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Understanding cohort effects in the Australian Population

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Abstract

The purpose of this paper is to understand mortality trends in Australia by capturing cohort effects using the Continuous Mortality Investigation (CMI) model developed by the British institute of actuaries. In particular, we look at what can be expected in terms of future mortality improvements over the next few years by extrapolating explainable cohort effects in the Australian population. We compare life expectancies at retirement age using the Australian Life Tables 2015-2017 (ALT15-17) and scenarios of mortality improvements consistent with historic cohort effects observed in the Australian population. We discuss whether excess mortality in Australia in 2023 is a glitch caused by COVID-19 or the early sign of a more deeply rooted pattern of mortality improvement slowdown, such that has been observed in other countries. The research shows some headwinds are already noticeable in the pre-COVID-19 data and suggests the 25-year mortality improvement factors of the ALT15-17 are likely to be optimistic for the general population.

Key words: Longevity, Cohort, Retirement, Mortality

1 Disclaimers

- This paper only reflects the views of the author. It does not represent views of any past or present employer.
- Only publicly available data were used. As a consequence, results presented in this paper may not be relevant to an insured population since selection and basis risk would not be captured. The author has previously discussed longevity risk by socio-economic category (Clark, 2023) and pointed out the volatility in mortality trends at the population level is disproportionately driven by more disadvantaged population groups, whereas the more advantaged, more insured, population groups display comparatively less volatile mortality trends.
- The Continuous Mortality Investigation (CMI) model presented and used to derive mortality projections is available to members of the Institute and Faculty of Actuaries subscribing directly or through their employer to the CMI.

2 Executive summary

The Australian Life Tables 2015-17 (ALT15-17) mortality improvements produced by the Australian Government Actuary do not capture the cohort effects evidenced by a shift in the mortality improvements' curve that appears every time data are updated. Since the 25-year average mortality improvements of the ALT15-17 were calculated over a period of high mortality dividends coming from smoking cessation and do not reflect the full effect of rise of obesity, they should be considered optimistic.

An Age-Period-Cohort with Improvements (APCI) stochastic modelling of the Australian population mortality shows similar patterns of cohort effects compared to the UK population due to similarities in underlying mortality drivers. Projected mortality improvements in the male Australian population using an APCI model are significantly lower than the ALT15-17 25-year average improvements for the cohorts coming into retirement in the 2020's. The difference in the female Australian population is more nuanced.

3 Background

3.1 Introduction

In 2011, the Australian Government Treasury stated that "Australians are living longer, healthier lives. In the last 100 years, the life expectancy of Australians has increased by 20 years." This message is regularly relayed by media. Australians indeed enjoy one of the highest life expectancies in the world and should celebrate this achievement. However, the latest mortality numbers have shown that the reduction in mortality rates should not be taken for granted. Obviously, Australia is still dealing with the aftermath of a major public health crisis worldwide, one that it managed to successfully push back longer than most countries could. But the recent excess mortality not directly attributed to COVID-19 raises the following questions: "Is Australian average lifespan going to continue increasing at the same pace?"

Mortality improvements often come in waves (Patkee, 2023), either linked to progress in healthcare or changes in lifestyle. There are still potential areas of progress in life expectancy, but is it possible that Australia might be following in the footsteps of other countries in the so-called "anglosphere", where life expectancies have plateaued? For (re)insurers dealing in longevity in Australia, what are the prospects for the new cohorts of retirees? This paper builds on what was learned in recent years about mortality trends and cohort effects in the United Kingdom and discusses whether these cohort effects are relevant to Australia and can inform prospective views on Australian mortality. Mortality projections will then be produced and discussed in light of recent developments in terms of cause of death.

3.2 Cohort effects and mortality projections in the United Kingdom

The United Kingdom has seen the development of a very competitive market for longevity risk with firms competing on the individual annuity market and on the group Defined Benefit pensions market with a variety of de-risking solutions for pension funds (buy-ins, buy-outs, longevity swaps). The recent increase in interest rates has provided fuel to this already buoyant market. With the competitive pressure, both base mortality assumptions and future mortality improvements assumptions have seen a push towards more granular methods. In this context, the mortality improvement model used by a majority of lifetime annuity providers in the United Kingdom is the Continuous Mortality Investigation (CMI) model, released annually by the Institute and Faculty of Actuaries, and based on an Age-Period-Cohort-Improvements (APCI) stochastic model since 2017. The data used by the core model are the England and Wales (E&W) population and number of deaths, which are provided by the Office of National Statistics. Each firm may or may not customise the core model to represent their in-house views of future mortality improvements.

In the late 2010's, British actuaries noticed mortality projections at retirement ages showed decreasing progress in life expectancy. This was an unexpected outcome after several decades of sustained mortality improvements. They initially looked at the post-financial crisis austerity policies of the early 2010's to explain the slowndown in life expectancy increase for new retirees. While those austerity policies certainly didn't help the National Health Service (NHS), it turned out this slowdown of mortality improvements was more deeply entrenched in the population and corresponded to some specific population groups.

Investigations into the underlying causes of this slowdown in mortality improvements showed the following patterns:

- Recent mortality improvements had been largely driven by the reduction in cardiovascular and circulatory mortality. However, cardiovascular and circulatory mortality improvements have mostly benefited the "golden cohorts" born around 1930 (Murphy, 2009) and early baby-boomers, but have been running out of steam since the 2010's in the UK and across developed economies (More on this later).
- The slowdown of mortality improvements is not evenly distributed across all groups, but is **disproportionally driven by the more disadvantaged socio-economic groups** falling behind in terms of life expectancy.
- The slowdown emerged in the 2010's for retirees, but is actually much more **deeply rooted in the cohorts born around 1955-1965** (Late baby-boomers). These cohorts have already seen poor mortality outcomes in their 40's and 50's and are reaching ages where mortality rates rapidly increase.

After making those observations, the next step was then to try to understand underling drivers of this adverse cohort effects affecting mortality of new retirees, and in particular explain why deprived groups were not "catching up" but actually "falling behind". What came out of the research was the following:

- People born around 1955-1965 and driving the slowdown in mortality improvements were of working age in the 1980's during a period of high unemployment and the de-industrialisation that affected the working class and pauperised many industrial communities. There is a link between unemployment and excess mortality (Moser, 1984), and also between economic inequalities and health inequalities (Marmot, 2010). Inequality creates a lifespan gap between socioeconomic groups, which drags the average lifespan.
- These cohorts were among the first to deal with the obesity crisis that surged in the 1980's and have continued since then. More deprived socio-economic groups have been more affected by obesity in the UK.
- While smoking prevalence dropped significantly in the UK, the population groups most resistant to measures against tobacco were the more deprived socio-economic groups.

Note the difficulty of quantifying the effects of any of these drivers and there remains a high level of subjectivity in assessing each of them.

It is probable that the golden cohorts born around 1930 have benefited from an unprecedented low level of wealth inequality, caused by a series of major crises (World Wars, Great Recession), manifested by a historically high proportion of labour income in the national revenue as opposed to capital income - which would have benefited the income of low-skilled workers comparatively to other time periods and improved health outcomes.

On the other hand, late baby-boomers of the 1955-1965 have seen a higher level of wealth inequality and a lower proportion of labour income through their working life - which may have contributed to the stagnation of their health outcomes (Clark, 2023).

It is conjectured that these socio-economic conditions have contributed to entrenched cohort effects noticeable in mortality projections. Note at this stage the difficulty of modelling cohort effects and the element of uncertainty inherent to any modelling approach (Palin, 2016).

More transiently, the NHS went through austerity in the post-financial crisis environment of the 2010's when healthcare needs of the 1955-1965 cohorts were growing rapidly due to ageing. If austerity measures were not enough, Brexit exacerbated a staffing shortage within the NHS, COVID-19 set NHS waiting lists several months back and the 2022/2023 cost of living crisis contributed to major strikes of medical staff.

It is difficult to disentangle all these drivers, but they all contribute to the stalling of life expectancy for new retirees of the 2020's, particularly for the more disadvantaged populations. These observations were presented earlier by the author (Clark, 2023) and can explain the slowdown of mortality improvements in the E&W general population since the 2010's. Similar observations were presented by (Yiu, 2023) to explain the slowdown in retirees' mortality improvements by cause of death in the UK and the authors suggest similar patterns of mortality improvement slowdown can be observed elsewhere.

Historical E&W mortality improvements are shown in the heatmaps below by index of multiple deprivation (IMD) group, which is an indicator of socio-economic status used by the CMI, from low (Disadvantaged) to high (Advantaged). The heatmaps illustrate periods of positive improvements in red and negative improvements in blue (the darker the colours, the higher the absolute values), with calendar years on the horizontal axis and age on the vertical axis. The colours suggest that more deprived groups have significantly larger age/year surface of low or negative improvements (in blue) compared to more advantaged groups over the observation period.

