



**Continuous
Mortality Investigation**

Institute and Faculty of Actuaries

CMI Research Update

IFoA Mortality & Longevity Conference 2016

Tim Gordon
Chairman, CMI Executive Committee

Mission and vision

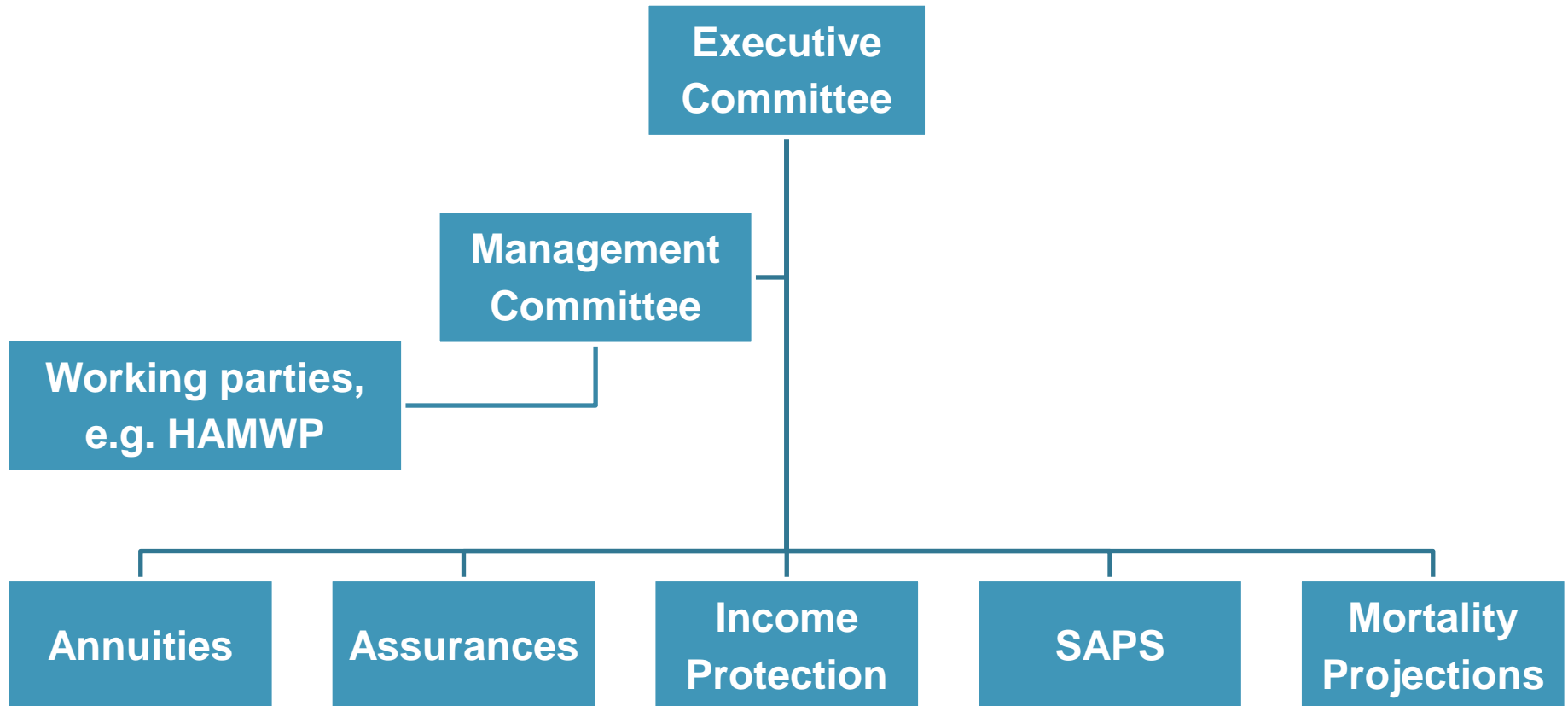
Mission

- To produce high-quality impartial analysis, standard tables and models of mortality and morbidity for long-term insurance products and pension scheme liabilities on behalf of subscribers and, in doing so, to further actuarial understanding.

Vision

- To be regarded across the world as setting the benchmark for the quality, depth and breadth of analysis of industry-wide insurance company and pension scheme experience studies.

CMI structure



Annuities

Annuities Committee activity

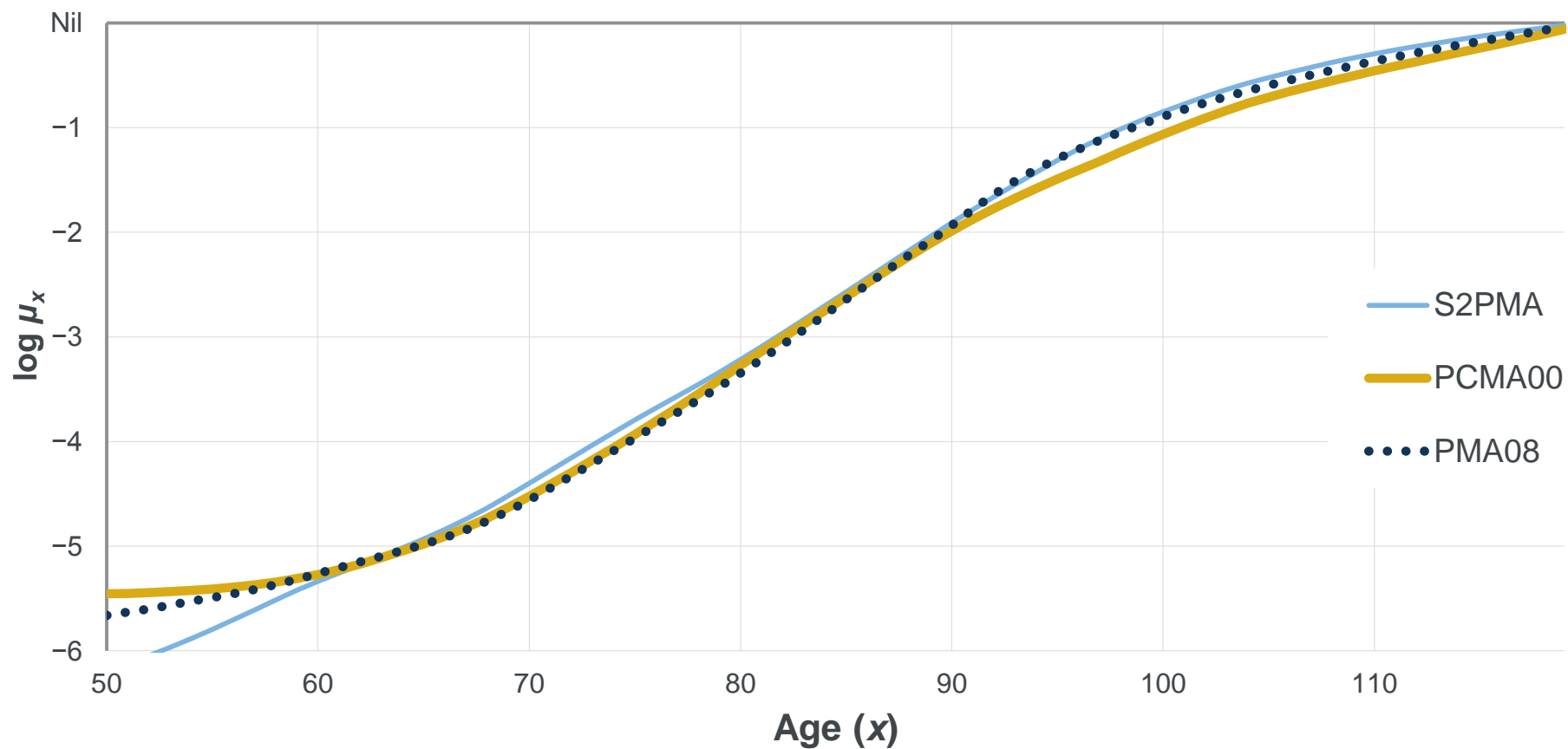
Date	Activity
October 2013	Experience report for 2007-2010
April 2015	Proposed 08 Series annuitant tables released for consultation
June 2015	Final 08 Series annuitant tables released
December 2015	Experience report for Enhanced Annuities in 2007-2010

