

Living longer, living healthier: the next actuarial frontier

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ABSTRACT

Background: Improvements in longevity reflect one of the greatest successes of modern healthcare and social progress. However, population ageing is not actuarially neutral. The financial consequences depend on whether additional years of life are lived in good health or with chronic disease, multimorbidity and increasing healthcare dependency. As a result, there is an opportunity for actuarial focus to optimise the relationship between lifespan and healthspan.

Methods: Using longitudinal demographic, mortality, morbidity and healthcare utilisation data from a large South African open medical scheme, this study examines trends in lifespan and healthspan between 2010 and 2025. Lifespan is assessed using period life table analysis, while healthspan is measured using two methods: major morbidity-free survival and Sullivan health-adjusted life expectancy (HALE). The analysis evaluates whether gains in survival have been accompanied by gains in healthy years of life.

Results: Longevity improved over the study period, with mortality rates declining and the modelled standardised mean age at death increasing from 80.6 to 81.6 years. In contrast, the mean age at first major healthspan-ending event declined from 67.7 to 63.8 years. As a result, the standardised gap between lifespan and healthspan widened from 13.0 to 17.9 years. The standardised Sullivan-style HALE estimate for the scheme population declined from 65.4 years in

2010 to 63.9 years in 2025, while the corresponding health gap increased from 14.8 to 17.4 health-adjusted years. This suggests that members are generally living longer but spending an increasing proportion of their life in poorer health. The findings are consistent with morbidity expansion rather than morbidity compression.

Conclusion and actuarial relevance: Longer life is not always equivalent to more years lived in good health. The widening gap between lifespan and healthspan has important implications for healthcare financing and sustainability across both public and private health systems, affecting contribution affordability, intergenerational fairness and the long-term sustainability of risk pools. This paper argues that extending healthspan should become a core actuarial objective, with actuaries playing a central role in measuring the lifespan-healthspan gap and shaping healthier ageing.

KEYWORDS

Longevity; mortality; morbidity; healthspan; healthy life expectancy; medical schemes; healthcare funding; chronic disease; healthcare expenditure; sustainability; survival modelling.

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1. INTRODUCTION

1.1 Improvements in longevity reflect one of the greatest achievements of modern healthcare and social progress. Over the past century, declining mortality has transformed societies across the globe and materially changed the liabilities of life insurers, retirement funds, healthcare funders and social security systems. Traditionally, actuarial practice has focused on the financial consequences of people living longer. However, the next frontier is increasingly defined by whether these additional years are lived in good health. World Health Organization estimates show that, between 2000 and 2019, global life expectancy increased by 6.4 years, while healthy life expectancy increased by only 5.3 years, indicating that healthy years have not kept pace with survival gains (World Health Organization, 2024a).

1.2 This divergence is closely linked to the concept of morbidity compression, first articulated by Fries (1980), which proposes that the onset of chronic illness can be delayed so that morbidity is concentrated into a shorter period near the end of life. More recent international evidence suggests that this ideal is not being achieved consistently. Garmany & Terzic (2024) estimate that the global healthspan-lifespan gap has widened across 183 World Health Organization member states, reaching an average of 9.6 years, and that this gap is associated with the burden of non-communicable disease and total morbidity. Permanyer et al. (2023) similarly show that longevity improvements are not

always accompanied by equivalent reductions in morbidity-related inequality, particularly in high-income settings.

1.3 Against this background, this paper uses longitudinal demographic, clinical and healthcare utilisation data from a large South African open medical scheme to examine whether improved survival is being matched by improved healthspan. The paper addresses four linked research questions that move from measurement to actuarial implication:

- How have longevity and morbidity outcomes changed over time in a large privately insured South African medical scheme population?
- To what extent have gains in longevity been accompanied by gains in healthy years of life?
- How do ageing and morbidity burden shape healthcare expenditure across the life course?
- What are the implications and opportunities for actuaries?

1.4 Together, these questions examine improved survival compared to healthier years of life, and implications for medical schemes which increasingly finance longer periods of morbidity. The evidence presented in this paper highlights both the actuarial challenge and opportunity: to measure the gap between lifespan and healthspan, quantify its drivers, and support interventions that extend healthy life years.

1.5 In line with the 2026 ASSA Convention theme of broadening boundaries, there is an opportunity for actuaries to move beyond traditional actuarial boundaries related to measuring longevity. This extends to incorporating strategies to compress morbidity, and linking across practice areas including healthcare, insurance, retirement, clinical science, behavioural risk and public health. The central tenet of this paper is that extending healthspan is the next frontier of actuarial advancement because it asks actuaries not only to price the consequences of ageing, but to help shape healthier ageing.

2. LITERATURE REVIEW

2.1 The literature supports four points relevant to this paper. First, longer life should not be treated as equivalent to healthier life: healthspan requires separate measurement alongside lifespan. Second, multimorbidity is a central mechanism through which additional years of life can become additional years of healthcare need. Third, actuarial models need to combine mortality, morbidity, disability, utilisation and cost trajectories in the context of mortality improvement. Fourth, the South African evidence base, while still developing, shows that multimorbidity is already substantial and socially patterned, making healthspan a relevant measure for local healthcare financing and risk-pool sustainability.

2.2 A consistent message from the medical literature is that the gains in survival achieved over recent decades have not automatically produced equivalent gains in disease-free or functionally independent life. Olshansky (2018) argues that the next phase of healthy ageing should shift attention from simply extending life expectancy to extending the period of life lived with preserved function, lower disease burden and independence. Similarly, Garmany et al. (2021) describe a persistent healthspan gap: life expectancy has increased substantially since the mid-twentieth century, but healthspan expansion has lagged because chronic diseases increasingly dominate morbidity at older ages.

2.3 The healthy ageing literature also emphasises that healthspan is shaped across the life course rather than only in old age. Jackisch & Liu (2024) argue that the accumulation of chronic disease reflects earlier-life, familial and socioeconomic risk exposures, reinforcing the need to understand multimorbidity as a dynamic process rather than a static late-life state. This is important for actuarial modelling because morbidity risk is cumulative, socially patterned and influenced by earlier risk exposures; it is not simply an age effect observed at the end of life.

2.4 Multimorbidity is a central driver of the healthspan challenge. An *eBioMedicine* editorial in The Lancet family of journals describes multimorbidity as an increasingly common global phenomenon, driven partly by population ageing and requiring a shift from single-disease care to more person-centred models (eBioMedicine, 2024). Ferrucci & Kohanski (2022) similarly argue that medical progress has improved survival from specific diseases such as cardiovascular disease and cancer, but care for older people with complex multimorbidity and frailty has not advanced at the same pace. For healthcare funders, this means that improved survival may increase the duration of exposure to complex, high-cost morbidity unless disease onset and progression are delayed.

2.5 South African evidence on healthspan is more limited than the international literature, but recent studies show that multimorbidity is already a material local concern. Lam et al. (2024) examine multimorbid life expectancy in South Africa using the South African National Income Dynamics Study and incidence-based multistate Markov modelling. They find that women live substantially more years with multimorbidity than men, with multimorbid life expectancy estimated at 17.3 years for females and 9.8 years for males, and that these patterns vary by race, education and socioeconomic position.

2.6 Further South African evidence from Hazell et al. (2025) reports a high burden of multimorbidity in a nationally representative survey. Multimorbidity was present in 45.3% of the study population, with hypertension and diabetes among the most common conditions and substantially higher odds among older adults. Although these studies do

not directly measure the same healthspan construct used in this paper, they show that the chronic disease burden required to widen the lifespan-healthspan gap is already substantial in South Africa.

2.7 Actuarial literature has long recognised mortality improvement as a core driver of longevity risk, with research focusing on cohort effects, stochastic mortality trends, parameter uncertainty and solvency implications. These models generally emphasise survival and mortality rates, whereas the healthspan challenge requires mortality improvement to be considered alongside morbidity onset, disability, healthcare utilisation and cost intensity.

2.8 In the South African actuarial context, mortality and morbidity have been considered in applied areas such as demographic and HIV/AIDS modelling, pandemic-era mortality and healthcare utilisation, and emerging work on climate-related morbidity and mortality. However, fewer local actuarial papers appear to integrate longevity improvement, morbidity onset, healthcare utilisation and funding sustainability through an explicit healthspan framework. This paper responds to that gap by applying a healthspan lens to longitudinal administrative, clinical and healthcare utilisation data from a large South African medical scheme population. It examines longevity improvements for insured lives and how these longevity gains are matched by healthier years as well as how the resulting morbidity duration and severity affect healthcare utilisation, expenditure and actuarial risk management.

2.9 Taken together, the literature indicates that lifespan, healthspan and multimorbid life expectancy should be treated as distinct but related measures. Population ageing is not actuarially neutral: the financial consequences depend on whether additional years are spent in good health, with manageable chronic disease, or with complex multimorbidity and late-life dependency. This distinction is directly relevant to medical schemes, where the cost of ageing is mediated through chronic disease prevalence, admission intensity, bed-day utilisation, proximity-to-death costs and the ability of younger, healthier members to sustain intergenerational cross-subsidies.

3. ARCHETYPES

3.1 The concept of ‘rectangularisation of survival curves’, as outlined by Fries (1980), refers to the demographic concept that, as mortality rates improve and premature deaths decline, the population survival curve becomes increasingly ‘rectangular’; most individuals survive to older ages, followed by a relatively compressed period of mortality near the end of life. In a fully ‘rectangularised’ survival curve, death is delayed for most of the population, implying longer and more predictable lifespans.

3.2 In health and longevity literature, changes in the shape of survival curves are often linked to three key themes:

- **Morbidity compression:** where additional years of life are ideally lived in good health, with illness and disability concentrated into a shorter period before death.
- **Morbidity expansion:** where gains in survival are accompanied by more years lived with chronic disease or disability.
- **Dynamic equilibrium:** where people live longer with disease, but the severity or disabling impact of disease is reduced.

These alternative patterns are central to interpreting improvements in life expectancy and health-adjusted life expectancy, because longer survival does not necessarily imply healthier survival.

3.3 To illustrate such differences in lifespan and healthspan, Scott et al. (2021) describe four archetypes linking lifespan and healthspan outcomes, as outlined in Figure 1.

- The **Peter Pan** case represents the most favourable trajectory, where biological ageing is substantially slowed and improvements in lifespan are accompanied by equivalent gains in healthspan. Individuals remain healthy and functionally independent for a greater proportion of life, resulting in both longer survival and an extended period free from chronic disease.
- The **Dorian Gray** case similarly reflects successful ageing, although with a different pattern: health remains good until close to death, after which morbidity is compressed into a relatively short period of rapid decline.
- The **Wolverine** case describes a partial slowing of ageing in which both healthspan and lifespan increase, although neither is extended dramatically. Individuals benefit from some delay in the onset of disease, but ageing remains only moderately altered.
- The **Struldbugg** case highlights individuals where longevity increases without corresponding improvements in healthspan, resulting in extended periods of chronic disease, disability and healthcare dependency. Individuals spend a growing proportion of life living with morbidity, creating sustained healthcare utilisation and increasing long-term financial pressures.

3.4 These archetypes highlight that longevity and health are not perfectly aligned and provide a useful framework for considering the implications of ageing. From an actuarial perspective, the distinction is important because each trajectory is associated with markedly different patterns of healthcare utilisation, morbidity burden and long-term financial liability. Understanding whether populations are moving towards Dorian Gray or Struldbugg trajectories is therefore central to assessing the sustainability of healthcare financing and the broader consequences of population ageing.

