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Driver-based Models for Longevity Best Estimates and Trend (New Information) Risk

Matthew Edwards
Richard Marshall
Caroline Roberts

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Driver-based Models

General applications and differences from extrapolative approaches

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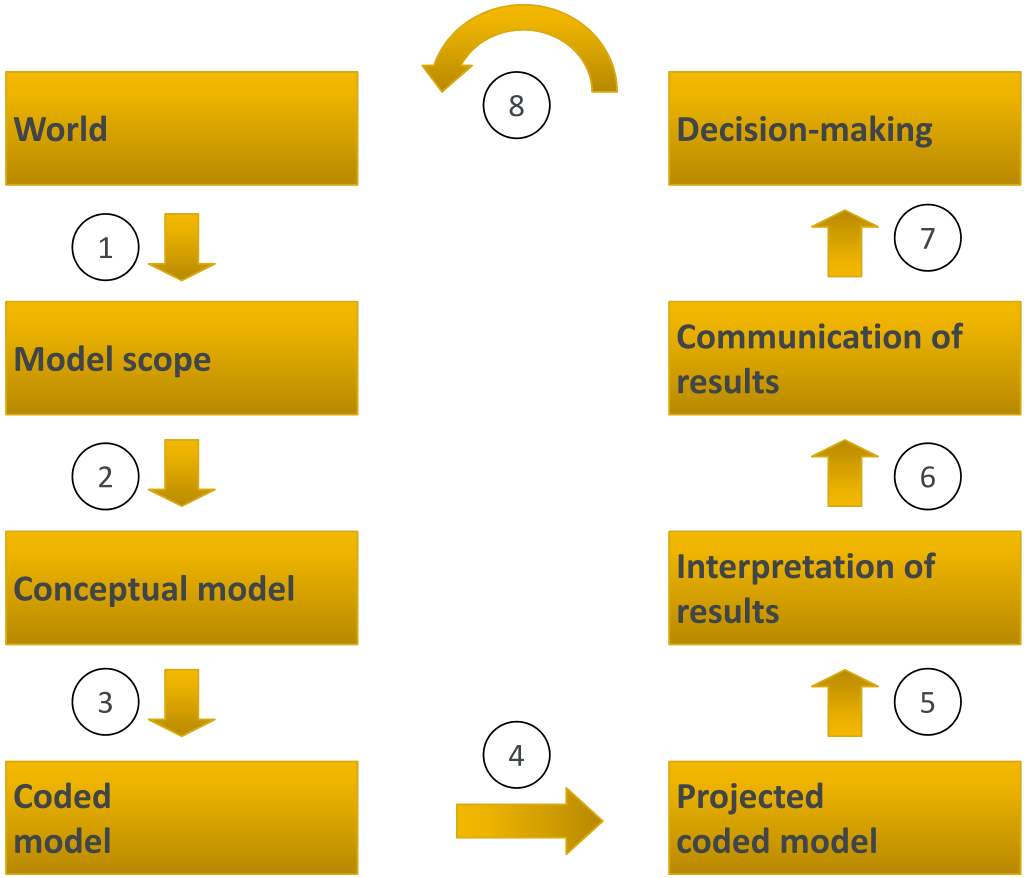
What is a model?

