



Continuous Mortality Investigation

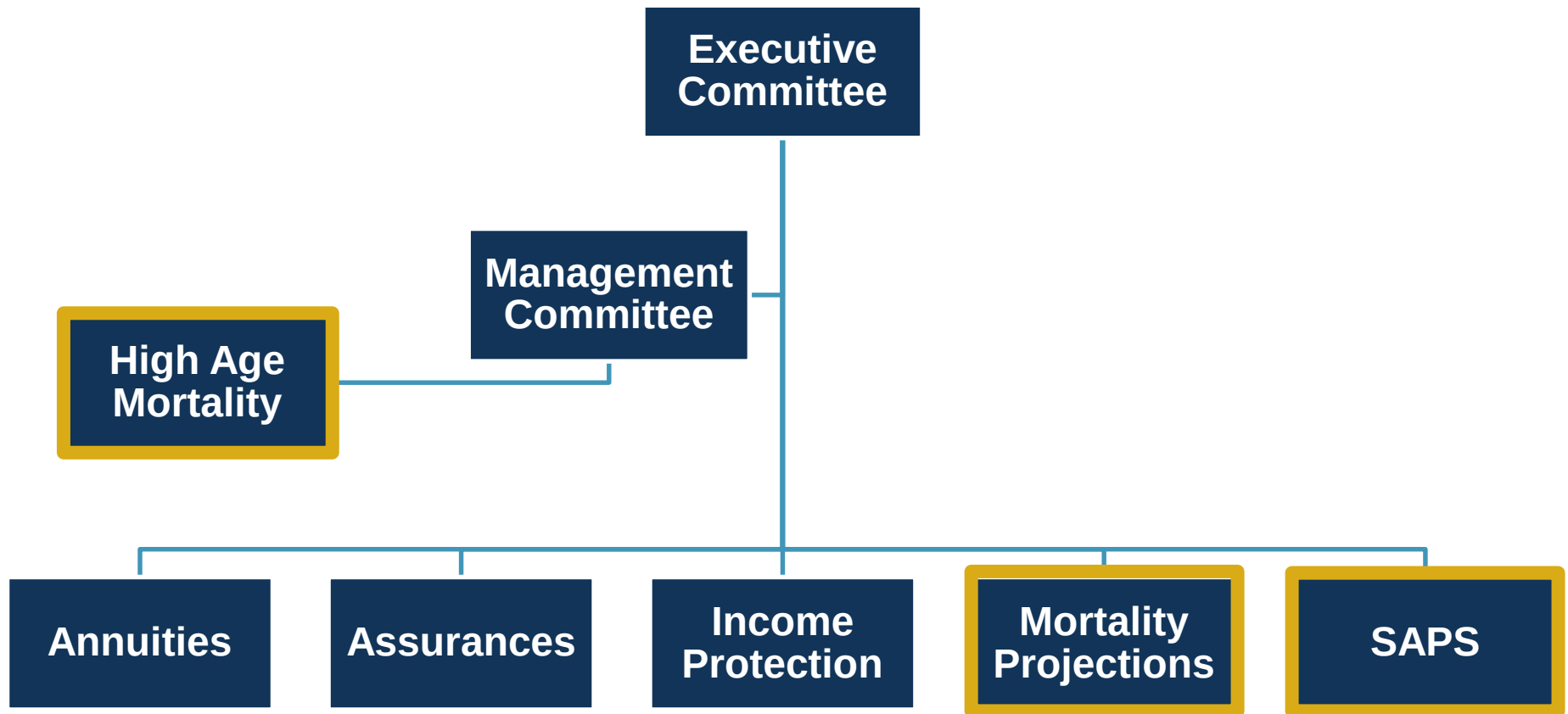
Institute and Faculty of Actuaries

CMI Update

ACA Conference 2015

Katherine Fossett

CMI Structure



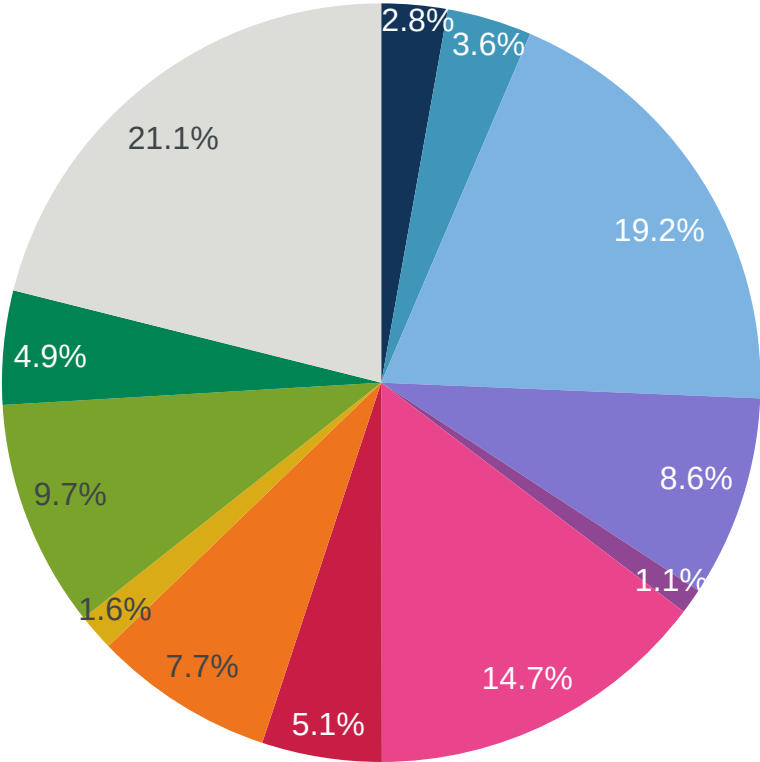
Self Administered Pension Schemes (SAPS)

SAPS timeline

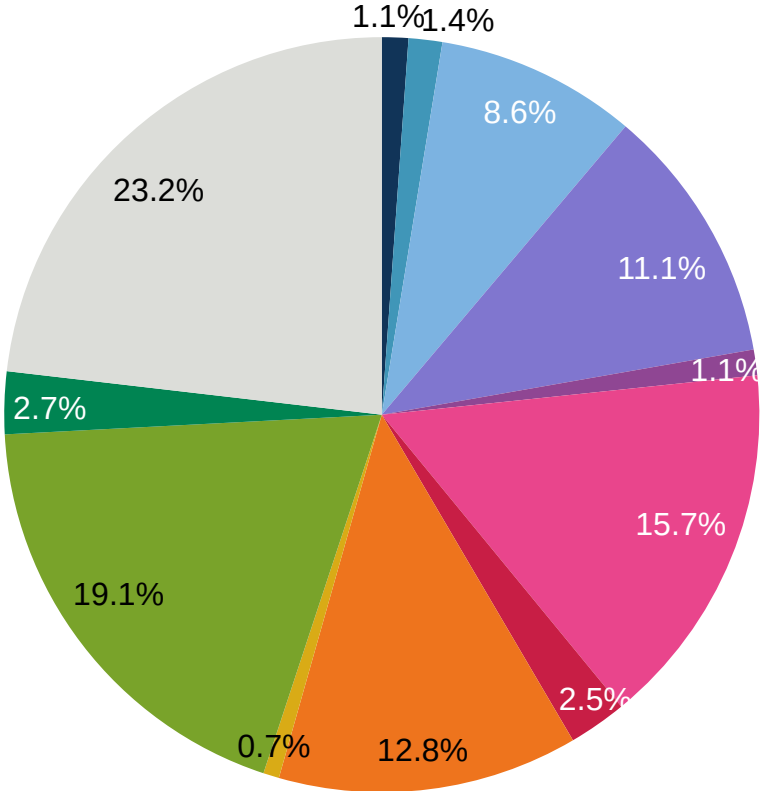
Date	Activity
2002 to 2006	Research and consultation
October 2008	“S1” Series tables released (based on data covering 2000-2006)
April 2010 & May 2011	Annual experience updates covering 2001-2008 & 2002-2009
July 2011	Mortality improvements of self-administered pension schemes
May 2012	Analysis of mortality experience by industry classification
May 2012 & April 2013	Annual experience updates covering 2003-2010 & 2004-2011
April - May 2013	Consultation on proposed “S2” Series tables
February 2014	“S2” Series tables released (based on data covering 2004-2011)
July 2014	Annual experience update covering 2005-2012
December 2014	Annual experience update covering 2006-2013
November 2015	Analysis of mortality experience by industry classification

