

Presentation to the Society of Actuaries in Ireland
Gordon Sharp and Neil Robjohns



The CMI Mortality Projections Model

Dublin, 30 March 2011

The CMI Mortality Projections Model

Agenda

- Irish mortality improvement assumptions – current practice
- Background and overview of the Model
- Highlights of the research on mortality improvement rates
- Parameterisation of the Model
- Change arising from incorporation of data for 2009
- How robust are the Model and default parameters?
- How do CMI_2010 core projections compare to the ICP?
- Further analysis of Irish population mortality.

Irish mortality improvements – current practice

Outline

- CSO Mortality Improvements
- SAI Assumptions
 - Pensions
 - Reserving
- Irish Population Mortality Trends – Update: 2006-2010.

Irish mortality improvements – current practice

CSO Mortality Improvement Assumptions

Assumed annual rates of mortality improvement

Ages	Sex	2005	2031	2005-2031	2031+
0 – 90	Males	5.0%	1.5%	Interpolation	1.5%
0 – 90	Females	3.5%	1.5%	Interpolation	1.5%
91 – 99	Both	Interpolation	Interpolation		Interpolation
100+	Both	0.0%	0.0%		0.0%

Irish mortality improvements – current practice

SAI Assumptions – Pensions

SAI Assumptions – Pensions

- ASP-Pen2 – Transfer Value Basis
- Proxy to 108% of 00 series Lives tables with CSO improvements applied in respect of 2006 onwards
- Post Retirement Mortality Assumptions
 - Males: 62% of PNML00
 - Females: 70% of PNFL00
 - Increase to annuity value (per year compound)
 - 0.50% males with no spouses pension
 - 0.38% females with no spouses pension
 - 0.39% male or female with spouses pension.

Irish mortality improvements – current practice

SAI Assumptions – Reserving

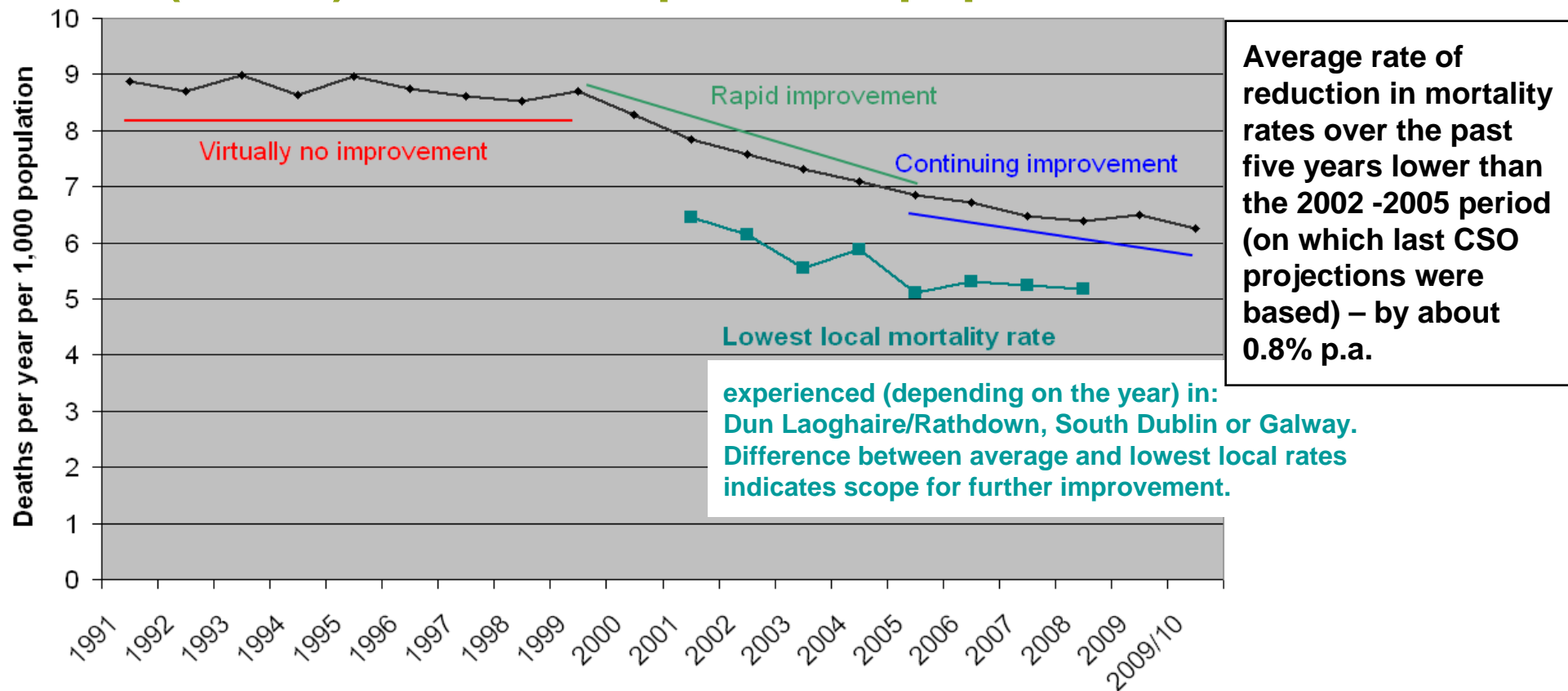
SAI Assumptions – Reserving

- Source: year-end 2009 regulatory returns for life companies
- Base experience – typically UK 2000 tables
 - E.g. 100% PNMA00/PNFA00
- Improvements
 - Majority medium cohort plus underpin
 - Underpin typically between 1.5% and 2%
 - Some different structure e.g. flat 3% per annum.

Irish mortality improvements – current practice

Population mortality trends – update 2006-2010

(Crude) death rates per 1,000 population



Reduction in crude death rates is lower than actual average rate of improvement given an ageing population (probably by around 1% p.a.)

The CMI Mortality Projections Model

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Background and overview of the Model

Background and motivation

- Interim Cohort Projections
 - Published in 2002, based on data to 1999
- ICPs have been in widespread use (albeit with modifications)
- Perceived advantages of the ICPs were:
 - They were valued as a common currency
 - They could be modified relatively easily
 - They could be applied to any base mortality table
- But the ICPs are significantly and increasingly out-of-date.

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Background and overview of the Model

Background and motivation

- CMI looked for stochastic projection model
 - P-spline – but vulnerable to edge effects
 - Lee-Carter – but poor fit to UK data (cohort effects)
 - No projections in “00” Series tables
- CMI Library of Mortality Projections
- Many other approaches & models developing
 - Stochastic models; mortality by cause; model by disease.

The CMI Mortality Projections Model

Background and overview of the Model

Background and motivation

- CMI Working Party established in 2008 to produce a projection model which shares the desirable features of the Interim Cohort Projections, but also:
 - reflects the latest experience on trends in mortality;
 - is relatively straightforward to understand and describe;
 - allows users the flexibility to modify projections to suit their own views and purpose; and
 - can be regularly updated over time to reflect emerging experience.

The CMI Mortality Projections Model

Background and overview of the Model

Key development stages and outputs

- Published in June / July 2009 for Consultation
 - A prototype version of the CMI Model: CPMv0.0
 - CMI Working Paper 38: Part I – Outline
 - CMI Working Paper 39: Part II – Detailed Analysis
- Launch of the CMI Model, November 2009:
 - CMI Working Paper 41: Feedback on the consultation
 - Updated version of the Model: CMI_2009
 - Updated User Guide and Parameter Sensitivity Test results
- First annual update, November 2010:
 - CMI Working Paper 49 and updated version CMI_2010.

The CMI Mortality Projections Model

Background and overview of the Model

The structure of the Model

- Project annual rates of mortality improvement
 - Relatively simple; accessible; flexible
 - Not a mathematical model of mortality fitted to data
- Deterministic projection driven by user inputs
 - Initial rates of mortality improvement
 - Long-term rate(s) of mortality improvement
 - Speed & pattern of convergence
 - Split projection by age or by year-of-birth cohort
- Core and Advanced parameter layers.

The CMI Mortality Projections Model

Background and overview of the Model

Convergence from current rates to a long-term rate

- In the short-term, the best guide to the likely pace of mortality improvement is the most recently observed experience
- In the long-term, the forces driving mortality change are likely to be very different; more subjective, better informed by expert opinion
- The Working Papers include research on:
 - Mortality improvement by cause-of-death
 - Long-run average rates of change in a range of countries
 - Analysis of implied long-term rates from sample of other projection models.

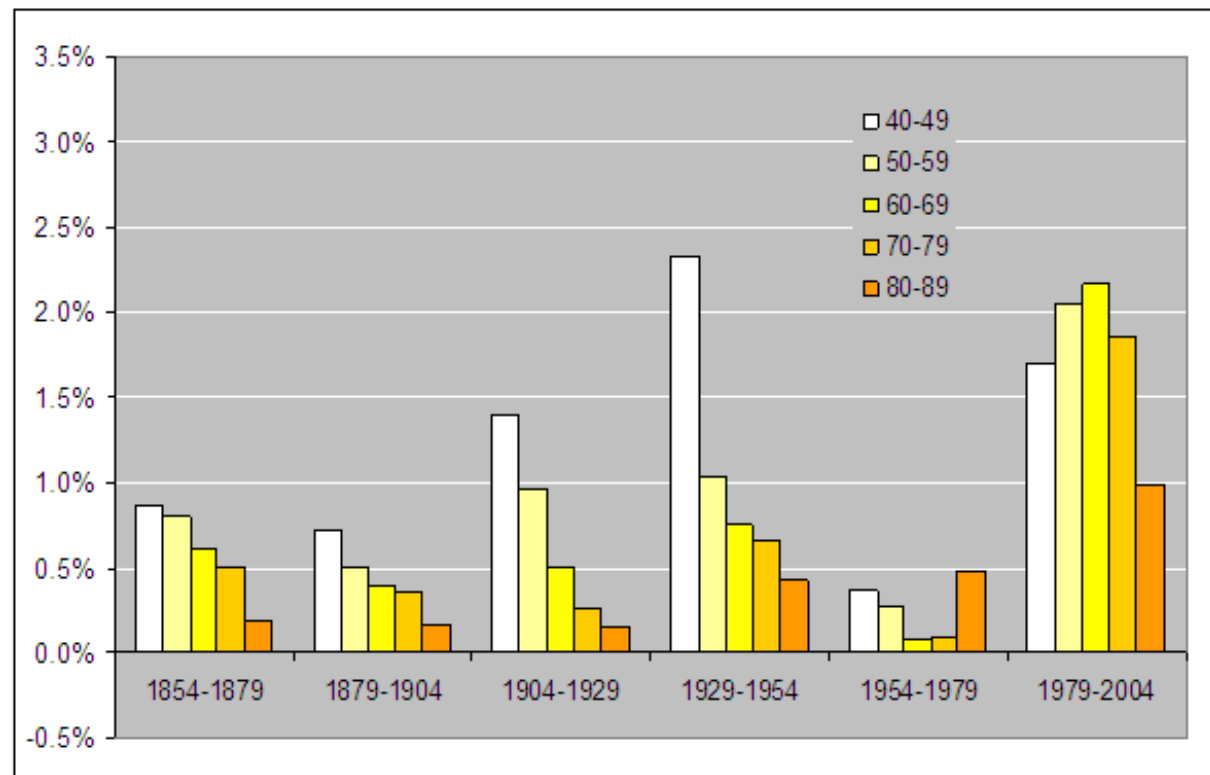
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Background and overview of the Model