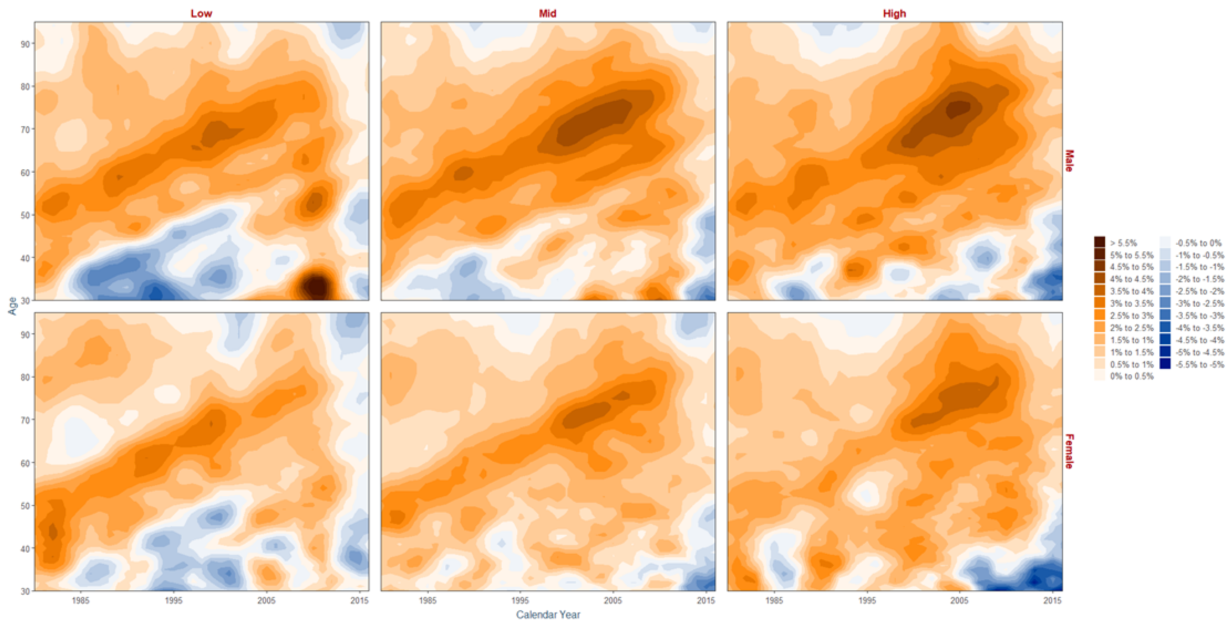

Figure 1: Heatmap of E&W mortality improvements by age, year of birth and socioeconomic group (CMI Data)

The dark orange diagonals at the top of the charts above correspond to the so-called "golden cohorts" (Murphy, 2009), sometimes called silent cohorts, that saw large mortality improvements and consequently extented their life expectancy. The blue diagonals are the 1955-1965 cohorts that have seen negative/adverse mortality improvements.

Some of the questions that preoccupy this paper are the following:

- Are any of these patterns relevant to the Australian population?
- Since drivers of cohort effects, such as smoking prevalence or obesity are not circumscribed to the E&W population, should one expect similar trends for Australian mortality improvements?
- Are we already seeing the patterns of mortality improvement slowdown that have been observed in the UK and other developed economies?

3.3 Comparing populations to understand Australian mortality trends

A rapid comparison between the England and Wales population and the Australian population can help us to understand the changes in mortality rates over time. In some respect, these two populations show similar drivers in mortality, such as:

- Modern medicine, as both populations have had wide access to modern healthcare systems that rely on the latest science;
- The rise and fall of smoking prevalence, peaking in the 1950's. Smoking is a major risk factor for heart disease and lung cancer;
- The rise of obesity, developing in the 1980's and affecting both populations today (Australia being above the UK in terms of obesity prevalence (Obesity, n.d.);
- Significant economic changes in the 1980's.(RBA, 2000)

The changes of Australian leading causes of death since the 1970's are somewhat similar to the story of England and Wales:

- The receding of smoking prevalence and modern medical treatments contributed to the reduction in cardiovascular mortality and lung cancer, especially for males;
- As cardiovascular mortality reduced, cancer became a more important cause of death before modern medical treatments started the slow process of cancer mortality reduction;
- As cardiovascular and cancer mortality recede, yet another killer emerges, dementia, and we are yet to see effective treatments against this disease.

As we consider the Australian population's mortality by cause over the last 70 years (AIHW, 2006), some interesting patterns emerge. Mortality rates in Australia were increasing for all ages in the early 1960's (As seen in the age-standardised death rates). It was not due to a single cause but a combination of different factors, in particular:

- For the younger ages, road fatalities were on the rise;
- For the 50+, ischaemic heart disease deaths were also increasing.

Both these causes were associated with past increases in living standards. Road fatalities in Australia peaked in the 1960's as automobile use became widespread, and subsequently fell in the 1970's as road safety measures were implemented. This is noticeable in the improvement heatmaps presented later on. While the same pattern in road fatalities was seen in E&W, the wave of road fatalities was not as dramatic. Road fatalities per capita in Australia were more than twice that of E&W in the 1960's. The most likely explanation is that Australian travel longer distances.

Smoking prevalence took off in the 1920's, firstly among males, and by the 1950's was negatively impacting mortality improvements. Subsequent public health initiatives, education on the health risks of smoking and modern treatments reduced heart disease prevalence from the 1970's onward. Heart disease mortality reduction became the most significant positive contributor to life expectancy increase from the 1970's, following the reduction in smoking prevalence and the improvements in treatments.(ABS, 2018) (AIHW, 2023). See below:

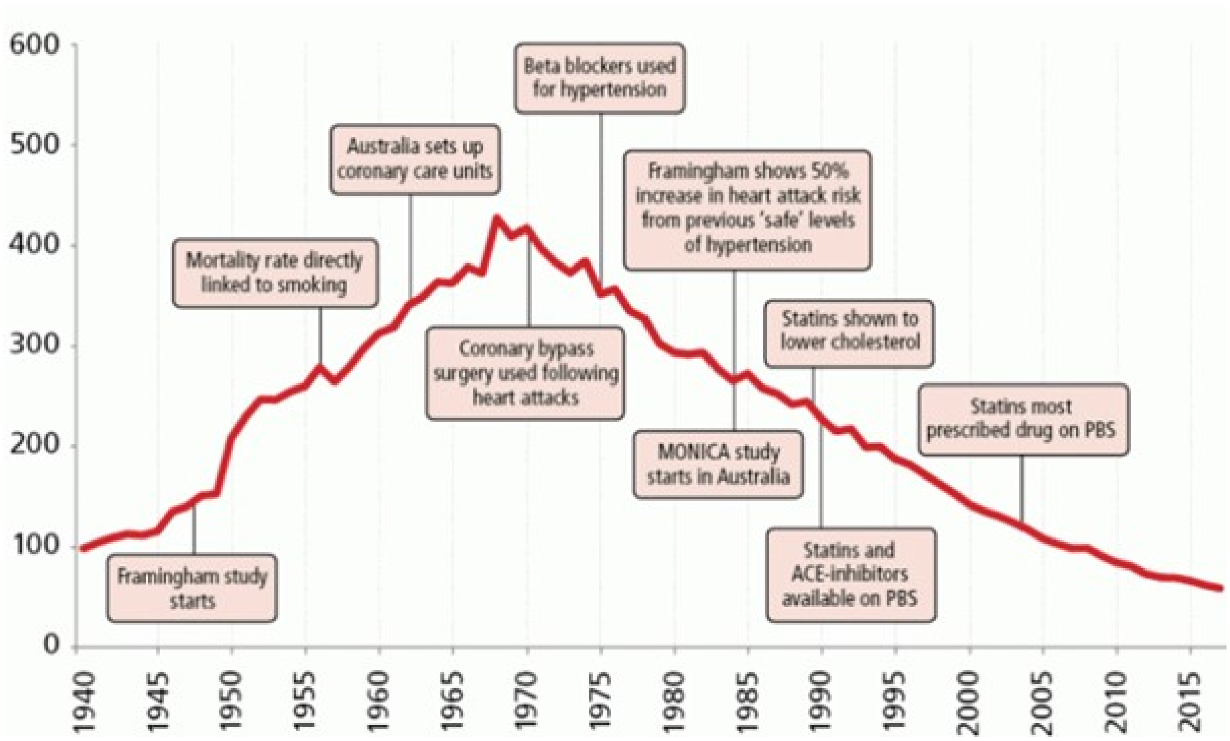

Figure 2: Number of coronary heart disease deaths in Australia per 100,000 since 1940 (Source: AIHW 2023)

There are however some notable differences between the two populations. For example, the E&W population has a comparatively high proportion of baby-boomers, while this is less so for Australia due to migration policies. Another significant difference that was found was that while obesity is very much differentiated by socio-economic group in E&W, this is less so for Australian males, as it seems society is much more "egalitarian" with waist size (AIHW, 2023).