08 Series vs 00 Series

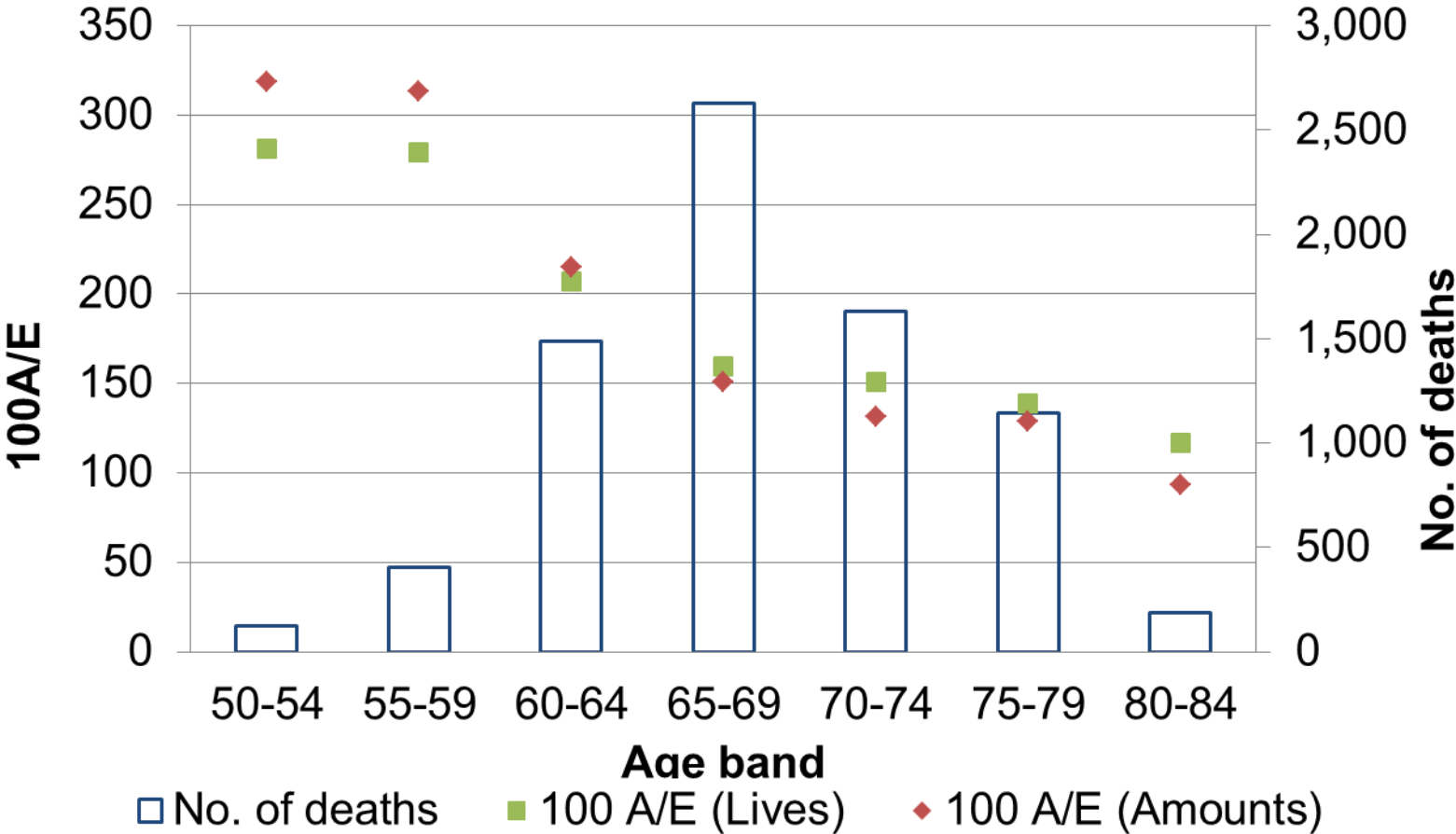
- Different offices
 - Only 7 had submitted data for 2003-2006
 - 10 were 'new' offices (in CMI terms)
- Flexible data format for 2007-2011 data collection
 - Increased volume: 250,000 deaths (2007-2010) vs 150,000 (1999-2002) for the 08 tables
 - But loss of granularity – couldn't separate these (in all cases):
 - Insured schemes vs individual annuitants (plus some bulks)
 - Retirees vs widows
- Better separation by product is a key future objective

PMA08 vs PCMA00

Log μ projected to mid 2015 (CMI_2014)



Male enhanced annuity experience



Expected calculated using PML08

Assurances

Assurances Committee activity

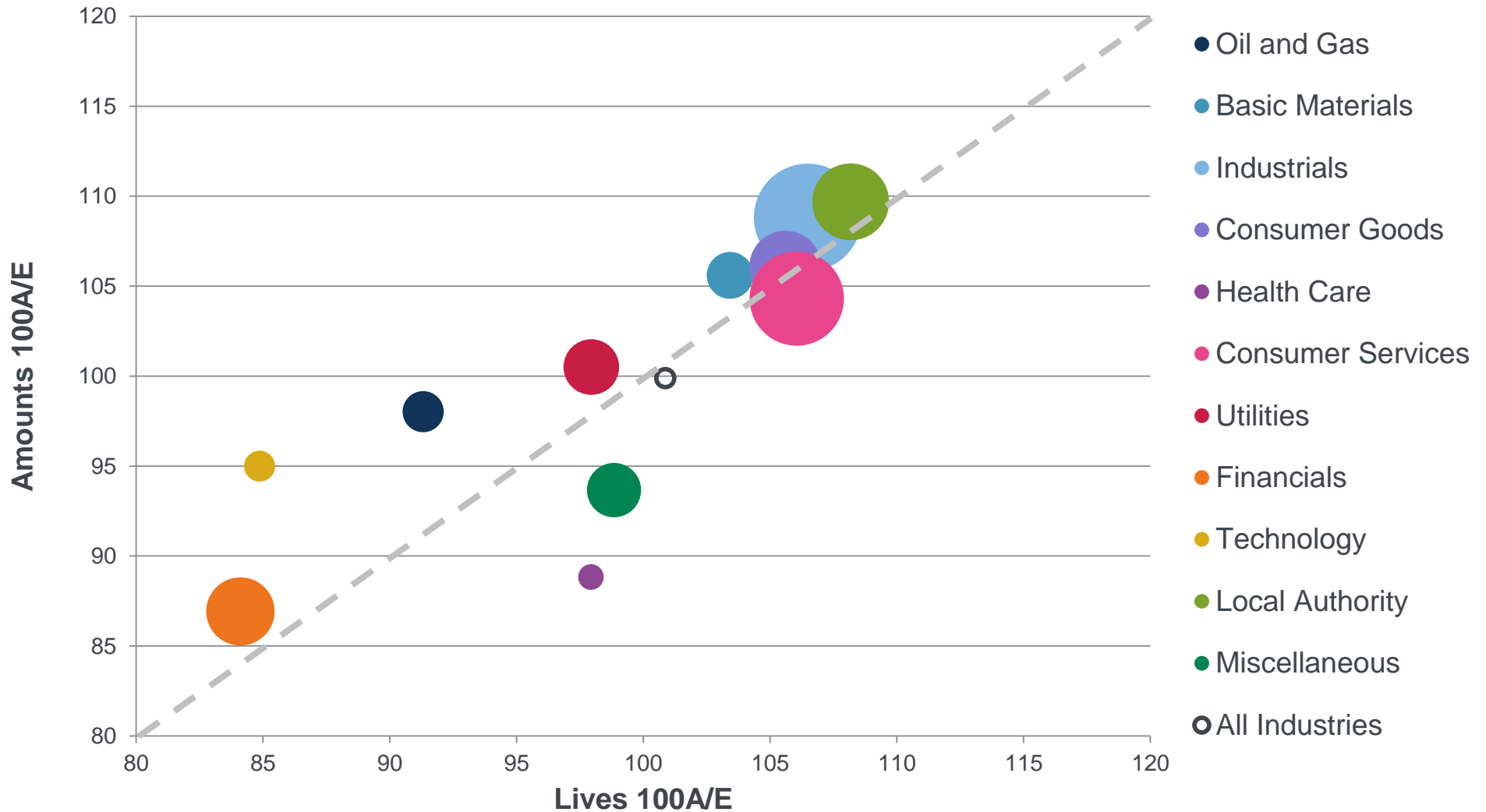
Date	Activity
December 2014	Experience report for 2007-2010
March 2016	Proposed 08 Series accelerated critical illness tables expected to be released for consultation
May 2016	Proposed 08 Series term assurance mortality tables expected to be released for consultation

Self Administered Pension Schemes (SAPS)

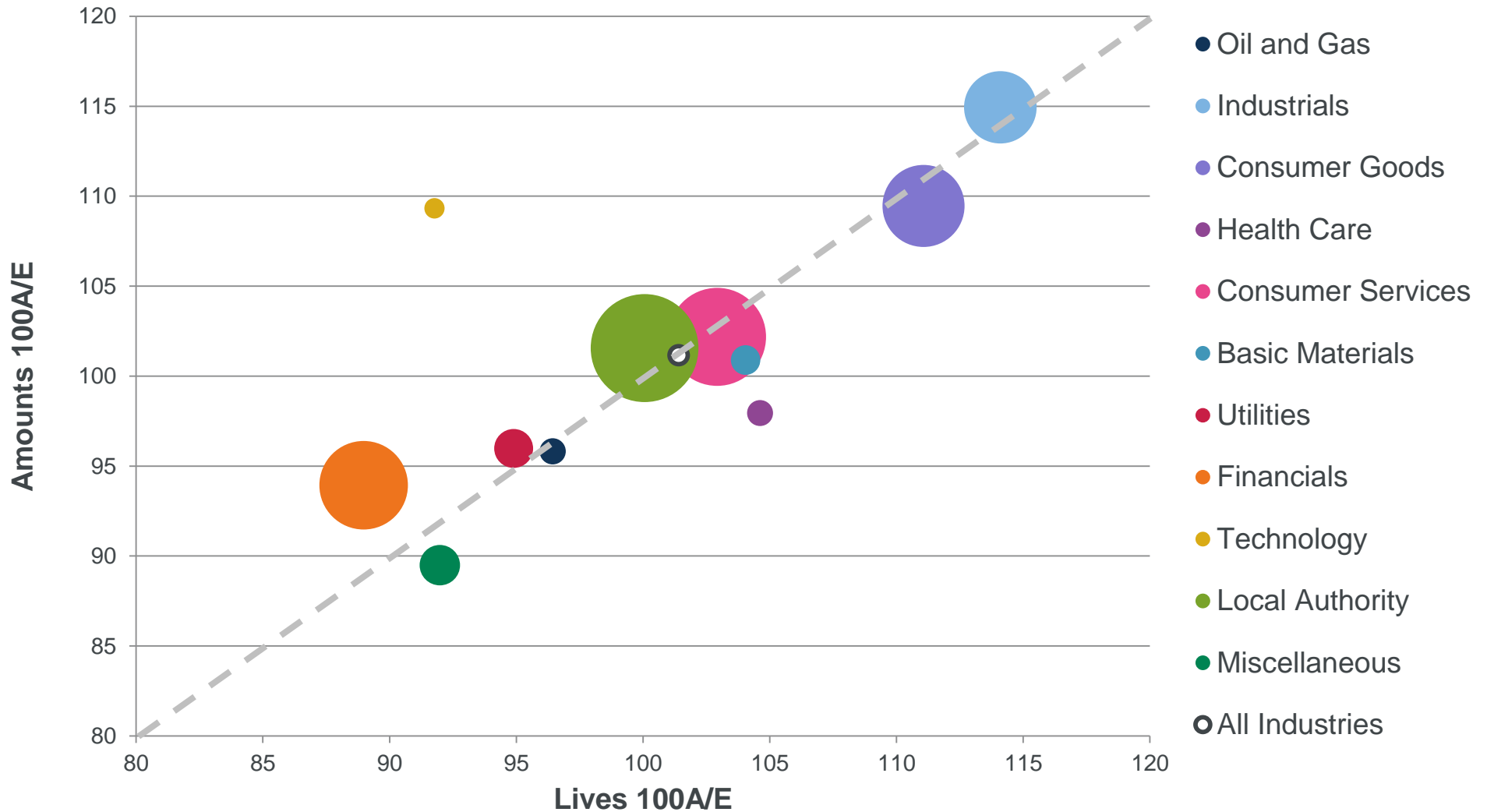
SAPS activity

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 to 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
February 2016	Annual experience update covering 2007-2014