Average annual rates of mortality improvement

7 countries; males; successive periods of 25 years, by age group

Belgium, Denmark, England & Wales, France, Netherlands, Norway and Sweden



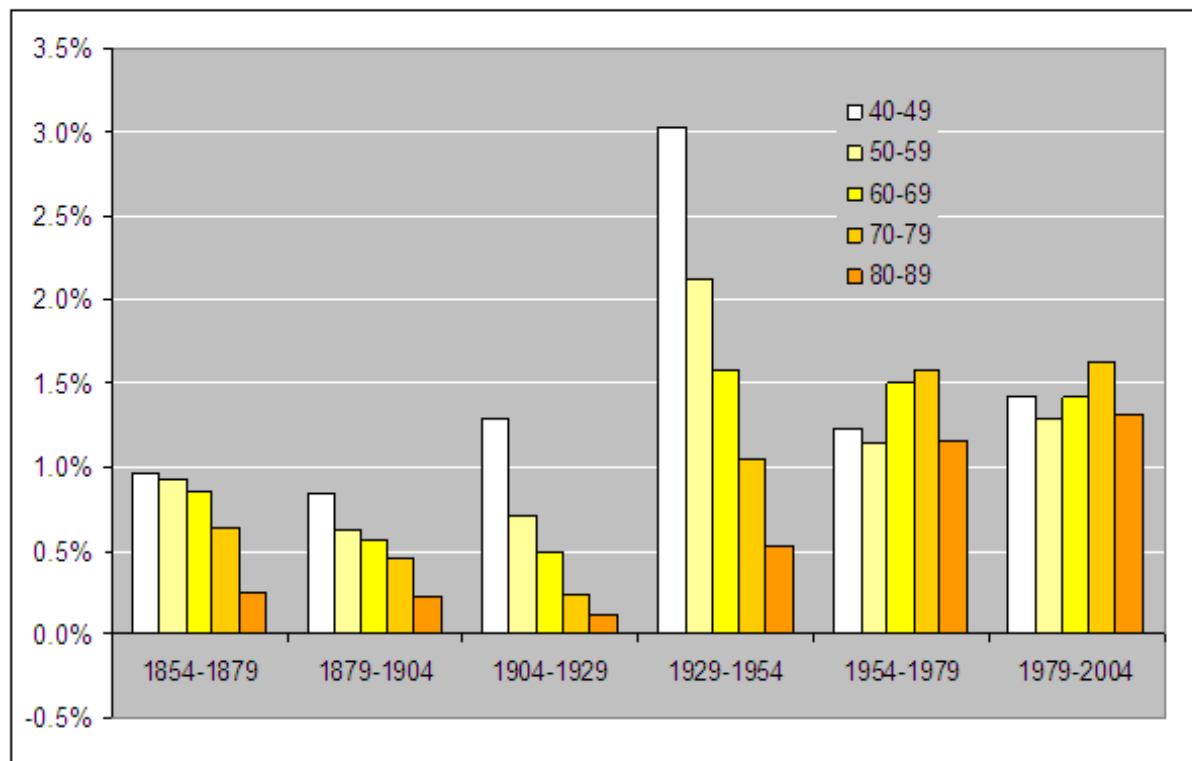
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Background and overview of the Model

Average annual rates of mortality improvement

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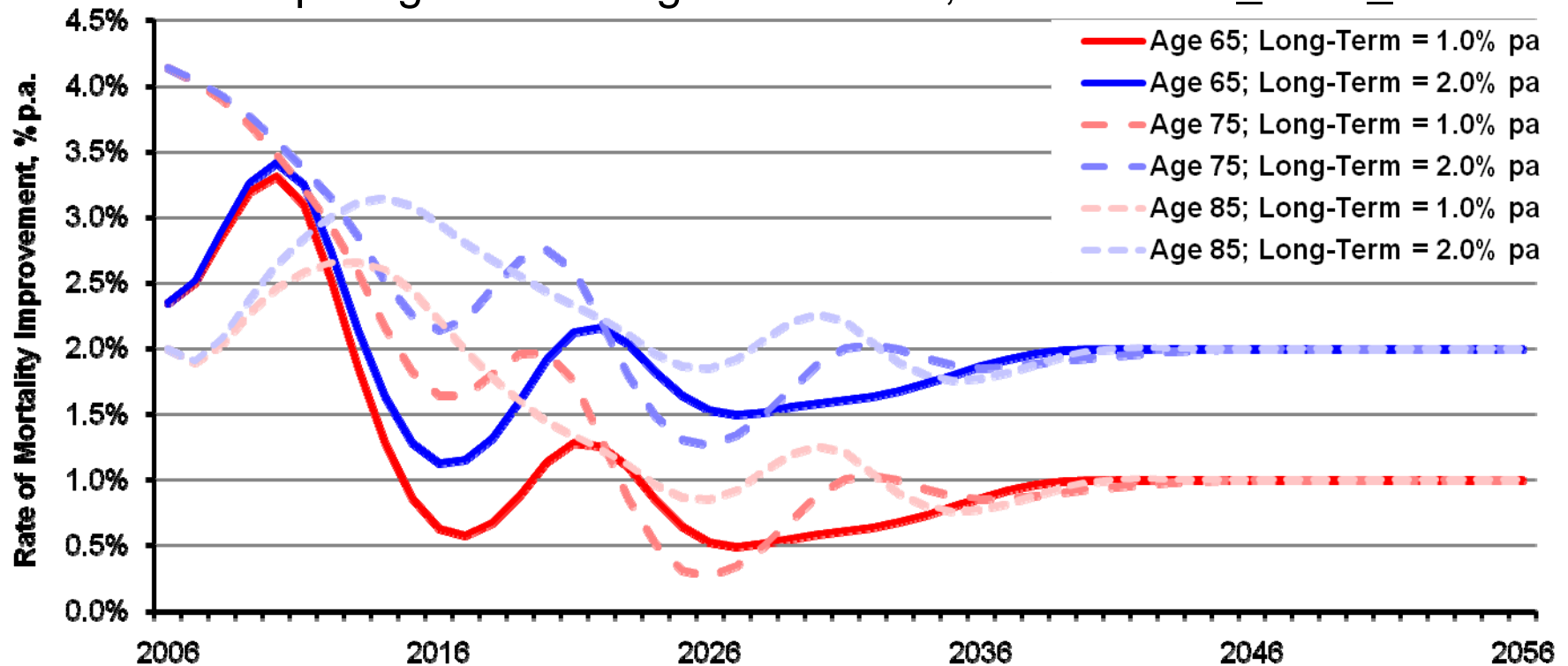
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Background and overview of the Model

Convergence from current rates to a long-term rate

Modelled Mortality Improvement Rates

Sample ages and Long-Term Rates; source: CMI_2009_M



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Background and overview of the Model

Core parameter layer

- Allows users to focus on two simplified parameters:
 - A Long-Term Rate of Mortality Improvement
 - A Constant Additional Rate of Mortality Improvement
- Default values are applied to other parameters.

Advanced parameter layer

- Gives users considerable flexibility; allowing specification of:
 - Initial Rates of Mortality Improvement
 - Cohort and Age/Period components of Initial Rates (by individual age & birth cohort)
 - Long-term Rates of Mortality Improvement (by individual age & birth cohort)
 - Period of Convergence (by individual age & birth cohort)
 - Proportion of Convergence remaining after Mid-point (by individual age & birth cohort)
 - Base Rates of Mortality.

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Highlights of the research

Brief review of selected topics

- Estimating mortality improvement rates
- Patterns of mortality change – by dataset
- Observations on the effect of data volumes

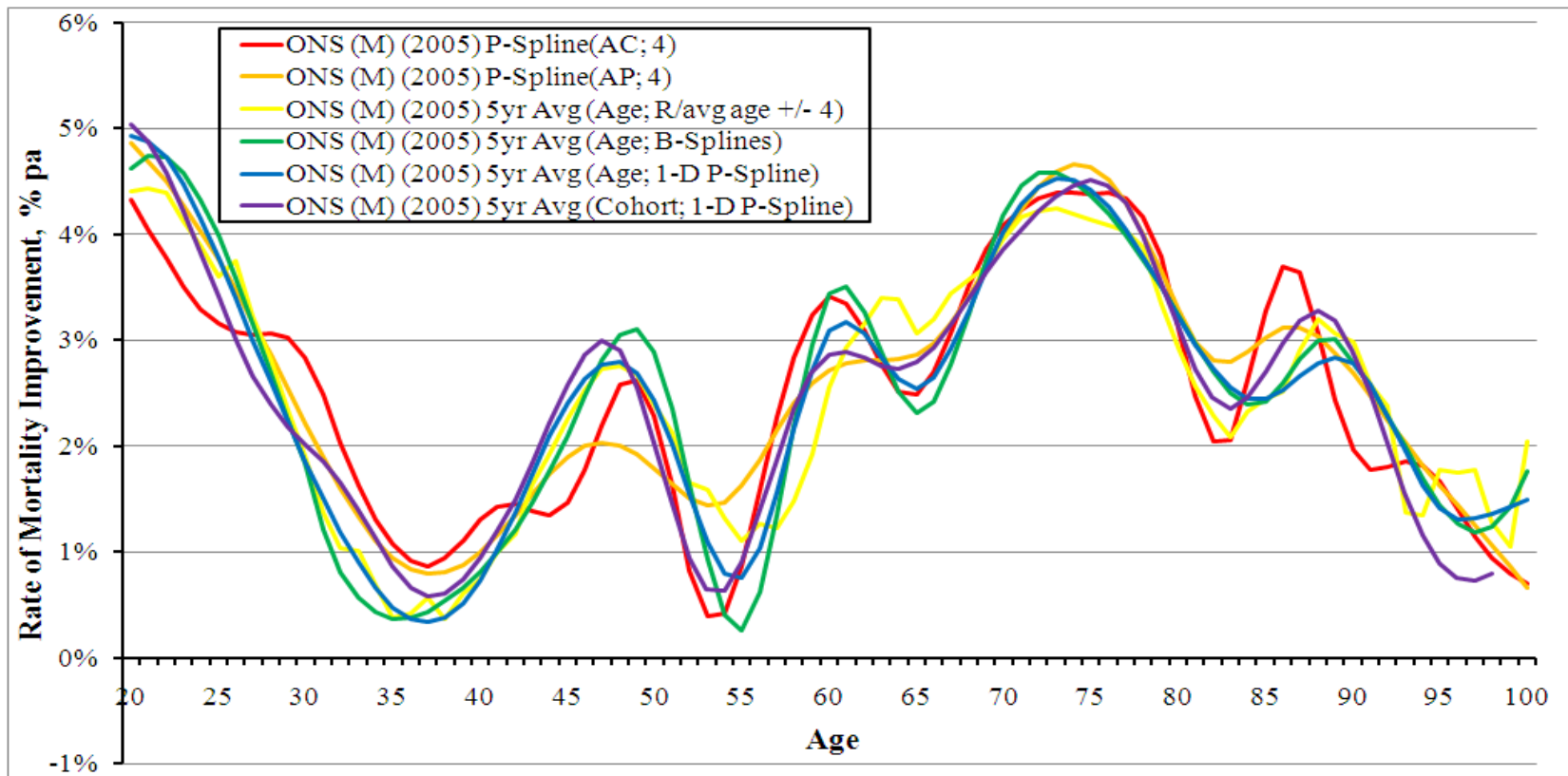
Overview of research on mortality improvement rates

- Main conclusions
- Round-up.

