Willis Towers Watson

PulseModel

Forward-looking longevity model

PulseModel and Solutions for Life

PulseModel is part of our Solutions for Life portfolio of integrated software, technology and consulting services – a holistic solution to managing the end-to-end risk reporting process.

For more information on Solutions for Life, turn to page 7 of this brochure or visit: solutionsforlife.willistowerswatson.com.

PulseModel

The Willis Towers Watson Medical Mortality Model

Getting *just the right* mortality basis poses a perennial challenge to insurers and reinsurers, a challenge made all the more difficult by:

- Specialist health-related products, such as enhanced annuities or critical illness
- The desire to use new rating factors, such as body mass index (BMI) and postcode
- Excessive reliance upon extrapolative approaches to future improvement assumptions
- The expectation that longevity assumptions should be stressed in a biologically plausible way

We developed PulseModel to help firms overcome these and many other mortality and longevity challenges. To date, we have used PulseModel to advise clients on areas such as:

- Mortality and morbidity improvement assumptions for critical-illness products
- Portfolio-specific longevity improvement assumptions
- Prospective improvement differentials across age, gender and socioeconomic groups
- Medical underwriting of pension scheme members
- Longevity stresses for internal model validation purposes

PulseModel's ability to add value in such projects is founded on two features of our approach:

1. The inclusion of the future trend opinions of a panel of 10 independent medical experts
2. The ability to infer portfolio medical and lifestyle information from postcode

Introduction

In PulseModel, mortality is modelled in a 'bottom-up' manner, according to the passage from a starting state (healthy or otherwise) through one of a number of disease groups, to eventual death. The transition probabilities between these states are modified by such risk factors as duration since diagnosis, BMI and socioeconomic status, as well as various medical markers. Changes in the transition probabilities over time – separate assumptions for morbidity and mortality for each disease group – are set on the basis of the advice of relevant medical experts.

Parameterisation

PulseModel parameters are based on a large database of UK primary care records in respect of around six million people.

This database provides crude transition probabilities for every individual slice of the population for movements from one state in the model to another – for instance, the probability of moving from healthy to diabetes, or from lung cancer to death. These transition probabilities are then modelled using generalised linear models to smooth out random noise (in particular, in the age and duration curves) and properly quantify the effect of the various risk factors.

There are also a number of more specific medical markers used for some of the transitions – for instance, for transitions involving diabetes, measures of blood glucose (via glycosylated haemoglobin HbA1c) are very predictive.

Figure 1 provides some typical results relating to the effect of risk factors on some of the transitions modelled.

Figure 1. **Example risk effects**

Effect of smoking on heart disease mortality

1. Smokers exhibit mortality rates 72% higher than non-smokers
2. Ex-smokers have mortality rates 23% higher than non-smokers

Effect of socioeconomic class on diabetic incidence

1. Quintiles based on Office for National Statistics (ONS) Index of Multiple Deprivation
2. Bottom quintile incidence rate = 166% top quintile ('white collar')

Model structure

Figure 2 below shows the structure of the multistate model. Healthy lives progress from their starting state to an initial major condition (the seven disease groups shown), and on to eventual death. For lives starting with a disease, the model takes into account the precise starting condition (for instance, which type of cancer). The probabilities relating to each transition are defined by the parameterisation work outlined previously.

The model runs a large number of simulations through all possible paths, applying a Monte Carlo process rather than trying to force a mathematical solution. The mean of the simulations gives us a bespoke mortality projection for each policyholder.

There is no explicit transition from any disease group back to healthy; rather, that effect is allowed for implicitly via a duration factor. Thus, a person who has survived for 10 years since his or her diagnosis of cancer will be modelled as almost healthy, while the duration effect can work the other way for chronic conditions such as diabetes.

Improvements

Future improvement rates applying to the disease transitions are provided by medical experts who advise us on the improvements that are reasonable to assume in their specialist fields, as well as feasible stresses to those improvements. These improvement rates cover both changes in disease incidence (that is, the trend moving from healthy to the disease group in question) and changes in mortality given a particular disease.

