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Research Centre

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of Actuaries

The Actuarial Research Centre (ARC)

A gateway to global actuarial research

The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' (IFoA) network of actuarial researchers around the world. The ARC seeks to deliver cutting-edge research programmes that address some of the significant, global challenges in actuarial science, through a partnership of the actuarial profession, the academic community and practitioners.

The 'Modelling, Measurement and Management of Longevity and Morbidity Risk' research programme is being funded by the ARC, the SoA and the CIA.

`www.actuaries.org.uk/arc`

Modelling, Measurement and Management of Longevity and Morbidity Risk

Andrew J.G. Cairns

Heriot-Watt University, Edinburgh

Principal Investigator

ARC Webinar Series, 17 May 2017

Poll 1

What age do you expect to live to?

- Less than 70
- 70-79
- 80-89
- 90-99
- 100+

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Plan For This Session

- Introduction to the Actuarial Research Centre longevity and morbidity research programme
  - Our sponsors
  - The research team
  - Research themes
  - Impact
- Questions from the audience
- Research so far: a taster
  - Case study: Danish mortality
  - Health (mortality) inequalities
  - Drivers: Cause-of-death inequalities
- Further questions

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Modelling, Measurement and Management of Longevity and Morbidity Risk

Our Sponsors:

- Institute and Faculty of Actuaries:
  Actuarial Research Centre
- Society of Actuaries
- Canadian Institute of Actuaries

Specific activities tailored to each.

Modelling, Measurement and Management of Longevity and Morbidity Risk

The Research Team:

Andrew Cairns	Principal investigator	Heriot-Watt Univ.
Angus Macdonald	Co-investigator	HWU
George Streftaris	Co-investigator	HWU
Torsten Kleinow	Co-investigator	HWU
David Blake	Co-investigator	Cass Bus. Sch.
Erengul Dodd	Co-investigator	U. Southampton
Stephen Richards		Longevitas

Plus: 2 postdoctoral researchers; 3 PhD students

Plus: Aarhus, Durham, California.

