" scale so <u>broadly</u> linear with age*

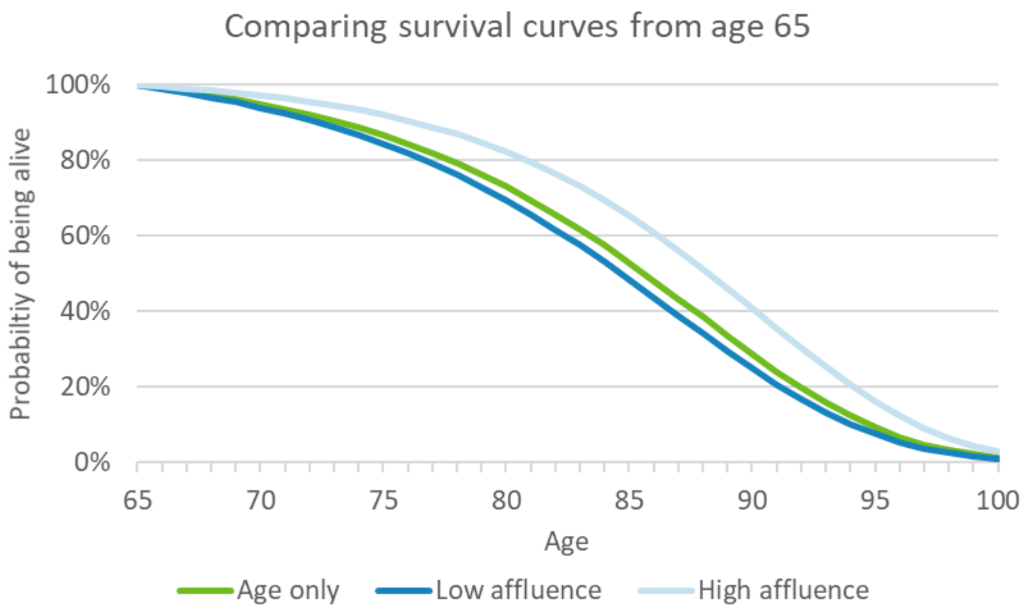



*Fit curves to across different combinations of affluence, postal code, occupation etc… <u>simultaneously</u>*

***Maximises the predictive power of the data***

# Checking fitted rates

- Important to validate generated rates
- Consider 'goodness of fit' to underlying data
  - Range of statistical, actuarial and validation tests applied
- Check internal consistency
  - Expect to increase with age
  - Curves in 'right' order
  - Less granular curves within extremes of more granular curves



# Using factor based models

## When they are useful

- Reflect diversified nature of pension plan
- Better fit at individual level than ‘average’
- Allow for changing demographics over time
- Smaller plans can benefit for wider ‘pool’ of experience data

## Limitations

- Dependent on data held by administrators
- Plan/Industry specific characteristics may not be fully reflected

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# 4 Experience analysis & credibility theory

# Overview

**What:** Comparison of ***actual*** deaths within plan to that ***expected*** under an assumption.

**When used:** To ***confirm*** appropriateness of proposed assumption.

To ***adjust*** proposed assumption for known plan effect.

**Limitations:** ***Generational stability*** assumption.

Seeking the perfect answer / ***false confidence.***

# Explaining the jargon

A **Actual** deaths experienced over the time period

E **Expected** deaths experienced over the time period

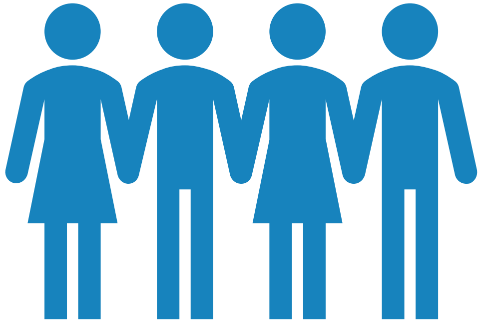
A / E "A over E ratio"

