Continuous
Mortality Investigation
Institute and Faculty of Actuaries

CMI Research Update

IFoA Pensions, Risk and Investment Conference 2016

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Chair, CMI SAPS Committee

06 April 2016

Mission and vision

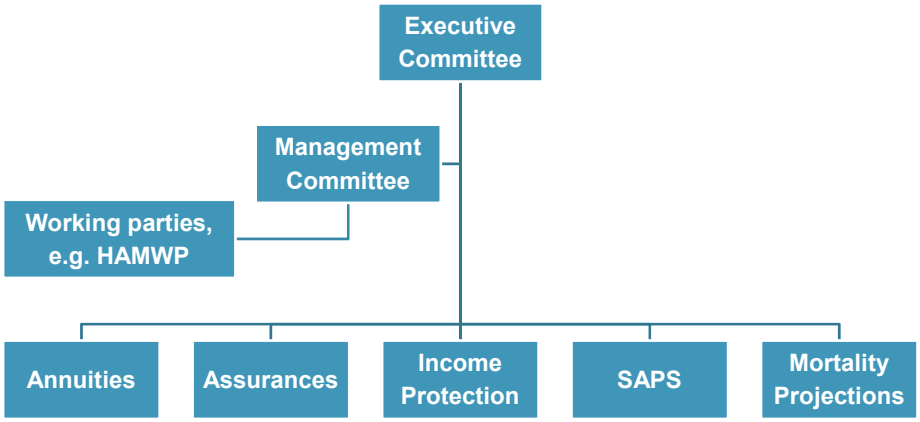
Mission

- 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



Self Administered Pension Schemes (SAPS)

SAPS activity

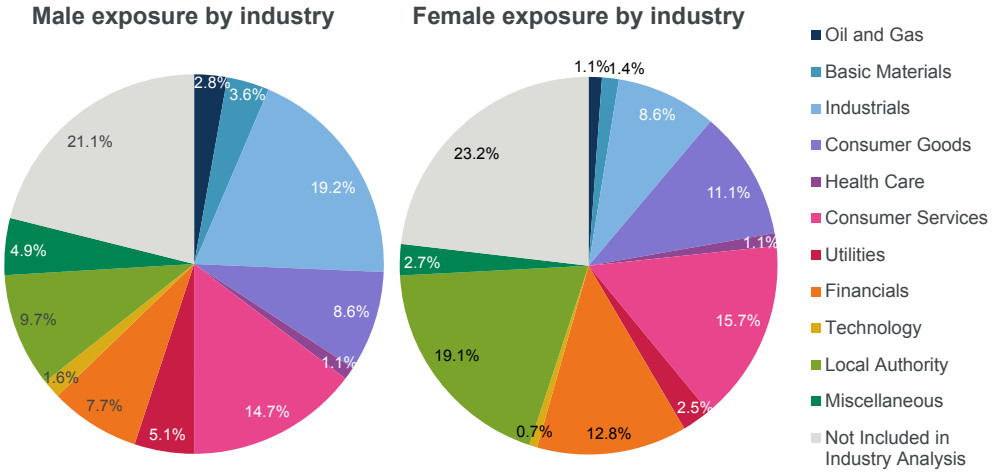
Date	Activity
2002 to 2006	Research and consultation
October 2008	**S1 Series tables released** (based on data covering 2000-2006)
April 2010 & May 2011	Annual experience updates covering 2001-2008 & 2002-2009
July 2011	Mortality improvements of self-administered pension schemes
May 2012	Analysis of 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

