



## “S3” Series mortality tables

June 2022

**Note:** Working paper 113 briefing note was originally issued in December 2018. This working paper uses data for a public sector pension scheme in 2012-2016 which is now known to be incorrect. We have not updated the working paper, but we have prepared [a note](#) that describes the nature of the incorrect data and the impact on CMI analyses so that Subscribers can consider whether to take any action.

### Summary

This Briefing note is issued alongside the “S3” Series mortality tables. These are the latest tables produced by the Continuous Mortality Investigation (CMI) and are based on **mortality rates** of members of defined benefit Self-administered Pension Schemes (SAPS).

Actuaries need assumptions about mortality rates in order to manage the finances of defined benefit pension schemes that commit to pay members a pension throughout their retirement. In general, mortality rates for pensioners are lower than those of the general population so many UK pension schemes use the CMI SAPS tables as the basis for their assumptions.

Actuaries often consider these assumptions in two stages:

- Assessing current mortality rates for that portfolio or pension scheme, perhaps reflecting its own recent experience, and
- Considering how these rates may change over time.

The “S3” tables relate only to current mortality rates. They update the previous “S2” and “S1” tables to reflect a larger and more recent dataset.

This note provides an overview of the “S3” tables and outlines the changes in the composition of the dataset, and the changes in methodology, from the “S2” tables. These changes mean that similarly named S2 and S3 tables are not necessarily based on equivalent data. Anyone using the S3 tables should consider both the choice of table and how this is adjusted, to ensure the mortality assumptions are appropriate to their scheme.

### Notes

This Briefing note provides an overview of the final “S3” mortality tables, the latest mortality tables produced by the CMI SAPS Committee. This note is intended for use by those who are presented with results where “S3” tables have been used as part of the mortality assumptions – such as trustees or sponsors of pension schemes. We strongly encourage actuaries using the “S3” tables to refer in addition to Working Papers 107 and 113 and their associated outputs.

While we frequently refer to just “S3” in the interests of brevity, in this note this should be understood as “final “S3” Series mortality tables” and we similarly refer to just “S2” and “S1”. We refer to “SAPS tables” as an umbrella term for all of the tables produced by the SAPS Committee, i.e. S1, S2 and S3.

Some background about the CMI and the SAPS tables as well as a definitions section are included at the end of this note; defined terms are indicated in **bold italics**.

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### Tables

The S3 Series consists of 30 tables; each relates to a subset of the total dataset. The tables are defined by:

- Gender



- Member type: “Pensioners” are members of the pension scheme in their own right and can be subdivided into “Normal health” and “Ill-health retirement” subsets, where the retirement type is known. “Dependants” became entitled to a pension on death of the original pension scheme member.
- Weighting: Most of the tables are “amounts-weighted”, where data is weighted according to pension amount, but we have also issued some “lives-weighted” tables, where each life has equal weighting.
- Pension amount band: The amounts-weighted data has also been split into “Heavy”, “Middle”, “Light” and “Very Light” subsets according to pension amount.

The naming convention for the S3 tables is of the form S3{Type}{Gender}{Weighting}\_{Band}. For example, the male Pensioner Amounts table for S3 is known as S3PMA. The naming convention is consistent with the S1 and S2 tables, with the exception of the Very Light tables, which are new for S3.

There is a wider range of tables in S3 than in its predecessors. Table 1 shows the S3 tables and how these compare with previous series. The presence of a digit 1, 2 or 3 in the table indicates inclusion of that table in the S1, S2 or S3 tables respectively. Gold highlighting is used for tables which are included in the S3 tables and were not included in the S2 tables.

Table 1: Tables included in the S1, S2 and S3 Series

		Lives			Amounts			Amounts			Amounts			Amounts			Amounts		
					All			Heavy			Middle			Light			Very Light		
Pensioners	Males	1	2	3	1	2	3	1	2	3		2	3	1	2	3			3
Pensioners	Females	1	2	3	1	2	3	1	2	3			3	1	2	3			3
Normal health	Males				1	2	3	1	2	3			3	1	2	3			3
Normal health	Females				1	2	3	1	2	3			3	1		3			3
Ill-health	Males				1	2	3												
Ill-health	Females				1	2	3												
Dependants	Males			3			3												
Dependants	Females	1	2	3	1	2	3	1						1		3			3

## Data

The SAPS tables are based mainly on data supplied by actuarial consultancies in respect of the mortality of members of the large pension schemes for which they act as Scheme Actuary. Additional private sector data is received from the Pension Protection Fund and public sector data is received from the Government Actuaries Department. The majority of data submissions cover a period of three years, consistent with many schemes having triennial valuations. Specifically, the S3 tables are based on data for 2009-2016 – this is both more recent and much larger than the S2 and S1 datasets. In particular, the datasets for female Pensioners and male Dependants are significantly larger for S3.