100%

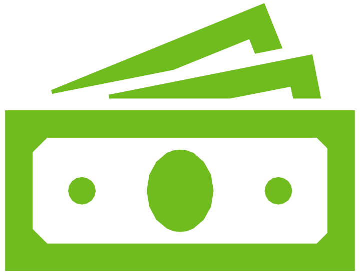
More deaths than expected
*Assumption **overstates** life expectancy*

Fewer deaths than expected
*Assumption **understates** life expectancy*

# “Lives” or “amounts”

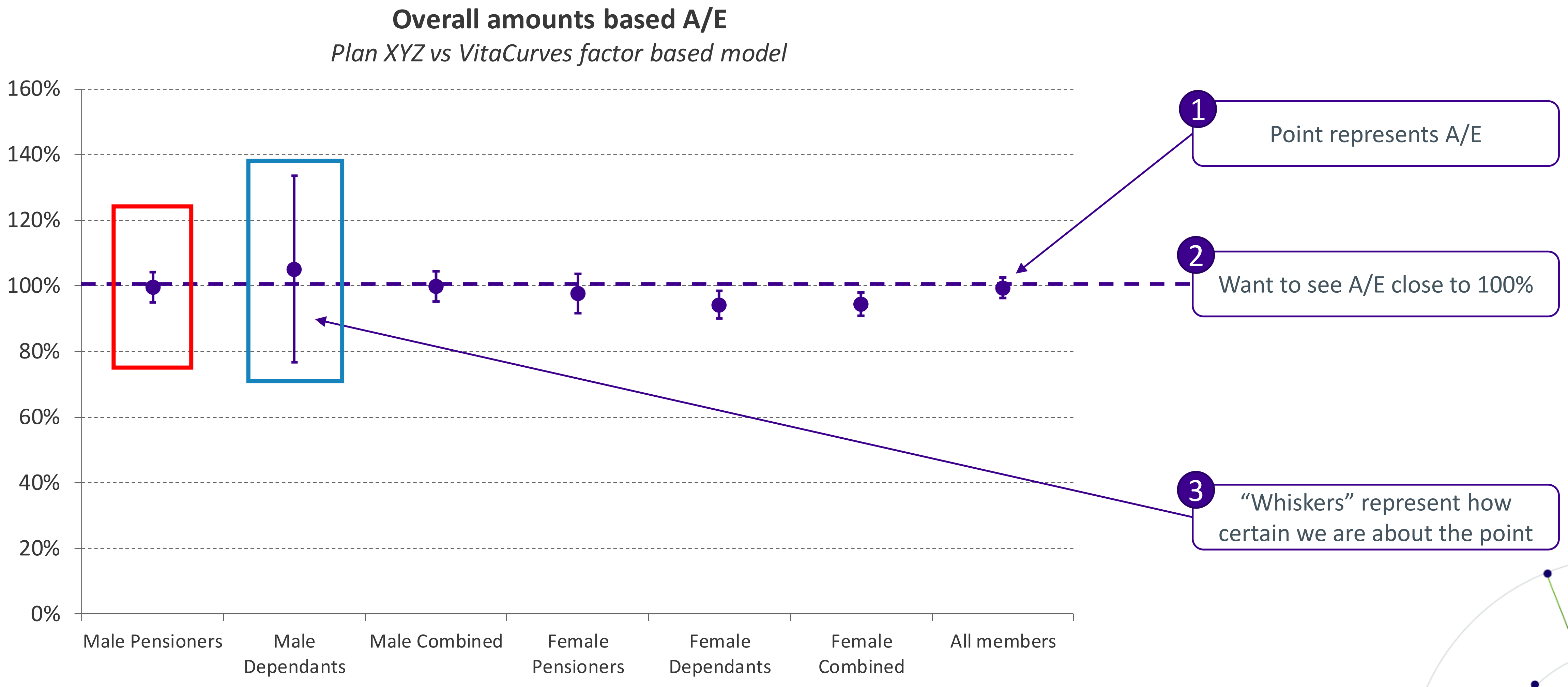