2. Current industry classifications

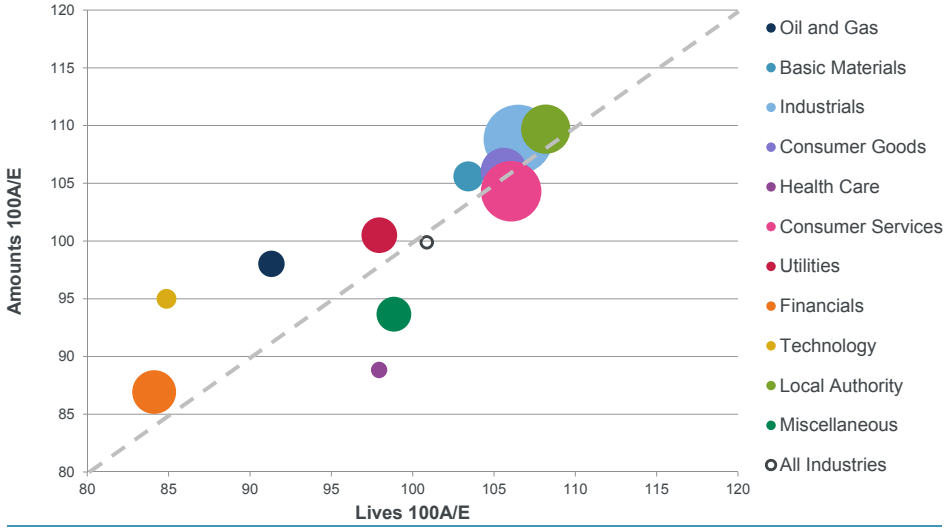
Code	Industry
51	Oil and gas
52	Basic materials
53	Industrials
54	Consumer goods
55	Healthcare
56	Consumer services
57	Telecommunications
58	Utilities
59	Financials
60	Technology
61	Public sector excluding local authorities
62	Local authorities
63	Miscellaneous

- SAPS industry classifications were updated in 2007 to bring them broadly in line with FTSE Actuaries Industry Sectors.
- The Coding Guide provides additional guidance on how to choose the most appropriate code including a detail breakdown of each of the high level codes.
- The SAPS industry for each scheme is chosen by the data contributor.

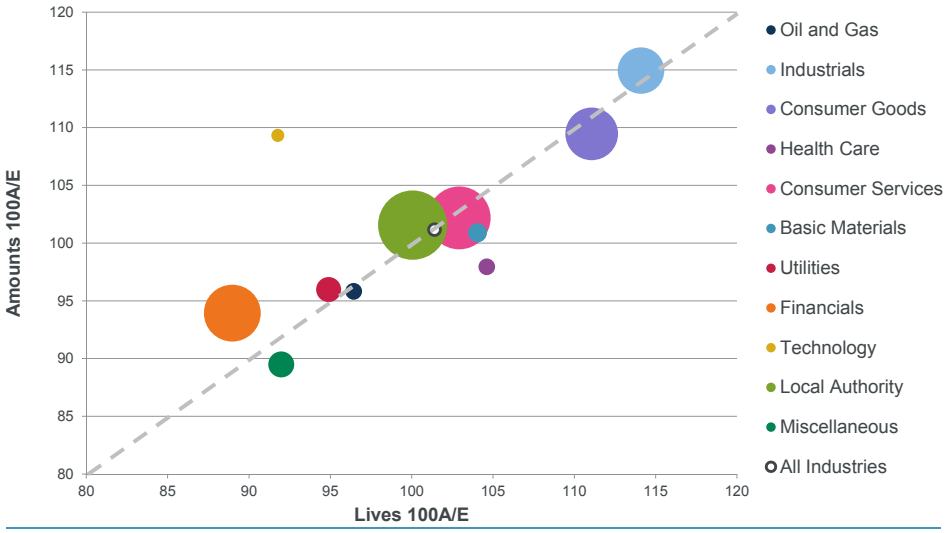
Industry analysis – exposure



Industry analysis – male experience vs S2



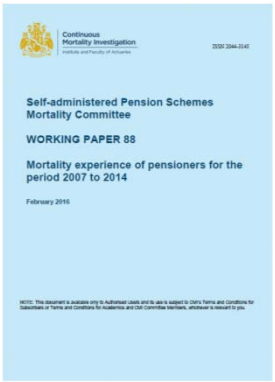
Industry analysis – female experience vs S2



Experience Analysis - Overview

Working Paper 88

- Covers 8 year period from 2007 to 2014
- Data submitted by 30 June 2015
- Modest decrease compared to 2006 to 2013 (WP 76)
  - 2.5% decrease in lives weighted exposure
  - 1% decrease in number of deaths
- Published on 24 February 2016
- Executive summary released publicly
- Main paper and data files are subscriber only