Industry analysis – male experience vs S2



Industry analysis – female experience vs S2

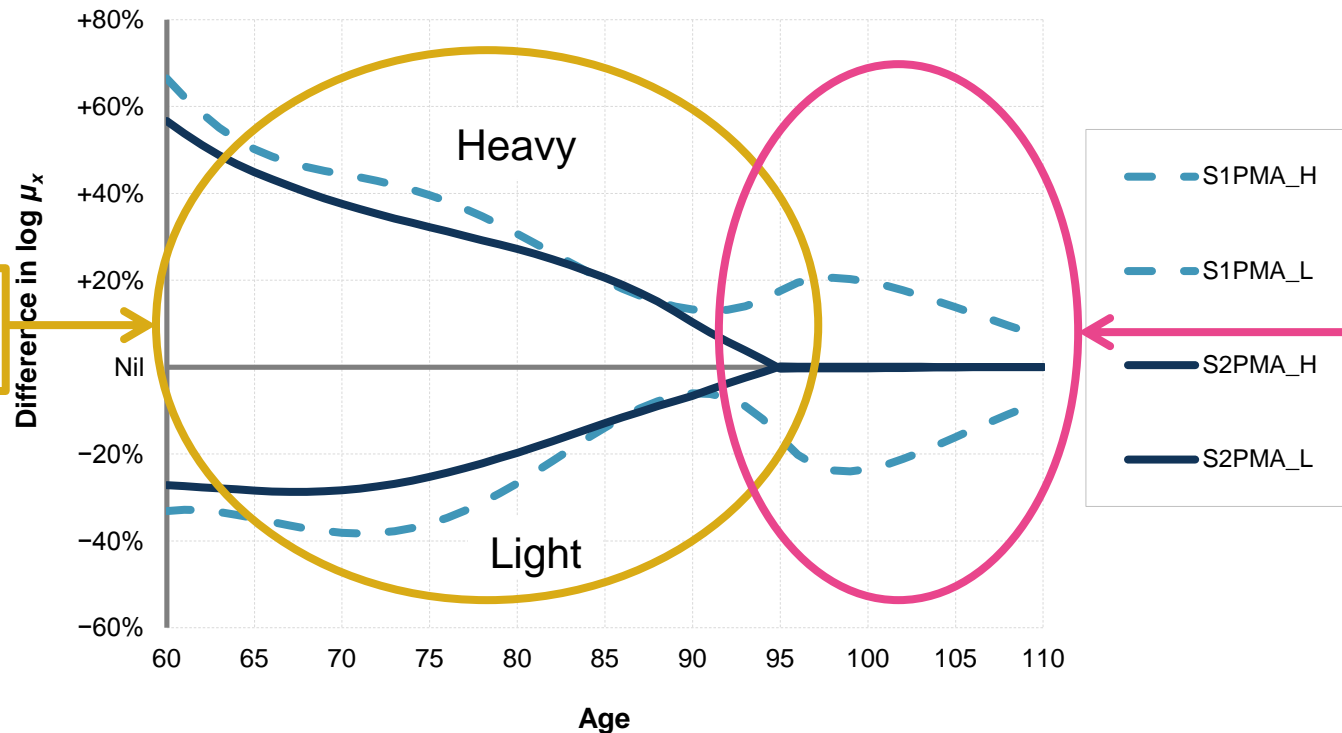


What next?

- Annual experience update for 2007-2014 published yesterday
- Analysis of public sector data
- Mortality improvements of self-administered pension schemes?
- S3 tables
 - Considering co-graduation
 - Awaiting HAMWP recommendations for high ages
 - No plans to release S3 for at least next 2 years

Variation and extrapolation

Difference in $\log \mu_x$ $SnPMA_X$ v $SnPMA$



• Edge-effects
• No co-graduation

High age mortality

High Age Mortality Working Party

Background

High Age Mortality Working Party (HAMWP)

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

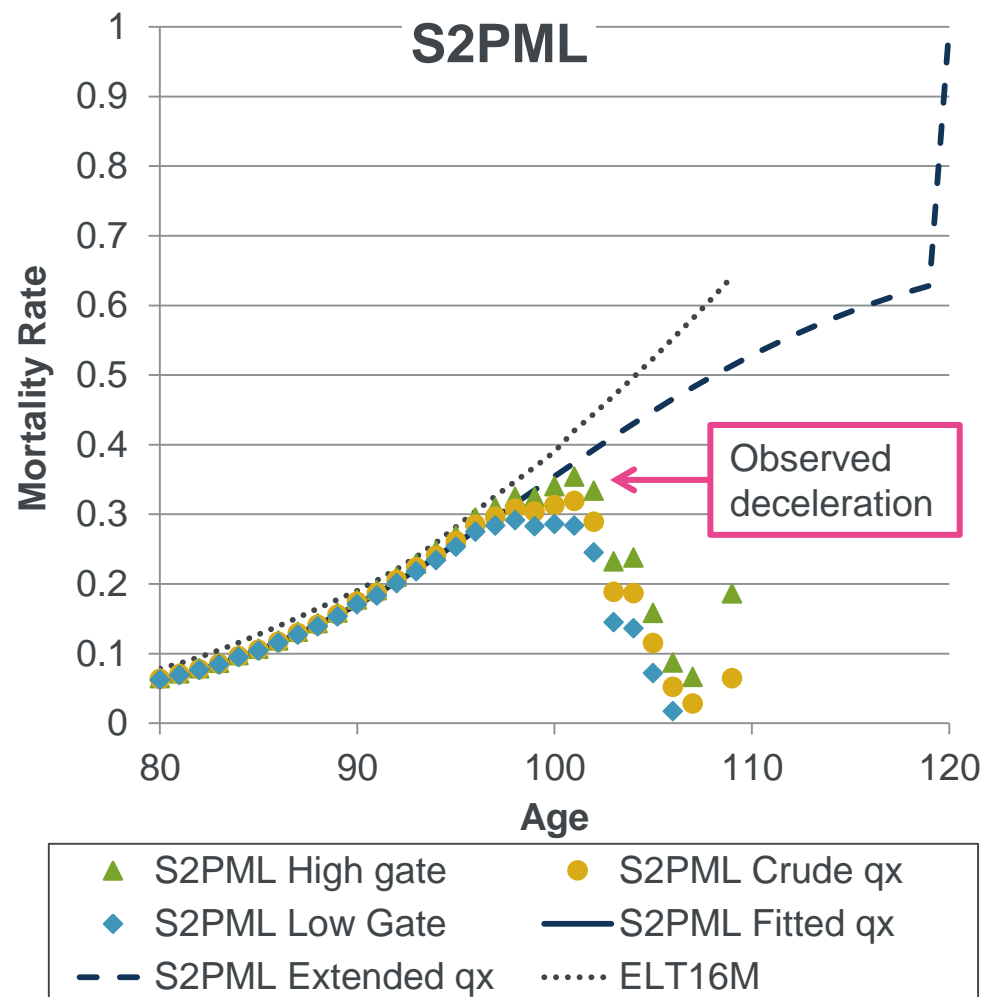
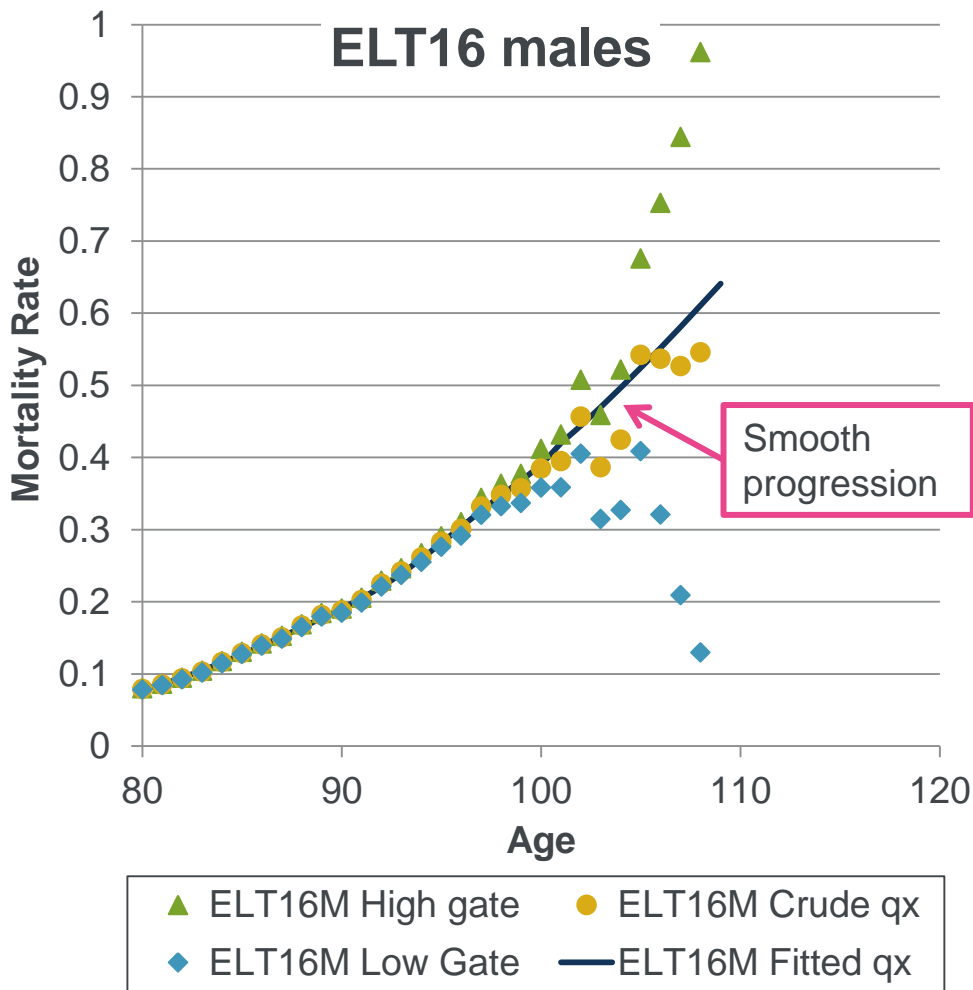
HAMWP terms of reference