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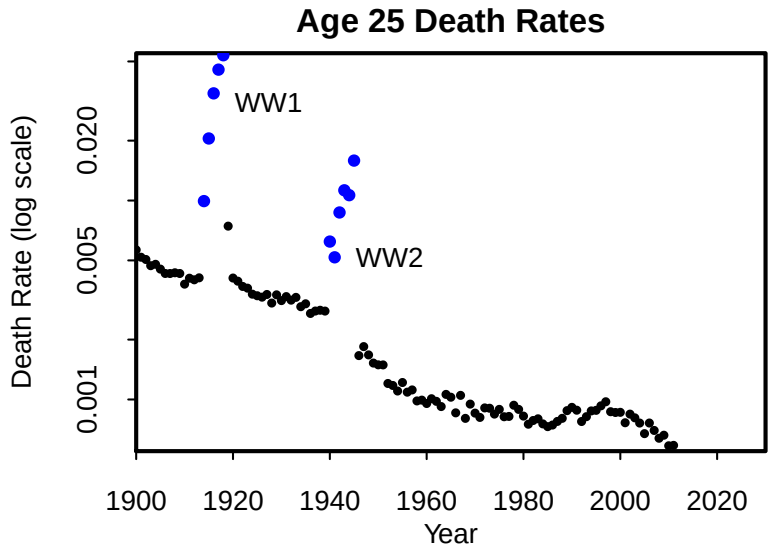
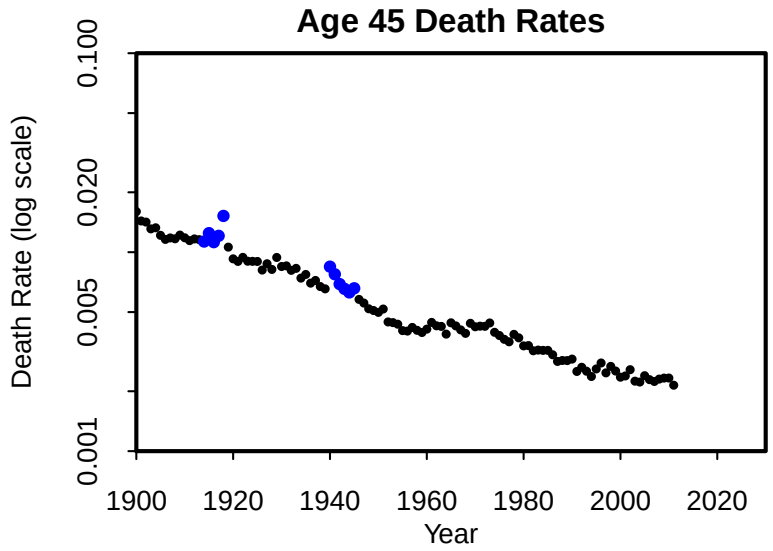
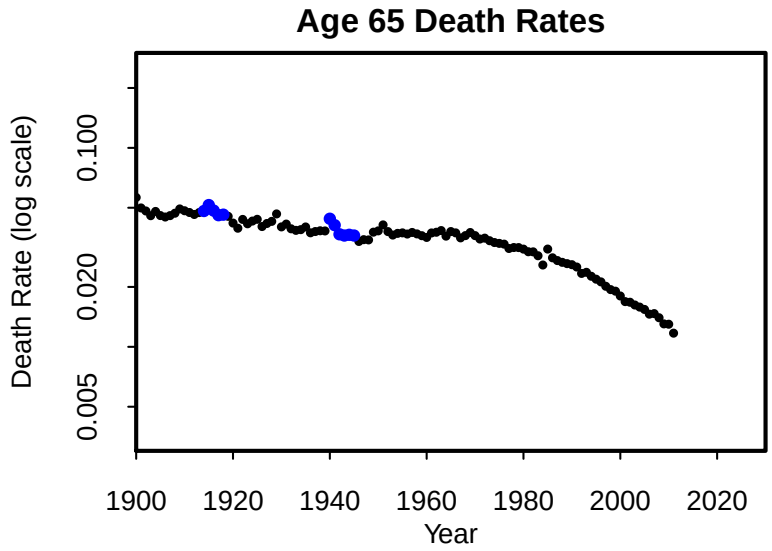
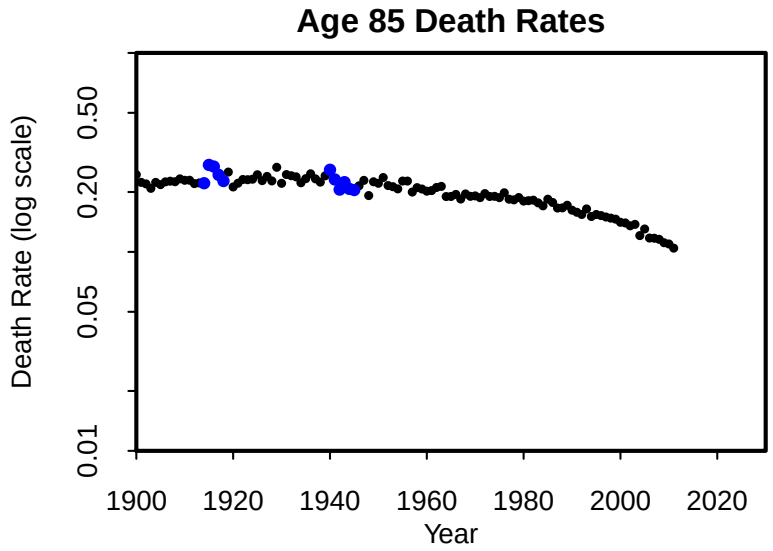
Historical Death Rates: Males, England and Wales









Future forecasts $\Rightarrow$ need for stochastic mortality models

Poll 2

Over the next 20 years:
what do you think is a reasonable assumption *per annum* for mortality improvement rates in the 60-70 age group?

- Less than 0%
- $0 - 1\%$
- $1 - 2\%$
- $2 - 3\%$
- More than 3%
- Don't know

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Poll 3

How much uncertainty is there in the actual outcome (per annum)?

- None – it will be exactly as I predict
- $\pm 0.5\%$
- $\pm 1.0\%$
- $\pm 1.5\%$
- $\pm 2\%$ or more
- Don't know

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Motivation for Stochastic Mortality Models

- Data $\Rightarrow$ uncertain future
- Modelling and measuring longevity risk is important in many actuarial applications
  - General risk assessment
  - Pricing: margin for systematic risk
  - Reserving: systematic risk in runoff
  - Reserving: systematic reserving risk over a 1-year horizon
  - Reserving: diversification benefit between two populations
  - Assessment of risk reduction in longevity hedges

Mortality and Longevity Modelling & Risk Assessment

- Central forecasts
- How much uncertainty around central forecasts?

- Understand and document how stochastic models are currently used in practice: identify gaps
- New single population models: e.g.
  - wider age range
  - flexible and robust estimation procedures
  - greater flexibility in modelling central forecasts
- New multipopulation models: e.g.
  - Data driven modelling
  - How to handle smaller populations?
  - Robust models
  - Realistic correlation term structure

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Emerging themes: recent discussions and research

E.g.

