Continuous Mortality Investigation

Innovations in the CMI's approach to graduation and modelling

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15 September 2014

Agenda

- Overview
- Data quality and implications
- Sub-annual deaths
- Co-graduation

Overview

CMI modelling

- Aim for CMI outputs to be commensurate with
  - its users' needs – expectations in the longevity space have increased
  - credibility of the data – available data has increased
- The CMI is *not* aiming to lead research …

  … but may well lead in its application
- Favour objective / simple / robust / cross-validated
- As stable as possible, but no more
- CMI models are not the whole answer …

  … but they are typically the (a) framework and (b) *lingua franca*

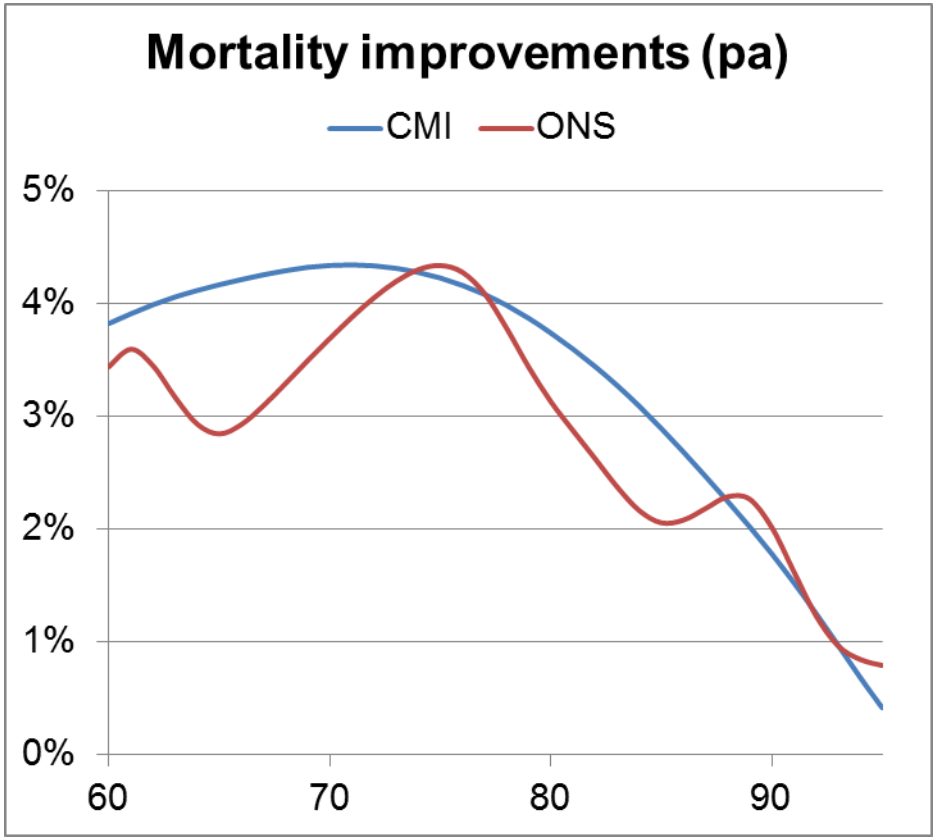
Areas of development

- Reviewing and updating
  - Technical baseline – Graduation and Modelling Working Party
  - Use applicable standard methods where appropriate
  - Transparency – make relevant data and software easier to access
- New initiatives
  - High Age Mortality Working Party
  - SAPS Mortality Improvements Sub Committee
  - CMI_2016 – possible new projections model
  - International comparability / population coherency

Data quality and implications

A mortality improvement puzzle

- ONS England & Wales data
  - p-spline model
- CMI pensioner data
  - implied change between SAPS S1PMA and S2PMA tables
- Both for males 2002-2007
- Why are the shapes different?



A mortality improvement puzzle

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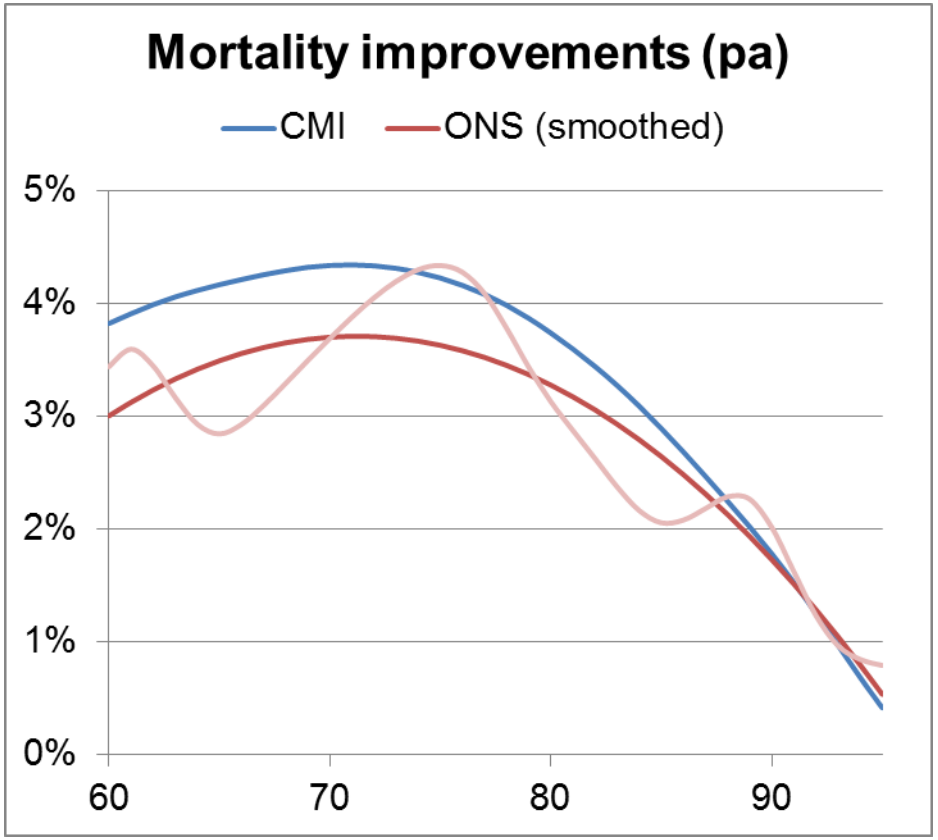
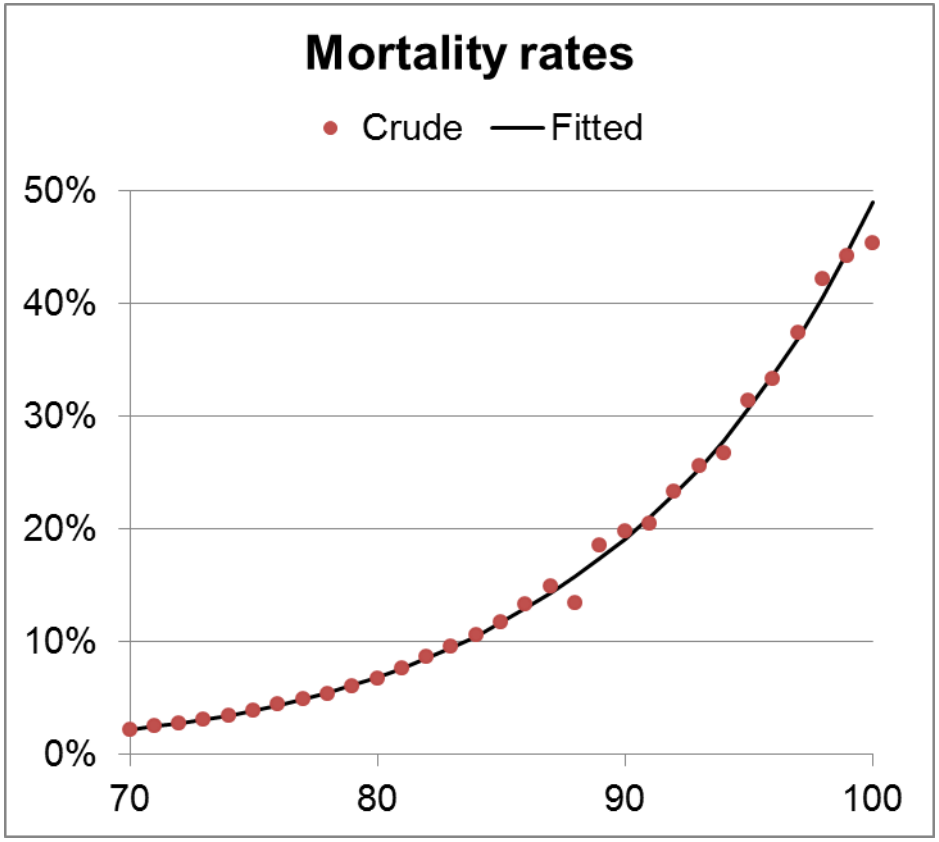


- Why are the shapes different?
- Are the SAPS improvements really higher?