Continuous Mortality Investigation

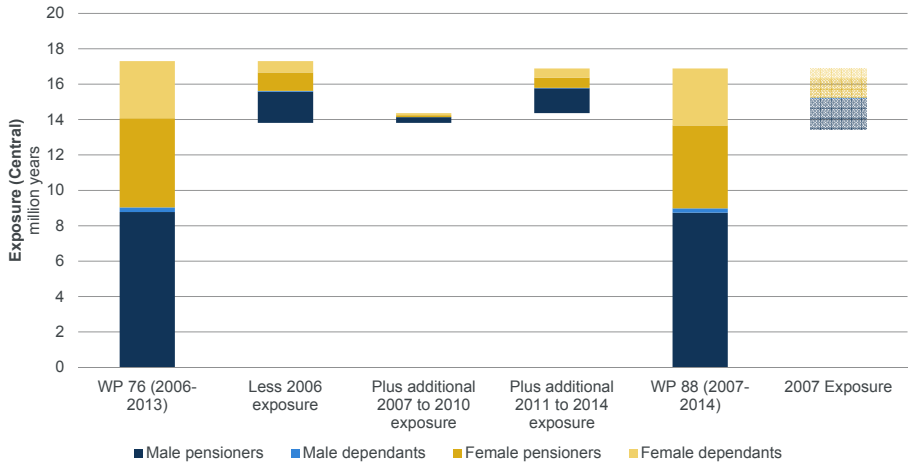
Self-administered Pension Schemes Mortality Committee

WORKING PAPER 88

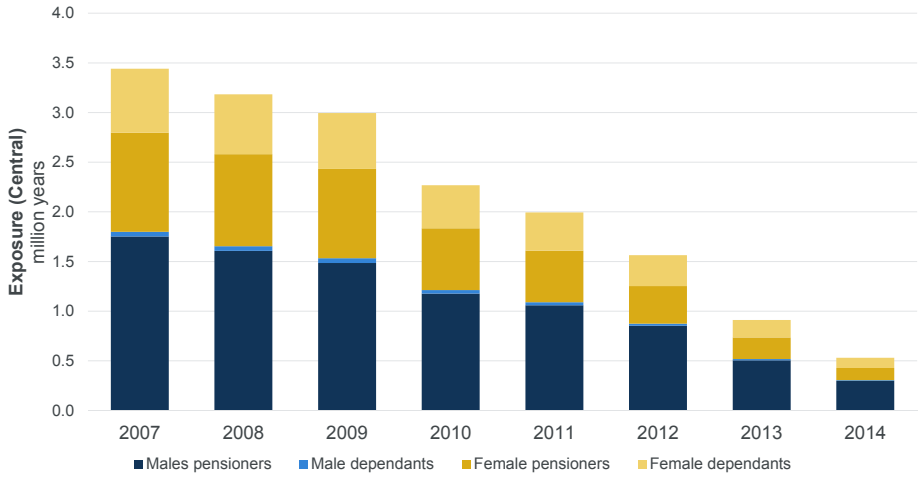
Mortality experience of pensioners for the period 2007 to 2014

February 2016

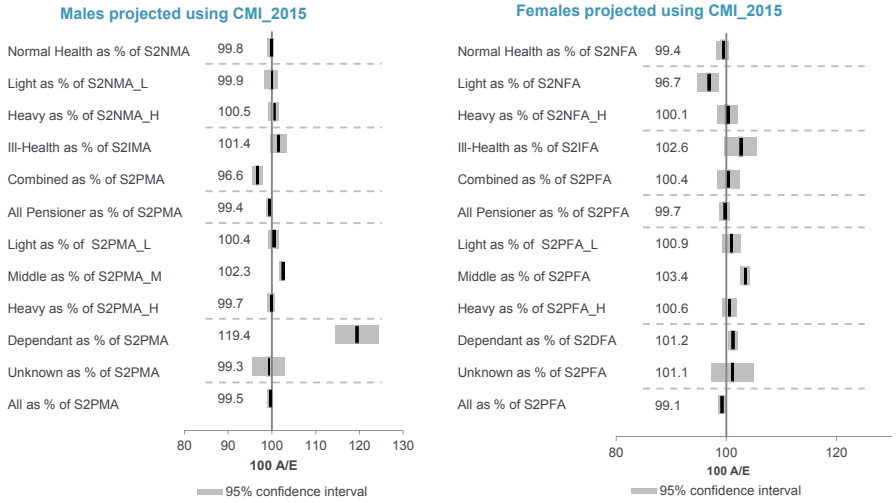
Experience Analysis - Data: Change in size