- 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

Mortality at high ages – crude and fitted rates

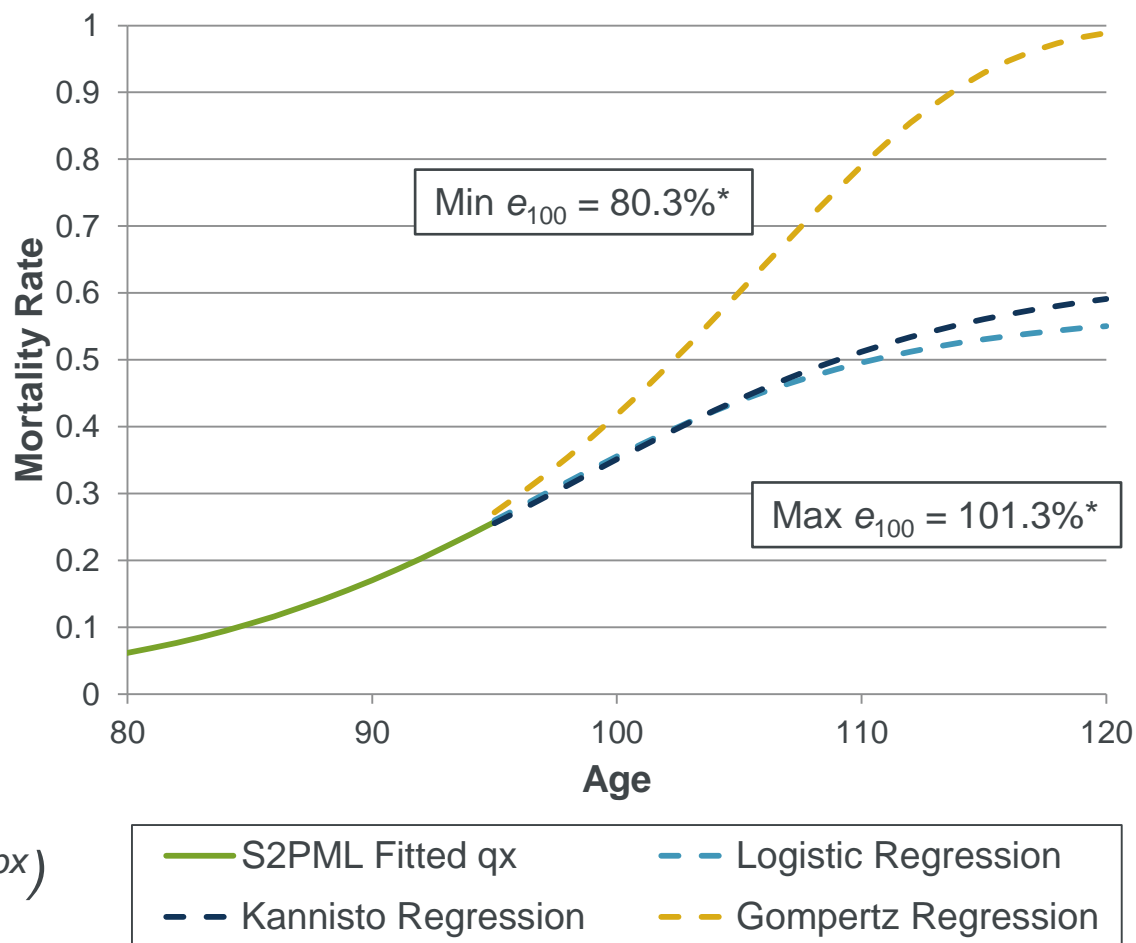


Theories on mortality patterns at high ages

- Is observed late life mortality deceleration
 - an artefact
 - a consequence of frailty
 - true for individual mortality
- 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

Parametric extrapolation

- 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: $\mu_x = c + ae^{bx} / (1 + \alpha e^{bx})$



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

Summary of published tables

Table	Run-in age	Extension method	Limit mortality rate
ELT16	n/a	Variable-knot spline regression fitted to 108, used for high age extensions	$m_{120} = 2 / q_{120} \approx 1$
S2 Series	95	Cubic spline with constraints	$\mu_{120} = 1 / q_{120} \approx 0.64$
08 Series	90	Non-linear interpolation	$\mu_{120} = 1 / q_{120} \approx 0.64$
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

What data issues should be considered?

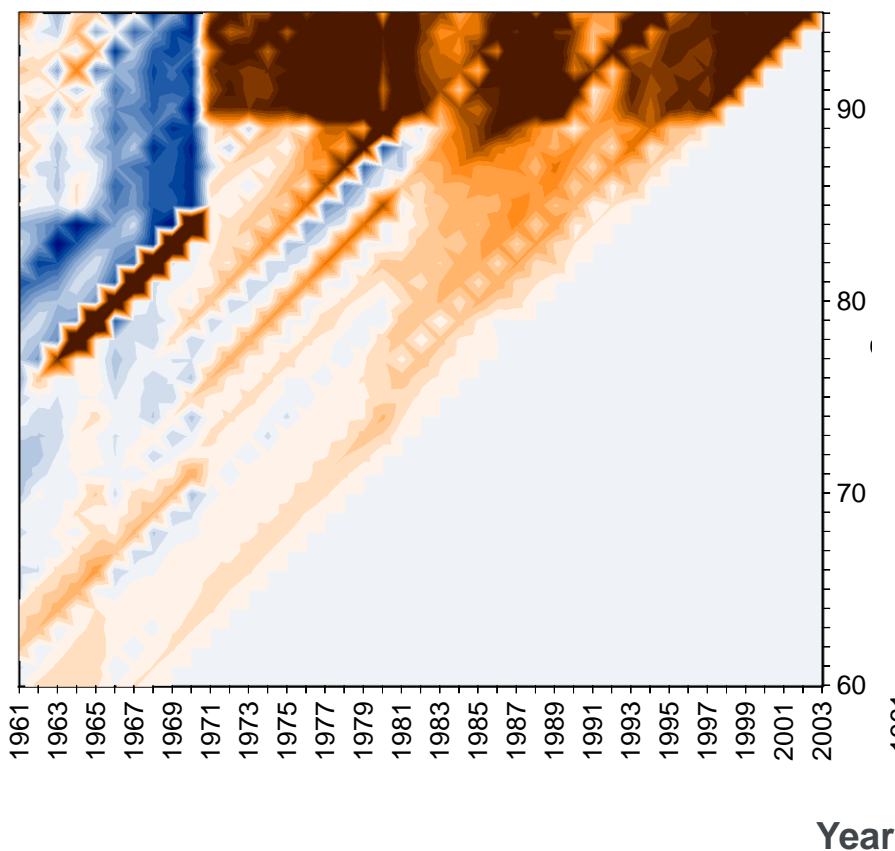
Issue	Population data	Portfolio data
Exposure estimation	Mid year population estimates used as proxy for exposed to risk	Exposed to risk calculated from data
Death reporting	Death registrations required within 5 days of death	Late reported / unreported deaths common
Phantoms	'Phantom' cohorts possible 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

Extinct generations

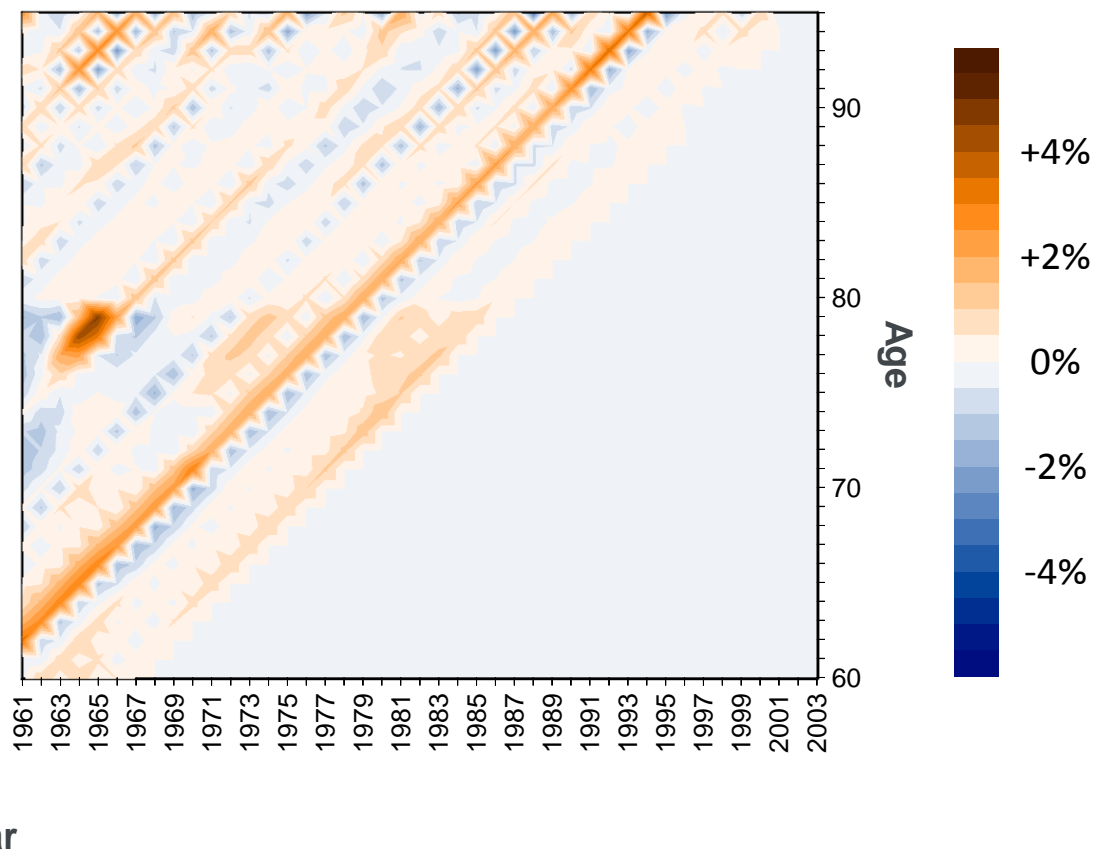
- Consider deaths for cohorts which are essentially extinct – assume this is 110th birthday
- Assumes nil migration
- Estimate historical populations (and mortality) from recorded deaths
 - Population for age x in calendar y year $y = P_{x,y}$
 - Deaths for age x in calendar y year $y = D_{x,y}$
 - $P_{max,y} = D_{110,y}$
 - $P_{x,y} = P_{x+1,y+1} + D_{x,y}$
- Implied mortality compared against ONS and HMD published mortality