On balance, drivers of mortality would suggest some patterns in future mortality improvements would be shared between the E&W and the Australian population. If the drivers of mortality improvements are similar between E&W and Australia, we may then expect the same slowdown that is being observed in E&W. This is corroborated by epidemilogy:

> *"Recent declines in mortality in Australia have been relatively modest. Together with the high prevalence of obesity and the limited scope for further increasing life expectancy by reducing the prevalence of smoking, this suggests that future life expectancy increases will be smaller than in other high income countries. Improved control of health risk factors will be required if further substantial life expectancy increases in Australia are to be achieved."* (Lopez, 2019)

3.4 Mortality improvements in the Australian Life Tables

The Australian Government Actuary publishes the Australian Life Tables, currently Tables 2015-17, that are based on the mortality of male and female Australians over the three calendar years centred on the 2016 Census of Population and Housing.

The publication includes period mortality tables and 2 sets of average mortality improvements calculated over either 25 years or 125 years, to be applied at the user's discretion.

Mortality improvements are hence assumed constant by age into the future: the same rates of improvements are applicable year after year. The Australian Government Actuary publication does point to the 5-year crude average improvements showing different patterns and suggesting future improvements may be more complex than a 25 or 125-year average. However, the 5-year crude average improvements are only indicative of what could be the current improvements and not an official release. Indeed 5 years is a very short period to consider due to the inherent volatility of mortality improvements. But in showing the 5-year average in comparison to the 25 or 125-year averages, the Australian Government Actuary provides a rationale for looking deeper into the pattern of current mortality improvements, which may be done through looking at cohort effects.

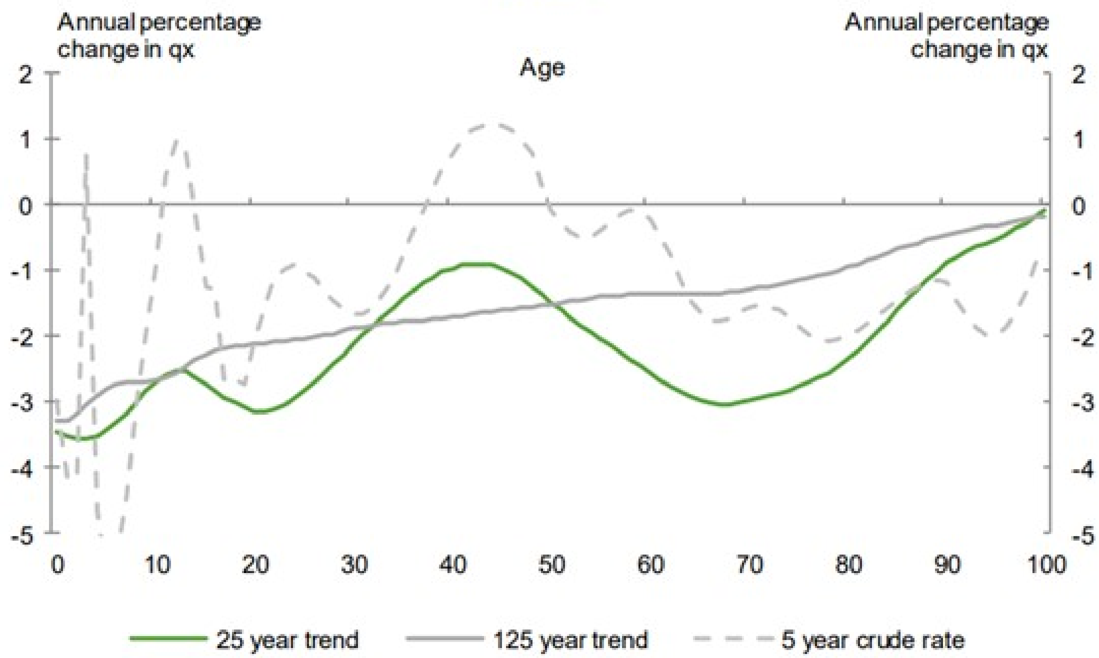

Figure 3: Mortality improvements - Males ALT 2015-17 (AGA 2021)

Going back to earlier ALT releases, a gradual shift of the last 25-year average improvement curves can be noticed as the observation period is shifted by 5 years each time. See below:

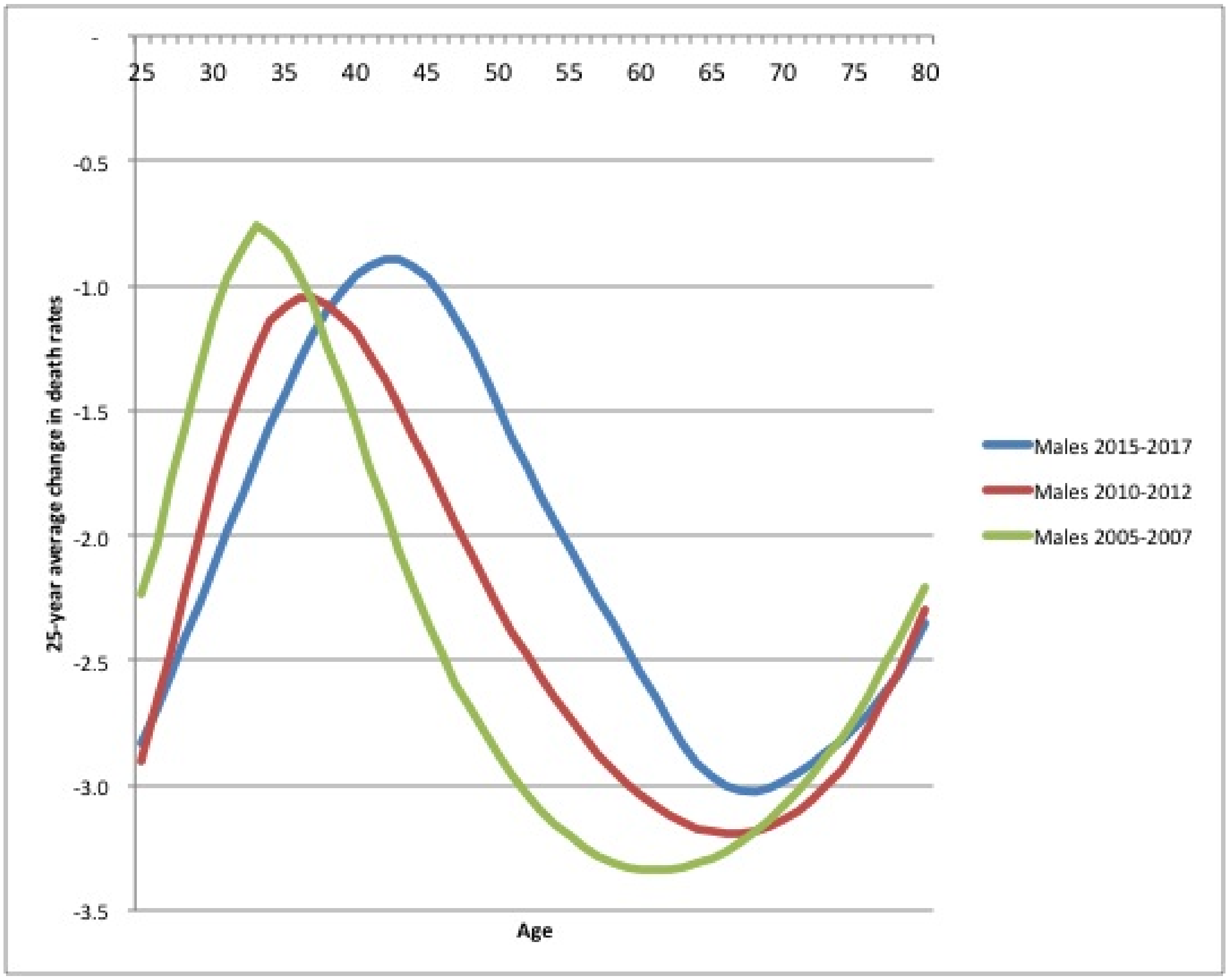

Figure 4: Australian Government Actuary's Mortality improvements (%) by observation period - Males