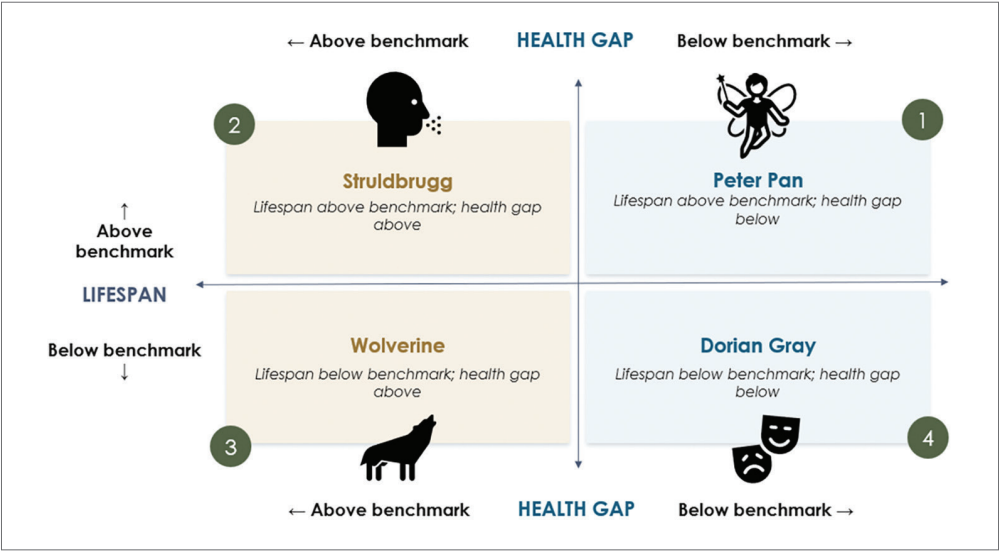


FIGURE 1. Lifespan and healthspan archetypes
(visual depiction of the work of Scott et al., 2021)

4. DATA AND METHODOLOGY

4.1 Data sources

The analysis uses anonymised administrative and clinical data from Discovery Health Medical Scheme (DHMS), the largest open medical scheme in South Africa, covering approximately 2.8 million beneficiaries in 2025. The dataset combines demographic information, mortality experience, chronic disease registration, oncology benefit registration, healthcare claims, hospital admissions, bed days and expenditure in and out of hospital from 2010 to 2025. All analyses are conducted at an aggregate or anonymised member level, subject to applicable governance, privacy and ethical requirements.

4.2 Study cohort and measured outcomes

4.2.1 The study population comprises beneficiaries with valid membership exposure during the observation period. Analyses are stratified by age, calendar year, chronic disease status, oncology status, mental health condition status and proximity to death where relevant. Members are followed until death, scheme exit or the end of the observation period, depending on the outcome being analysed.

4.2.2 Key outcomes include mortality rates, average age at death, expected lifespan, expected healthspan, chronic disease onset, multimorbidity prevalence, hospital admission rates, bed-day utilisation, healthcare expenditure per life per month, net healthcare result by age, and healthcare costs in the years and months preceding death. Where appropriate, expenditure is adjusted to constant 2025 values to distinguish utilisation and morbidity effects from general price inflation.

4.3 Research Question 1: How have longevity and morbidity outcomes changed over time?

4.3.1 Figure 2 highlights a fundamental shift in the demographic profile of DHMS members. Between 2010 and 2025, the membership distribution has progressively shifted towards older ages, resulting in an older insured population. This trend reflects both improvements in member survival and longevity, as well as a declining representation of younger beneficiaries within the scheme. Changes in the uptake and retention of medical scheme cover, particularly among younger adults, have likely contributed to this ageing profile. Together, these dynamics indicate that a growing proportion of members are reaching ages at which chronic disease, healthcare utilisation and healthcare expenditure become increasingly prevalent.

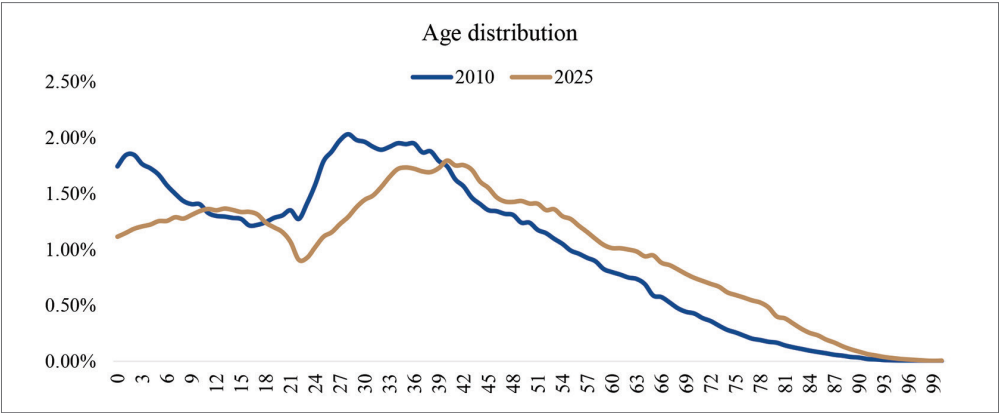


FIGURE 2. Proportion of scheme membership by age in 2010 and 2025

4.3.2 Figure 3 shows a broad decline in the age-standardised mortality rate per 1,000 lives between 2010 and 2025, after controlling for changes in the age profile of the scheme population. The rate decreased from 3.87 in 2010 to 3.36 in 2025, representing an overall reduction of approximately 13.2%. This underlying improvement was interrupted by a pronounced increase in 2020 and 2021 due to COVID-19, with the rate reaching 5.83 in 2021, before falling sharply in 2022 and returning below pre-2020 levels by 2025. The observed decline in age-standardised mortality rates is consistent with an improvement in mortality experience within the scheme population.

4.3.3 The impact of improved survival is further reflected in the average age at death in Figure 4, which increased by approximately one year between 2010 and 2025. Although average age at death is influenced by the changing composition of the insured population, the upward trend is consistent with the observed mortality improvements and provides additional evidence that longevity gains are being realised within the scheme. These gains demonstrate success in delaying mortality; however, they do not necessarily indicate that members are remaining healthy for longer.

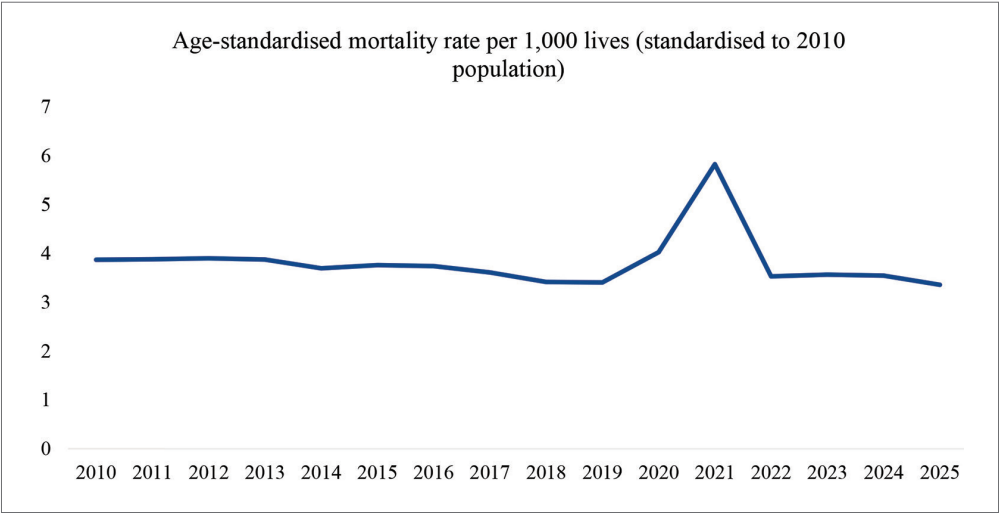


FIGURE 3. Age-standardised mortality rate from 2010 to 2025

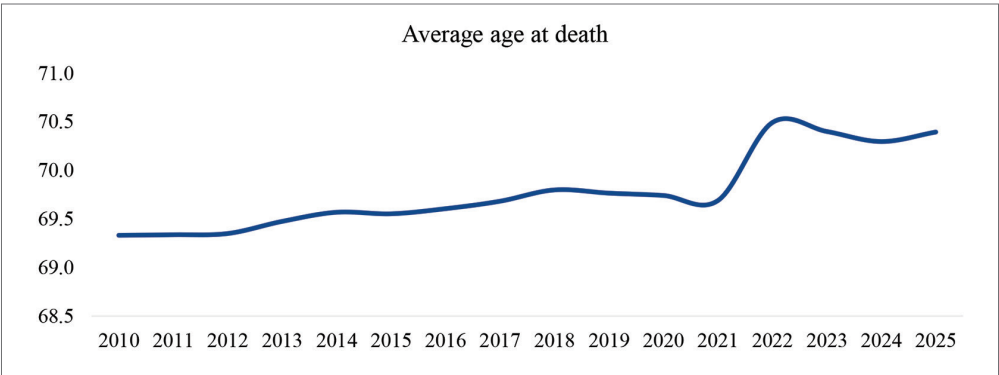


FIGURE 4. Average age at death from 2010 to 2025

4.3.4 The analysis does not isolate the mechanisms underlying this improvement, which may include changes in treatment, disease management, member composition and other temporal factors. As a result, an increasing number of members are reaching advanced ages, contributing to the broader ageing of the scheme population. While this represents a positive public health outcome, it also increases the number of members exposed to age-related morbidity and the healthcare demands that accompany longer survival.

4.3.5 In the South African medical scheme environment, Chronic Disease List (CDL) conditions refer to the specified chronic conditions covered as part of Prescribed Minimum Benefits, for which registered medical schemes must fund diagnosis, treatment and ongoing care in line with the Medical Schemes Act and applicable benefit rules (Republic of South Africa, 1998).

4.3.6 Longevity gains have been accompanied by a growing burden of chronic disease, as illustrated in Figure 5. The prevalence of scheme membership with at least one CDL registered condition has increased over time across a broad range of ages.

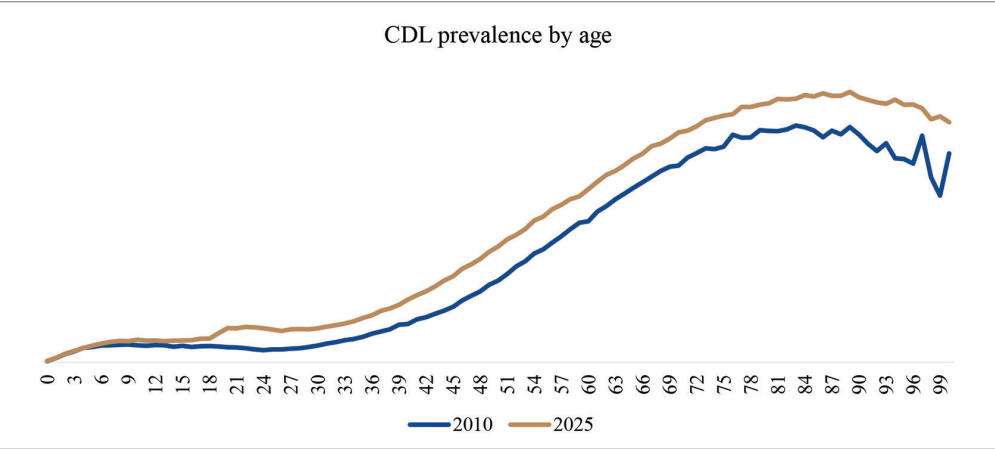


FIGURE 5. Prevalence of CDL chronic conditions per year from 2010 to 2025

4.3.7 The average number of registered CDL conditions per member has also increased over time, as shown in Figure 6. This finding is consistent with a population that is accumulating additional morbidity over time. The increase is also observed across a broad range of ages. From a healthcare financing perspective, this is significant because chronic disease increases the need for ongoing treatment, monitoring and coordinated care, extending both the duration and intensity of healthcare utilisation.

