Insuring Healthy Futures
TECHNICAL REPORT

Vitality®

Contents

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Personalised Risk Prediction within the Context of Shared-Value Insurance

Insurance comprises the art and science of risk prediction and taking risk. Life and health insurance companies have traditionally assessed risk at the point of policy issue, based on declared and tested policyholder risk profiles, allowing for an expected deterioration in these risk factors as policies and policyholders age. This practically means that the price of insurance is set up front and typically does not change throughout the duration of the insurance contract based on factors within a policyholder's control.

Shared-value insurance fundamentally changes this approach, recognizing that people's risk pathways are mostly not pre-determined, and that ongoing personal behaviours and choices have a material impact on a person's risk. Through evidence-based programmes and consumer experiences rooted in behavioural science, insurance companies can help people make better decisions and take actions to create healthier futures; the value unlocked through these improvements serve as incentives for these actions. The global network of Vitality partners is committed to helping increase the number of people achieving lifetime healthy pathways through the workings of shared-value insurance.

It follows that within a shared-value model both the insurance company and the person need an understanding of the relationships between their behaviours and risks. Our research shows that people have a keen interest in what technology can show them about the link between their behaviours, risk characteristics and the implications for their future "healthy" self. People are, however, not uniformly interested in the same information and so insights need to be tailored – for example, whilst some people might wish to understand the one action that will materially impact their future, others might be interested in metrics such as how long they might live, or how healthy they might be in future. This information may serve a pivotal goal – equipping people with the information they need to make better choices about their current and future health habits.

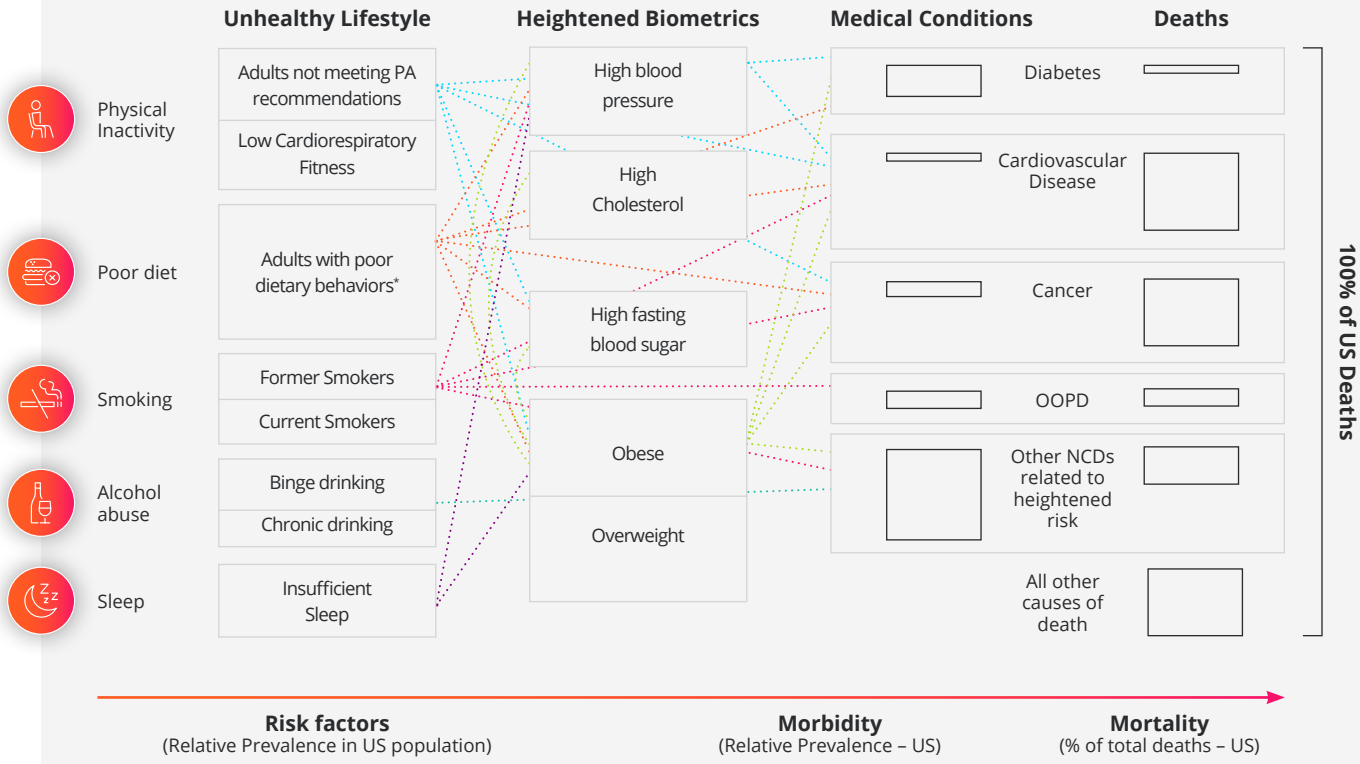
Our Healthy Futures work provides people with precisely these insights and allows for the personalization of programmes and experiences that accommodate diverse risk profiles. The technology that enables these programmes and experiences has been built over many years and requires: (i) an infrastructure to track important behaviours such as physical activity, cardiorespiratory fitness and nutrition continuously; (ii) predictive models to translate individual behaviours and characteristics into complex insurance risk scores; (iii) simple and meaningful personal risk insights; and (iv) personalized programmes, experiences and incentives to help people realize their best futures.