- Understanding the recent trend change in the UK and Canada and other countries
  $\Rightarrow$ How do we model this?

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Poll 4

Background:
Between 1995 and 2015 UK male life expectancy from age 65 has increased by about 4 years.
Since 2010 the rate of increase has halved.

Question: Do you think that improvements in life expectancy over the next 20 years will be

- much lower (+1 years or less)
- lower (+1 to +3 years)
- about the same (+3 to +5 years)
- higher (+5 years or more)?

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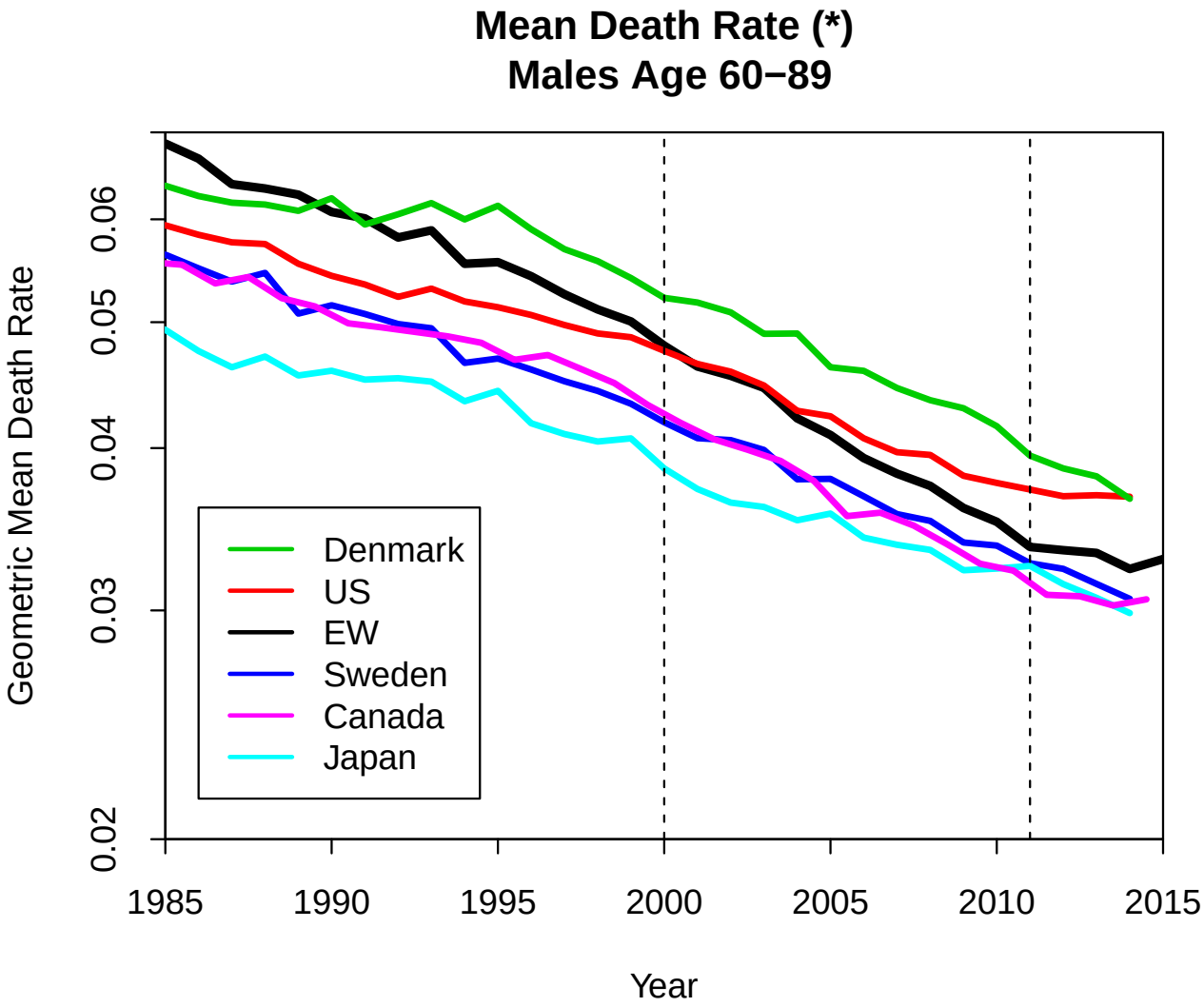
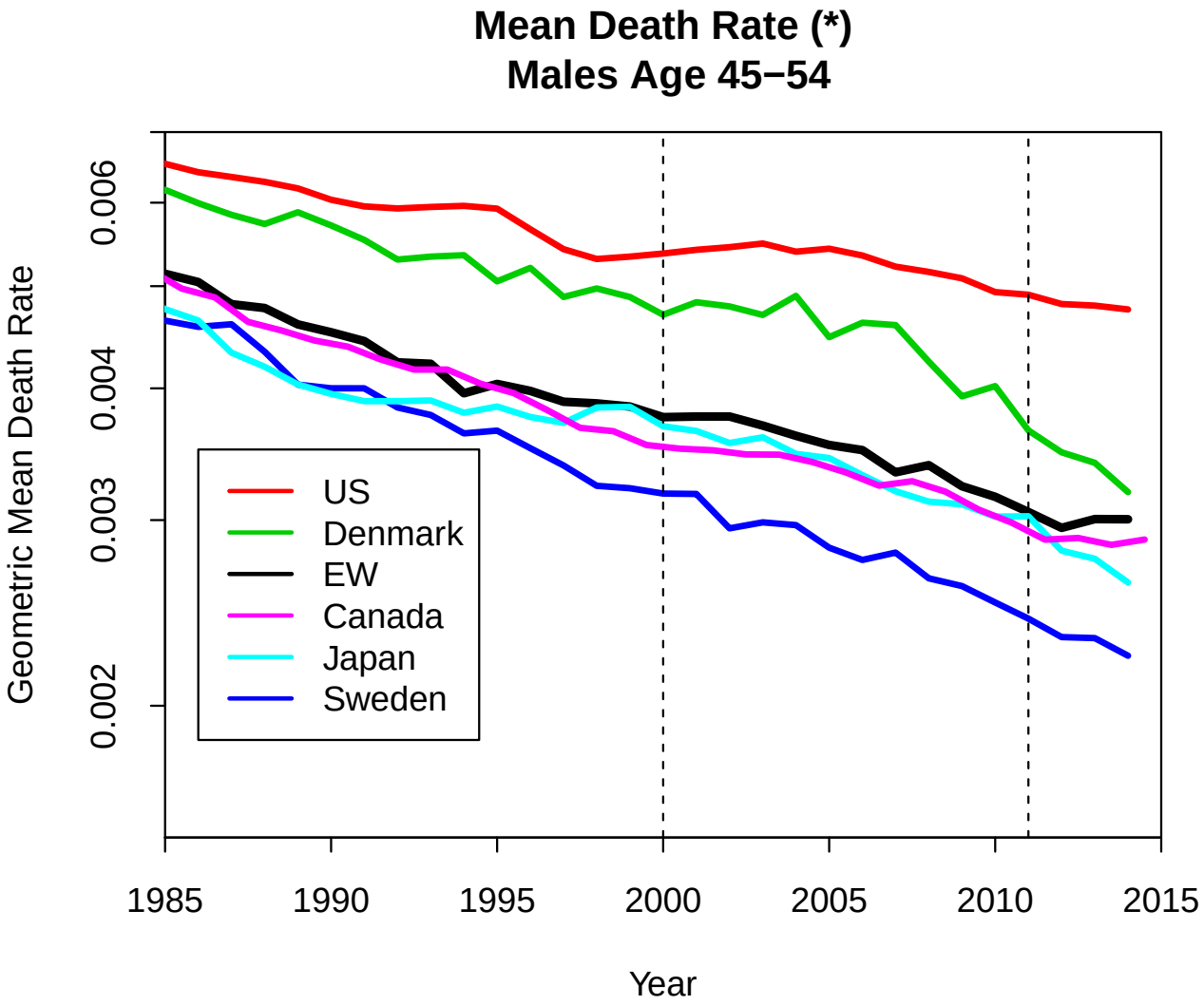
Male Death Rates in 6 Countries: Retired