The CMI Mortality Projections Model - Research

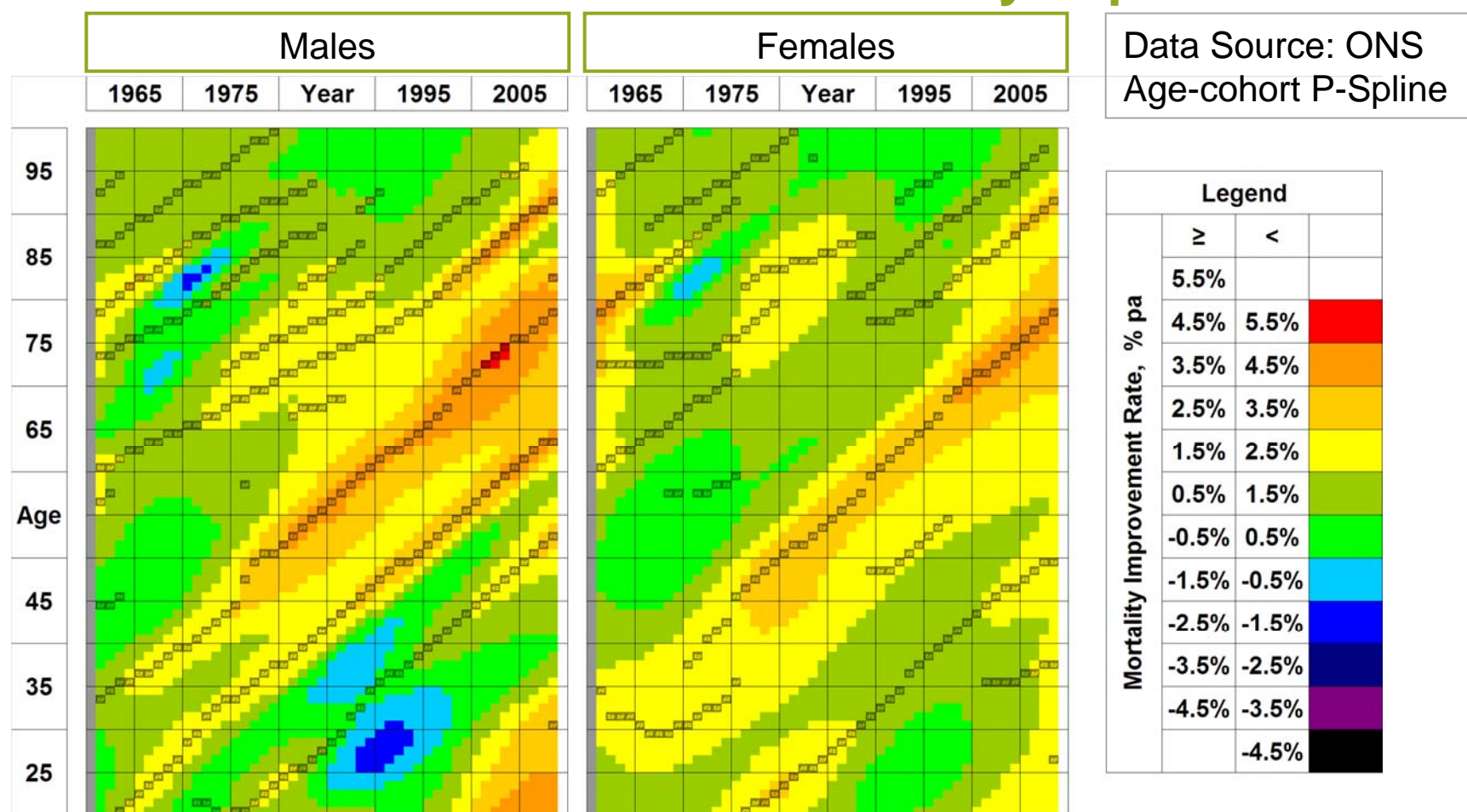
Estimating mortality improvement rates

Estimates of annual rates of mortality improvement in 2005
Alternative methodologies; Population of England & Wales; Males



The CMI Mortality Projections Model - Research Patterns of mortality change: population of E&W

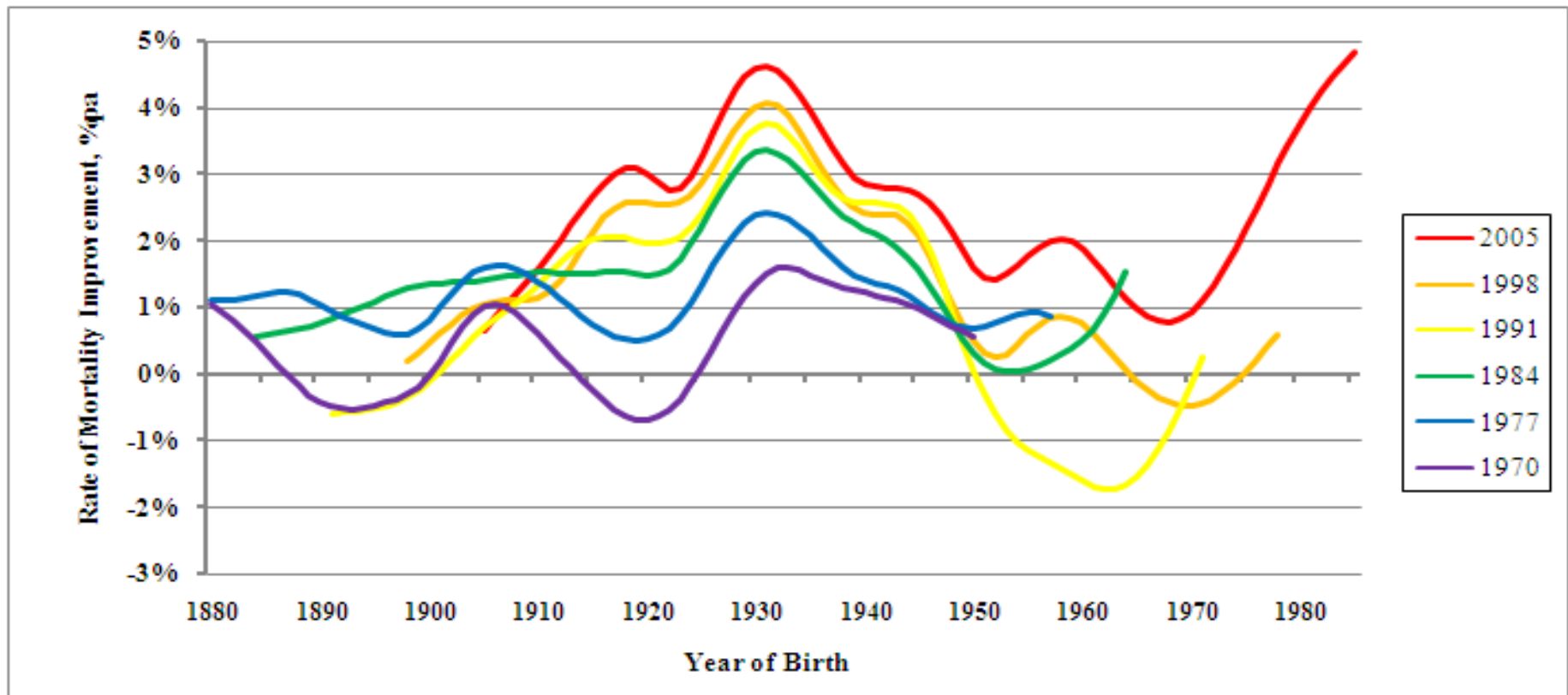
Estimates of annual rates of mortality improvement



The CMI Mortality Projections Model - Research

Patterns of mortality change: population of E&W

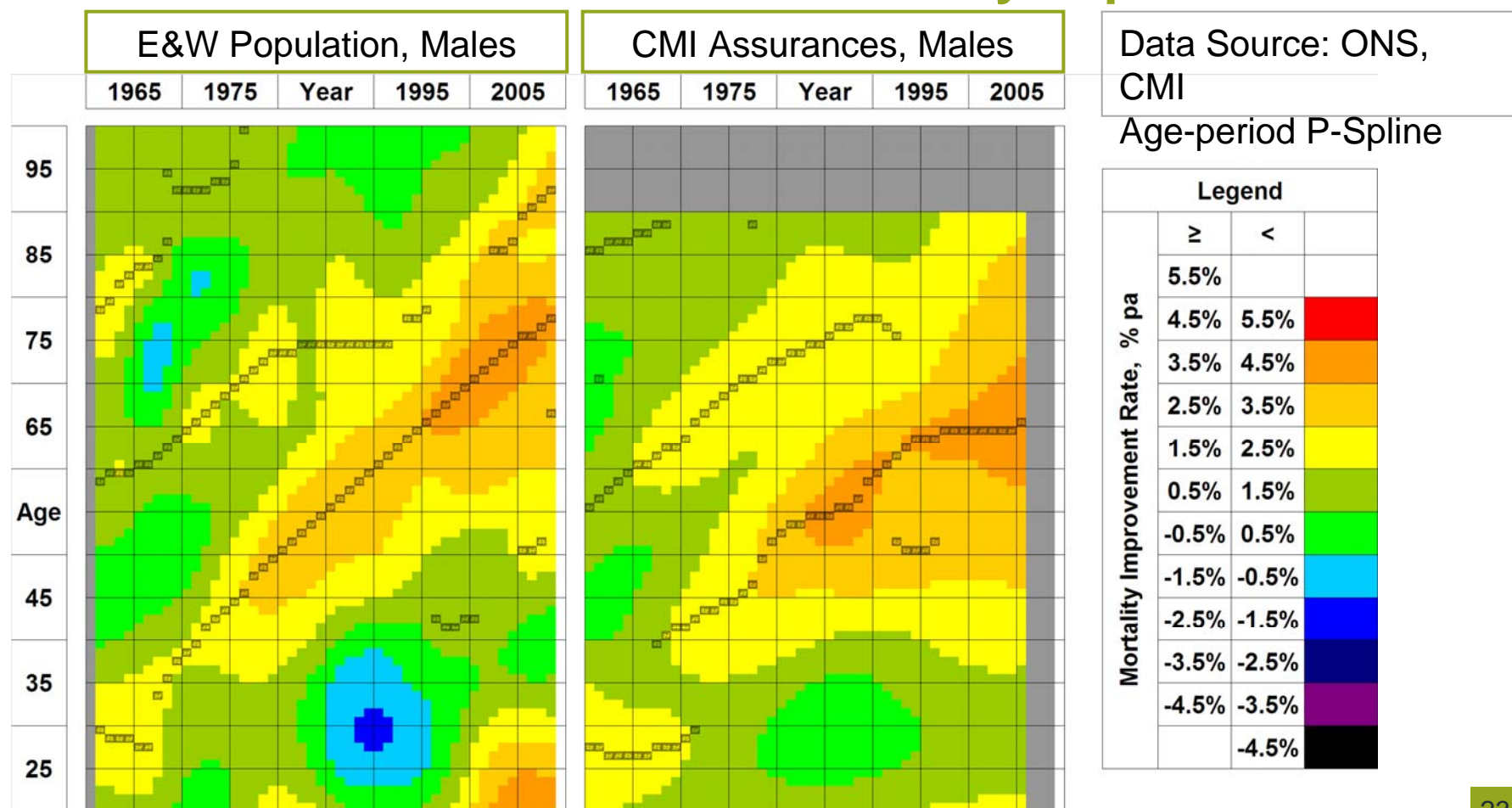
Estimates of annual rates of mortality improvement by year
Population of England & Wales; Males; Age-period P-Spline



The CMI Mortality Projections Model - Research

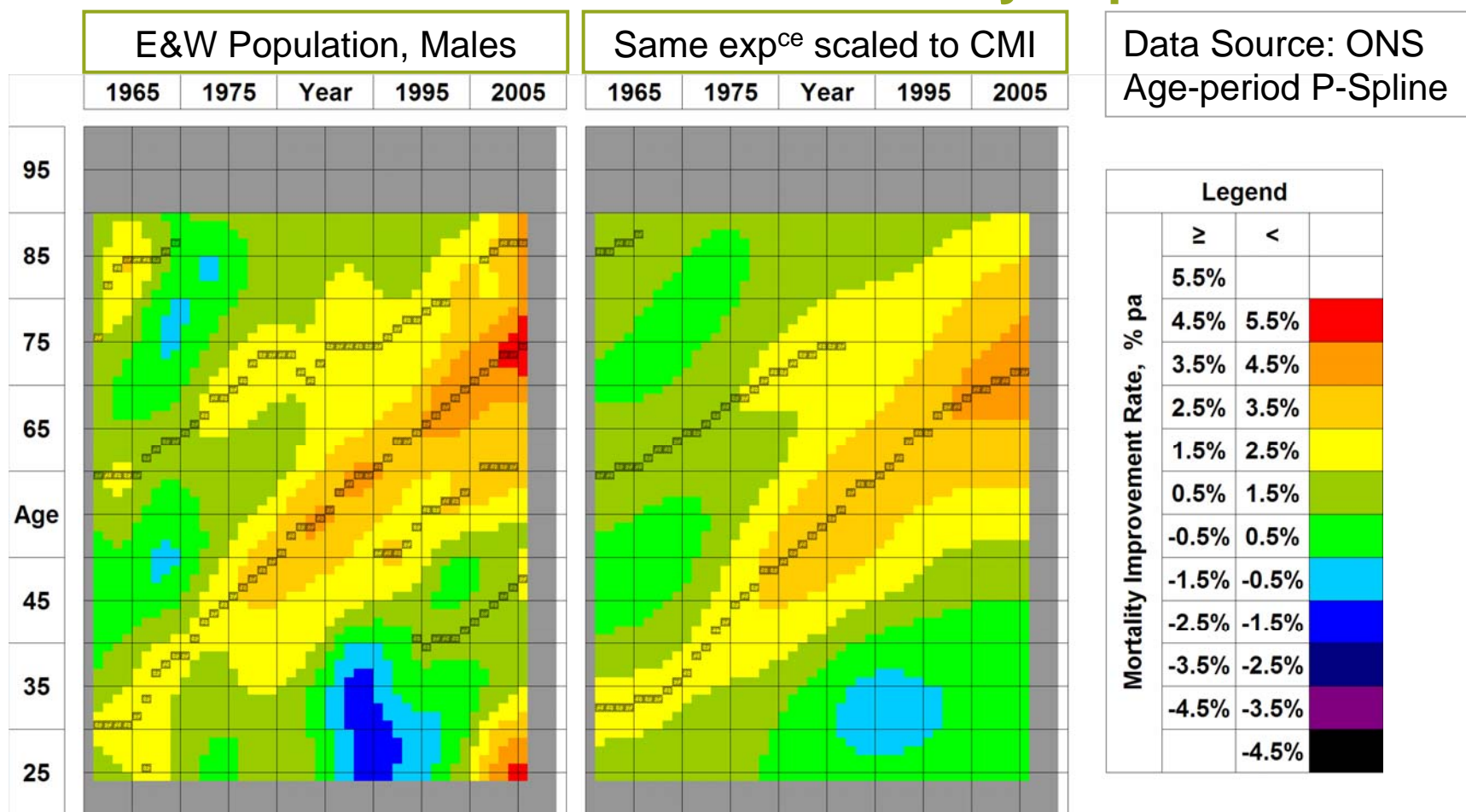
Patterns of mortality change: CMI Assurances