Simplifying Complexity

Epidemiology is described as the science of public health and establishes robust causal frameworks between risk factors and causes of death and disability. These relationships are complex and risk assessment must account for both direct and indirect interactions between risk factors and causes of death and disability. For example, higher physical activity is linked to lower future blood pressure, but both are directly linked to heart disease. Therefore, physical activity has an indirect link to heart disease through blood pressure, but improved physical activity also directly lowers the risk of heart disease.

Figure 1 is an illustration of the complex direct and indirect interactions between and among unhealthy lifestyle risk, heightened metabolic risks[1], medical conditions, and ultimately, death.

FIGURE 1 – ILLUSTRATION OF THE INTERACTIONS BETWEEN LIFESTYLE RISKS, BIOMETRIC RISKS, MEDICAL CONDITIONS AND RISK OUTCOMES



** Dietary behaviors encompass the consumption of fruits and vegetables, legumes, nuts and seeds, whole grains and high fiber starch, red and processed meat, sugary beverages, and added salt*

Sources: CDC: Behavioral Risk Factor Surveillance System (BRFSS).

With the appropriate data and predictive models, insurance companies are well-placed to assess these relationships and risks. However, the same does not hold for individuals. Behavioural economics demonstrates that individual rationality is bounded, especially when it comes to understanding and contextualizing risks and probabilities, and taking meaningful actions based on that information. Vitality recognized this disjuncture early and designed a user experience around three intuitive journeys that inform and steer individuals towards better health: Know Your Health, Improve Your Health, and Get Rewarded.

Within the Know Your Health category the concept of Vitality Age was introduced as a key health indicator, effectively showing an individual's overall health status through a single intuitive number. Vitality Age represents an adjustment to an individual's chronological age based on the predicted impact of their health behaviours and other risk factors on their life expectancy. As such, a healthy person would see a lower age, reflecting a longer life expectancy, whilst an unhealthy person would see a higher age. The Vitality Age risk prediction has evolved since its conception, aligned with the availability of new evidence and Vitality's own data insights and business expansion.

[1] Such as systolic blood pressure, cholesterol, fasting plasma glucose, body-mass index (BMI).

VITALITY AGE 1.0

The Vitality Age risk prediction was originally developed in collaboration with researchers from the University of Cape Town (UCT). The algorithm was based on 65 peer-reviewed studies, yielding multivariate-adjusted, continuous risk estimates for nine modifiable lifestyle risk factors.

A systematic literature review was completed to identify the relevant modifiable risk factors, and only articles that adjusted for multivariate confounders in estimating relative risk were included.

The algorithm quantified the impact of future mortality risk by multiplicatively combining age-independent relative risks into a single relative risk applied to a standard mortality curve. Vitality Age was thus estimated as an actual age adjusted for the difference between standard and adjusted life expectancy.

VITALITY AGE 2.0

Through a continuation of the collaboration with UCT, an update to the risk prediction was developed in 2011. This allowed for the incorporation of the latest available research and the addition of risk factors.

The evidence supporting the update included published research between 1990 to 2010. A total of 5,706 articles were initially screened, of which 204 were selected for review and ultimately 87 were selected to construct the algorithm. Only papers that adjusted for multivariate confounders in estimating relative risk were included.