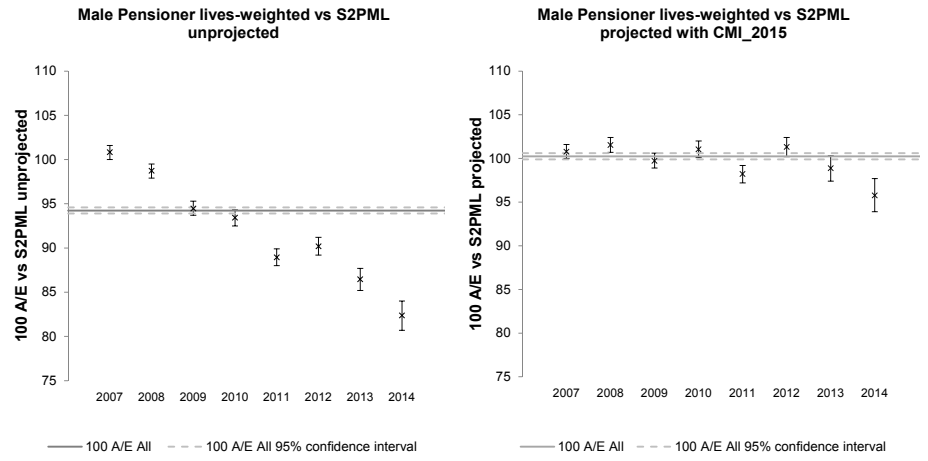
Experience Analysis - Data: By calendar year



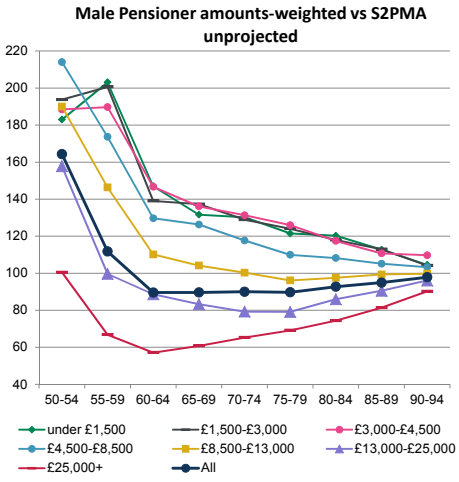
Experience Analysis - Results: By group (amounts)

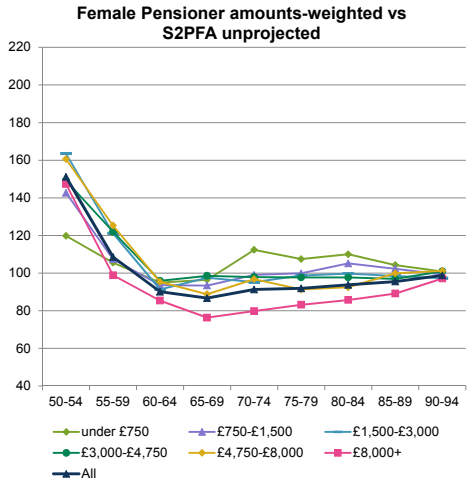


Experience Analysis - Results: By calendar year (lives)



Experience Analysis - Results: By pension amount (amounts)

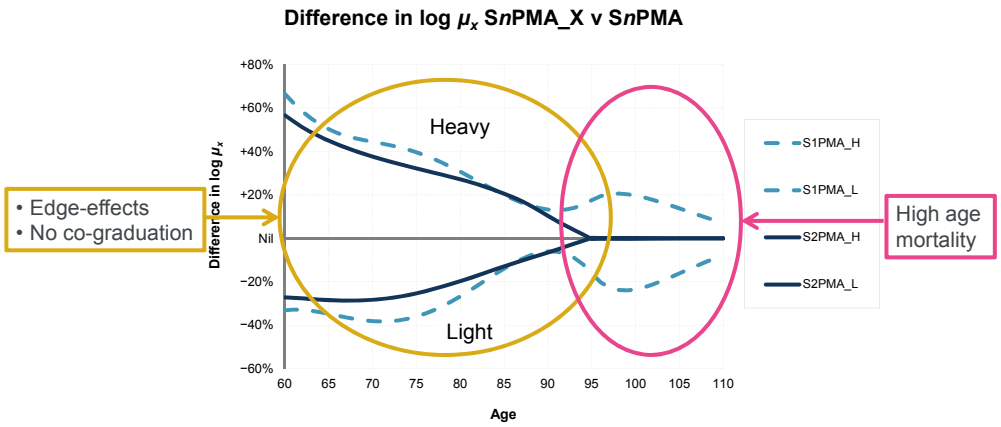




What next?