'The Philosophy of Modelling', Edwards/Hoosain, SIAS 2012



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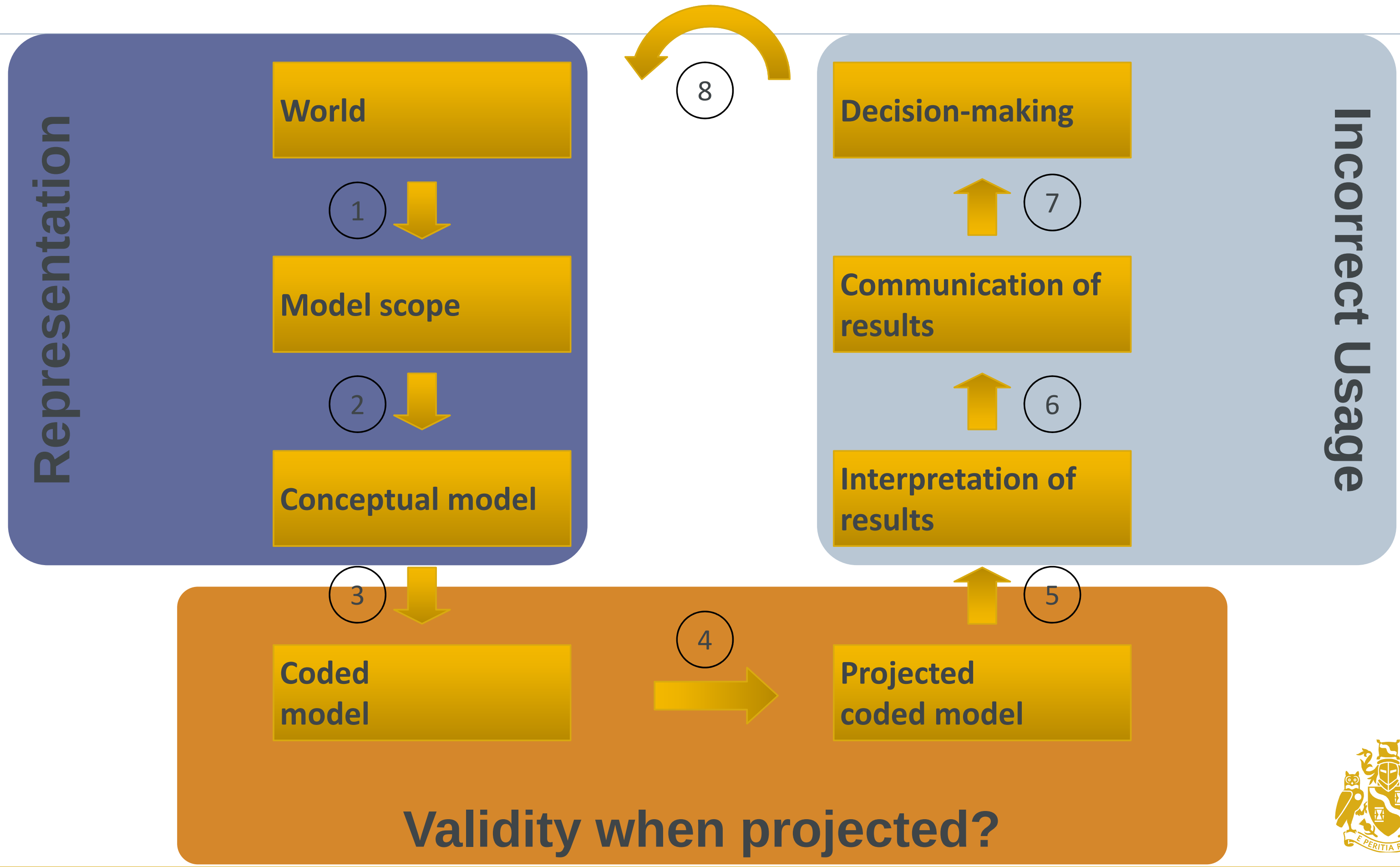
Model risk: what can go wrong?



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What is a driver-based model?

The 'projection' step will only produce valid results if we think the environment moving to world B will stay exactly the same as world A.