**Lives**
**Number of people dying**

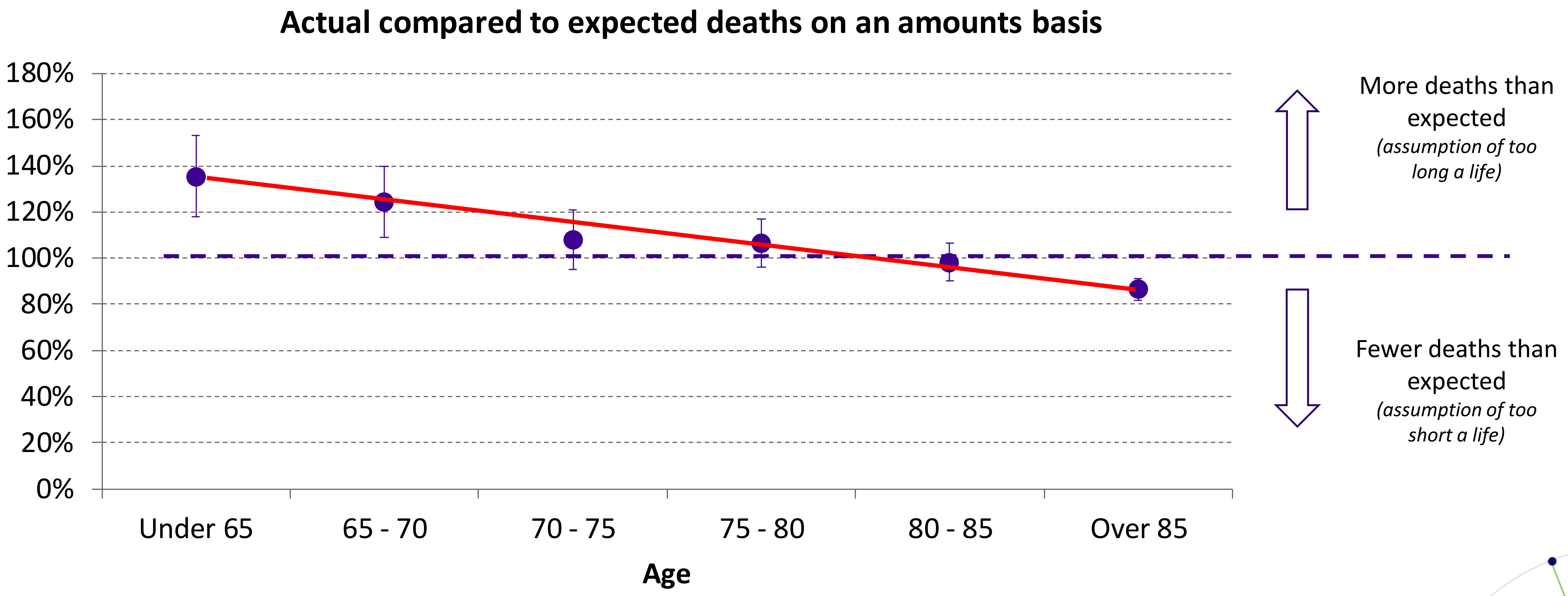


**Amounts**
**Amount of pension ceasing**

# The "A over E" chart



# Getting the age shape right

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# Adjusting baseline to get A/E close to 1