Looking into the ONS data

- ONS England & Wales data
  - Males in 2007
  - Crude mortality rates
  - P-spline fit

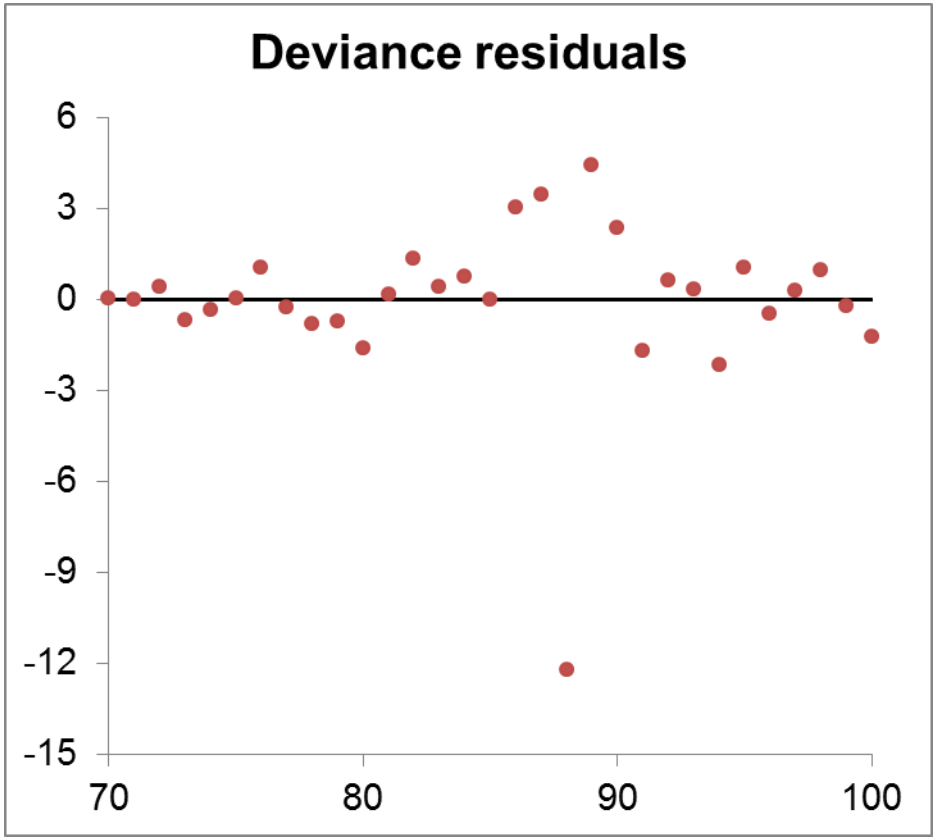
- Age 88 looks a little odd



ONS data – deviance residuals by age

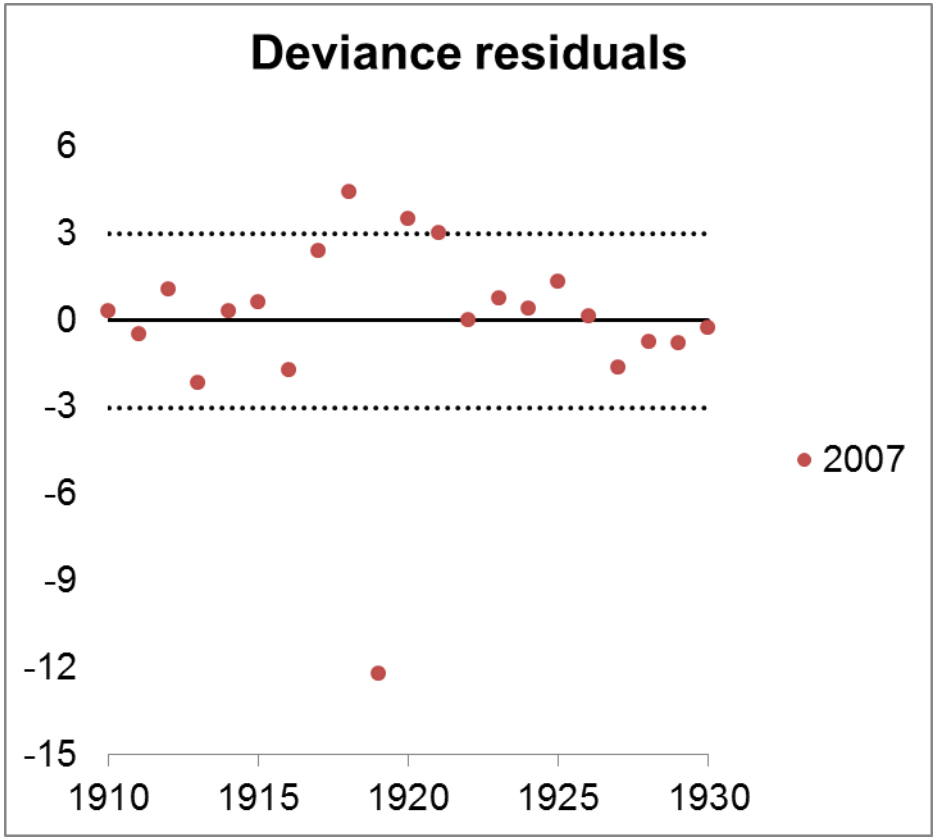
- Deviance residuals by age for the p-spline fit for 2007

- Age 88 looks very odd
  - 12+ standard deviation event



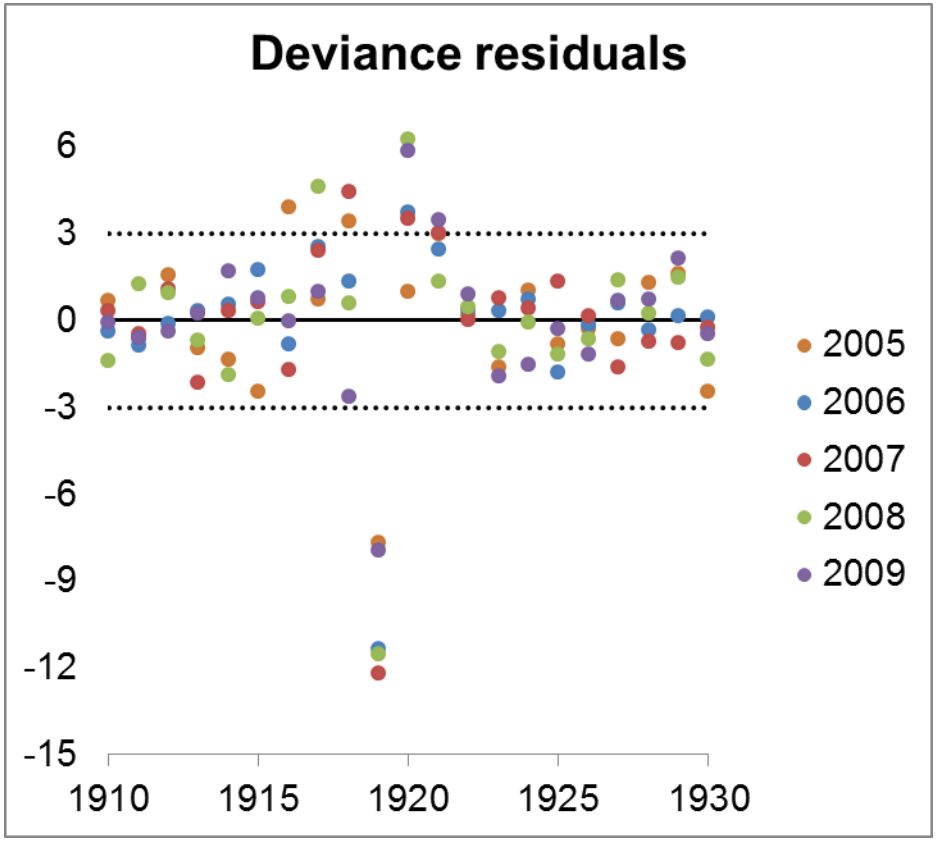
ONS data – deviance residuals by cohort

- Plot by cohort, not by age



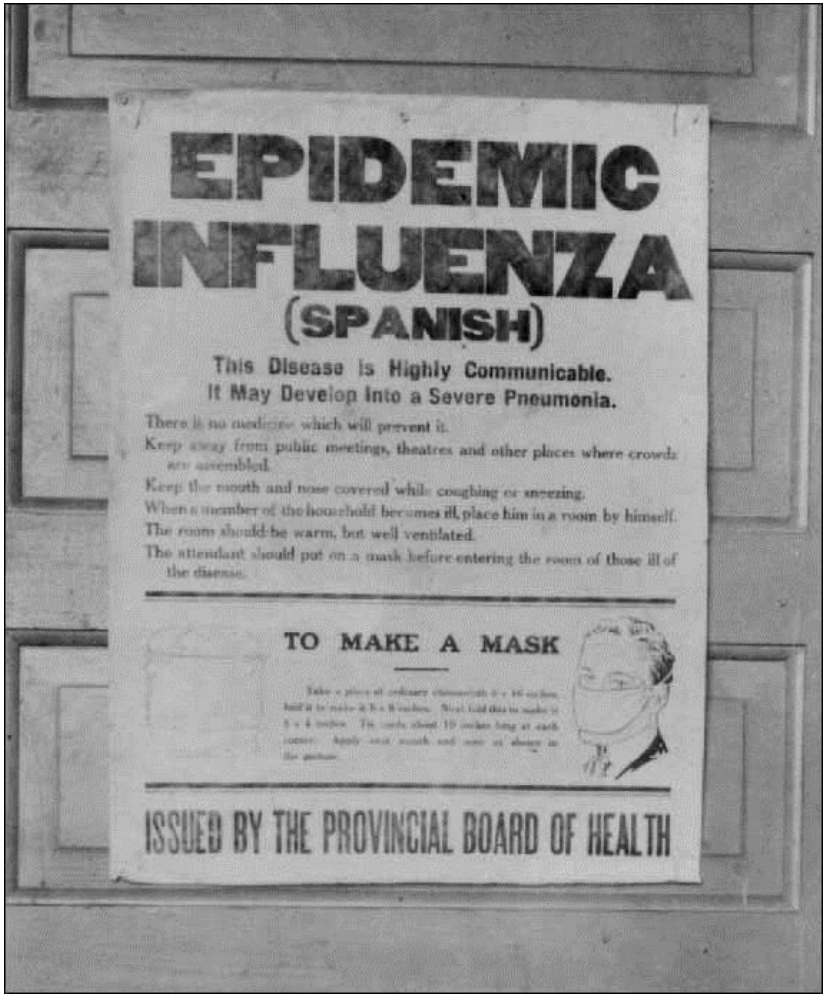
ONS data – deviance residuals by cohort

- Deviance residuals by cohort for calendar years 2005-2009
- Persistently odd results for 1919 cohort