Industry Analysis – Exposure

Exposure by Industry - Males

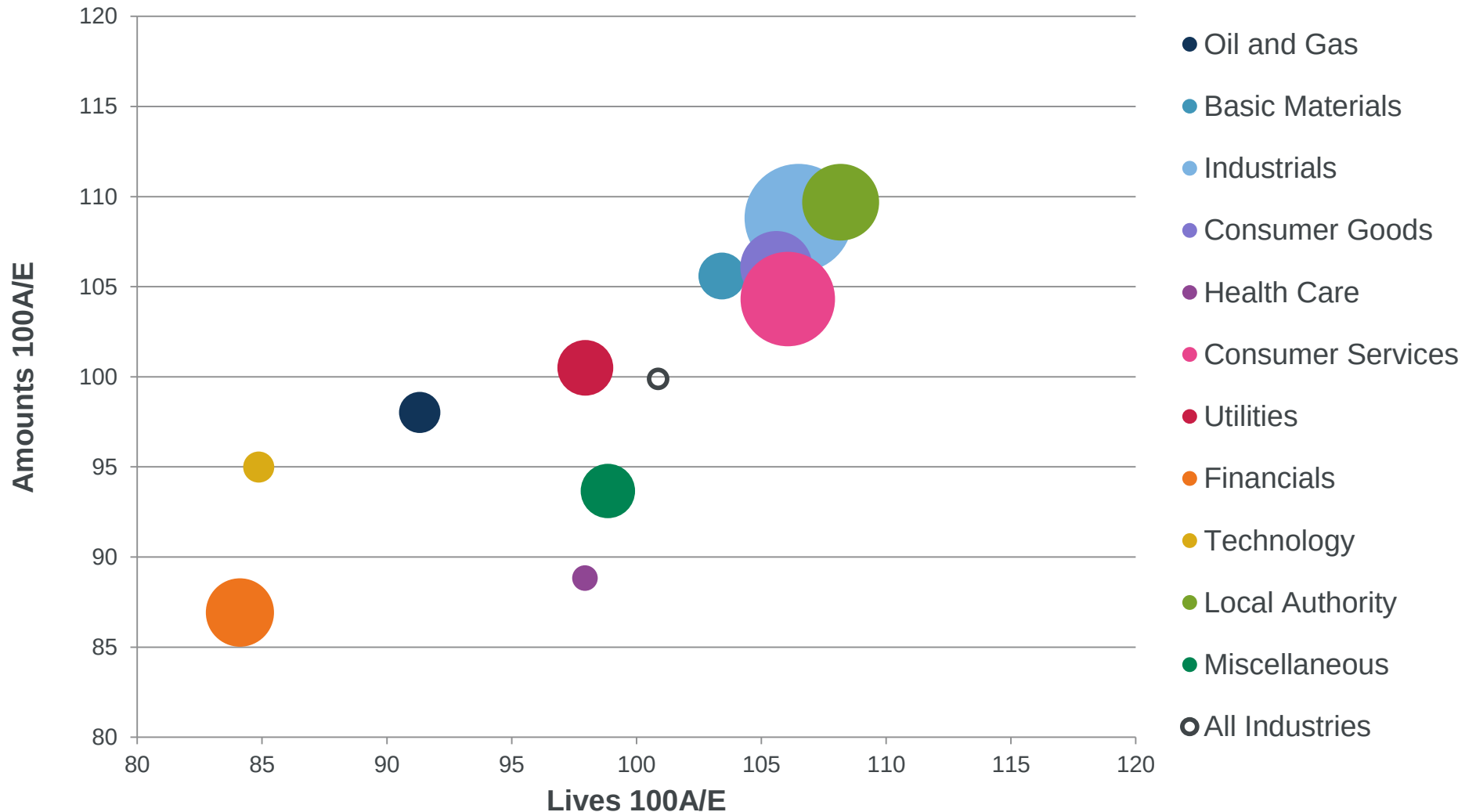


Exposure by Industry - Females

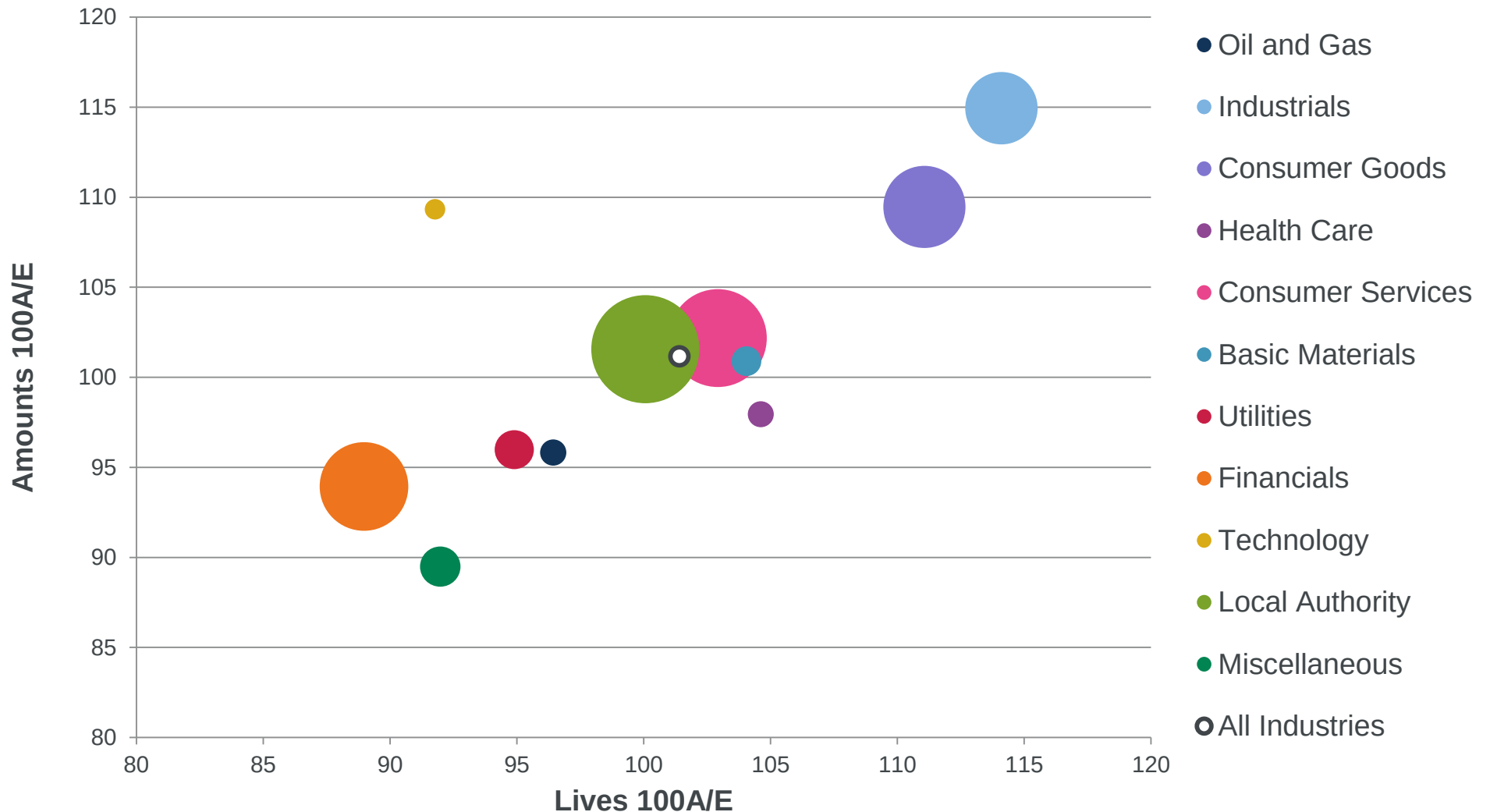


- Oil and Gas
- Basic Materials
- Industrials
- Consumer Goods
- Health Care
- Consumer Services
- Utilities
- Financials
- Technology
- Local Authority
- Miscellaneous
- Not Included in Industry Analysis

Industry Analysis – Experience – Males



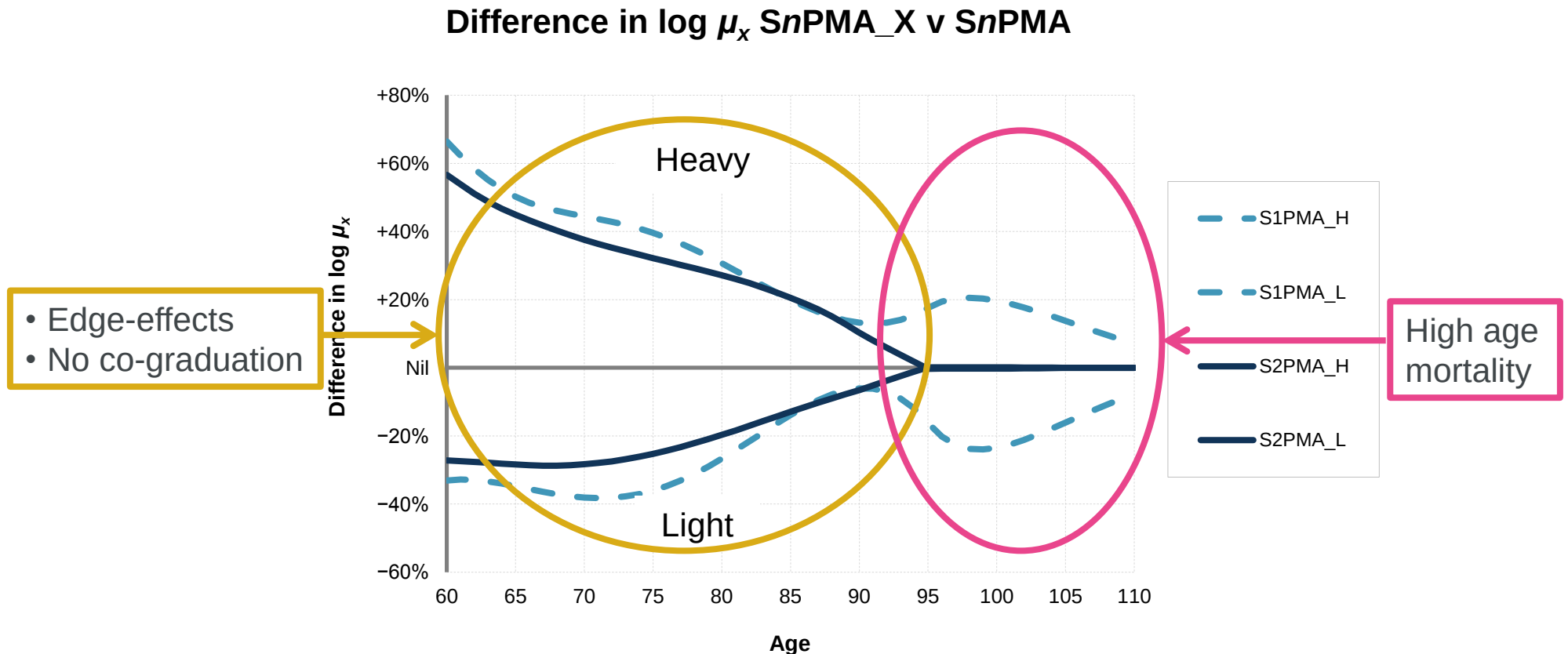
Industry Analysis – Experience – Females



What is next for SAPS?