- 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



High Age Mortality Working Party

Background

High Age Mortality Working Party (HAMWP)

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

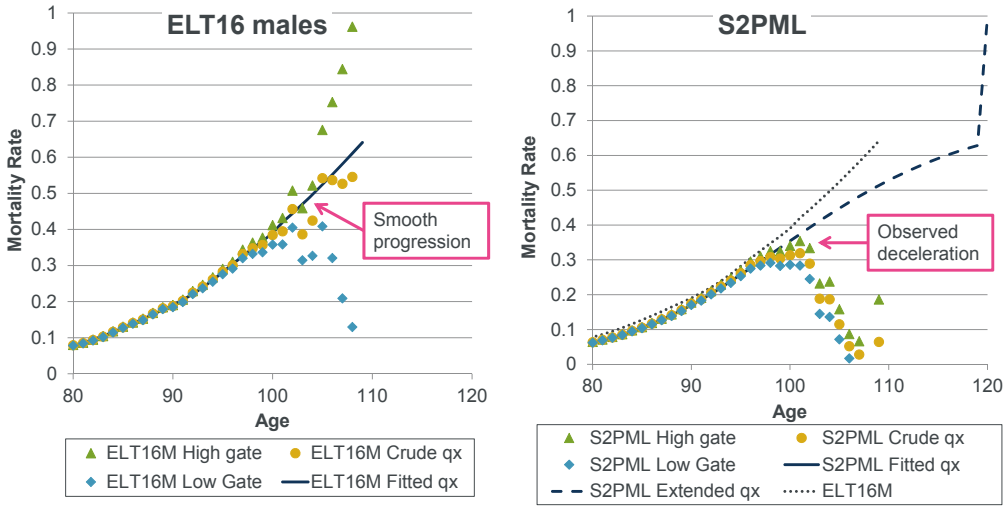
HAMWP terms of reference

- 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

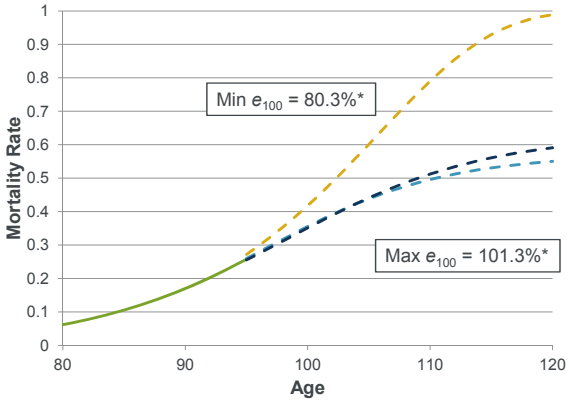
Mortality at high ages – crude and fitted rates



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

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

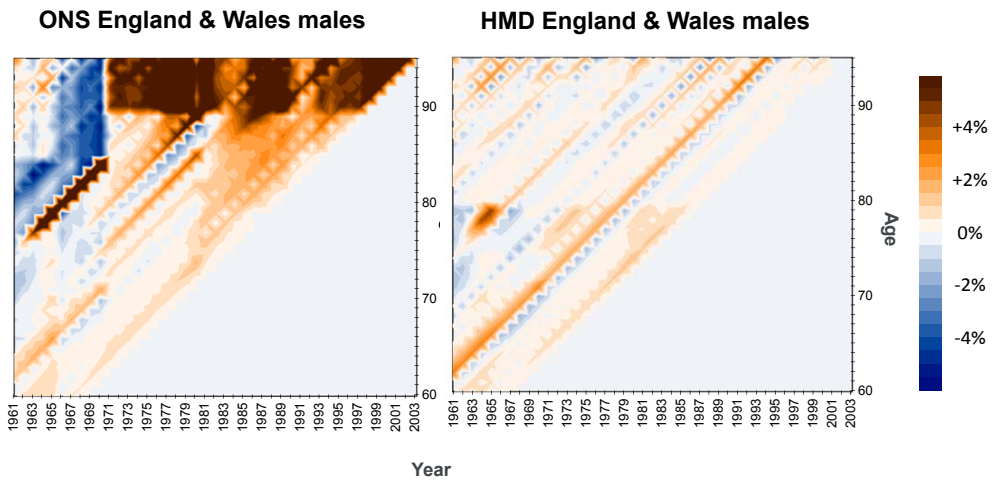
What data issues should be considered?