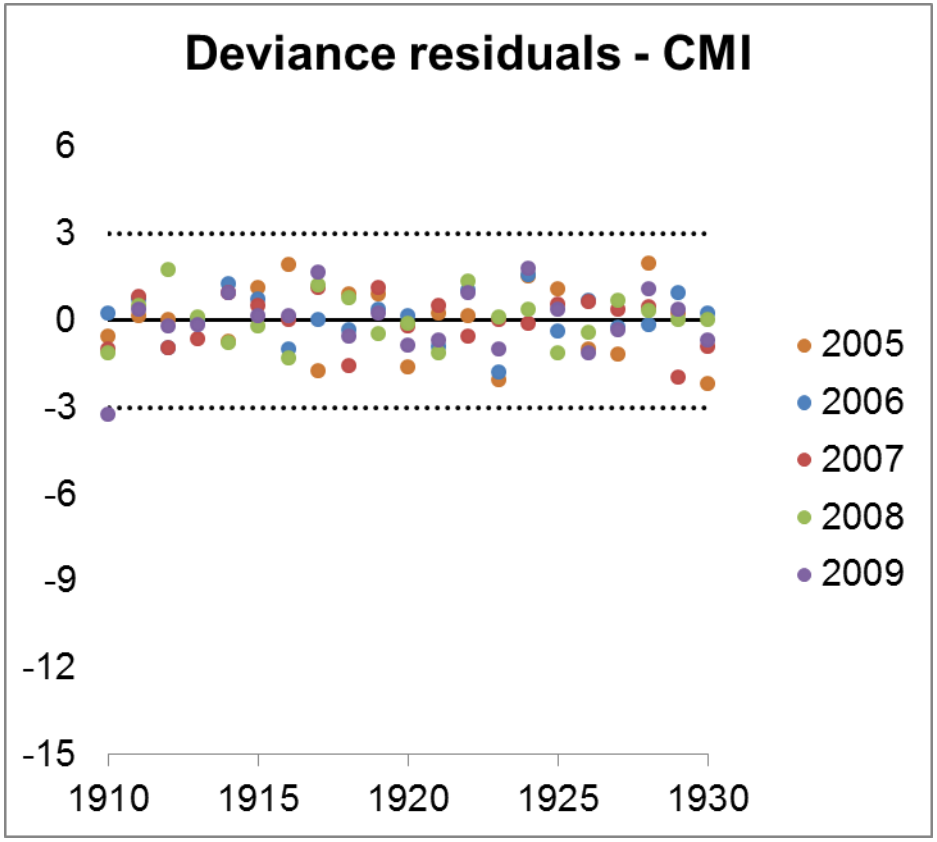


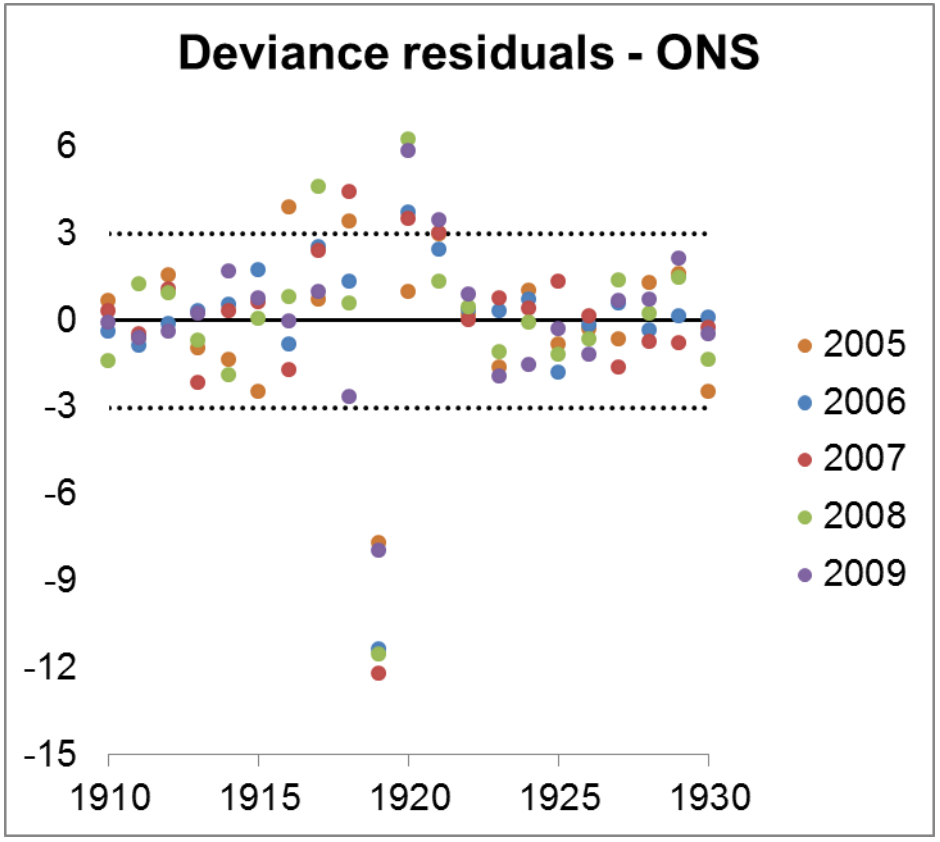
Why is the ONS 1919 cohort unusual?

- Caused by the 1918 H1N1 influenza pandemic?
- If so then we would expect to see it in other data sets



CMI and ONS – deviance residuals





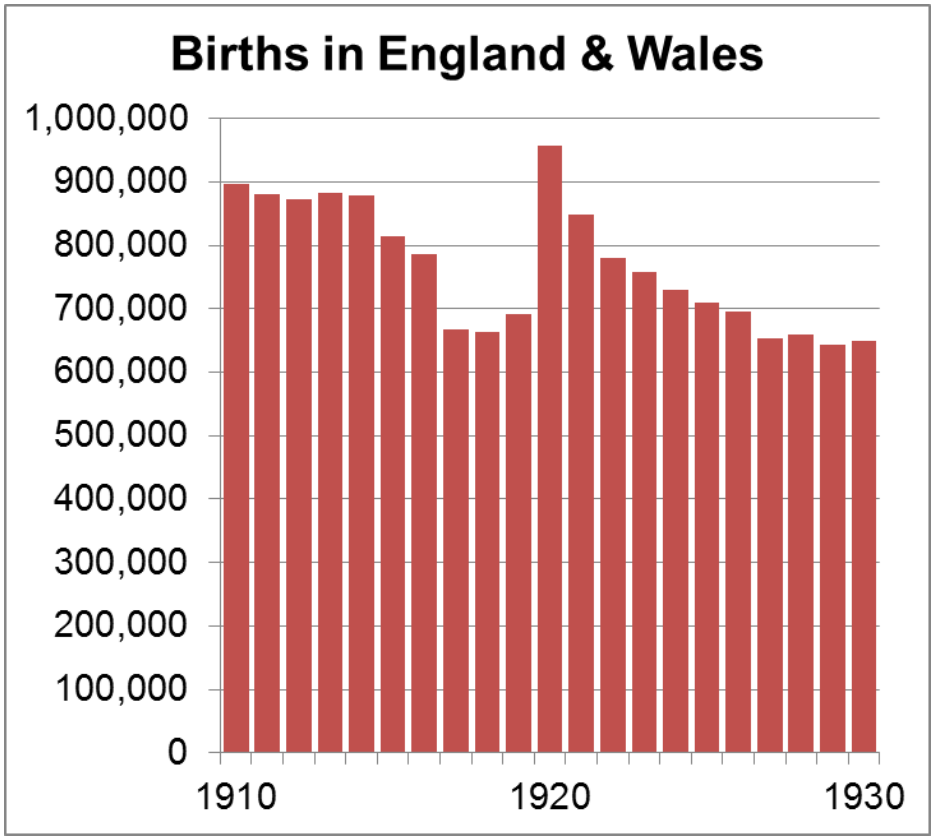
Why is the ONS 1919 cohort unusual?

- ~~Caused by the 1918 H1N1 influenza pandemic?~~
- A quirk of the ONS data rather than a genuine mortality effect?