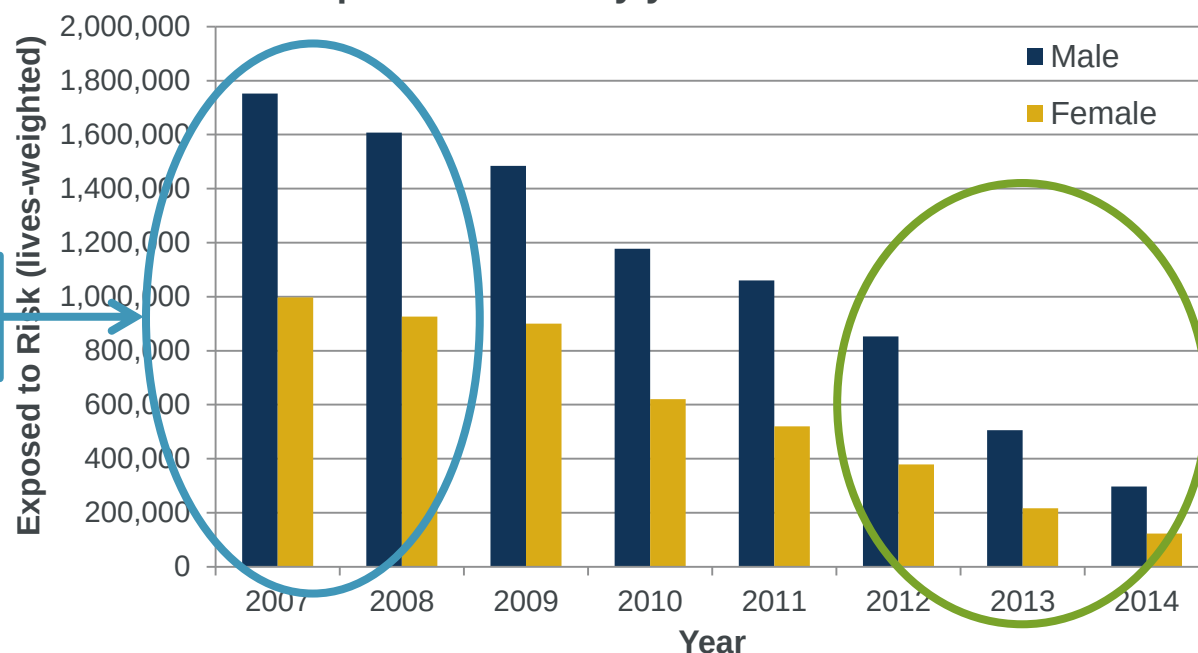
- Annual experience update for 2007-2014
 - Due for release soon
- Analysis of public sector data
- Mortality Improvements of self-administered pension schemes?
- “S3” Series tables?
 - Considering co-graduation
 - Awaiting recommendations for high ages
 - No immediate plans to begin work on “S3” Series

High Age Extrapolation of “S2” Series



Data Collection – Size of Current Dataset

Exposed to Risk by year - 2007-2014 dataset



Lots of data in earlier years.

Later years incomplete

- Total: 8.7m Male Pensioners and 4.7m Female Pensioners
- Dataset is large but could still be larger
- Continued submissions essential to ensure analyses remain current

Data Collection – Submitting Data

- Data submission specifications in [SAPS Coding Guide](#)
 - Continuation data to be submitted where possible
 - Ideally submit data starting from earliest date possible (i.e. include previous valuation cycles, even if already submitted)
- CMI has reviewed its data handling procedures
- Postcode data has proved insufficient for analysis
 - Committee will stop collecting postcode data

High Age Mortality Working Party

Background

High Age Mortality Working Party (HAMWP)

- Established Summer 2014
- Members predominantly drawn from CMI investigation committees

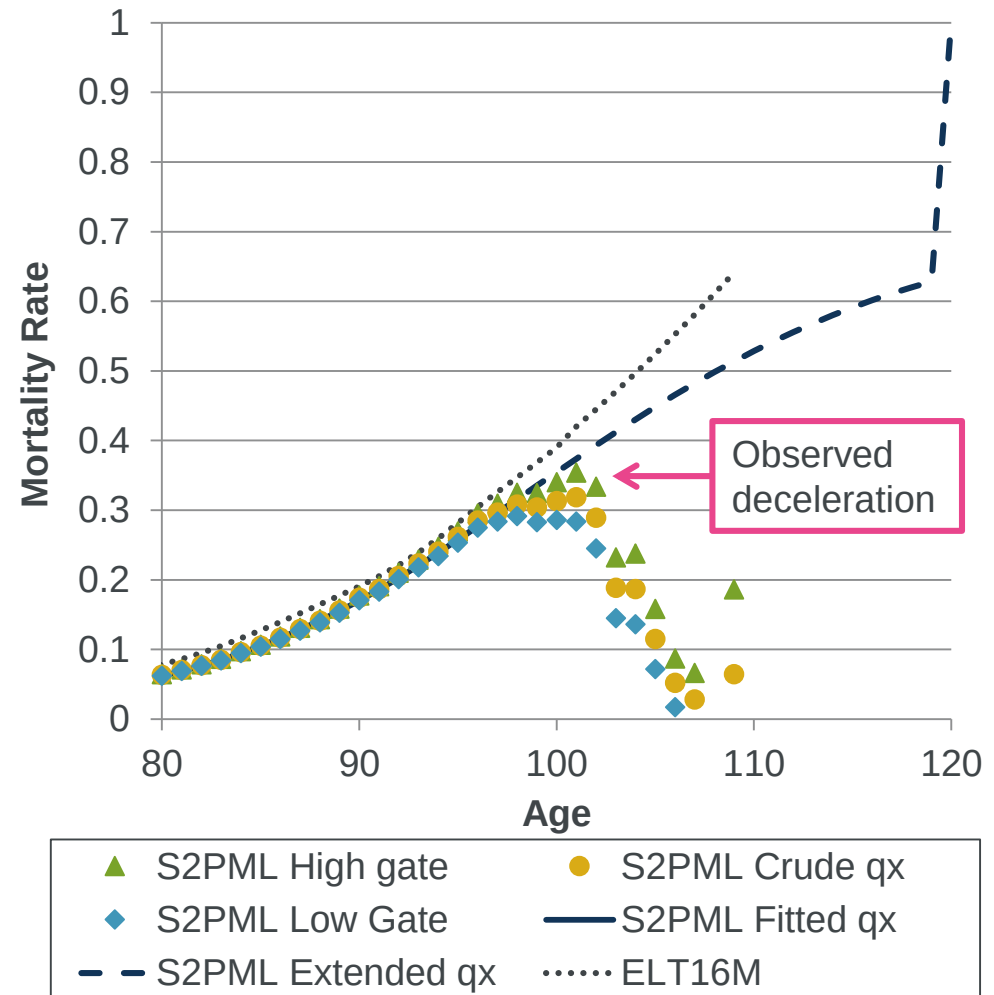
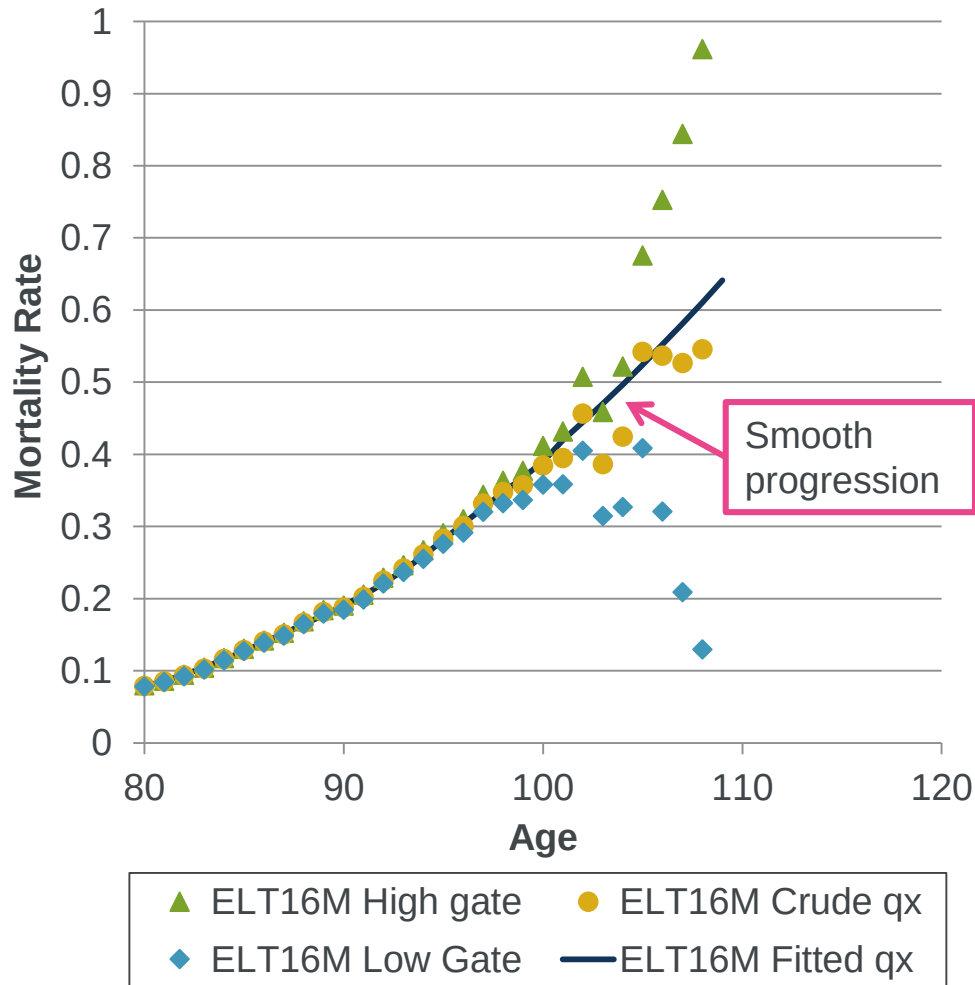
HAMWP terms of reference

- Investigate and summarise published research on high age mortality (90+)
- Investigate absolute mortality rates in respect of closing published tables
- Analyse data issues with available data sets (population / portfolio data)