Estimates of annual rates of mortality improvement



The CMI Mortality Projections Model - Research Observation on effects of data volume

Estimates of annual rates of mortality improvement



The CMI Mortality Projections Model

Highlights of the research

Research on mortality improvement rates: main conclusions

- England & Wales Population Data
 - Clearly shows 2 major features of mortality change
 - Persistent year-of-birth cohort peaks and troughs; most notable peak for 1931 cohort
 - A general increase over the last 15 years across a wide age-range
 - So model age/period and cohort components.
- Insured & Pensioner Data
 - Lower data volumes reduce clarity of observations
 - Unable to distinguish between concurrent features
 - Much more difficult to interpret trends
 - So base defaults for Model on population data.

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Highlights of the research

Research on mortality improvement rates : round-up

- Evidence no longer supports 1926 cohort feature of the ICPs
- Step 2 years inside edge of data to reduce estimation uncertainty
- Variety of features of mortality improvement
 - cohorts (25+ yrs; above age 40);
 - age/period (typically shorter)
- Improvement rates tend to run to zero for age 100+
- No clear picture on trends by social class
- Even 25-year averages of improvement rates vary significantly.

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Parameterisation of the Model

Initial Rates of Mortality Improvement

- Informed by recent observed experience
- Use E&W population data for Core parameter default values
 - For CMI_2010 use data to 2009; estimate rates for 2007
 - Smooth using age-cohort P-Spline model
- Estimate age/period and cohort components
 - Use bespoke age-period-cohort model
 - Need to set constraints - arbitrarily set $\Sigma_{\text{age}} = \Sigma_{\text{cohort}} = 0$
- Maintained consistent methodology
 - Used for Prototype, CMI_2009 and CMI_2010.

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Parameterisation of the Model

Long Term Rates of Mortality Improvement

- No default parameter values set – user input required!
 - But there is a default pattern by age (input rate to age 90, then linearly to zero at age 120)
- Some possible sources to help inform opinion
 - National and international mortality data
 - Observed trends and long-term rates of mortality improvement
 - Other mortality projections and projection tools
 - Mathematical models: CBD, Lee-Carter, P-Spline, ...
 - National and international ‘governmental’ population / mortality projections
 - Analysis / modelling of trends by cause-of-death or disease processes
 - Research on past, current and expected medical and social changes
 - Expert opinion.

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Parameterisation of the Model

Convergence Period and Path

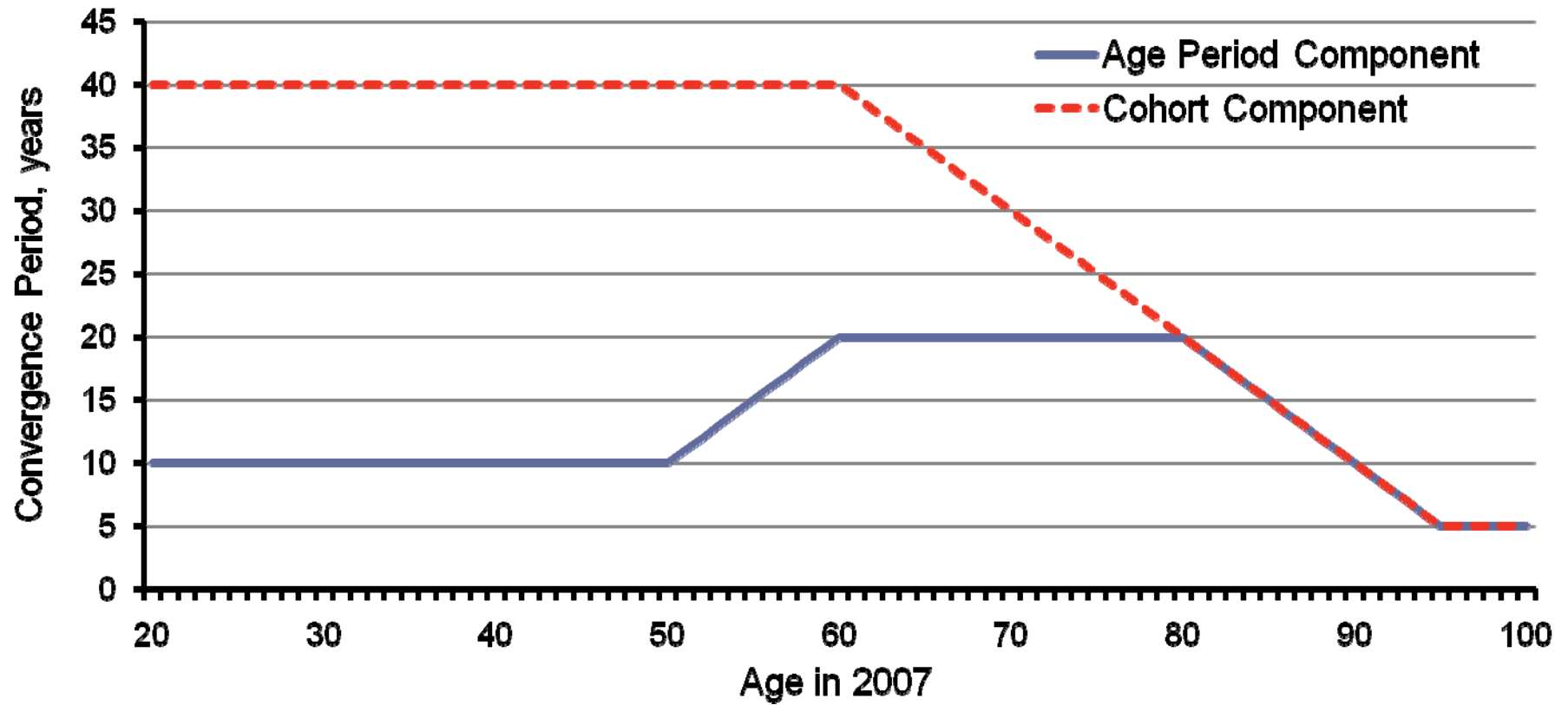
- Convergence Periods based on qualitative research
 - Review of patterns seen in UK and international experience
- Convergence Path
 - Broadly ‘straight-line’ for Core parameter default values
- Maintained pattern for successive versions of the Model
 - Age/Period component
 - Maintained period (shift start and end forward by 1 year)
 - Re-sets the period by taking a fresh view on emerging trends
 - Cohort Component
 - Maintained rule: period runs to age 100, but min=5, max=40.

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Default values for Core parameters of CMI_2010

Period of Convergence

Core parameter values in CMI_2010



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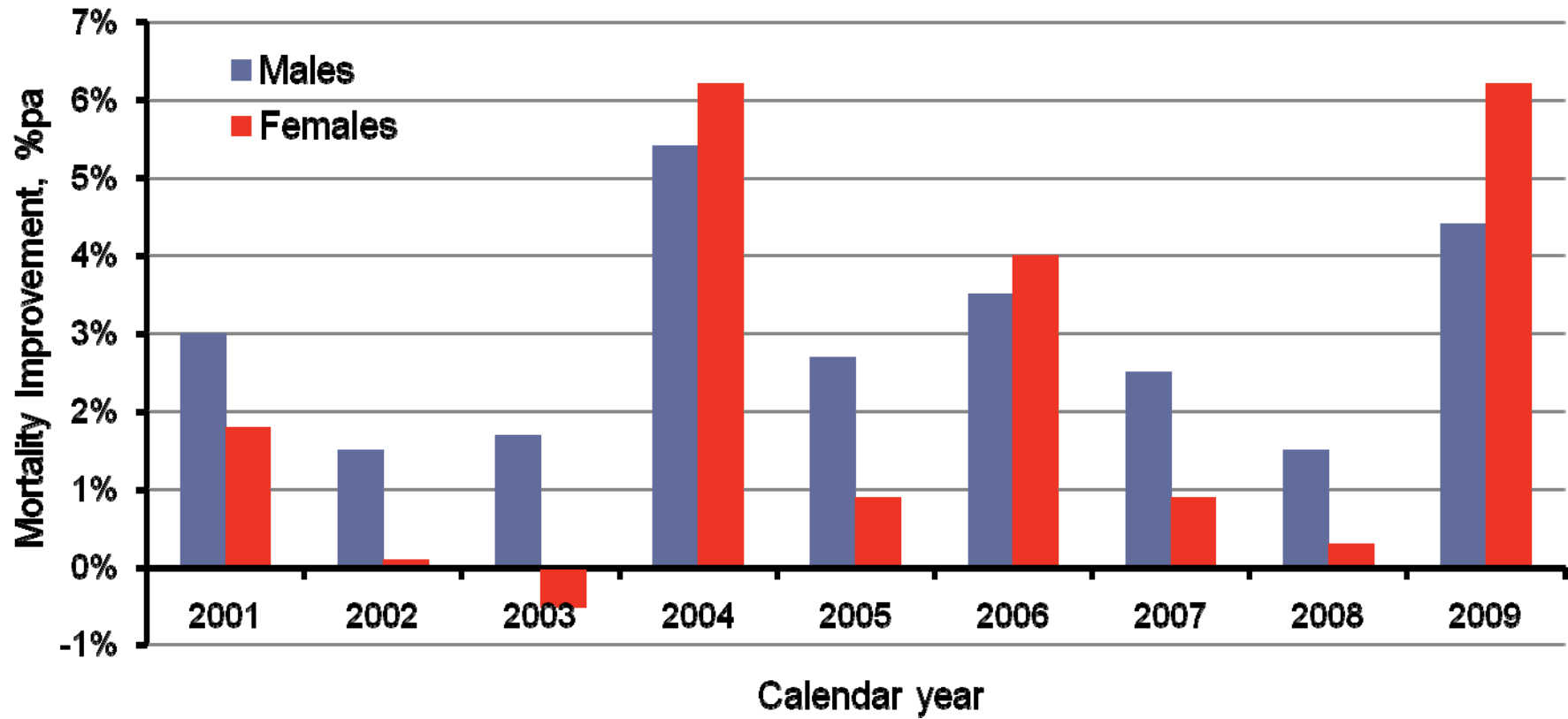
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Change arising from incorporation of data for 2009