Why is the ONS 1919 cohort unusual?

- Exposure ≈ mid-year population
- But not a good approximation when birth pattern is irregular
- Baby-boom following WWI
- Knock-on effect on projections

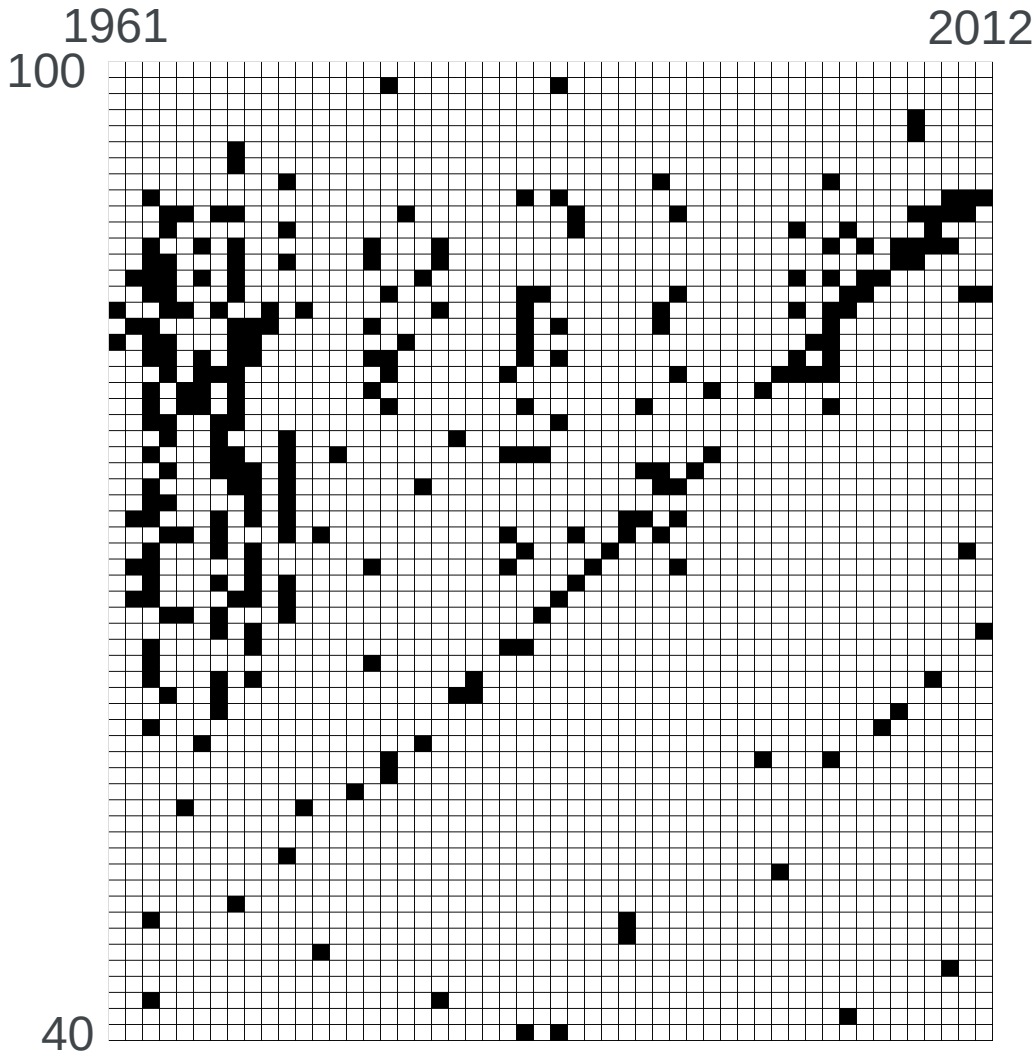
- See Cairns et al for more details (workshop B1 tomorrow)



Deviance residuals

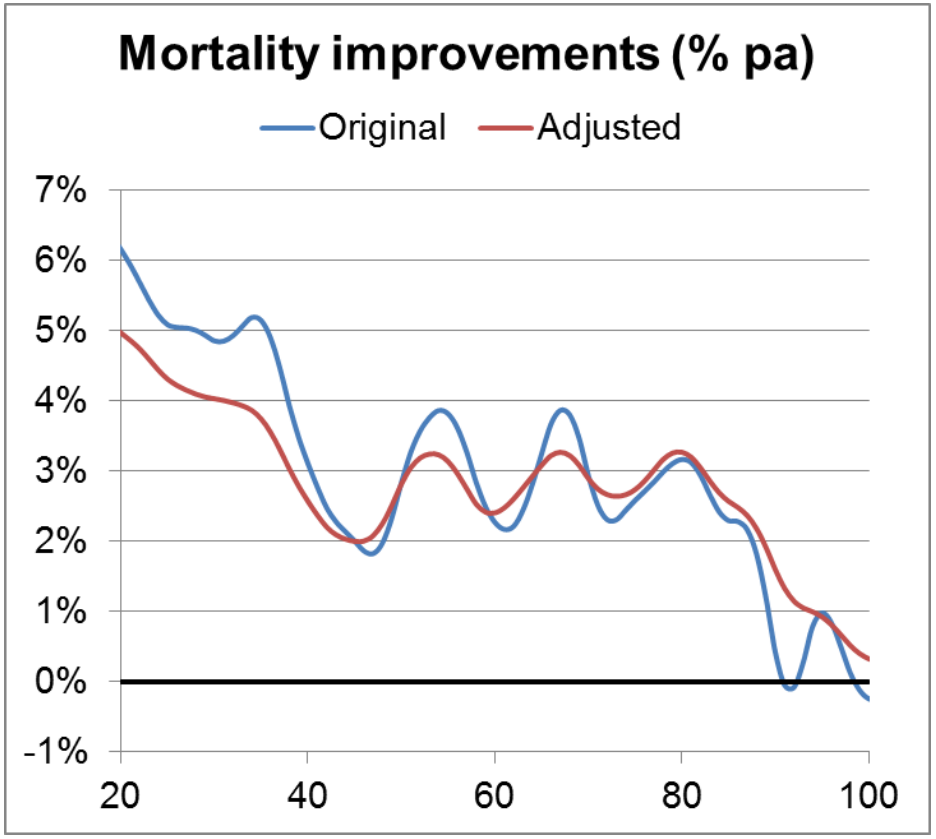
- Deviance residuals for p-spline fit to ONS data
- Highlighted age/year cells have absolute deviance ≥3

- Main features
  - 1919 cohort
  - 1960s



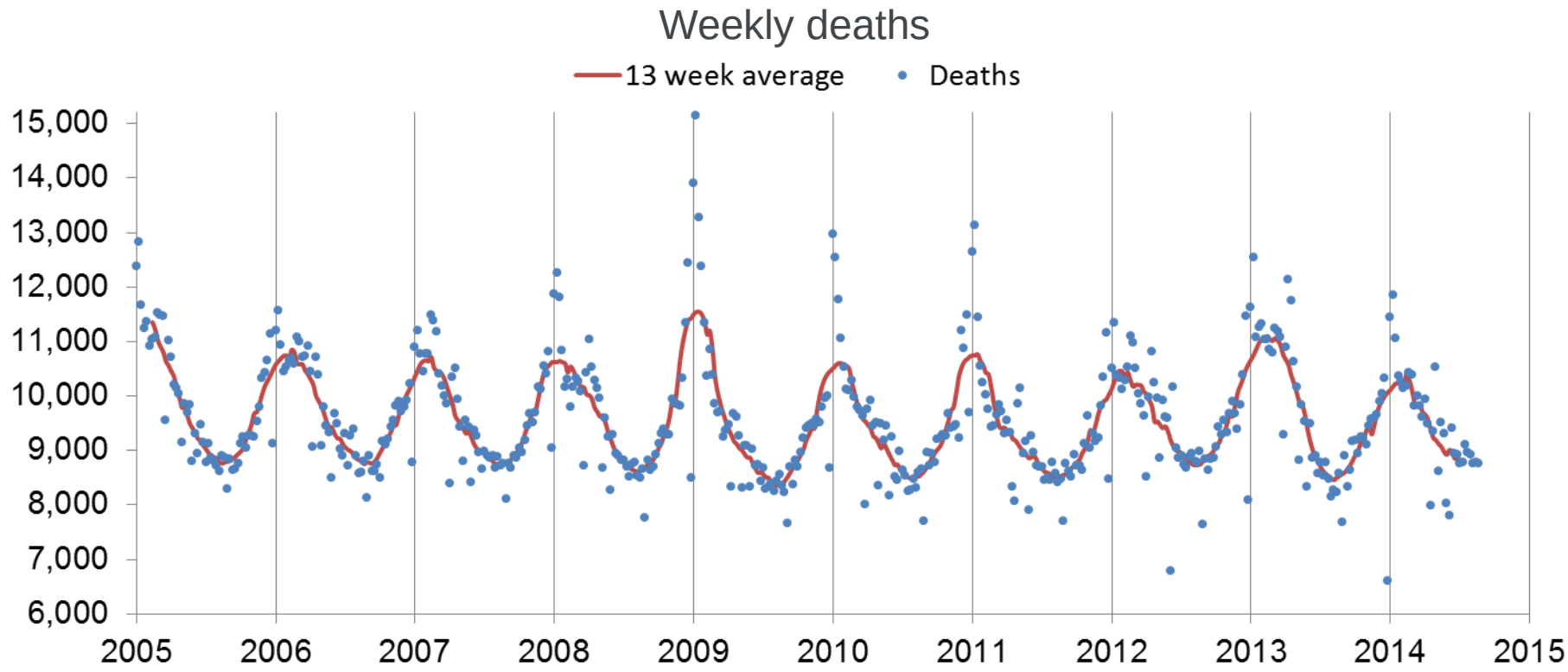
Data problems – what to do about it?