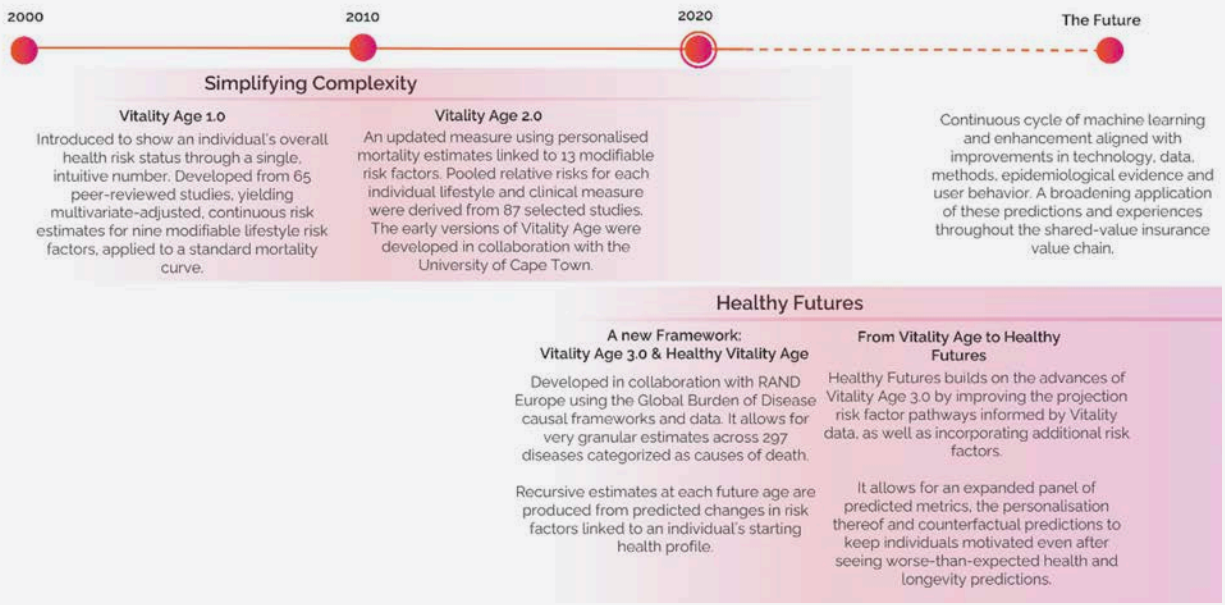
Pooled relative risks for each individual lifestyle and clinical measure were derived along a continuum of exposures. From these, combined relative risk factors were calculated and applied to mortality rates to adjust life expectancy and calculate Vitality Age.

Healthy Futures

Subsequently, advances in technology, computing power and the availability of data have allowed us to explore novel approaches to risk prediction. This is also aligned with the shifting role of metrics for individuals more broadly – from relatively static sources of information early in the quantified-self movement to ongoing and prospective risk prediction and mitigation tools, leveraging an ever-expanding suite of technology that help people as and when it matters.

The progression from Vitality Age to Healthy Futures comprised two substantial projects – the first established a new framework for comprehensive risk prediction, harnessing granular risk and disease data with modern processing capacity; and the second expanded upon the risk factors and risk metrics to allow for personalization and broader application within a shared-value insurance model. This evolution is summarized in Figure 2, alongside the earlier phases of Vitality Age.