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

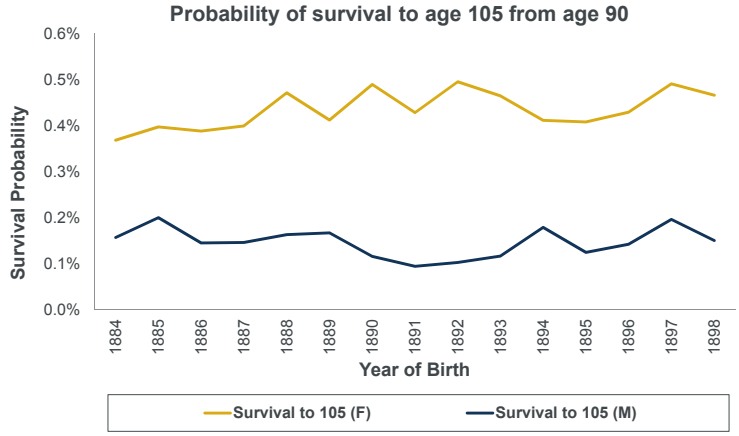
Extinct generations

- 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



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
June 2016		*Consultation on the future of the Model*
Mar 2017	*CMI_2016*	*First version of revised model*

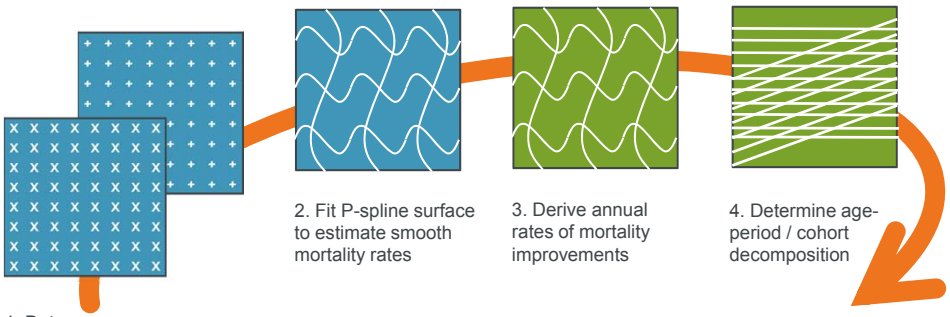
Current CMI Model – very high level overview

Estimate *current* improvements	◄◄ Stitch together ►►	Estimate '*long term*' improvements
Uncertain	More uncertain	Guess (educated)

In the short-term, the best guide to the likely pace of mortality improvement is the most recently observed experience.

The forces driving mortality change are themselves subject to change over time. Inform assumption choice less by analysis, more by subjective judgement.

Current CMI Model – overview



1. Data
(a) ONS provides raw death and population data for England & Wales
(b) Population data at high ages constructed by CMI (using ONS methodology)
(c) CMI caps unlikely data points

2. Fit P-spline surface to estimate smooth mortality rates

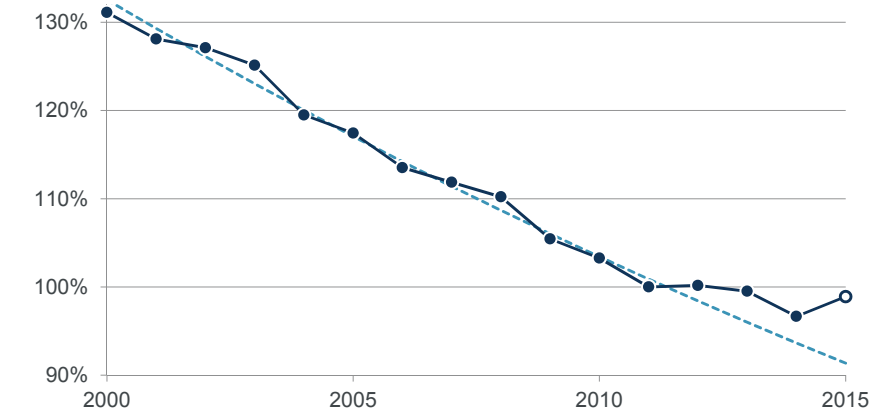
3. Derive annual rates of mortality improvements