(*) Geometric mean; log scale

Male Death Rates in 6 Countries: Middle Aged



(*) Geometric mean; log scale

Models $\longrightarrow$ Longevity Risk Management

- What options for managing longevity risk including index-based hedges?
- How to model and assess the impact?
- Impact of risk management on regulatory and economic capital
- Impact of risk management on economic value
- What barriers to innovation?
  - Data accuracy
  - Active pension plan members
  - Price disagreements
  - Regulatory approval: admissible; fair

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Morbidity Risk for Critical Illness Insurance (CII)

- Impact of current and emerging morbidity risks on CII
- Underlying drivers (link to mortality work)
- Short and long term horizons
- Innovative estimation methods, tools and techniques
- Evolution of morbidity risks over time
- Utilise data from different sources:
  - CMI
  - National databases
  - Asia-Pacific CII data

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Outputs and knowledge exchange

- Papers and articles → journals, magazines

  open access

  `www.macs.hw.ac.uk/~andrewc/ARCresources`

- Data: open access where feasible
- Events:

  `www.actuaries.org.uk/learn-develop/attend-event`

  - Sessional meetings: January 2018 and 2019/20
  - IFoA conferences: life, pensions, health & care, risk
  - IFoA specialised conferences and regional events
  - ARC training/CPD events including webinars
  - IFoA Asia
  - North America: SoA, CIA
  - IAA conferences: ICA 2018 + section colloquia
  - Very willing to discuss research at individual organisations

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Case studies and impact

Various forms of impact to be pursued including

- Adoption of new models by users:
  - assessment of the impact of longevity risk
  - facilitated through training events
  - increased confidence in use of models
- Regulation
- Innovation in risk management

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Thank You!

Questions Part 1

Case Study: Danish Mortality

- Data from Statistics Denmark national register database
- One paper complete; available online
- Other lines of research ongoing

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Danish Data

Many potential covariates

- Income and wealth $\longrightarrow$ affluence
- Educational attainment
- Marital status, occupation, health information, cause of death, ...
- Much richer dataset than other countries e.g. UK: mortality by occupation group only

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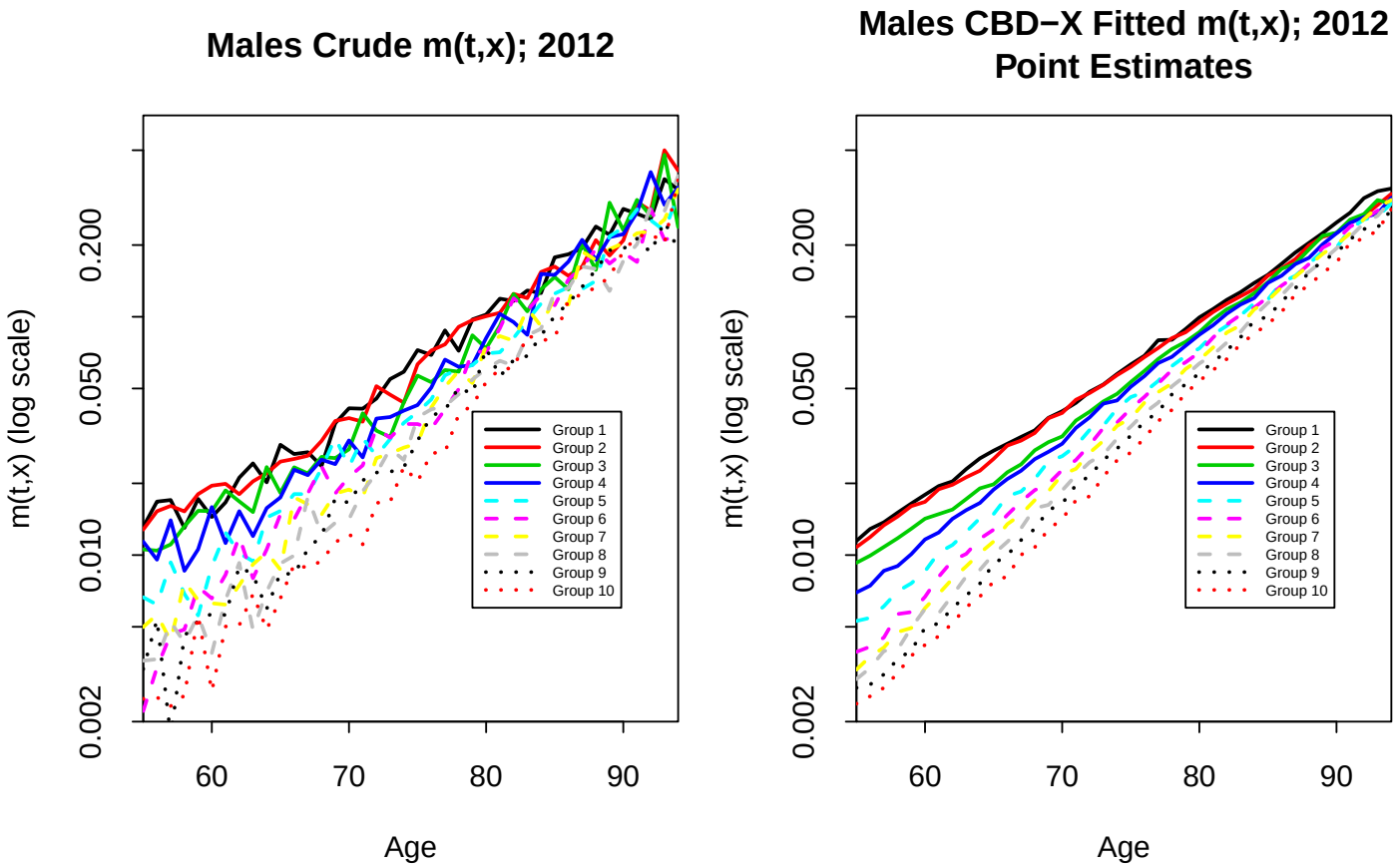
Core Study: Subdivide into 10 Affluence Groups