FIGURE 2 – EVOLUTION OF VITALITY AGE FROM SIMPLIFYING COMPLEXITY TO HEALTHY FUTURES

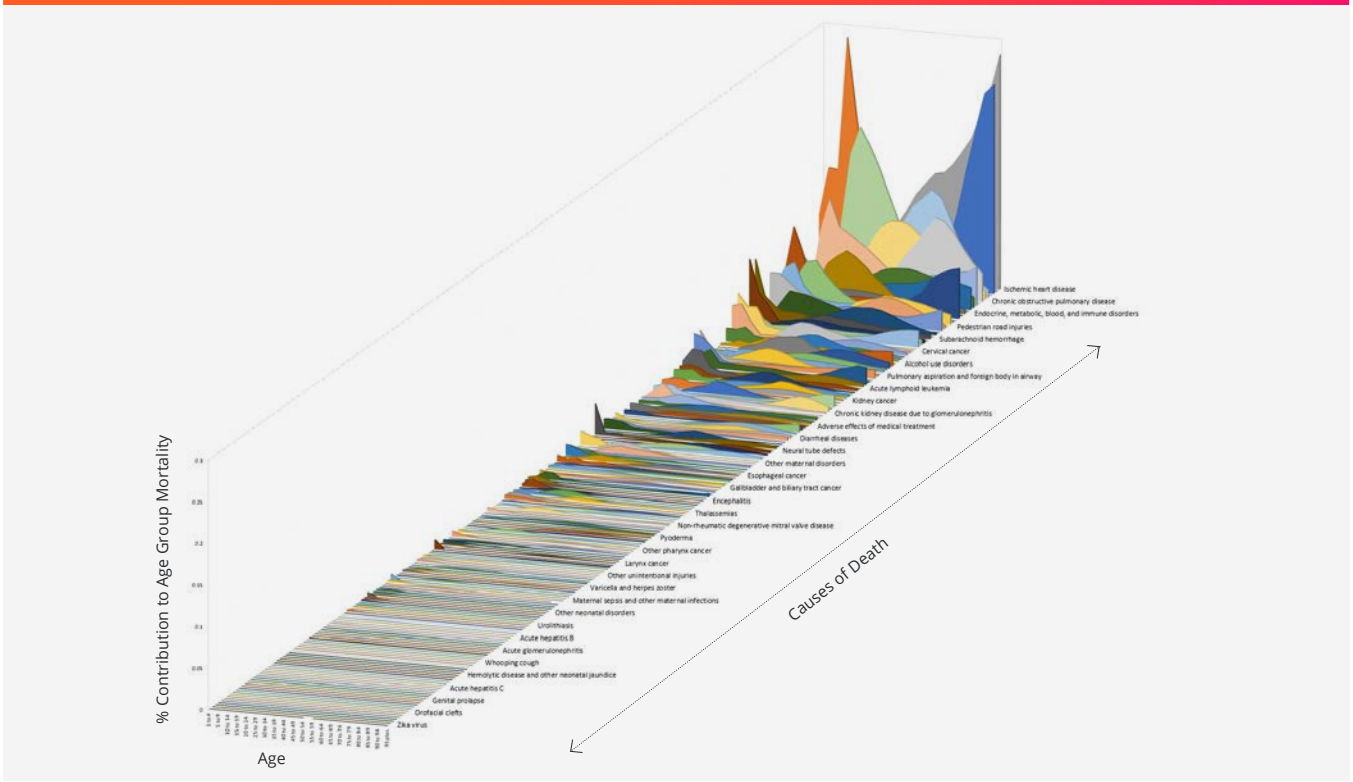


ESTABLISHING A NEW FRAMEWORK: VITALITY AGE 3.0 AND HEALTHY VITALITY AGE

Vitality Age 3.0 was developed in collaboration with RAND Europe, along with a complete technical report[2] outlining the development process and methods supporting the prediction algorithm.

It uses the Global Burden of Disease (GBD) data under license from the Institute for Health Metrics and Evaluation at the University of Washington. The GBD data have the advantage of not being associated with a single cohort of individuals or methodologies, but rather being a product of a multitude of studies from countries all over the world and are widely used in scientific literature. The database also explicitly models, among other things, the mediation effects discussed earlier using very sophisticated meta-analytical framework updated over time. The data is available at regional and country specific levels to facilitate risk prediction across companies operating in different geographies within the Global Vitality Network. The data further allow for calculations to be performed at a very granular disease (cause) level, effectively creating mortality estimates across 297 diseases categorized as causes of death (available on a country specific level). This is illustrated in Figure 3.