Crude annual mortality improvement rates

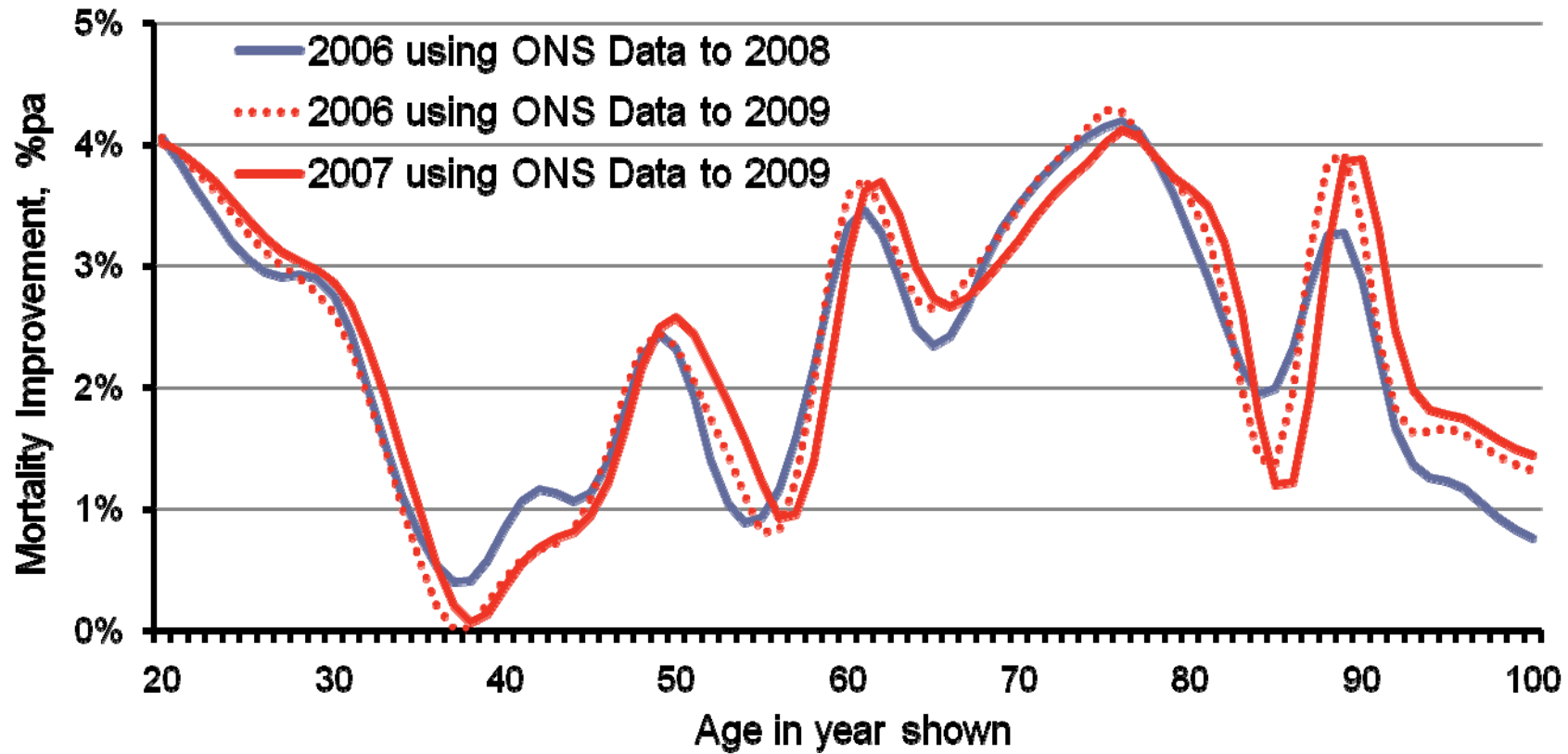
Population of England & Wales; age 18-102; age standardised



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Change arising from incorporation of data for 2009

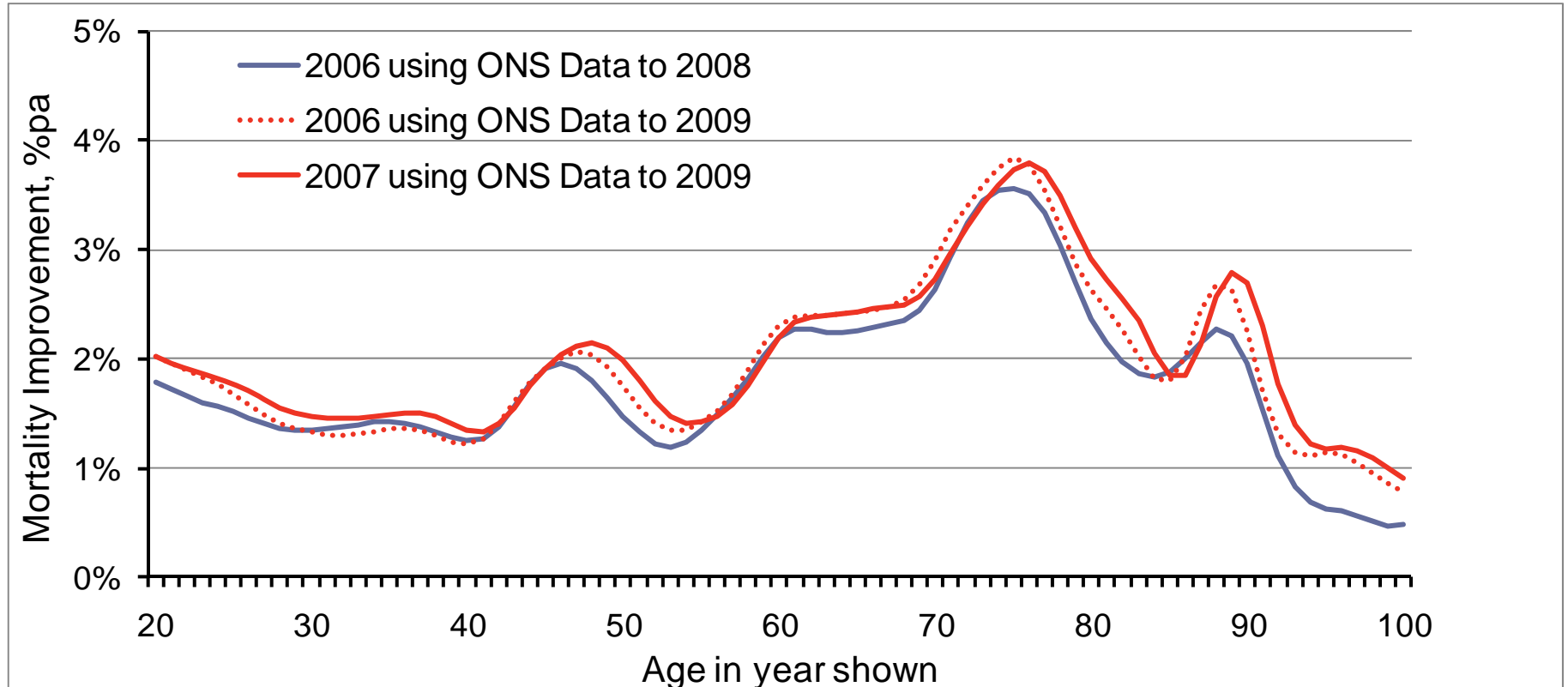
Annual rates of mortality improvement, by age, year and data
P-Spline models; population of England & Wales; males



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Change arising from incorporation of data for 2009

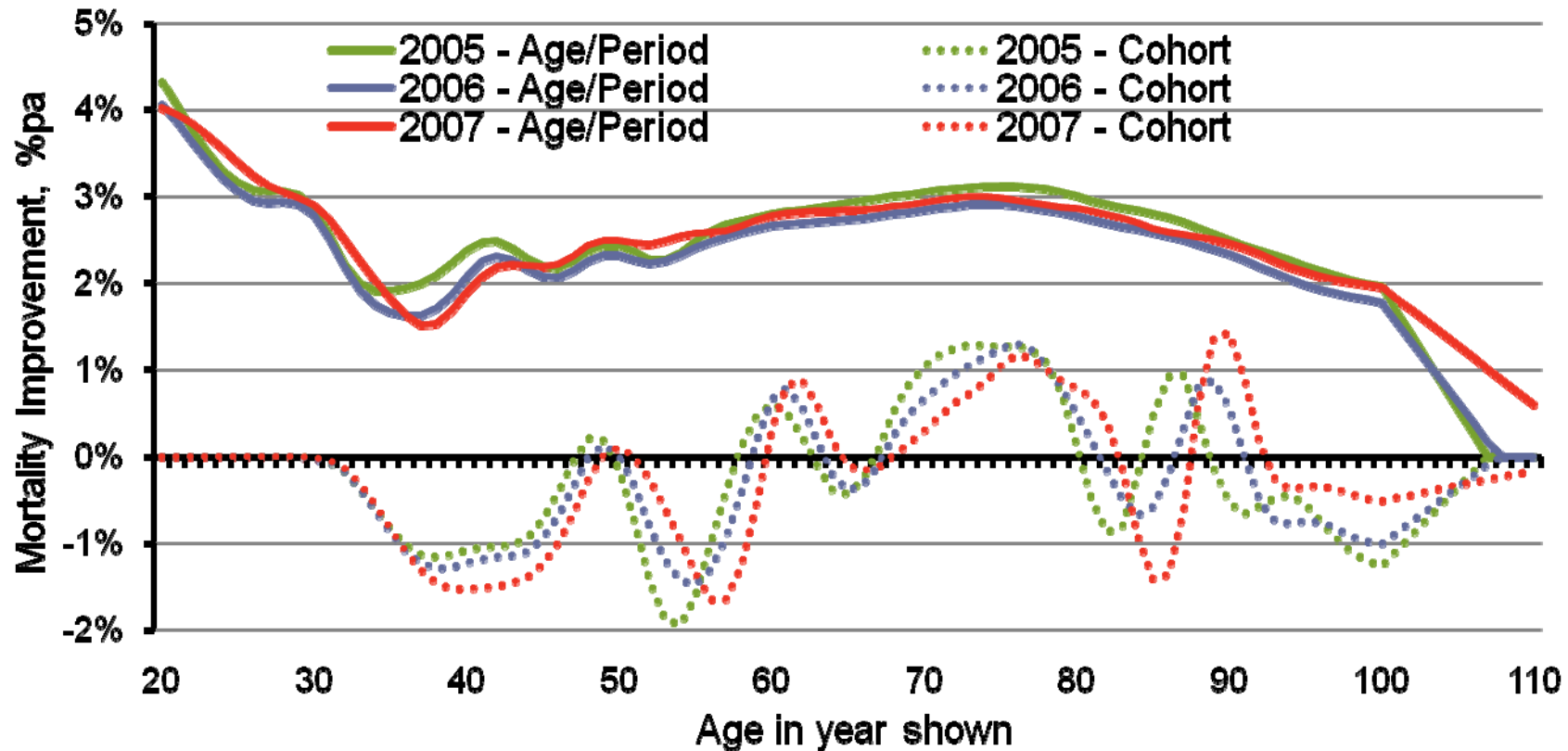
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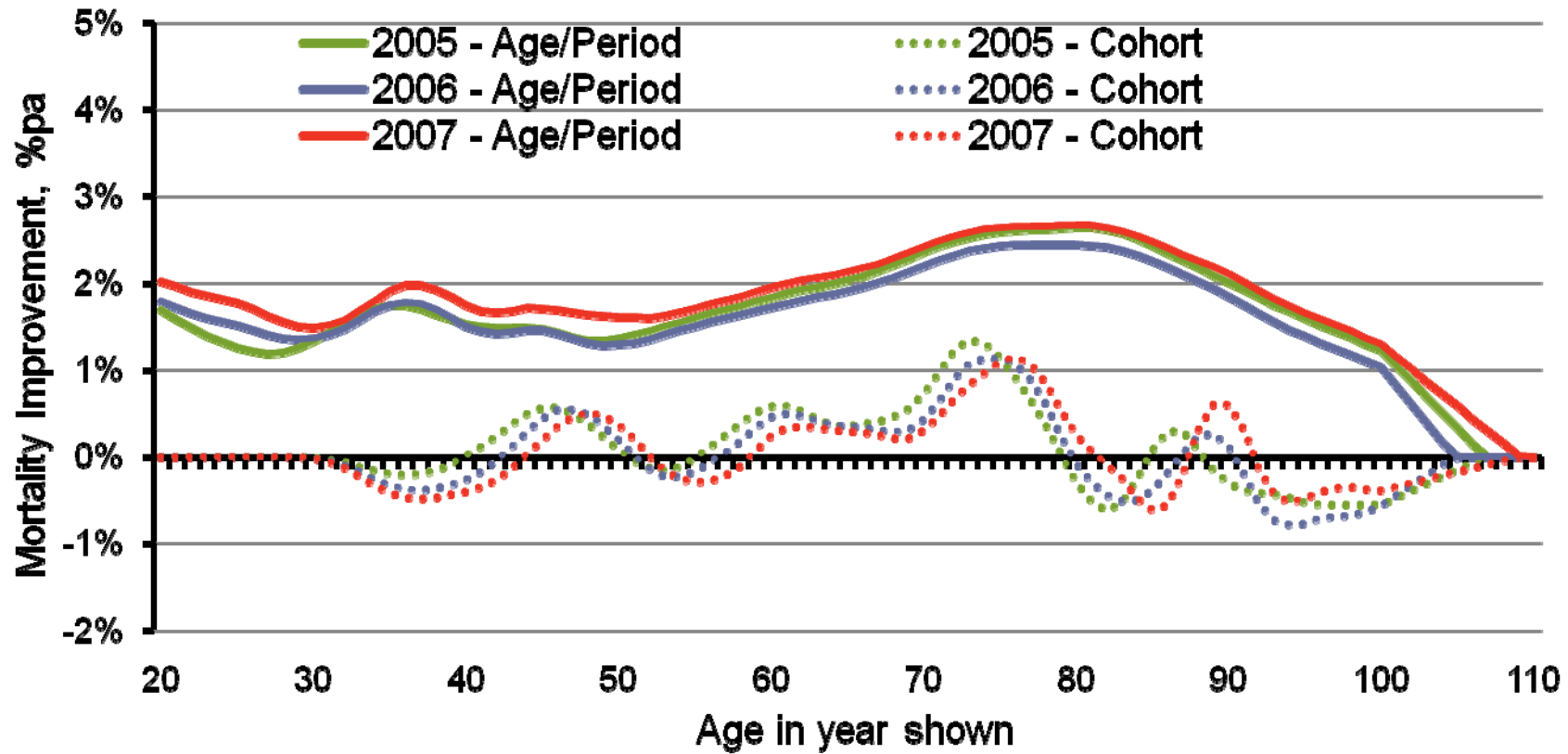
Age/Period and Cohort components of mortality improvement
by age and year; population of England & Wales; males