CMI Working Paper 85

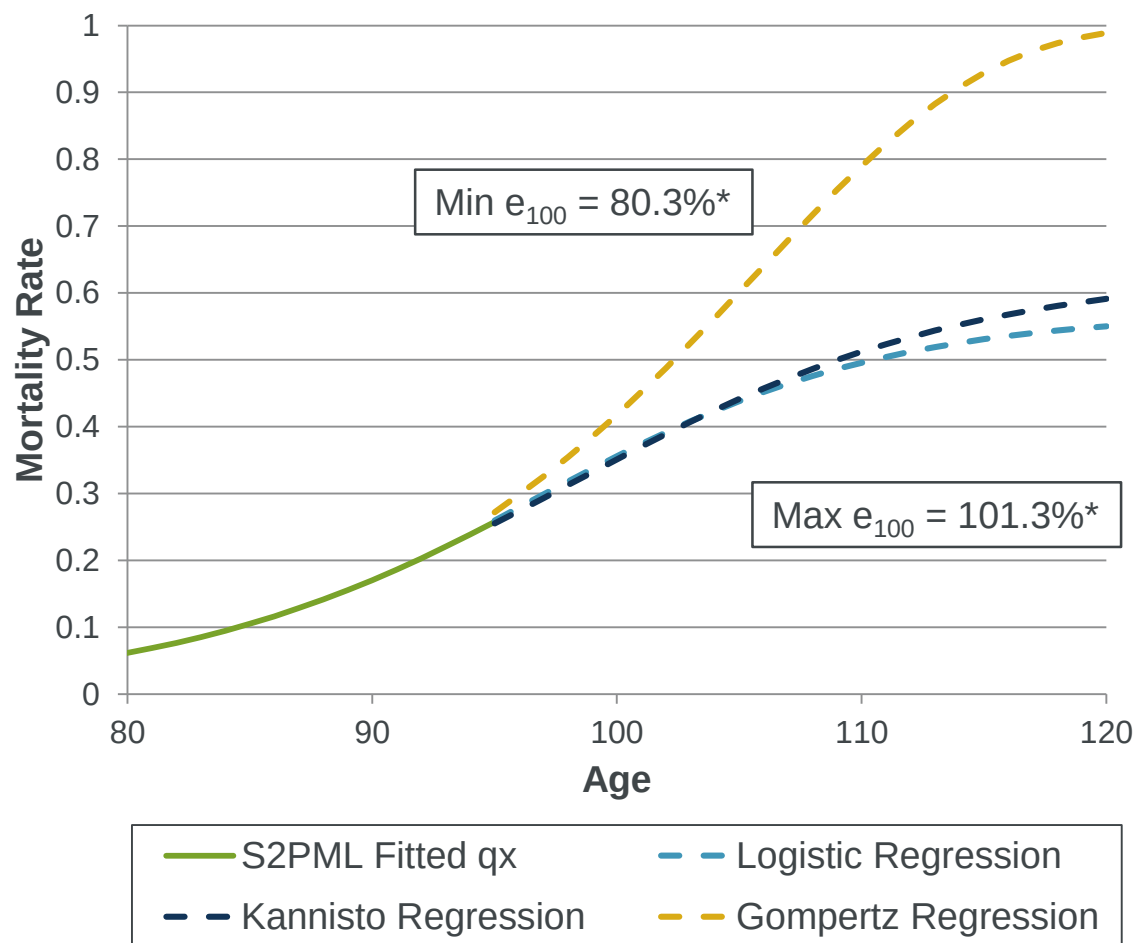
- Details analysis to date and possible future work

Fitting mortality rates at high ages



Academic Contributions

- A range of functional forms have been proposed for shape of mortality curve at older ages
- Graph shows impact on S2PML curve of **regressing** common functional forms
- Gompertz: $\mu_x = ae^{bx}$
- Kannisto: $\mu_x = ae^{bx}/(1 + ae^{bx})$
- Logistic: $\mu_x = c + ae^{bx}/(1 + ae^{bx})$



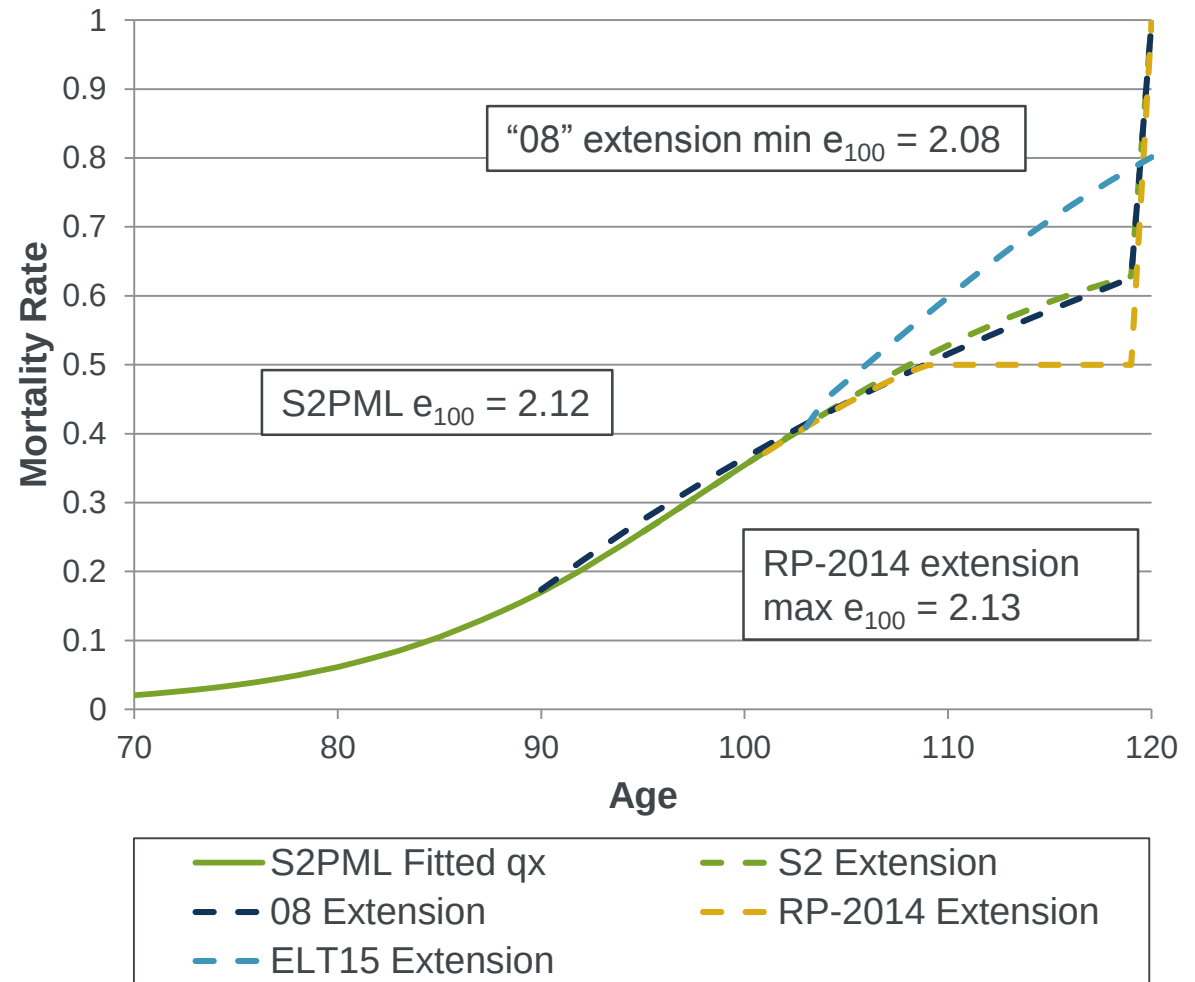
*relative to S2PML extension (baseline $e_{100} = 2.12$)

Summary of published tables

Table	Run in Age	Extension Approach	Limit mortality rate
ELT16	n/a	Variable-knot spline regression fitted to 108, used for high age extensions	$m_{120} = 2 / q_{120} \sim 1$
“S2” Series	95	Cubic spline with constraints	$\mu_{120} = 1 / q_{120} \sim 0.64$
“08” Series	90	Non-linear interpolation	$\mu_{120} = 1 / q_{120} \sim 0.64$
Canadian CPM2014	94	Quartic polynomial to bridge graduated rate to population rates at age 103	$q_{114} = 0.66$
US RP-2014	Between 75 and 100	Kannisto regression for high ages 75-104 / interpolation between main regression and high age	Cap on q_x of 0.5

Comparison of published graduations

- S2PML extended using methodologies underlying various industry tables
- Run in age used for each table applied to S2PML data
- Very little variation in e_{100} for the extensions shown due to closeness of q_x values near 100



Theories on mortality patterns at high ages

- Debate around mortality deceleration vs Gompertz progression at high ages
- A number of authors support deceleration with heterogeneous populations (frail die young) seen as main cause
- Gavrilov and Gavrilova (2011, 2014) propose no underlying deceleration, primarily due to:
 - Age misreporting
 - Aggregation of single year birth cohorts (heterogeneity)
 - Studying age-specific probabilities of death rather than force of mortality
 - Data recording in older studies was less accurate

What data issues should be considered?

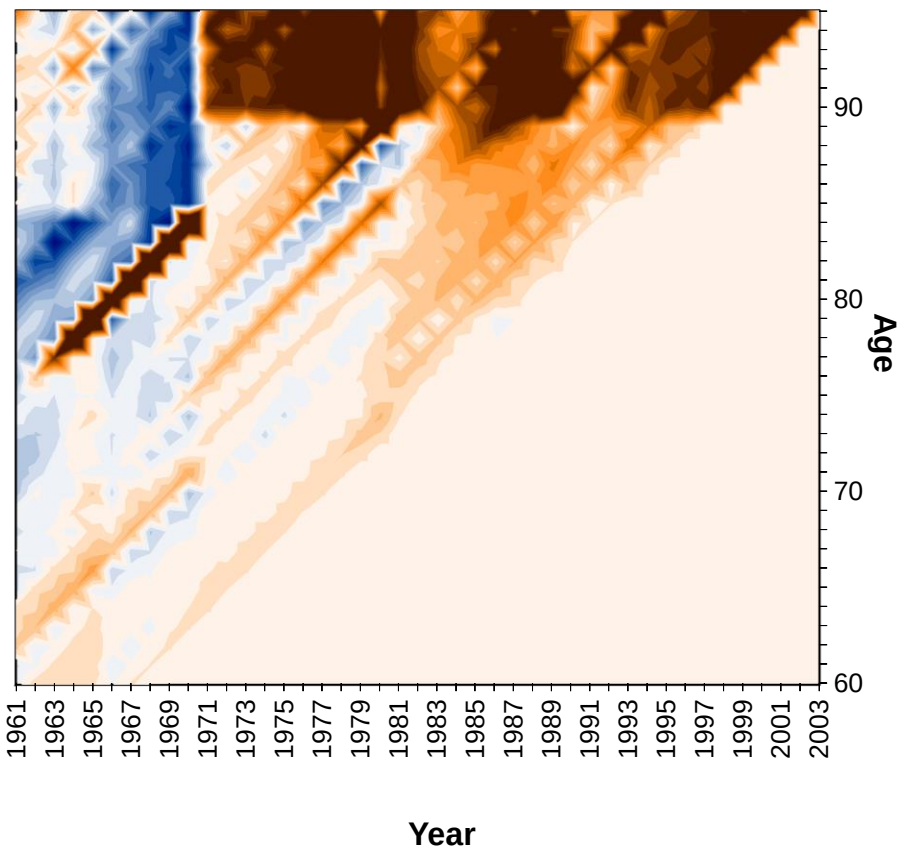
Issue	Population Data	Portfolio Data
Exposure estimation	Mid year population estimates used as proxy for exposed to risk	Exposed to risk calculated from data
Death reporting	Death registrations required within 5 days of death	Late reported / unreported deaths common
Phantoms	“Phantom” cohorts possible due to rolling forward of census data	“Phantom” exposures possible if deaths not removed from data set
Migration	Assumption required for impact on exposures	Tracing overseas deaths difficult, likely delays in reporting