4.3.8 Figure 7 highlights how the morbidity profile of the population shifts as members age, comparing the reasons for death recorded across age groups in 2025 (where

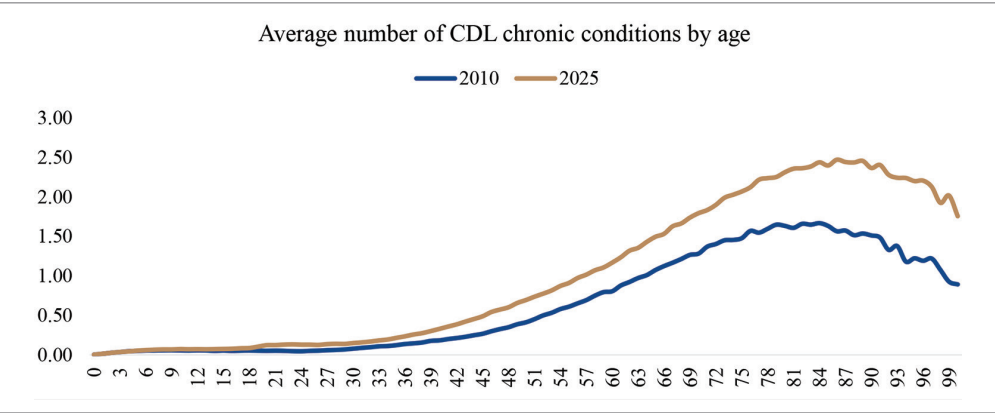


FIGURE 6. Average number of CDL chronic conditions registered for per member per year from 2010 to 2025

reason for death are determined based on audited ICD-10 coding). While mortality at younger ages is distributed across a broader range of causes, cardiovascular disease and oncology account for an increasing share of deaths at older ages. This pattern reflects the growing importance of chronic non-communicable diseases in later life and suggests that many of the gains in longevity are accompanied by extended periods of disease management and healthcare utilisation. From a healthspan perspective, the findings underscore the importance of not only extending life but also delaying the onset and progression of chronic disease.

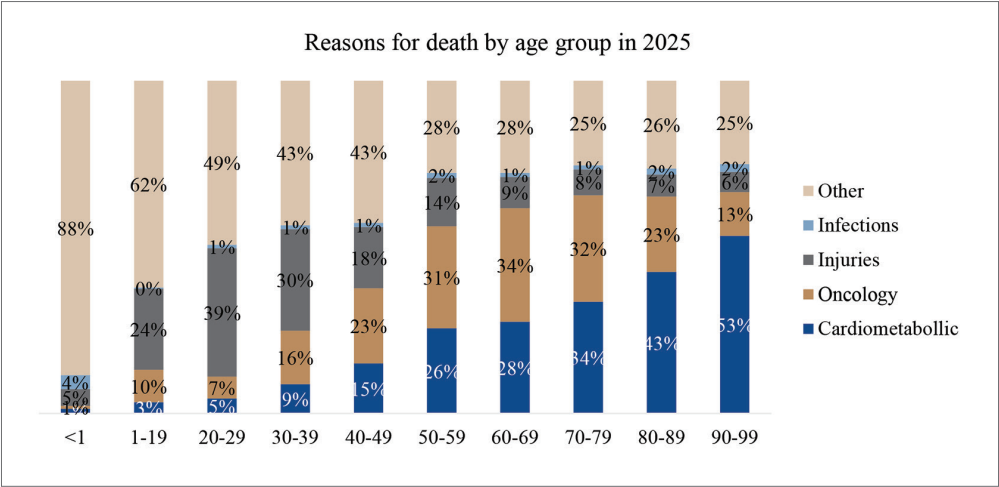


FIGURE 7. Distribution of deaths for Discovery Health Medical Scheme by Reason for Death in 2025

4.3.9 Taken together, these results paint a consistent picture of improving longevity within the medical scheme population. Members are surviving to older ages, mortality rates have declined, and the average age at death has increased. However, these longevity gains are occurring alongside a growing burden of chronic disease and multimorbidity. The findings suggest that while members are living longer, they are not necessarily spending all these additional years in good health. This raises the key question explored in the next section: whether gains in lifespan are being matched by equivalent gains in healthspan, or whether the period lived with morbidity is expanding over time.

4.4 Research Question 2: To what extent have gains in longevity been accompanied by gains in healthy years of life?

The evidence outlined in the previous section highlights trends in population mortality and morbidity rates amongst South African medical scheme members. To contrast longevity improvements with various metrics of population health, three statistical methods were applied:

- Binary major morbidity-free period life-table approach
- Sullivan-style health-adjusted life expectancy approach
- Multi-state modelling approach examining cardiometabolic disease progression over a five-year horizon

The following sections outline the methodology and underlying assumptions for each approach.

4.4.1 *Methodology: measuring life and healthspan using the period life table approach*

4.4.1.1 To quantify shifts in population longevity, the divergence between healthspan and lifespan was first measured on the attained-age scale, using the established framework of the actuarial period life table. This period life-table approach estimates the ages at which morbidity and death occur and examines how the shape of the survival curve changes across calendar periods, providing a non-parametric way of assessing whether changes in longevity arise through a rightward shift of the survival curve, compression of adverse health experience into later ages, or a broader change in the distribution of morbidity and mortality across age.

4.4.1.2 The analysis is built on a member-calendar-year dataset and contains each analysed member’s date of entry into the scheme, withdrawal out of the scheme, death, date of healthspan-ending, age, gender and benefit option. Two end points were measured for each member across their scheme membership:

- **End of lifespan:** defined as their date of death.
- **End of healthspan:** defined as the earlier of their first major health event as outlined in Table 1, or death.

TABLE 1. Definition of end of healthspan

Broad category of healthspan-ending event	Literature reference
Transplant, life support and amputation	Masfiah et al., 2025 (healthspan = onset of chronic disease/disability) Fries, 1980 (compression of morbidity)
Major adverse cardiac events	Garmany & Terzic, 2024 (non-communicable disease burden drives the healthspan-lifespan gap)
Neurodegenerative conditions	Masfiah et al., 2025 (healthspan = onset of chronic disease/disability) Fries, 1980 (compression of morbidity)
Cancer	Garmany & Terzic, 2024 (non-communicable disease onset)
Chronic organ failure	Masfiah et al., 2025 (healthspan = onset of chronic disease/disability) Fries, 1980 (compression of morbidity)
Advanced HIV	Masfiah et al., 2025 (healthspan = onset of chronic disease/disability) Fries, 1980 (compression of morbidity)

4.4.1.3 There is no standardised definition of healthspan. To determine the point at which healthspan ends, a list of in-hospital major diagnostic categories and claims episodes associated with severe health conditions was identified through a literature review and applied to healthcare claims data. In this study, healthspan is defined as major morbidity-free survival, rather than a broader measure of healthy life expectancy.

4.4.1.4 A healthspan-ending event is defined as the first occurrence of a severe health event identified through clinical diagnoses, hospital admissions or claims history, or death where no prior qualifying event has occurred. This definition captures the onset of significant morbidity observable within administrative healthcare data and provides a practical proxy for healthspan in an insured population.

4.4.1.5 Two actuarial life tables were constructed, providing the following figures for each age, x , and year:

1. l_x^l , the number of lives alive at age x
2. l_x^h , the number of lives that have not experienced a healthspan-ending event, at age x

4.4.1.6 This discrete hazard is converted to a continuous probability of the event occurring within the single year of age $[x, x+1)$, under the standard assumption of a constant force of decrement across the interval.

$$q_x^i = 1 - e^{-m_x^i}$$

4.4.1.7 A synthetic cohort, beginning at a starting radix of 100,000, is then projected forward one year at a time with the resulting survival function given by

$$S_i(x) = \frac{l_x^i}{100,000} \quad \text{where } l_{x+1}^i = l_x^i \times (1 - q_x^i)$$

The person-years lived within each age band, using the standard mid-point approximation, is determined as

$$L_x^i = \frac{l_x^i + l_{x+1}^i}{2}$$

4.4.1.8 The mean age at which the event occurs is given by the area under the survival curve, added to the starting age, evaluated numerically by the trapezoidal rule over the discrete age grid, where ω denotes the final age interval of the table.

$$\text{Mean Age} = \text{start age} + \int_{\text{start age}}^{\omega} S_i(t) dt$$

$$\text{Median Age} = S_i^{-1}(0.5)$$

4.4.1.9 The healthspan gap is the area between the two survival curves, namely the expected number of years a member spends alive but no longer healthy, with the

healthspan curve capped at the lifespan curve at every age. A rising gap area across successive periods indicates a widening morbidity burden, whereas a narrowing gap area indicates a reducing morbidity burden.

$$Gap\ Area = \int_{start\ age}^{\omega} S_l(t) - S_h(t) \, dt$$

4.4.1.10 Comparing these results across successive calendar years could include the effects of scheme membership ageing or shifting toward a different gender or benefit-option mix. To account for this, metrics were standardised by holding population mix fixed at a chosen reference distribution described further below, to determine how the age, gender and benefit option-specific rate itself moved, holding composition constant.

4.4.1.11 The crude hazard rate was calculated within each age $\times$ gender $\times$ benefit-option cell, and these cell rates are combined at each age using fixed weights $w(x, g, b)$, taken from a single reference period’s observed exposure distribution and held constant thereafter.

$$m_{x,g,b}^i = \frac{EV_{x,g,b}^i}{PY_{x,g,b}^i}$$
$$m_x^{i*} = \frac{\sum_{g,b} [m_{x,g,b}^i \times w_{x,g,b}]}{\sum_{g,b} w_{x,g,b}}$$

Any subsequent movement in the standardised statistics is therefore more reflective of shifts in life and healthspan as opposed to changes in the scheme’s own composition.

4.4.1.12 The next component of the methodology addresses the share of the population in each of the four combinations of long or short lifespan and healthy gap, relative to a fixed distribution, and whether this has changed over the years considered. To understand this, four quadrants were constructed in line with Scott’s definitions of health and lifespan archetypes (Scott et al., 2021) (Table 2).

TABLE 2. Lifespan and healthspan archetypes

Quadrant	Description	Approximate archetype equivalent
1	Lifespan above benchmark, health gap below benchmark	Peter Pan archetype
2	Lifespan above benchmark, health gap above benchmark	Struldbrugg archetype
3	Lifespan below benchmark, health gap below benchmark	Dorian Gray archetype
4	Lifespan below benchmark, health gap above benchmark	Wolverine archetype

4.4.1.13 The lifespan benchmark was determined as the 2010 reference period's mean estimated lifespan. The health gap benchmark was determined based on the 2010 reference period's mean age at first healthspan-ending event, restricted to those with a healthspan ending event and computed separately for those with a lifespan above or below the aforementioned benchmark. Both benchmarks were held fixed thereafter.

$$\text{Benchmark lifespan} = \text{Mean lifespan, reference period}(2010)$$

$$\text{Benchmark health gap} = \text{Mean lifespan} - \text{Mean age at first healthspan ending event in the reference period}(2010)$$

4.4.1.14 Each member's own best-estimate lifespan and healthspan are determined using the age at which the healthspan event occurred if a healthspan-ending event has already occurred or using a projected value determined as their current age plus remaining expectancy at that age if they have not experienced a healthspan-ending event.

$$\text{Lifespan} = \begin{cases} \text{Age}_{\text{death}} & x \geq \text{age of death} \\ \text{current age} + e_x^l & x < \text{age of death} \end{cases}$$

$$\text{Healthspan} = \begin{cases} \text{Age}_{\text{healthspan ending event}} & x \geq \text{age of healthspan ending event} \\ \text{current age} + e_x^h & x < \text{age of healthspan ending event} \end{cases}$$

$$\text{where } e_x^i = \frac{\int_x^\omega S_i(t) dt}{S_i(x)} \text{ for } i = l, h$$

4.4.1.15 Each member was then assigned to one of the four quadrants using the fixed benchmarks. Because most members have not yet reached either endpoint, the quadrant allocation should be interpreted as a modelled classification relative to a fixed benchmark, rather than an observed transition pathway for individual members. Changes in quadrant membership over time indicate shifts in the number of members falling into each archetype.