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Change arising from incorporation of data for 2009

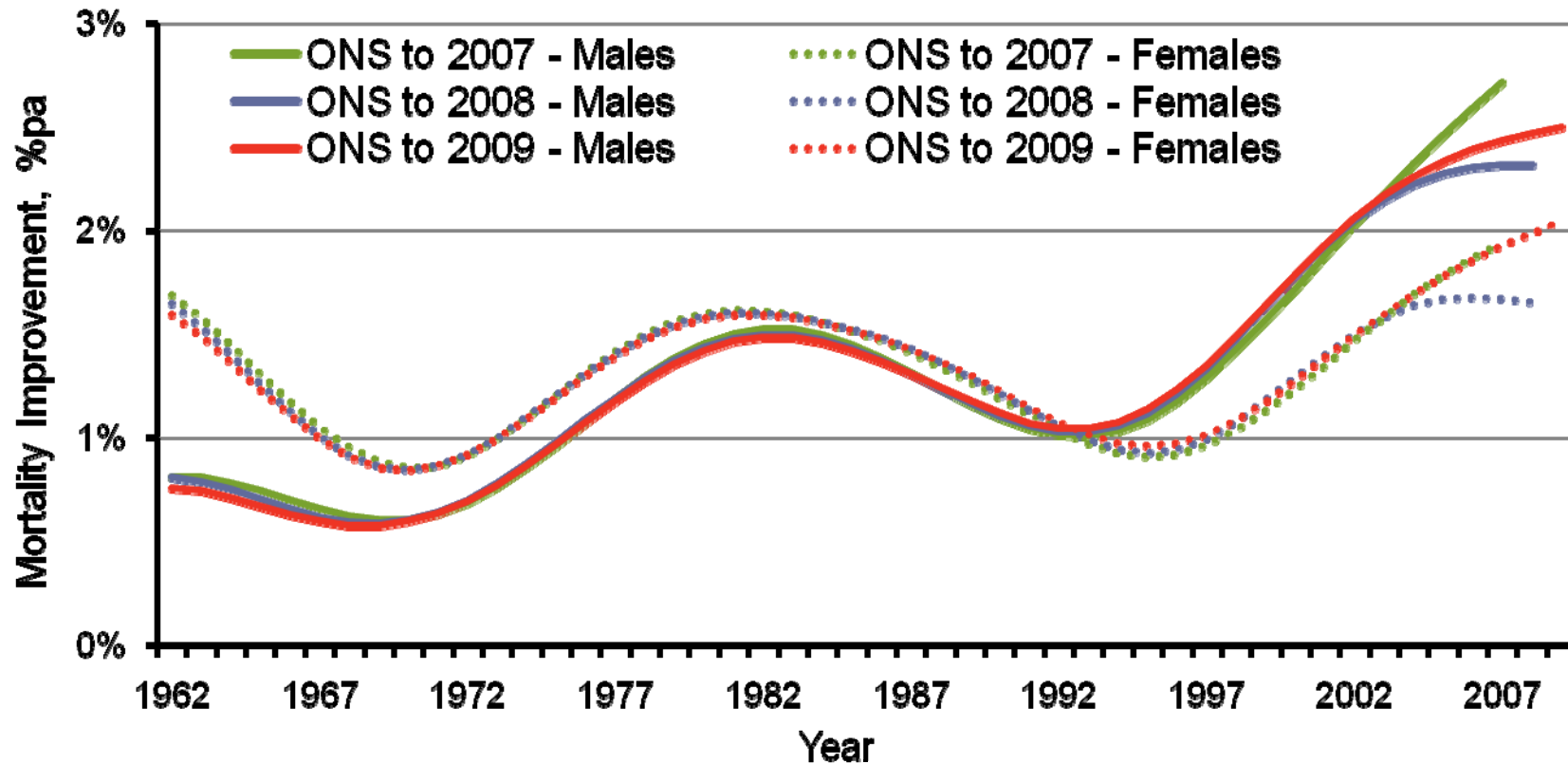
Age/Period and Cohort components of mortality improvement
by age and year; population of England & Wales; females



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Change arising from incorporation of data for 2009

Estimated Period component of mortality improvement
1962 - 2009; population of England & Wales



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Change arising from incorporation of data for 2009

Addition of data leads to revision of estimates

- Estimates slightly increased for recent improvement rates
- Revisions fall within expected range
- ... and show methodology gives relatively stable results

Cohort EoLs increase on average by:

- around 0.3% to 0.7% for males
- around 0.5% to 1.5% for females
 - depending on spread of ages
- [+1% on long-term rate increases EoL by 5% at age 65].

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The CMI Mortality Projections Model

How robust are the Model and default parameters?

Consultation and review

- Wide consultation (July / August 2009)
 - Model structure, default parameters and supporting analysis
 - 2 discussion meetings; 31 written responses received
- Disclosure
 - Open structure: Model mechanics are open for users to see
 - Supporting analysis and rationale disclosed for default parameters
- P-Spline models (used to smooth mortality data in two dimensions)
 - Published and peer reviewed in both actuarial and statistical fields
 - Also used in analysis supporting Interim Cohort Projections.

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How robust are the Model and default parameters?

Controlled evolution

- Balance responsiveness to new data with stability of structure
- Limited annual updates
 - Core default for Initial Rates of Mortality Improvement
 - Incorporate each successive year's population data
 - Process designed for 'smooth evolution'
- Structure and other default parameters
 - Subject to periodic general review
 - Avoid potential confusion / disruption of frequent change
 - Do 'when necessary' (say every 3 to 5 years).

The CMI Mortality Projections Model

How robust are the Model and default parameters?

Sensitivity of results to parameters

- For illustration, measure change in cohort e_{70}

Core parameters

- Long-Term Rate of Mortality Improvement
 - e_{70} increases by ~0.9 years for each 1% in Long-Term Rate
- Constant Additional Rate of Mortality Improvement
 - e_{70} increases by ~1.6 years for each 1% Constant Addition.

The CMI Mortality Projections Model

How robust are the Model and default parameters?

Sensitivity of results to parameters

Advanced parameters (where default values set for Core layer)

- Initial Rates of Mortality Improvement
 - e_{70} changes by 0.6 to 0.9 years for each 1% pa change in Initial Rates
 - e_{70} changes by ~0.3 years for a 1% pa switch between Cohort and Age Components
- Long-Term Rates of Mortality Improvement at high ages
 - e_{70} only increase by 0.1 to 0.2% even if improvement rates don't run to zero until age 150
- Period of Convergence
 - e_{70} changes by around 0.1 years for a 10 year change in Period
- Pattern of Convergence
 - e_{70} changes by 0.2 to 0.4 years for a 25% change in proportion remaining at mid-point.

The CMI Mortality Projections Model

How robust are the Model and default parameters?

Summary

- The Model and parameters have been exposed to review
 - Wide consultation and peer review
 - Comprehensive disclosure of supporting analysis
- The CMI has committed to controlled evolution of the Model
 - Balance responsiveness and stability
 - Update process for new data is designed for ‘smooth evolution’
- Sensitivity of results to default parameters is generally low
 - Higher sensitivity to Initial Rates, but no viable alternative
 - Sensitivity to methodology also assessed and disclosed.

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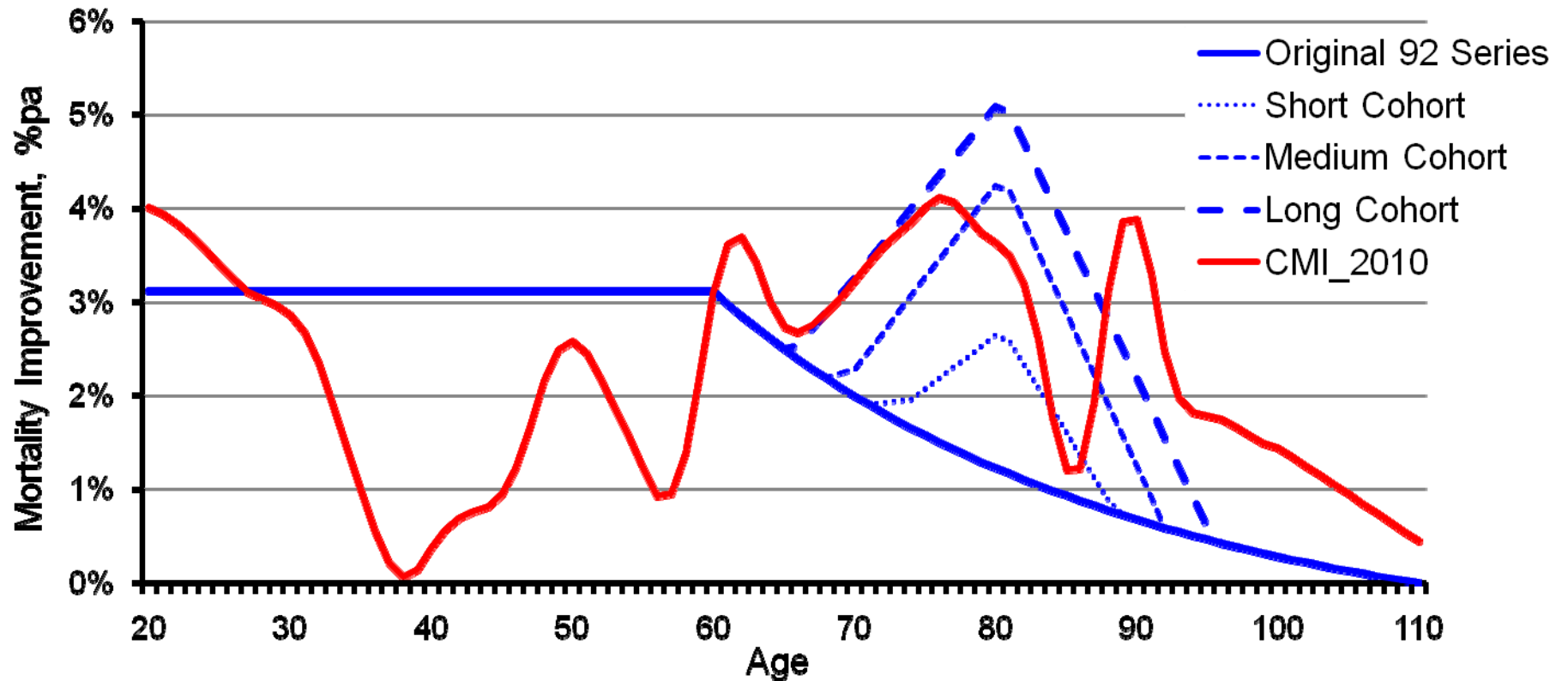
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How do CMI_2010 Core Projections compare to ICP?