Extinct generations vs ONS/HMD mortality

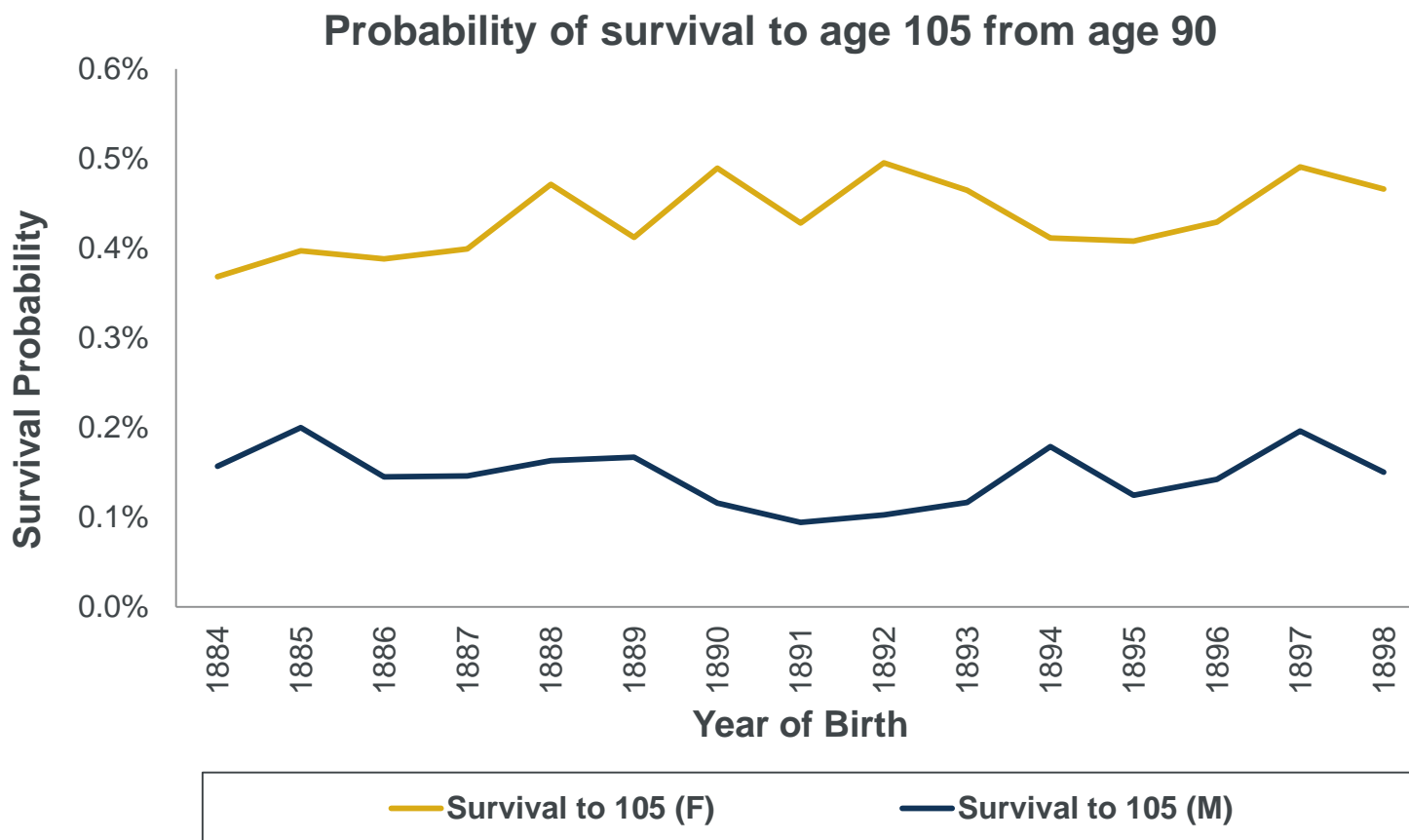
ONS England & Wales males



HMD England & Wales males



Areas of further investigation – time trends



- No clear evidence of material change in mortality between 1884 and 1898 cohorts in England & Wales data

Summary of findings so far

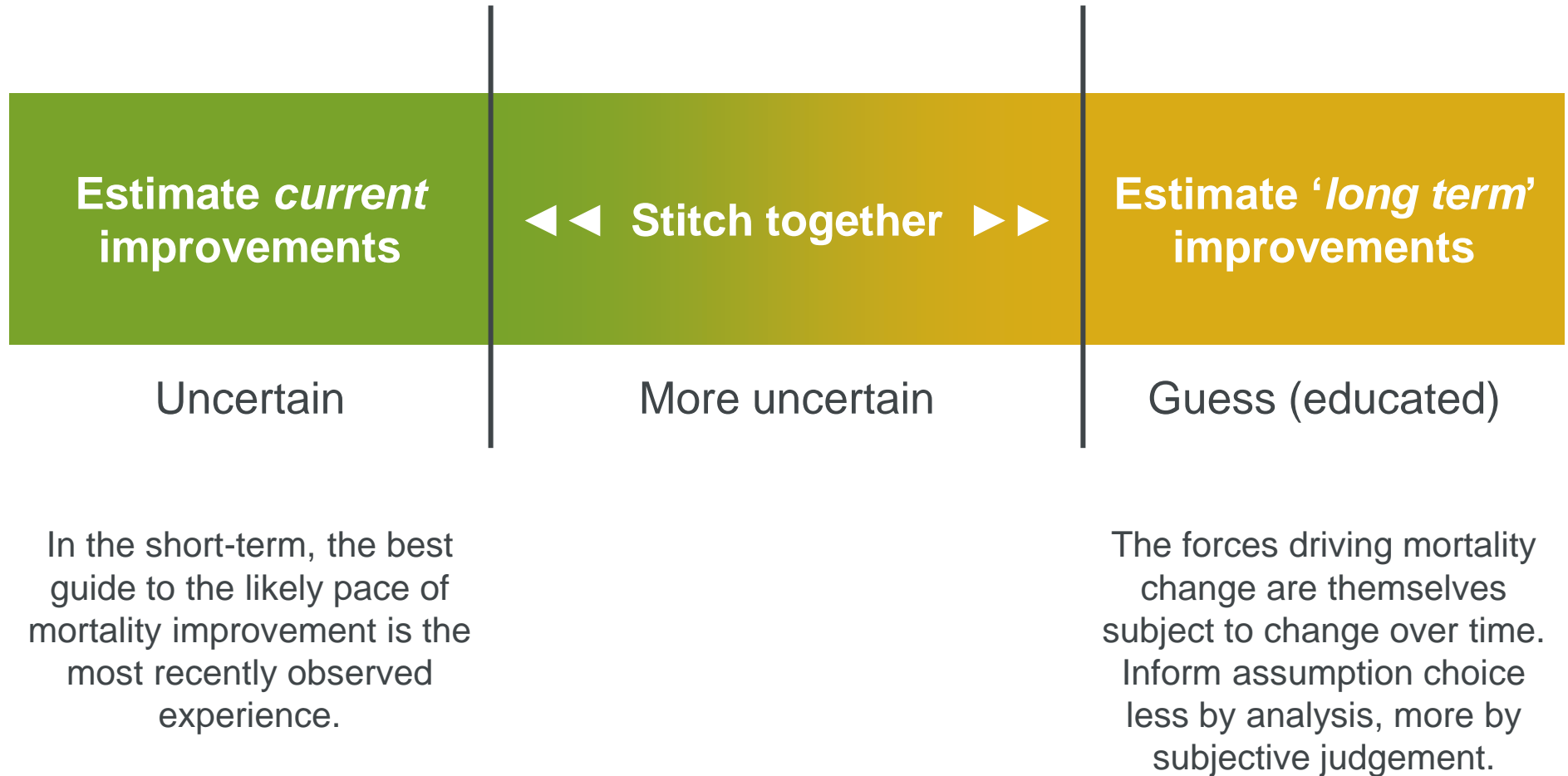
- Data and modelling issues at very high ages:
 - Inconclusive debate on mortality shape at high ages
 - Users should consider age misstatement and late reporting issues
 - Published closed cohorts mortality appears to be understated
- Impact of different mortality rates derived using different models 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