Figure 2. **Multistate transition process**

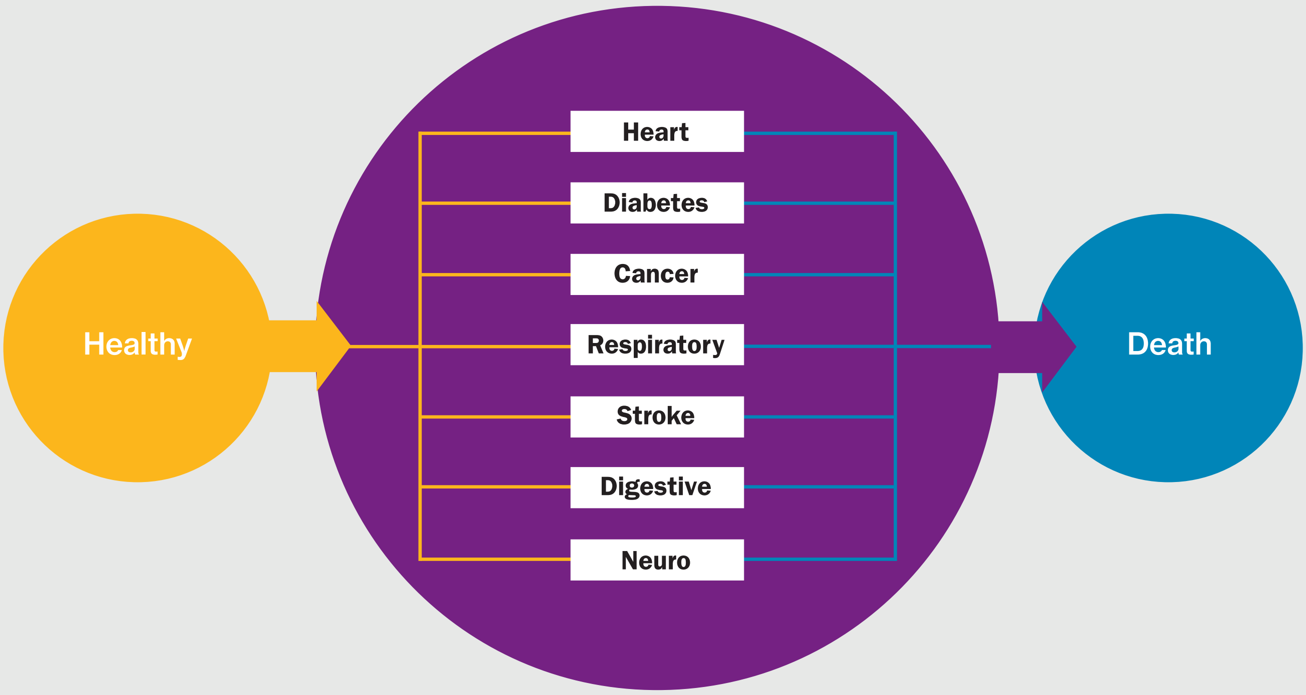


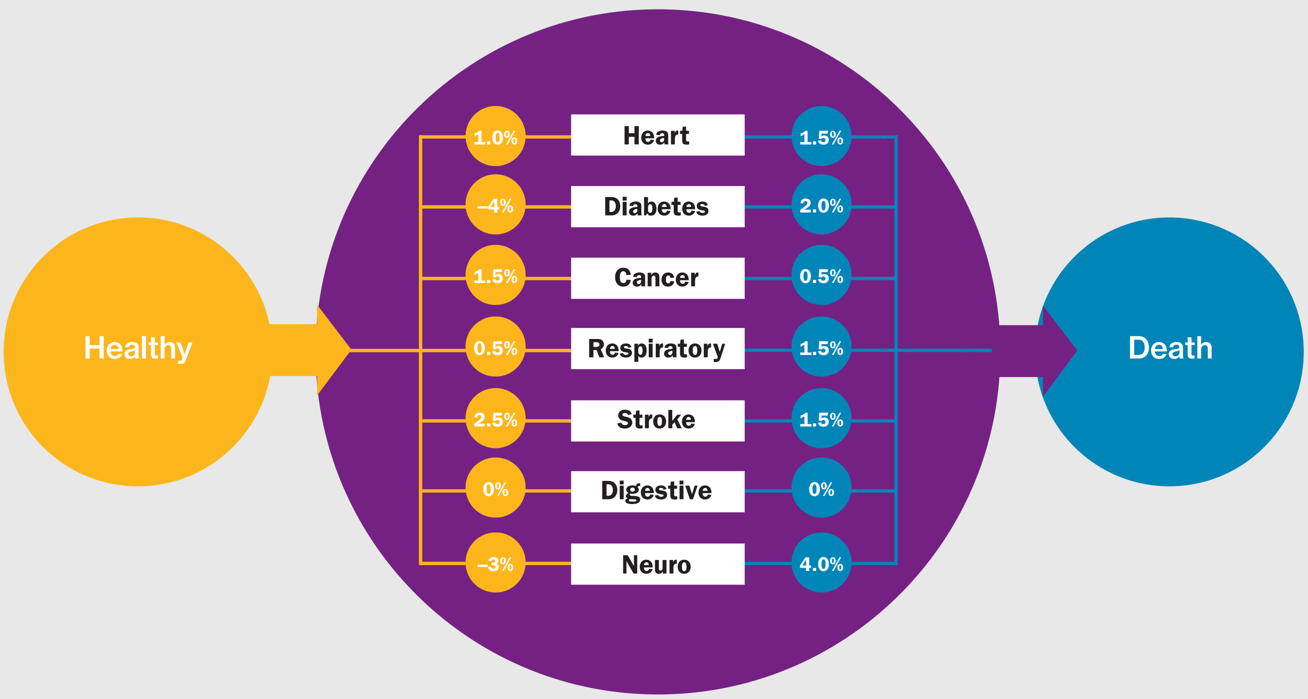
Figure 3 below shows an example of how the various possible inputs regarding expected annual morbidity and mortality improvements can be combined in the modelling framework (the numbers shown are illustrative only). The parameterisation of 'base' morbidity and mortality provides a valid structure to weight these improvement assumptions (and this weighting can be portfolio-specific).

An example of the thought process being applied here is the opinion of our stroke expert (a professor of stroke medicine). The process starts with a quantification of recent changes in stroke mortality and identification of the underlying drivers of those improvements. The majority were attributed to organisational changes, such as the establishment of dedicated stroke units in many hospitals, though there was some contribution from such treatments as thrombolysis and thrombectomies.

The next step is the identification of future drivers and quantification of their impact. Consideration of what's happening within the health service, the impact of any emerging medical treatments and pharmaceutical developments, and the effects of smoking and other lifestyle trends leads to a sensible medically reasoned estimate of how stroke mortality will move over the next 10 years or so. Importantly, the drivers of past improvements differ significantly from those likely to be responsible for future improvements.

Our advisors also provide opinions on biologically and medically plausible stresses to these improvements, allowing the model to provide meaningful longevity improvement stresses that reflect current reality. The nature of the model also means these stresses can be communicated to senior management in a very clear way.

Figure 3. **Disease-specific improvement assumptions (illustrative only)**



Business applications

PulseModel is ideally suited to help businesses across a range of areas:

Improvement assumptions – PulseModel provides a forward-looking view of mortality/longevity improvement assumptions, combining the views of a wide pool of medical experts across a range of conditions. This can be tailored to individual portfolios using age, gender and postcode information (where we infer a distribution of medical conditions from the postcodes).

Segmentation – The risk factor information inherent in PulseModel's parameters allows firms to consider greater segmentation on standard (nonmedical) business – for instance, regarding the mortality effect of BMI or smoking status.

Medical underwriting – PulseModel provides pricing assumptions for any business with benefits or premium payment contingent on medical status or events. There should also be scope to reduce the cost of medical underwriting (that is, to reduce the involvement of medical professionals).

Longevity stresses – PulseModel can provide biologically plausible stresses to longevity improvement assumptions, quantifying the 'new information' (or 'new event') part of longevity stress. This is done in a way that reflects age variations and portfolio-specific postcode distributions.

Outputs

The model provides bespoke mortality projections for every policyholder, as shown graphically in *Figure 4* (survival curves), as well as information as to the progression of states over time to aid understanding of the primary drivers of mortality *(Figure 5)*.