Projected mortality improvement rates for males in 2007

CMI_2010 uses estimated actual derived from E&W population data



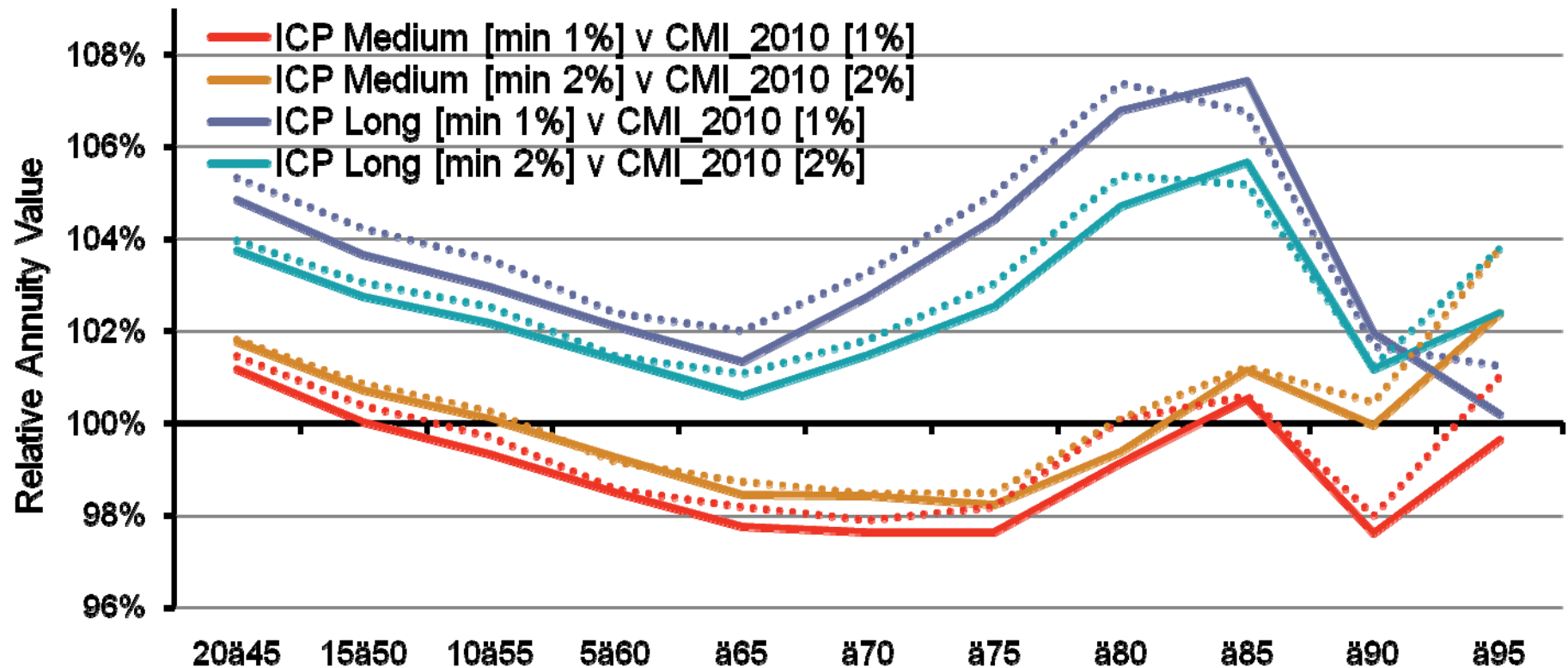
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How do CMI_2010 Core Projections compare to ICP?

Comparison of projected cohort annuity values

Males; age exact as at 31/12/2010; value at 3% p.a.

Base Mortality : 100% S1PMA for life aged x exact on 01/09/2002



Solid Lines: CMI_2010; value @ 31/12/2010; roll mortality forward using actual improvement rates to 2007, vary projection from 2008
 Dotted Lines: CMI_2009; value @ 31/12/2009; roll mortality forward using actual improvement rates to 2006, vary projection from 2007

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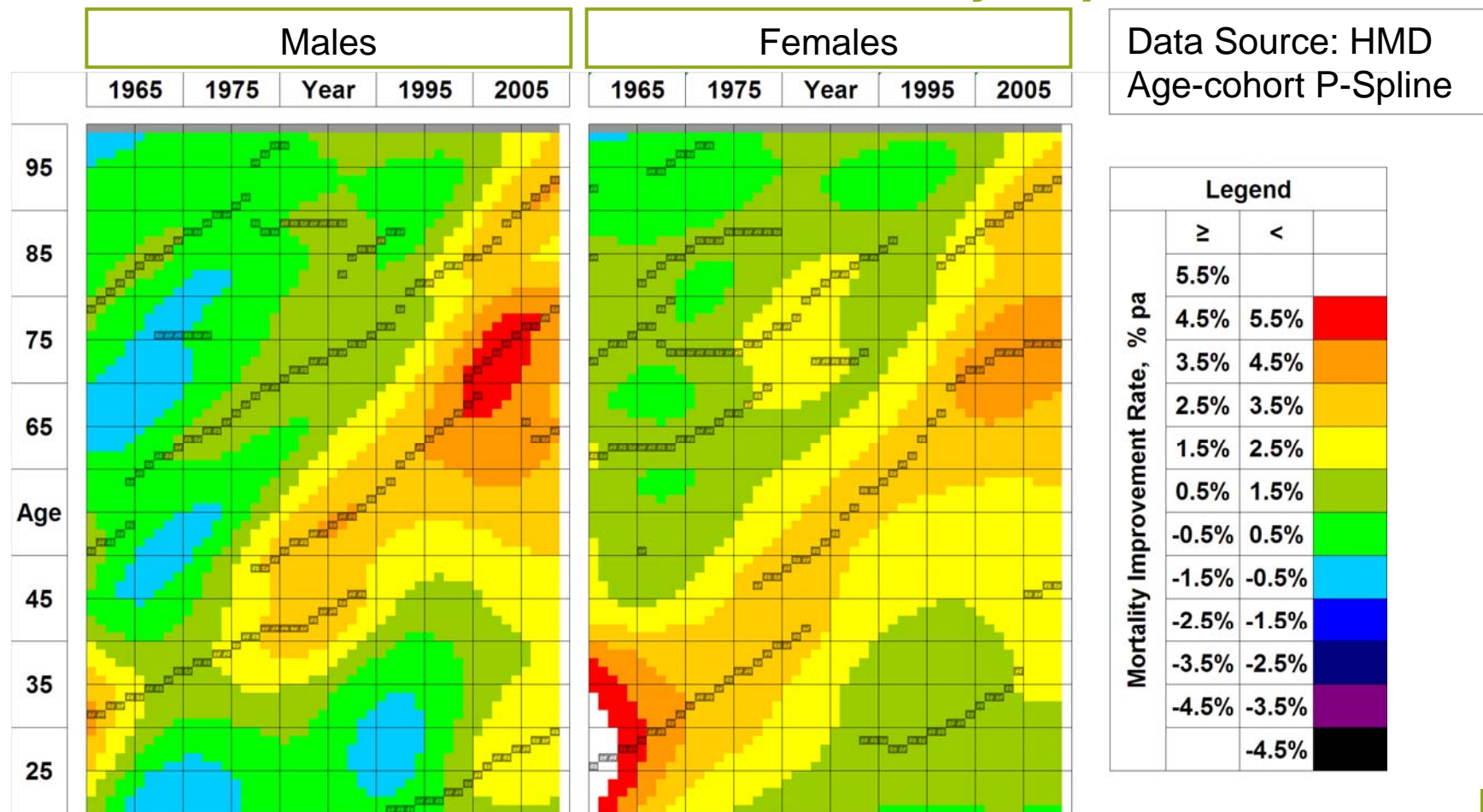
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Irish Population Mortality

Patterns of mortality change: population of Ireland

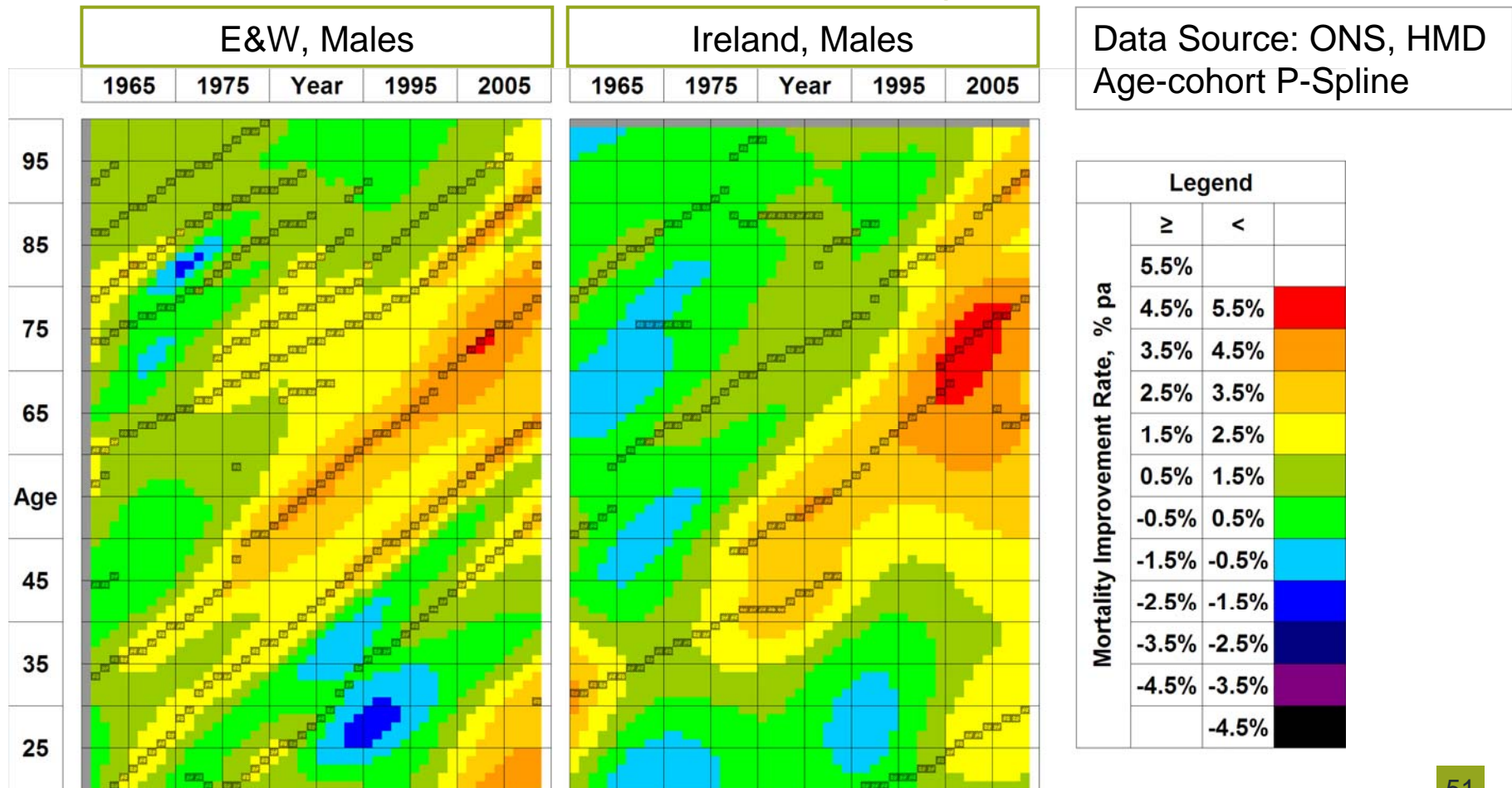
Estimated annual rates of mortality improvement