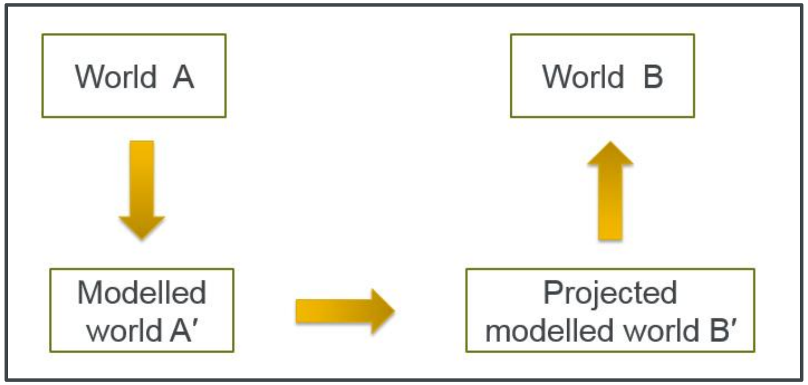
But is this likely? For instance, in considering mortality improvements, is it likely that the dynamics of the last (say) 40 years – large smoking reductions and massive NHS budget increases – will be repeated?

In a driver-based model, rather than model the 'surface' of a phenomenon (ie extrapolate), we model its 'interior' – those things which cause it to change.

Examples include:

- The Wilkie model (stochastic model for assets)
- The JEDI (Jobs and Economic Development Impact) models
- The model we discuss today!

Driver-based models seek to be more predictive in contexts where the underlying drivers are likely to move. They also help to quantify *why* the modelled phenomenon moves in a particular way, and hence aid understanding.



Validity when projected?

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Longevity in a Solvency II World

The context for trend modelling and “new information”

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A reminder of some concepts from Solvency II

Solvency Capital Requirement (SCR)

- Calibrated with the intention of capturing the 99.5th percentile value at risk ("VaR") over one year due to a range of risk events.

One year Value at Risk

- The amount such that:
  - the "own funds" (typically considered to be the value of assets less the best-estimate value of liabilities ("BEL") for this purpose)
  - would reduce by at least this amount
  - in exactly 0.5% of all realistic future scenarios
- Normally, realistic is equated with modelled

Longevity can be a significant driver of both the BEL and the SCR, so modelling longevity accurately can be key to both capital management and product pricing.

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Recap of longevity modelling concepts

Longevity model components

- Level – base mortality rates at the date of projection
- Trend – improvement rates for all relevant future periods

Level risk

The risk that initial rates of mortality do not accurately reflect the current experience of the modelled population.

- Model risk
- Parameter mis-estimation risk
- Random variation risk
- Basis risk
- Selection risk

Trend risk

The risk that modelled improvements do not accurately reflect the future experience for the modelled population.

- Model risk
- Parameter mis-estimation risk
- Random variation risk
- Basis risk
- **New information risk**

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What is new information risk (1)?

The PRA classification of longevity trend risk

- Longevity trend risk
  - Data risk
    - Model risk
    - Parameter risk
    - Basis risk
  - Event risk
    - Random variation risk
    - **New information risk**

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What is “new information” risk (2)?

Definition:

The risk that an event will occur:

- **Within one year** from the date of projection,
- whose **impact on expected rates of mortality** beyond that one year
- **is greater than** that captured in the changes to the best estimate due to model recalibration **including one year’s additional data.**

If using a longer time horizon than one year, then “one year” can be replaced by that time horizon throughout the definition.

New information can loosely be thought of as filling the gap between the **one-year VaR approach** and **the run-off approach** when calculating capital requirements.

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A framework for assessing the impact of new information risk

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Assessing new information risk

There are several stages involved in the assessment of new information risk.

Identify drivers of mortality

- Longlisting
- Shortlisting
- Selection

Set scenarios

- Best-estimate
- Significance level selection
- Event specification

Determine causal links between drivers and mortality

- Academic research
- National statistics
- Proprietary models of morbidity

Improvement rate calculation

- Aggregation
- Consistency with modelled "best-estimate" mortality improvements
- Impact measure

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Longlisting and shortlisting of longevity drivers

The aims of longlisting are to:

- Identify as many possible areas within which an event could occur which might affect future mortality improvements
- Qualitatively, assess the feasibility of an event within the next year
- Qualitatively, assess the potential for an event of each type to have an impact on mortality improvements
- Classify the events into medical and non-medical groups (possibly with further sub-divisions).