FIGURE 3 – CAUSE-SPECIFIC MORTALITY PROFILES ALLOWS FOR PERSONALIZED MORTALITY ESTIMATES ACROSS THESE DISEASES

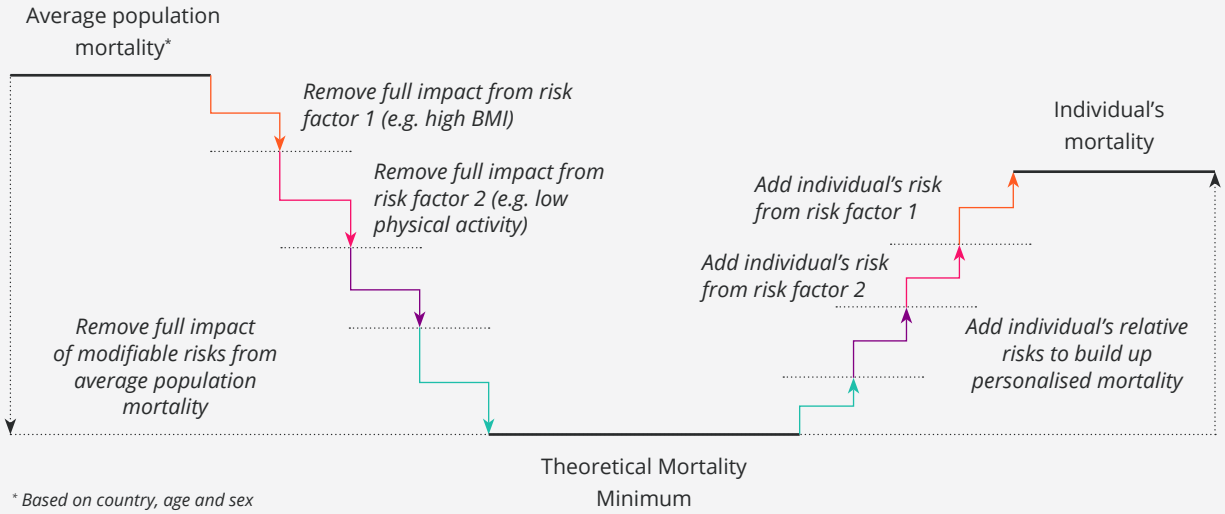


Vitality Age 3.0 uses this data to create cause-specific mortality estimates, starting with the population average mortality rates and removing excess deaths associated with modifiable behavioral and metabolic risk to produce estimates of risk-free probabilities of death that serve as a baseline. Thereafter, based on individual characteristics, modifiable risks are re-introduced aligned with the relationship between an individual's risk factors and causes of death. These cause-specific mortality rates are then combined to produce all-cause mortality curves. This process is illustrated in Figure 4 and the framework has been validated in Lim et al. (2015)[3].

[2] Stepanek, Martin, Howard Bolnick, Francois Millard, Christian Van Stolk, Bryn Garrod, Catherine L. Saunders, and Janna van Belle, Vitality Age V.3: Technical Report. Santa Monica, CA: RAND Corporation, 2018. https://www.rand.org/pubs/research_reports/RR2484.html

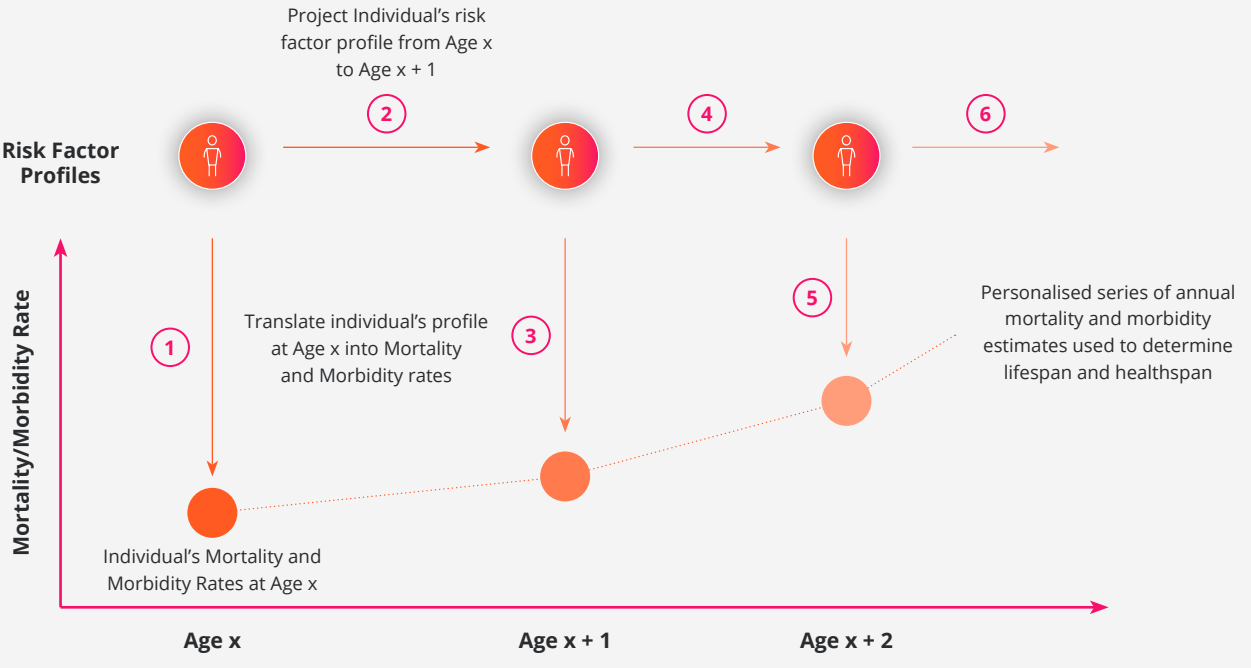
[3] Lim, S., E. Carnahan, E. Nelson, C. Gillespie, A. Mokdad, C. Murray & E. Fisher. 2015. 'Validation of a new predictive risk model: measuring the impact of the major modifiable risks of death for patients and populations.' Population Health Metrics 13(1):27

FIGURE 4 – AN ILLUSTRATION OF THE BUILDUP OF INDIVIDUALIZED RISK ESTIMATES UNDERLYING THE VITALITY AGE 3.0 MORTALITY PREDICTIONS



In addition to calculating the cause-specific mortality estimates at an individual's current age, the calculation is repeated at each future age, based on an expected change in these risk factors over time. These age-projected mortality rates are then used for the life expectancy (lifespan) estimation, the details of which are highlighted in Figure 5.