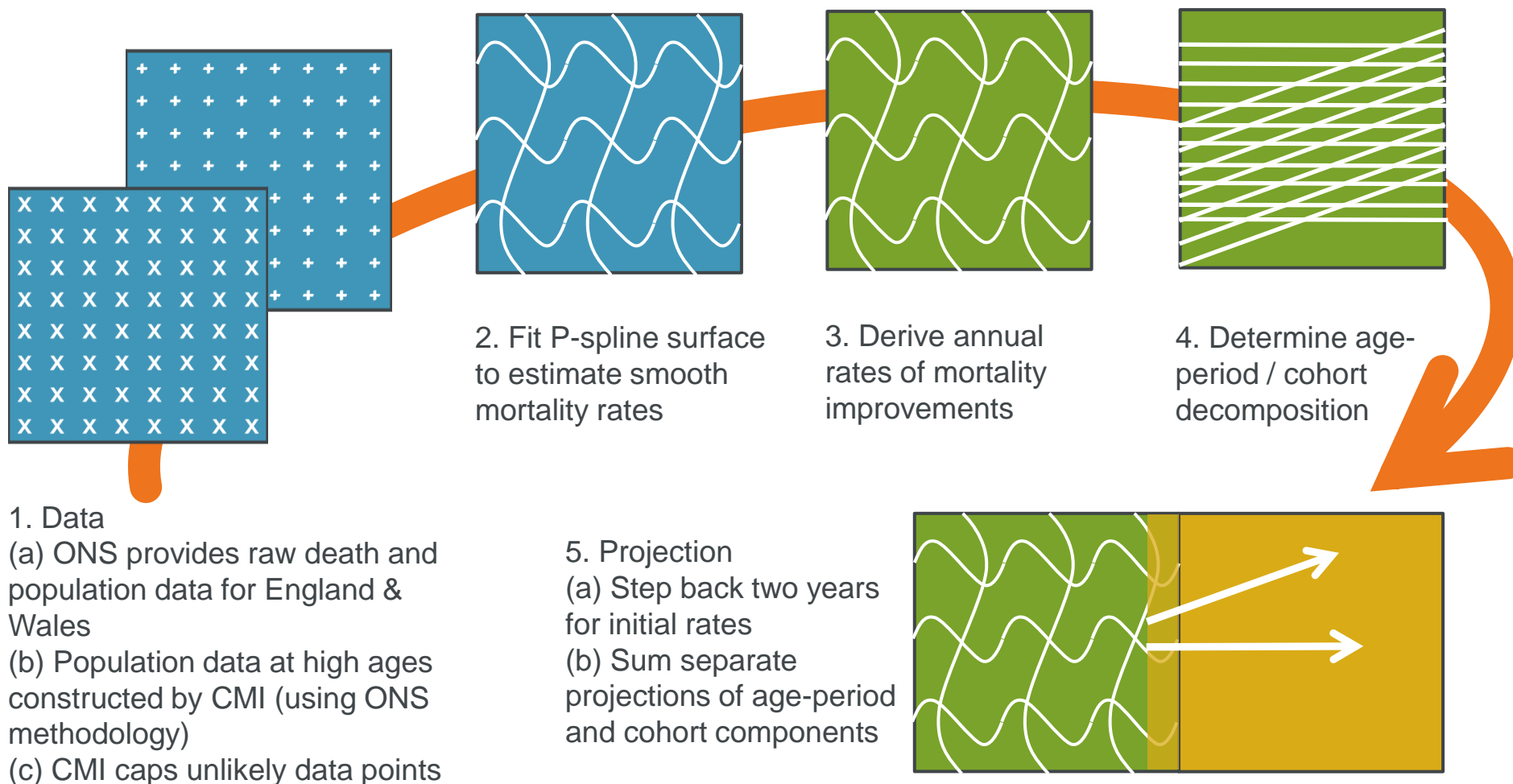
CMI Model timeline

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
Oct 2015		Consultation meetings in Edinburgh and London
<i>June 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

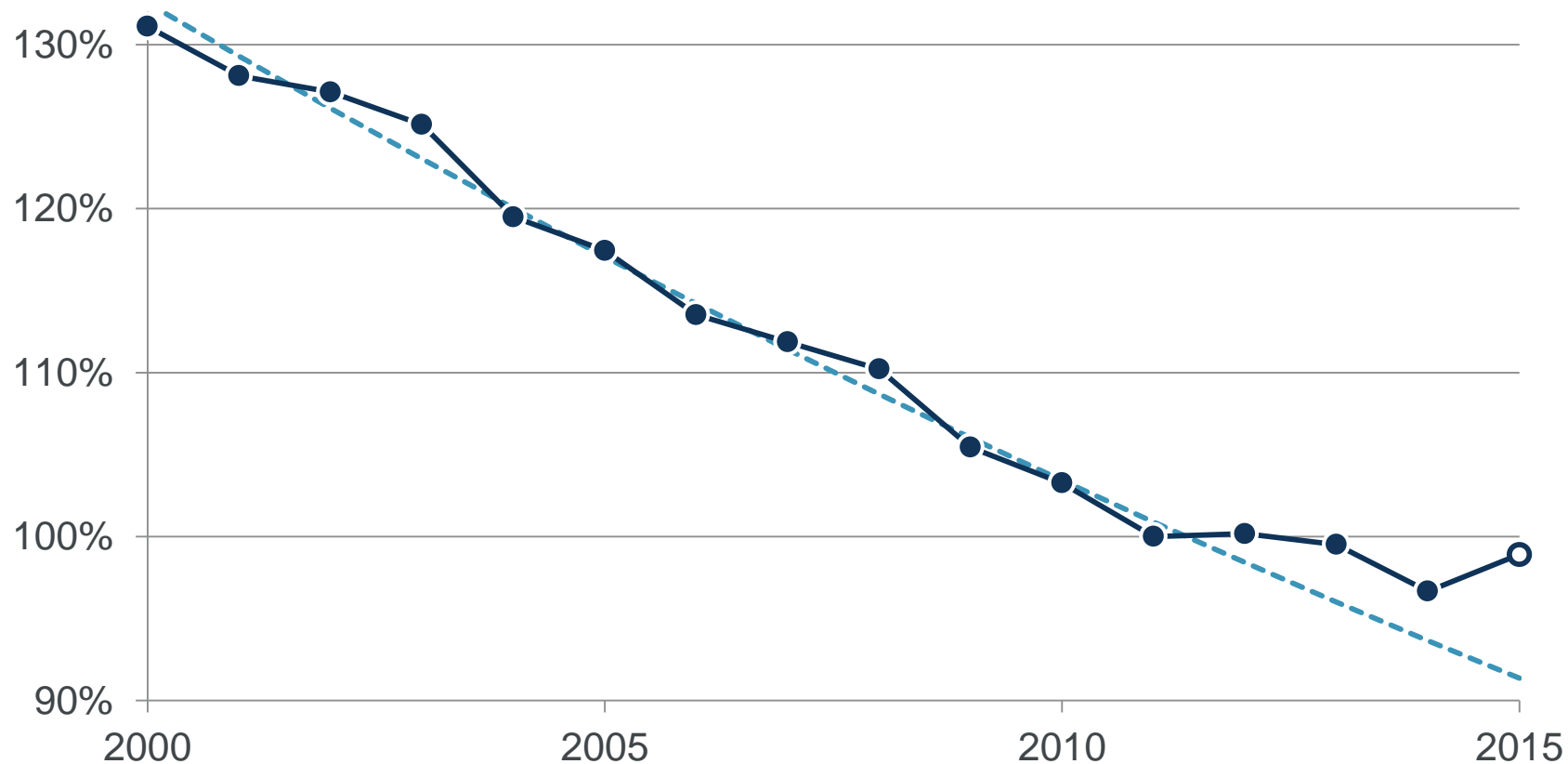


Current CMI Model – overview



Recent mortality

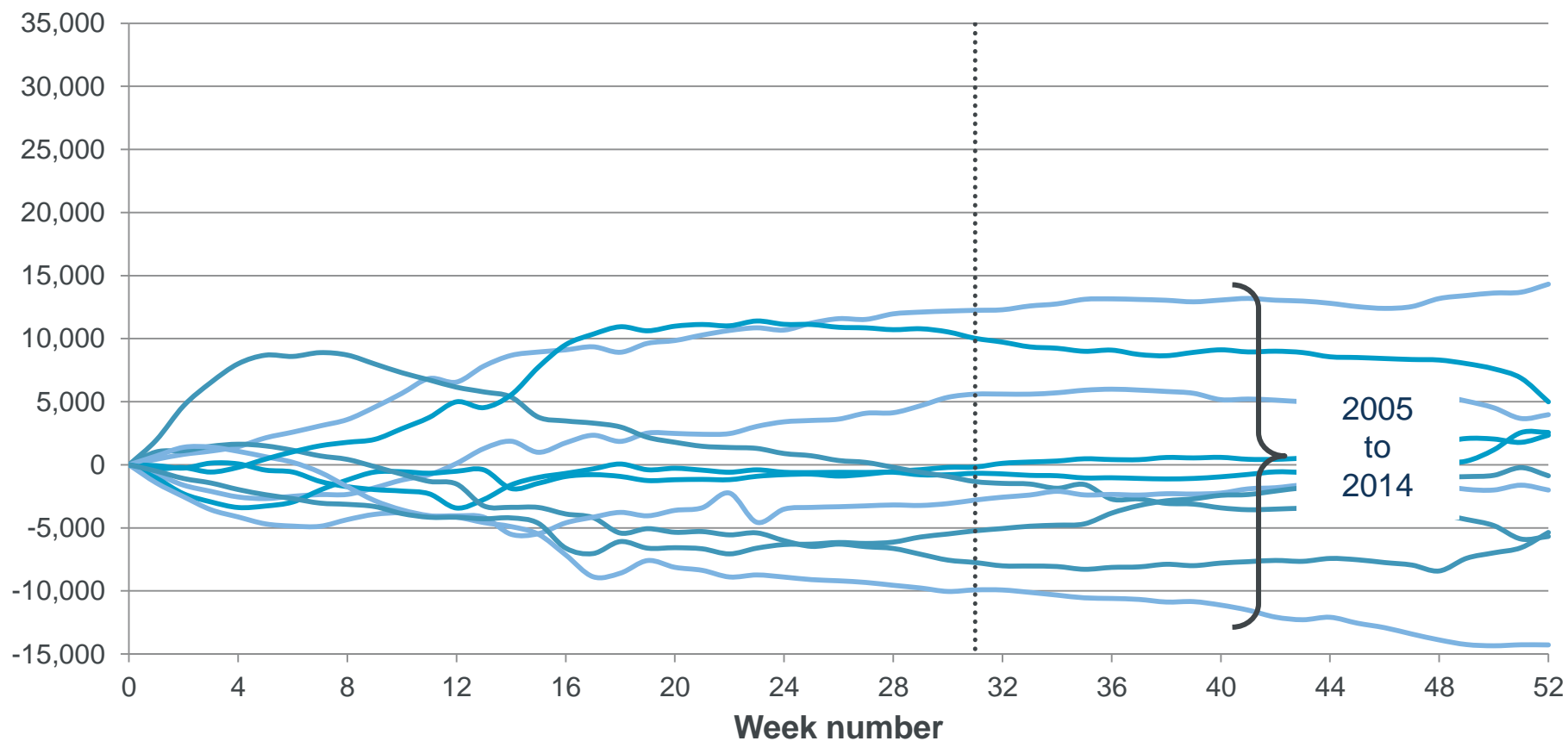
Standardised mortality ratio (2011), England & Wales, and 2000-2011 trend