For more information

Visit: willistowerswatson.com/pulsemodel
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Figure 4. **Survival curve**

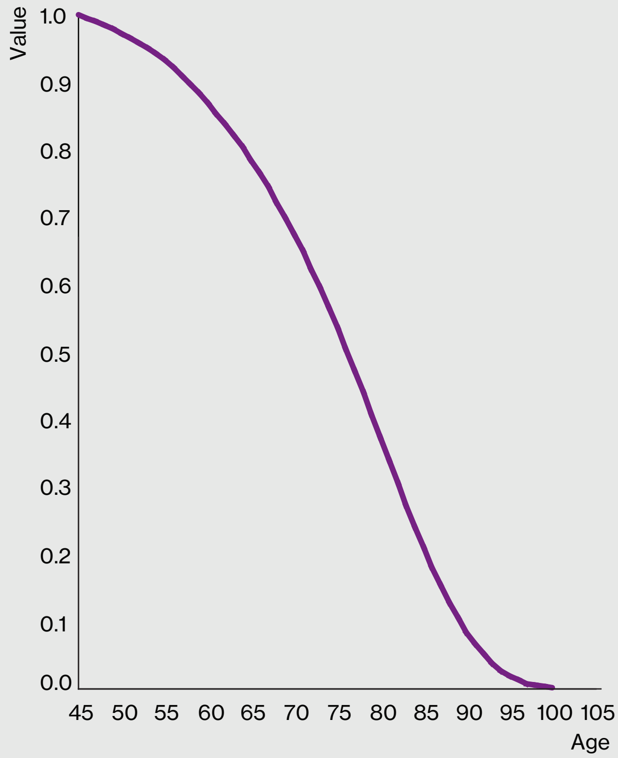
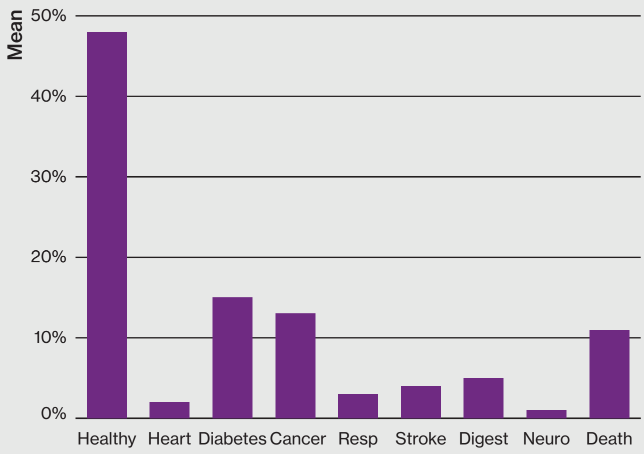


Figure 5. **Distribution of states – 20 years on from a 100% healthy population**



A holistic approach to the wider risk reporting process

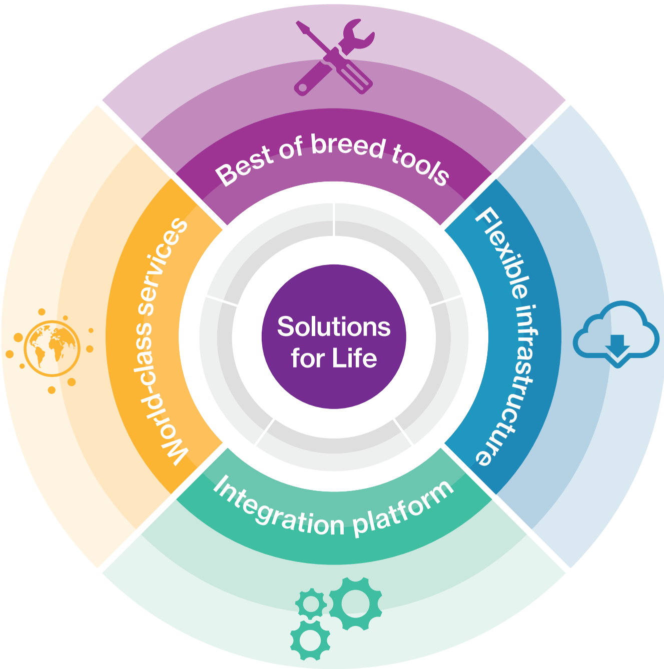
Solutions for Life

Solutions for Life is a portfolio of integrated software, technology and consulting services for life insurers that ensures your risk and actuarial processes adapt to meet changing business requirements – enabling you to save time and money, comply with regulatory demands and optimise legacy systems.