FIGURE 5 – RECURSIVE CALCULATIONS WITHIN THE VITALITY AGE 3.0 PREDICTIONS



In parallel with the development of Vitality Age 3.0, a new Healthy Vitality Age[4] prediction has been developed, introducing morbidity (or disability) to the Vitality Age prediction. The steps of the calculation are principally akin to that of the mortality calculation but is focused on morbidity (disability). This prediction allows for the estimation of years lived in good health (healthspan).

Risk factors related to both physical and mental health serve as input to the models.

Importantly, the risk-cause-outcome framework supporting both the Vitality Age 3.0 and Healthy Vitality Age predictions provides full transparency on the calculations and results, making the models fully explainable in contrast with emerging black box solutions which are challenging to implement in insurance applications. The models produce very detailed results beyond Vitality Age to support actuarial modeling and user experiences.

[4] Patil, Sunil, Christian Van Stolk, Cloé Gendronneau, Martin Stepanek, Francois Millard, and Howard Bolnick, Healthy Vitality Age. Santa Monica, CA: RAND Corporation, 2019. https://www.rand.org/pubs/research_reports/RR2484z2.html

FROM VITALITY AGE TO HEALTHY FUTURES

The new Healthy Futures set of predictions improves upon Vitality Age 3.0 through the incorporation of additional risk factors and refinements in the risk-cause relationships, based on both Vitality and external epidemiology and clinical evidence. The project focused on two dimensions:

- Incorporating new risk factors over and above those included in Vitality Age 3.0, such as cardiorespiratory fitness (CRF), whilst still adhering to the comparative risk assessment framework established within the GBD structure.
- Refinements were made to the methodology used to create projections of an individual's lifetime metabolic risk factor pathways based on longitudinal pathways informed by the literature and modelled from the Vitality data.

CRF, as measured by VO_2 max, is a better differentiator of cardiovascular risk than physical activity alone. With the recent advancements in wearable technology, VO_2 max can now also be incorporated in the Vitality programme in a meaningful way.

The Healthy Futures predictions also allow for:

- Low-density lipoprotein (LDL), aligned with epidemiological literature supporting the use of LDL as a better risk measure compared to total cholesterol.
- The nutrition assessment in the Healthy Futures calculator has been enhanced with both added food categories (i.e. sugar and salt intake, red meat and legumes) and enhancements to the survey question framing.

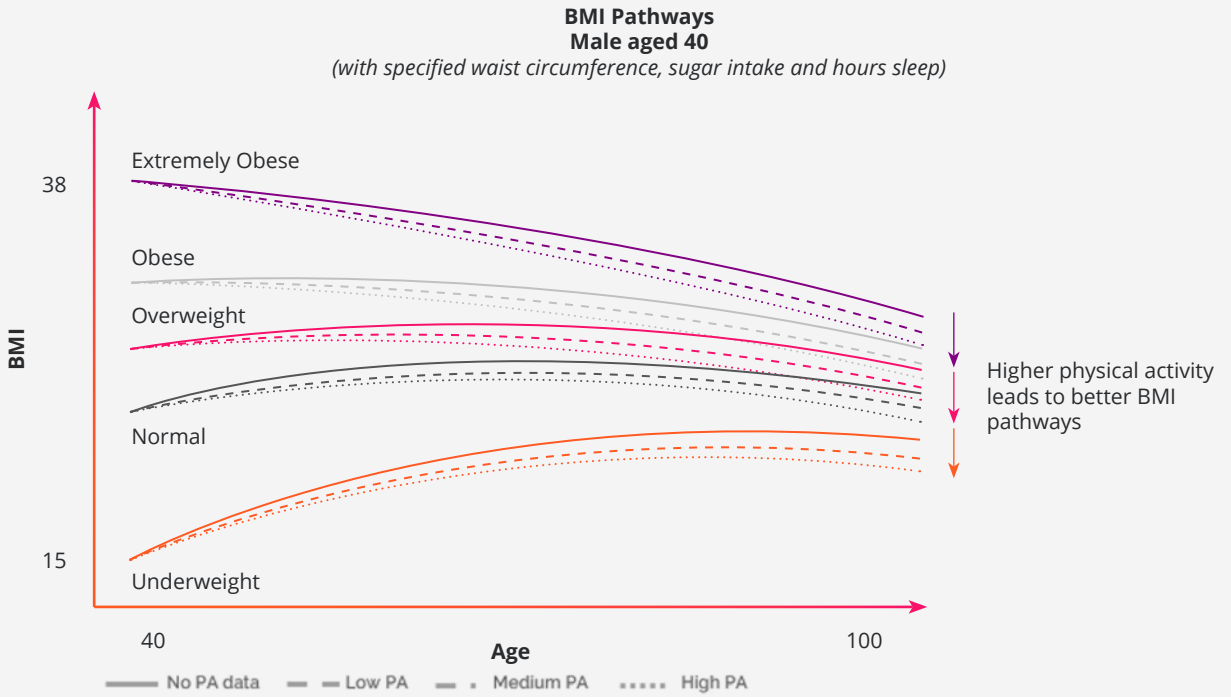
  These enhancements seek to improve the quality of the nutrition information gathered by providing individuals with a journey that balances scientific veracity with questions framed in an intuitive and meaningful manner.
- Allowance for prevalent pre-existing lifestyle related diseases, such as hypertension and diabetes, as well as the treatment of hypertension through medication adherence, which significantly lowers future hypertension pathways.
- Sleep behaviour.
- Waist circumference to approximate visceral adiposity.
- Enhanced risk-cause pathways, especially related to physical activity, explained below.