- What to do about it?
  - Exclude the 1960s
  - Exclude or adjust outliers
  - Allow for overdispersion
- Results in smoother improvements



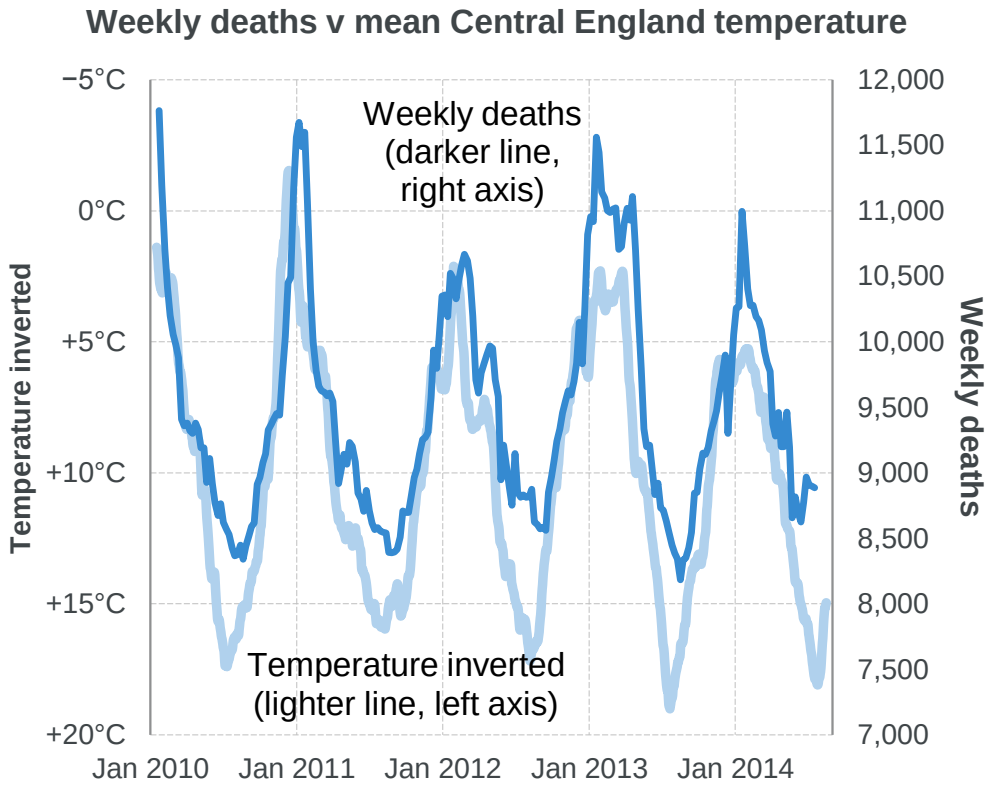
Sub-annual mortality

Sub-annual mortality



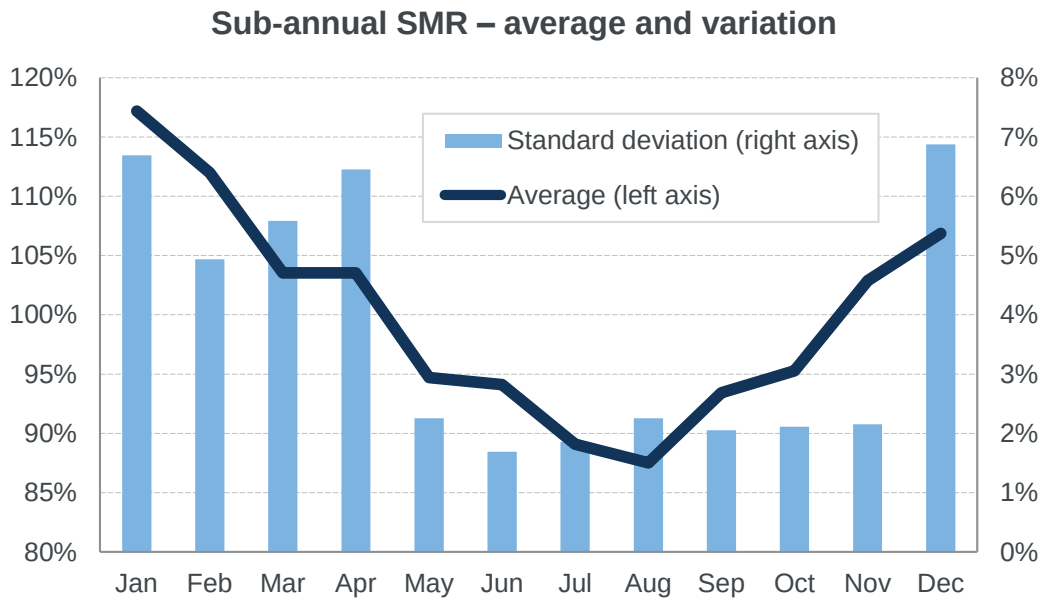
- Modern best practice is to allow for mortality experience to date using weekly deaths

Temperature as a driver



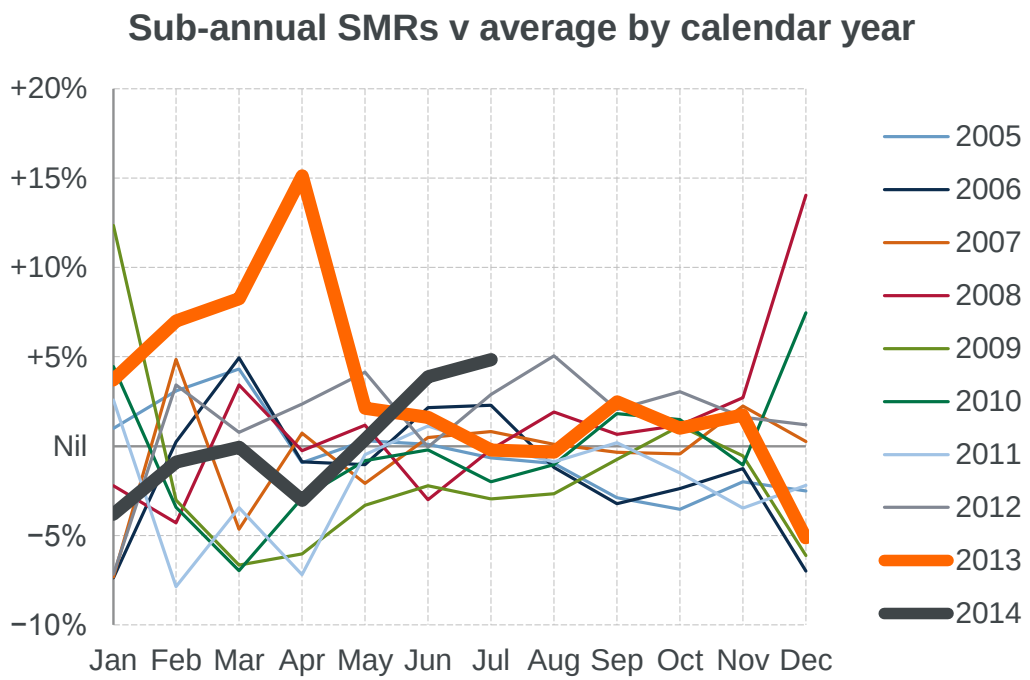
- Correlation with (inverted) temperature is striking …
- … but not *predictive*
- (unless you can predict temperature)

Sub-annual mortality – SMRs



- Need to use SMRs to account for ageing
- Pronounced pattern to average and variance
- Annual noise arises because of
  - True annual variation
  - Calendar year cut-off
- August / September cut-off ideal

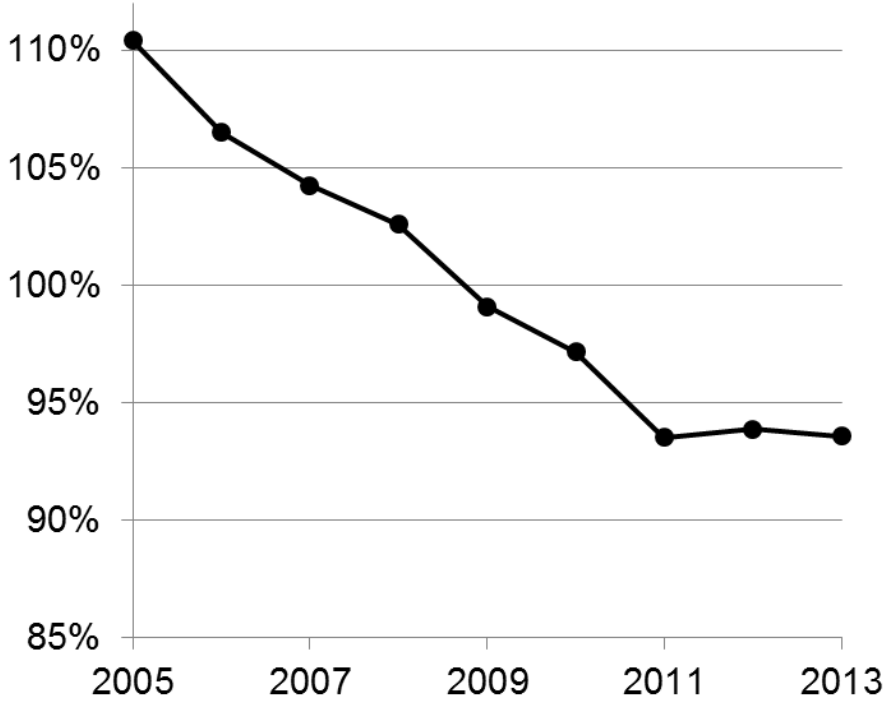
Sub-annual mortality – individual years



- 2013 was an exceptionally heavy year for mortality
- The CMI model not built from ground up to deal with volatility
- Propose to take account of 2014 data in CMI_2014