Closed cohort mortality

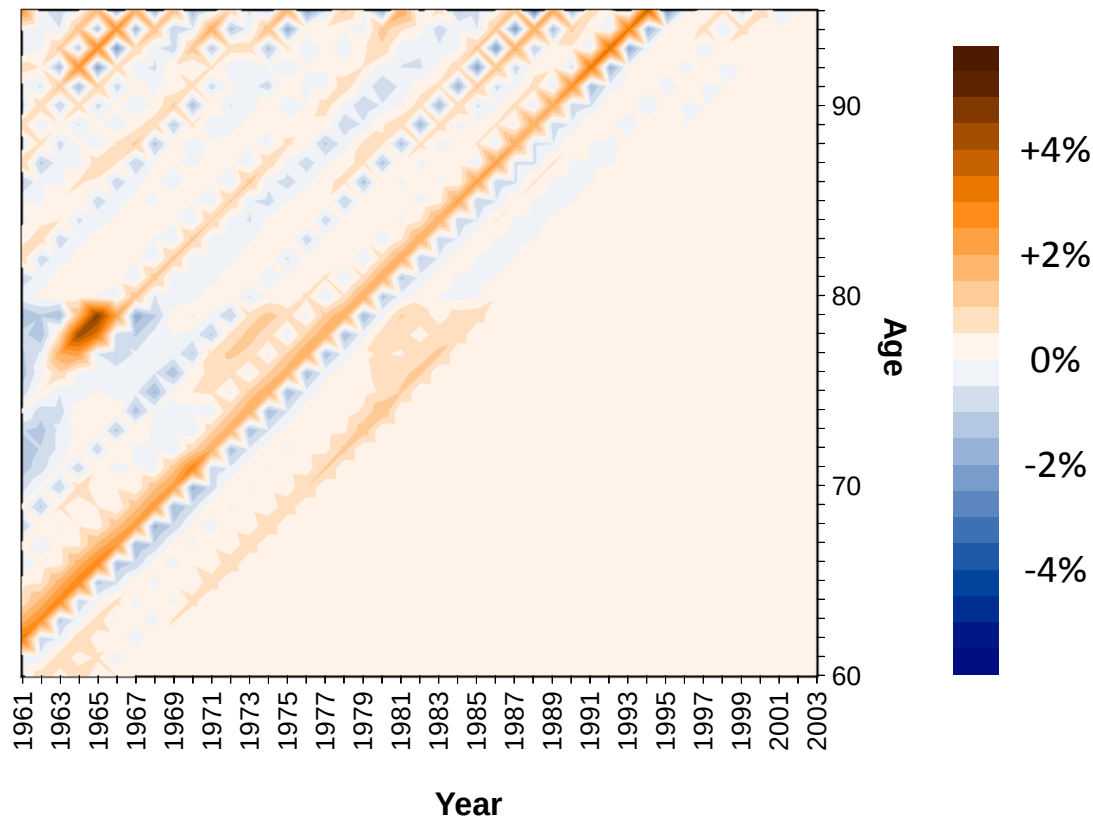
- Considered deaths for cohorts which are essentially extinct (reached their 110th birthday)
- Estimate historical populations (and mortality) from recorded deaths
 - Population for age x in calendar y year $y = P_{x,y}$
 - Deaths for age x in calendar y year $y = D_{x,y}$
 - $P_{\max,y} = D_{110,y}$
 - $P_{x,y} = P_{x+1, y+1} + D_{x,y}$
- Implied mortality compared against ONS and HMD published mortality

Closed cohort mortality

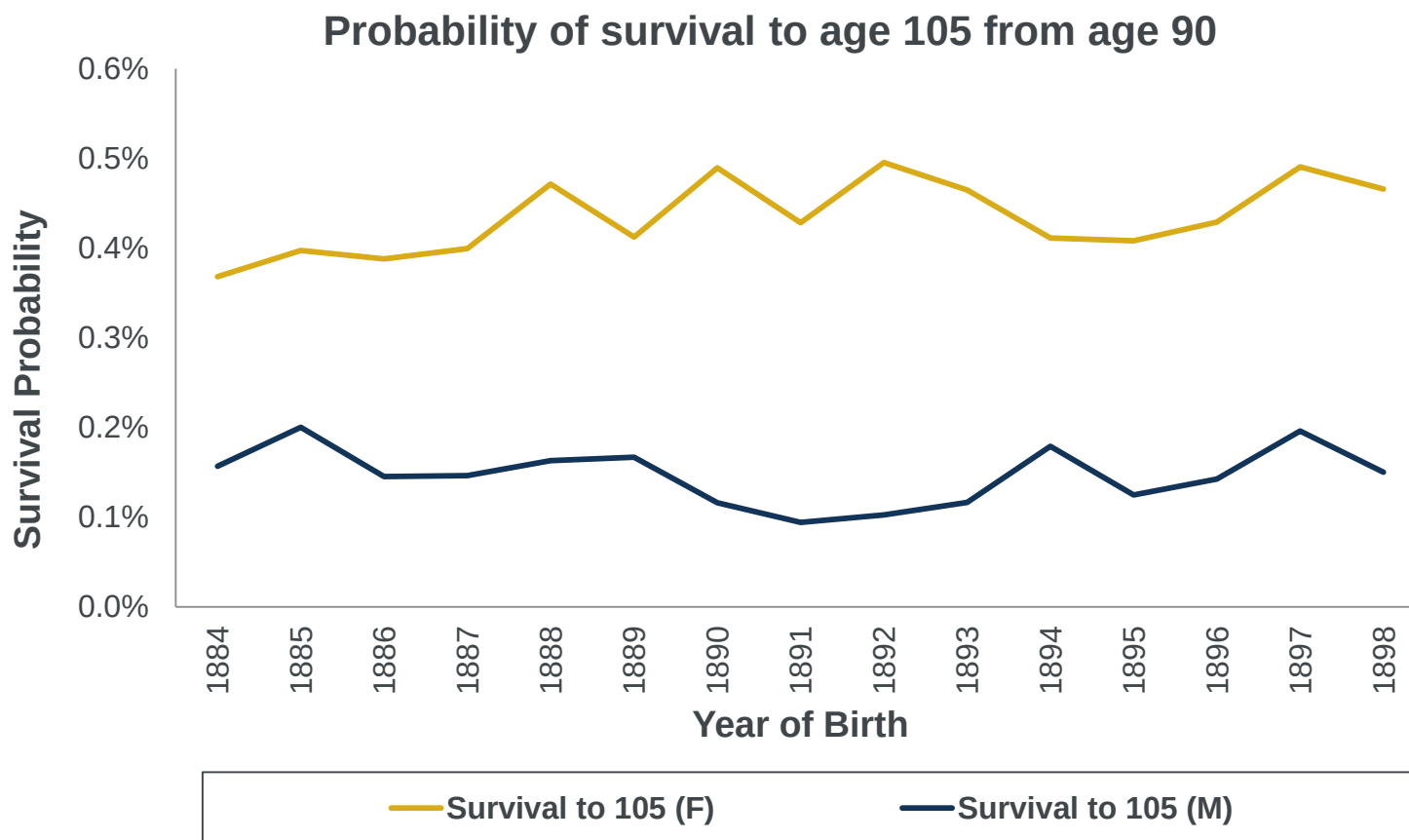
Extinct Generation mortality / ONS mortality -
England & Wales, Males



Extinct Generation mortality / HMD mortality -
England & Wales, Males



Areas of further investigation – time trends



- No clear evidence for a material change in mortality patterns for lives born between 1884 and 1898 in England & Wales data.

Summary of findings so far

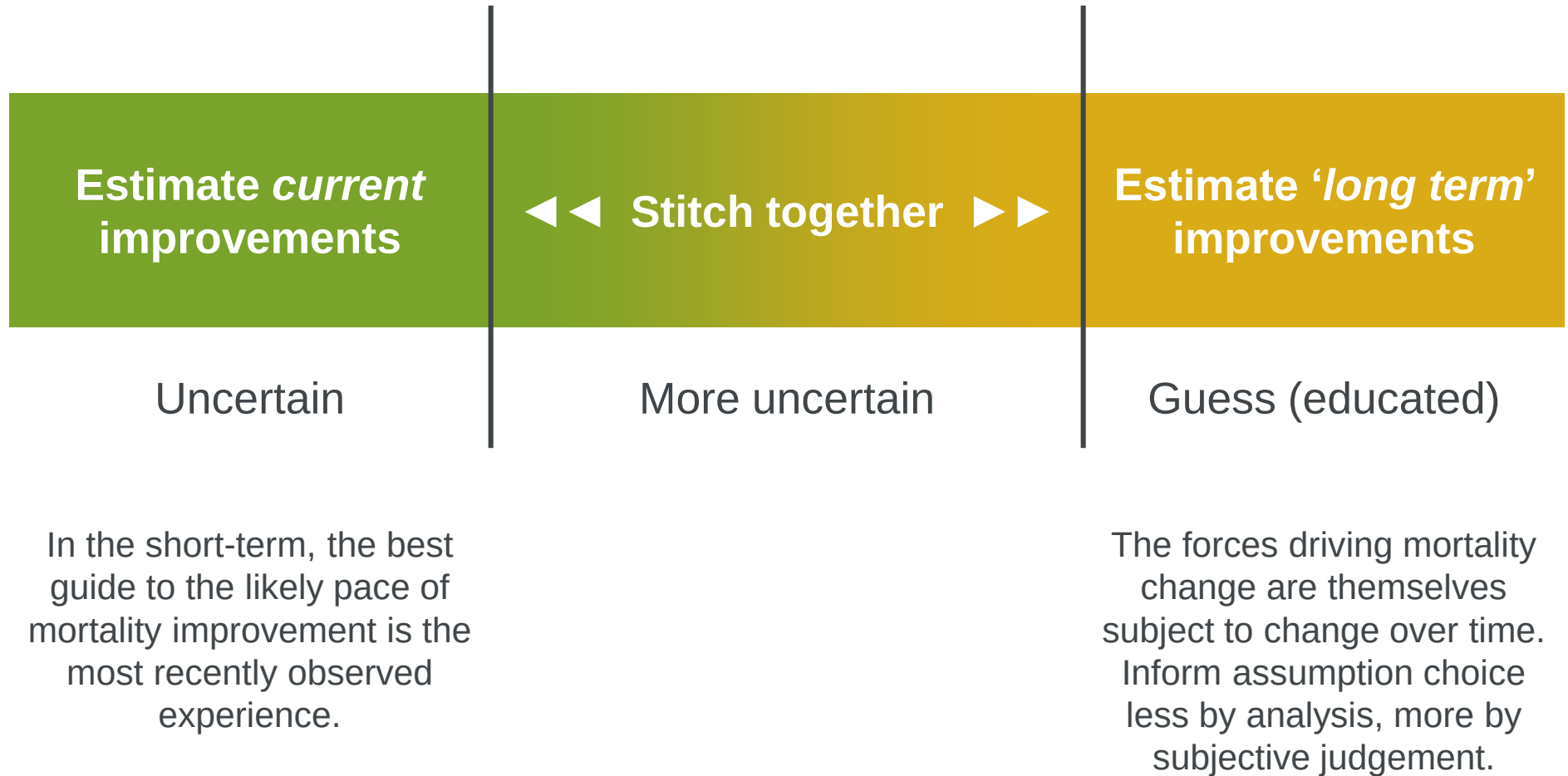
- Data and modelling issues at very high ages:
 - Inconclusive debate on mortality shape at high ages
 - Users should consider age misstatement and late reporting issues
 - Published closed cohorts mortality appears to be understated
- Impact of different mortality rates derived using different models generally not material except at very old ages
- Given this and data issues mentioned above, the Working Party feels that old age extrapolation choices in recent graduated CMI tables were reasonable
- Second phase of work now in early stages