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

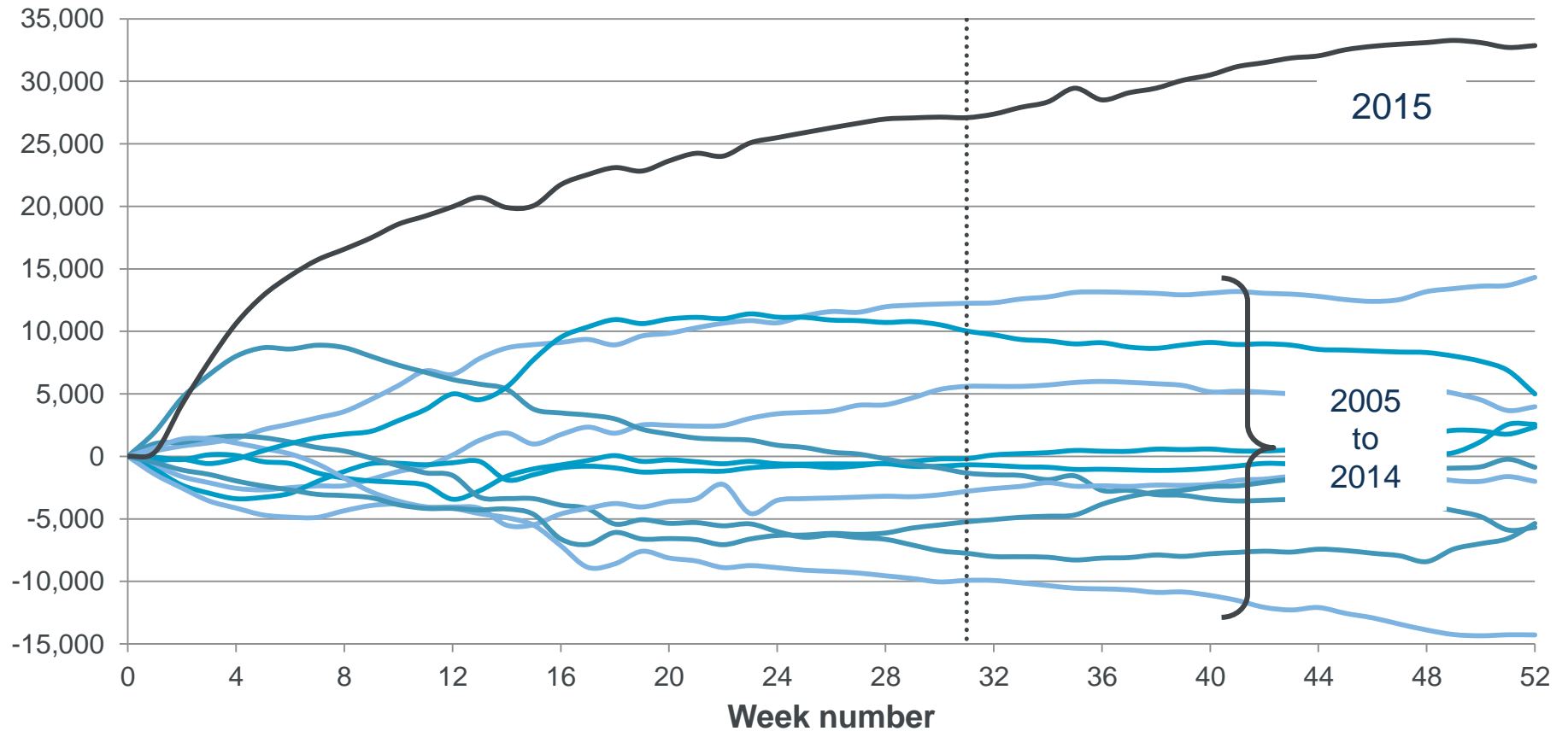
Recent mortality – deaths since CMI_2015

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



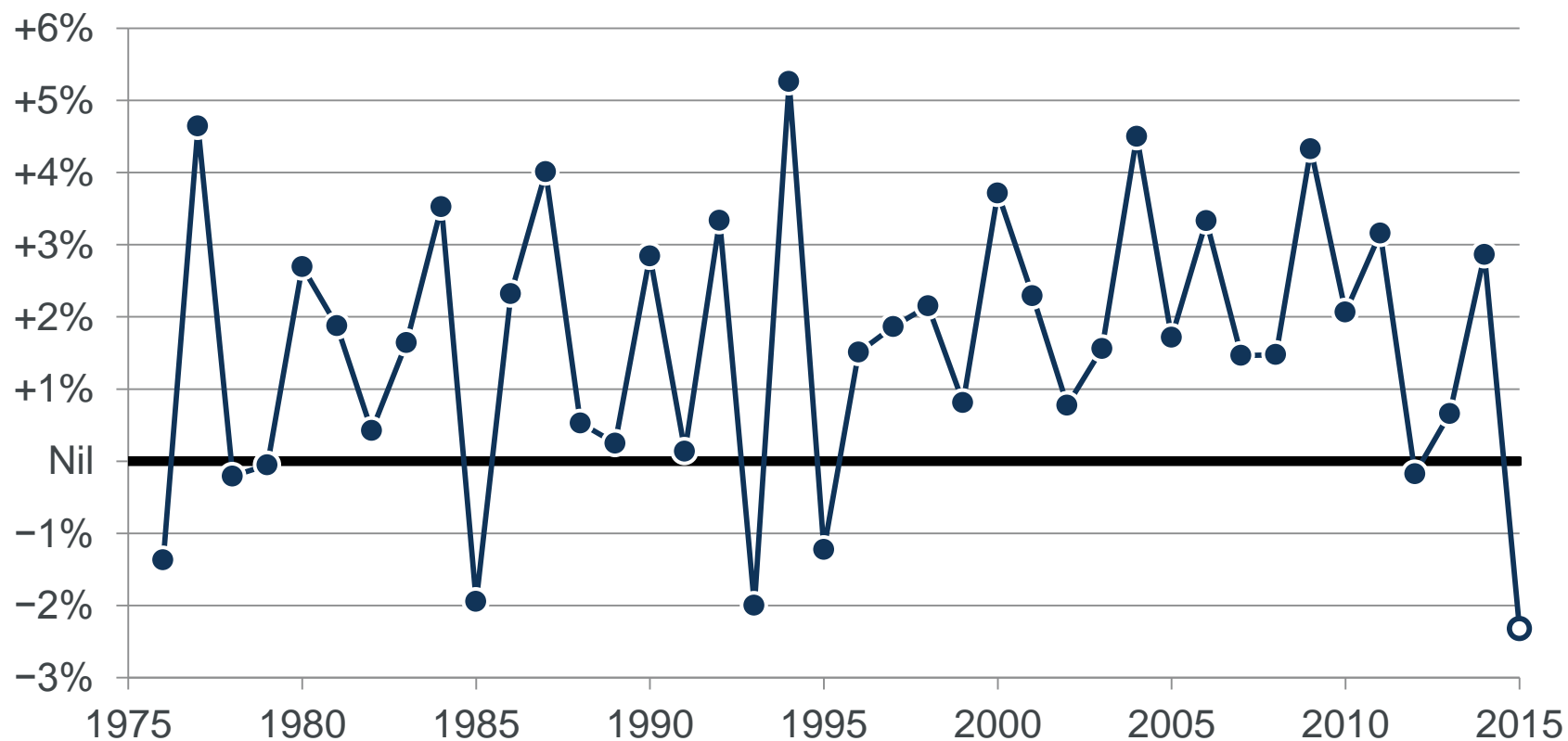
Recent mortality – deaths since CMI_2015

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



Recent mortality improvements

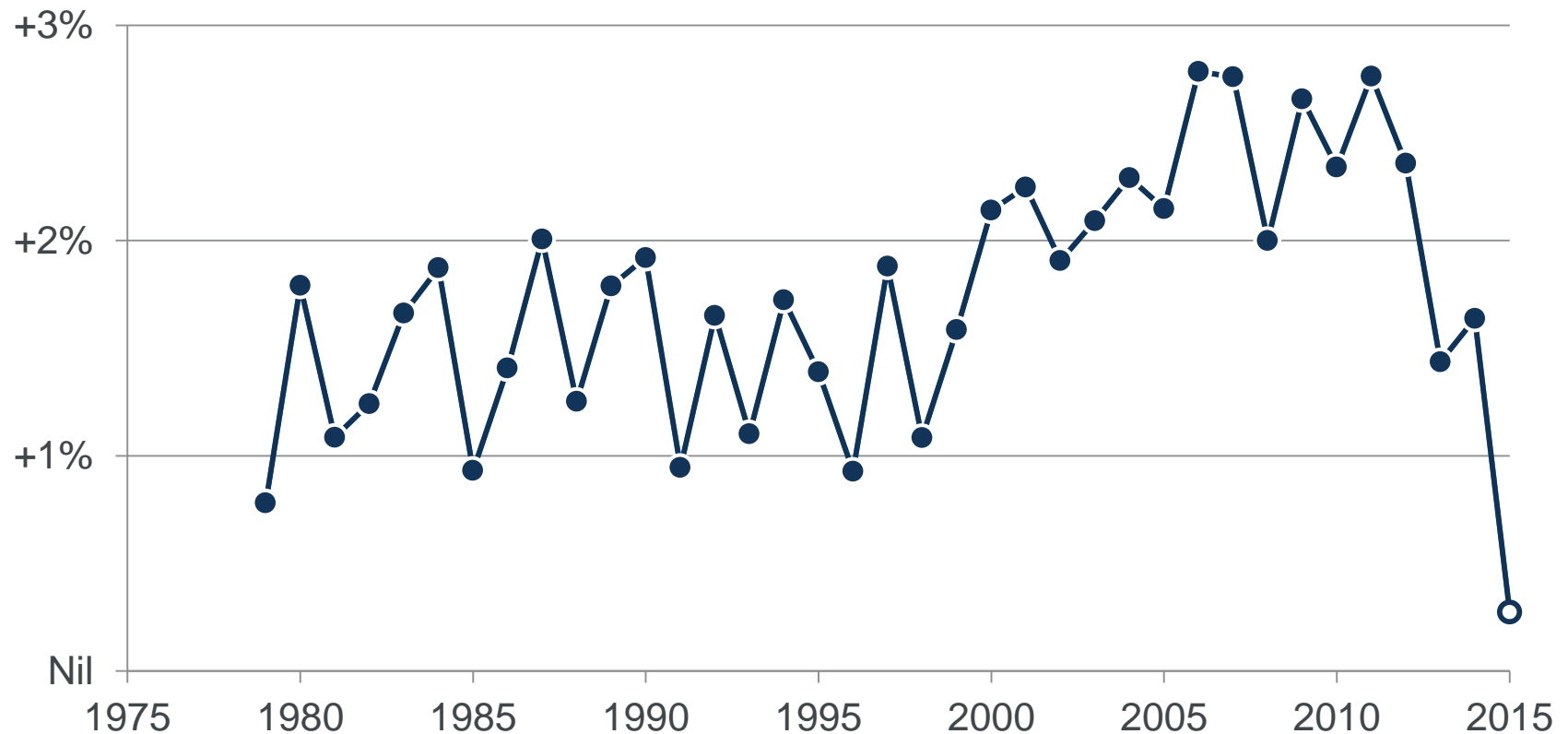
Annual mortality improvements (1976-2015)