As illustrated in Figure 5 above, the complex risk-cause relationship in the Healthy Futures calculator requires a projection of individuals' risk factor profiles over time. The methodology to produce these projections for body mass index (BMI), systolic blood pressure and fasting plasma glucose has been significantly enhanced based on longitudinal pathways analysed from the Vitality data. Figure 6 illustrates the range of factors that are accounted for in each risk factor pathway projection. (For example, an individual's pathway projection of BMI incorporates the impact of physical activity, waist-circumference, sleep length and the intake of sugar.)

FIGURE 6 – ENHANCEMENTS IN THE HEALTHY FUTURES CALCULATOR

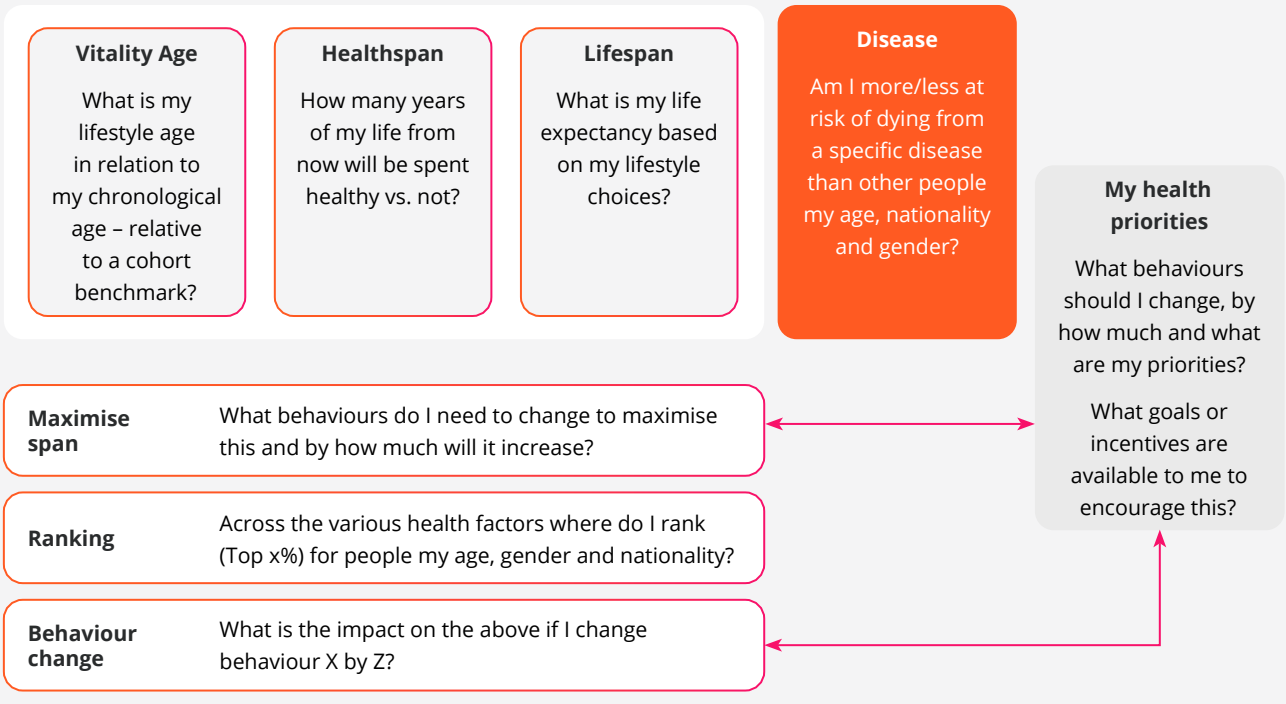
Figure 7 provides an illustrative example of how physical activity would impact the lifetime projection of BMI for a 40-year-old male based on different starting categories of BMI. Naturally, higher levels of physical activity result in greater improvements to an individual's BMI pathways over time.