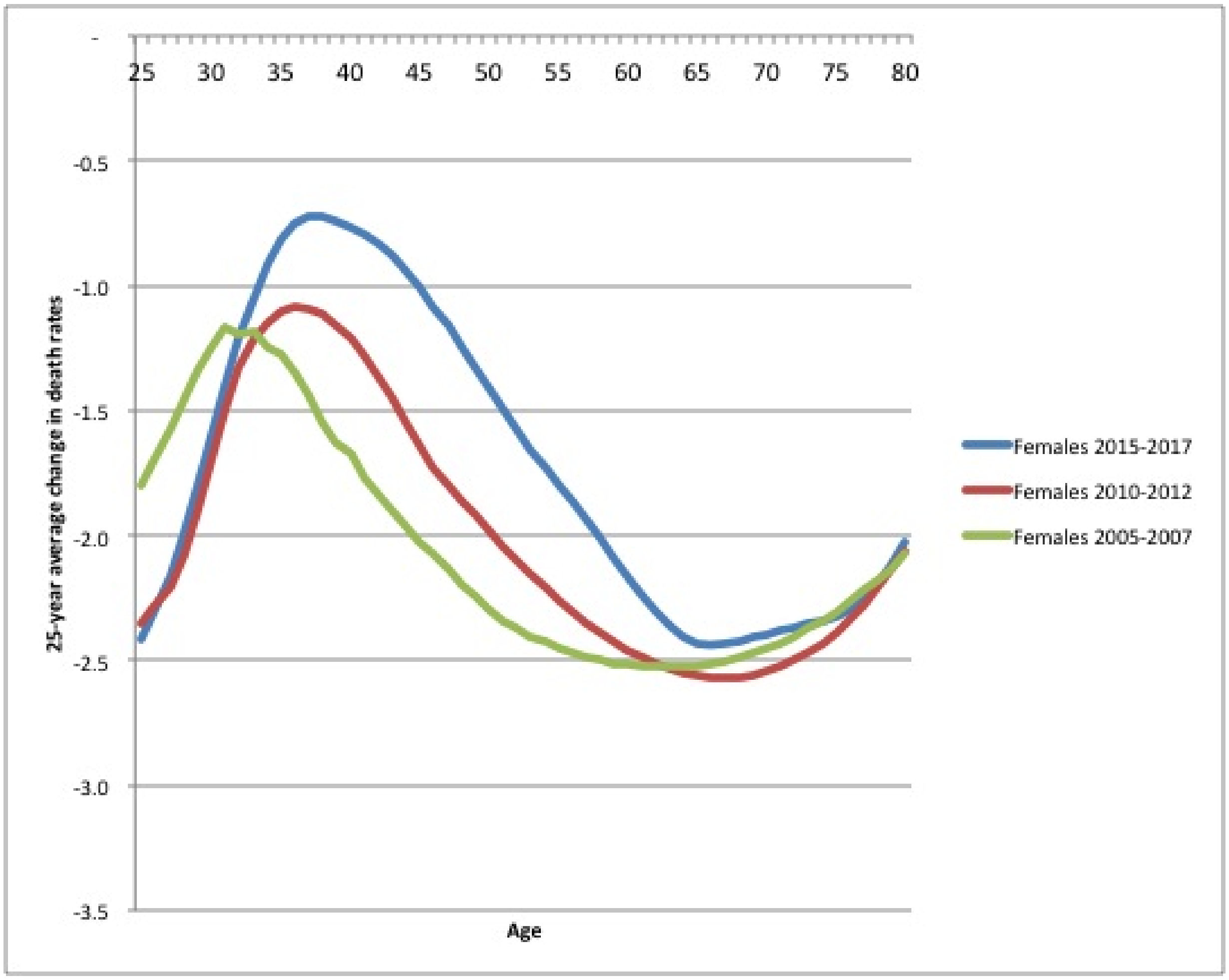

Figure 5: Australian Government Actuary's Mortality improvements (%) by observation period - Females

The 5-year shift of the shape each time the Australian Government Actuary updates the curve is characterised as follows:

- The point of high improvements (Large negatives) consistently coincides with 25-year average centred around the cohort born in 1933.
- The point of low improvements (Small negatives) coincides with 25-year average centred around the cohort born in 1961.

These points correspond respectively to the golden cohorts and to the late baby-boomers' cohorts identified previously in the E&W Population.

The shift of the shape by age, which closely matches the shift in observation period, suggests there is a cohort component to mortality improvements in the ALT, which deserves our attention.

The next section compares the ALT 2015-17 mortality improvements to future mortality improvements produced by the CMI model using Australian population data from 1962 to 2020.

4 Modelling Method

4.1 Introduction of the CMI model

The UK's Institute and Faculty of Actuaries' Continuous Mortality Investigation (CMI) committee introduced in 2017 a new model for fitting to mortality data: the Age-Period-Cohort-Improvement (APCI) model (CMI, 2016). This model has become industry standard in the UK (CMI, 2023), with a wide subscription base. The annual upgrades of the model involve the update of the observation period and secondary functionalities (such as putting different weights on outliers when there is a pandemic), but the core of the model has been stable since 2017.

The CMI's APCI model takes some features from the Age–Period–Cohort (APC) model and Lee-Carter model for the purpose of fitting past mortality improvement and then forecasting future mortality improvements.

The modelling of the force of mortality at age x and year y is as follows:

$\log m_{x,y} = \alpha_x + \beta_x(y - y_0) + \kappa_y + \gamma_{y-x}$

The reader may find ample documentation on the APCI model, and this paper will not go into too many details of the core model - note core parameters were unchanged as much as practically possible except when inadapted to the Australian population. The CMI model is in effect a packaged version of the APCI model with the England and Wales (E&W) data and some default or "core" parameters. Where the CMI refrains from providing a core parameter is for the long-term improvement rate (LTIR) target, although the CMI does provide core parameters for the convergence period to the LTIR and the tapering of the LTIR at older ages. The CMI model can be fairly straight-forward to use by a beginner user, yet can also accommodate an advanced user who is interested in refining each parameter (Which is typically the case with firms with large longevity exposures).

The strength of the CMI model is that it can capture cohort effects in the historical data and project them into future mortality improvements - in that respect, the model has at least 2 distinct purposes when it comes to mortality improvements: to smooth past improvements and to forecast future improvements. The model shows what portion of mortality improvements is attributable to the cohort effect, and what portion is attributable to the period.

The model does however have limitations. One such limitation, which is not specific to the APCI method, is its inability to deal with mortality shocks. In 2020, the UK saw a 14% above expected mortality in the first year of the COVID-19 pandemic. The CMI model's forecast did not react well to the shock, in particular with the notion that a virus would create multiple though receding waves of excess mortality. The questions actuaries tried to answer were "When will mortality stabilise?" and "Where will it settle once it stabilises?" The CMI model could not answer those questions. The CMI model has no predictive ability after a mortality shock. This is more an epidemiological question.

The CMI committee initially excluded 2020 data from the calibration, effectively assuming a slightly delayed return to pre-COVID projections. But 2022 was the year when the majority of first COVID infections happened, with the Omicron variant. The CMI model as it stands in early 2024 is not a typical model where the inputs are calibrated in order to get some outputs. The arbitrary decision of assigning different weights on 2020 to 2023 data makes the CMI model a teleological model in that some input parameters are used to target a specific outcome, in this case an age-standardised mortality rate trajectory that was deemed "plausible" by the CMI committee at a particular time and based on expert judgement. The model then works out what this means for improvements by age and year of birth.

When applying the CMI model on Australian population, the approach has been to use data up to and including year 2020 when COVID-19 was still a marginal cause of death in Australia and hadn't become endemic. COVID-19 has immediate and measurable effects on mortality when it first spreads through a population. What is much more uncertain is the long-term effect on lifespan for a population that ends up getting exposed multiple times to various strands of the virus. By limiting the use of data to 2020, the results may be deemed slightly optimistic because a new cause of death is altogether ignored, but assigning any (arbitrary) weight to 2021 to 2023 data would potentially overestimate the effect of COVID-19 fo years beyond 2023.

Nonetheless, the CMI model can identify historic cohort effects, which are then very informative for future morality trends. Cohort effects are patterns in the mortality improvements that are specific to a particular generation, as opposed to a particular period. Cohort effects are often associated with controllable risk factors in the population, such as smoking prevalence (Cairns, 2023).

4.2 Results: Fitted mortality improvements in the Australian population

The figures below show the heatmaps of mortality improvements in the Australian general population (HMD database (HMD, 2021)) based on CMI 2020 core model with convergence after 2020 to the 125-year average improvements (Note again that the insured population may display different patterns).