The aims of shortlisting are to:

- Include only those drivers for which events:
  - are feasible within the next year, and
  - if they occurred, would have the potential to have a material impact on improvements
- Reduce the number of drivers to be modelled:
  - Parsimony
  - Fewer interactions to consider
  - Easier to calibrate
- Identify commonality between drivers and combine where appropriate.

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Selection of drivers

Ensure good coverage of classes of driver (medical/non-medical)

Existence of research and data for calibration

Driver selection

Avoid excessive interactions

Stable impact on mortality over time

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Considerations for scenario setting

Best estimate	• Only changes in a driver **relative to the best estimate projection of that driver** are meaningful in the context of new information risk • Therefore, we need a set of best-estimate scenarios which are together **consistent with the improvements used to set the best-estimate liabilities**.
Target stress percentile	• Solvency II requirement (99.5^{th} percentile stress) • Practicality of defining an event of such extreme severity.
Event definition	• Plausible event (considering the target percentile stress to that driver) • Impact of the event on the driver over time vs best estimate • Minimal unintended interaction with other drivers

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Causal links – how drivers impact mortality

Ways to quantify the impact of a change in a driver on mortality:

- By scenario definition (the event is defined to have a set impact on all-cause or cause-specific mortality)
- By setting a simple (e.g. linear) relationship between changes in driver value and improvements in all-cause or cause-specific mortality.
- By use of relative risks for cause-specific mortality and latency periods between changes in drivers and changes in mortality
- By defining impacts of driver changes on both morbidity (disease inception rates) and mortality within a multi-state model.

Other than the “scenario definition” approach, all require careful calibration.

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Example of causal links: Real-terms NHS funding

The following approach can link NHS funding improvements with changes in mortality:

- Identify the causes of mortality which could respond to increased availability of healthcare provision.
  - **Amenable mortality** is measured annually by the ONS.
  - Arguably, the limit age of 75 for some conditions under this definition is too restrictive, but it's a reasonable proxy.
- Compare historic real-terms increases in public healthcare spending with decreases in amenable mortality.
  - Determine the impact of a 1% real increase in NHS funding as an X% decrease in amenable mortality.
- Consider allowances for diminishing returns.
  - E.g. use compound impacts so that:
  - each 1% real increase is larger in absolute terms, and
  - each X% decrease in amenable mortality is smaller in absolute terms.
- Consider interactions with any other scenarios
  - What else could be increasing/reducing amenable mortality?
  - What could make the 1% real increase in funding have a larger/smaller impact on amenable mortality?

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Calculating improvement rates: driver-based modelling

To asses new information risk, we use a "cause of cause of death" model

- Drivers are projected on best-estimate or stressed assumptions
- Cause-specific mortality is derived for each future year based on:
  - National statistics for past causes of death
  - Driver mediated improvements
  - Scenario specific improvements
- Improvements are derived after aggregating all causes of death
- Scenario impacts can be measured in terms of
  - Change in improvements over a given period
  - Change in expectation of life at a range of ages
- There are challenges around consistency with best-estimate assumptions.

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Practical application of a driver-based model

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Understanding what goes into the model

- What are the final drivers – medical and non-medical?
- What is the best estimate scenario?
- What is the stress event and scenario?
- What probability level do we assess the stress event at ?
- How do we combine stressed events?
- How does this impact future improvements (all causes of death or targeted?)
- Challenge of the assumptions – any alternative research