Mortality Projections

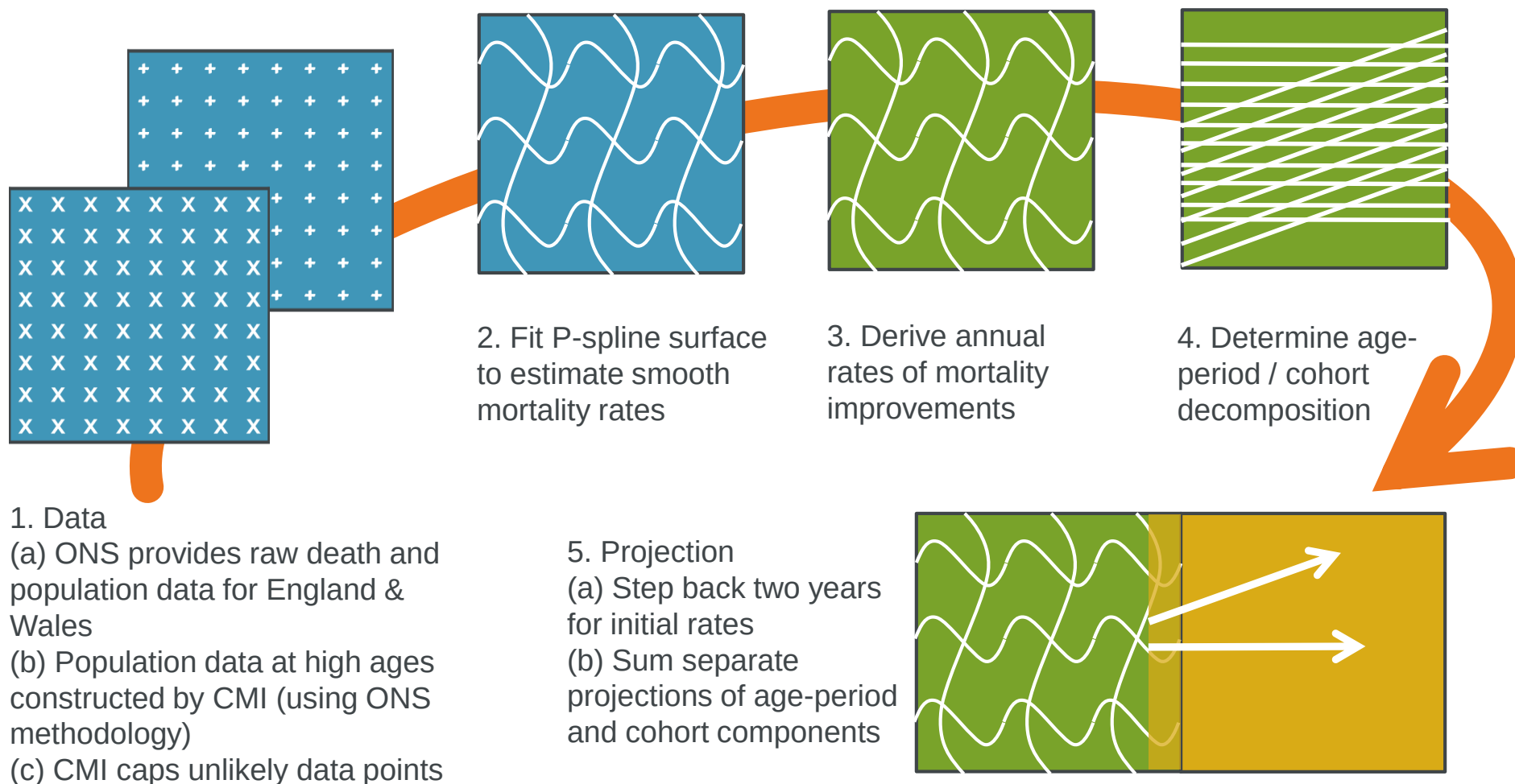
CMI Model timeline

Date	Model	Activity
2004 to 2008		Research and consultation
Nov 2009	CMI_2009	First version of the Model
Nov 2010	CMI_2010	Annual update
Sep 2011	CMI_2011	Annual update – CMI estimate of high age population
Feb 2013	CMI_2012	Annual update – Revised population estimates after 2011 Census
Apr 2013		Consultation on the Model
Sep 2013	CMI_2013	Annual update
Nov 2014	CMI_2014	Annual update – revisions to calibration method
Mar 2015		Consultation on the release date of future updates to the Model
Sep 2015	CMI_2015	Annual update plus paper on recent mortality
<i>Spring 2016</i>		<i>Consultation on the future of the Model</i>
<i>Mar 2017</i>	<i>CMI_2016</i>	<i>First version of revised model</i>