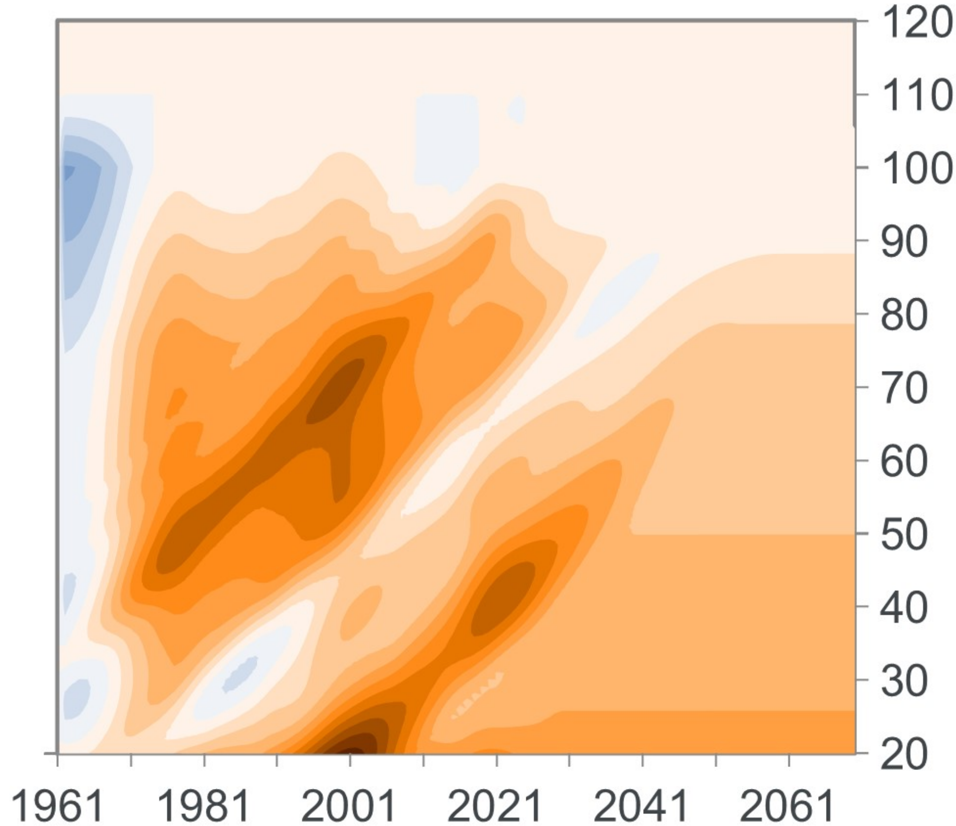

Figure 6: Male mortality improvements heatmap based on own calculation

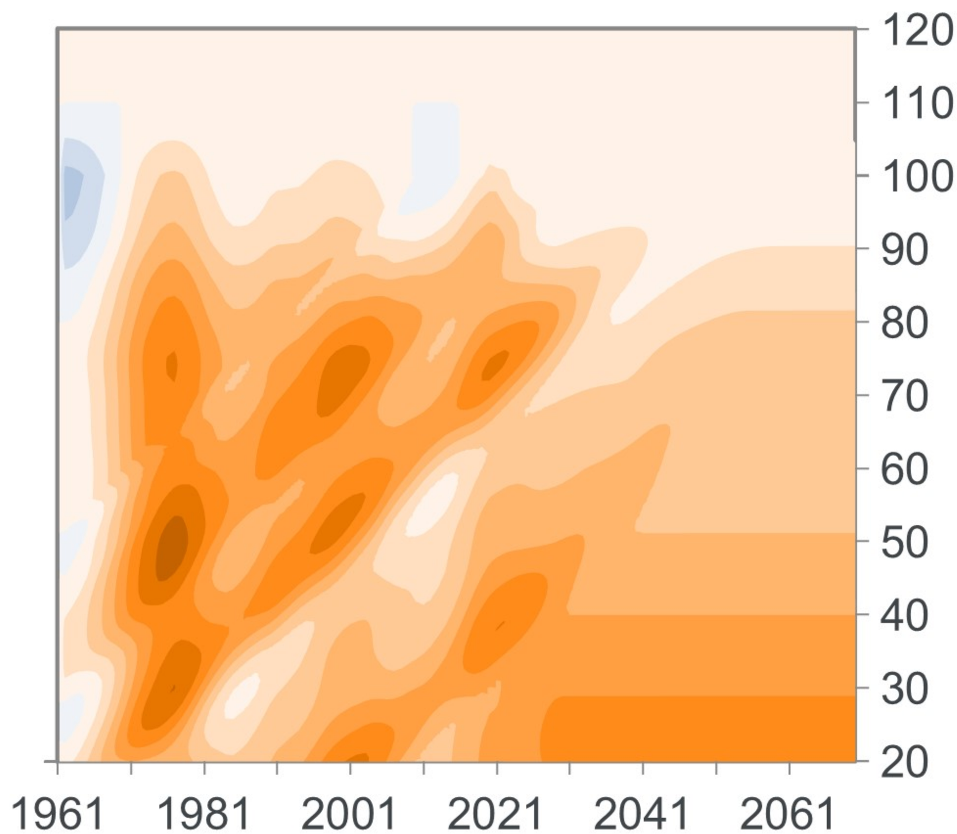

Figure 7: Female mortality improvements heatmap based on own calculation

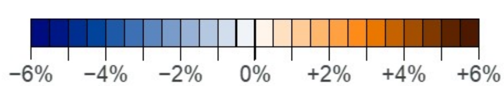

Figure 8: Improvement colour coding

The heatmaps clearly display diagonals in the historic zone (before 2020), such that have been observed on the E&W population. A distinguishable diagonal in the heatmap is the pattern of a cohort effect. A dark orange diagonal characterises the "golden cohort" (Cohort 1930) that was mentioned earlier and documented by Murphy (Murphy, 2009). It is expected some of the same drivers are behind the sharp reduction in mortality for people born around 1930 across the developed countries.

Mortality improvements for cohorts born in 1955-1965 (Blue/White diagonal) are significantly lower at the same ages than mortality improvements for cohorts born a generation before.

The figure below shows mortality improvements on the last year of the observation period (2020) and corresponds to what is called the initial mortality improvements - that is the improvement at time 0 of the projection. Note that improvements in the CMI model are defined as (1 - Qx(n+1)/Qx(n)), so a positive number corresponds to a reduction in mortality, while for the Australian Government Actuary a negative number in the table corresponds to a reduction in mortality.

Notice the drop in mortality improvements in the early 60's - that is the Australian population born around 1960.

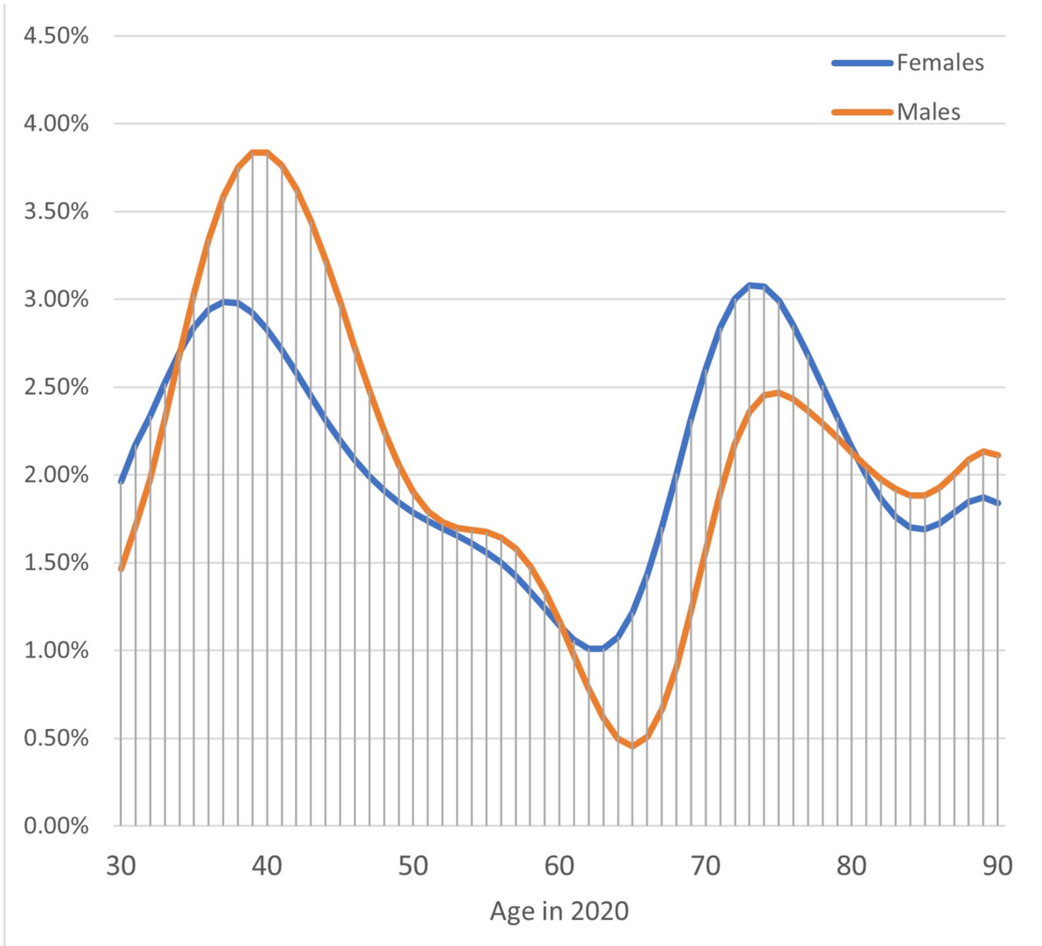

Figure 9: Initial mortality improvements in 2020 by age - Australian Population, APCI modelling

The CMI model produces a split of these initial improvements to separate cohort effect (Specific to a birth year) from period effect (Specific to a calendar year). Below is the breakdown of the fitted mortality improvements in 2020 between cohort effect and age-period effect produced by the CMI model using the Australian population data:

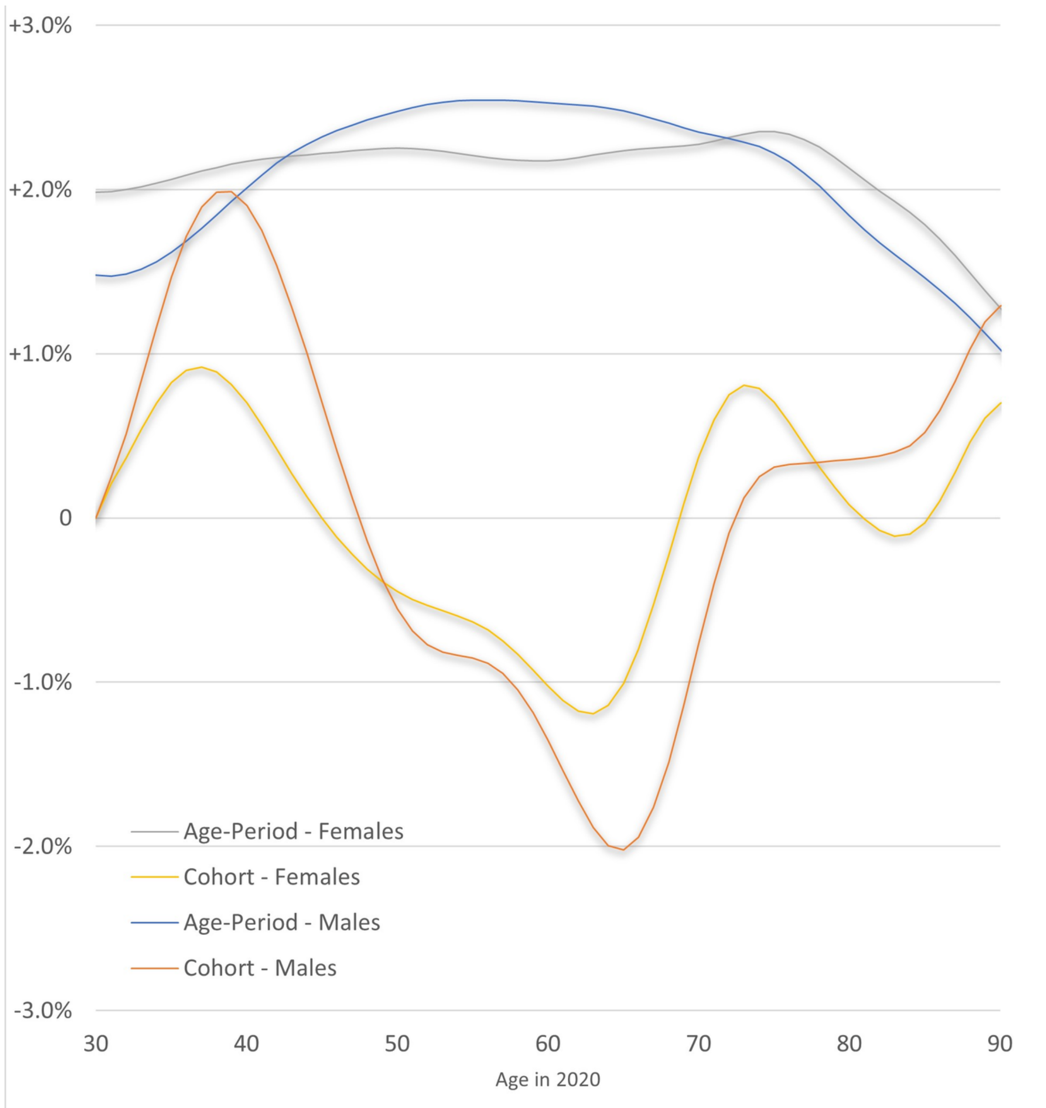

Figure 10: Period and Cohort components of Mortality improvement in 2020 by age - Australian Population, APCI modelling

The graph shows a fairly stable age-period mortality improvement component of around 2%. On the other hand, the cohort component is much more irregular, with negative cohort effect between age 50 and 70 (People born between 1950 and 1970). The CMI model shows similar patterns of cohort effects in both the E&W and the Australian populations with people born between 1950 and 1970 displaying low mortality improvements. These are the cohorts reaching retirement in the 2020's. One can expect these cohort effects to persist into the short to medium term and lead to lower mortality improvements for people going into retirement.

4.3 Results: Projected age-standardised mortality improvements in the Australian population

Below are the projected age-standardised mortality improvements (Based on 2020 Australian Population by age and sex) of the 65+ produced by the CMI model extrapolating the cohort effects and converging to either the ALT 2015-17 125-year average improvements or the ALT 2015-17 25-year average improvements.

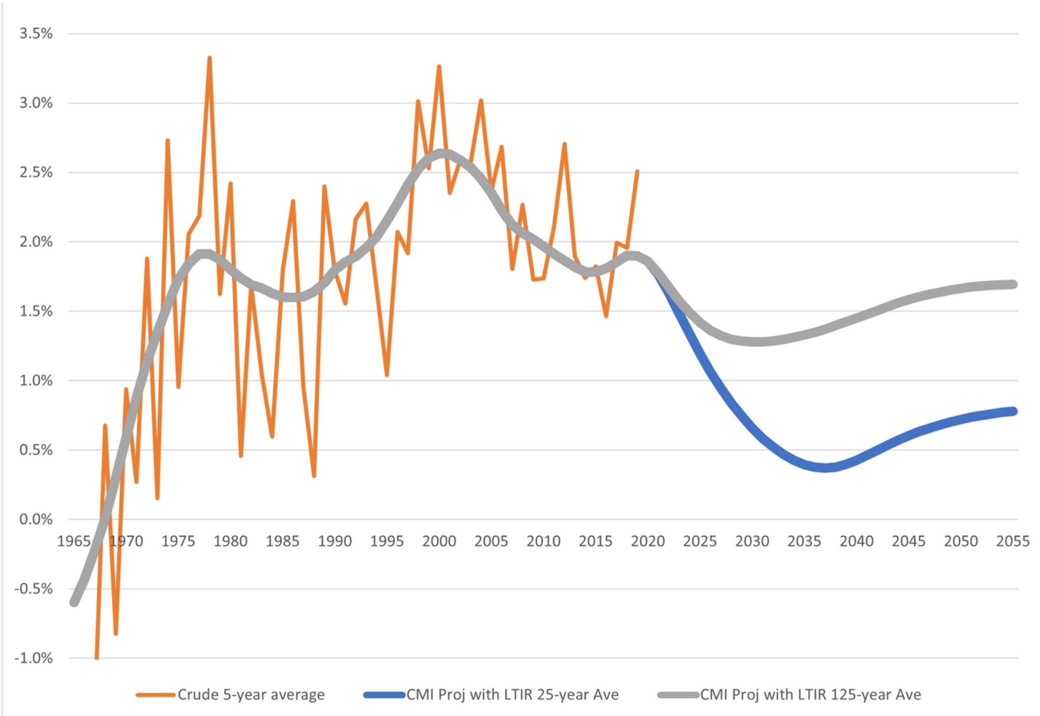

Figure 11: Age-Standardised Mortality improvements - Males 65+

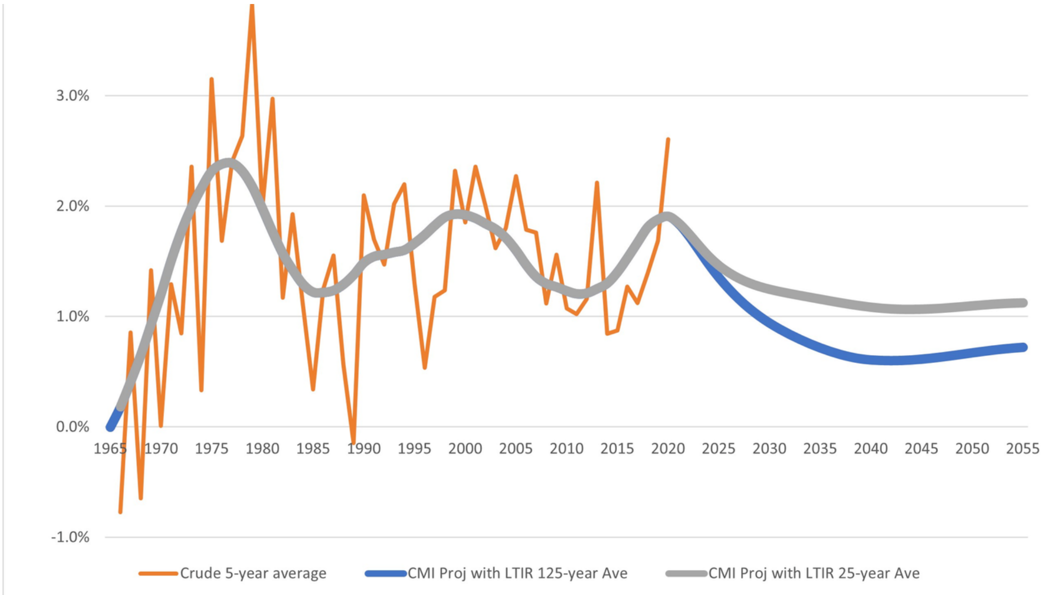

Figure 12: Age-Standardised Mortality improvements - Females 65+

Whether converging to the ALT 2015-17 125-year average improvements or the ALT 2015-17 25-year average improvements, the CMI model predicts a period of improvement slowdown for the 65+ in the 2020's, with improvements lower than their long-term target for males. The gap between the projections and the long-term target is more pronounced for males than for females, indicating ALT 2015-2017 expectancies for males are likely to be optimistic compared to life expectancies calculated on the CMI model. In other words, cohort life expectancies relying on the ALT 2015-2017 25-year average improvements are likely to be optimistic considering the ALT 2015-2017 do not capture the adverse cohort effect for people born in 1955-1965.