The S3 tables have an **effective date** of 1 January 2013 for **initial rates of mortality**,  $q_x$ . The **exposure** data for each year in the S3 dataset was adjusted prior to graduation, by projecting forward or backward to 2013, using the latest version of the CMI Mortality Projections Model, CMI\_2017.

## Pension amount bands

For each set of SAPS tables, we segment the data by pension amount band. This is used as a proxy for socio-economic status:



- Those with large pensions are likely to have had higher earnings and to exhibit lighter mortality;
- In contrast, those with low pensions are likely to have had lower earnings and to exhibit heavier mortality.

For S3, the Committee carried out a review of how mortality varies by pension amount. As a result, the band limits for S3 are quite different to S1 and S2. In addition, the “Very Light” band was introduced; this is a subset of the “Light” band for individuals with pensions in excess of £40,000 p.a. for males and £16,000 p.a. for females.

Table 2 shows the limits of each Pensioner band for the S1, S2 and S3 tables – the same limits are used for Normal health tables and the Light and Very Light female Dependant tables.

**Table 2: Amount band limits (£ p.a.) by gender**

	Males			Females		
	S1	S2	S3	S1	S2	S3
Heavy	0 - 1,500	0 - 1,700	300 - 5,000	0 - 750	0 - 850	0 - 1,000
Middle	1,500 - 13,000	1,700 - 14,750	5,000 - 20,000	750 - 4,750	850 - 5,500	1,000 - 8,000
Light	13,000+	14,750+	20,000+	4,750+	5,500+	8,000+
Very Light			40,000+			16,000+

The S3 amounts bands were chosen based on analysis of the variation in mortality experience by pension amount.

For male Pensioners:

- Experience for individuals with very low pensions (less than £300 p.a.) appeared anomalous compared with larger pension amounts. The Committee believes this is more likely to be due to errors or artefacts in the data than reflecting genuine experience, therefore this data was removed from the S3 dataset.
- Experience was fairly similar for pensions between £300 p.a. and £5,000 p.a. meaning that it was a straightforward decision to group these into the Heavy band. This resulted in a much wider Heavy amounts band than for S1 and S2.
- The choice of boundary for the Middle and Light tables was less clear cut, but this was chosen with reference to the corresponding S2 limit, increased with the Retail Prices Index, and the shape of experience.

For female Pensioners there is less variation in mortality experience by pension amount, compared with male Pensioners. However, a similar approach was adopted to set the updated amounts band limits.

## Construction of the tables

The S3 tables use a typical CMI approach:

- Data was graduated over age ranges for which we consider the data to be reliable. The remaining data is not used and instead extensions are applied to lower and higher ages; this process involves some judgement.
- Mathematical formulae were used for the **graduations**; the formula for each table was selected using a combination of statistical tests and pragmatic judgement.
- The graduated rates were then extended to lower and higher ages, to produce a complete set of rates from age 20 to 120.

The broad approach is similar to the S1 and S2 tables; however, there were some differences:

- Age range: For some tables the graduated age range was different for S3. In particular, this affected the ill-health tables, which were graduated over the age range 35-95 for S2 but the age range 60-95 was



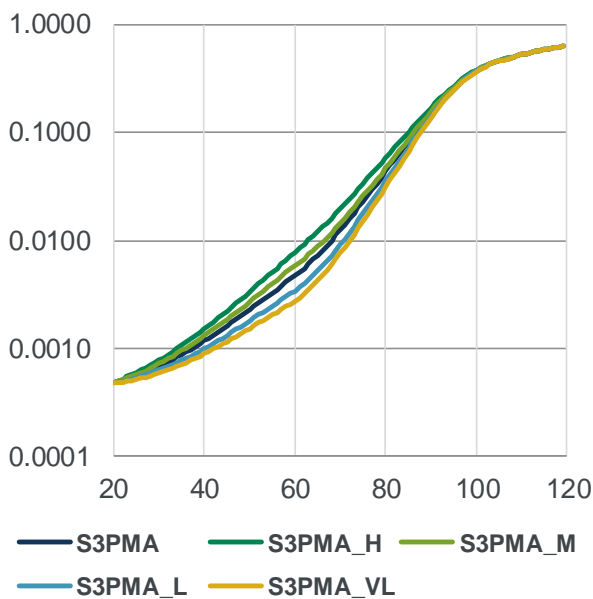
used for S3. This change reflects significant differences in ill-health mortality rates in the S3 dataset at younger ages, compared with S2.