Current CMI Model – very high level overview

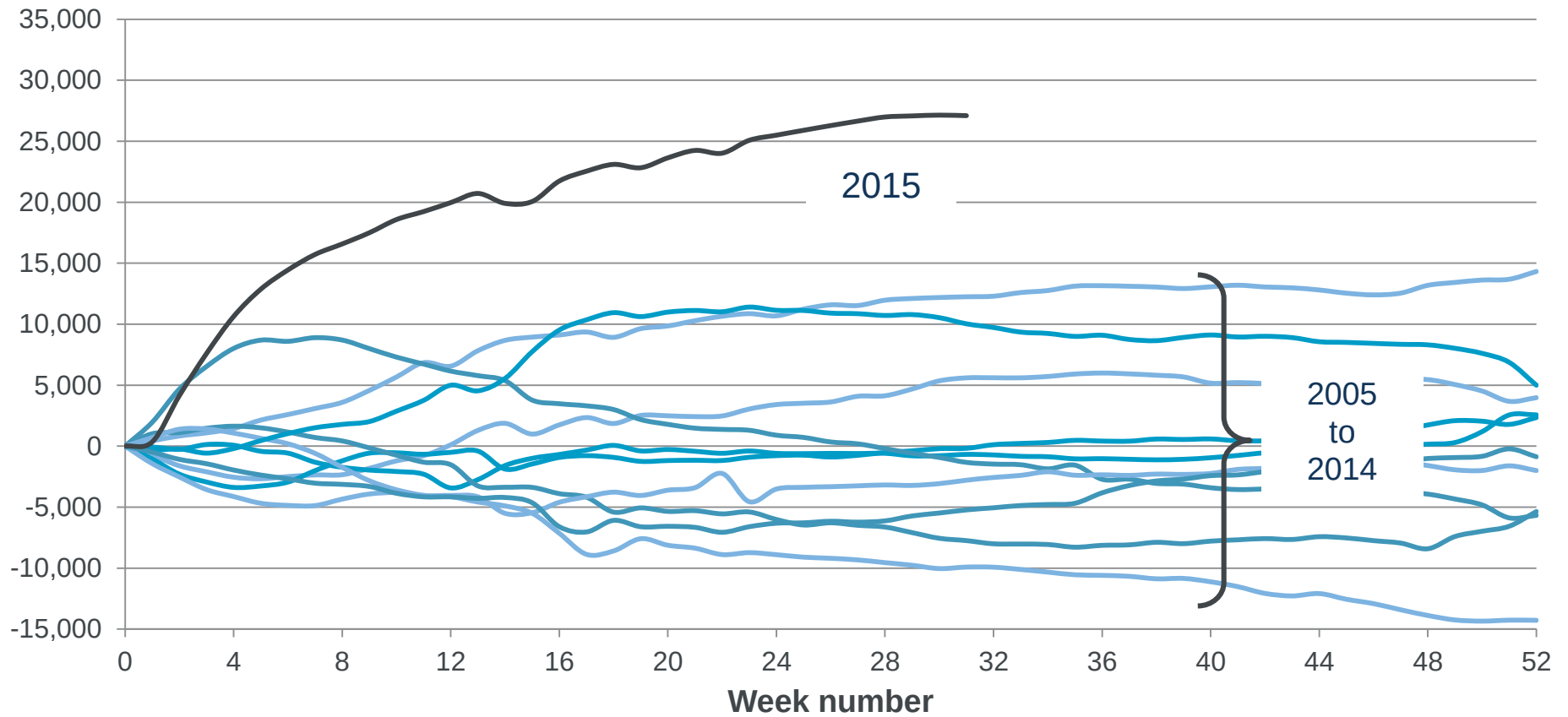


Current CMI Model – overview



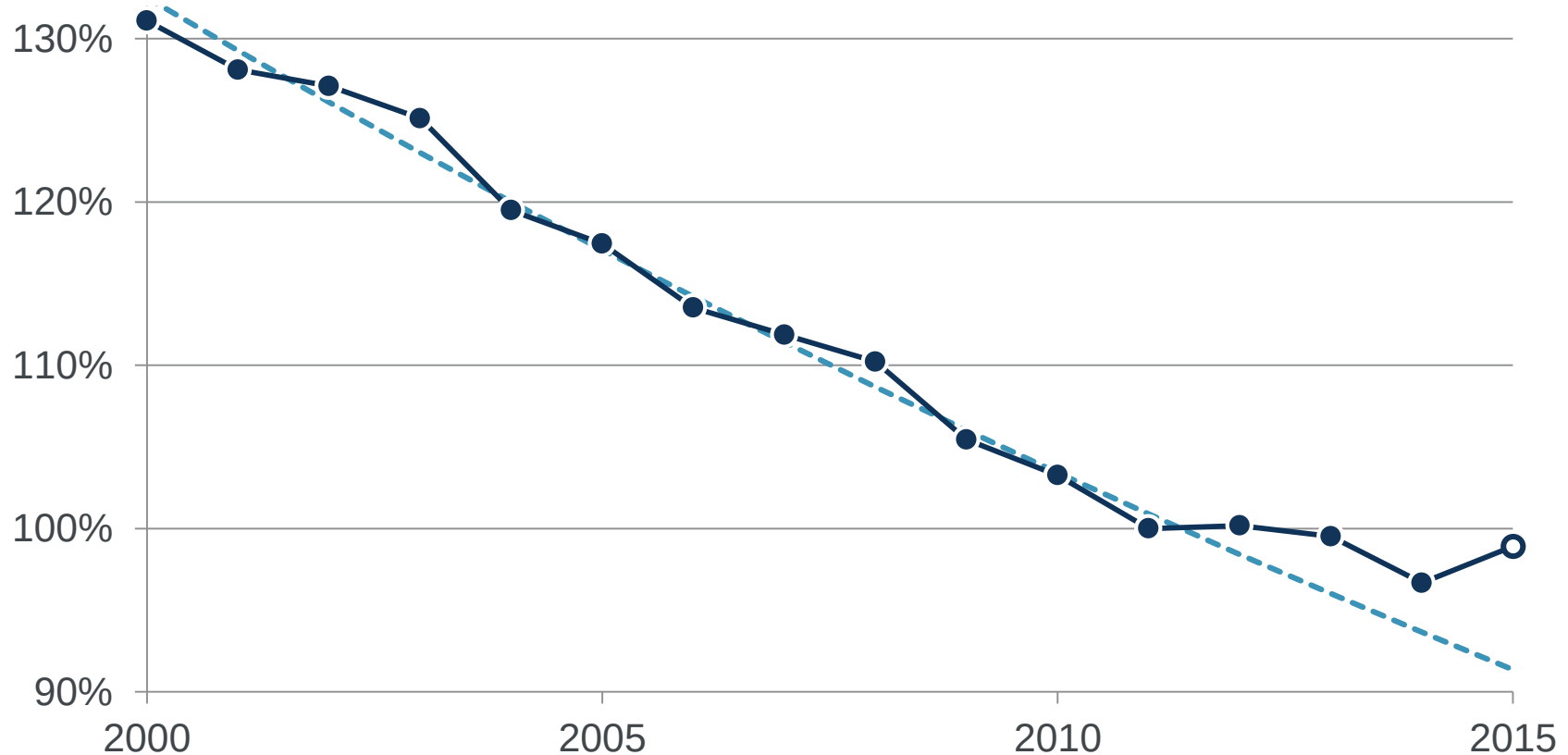
Recent mortality

Cumulative report deaths by week
compared with average over 2005 to 2014



Recent mortality

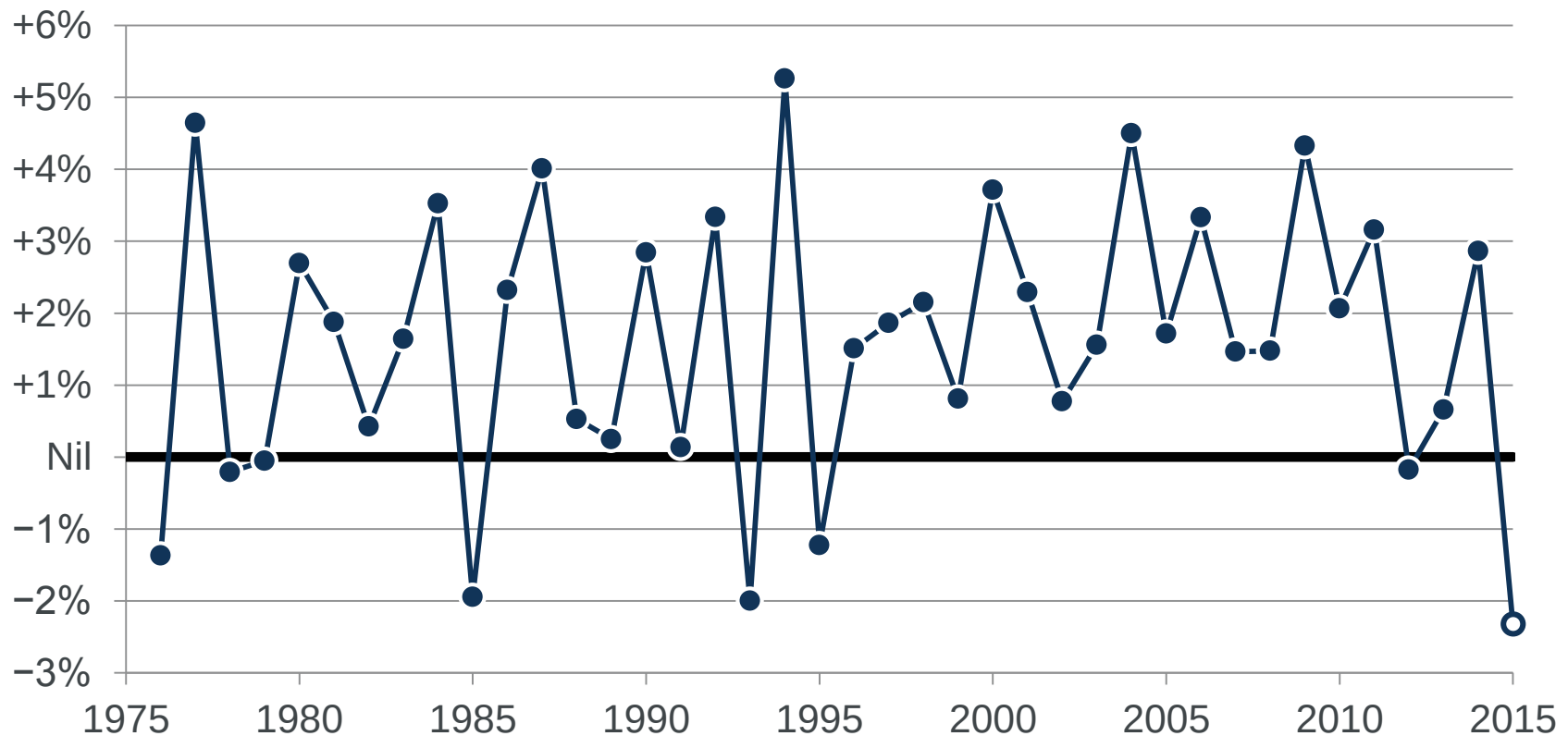
Standardised mortality ratio (2011), England & Wales, and 2000-2011 trend



Note: 2015 data has been estimated based on actual deaths to 31 July.

Recent mortality improvements

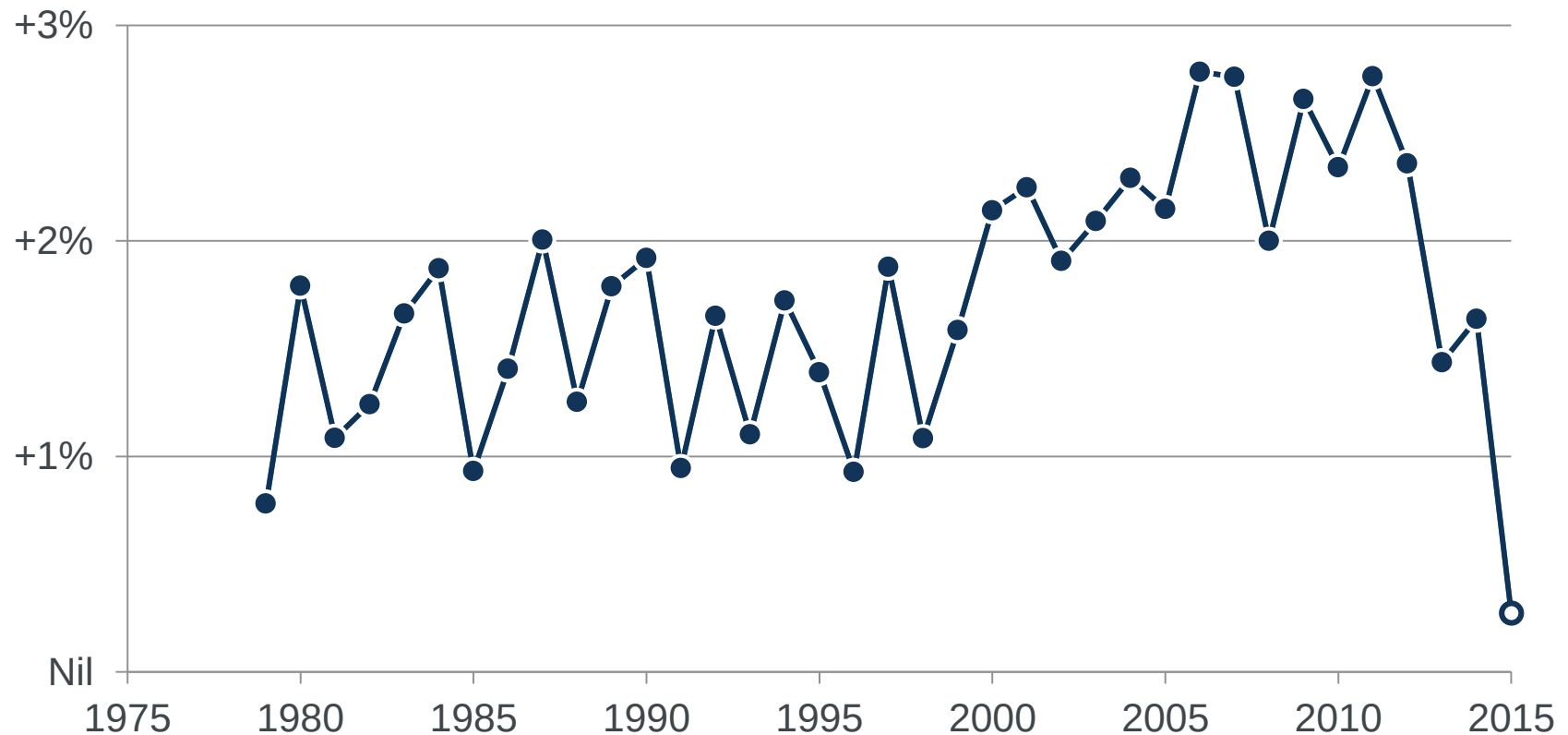
Annual mortality improvements (1976-2015)



Note: 2015 data has been estimated based on actual deaths to 31 July.