4. Determine age-period / cohort decomposition

5. Projection
(a) Step back two years for initial rates
(b) Sum separate projections of age-period and cohort components

Recent mortality

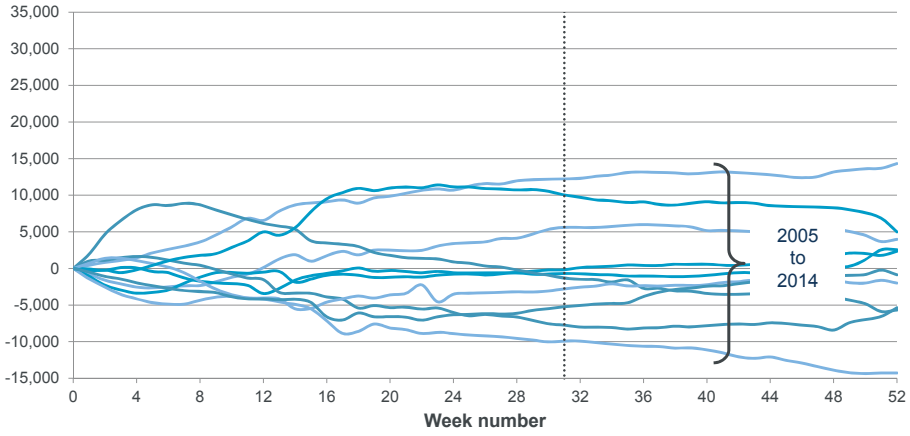
Standardised mortality ratio (2011), England & Wales, and 2000-2011 trend



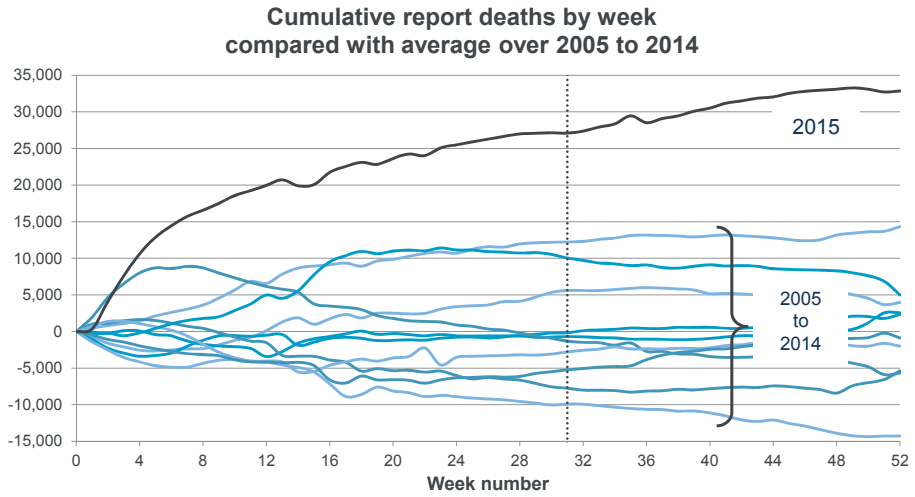
Note: 2015 data has been estimated based on actual deaths to 31 July.

Recent mortality – deaths since CMI_2015

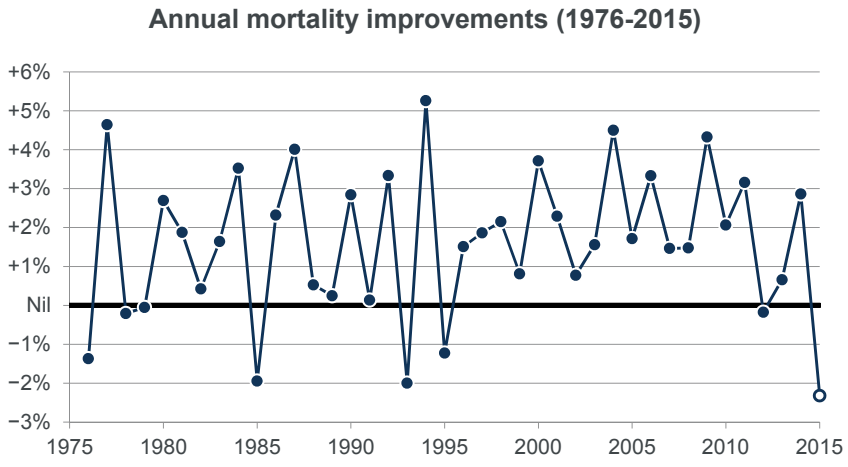
Cumulative report deaths by week compared with average over 2005 to 2014