- Formula selection: For the S3 tables, more emphasis has been placed on choosing formulae which are simple and consistent, rather than focusing on the best-fitting formula for each individual table.
- The method used to extend the graduated S3 rates to advanced ages was the method proposed by the CMI’s High Age Mortality Working Party. This assumes that mortality rates converge towards those of a more reliable “reference” population as age increases; we used national population mortality for the United Kingdom as the reference.
- The extensions of the graduated rates to younger ages have limited financial materiality but are produced for completeness. For most of the S3 tables, the rates are extended so that mortality rates reduce smoothly to reach national population mortality for the appropriate gender at age 20.

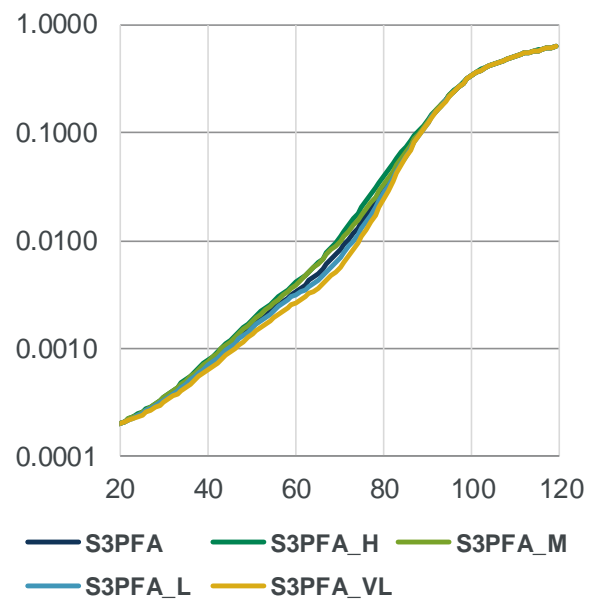
## Results

Charts 1 and 2 show initial mortality rates  $q_x$  between ages 20 and 120, including low and high age extensions, and compare rates for related tables. There is a greater distinction between Male Pensioner Amounts tables than female Pensioner Amounts tables.

**Chart 1: Mortality rates ( $q_x$ ) for male Pensioner amounts tables (log scale)**



**Chart 2: Mortality rates ( $q_x$ ) for female Pensioner amounts tables (log scale)**



**Period life expectancies** at age 60 for the male and female Pensioner Amounts tables are shown in Table 3. The variation in mortality rates that was seen in Charts 1 and 2 translates to a 4.7 year gap in life expectancy for males between the Heavy to the Very Light tables. For females the difference is only 2.5 years. Life expectancies for the All tables (i.e. the data before being divided into pension amount bands) sit between the Middle and Light bands for both males and females.

**Table 3: Period life expectancies at age 60 for S3 Pensioner Amounts tables on 1 January 2013**

	Table	Males	Females
All	S3PMA, S3PFA	24.9	27.2
Heavy	S3PMA_H, S3PFA_H	22.4	25.8
Middle	S3PMA_M, S3PFA_M	24.2	26.6



Light	S3PMA_L, S3PFA_L	26.3	27.7
Very Light	S3PMA_VL, S3PFA_VL	27.1	28.3

## Changes from S2 to S3

The changes in the method and composition of the dataset used in the S3 tables means that similarly named S2 and S3 tables are not necessarily based on equivalent data. Anyone using the S3 tables should consider both the choice of table and how this is adjusted, to ensure the mortality assumptions are appropriate to their scheme.

The key differences between the S2 and S3 tables are:

- Changes to the composition of the SAPS dataset. The SAPS dataset changes over time as pension schemes, or their advisors, decide to start or cease contributing to SAPS. In particular, data has recently been submitted to SAPS for a number of large public sector schemes.
- Changes to the amount band limits. As noted above, the amounts bands are defined differently for S3 compared with S2. In particular, the Male Heavy tables represent a larger proportion of the data in S3 than in S2.
- Mortality improvements for pension scheme members in the S3 dataset appear to have been higher, over the time period of the dataset, than those in the general population. For comparison purposes, the S2 tables are adjusted using the CMI Mortality Projections Model, which is calibrated to population-level improvements.
- Changes in formulae used to produce the tables. Many of the tables use a different graduation formula for S3 compared with S2. This could lead to changes in the shape of graduated tables, even if the underlying data was consistent.
- Changes to graduation methods. The high age and low age extension methods have been amended from those used in the S2 tables.

Table 4 shows the change in period life expectancies at age 60 moving from S2 rates (projected to a consistent date of 1 January 2013 using the latest version of CMI Mortality Projections Model, CMI\_2017) to S3 rates. A positive value means that the S3 table gives a higher life expectancy than the equivalent projected S2 table.

**Table 4: Change in period life expectancies at age 60 on 1 January 2013, S3 Pensioner Amounts tables compared with S2 Pensioner Amounts tables projected with the CMI Mortality Projections Model**

	Table	Males	Females
All	S2PMA, S2PFA	+1.5%	+3.0%
Heavy	S2PMA_H, S2PFA_H	+0.4%	-0.1%
Middle	S2PMA_M	+2.7%	N/A
Light	S2PMA_L, S2PFA_L	+1.8%	+3.8%

## About the CMI

The Continuous Mortality Investigation (CMI) provides authoritative and independent mortality and sickness rate tables for actuaries advising UK life insurers and pension funds.