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

Recent mortality improvements

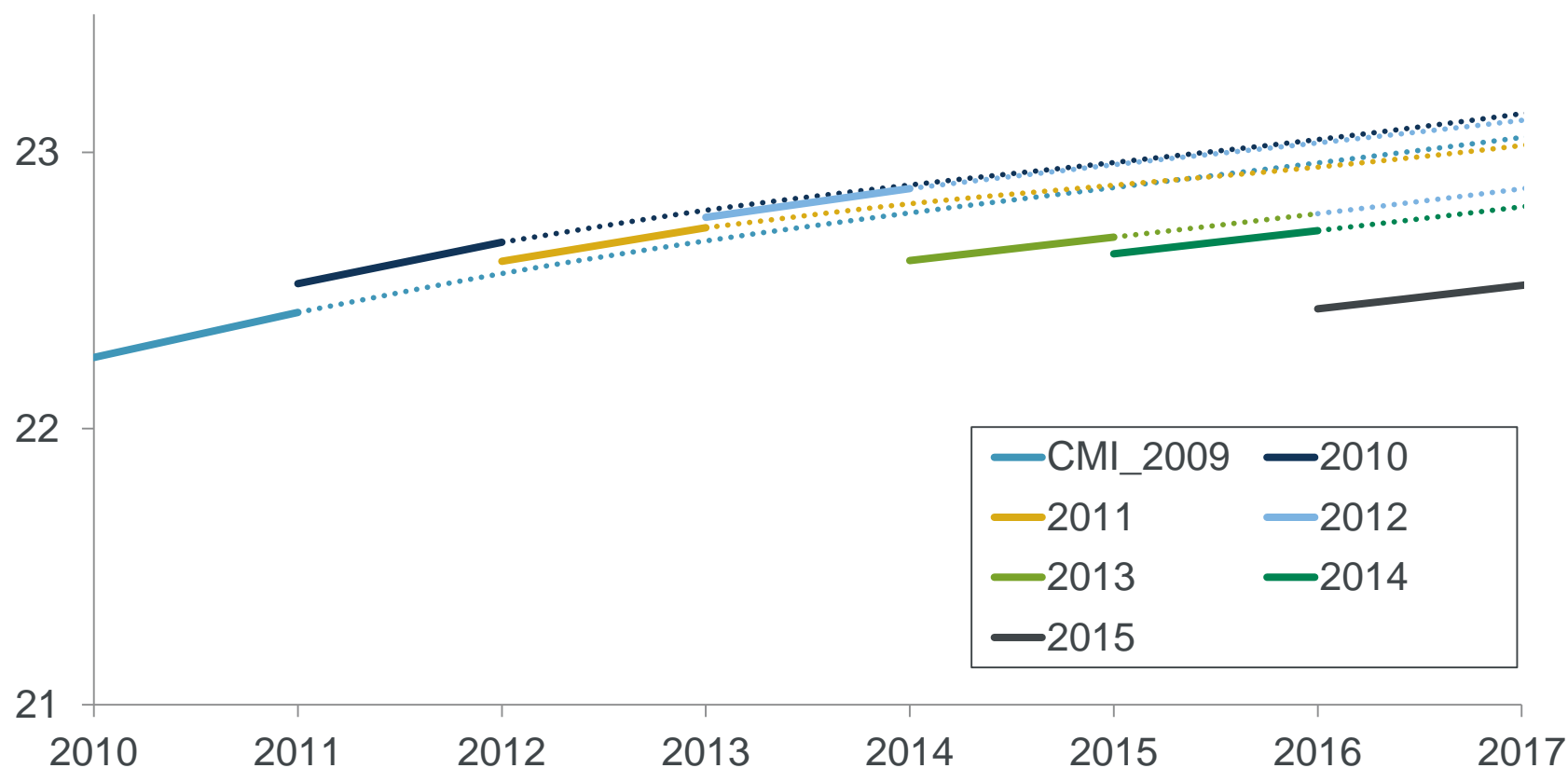
Four-year average annualised mortality improvements (1979-2015)



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

Direction of travel is volatile

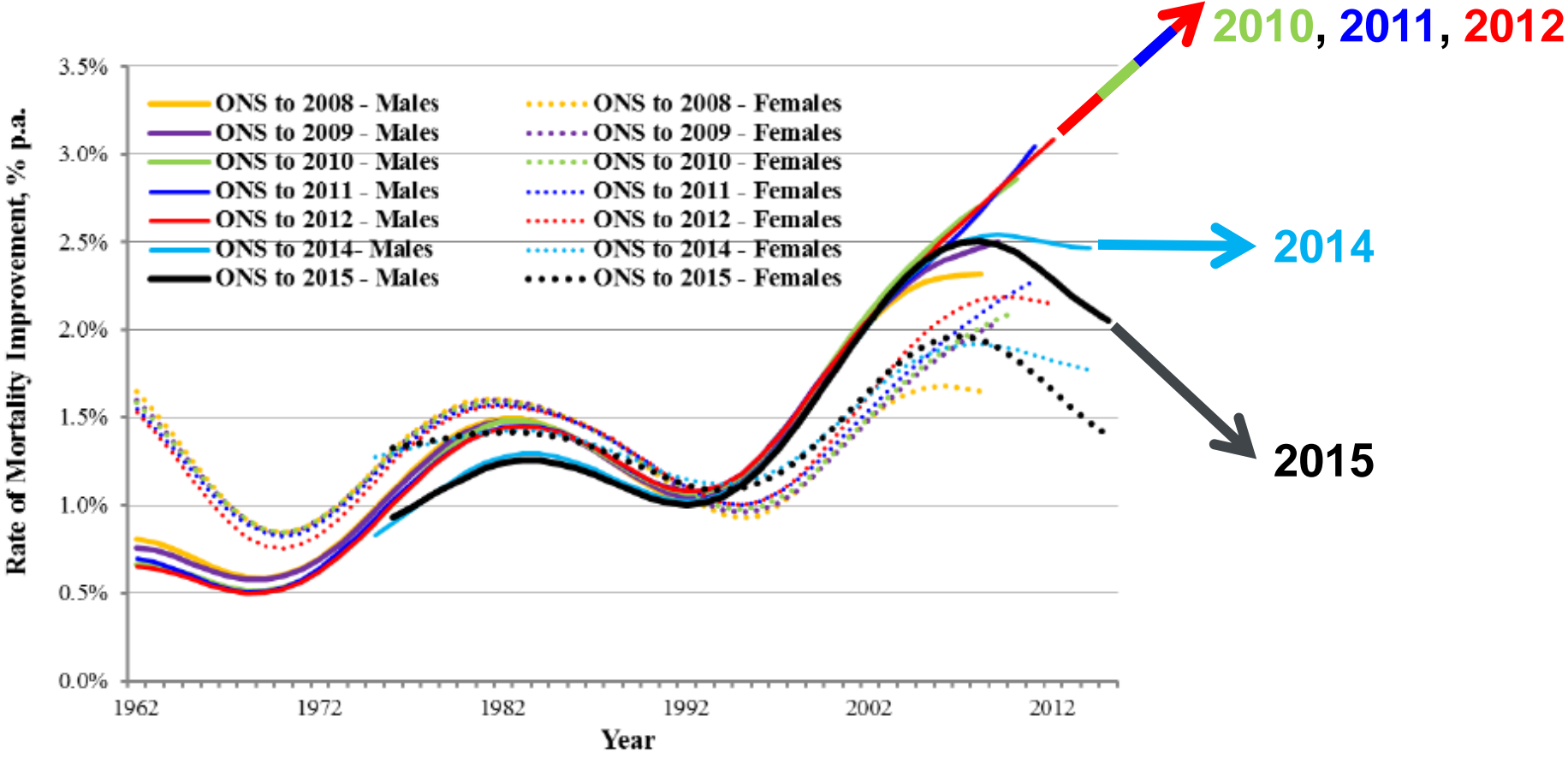


Figure 14: Period Component of the Rate of Mortality Improvement, by year, dataset, and gender; England & Wales Population
 Estimates derived by fitting APC models to smoothed mortality improvement rates

Avenues of investigation

Data

- Correction of artefacts
- High age mortality

Possible features

- 1 step calibration
- Cohort convergence vs age variation
- Consistent projections
- Incorporate direction of travel?

Statistical understanding

- Current level of improvements
- Current direction of travel
- Convergence patterns

Post CMI_2016 wish list

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

Things to look out for in 2016

Things to look out for in 2016

- SAPS annual experience update for 2007-2014
- 2007-2010 Assurances graduations – Spring 2016
- CMI Projection Model consultation
 - Consultation paper during June 2016
 - Public meetings
 - CMI_2016 due in March 2017 – NB 1½ years after CMI_2015
- 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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