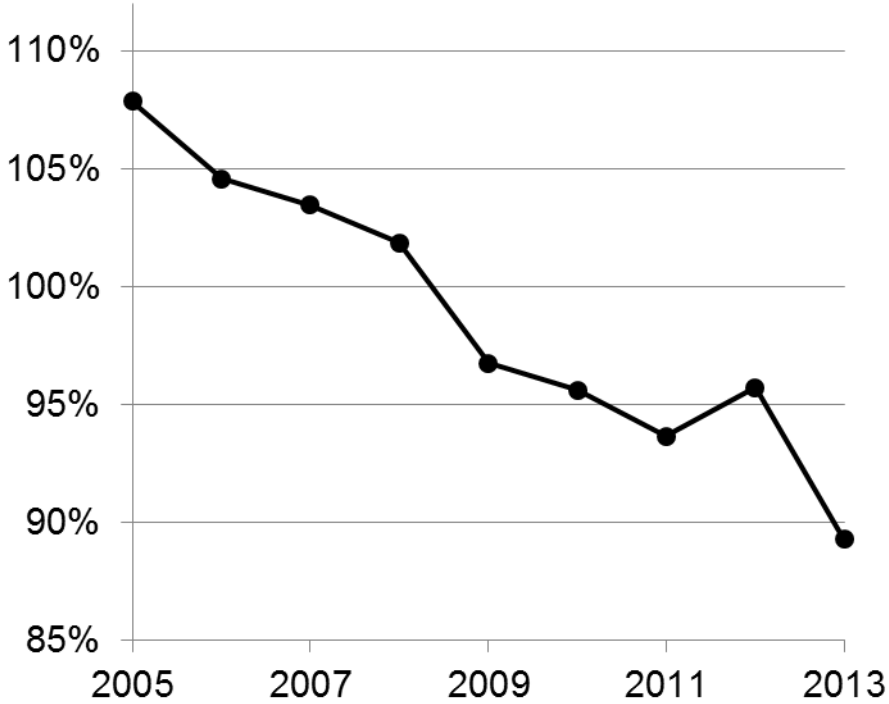
The annual cut-off can be misleading

SMR using calendar years



- Improvements have stalled?

SMR using ‘mid years’

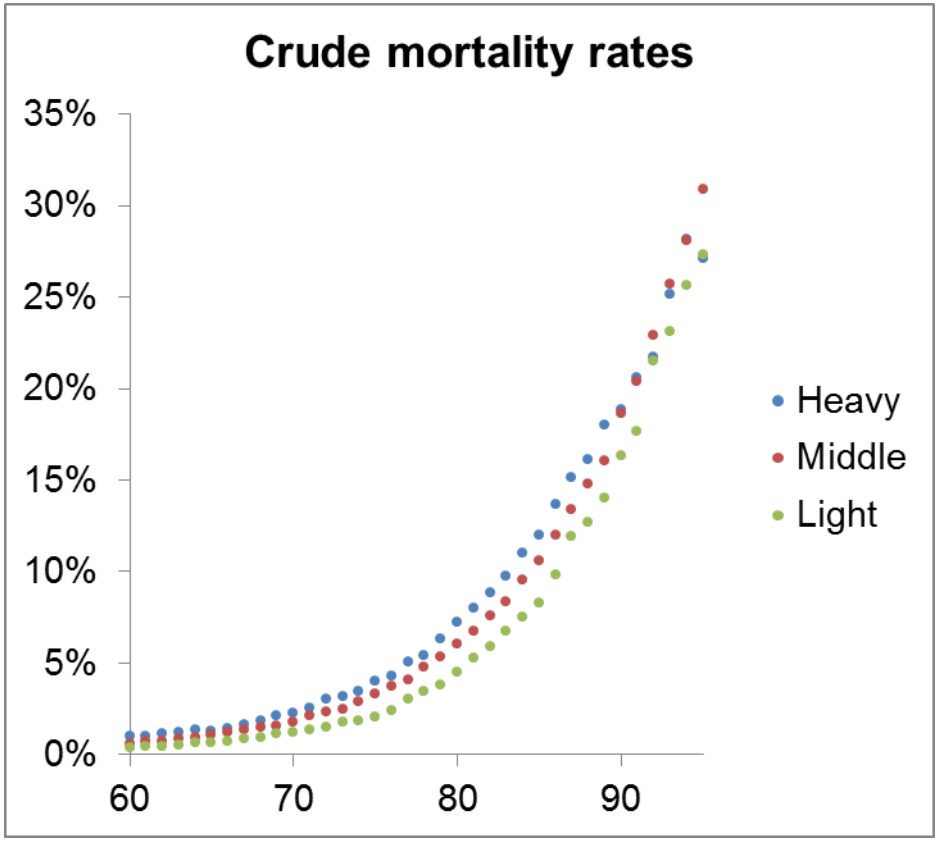


- 2012 is a blip?

Co-graduation

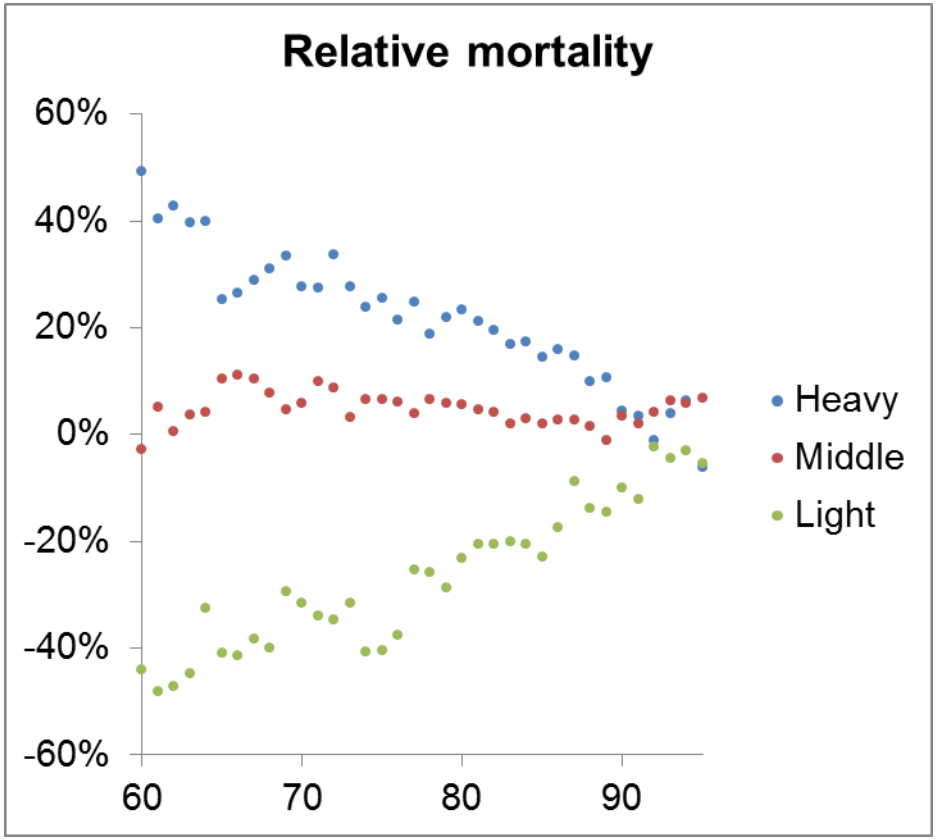
Mortality by pension amount

- CMI pension scheme data
- Low, medium, high amounts ⇒ heavy, middle, light mortality
- Basis risk: use the right mortality for the right people