The CMI operates as a private company which is wholly owned by the Institute and Faculty of Actuaries (IFoA). The company has a board of two directors, appointed by the IFoA, and an Executive Committee which oversees the CMI's work. The CMI is funded by subscriptions from commercial users. Subscribers have access to all of



the outputs produced by the CMI; these are also made available to academics and researchers for non-commercial use<sup>1</sup>.

A key area of the CMI’s work is to produce mortality base tables that reflect the most recently available data. The S3 tables are the latest CMI mortality tables for UK self-administered pension schemes, produced by the CMI Self-administered Pensions (SAPS) Mortality Committee, and are the focus of this note. The Committee consists of volunteers from a variety of employers, including most of the leading actuarial consultancies; vacancies for new members are widely advertised in the actuarial community when they arise.

### Why are SAPS mortality tables needed?

The Office for National Statistics (ONS) publishes population mortality tables for the United Kingdom on an annual basis. However the shape and level of mortality rates differ for members of pension schemes, compared with the general population. Pension scheme members tend to have lighter mortality (i.e. they are likely to live longer) than the general population. Pension schemes also often use amounts-weighted mortality assumptions, where mortality data is weighted by amount of pension, as individuals with higher pensions tend to live longer, but population tables are lives-weighted.

Table 5 shows that, in 2013 when the S3 tables apply, male Pensioners aged 60 were expected to live 0.9 years longer than males in the general population. The gap for female Pensioners was slightly larger at 1.2 years. Note these are **period life expectancies**, meaning that there is no allowance for future improvements in mortality rates.

**Table 5: Period life expectancies at age 60 for population tables and S3 tables on 1 January 2013**

	Table	Males	Females
Population table	NLT12-14	22.6	25.3
S3 table	S3PML, S3PFL	23.5	26.5

### History of SAPS mortality tables

The SAPS mortality investigation started to collect data from pensions consultancies in January 2003 and the Committee issued S1 tables in 2008. Consultancies continued to submit mortality data on behalf of their clients and in 2014 the Committee issued the S2 tables, based on an updated dataset. The S3 tables are a further update, based on data for 2009-2016, a larger and more recent dataset than for the S1 and S2 tables.

The history of SAPS tables is summarised in Table 6.

**Table 6: Summary history of SAPS mortality tables**

Series	Underlying data	Effective date	Working Paper (proposed tables)	Working Paper (final tables)
S1	1 January 2000 – 31 December 2006	1 September 2002	WP32 (January 2008)	WP35 (October 2008)
S2	1 January 2004 – 31 December 2011	1 January 2007	WP66 (April 2013)	WP71 (February 2014)
S3	1 January 2009 – 31 December 2016	1 January 2013	WP107 (June 2018)	WP113 (December 2018)

<sup>1</sup> Details of how to access the final “S3” Series tables, Working Paper 113 and the CMI’s other research can be found on the [CMI section of the IFoA’s website](#). The website also sets out current subscription fees which vary according to the size of the organisation, currently starting at £300 pa per qualified actuary for a small consultancy.



## Definitions

A **mortality rate** is the proportion of people, of a given age and gender, that are expected to die in the following year. These can be expressed in different ways but, in particular, an **initial rate of mortality** ( $q_x$ ) is the probability that a person aged  $x$  dies before reaching age  $x + 1$ .

**Exposure** is a measure of the number of people in receipt of a pension at each age and gender during a year. We divide the number of people dying at a particular age by the exposure at that age to calculate the mortality rate. For amounts-weighted tables, we use the amount of pension being paid instead of the number of people.

In constructing a mortality table, we normally use data for a number of years to avoid volatility that can arise; for example as a result of a particularly harsh winter.

The **effective date** of a mortality table is the date at which the mortality rates apply. If actuarial calculations are being carried out at any date other than the effective date, users should consider allowing for changes in mortality between these dates.

A **graduation** of mortality rates is a form of smoothing, to produce rates that progress smoothly between ages. Graduation usually uses a mathematical formula to represent the shape and level of the rates, with parameters for the formula chosen to fit the underlying data.

Life expectancy is a measure of how long – on average – someone of a particular age and gender will live.

**Period life expectancy** only depends on mortality rates at a point in time, with no allowance for mortality rates to change in future. It is an objective measure that is often reported by the Office for National Statistics. (In contrast, **cohort life expectancy** also depends on assumptions regarding future changes in mortality. Consequently, it is a subjective measure, and is typically used by actuaries who need to use realistic assumptions about what may happen in the future.)

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