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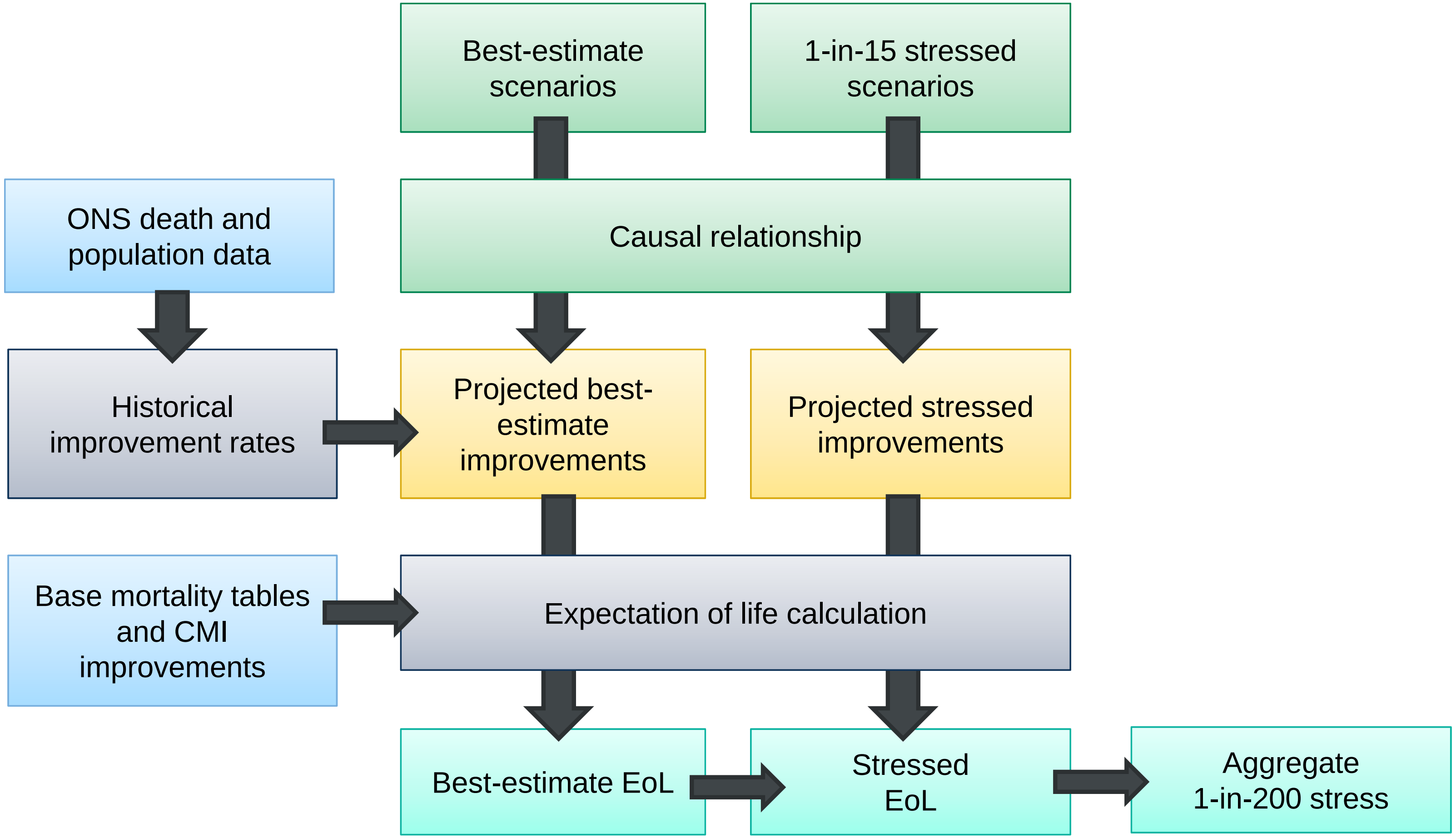
Model Structure