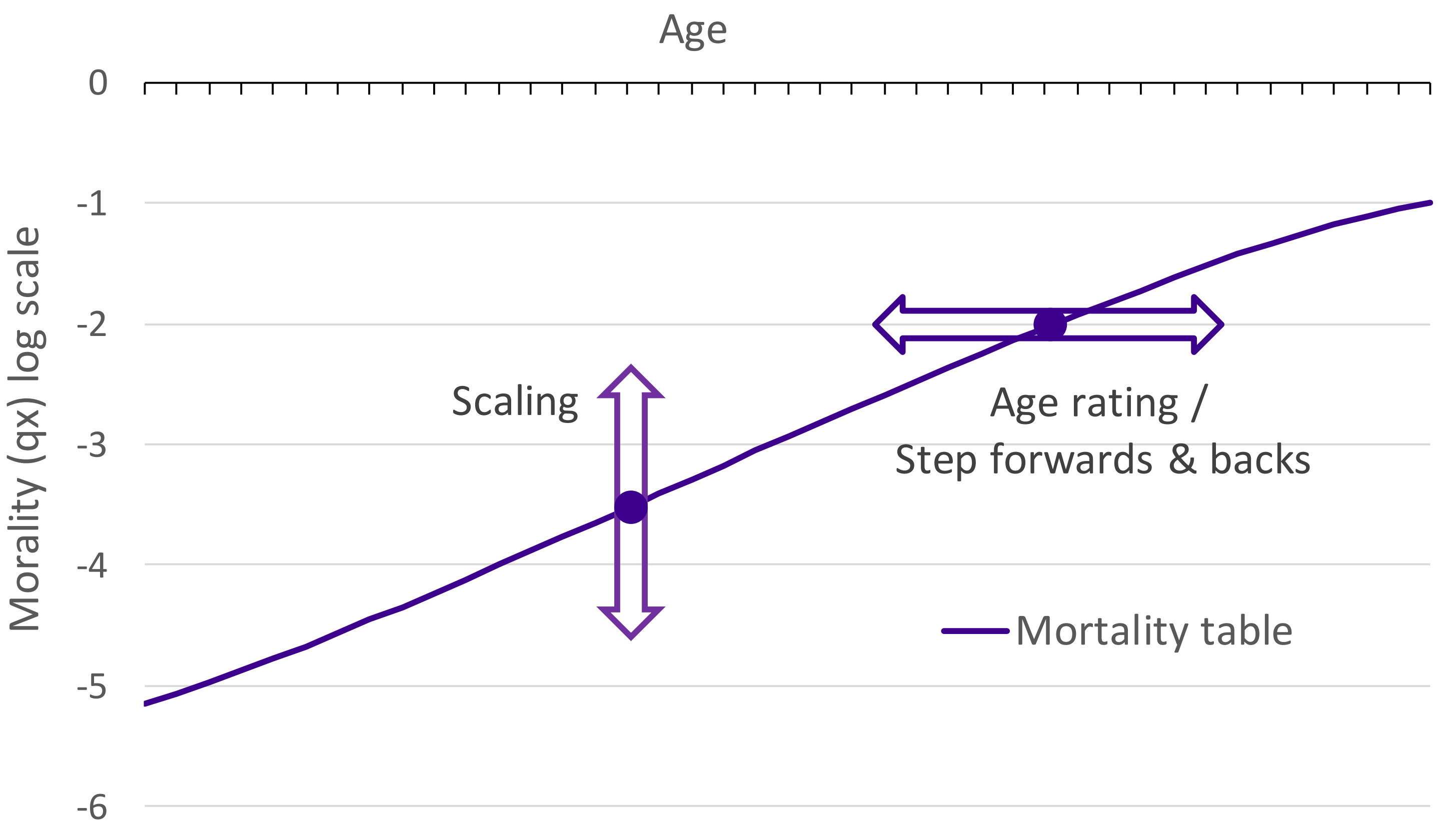
**Scaling**

120% * rates in table

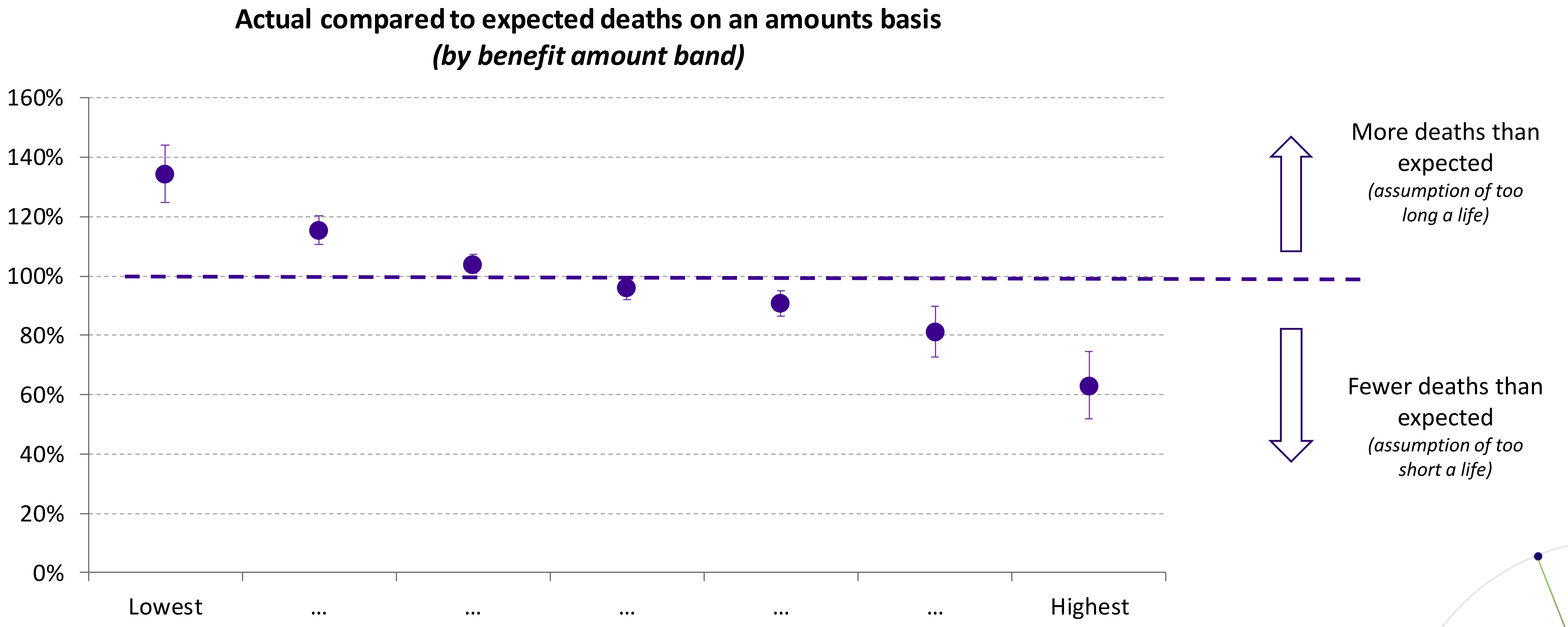
**Age rating / Step**

Treat everyone is if

3 years older



# Capturing diversity

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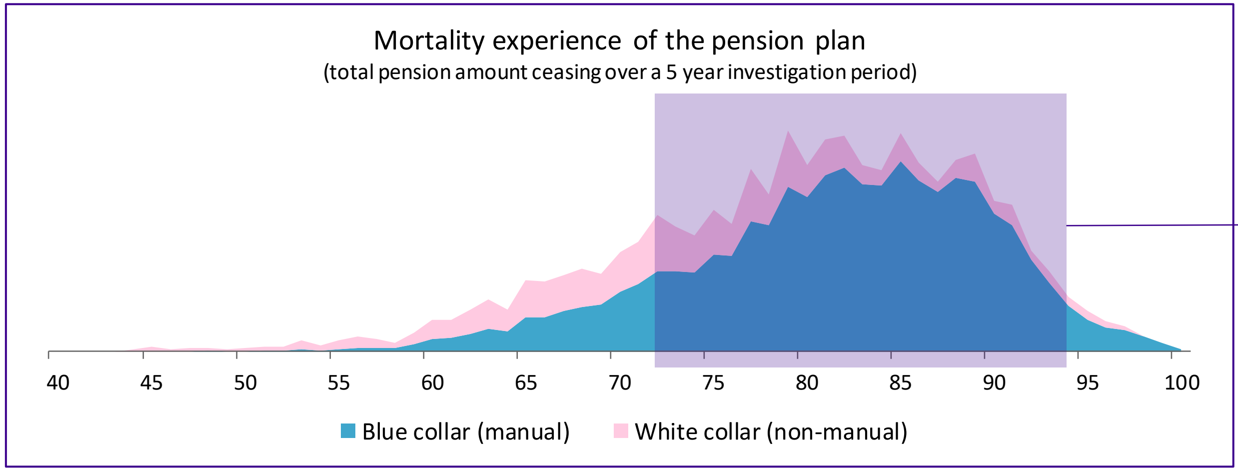
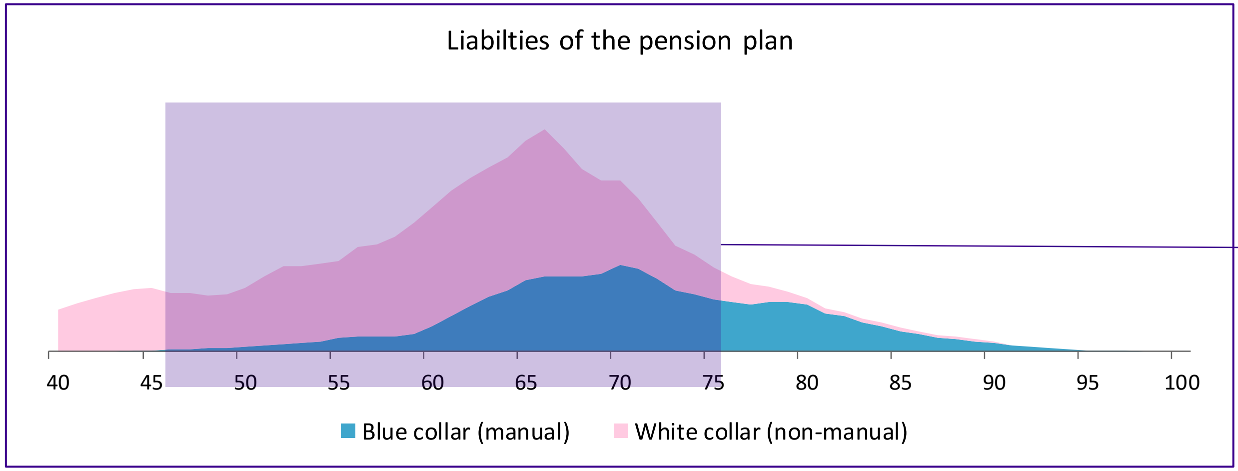
# Limitation: "Generational stability"




Experience analyses focus on where **most pensioner deaths occur**.

*For this plan this is a generation of* ***blue collar*** *workers*




Many plans will have majority of liabilities relating to **younger lives**

*For this plan this is primarily* ***white collar*** *workers*

1. Ensure assumption underpinning experience analyses is able to pick up these differences
2. Smaller adjustments preferable (more likely to apply across generations)

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# Applying credibility theory

- Mechanism for deciding how much **belief** to have in plan experience:

| | | | | |
|---|---|---|---|---|
| **weight = 100%**<br>entirely relies on experience analysis | $weight \ * Plan\ experience$ | $+$ | $(1 - weight) * Unadjusted\ table$ | **weight = 0%**<br>entirely relies on unadjusted tables |

- Value of ***weight*** determined by a formula reflecting statistical confidence in unadjusted tables or experience analysis
- ***Never*** exactly 100% ("entirely self-credible")
- **Guide only:** Lots of considerations including can you rationalise, data weaknesses etc…

**Session 201 will explore issues in more detail**

# Thank you