Recent mortality improvements

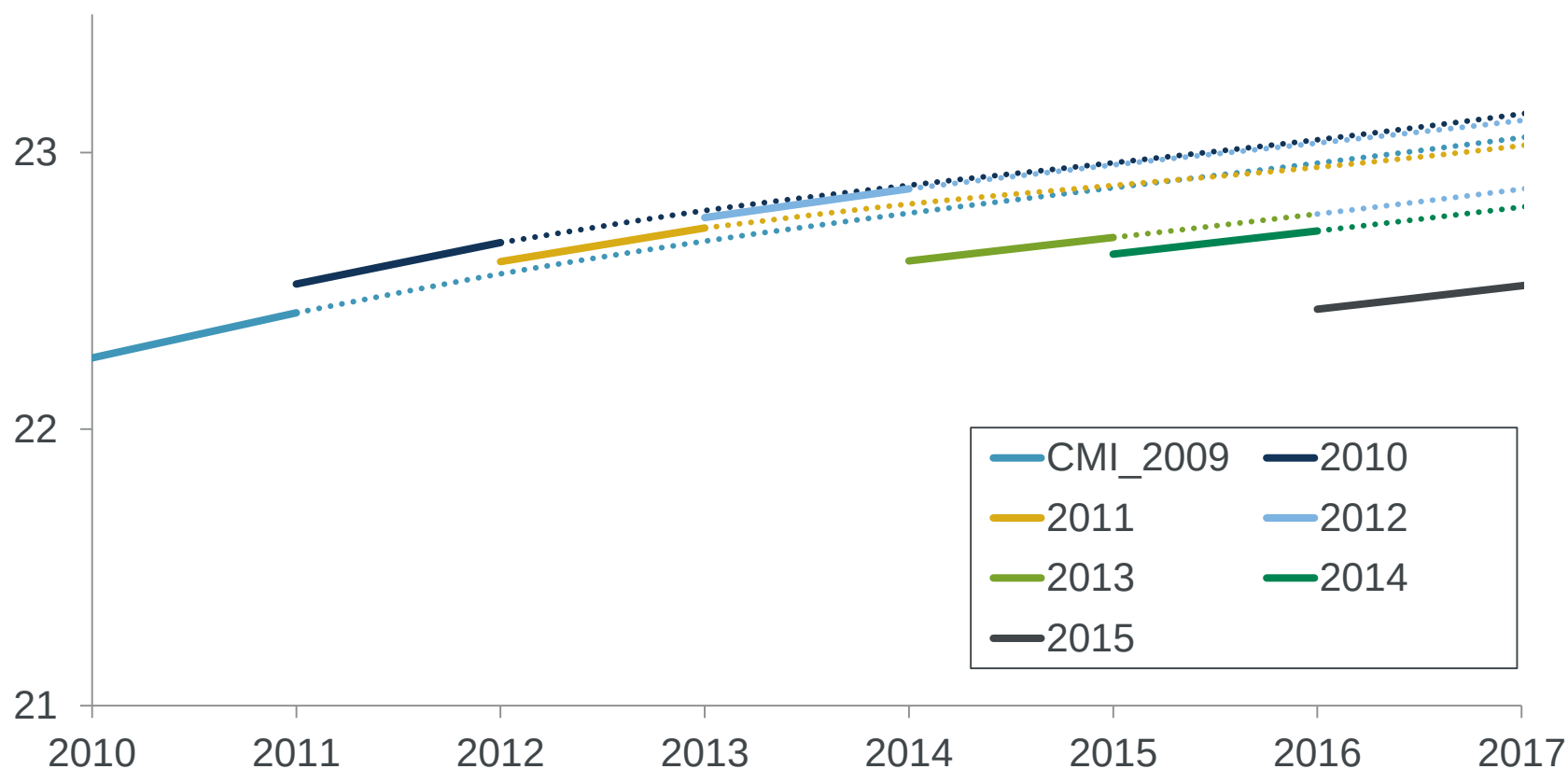
Four-year average annualised mortality improvements (1979-2015)



Note: 2015 data has been estimated based on actual deaths to 31 July.

Changes between CMI Model versions

Male life expectancy at age 65, male, for different Model versions



Assumptions: S2PMA at 1 January 2007, projected using CMI_20yy_M[1.5%]

Financial impact CMI_2015 vs CMI_2014

- Change in cohort expectation of life*:

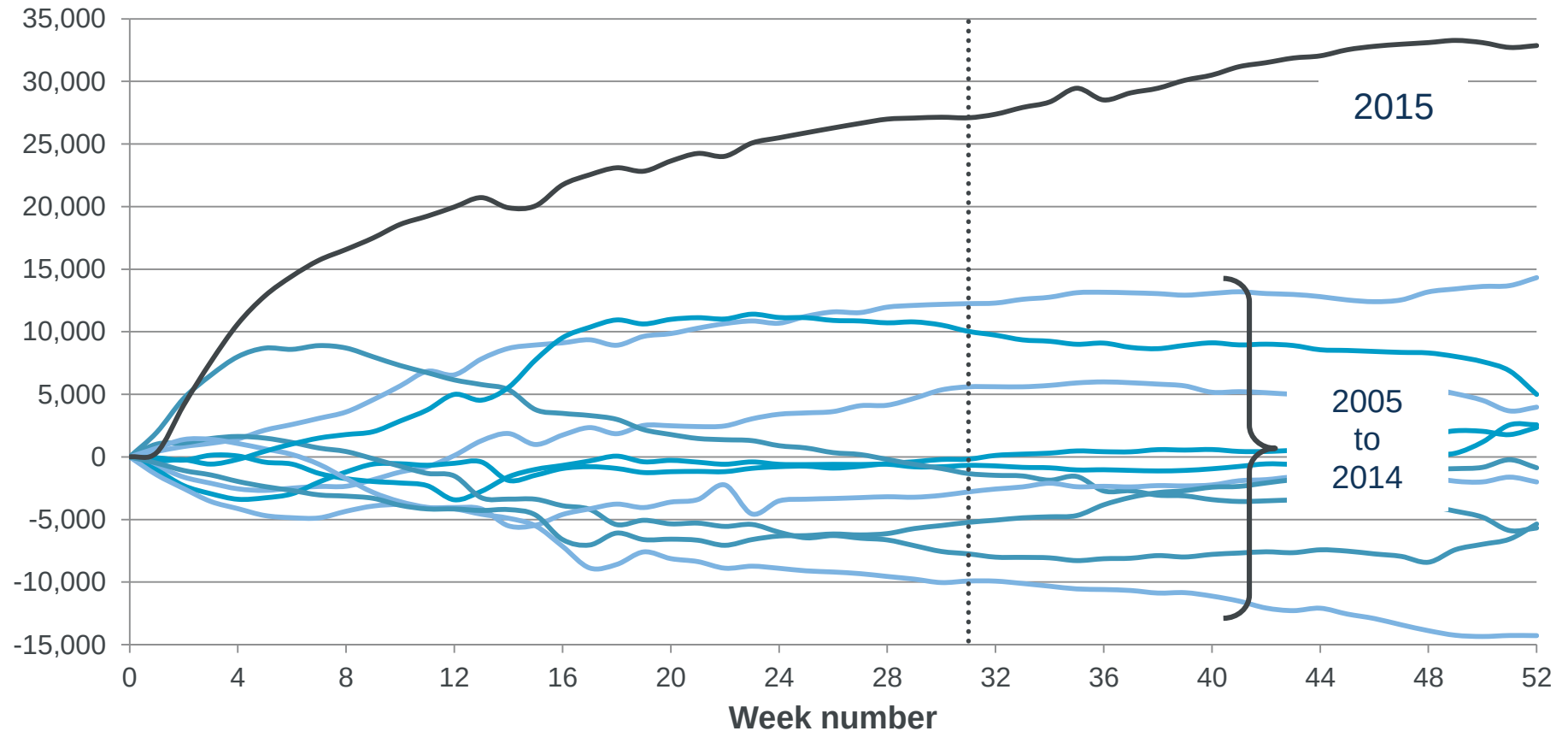
Age	Male	Female
55	-0.9%	-0.9%
65	-1.2%	-1.4%
75	-1.8%	-1.9%
85	-1.9%	-2.0%

** Age exact on 31 December 2015 and S2Px_A + CMI_ 2015 vs CMI_2014 (LTR=1.5%).*

- Impact of moving from CMI_2012 considerably greater

Recent mortality – deaths since CMI_2015

Cumulative report deaths by week
compared with average over 2005 to 2014



Reviewing the CMI Model – Avenues of investigation

Data

- Correcting for artefacts
- High age mortality

Deterministic projection models

- Deal with concerns with the current model
- Consider alternative models

State space modelling

- Able to answer statistically the questions:
(a) where are we now?
(b) how certain of that are we?
- This would be a fundamental change in methodology

Other

- Guidance on parameterisation
- Coherent modelling of multiple populations
- Cause of death modelling

What is coming next?

Things to look out for in 2016

- SAPS annual experience update for 2007-2014
- CMI Model consultation
 - Consultation paper during Spring 2016
 - Public meetings in April/May 2016
- No CMI Model release during 2016
 - CMI_2016 due out in March 2017
- HAMWP second phase working paper



Questions



Comments

The views expressed in this presentation are those of the presenter.

Please send any questions, views or feedback to
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Continuous Mortality Investigation

Institute and Faculty of Actuaries

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