Irish Population Mortality

Patterns of mortality change: Ireland vs E&W

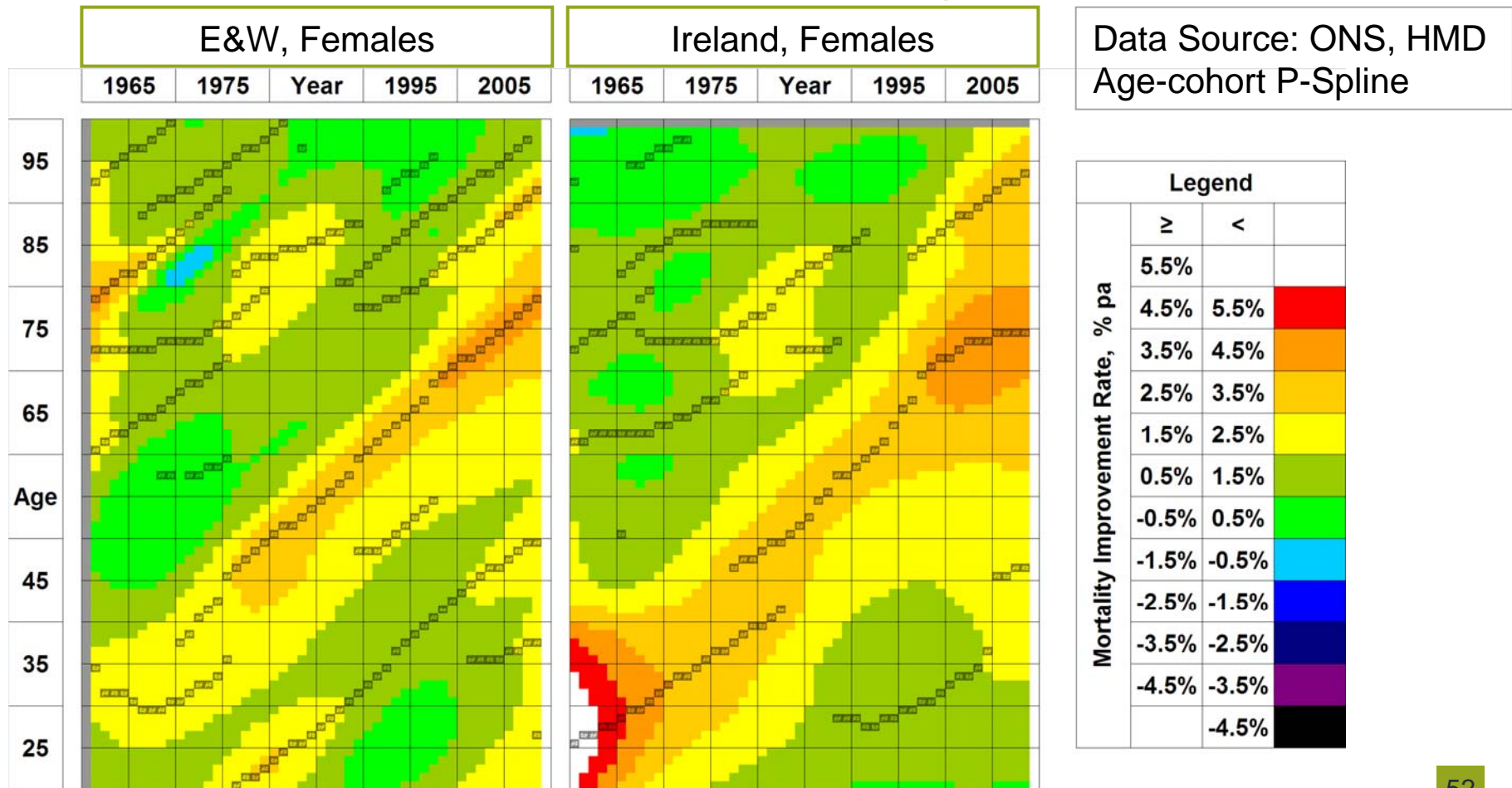
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Irish Population Mortality

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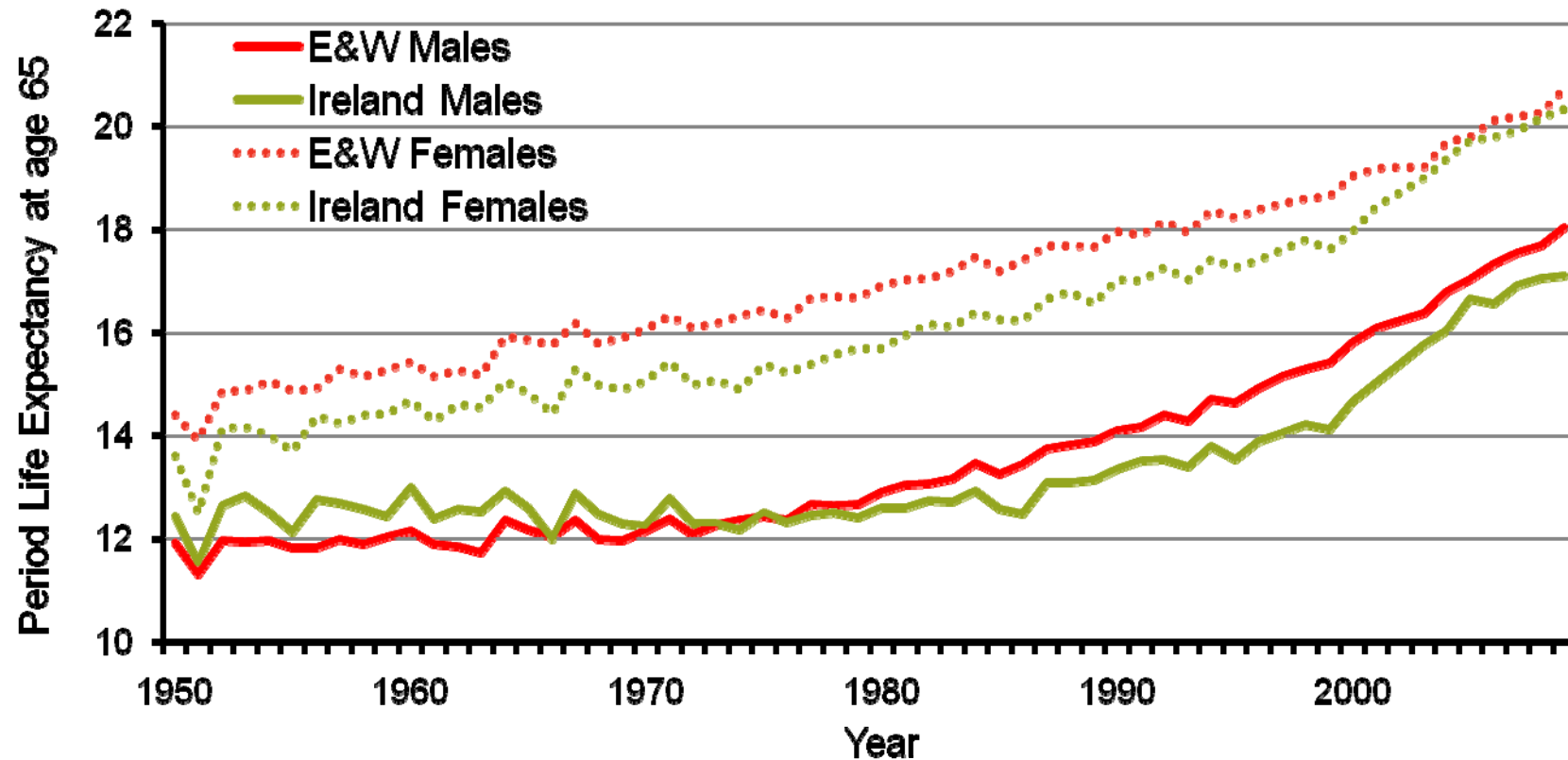


Irish Population Mortality

Patterns of mortality change: Ireland vs E&W

Period life expectancy at age 65

Data source and calculation agent: HMD

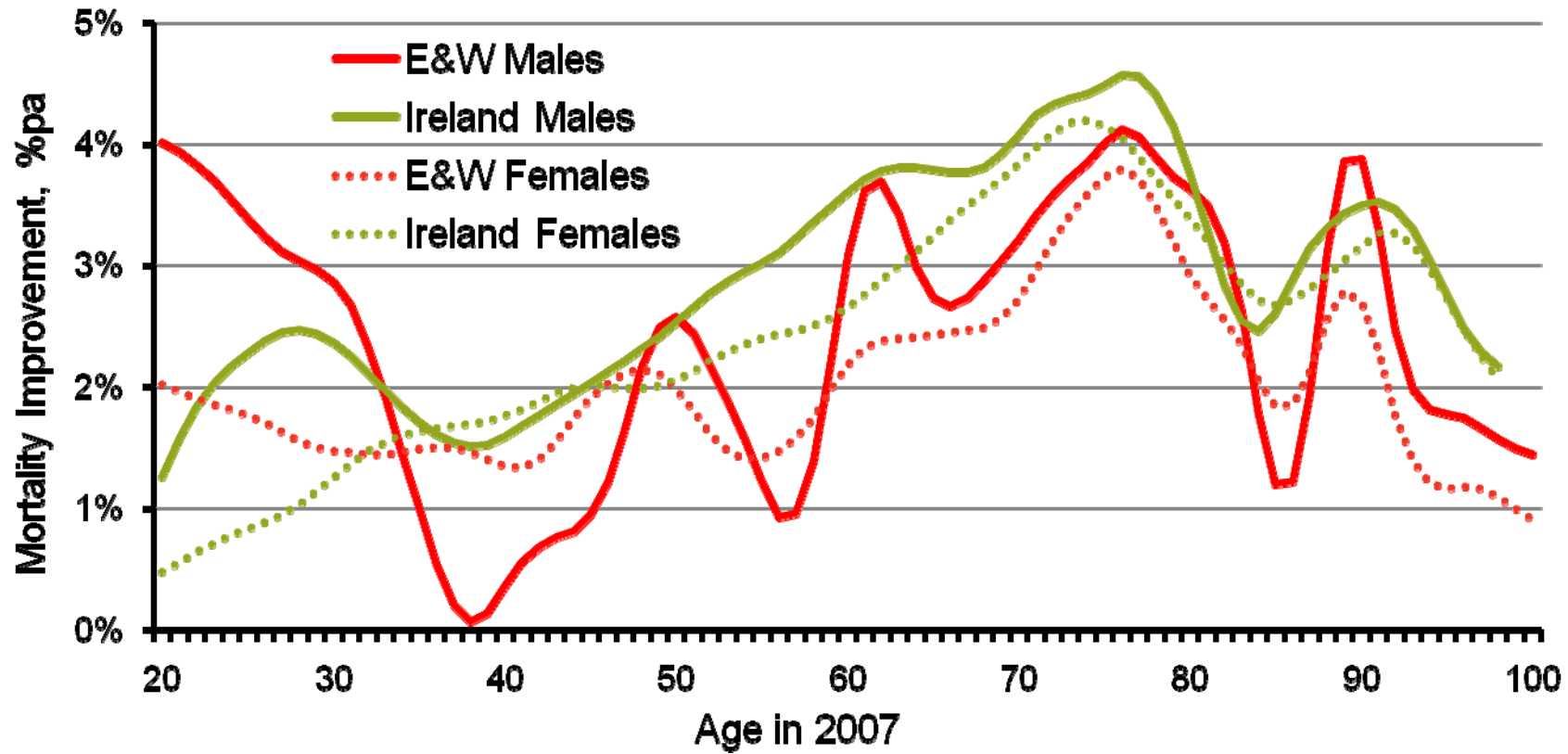


Irish Population Mortality

Patterns of mortality change: Ireland vs E&W

Estimated annual rates of mortality improvement in 2007

P-Spline models; population of England & Wales; males



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Questions or comments?

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



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Thank you for your
attention and participation

Dublin, 30 March 2011