4.4.2 Assumptions of the binary healthspan method

- The conversion from hazard rate to probability assumes a constant force of decrement within each single-year age band.
- Death is defined as always ending healthspan for members with no prior recorded complication. This assumes death is an appropriate proxy for a healthspan-ending state even where the cause of death may be unrelated to any progressive morbidity process.
- Members were censored on withdrawal from the scheme.
- The 2010 population distribution was used as the basis for all standardisation.

- The incidence of new complications or healthspan-ending events within three months of a member's date of entry to the scheme were excluded to account for potential pre-existing conditions that would not be reflective of a new diagnosis.
- The first-event definition of healthspan does not account for increases in the number of conditions a member is diagnosed with after their first qualifying event, or progressions in disease severity.
- The population analysed is a medical-scheme membership base, not a nationally representative population, and results should not be extrapolated to national health-expectancy statistics without further standardisation to a common external reference population.
- Members are only observed from scheme entry which limits observation time for members across their entire lifespan.
- The incidence of new healthspan-ending event at each year was only calculated for members free of any healthspan-ending event in the prior observed years.

4.4.3 *Alternative healthspan measure methodology: Sullivan health-adjusted life expectancy*

4.4.3.1 While the major morbidity-free survival framework provides an intuitive measure of the age at which members experience a significant deterioration in health, health does not decline as a binary state. Many members continue to live for extended periods with varying degrees of morbidity, disability and functional limitation after the onset of a major health event.

4.4.3.2 To provide a complementary perspective on healthspan, a Sullivan-style health-adjusted life expectancy (HALE) methodology was also applied. Sullivan's method, originally proposed by Sullivan (1971), underpins many international estimates of healthy life expectancy, including those published by the World Health Organization and the Global Burden of Disease Study (GBD) (Sullivan, 1971; World Health Organization, 2024b). Rather than classifying members as either healthy or unhealthy, the methodology weights each year of life according to the severity of morbidity experienced.

4.4.3.3 In this study, healthcare conditions observed within DHMS data were mapped to disability weights derived from the GBD framework (GBD 2021 Diseases and Injuries Collaborators, 2024). Where members experienced multiple conditions, an aggregate health-loss score was calculated to reflect the cumulative burden of disease. These disability weights were then used to estimate the proportion of each year lived in full health.

4.4.3.4 At each attained age, the average disability burden was calculated across the population and applied to the corresponding life-table person-years lived. Health-adjusted life expectancy was then derived as:

$$HALE = \sum L_x (1 - w_x) / l_0$$

where:

- L_x represents person-years lived in the life table;
- w_x represents the average disability weight at age x ; and
- l_0 represents the life-table radix.

Under this approach, a year lived with no morbidity contributes one full healthy year, while years lived with morbidity contribute proportionately fewer healthy years depending on disease severity.

4.4.3.5 Unlike the major morbidity-free survival framework, which focuses on the timing of first severe morbidity, the Sullivan methodology captures the cumulative burden of morbidity experienced throughout life. The two methods therefore measure different but complementary aspects of healthspan. The first estimates the timing of major health deterioration, while the second measures the quantity of life lived in good health after accounting for disease severity.

4.4.4 *Results: comparing healthspan and lifespan using the period life table approach*

4.4.4.1 Table 3 summarises the headline metrics of the healthspan analysis for the overall population, standardised for age, gender and benefit option, for each of the four periods examined.

TABLE 3. Summary of morbidity and survival curve outputs using the binary healthspan method

Period	Mean standardised age at death	Mean standardised age at first healthspan-ending event	Crude gap (years)	Standardised morbidity gap (years)
2010	80.64	67.69	12.95	12.95
2015	80.80	65.66	15.48	15.14
2019	81.86	62.39	19.87	19.47
2025	81.64	63.76	18.67	17.87

4.4.4.2 The risk-adjusted mean age at death rose from 80.64 years in 2010 to 81.64 years in 2025, which is an increase of 1.00 years (+1.24%), and is in line with the trends observed in the previous research question regarding mortality rates. The crude mean age at death increased by 1.55 years over the same period, indicating that part, but not all, of the crude improvement in longevity reflects a genuinely ageing population, rather than purely a change in underlying mortality risk.

4.4.4.3 Over the same period and standardised basis, the mean age at which members experience their first healthspan-ending event reduced from 67.69 years in 2010 to 63.76 years in 2025, equal to a decline of 3.93 years (–5.80%).

4.4.4.4 The principal comparison of this analysis is a comparison of the lifespan

survival curve and the healthspan survival curve for successive calendar periods on one set of axes, shaded from lightest (earliest period) to darkest (most recent). The direction each curve moves carries a precise meaning.

- A survival curve that shifts rightward (a given share of the cohort surviving to a higher age in the later period) indicates that age-specific mortality risk has reduced, after standardising for gender and benefit option shifts. This is a trend consistent with improved longevity and corresponds to a rising mean and median age at death.
- A healthspan curve that shifts leftward (the cohort crossing into ill health at a lower age in the later period) suggests that the mean and median age at first healthspan-ending events have declined.

4.4.4.5 Figure 8 shows that the lifespan (survival) curves shift visibly and consistently to the right from 2010 to 2025 with each successive period, from the lightest shade (2010, the earliest period) to the darkest (2025, the most recent). This indicates that at any given attained age, a larger proportion of the later cohort remains alive than of the earlier cohort. This rightward shift is consistent with lower modelled age-specific mortality rates and a higher expected age at death in recent periods.

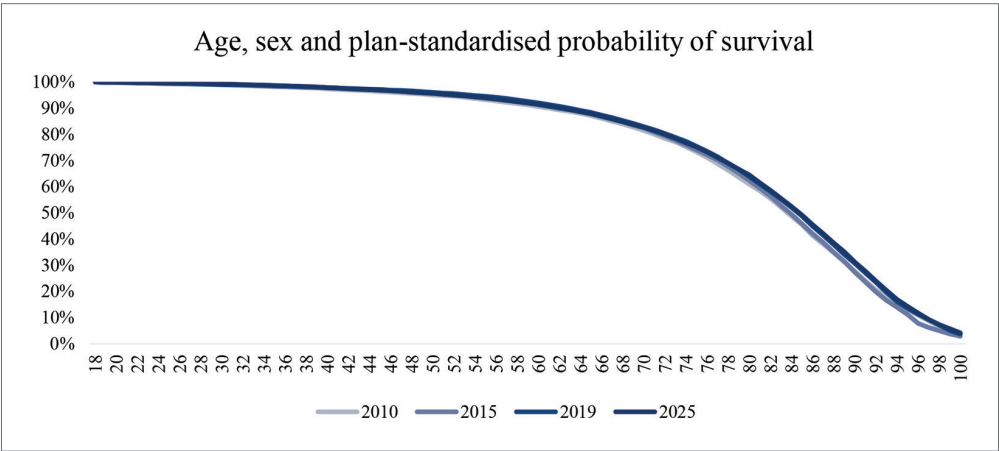


FIGURE 8. Lifespan curve from 2010 to 2025

4.4.4.6 In Figure 9, the healthspan curves shift visibly to the left with each successive period, which is in the opposite direction to the lifespan curves. At any given attained age, a smaller proportion of the later cohort remains healthspan-event-free than of the earlier cohort. This suggests that, based on the period life table modelling approach, qualifying major morbidity was first recorded at progressively younger ages on a standardised basis.

4.4.4.7 The area between the lifespan and healthspan survival curves represents the expected number of years a member of the cohort lives in a state of ill health before

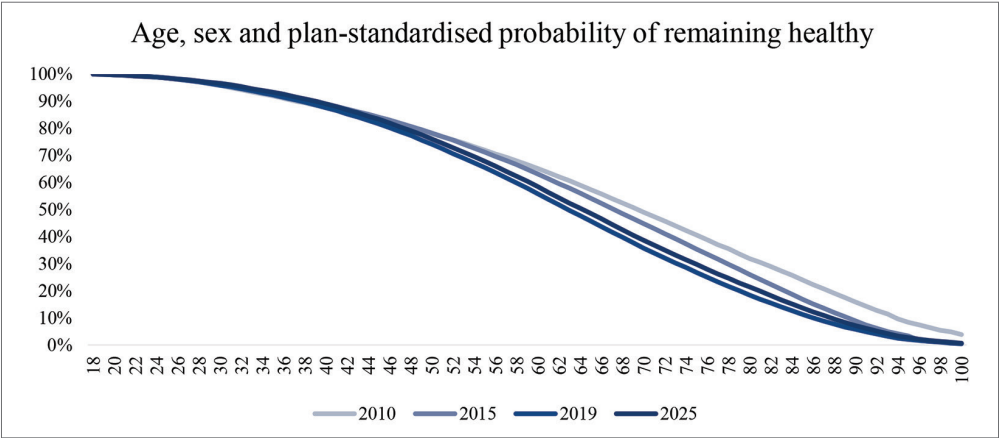


FIGURE 9. Healthspan curve from 2010 to 2025

death. Table 3 illustrates that the standardised morbidity gap widened from 12.95 to 17.87 years, an increase of 4.9 years, as confirmed in Figure 10.

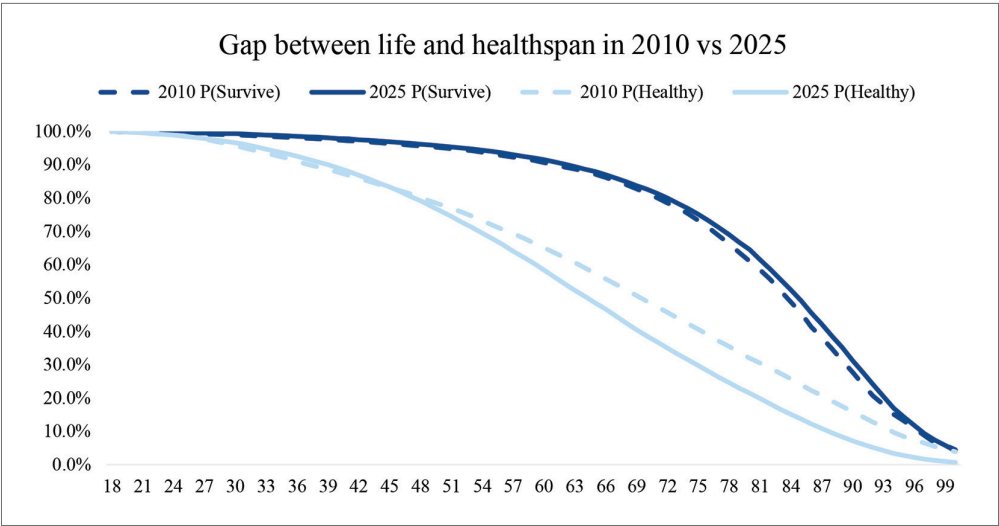


FIGURE 10. Gap between life and healthspan curve

4.4.4.8 Fries (1980) proposed that gains in longevity should ideally be accompanied by a delay in the onset of morbidity, resulting in a shorter period of illness before death, a phenomenon known as morbidity compression. Under this scenario, healthspan would increase at least as rapidly as lifespan and the gap between the two would narrow over time. The opposite pattern, morbidity expansion, occurs when improvements in survival outpace improvements in healthspan, resulting in a growing number of years lived with chronic disease, disability or significant healthcare need.