Death rates, $m(t, x)$ for affluence groups 1 to 10



- CBD-X: Extended Cairns-Blake-Dowd model
- Consistent picture over 1985-2012

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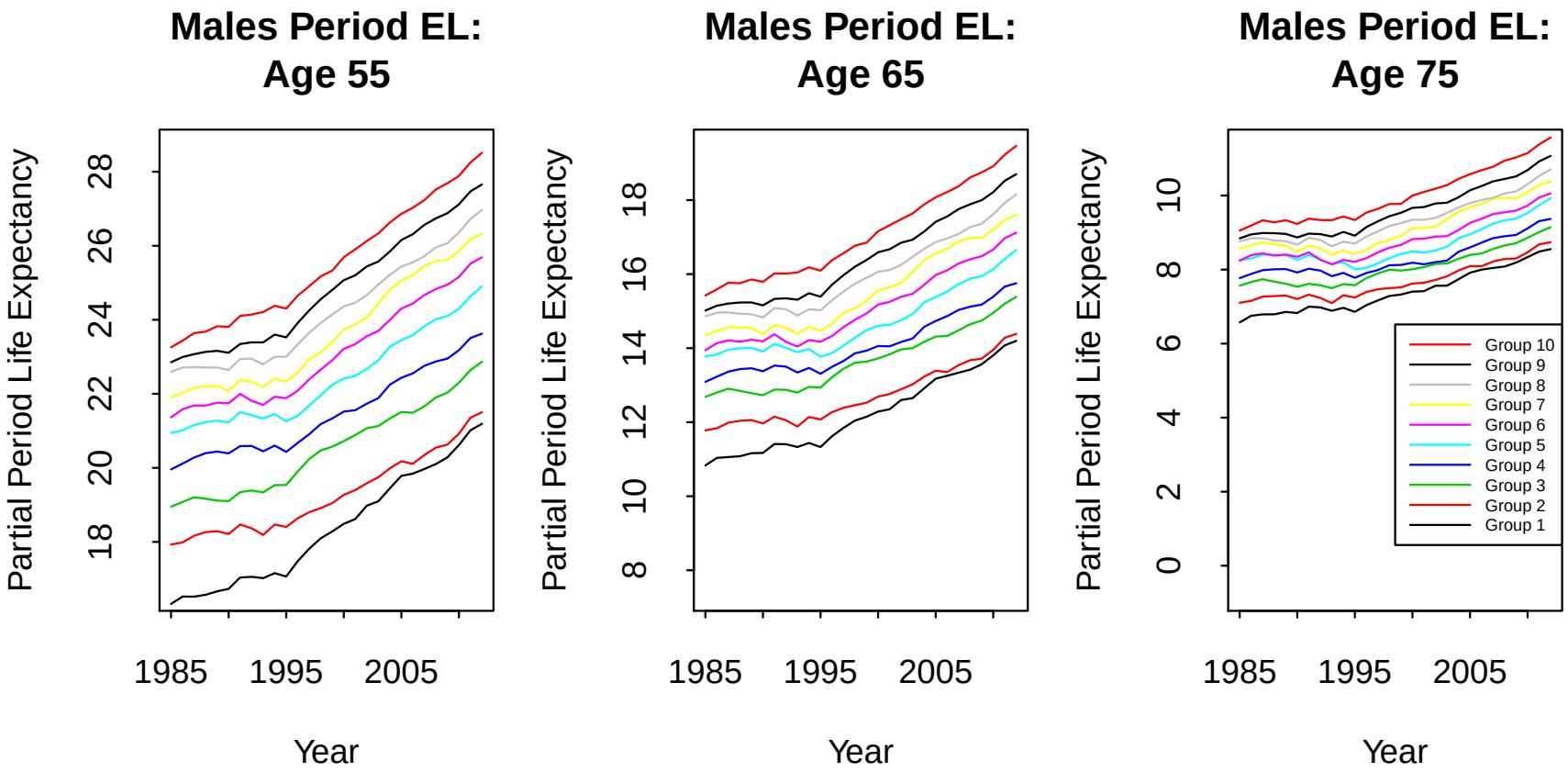
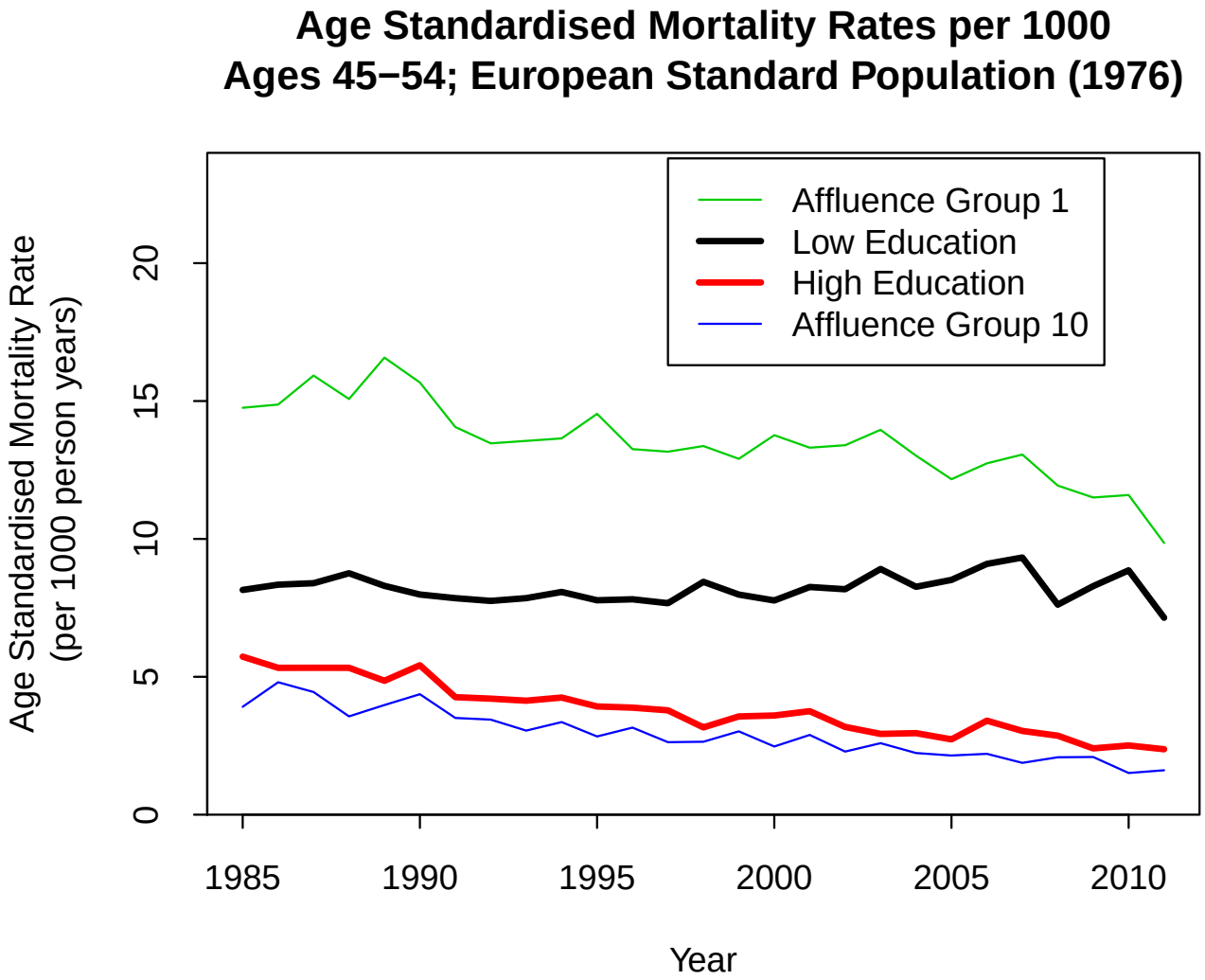
Partial Period Life Expectancy for Groups 1-10



("Partial" $\Rightarrow$ up to age 95.)