Recent mortality – deaths since CMI_2015



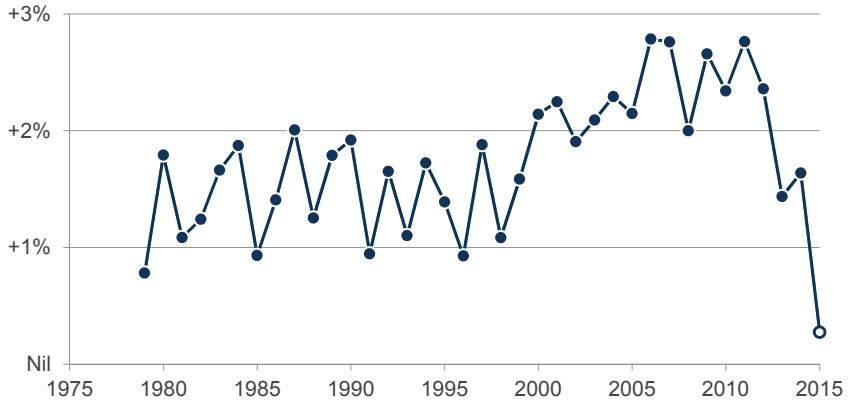
Recent mortality improvements



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

Recent mortality improvements

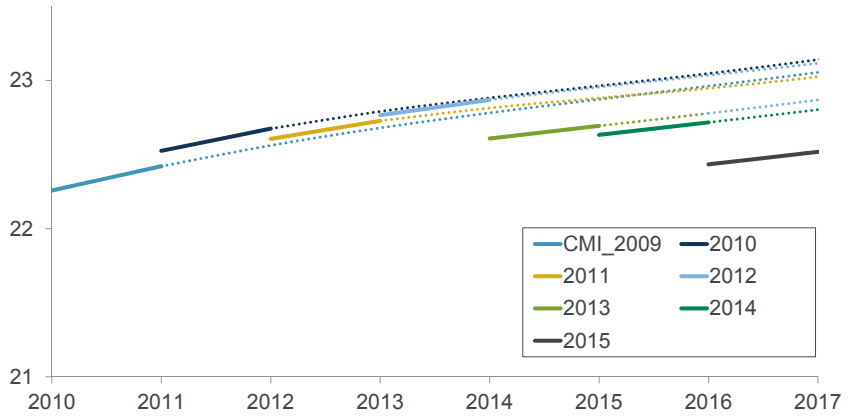
Four-year average annualised mortality improvements (1979-2015)



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 S2PxA + CMI_ 2015 vs CMI_2014 (LTR=1.5%).*

- Impact of moving from CMI_2012 considerably greater

Direction of travel is volatile

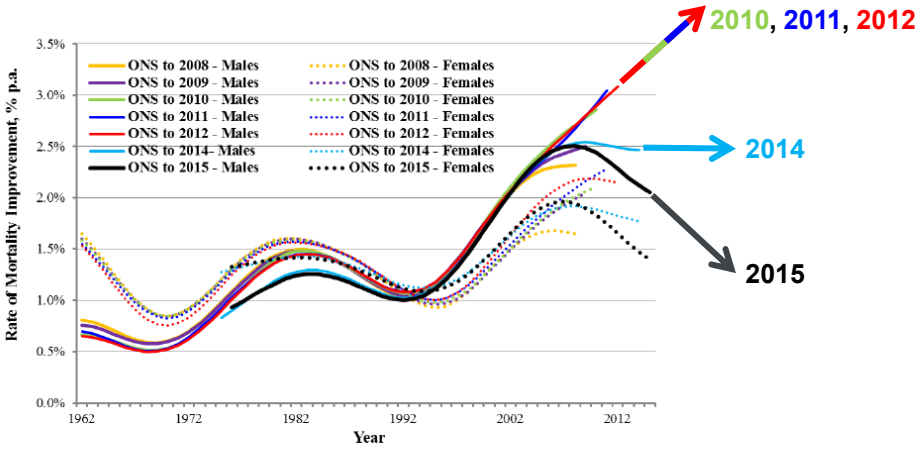


Figure 14: Period Component of the Rate of Mortality Improvement, by year, dataset, and gender; England & Wales Population Estimates derived by fitting APC models to smoothed mortality improvement rates

Avenues of investigation

Data	Possible features	Statistical understanding	Post CMI_2016 wish list
• Correction of artefacts • High age mortality	• 1 step calibration • Cohort convergence vs age variation • Consistent projections • Incorporate direction of travel?	• Current level of improvements • Current direction of travel • Convergence patterns	• 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

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

Please send any questions, views or feedback to info@cmilimited.co.uk

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