4.4.4.9 The results presented in Figures 8 to 10 are more consistent with morbidity expansion than morbidity compression. While the lifespan survival curves shift progressively to older ages, indicating improved survival, the healthspan curves shift in the opposite direction, indicating earlier onset of major morbidity. Consequently, the expected period between the first qualifying morbidity event and death increased; see Figure 10.

4.4.4.10 Although the healthspan distribution becomes narrower over time, this should not be interpreted as favourable morbidity compression. The narrowing occurs around earlier ages of morbidity onset, while survival continues to extend into older ages. The combined effect is an expansion in the expected duration of life lived after a major healthspan-ending event, increasing the burden borne by members, healthcare providers and medical scheme funders.

4.4.5 *Results of quantifying health-adjusted life expectancy using Sullivan’s approach*

4.4.5.1 To complement the major morbidity-free survival analysis, HALE was estimated using the Sullivan methodology (Sullivan, 1971). This approach incorporates both mortality and the severity of morbidity experienced throughout life and therefore provides a continuous measure of healthy longevity rather than a discrete healthspan-ending event. The resulting estimates of life expectancy, health-adjusted life expectancy and the implied health gap for an adult scheme member (at age 18) as well as age-standardised values are presented in Table 4 in years.

TABLE 4. Sullivan HALE estimates, based on disability-weighted life-table calculations

Period	Raw life expectancy	Standardised life expectancy	Raw HALE	Standardised HALE	Raw health gap	Standardised health gap
2010	80.55	80.19	65.68	65.44	14.88	14.75
2015	80.81	80.31	65.06	64.75	15.75	15.56
2019	81.79	81.19	65.01	64.63	16.77	16.56
2025	82.06	81.35	64.36	63.91	17.70	17.43

4.4.5.2 In order to understand changes in the health gap over time using this approach, the age-specific survivorship curve (determined as l_x / l_0 and remaining unchanged from the period life-table method), was compared to the morbidity curve reconstructed using the Sullivan method in place of the original binary, event-based construction.

4.4.5.3 To achieve this, the all-cause survival curve l_x / l_0 is scaled down at each age by w_x , the population’s (or cohort’s) average disability weight at that age, derived from ICD-10 claims mapped to published GBD disability weights and combined across co-occurring conditions via the standard multiplicative-independence formula (as outlined in the Methodology section above). This produces $P(Healthy)_x = (l_x / l_0) \times (1 - w_x)$, or the disability-weighted survivorship curve.

4.4.5.4 The area under this curve, integrated across all attained ages, is equivalent to HALE. The area between the unadjusted survival curve and the disability-weighted curve represents the health gap, or the expected number of years a member of the cohort lives in a state of reduced health before death, on a health-adjusted rather than an event-based basis.

4.4.5.5 The Sullivan analysis provides a complementary perspective on the findings presented earlier. While longevity continued to improve over the study period, the estimated HALE reduced over the same period. Consequently, the number of years lived in less than full health increased over time, widening the gap between total and healthy life expectancy.

4.4.5.6 Both approaches are built from the same standardised life table and express the health gap as the area between a survivorship curve and a health-adjusted curve over the same age range. They differ only in how healthspan itself is defined. Figure 10 treats healthspan as ending permanently at the first occurrence of a defined severe clinical event, while Figure 11 (the Sullivan method) continuously discounts survivorship at each age by that age’s average disability weight, derived from ICD-10-mapped GBD disability weights. Despite this difference, both approaches show a widening separation between survivorship and the corresponding health-adjusted measure.

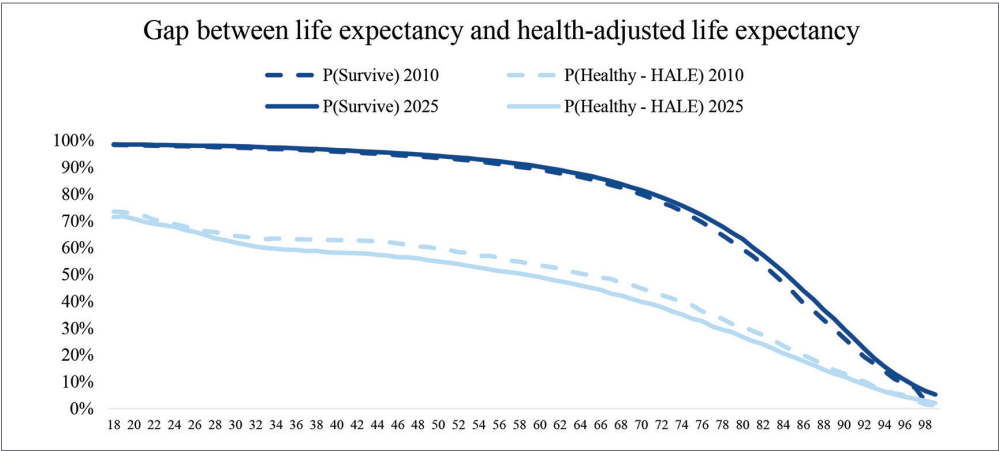


FIGURE 11. Life expectancy, health-adjusted life expectancy and health gap (2010–2025)

4.4.5.7 Both methods converge to three consistent trends that are indicative of morbidity expansion. Firstly, an increase in average life expectancy from 2010 to 2025 was observed across both methods. Secondly, both illustrated a decline in healthspan over the period (5.8% reduction in the mean standardised age at first healthspan-ending event in Table 3 versus 2.3% reduction in HALE in Table 4). Thirdly, the modelled lifespan-healthspan gap increased from 2010 to 2025 across both methods (37.9% increase in Table 3 versus 18.2% increase in Table 4).

4.4.5.8 The two morbidity curves differ in shape through the middle-to-older age range. In Figure 10, the binary method’s P(Healthy) curve declines sharply between approximately ages 45 and 80, consistent with a member’s classification changing abruptly and permanently at the single age their first qualifying complication occurs. The morbidity curve using the HALE methodology in Figure 11 declines more gradually and consistently across the full age range. This may be indicative of disability weights accumulating continuously from a much broader base of ICD-10-coded conditions including milder diagnoses that would not meet the threshold for a healthspan-ending event under the binary definition.

4.4.5.9 Despite conceptual differences, the two methodologies produce a consistent narrative. The major morbidity-free survival analysis suggests that members experience significant morbidity at progressively younger ages, while the Sullivan analysis indicates that the overall burden of morbidity is increasing across the life course. Viewed together, they allow both the timing and burden of morbidity to be quantified.

4.4.5.10 In both cases, the evidence is more consistent with morbidity expansion than morbidity compression, indicating that gains in longevity have outpaced gains in healthy longevity. The former highlights progressively earlier onset of major morbidity, while the latter demonstrates increasing cumulative morbidity throughout life.

4.4.6 *Overlaying healthspan and lifespan archetypes*

4.4.6.1 To understand how these changes affect the distribution of members across different lifespan and health gap trajectories, a quadrant-based archetype analysis was performed. This analysis is based on the major morbidity-free survival measure of healthspan only using the period life table approach, (where healthspan is defined as the age at first healthspan-ending event) and does not incorporate the Sullivan HALE measure.

4.4.6.2 The quadrant analysis classifies each member, in each period, into one of four archetypes of lifespan and health gap compared to a standardised benchmark derived from the 2010 reference period, based on the healthspan and survival curves outlined in Figure 10. Because the benchmark is held constant, shifts in the distribution across these four categories over time are more reflective of changes in modelled outcomes (lifespan and healthspan), as opposed to population ageing.

4.4.6.3 Table 5 illustrates the volume of membership in each of these quadrants over time.

TABLE 5. Distribution of members by archetype over time

Period	Long life, high health gap	Long life, low health gap	Short life, high health gap	Short life, low health gap	Grand total
2010	825,216 (46.46%)	914,784 (51.50%)	30,947 (1.74%)	5,375 (0.30%)	1,776,322
2025	1,671,076 (74.19%)	571,550 (25.38%)	1,135 (0.05%)	8,587 (0.38%)	2,252,348

4.4.6.4 Figure 12 shows this distribution directly as a percentage of each period’s classified population.

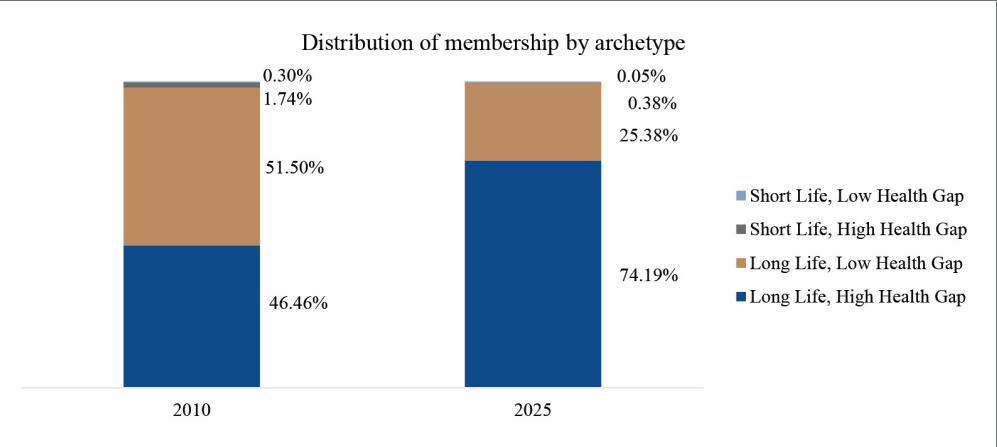


FIGURE 12. Membership distribution by archetype (2010 vs 2025)

4.4.6.5 The ‘Long Life, High Health Gap’ group increased from 46.46% of the population in 2010 to 74.19% in 2025. The ‘Short Life, High Health Gap’ category reduced from 1.74% to 0.05% of the population, consistent with the findings of mortality improvement highlighted in the sections above. The ‘Long Life, Low Health Gap’ category reduced from 51.50% to 25.38% over the same period.

4.4.6.6 The distribution shifts are consistent with a declining share of members classified as Short Life, High Health Gap (Struldbugg archetype) alongside a growing share classified as Long Life, Low Health Gap (Peter Pan archetype). This pattern suggests that improved survival has not been accompanied by an equivalent improvement in projected healthspan, although the analysis does not directly observe transitions between categories for the same individuals. As these classifications combine observed events with modelled remaining expectancy and are evaluated against fixed 2010 benchmarks, they should be interpreted as shifts in modelled classification rather than observed individual transitions.

4.4.6.7 Overall, the findings suggest that longevity gains have not been matched by corresponding improvements in health status. Although a growing proportion of members achieve longer lifespans, an increasing share of these individuals spend their additional years in poorer health.

4.4.7 Multi-state modelling methodology within the cardiometabolic population

4.4.7.1 Both the period life table and HALE approaches presented above measure shifts in life and healthspan using age-specific hazard rates, converted to a survival function, from which the gap between lifespan and healthspan are derived. A natural extension of this is to determine how quickly members progress through successive stages of disease severity,

and how much of their remaining lifespan is expected to be spent at each stage. This requires moving from a single binary endpoint (the first qualifying healthspan-ending event) or a weighted life expectancy measure (Health-Adjusted Lifespan using the GBD weightings) to measuring a member’s progression between healthcare states over time.

4.4.7.2 A progressive, continuous-time multistate model was used to evaluate whether members have progressed to poorer cardiometabolic health states more rapidly, and whether they were expected to spend more or less time in these states, over time. Where the period life table and HALE methods draw on the full range of major healthspan-ending events defined in Table 1, the multistate modelling approach taken in the following section is restricted to the cardiometabolic disease pathway only. Cardiometabolic disease (including hypertension, type 2 diabetes, ischaemic heart disease and chronic renal failure) was selected as the focus of this extension as it is the leading global cause of both mortality and disability according to the GBD study in 2023 (GBD 2023 Collaborators, 2025).