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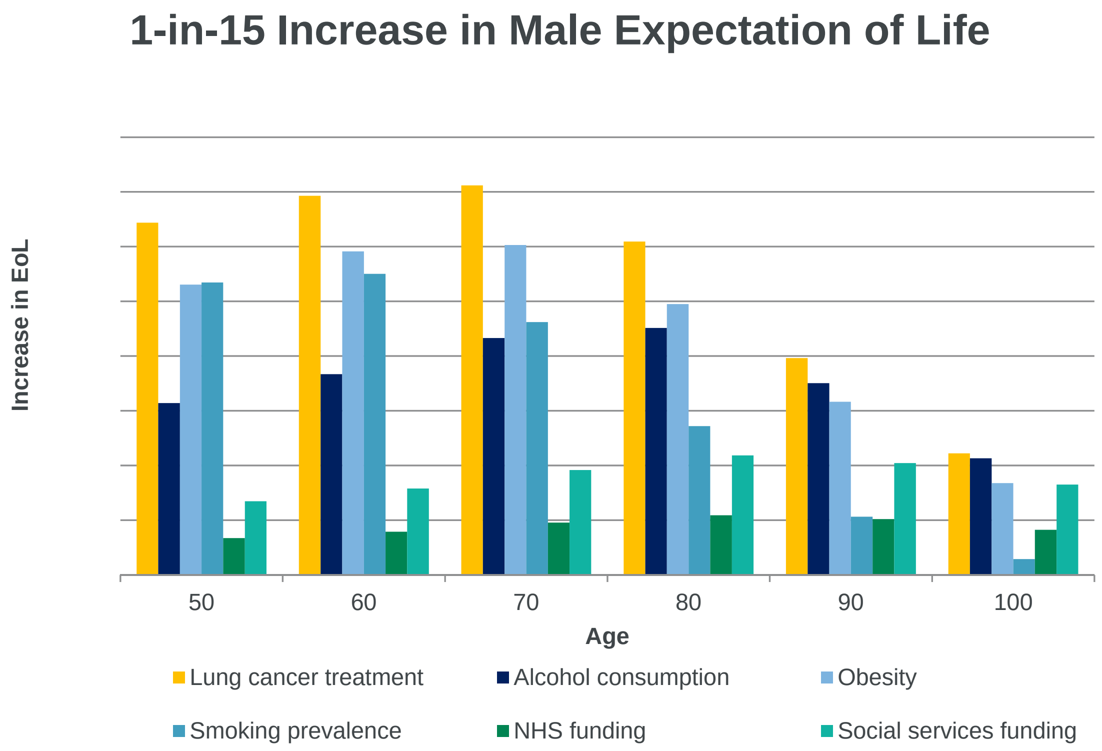
Output



1-in-15 Increase in Male Expectation of Life
Increase in EoL
50
60
70
80
90
100
Age
Lung cancer treatment
Alcohol consumption
Obesity
Smoking prevalence
NHS funding
Social services funding

Aggregation

1 in 15
- Increase in EoL for each driver

1 in 15
- Single Aggregated increase in EoL

1 in 200
- Single Aggregated increase in EoL

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Just one part of the final answer

Impact of one year's additional data	Stochastic Modelling
A change in long term view of future improvements	Driver based model
A change in model used to set improvement assumption	Scenario testing of different models

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Validation and Governance

Backtesting

- How does the result compare to historic events such as introduction of interim cohort tables

Sensitivities

- How does the output change to different assumptions

Other points on the PDF

- When extrapolating to a 1 in 4 event, how does that compare with recent history

Expert Judgement

- Model relies on large number of expert judgements which requires strong governance

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Best-estimate longevity improvements

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Driver-based models for best estimate

The above modelling was developed with particular reference to plausible factors of material mortality impact.

Can this approach lend itself to better consideration of best estimate longevity improvements?

Where do longevity improvements come from?

In the absence of change, by definition mortality remains constant.

Mortality will vary because of change –

- the ‘big ticket’ changes could be those already considered (albeit it has been a largely one-directional perspective)
- there will also (probably) be variation in ‘small ticket’ aspects

Approaches to ‘small tickets’

- Explicit modelling of these factors – individually

- Modelling of overall effect
  - Look at historical periods and strip out quantifiable effects
  - ‘Expert judgement’ of combined effect
  - Assumption of 0% (combined + and – effects)

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Questions

Comments

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