FIGURE 7 – ILLUSTRATION OF BMI PATHWAY PROJECTIONS



The Healthy Futures calculator now includes a multitude of enhanced outputs, shown in Figure 8, to enable several potential avenues of communicating lifestyle and health risk to people, including lifespan and healthspan metrics; a ranking of risk factors that would maximise these two metrics; and the details of the medical conditions that are most likely to cause death or disability.

FIGURE 8 – SAMPLING OF OUTPUTS AND APPLICATIONS FROM HEALTHY FUTURES PREDICTIONS



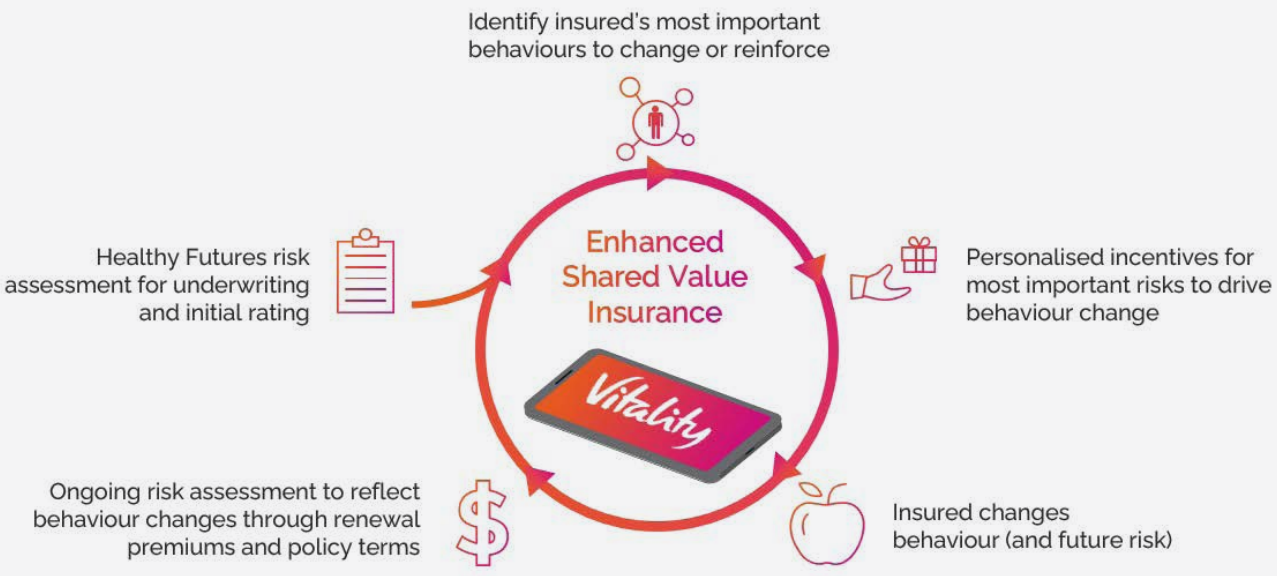
However, as noted earlier, there is no one-size-fits-all approach to risk communication. Research undertaken in collaboration with the University of California, Los Angeles (UCLA) bridges the gap between the technical workings and the insights derived from the Healthy Futures calculator to create a resonant experience. This is facilitated through personalized communication based on individual archetypes, thereby encouraging an individual to act towards a healthier future.

Personalized Programmes, Experiences and Incentives

Healthy Futures is not simply about risk prediction but, more importantly, aligns with the broader predict-value-intervene framework. Through its advanced functionality, Healthy Futures not only predicts an individual's health risk, but also allows for the valuation of potential health improvement through behaviour change, and personalized interventions through the algorithm's recommended next best action(s).

Ultimately, this aligns with the shared-value model assisting insurance companies benefit from improved mortality and morbidity, but also the other dimensions of the insurance value chain, such as those shown in Figure 9.

FIGURE 9 – HEALTHY FUTURES ENHANCES SHARED-VALUE INSURANCE



The Future

Significant enhancements have been made since the first introduction of Vitality Age to cement it as a credible and leading scientific risk assessment tool. The new Healthy Futures predictions and applications will continue to improve as the science of "big data" evolves; as human wearable technology advances (providing opportunities for enhanced, personalized and meaningful biometric feedback); and new algorithms are introduced which are able to incorporate these factors to provide a more enriched user experience. Healthy Futures is not a static concept, but a dynamic framework that will remain central to delivering on the network of Vitality companies' Shared-Value Insurance mission.

Vitality®