4.4.7.3 Members were longitudinally tracked across five mutually exclusive cardiometabolic disease severity states, defined according to registrations on the CDL. Progression through these states reflected increasing disease severity, from the absence of cardiometabolic disease to advanced end organ failure. The disease states are described in Table 6.

TABLE 6. Definition of cardiometabolic states used for multi-state model

State	Definition
1) Healthy	No CDL registration for any cardiometabolic condition
2) Early risk	Newly registered for hypertension or hypercholesterolaemia
3) Established disease	Newly registered for diabetes mellitus or ischaemic heart disease
4) End-organ failure	Newly registered for congestive cardiac failure or chronic renal failure

4.4.7.4 A member’s disease progression history was assumed to be progressive, therefore once a member entered a more advanced state, they could not recover to a less advanced state. Death was also constructed as an absorbing state that could be transitioned to from all states.

4.4.7.5 Three non-overlapping six-year periods were compared from 2008 to 2025, to allow sufficient time for members to transition between states, and a closed cohort of members was constructed for each period.

4.4.7.6 A separate transition-specific Cox proportional-hazards model using exact attained age as the underlying time scale was fitted for each permitted transition, within each calendar period. For transition $j \rightarrow k$, the hazard at attained age a was specified as:

$$h_{jk}(a | X) = h_{jk,0}(a) \times \exp(\beta_{jk}^T X)$$

where $h_{jk,0}(a)$ is the transition-specific baseline hazard and X refers to the set of covariates (gender and benefit option). These models estimate hazards separately for each transition between the different states.

4.4.7.7 The joint probability of occupying each state over time was obtained by combining the fitted hazards via a product-integral approximation. This is directly analogous to the way a single survival curve is derived from a single hazard function in the period life-table method, extended here to multiple, simultaneously competing states.

4.4.7.8 For each reference profile, prediction began in the Healthy state:

$$p(0) = (1, 0, 0, 0, 0)$$

where $p(t) = (p_h(t), p_e(t), p_c(t), p_f(t), p_d(t))$ denotes the probabilities of occupying Healthy, Early risk, established disease, end-organ failure, and death at time t respectively. A five-year prediction horizon was divided into monthly intervals and for each transition, the Cox model produced a cumulative-hazard increment between attained ages a_m and a_{m+1} , defined as:

$$\Delta H_{jk,m} = [H_{jk,0}(a_{m+1}) - H_{jk,0}(a_m)] \times \exp(\beta_{jk}^T X)$$

4.4.7.9 These increments were arranged into a transition-increment matrix ΔA_m , with each diagonal element equal to the negative sum of all increments leaving that state, and the state-occupancy vector updated each month as $p(t_{m+1}) = p(t_m)(I + \Delta A_m)$. Repeating this over all monthly intervals approximates the continuous-time product integral $P(0, t) = \prod_{0 \leq u \leq t} [I + dA(u)]$, which is the multistate analogue of a survival curve derived from a single hazard model, and allows all competing progression and death hazards to operate simultaneously.

4.4.7.10 Resulting state probabilities were recorded at the five-year landmark, across all states. At each horizon, $p_h(t) + p_e(t) + p_c(t) + p_f(t) + p_d(t) = 1$.

4.4.7.11 Expected state time was estimated by integrating the state-occupancy probability over the five-year horizon, using the trapezoidal rule over the monthly predictions. This construction is directly analogous to calculations used throughout the period life-table method, here restricted to a five-year forward horizon from each member's current attained age, rather than integrated over a full lifetime from a fixed starting age.

4.4.7.12 The product-integral calculation was also used to derive standardised transition rates, using 2008 as the fixed reference population, to isolate changes in the underlying transition hazards from changes in population composition.

4.4.7.13 The following assumptions were relevant in this multi-state model:

- A member was assumed not to be able to recover from the cardiometabolic states, which is a simplification relative to the general multistate framework.
- Members who withdrew from the scheme from this period were excluded from the analysis.

- The model assumes a constant hazard ratio (Cox proportional-hazards assumption) for gender and benefit-option level across attained age, within each transition and period.
- The multistate model restricts each period’s cohort to members observable at both period start and period end (or who die within the period).
- New joiners were only considered eligible for the multi-state model analysis twelve months after their episode start date, to reduce the risk of a pre-existing condition being misclassified as a new diagnosis.

All expected time and probability measures in this section are restricted to a five-year forward horizon from each member’s current attained age and are not lifetime measures.

4.4.8 Results of the cardiometabolic multi-state model

4.4.8.1 Figure 13 shows the age standardised annual transition rates between the cardiometabolic disease stages, holding the reference population’s age, gender, and benefit-option composition fixed across all three periods. All three progression transitions increased over the periods considered. In particular, the standardised rate of transition from Healthy to Early risk rose from 2.05% to 2.69% (+31.2%), from Early risk to Established disease rose from 1.73% to 2.02% (+16.8%), and from Established disease to End-organ failure rose from 0.94% to 1.35%, a 43.6% relative increase. The acceleration in this final transition is the largest of the three in relative terms, indicating that members with established cardiometabolic disease are progressing to end-organ failure at a faster rate than a comparable member would have in prior periods

4.4.8.2 Figure 14 shows the age, gender and benefit option standardised annual rate of death conditional on occupying each disease state.

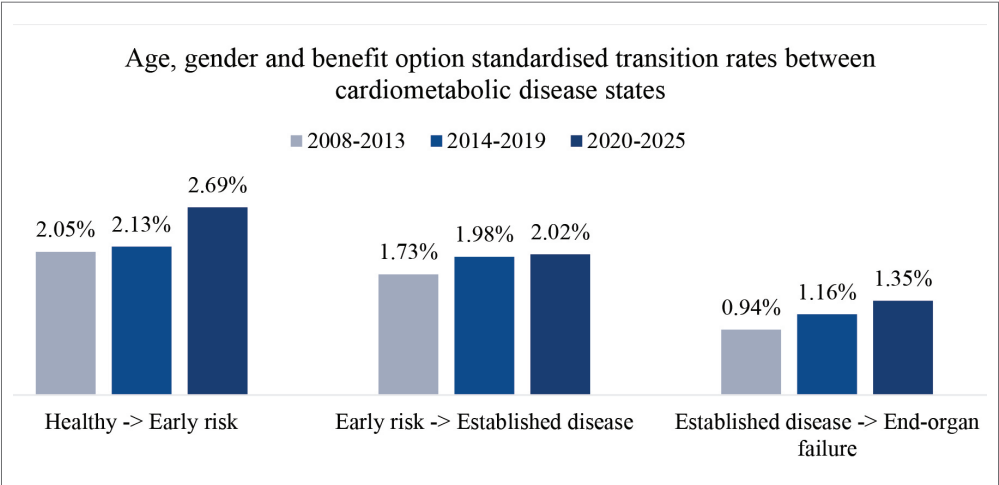


FIGURE 13. Age, gender and benefit option standardised transition rates between cardiometabolic disease states

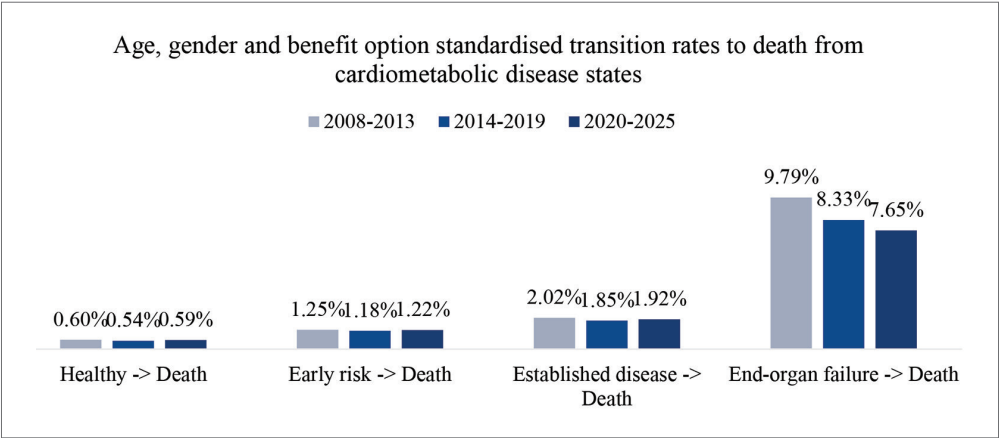


FIGURE 14. Age, gender and benefit option standardised transition rates to death in the modelled population

4.4.8.3 In contrast to the transition rates between disease stages, none of the four death transitions worsened over the same period. The rate of death from Healthy, Early risk, and Established disease each remained broadly flat, whereas the rate of death from End-organ failure reduced by 21.9% from 9.79% to 7.65%. This suggests that members are progressing into more severe cardiometabolic disease states at an accelerating rate, while, conditional on having reached even the most severe state modelled, their prospects of survival have measurably improved.

4.4.8.4 Figure 15 presents the age, gender and benefit option standardised expected time spent in each disease state over the five-year prediction horizon, expressed as a percentage of the horizon, for a reference cohort beginning entirely in the Healthy state. Rather than showing where members are located at a single point in time, this quantifies the cumulative time spent in each state across the full five years.

4.4.8.5 Expected time in every disease state beyond Healthy increased over the periods considered, with the magnitude of the increase growing sharply with disease severity. Expected time in Early risk rose from 4.58% to 5.93% of the horizon (a relative increase of 29.4%). Expected time in Established disease rose from 0.13% to 0.19% of the horizon (a 51.1% relative increase). Expected time in End-organ failure rose from 0.001% to 0.003% (a 122.9% relative increase), which was the largest proportional increase of the three states, mirroring the pattern already observed in the corresponding transition rates. However, the absolute magnitude of this increase is small for the more severe states, as only a small proportion of the total cohort reaches these states within a five-year period.

4.4.8.6 Relative increases were larger for more severe states, although the absolute expected time in established disease and end-organ failure remained small over the five-year horizon. This suggests that the acceleration in disease progression documented in the transition-rate analysis is also correlated with disproportionately more cumulative time

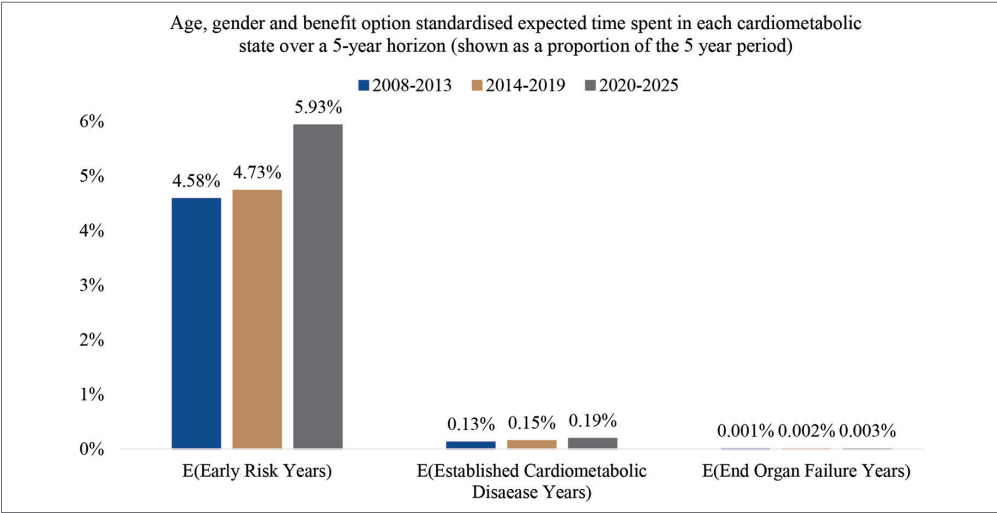


FIGURE 15. Age, gender and benefit option standardised expected time spent in each cardiometabolic state over a five-year horizon (shown as a proportion of the five-year period)

spent in the most severe states. These results suggest that scheme members are not only progressing into more severe cardiometabolic states more quickly but are also spending a growing share of their time in states of greater disease severity than a comparable member in prior periods.