Education as an Alternative Covariate

Education levels: low, medium, high



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Education as an Alternative Covariate

- Education $\Rightarrow$ work in progress
- Affluence is a stronger predictor
- But education seems to be increasing in importance
- E.g. high/low education diverging more than affluence
  similar divergence in other countries e.g. US

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Denmark: Cause of Death Data – Health Inequalities

- Deaths subdivided into 29 CoD groups
- Compare affluence groups
- Biggest differences at younger age groups e.g. 51-55
- Causes of death linked to lifestyle
  $\Rightarrow$ some CoD death rates are up to 20$\times$ higher for low affluence groups
- Growing gaps: liver diseases; diabetes
- *Almost all CoD groups have a strong statistically significant difference*

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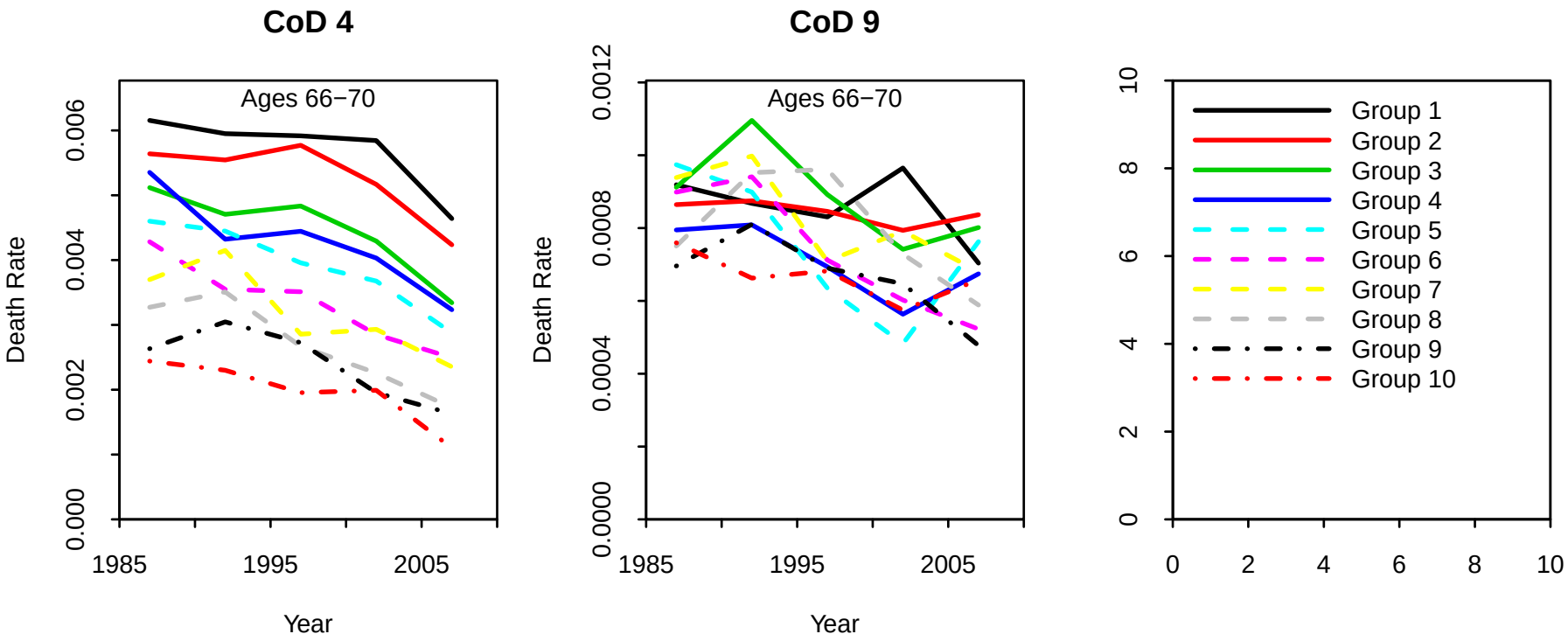
Denmark: Cause of Death Data – Health Inequalities



- 5×5 ages and years
- CoD4: Lung cancer and related cancers
- CoD9: Cancer of lymphatic or blood-forming tissues

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Denmark: Cause of Death Data – Health Inequalities

- Some causes of death have no obvious link to lifestyle/affluence/education
- Possible explanations (a very non-expert view)
  - *onset* is not dependent on lifestyle/affluence/education
  - BUT less affluent/educated $\Rightarrow$
    ??? later diagnosis
    ??? engage less well with treatment process

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Next Steps: Develop Mortality Database

Key point

- Requirement for good quality and appropriate data $\Rightarrow$
  - sub-populations with various socio-economic characteristics
  - sub-populations of different sizes
  - different countries or regions (e.g. Denmark, UK, Canada, US)
- more effective road tests for new (and old) models
- users can have greater confidence in the models they might use

- Resource for other model developers
- How to de-sensitise commercially sensitive data?

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Poll 5

Type in three distinct key words that you take away from this webinar?

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Thank You!

Questions Part 2

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