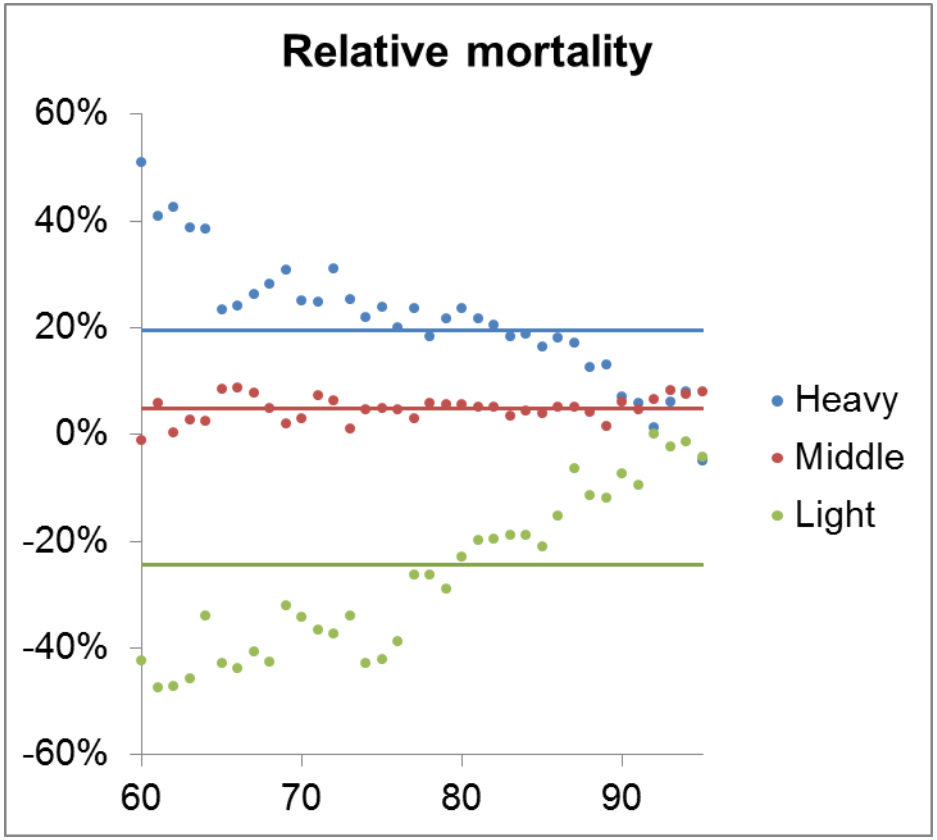
Mortality by pension amount

- Hard to see differences on previous chart
- Plot “relative mortality”, the difference between
  - log(m) for the amount band; and
  - fitted average log(m)



Scaling mortality tables

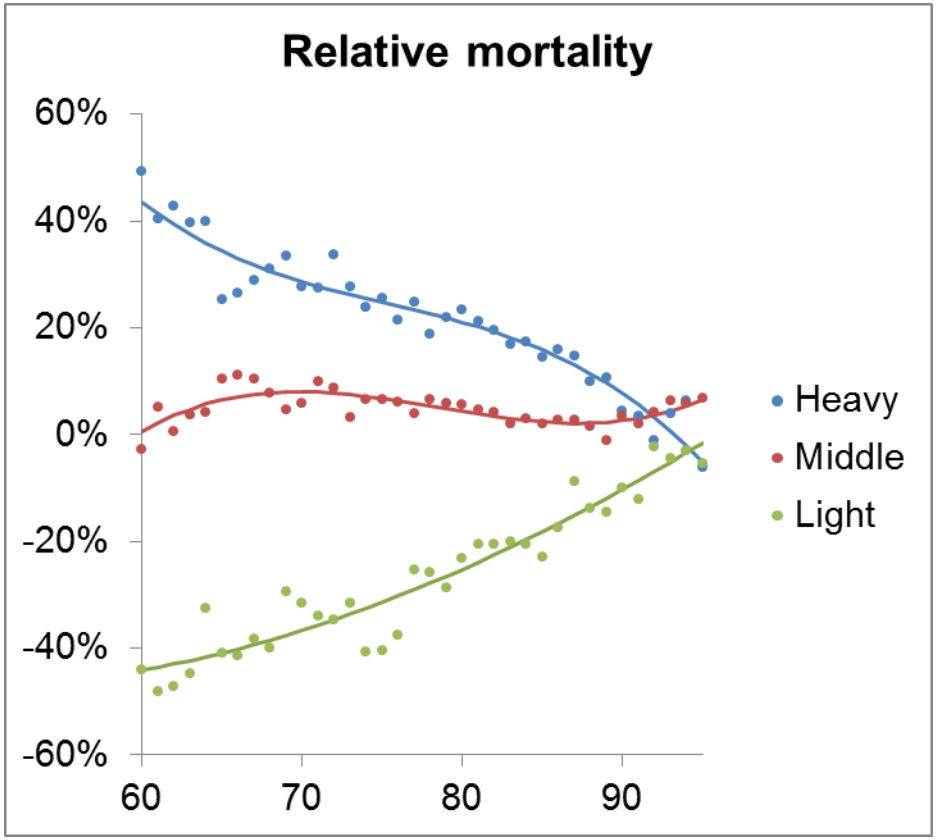
- Simplest model
  - $\log m(x,i) = s_i \times Base(x)$
- A simple scaling isn't right at every age
- So produce separate tables



Independent tables

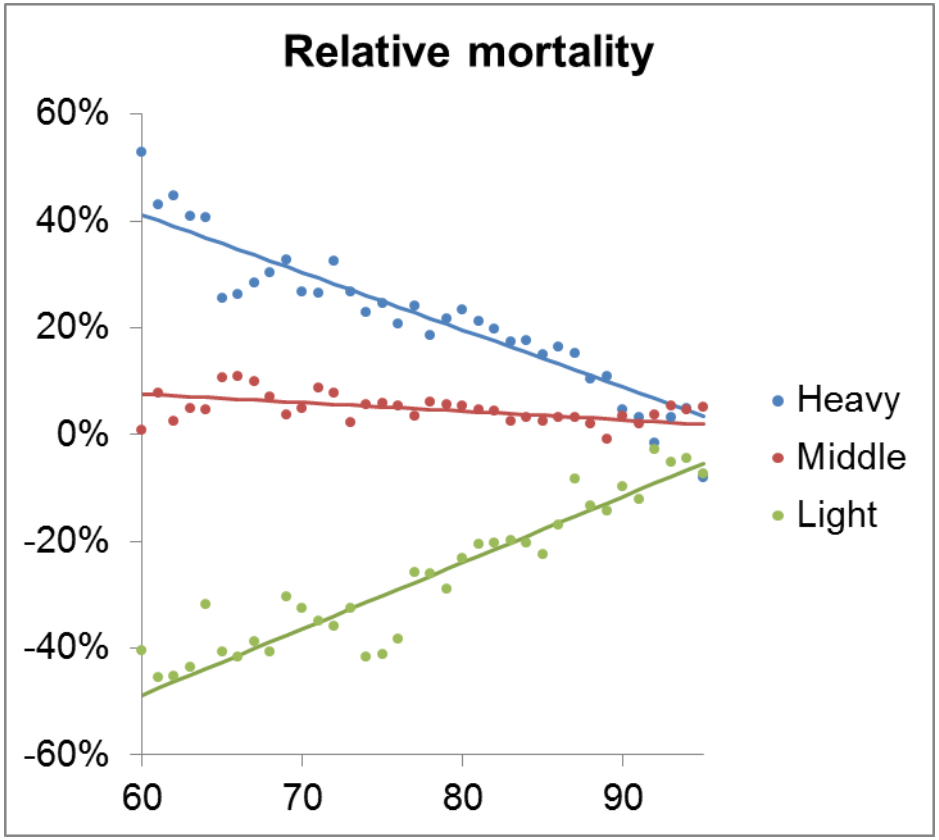
- Independent tables
  - $\log m(x,i) = B_i(x)$
- Cubic $B_i(x)$ for each band i

- Tables pass standard tests, but:
  - Crossover at older ages
  - Heavy/middle diverging at 60



Co-graduation

- $\log m(x,i) = A(x) + B_i(x)$
- $A(x)$ is a common higher-order function (eg cubic)
- $B_i(x)$ is a lower-order adjustment (eg linear)

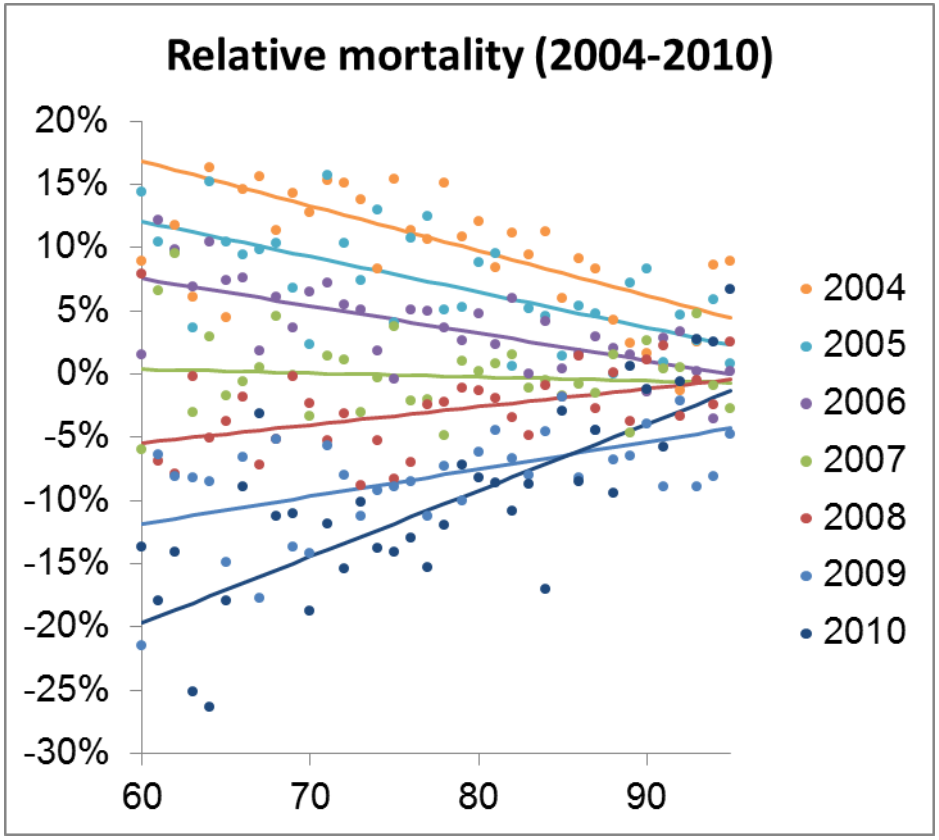


Why co-graduate?