4.4.8.7 The combination of faster entry into, and shorter expected time spent free of, each successive disease state, without a corresponding deterioration in near-term survival, is a disease-specific example of the paper’s central finding that members of the scheme are living longer, but an increasing share of that additional time is spent in states of accumulating cardiometabolic morbidity.

4.5 Research Question 3: How do ageing and morbidity burden shape healthcare expenditure across the life course?

4.5.1 The preceding sections established that DHMS members are living longer, but that these additional years may be increasingly affected by chronic disease, multimorbidity, driven by underlying cardiometabolic disease progression specifically. Research Question 3 turns to the financial consequence of this pattern. As members survive longer while carrying a growing burden of chronic disease, there is evidence that healthcare utilisation becomes both more prolonged and more intensive, extending the duration, and increasing the cost, of the scheme’s healthcare funding obligation.

4.5.2 The relationship between longevity and healthcare expenditure among DHMS members is illustrated by the simultaneous decline in mortality and increase in healthcare costs observed across most age groups in Figure 16. Between 2010 and 2025, mortality rates declined across every age group over one year old. The biggest improvement

was among young adults aged 24 to 39, where deaths per 100,000 lives fell by 16.3%. Mortality among members aged 75 and older declined by 7.8%, while mortality among adults aged 40 to 74 declined by 2.5%.

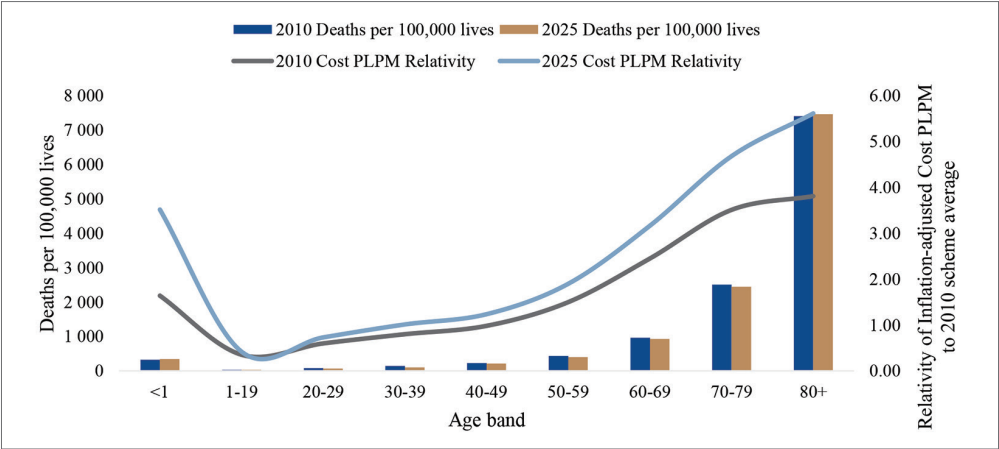


FIGURE 16. Deaths per 100,000 lives and inflation-adjusted cost per life per month (PLPM) relativities by age band

4.5.3 Survival has improved over the past decade, as highlighted for this population in the previous sections and in Figure 16; inflation-adjusted healthcare costs amongst scheme members have increased across all age bands, particularly amongst older members. The simultaneous improvement in mortality and increase in inflation-adjusted expenditure is consistent with members surviving longer while healthcare costs remain substantial at older ages.

4.5.4 Hospital admission patterns further demonstrate how the healthcare consequences of ageing are changing. Admission rates have remained stable or improved among younger adults but have increased from approximately age 60 onwards. At the oldest ages, annual admission rates approach two-thirds of members, indicating that hospital-based care forms an increasingly important component of healthcare utilisation later in life. These findings suggest that gains in longevity are accompanied by longer periods of exposure to healthcare-intensive states rather than a simple postponement of healthcare need (Figure 17).

4.5.5 The increase in healthcare utilisation is even more pronounced when examining average bed days per life per annum in Figure 18. While utilisation at younger ages has remained relatively stable, members aged 55 years and older are spending progressively more time in hospital. The divergence becomes particularly pronounced at advanced ages, where both admission rates and lengths of stay increase. This suggests that healthcare utilisation, particularly in-hospital, is becoming more intensive as members age and should be interpreted alongside the growing burden of chronic disease, multi-

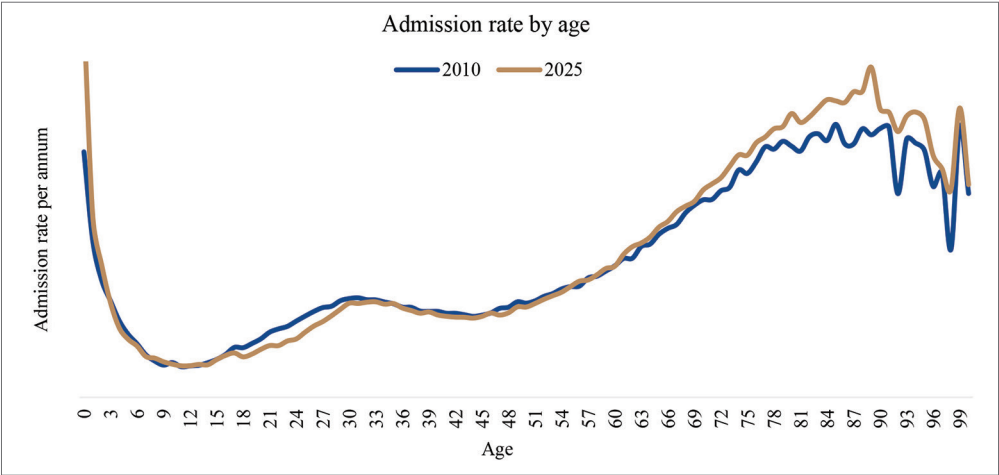


FIGURE 17. Hospitalisation rates by age in 2010 and 2025

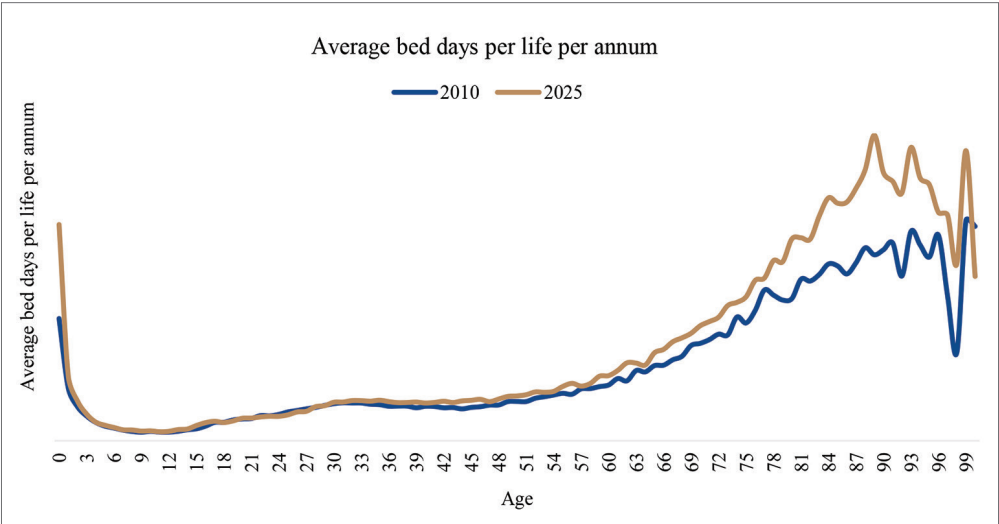


FIGURE 18. Average bed days per life per annum in 2010 and 2025

morbidity and clinical complexity among members who are surviving to older ages that were highlighted in the preceding sections.

4.5.6 Figure 19 demonstrates the significant financial impact of multimorbidity. After adjusting for age, gender and benefit-option mix, members with three or more chronic conditions incur healthcare costs approximately 2.6 times higher than members without registered chronic disease. As members progress from healthy states to increasingly complex combinations of chronic disease, healthcare needs become more intensive, resulting in higher utilisation, greater care complexity and substantially higher expenditure.

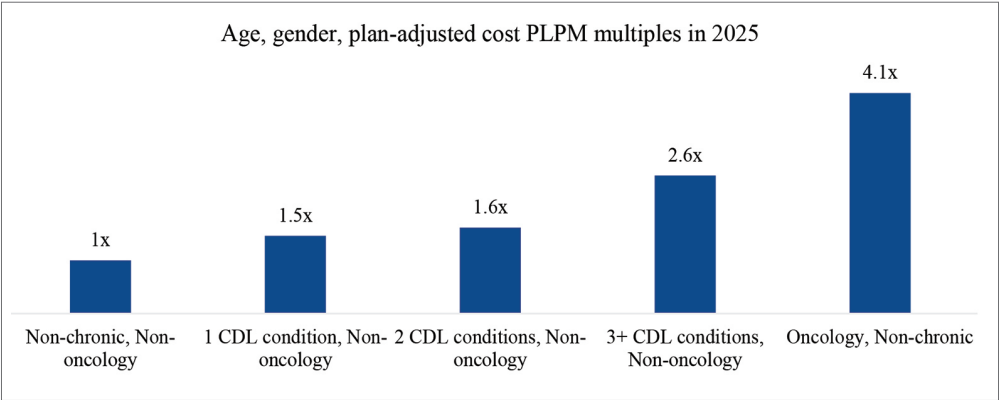


FIGURE 19. Age, gender, benefit option-adjusted cost PLPM multiples

4.5.7 From an actuarial perspective, the ageing of the membership base alters both the level and distribution of future healthcare expenditure. Traditional medical scheme funding models rely on intergenerational cross-subsidisation, whereby younger and healthier members contribute disproportionately relative to their healthcare consumption. As the proportion of elderly members increases, the balance between contributors and beneficiaries requiring high-cost care becomes increasingly strained. The shift therefore places upward pressure on claims costs, solvency requirements and contribution levels, while simultaneously increasing uncertainty around long-term healthcare liabilities.

4.5.8 The shift in morbidity burden ultimately manifests in the financial profile of medical schemes. Figure 20 shows that members generate positive net healthcare results at younger ages, before transitioning to deficits later in life. The magnitude of these deficits increases substantially with age, particularly among members aged 70 years and older, reflecting the growing healthcare needs associated with chronic disease, multimorbidity and functional decline. These findings highlight that later life remains a period of significant healthcare expenditure and suggest that extended longevity is accompanied by a prolonged need for complex and costly healthcare interventions.

4.5.9 These age-specific patterns in net healthcare result shown in Figure 20 translate to the concept of intergenerational cross-subsidisation within medical schemes, whereby healthcare deficits generated by older members are often offset by surplus contributions from younger, healthier members. To illustrate the practical funding implication of these trends, a simplified scenario was constructed estimating the number of younger members required to offset the average healthcare deficit generated by a pensioner (defined as a member aged 65 and older) in Figure 21. The scenario holds total scheme membership fixed at its 2025 level and combines two effects: first, the continued rise in the pensioner share of the membership (linearly projected from 2025 to 2030); and second, continued growth in the average healthcare deficit per pensioner. Non-pensioner surplus per life is deliberately held fixed at its 2025 value throughout.