It is made up of four main components:

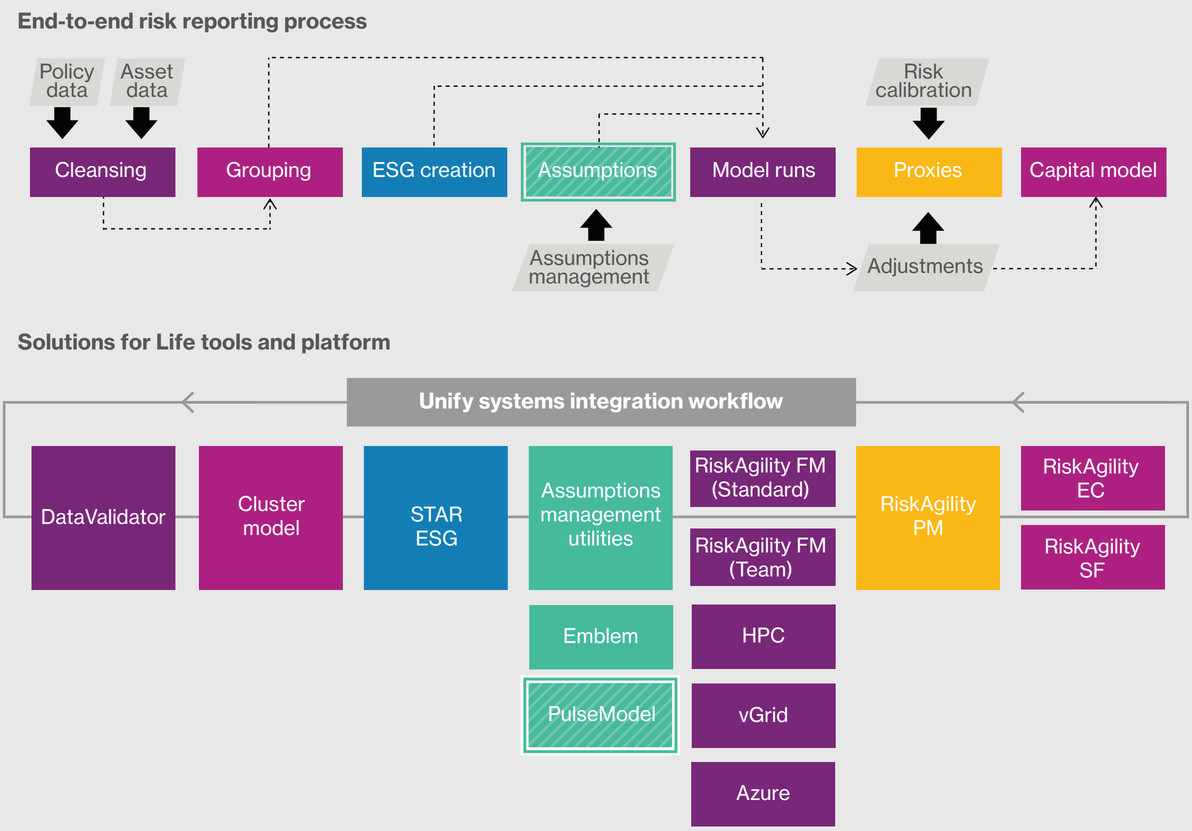
- Best of breed software tools
- Flexible infrastructure
- Integration platform
- World-class advisory and support services

Solutions for Life breaks down barriers, solves problems and provides confidence through accuracy, performance and control by employing industry thought leadership and advanced technology. For more information, visit solutionsforlife.willistowerswatson.com.



Solutions for Life end-to-end risk reporting process

How PulseModel fits within the Solutions for Life example end-to-end risk reporting process



About Willis Towers Watson

Willis Towers Watson (NASDAQ: WLTW) is a leading global advisory, broking and solutions company that helps clients around the world turn risk into a path for growth. With roots dating to 1828, Willis Towers Watson has 40,000 employees serving more than 140 countries. We design and deliver solutions that manage risk, optimise benefits, cultivate talent, and expand the power of capital to protect and strengthen institutions and individuals. Our unique perspective allows us to see the critical intersections between talent, assets and ideas – the dynamic formula that drives business performance. Together, we unlock potential. Learn more at willistowerswatson.com.

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