Also, since the ALT 2015-17 25-year average improvements include a period of relatively high improvements for the 65+ corresponding to the golden cohorts born in the 1930's (orange diagonal in the heatmaps), it is questionable whether these improvements should serve as long-term targets. Note improvements were higher for males for these cohorts due to the effect of smoking cessation, which was a male-dominated habit. Hence it would make more sense to use a longer time-period to derive the long-term improvement rates instead of the 25-year period.

Below are average age-standardised annual mortality improvements for the 65+ by period. The 1991-2016 period corresponds to the 25 years leading up to the ALT 2015-17 25-year average improvements, so these are actual improvements used to derive the proposed ALT 2015-17 improvements tables. The 2013-2019 period is the more recent pre-pandemic period that, 2020 being excluded due to the "COVID effect" that might have reduced respiratory deaths for a limited period of time as masks and other measures limited exposure to respiratory infections. As can be seen, and consistent with the message from the Australian Government Actuary, more recent mortality improvements are weaker than the 25-year average. The 2024-2034 shows projected average annual improvements using the CMI projection model with LTIR target 125-year average. It suggests that the absolute rate of improvements continues to decrease over the next 10 years, in particular for males.

Annual Mortality Improvements	M	F
1991-2016 (Crude)	2.0%	1.4%
2013-2019 (Crude)	1.8%	1.1%

2024-2034 (Projection)	0.7%	1.0%

Table 1 - Average mortality improvements by period

Below is the remaining cohort life expectancies (LE) in years at age 65 in 2023 using the ALT 2015-17 for base mortality and different scenarios of mortality improvements:

Improvements	LE Males	vs base	LE Females	vs base
ALT Impr. 25-year average (Base)	22.7		24.6	
CMI LTIR 25-year average	22.0	-3.1%	24.8	+0.6%
CMI LTIR 125-year average	21.3	-6.2%	24.3	-1.4%
ALT Imp. 125-year average	21.1	-7.2%	23.8	-3.4%

Table 2 - Life expectancies at age 65

The ALT 25-year average mortality (ALT Impr. 25-year average) improvements are the Australian Government Actuary base scenario and produce the highest remaining life expectancies for males, while the CMI improvements with long-term improvement rate calculated on the 25-year average (CMI LTIR 25-year average) produce the highest remaining life expectancies for females. Using the more reasonable 125-year average improvements for the long-term rate reduces remaining life expectancies by 6.2% (-1.4 years) for males and 1.4% (-0.3 year) for females compared to the base.

The ALT 125-year average mortality (ALT Impr. 125-year average) improvements are considered pessimistic, showing the lowest life expectancies.

5 Discussion

5.1 Are CMI Projections on the Australian Population plausible?

Modelling cohort effects in the Australian population leads to a similar conclusion otherwise reached from an epidemiological point of view even before the pandemic (Lopez, 2019), which is that mortality improvements for retirees over the 2020's decade are unlikely to be as high as the previous 25-year average, in particular for males. This can be explained by the following:

- High mortality improvements for males were driven by smoking cessation reducing cardiovascular risk, and are unlikely to continue at the same pace;
- The current cohort of new retirees are dealing with an obesity issue that was a lot less prevalent in the previous cohorts of retirees (AIHW, 2023).

Cardiovascular mortality has been the main driver of mortality improvements, accounting for over 80% of all-cause mortality improvements in Australia since 1980. Below is the change in age-standardised number of deaths in Australia from 1980 to 2020 by main cause.

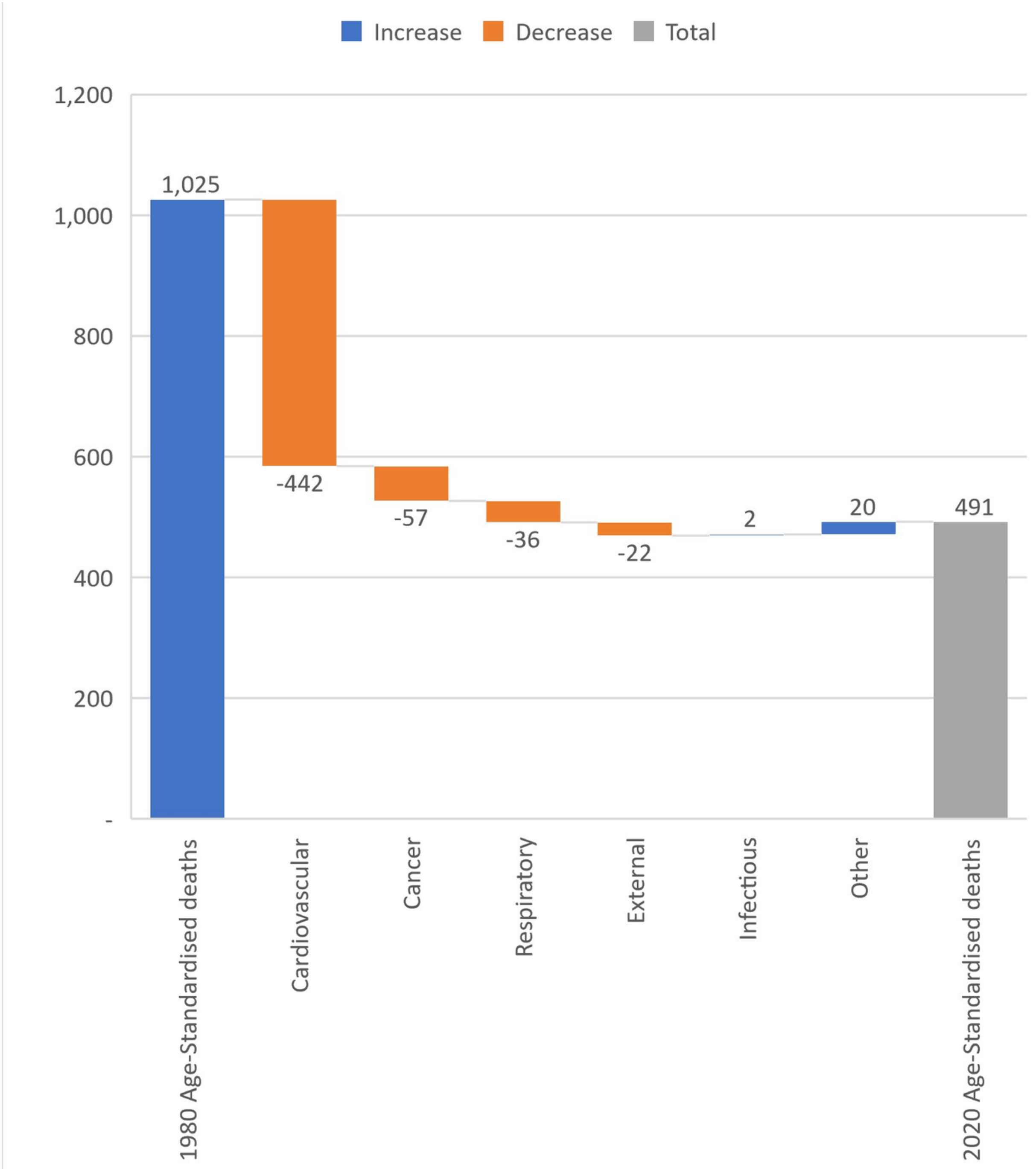

Figure 13: Change in Age-Standardised Deaths (all ages) for 100 000 in Australia between 1980 and 2020 - Data Source: ABS, own calculation

Improvements in cardiovascular mortality are by far the main explanation for the reduction in death rates in Australia since 1980. However, the 2010's was a period of next to nil cardiovascular mortality improvements in several developed economies. Talking about E&W population:

"The reduction in the improvements in all-cause mortality rates follows the reduction in the improvements in circulatory system disease mortality after 2011" (Yiu, 2023).

Based on recent trends, cardiovascular mortality rates in Australia may be slowly converging - suggesting the era of large cardiovascular mortality improvements may be coming to an end (Adair, 2020). The graphs below show age-standardised trends in cardiovascular mortality by country using Health Metrics and Evaluation (IHME), Global Burden of Disease (2019) data.