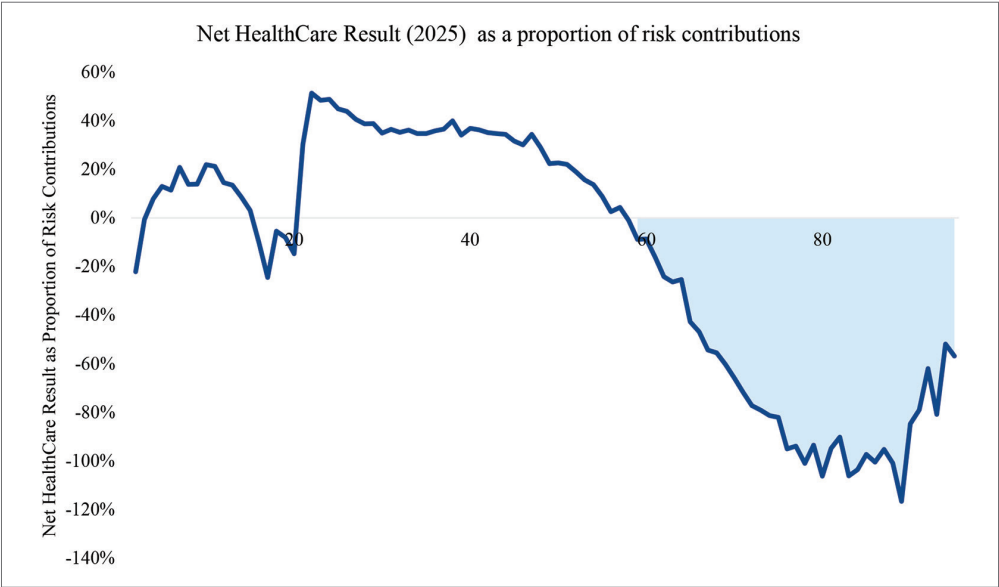


FIGURE 20. Net healthcare result for members aged 1–100 expressed as proportion of risk contributions

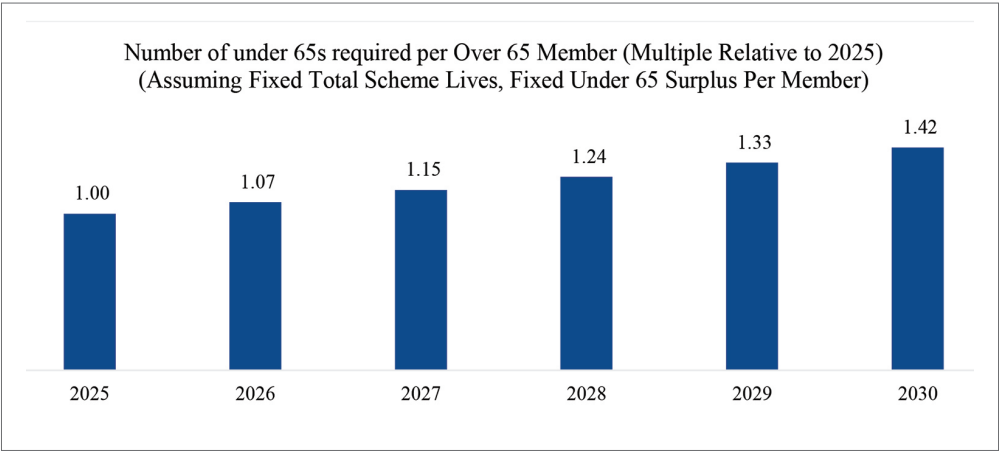


FIGURE 21. Number of under 65s required per over 65 member (multiple relative to 2025) (assuming fixed total scheme lives, fixed under 65 surplus per member)

4.5.10 Under this scenario, the modelled cross-subsidy requirement, expressed in terms of the equivalent non-pensioners required to support each pensioner, rose by 42% over the next five years. This relationship demonstrates the sensitivity of the cross-subsidy requirement of medical schemes to demographic and cost pressures. It also foregrounds the compounding pressure of ageing and resource intensity due to morbidity which further influence scheme funding sustainability.

4.5.11 Taken together, the findings suggest that the financial consequences of population ageing are driven not simply by increasing age, but by the duration and complexity of morbidity experienced during later life. As members survive to older ages, healthcare expenditure is incurred over a longer period and increasingly concentrated among individuals living with chronic disease and multimorbidity. The cost of ageing therefore depends not only on longevity gains, but also on the extent to which those additional years are lived in good health. From an actuarial perspective, the central challenge is not merely financing longer lives, but financing longer lives while managing the growing burden of morbidity and healthcare need.

4.6 Research Question 4: What are the implications and opportunities for actuaries?

4.6.1 The findings point to a broader definition of actuarial relevance. Longevity improvement remains important, but the central sustainability question is the extent to which longer lives are also healthier lives. If medical schemes finance longer survival without a corresponding extension of healthspan, the result is rising chronic disease prevalence, greater multimorbidity, higher late-life utilisation and increasing pressure on intergenerational cross-subsidies. Conversely, successful healthspan extension could delay morbidity onset, slow progression to complex disease states, improve member wellbeing and strengthen the long-term resilience of healthcare funding.

4.6.2 This creates an opportunity to expand actuarial practice from measuring the financial consequences of morbidity to helping shape healthier longevity. Actuaries can develop healthspan indices, morbidity transition tables, pathway-based expenditure models and intervention value frameworks. These tools can quantify the financial and societal value of delaying chronic disease onset, preventing multimorbidity, reducing avoidable admissions and moderating end-of-life cost intensity. In this way, actuarial work can move beyond annual claims forecasting towards population health intelligence, lifecycle risk management and system design.

4.6.3 For South African medical schemes, this shift is particularly important. Schemes operate within community-rated annual contribution cycles but carry long-term morbidity risk. Younger and healthier members remain essential to risk-pool sustainability, yet the uptake and retention of young members remain a challenge. Older members are living longer, but late-life expenditure remains substantial and increasingly concentrated. The actuarial opportunity is therefore to connect these dynamics into a lifecycle view of health financing: measuring how morbidity emerges, how it progresses, how it affects healthcare utilisation and how earlier interventions can change the long-term claims trajectory.

4.6.4 The implications extend beyond medical schemes. For retirement provision and planning, healthspan measures can improve projections of retirement adequacy by distinguishing between years lived independently and years requiring significant healthcare, care or support. In life and health insurance, incorporating healthspan into pricing, underwriting, product design and incentives could enable more

dynamic risk models that associate product design with delayed disease onset. In banking and wealth management, longer healthy working lives may affect savings behaviour, borrowing needs, retirement timing and intergenerational wealth transfer.

4.6.5 As longevity becomes a multidisciplinary challenge, actuaries are well positioned to integrate mortality, morbidity, healthcare utilisation, behavioural risk and financial outcomes into a unified healthy-longevity framework. The actuarial contribution is not only to price the risk of longer lives, but to quantify the value of healthier lives and support interventions that improve member outcomes, strengthen risk-pool sustainability and create long-term social value.

5. CONCLUSION AND ACTUARIAL RELEVANCE

5.1 From lifespan to healthspan

5.1.1 This paper provides evidence to suggest that longevity improvements within the insured medical scheme population are real, measurable and actuarially significant. Based on the analysis, members are surviving to older ages, and mortality has improved across key age groups, which is an important success of healthcare and social progress. However, the findings also indicate that longer survival is not automatically translating into longer healthy life. Both healthspan methodologies indicate a widening modelled gap, while the cardiometabolic multi-state analysis provides evidence of faster recorded disease progression and increased expected time in morbidity states. This is indicative of more years spent with chronic disease, multimorbidity and sustained healthcare need.

5.1.2 The evidence across the paper points to a consistent pattern that healthcare utilisation and expenditure are increasing at older ages. At the same time, the increasing burden of chronic disease indicates that medical schemes are financing longer periods of managed morbidity, not only isolated episodes of acute care. These trends place pressure on contribution affordability, risk-pool sustainability and intergenerational cross-subsidies.

5.1.3 The actuarial implication is that longevity risk can no longer be understood through mortality alone. Healthspan should become an explicit actuarial measure, alongside lifespan, morbidity prevalence, disease progression, healthcare utilisation and cost intensity. This creates an opportunity for actuaries to develop healthspan indices, morbidity transition tables, pathway-based expenditure models and intervention value frameworks that quantify the value of delaying disease onset, preventing multimorbidity and reducing avoidable late-life healthcare intensity.

5.1.4 The central message is therefore clear: living longer is one of the great achievements of modern society but living healthier for longer is the next actuarial frontier. The actuarial profession's contribution will be to quantify the lifespan-healthspan gap, understand its drivers, design sustainable funding responses and support interventions that help members, institutions and society convert longevity gains into healthier, more productive and more affordable years of life.

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DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the authors upon reasonable request, subject to ethical approval and institutional regulations.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that generative artificial intelligence (GenAI) and AI-assisted tools were used in a limited and responsible manner during the preparation of this manuscript. The authors take full responsibility for the final content of this manuscript.

REFERENCES

- Ebiomedicine* (2024). Multimorbidity: A complex challenge to support and optimise individual health. *The Lancet Ebiomedicine* Editorial, 99, p.104973
- Ferrucci, L & Kohanski, R (2022). Better care for older patients with complex multimorbidity and frailty: a call to action. *The Lancet Healthy Longevity* 3(9), e581–e583
- Fries, JF (1980). Aging, natural death, and the compression of morbidity. *New England Journal of Medicine*, 130–135
- Garmany, A & Terzic, A (2024). Global healthspan-lifespan gaps among 183 World Health Organization member states. *JAMA Network Open*
- Garmany, A, Yamada, S, & Terzic, A (2021). Longevity leap: mind the healthspan gap. *NPJ Regen Med* 6, 57
- Global Burden of Disease Study (GBD) 2021. Diseases and Injuries Collaborators (2024). Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories. *The Lancet*
- Global Burden of Disease Study (GBD) 2023. Diseases and Injury and Risk Factor Collaborators (2025). Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *The Lancet* 406(10513), 1873–1922
- Hazell, M, Kengne, AP, Gill, P, Taylor, D & Uthman, O (2025). Prevalence, patterns, and determinants of multimorbidity in South Africa: Insights from a nationally representative survey. *PLOS Global Public Health* 5(5), e0004603
- Jackisch, J & Liu, C (2024). Taking a life course approach to healthy ageing and multimorbidity: Defining risk factors is not the end, we can do more. *The Lancet Healthy Longevity* 5(1), e8–e9
- Lam, A, Keenan, K, Myrskylä, M & Kulu, H (2024). Multimorbid life expectancy across race, socio-economic status, and sex in South Africa. *Population Studies* 79(1), 1–26
- Masfiah, S, Kurnialandi, A, Meij, JJ & Maier, AB (2025). Definitions of healthspan: A systematic review. *Ageing Research Reviews* 111, 102806
- Olshansky, S (2018). From lifespan to healthspan. *JAMA* 320(13), 1323–1324
- Permanyer, I, Villavicencio, F & Trias-Llimós, S (2023). Healthy lifespan inequality: Morbidity compression from a global perspective. *European Journal of Epidemiology* 511–521
- Republic of South Africa (1998). Medical Schemes Act, No. 131 of 1998. *Government Gazette*, No. 19545. Cape Town: Government Printer
- Scott, AJ, Ellison, M & Sinclair, DA (2021). The economic value of targeting aging. *Nature Aging*, 1(7), 616–623. <https://doi.org/10.1038/s43587-021-00080-0>. PMID: 37117804
- Sullivan, D (1971). A single index of mortality and morbidity. *HSMHA Health Reports* 86(4), 347–354

World Health Organization (2024a). WHO methods and data sources for life tables 2000–2021. Geneva WHO

World Health Organization (2024b). Life expectancy and healthy life expectancy. Available at Global Health Observatory: <https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-life-expectancy-and-healthy-life-expectancy>) Retrieved 5 July 2026)