- Better relationships between tables.
- Fewer parameters. (Eight versus twelve in our case).
- Better use of limited data. All data affects all graduations.

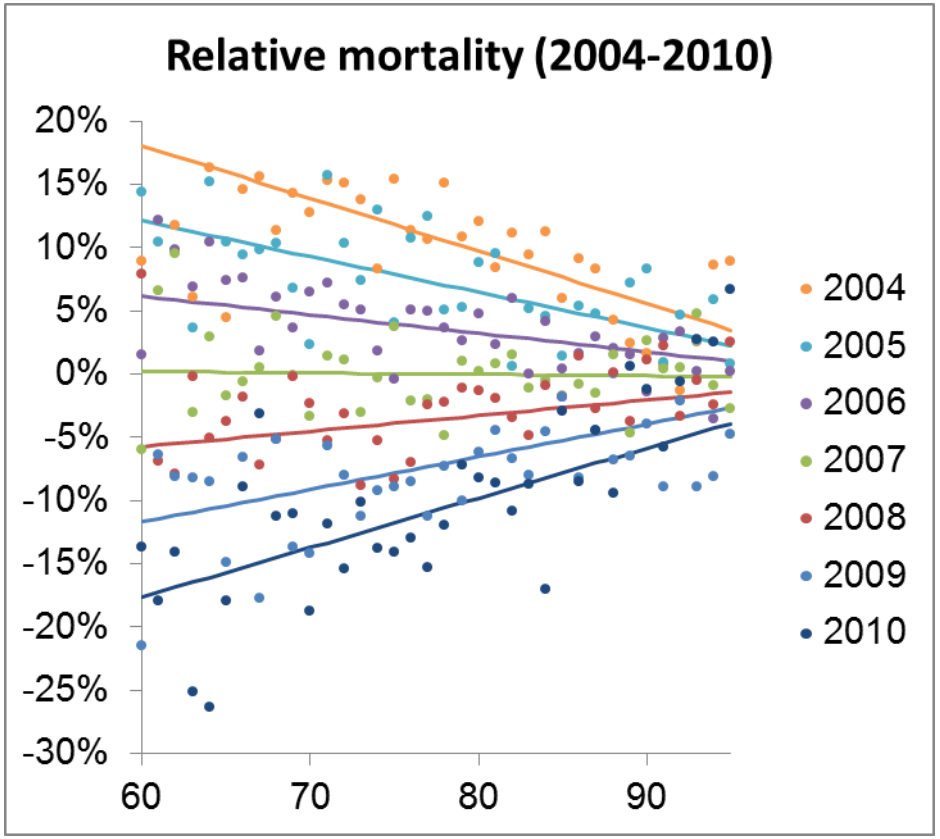
Mortality improvements

- Co-graduation of different years
  - $\log m(x,t) = A(x) + B_t(x)$
- Illustrative results for SAPS data with linear $B_t(x)$
- Some crossover at high ages

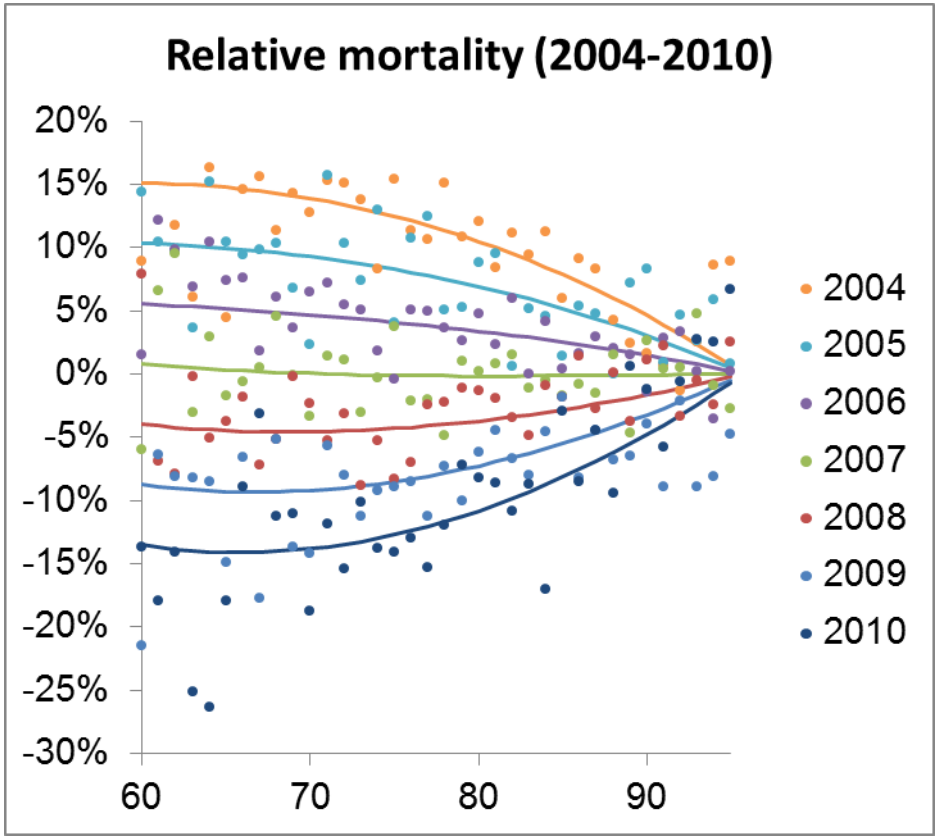


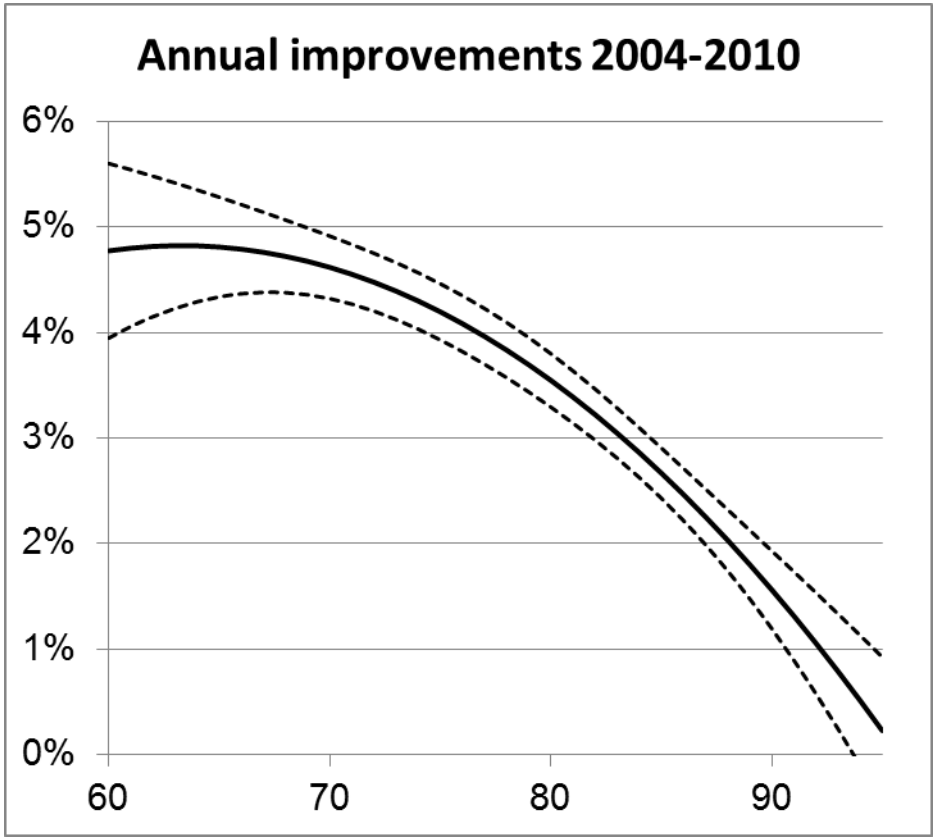
Mortality improvements

- Previously
  - $\log m(x,t) = A(x) + B_t(x)$
- If we suspect a steady progression by time then
  - $\log m(x,t) = A(x) - t.B(x)$
- $B(x)$ is then the mortality improvement
- No crossover, and fewer parameters used



Mortality improvements





- Quadratic $B(x)$ for improvements

Going further

- Co-graduation for mortality improvements
  - CMI and ONS data
  - Males and females
  - Multiple countries

Summary

Expressions of individual views by members of the Institute and Faculty of Actuaries and its staff are encouraged.

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

Continuous
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