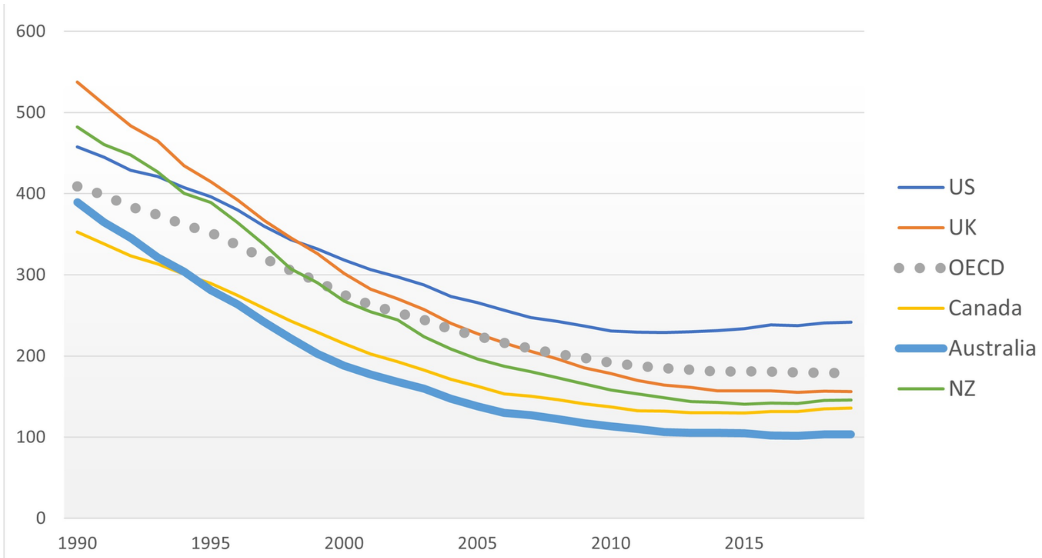

Figure 14: Age-Standardised cardiovascular deaths per 100 000, by country - 50 to 69 y/o - Source: IHME

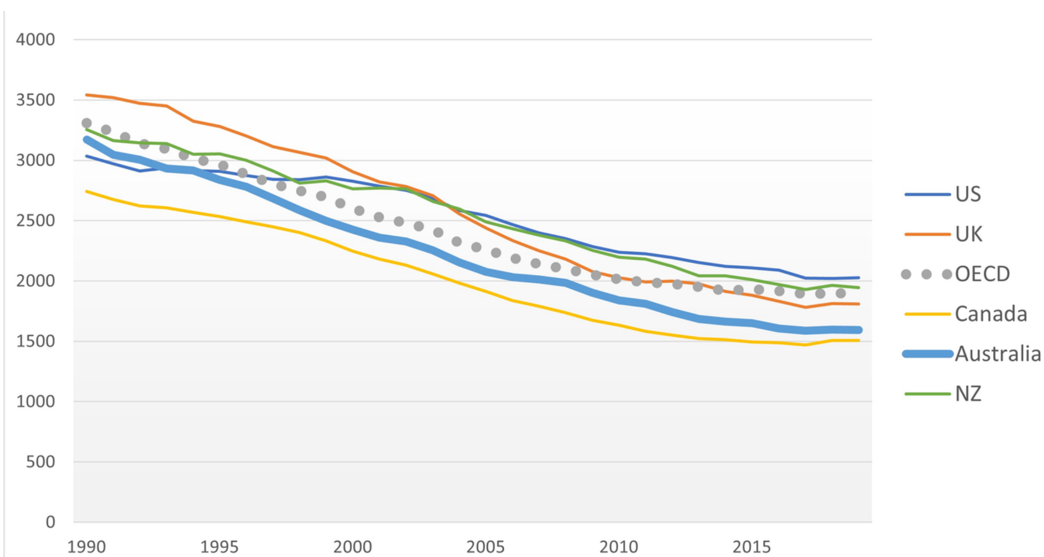

Figure 15: Age-Standardised cardiovascular deaths per 100 000, by country - 70+ y/o - Source: IHME

Progress in cardiovascular mortality was rapid in the 1990's and 2000's (The Golden cohorts being the main beneficiaries of progress). The 2010's saw progress slowing down in developed economies. Not represented in the charts above is the cardiovascular mortality in the early 2020's, which has been higher than expected in Australia and other countries and may suggest a reversal of the progress made so far. However, because cardiovascular excess mortality is correlated to COVID-19 and its effects on metabolism (Which in itself is huge topic), it seems premature to use 2020-2023 cardiovascular mortality data to draw any meaningful conclusions.

In summary, it is very plausible that mortality improvements for new retirees may reduce significantly by the end of the 2020's based on APCI projections that support the epidemiological expectations around cardiovascular mortality - notwithstanding any significant medical breakthrough. When the Actuaries Institute released its 2012 white paper, *Australia's Longevity Tsunami (AI, 2012),* progress in cardiovascular mortality was very much supporting overall improvements. 12 years on, actuaries have to contend with the reality cardiovascular progress is stalling.

5.2 Public health and cardiovascular mortality

In the background of these cohort effects, is the issue of obesity and associated morbidities (Hypertension, Diabetes), which has gradually spread to all cohorts. Growing from a marginal issue in the early 1980's to an issue that affects almost 1 in 3 Australians today, obesity constitutes a serious drag for mortality improvements. It seems obesity is very much a component of the cohort effects that have been identified by the APCI model and that is now affecting late baby-boomers' mortality.

Considering the excess mortality observed in people with metabolic issues caused by obesity, this drag could be significant - although it is difficult to give a precise number since the health system continually adapts to this challenge. Swiss Re recently noted that plateauing life expectancy gains have been linked to deteriorating metabolic health, including rising prevalence of obesity and diabetes (Descombes, 2023).

Talking about Americans born 1945–1960 for females and 1940–1955 for males, Villegas notes:

> *"In particular, this generation marked the start of a turning point in generational patterns of circulatory disease mortality with cohorts born from around 1945 to 1950 onwards showing negative cohort effects for this group of causes. This pattern coincides with similar turning points in the mortality rates from markers of cardiovascular risk factors including hypertension, obesity and diabetes." (Villegas, 2023)*

According to this analysis, circulatory diseases have led to an adverse cohort effect in the US, which has contributed to low mortality improvements in the 2010's. The US have been about a decade ahead of Australia and the UK in terms of obesity prevalence. Late baby-boomers' adverse cohort effects identified by the CMI model in the Australian and E&W populations may present similarities in terms of cause of death trends with early baby-boomers' adverse cohort effect identified by Villegas in the US population.

The SOA Research Institute recently published a thorough analysis of the effects of obesity by education level in the US. One of the key findings is that "There has been, and is forecast to be, a divergence in CVD mortality trends for obese vs non-obese populations" (SOA, 2024)

The paper evidences that while mortality is stable or reducing for non-obese populations, mortality is stable or increasing for the obese populations. If these observations were to be relevant to the Australian population, it would mean the rise of obesity over the last 4 decades will lead to divergence between the obese and the non-obese populations and mechanically reduce the average pace of life expectancy progress.

5.3 Considerations on health inequalities

Another aspect of Australian mortality trends that is not analysed in this paper is the gap between socio-economic subgroups, such as the gaps between different levels of advantage or between the Australian-born and the immigrant subgroups. The Australian Government Actuary notes:

"Between ages 10 and 60, the mortality of those born overseas is clearly lower than those born in Australia. It is interesting to speculate about potential reasons for this. One likely explanation may be the presence of a selection effect for those moving to Australia. This could arise because, in general, [1] healthy people are probably more inclined to relocate to a new country, [2] those seeking permanent residency must pass minimum health requirements, thereby providing an underwriting effect, and [3] many immigrants arrive on a work visa, often a skilled work visa. This points to selection pressures operating at multiple levels, giving rise to the 'healthy migrant effect'." (AGA, 2021)

The Australian Government Centre for Population (AGCP) shows that for cohorts of interest born between 1955 and 1965, the Australian-born population, representing about 2/3 of the total for these cohorts, has seen quasi-nil or sometimes negative mortality improvements in the 2010's (AGCP, 2021). AGCP analyses effectively point to a stalling in life expectancy for Australian-born, in particular rural, subgroups. We could not independently verify these insights coming from the due to lack of access to the data, but it paints a preoccupying picture of future mortality improvements that could be part of a further analysis of mortality improvements by sub-group.

6 Conclusion

This paper set out to show that:

- The 25-year average mortality improvements last released by the Australian Government Actuary were derived over a period of relatively high mortality improvements for Australians of retirement age and these relatively high mortality improvements are unlikely to continue at the same pace in future years in light of more recent mortality trends of the late baby-boomers.
- Cardiovascular mortality reduction has been the main driver of mortality improvements over the last few decades, but progress in cardiovascular mortality is stalling in many developed economies, not least as a result of the obesity issue. There are some indication this stalling is also happening in the Australian population.

Note the latest analysis by the Actuaries Institute's Mortality Working Group (AI, 2023), showing +5% excess mortality in 2023 compared to pre-pandemic projections. COVID-19 deaths represented 55% of this excess mortality, while cardiovascular conditions and diabetes account for most of the non-COVID-19 excess deaths.

This brings us back to the following discussion point: Is excess mortality in Australia in 2023 a temporary setback caused by COVID-19 - as we know COVID-19 can provoke cardiovascular disease - or is it an early sign of a more deeply rooted pattern of mortality improvement slowdown, such as the turning point Villegas described in the American population (Villegas, 2023)?

This question is at the core of modelling future mortality rates, ever since it was noticed in early 2022 that cardiovascular deaths were on the rise in some economies (including in the UK) despite the initial expectation they would continue to reduce, at least due to the displacement effect, whereby a proportion of COVID-19 deaths involved people who would have died of other causes in the same year. At this time, the question remains still open.

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