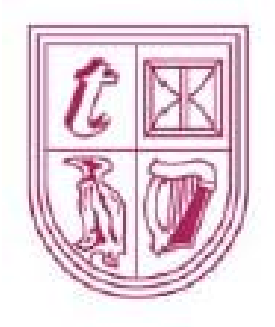


Society of Actuaries in Ireland

Irish Mortality in the 20th and 21st Century

11th October 2011

Agenda

- Irish Mortality: 1901 to 2006
  - All-cause mortality - 1901 to 2006
  - By cause of death - 1926 to 2006
  - Relative mortality risk
    - Northern Ireland
    - England and Wales
- Mortality Projections:
  - Methods
  - Irish population projections in the 21st Century

Irish Mortality:1901 to 2006

- Data & Methods
- All-Cause Mortality
  - Standardised Death Rate (SDR)
  - SDR by Age Group
  - Proportion of Deaths
  - Relative Risk – NI & E+W
- By-Cause of Death

Data

- Ireland - Central Statistics Office (CSO)
- Northern Ireland - Human Mortality Database (HMD)
  - Northern Ireland Statistics and Research Agency (NISRA)
- England and Wales - HMD
  - Office for National Statistics (ONS)

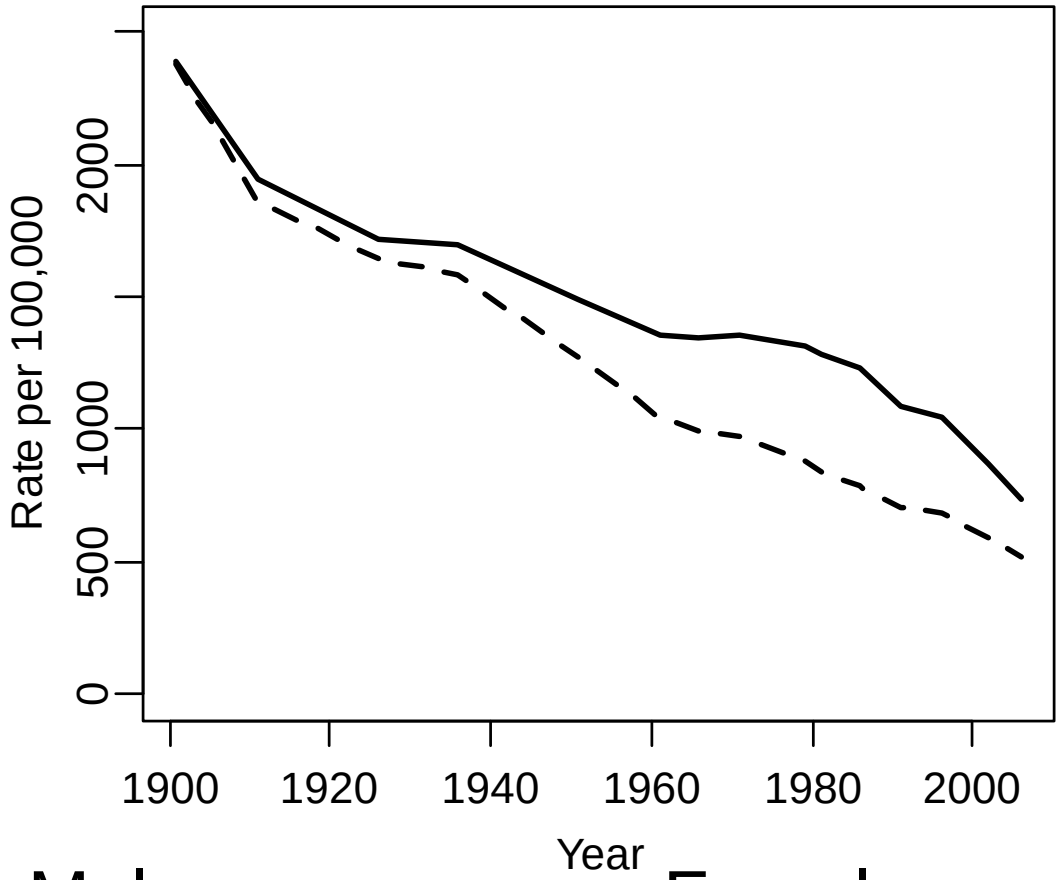
Methods

- Census years from 1901 to 2006
- Death Rate:

$$\frac{D_{x,t}}{P_{x,t}} = \frac{average\ no.of\ deaths\ in\ age\ group\ x\ in\ the\ three\ years\ centred\ on\ year\ t}{population\ count\ for\ age\ group\ x\ in\ year\ t}$$

- Directly age standardised death rates
  - Standardised to the European Standard Population

Directly Age Standardised All-Cause Death Rates for Ireland 1901 to 2006



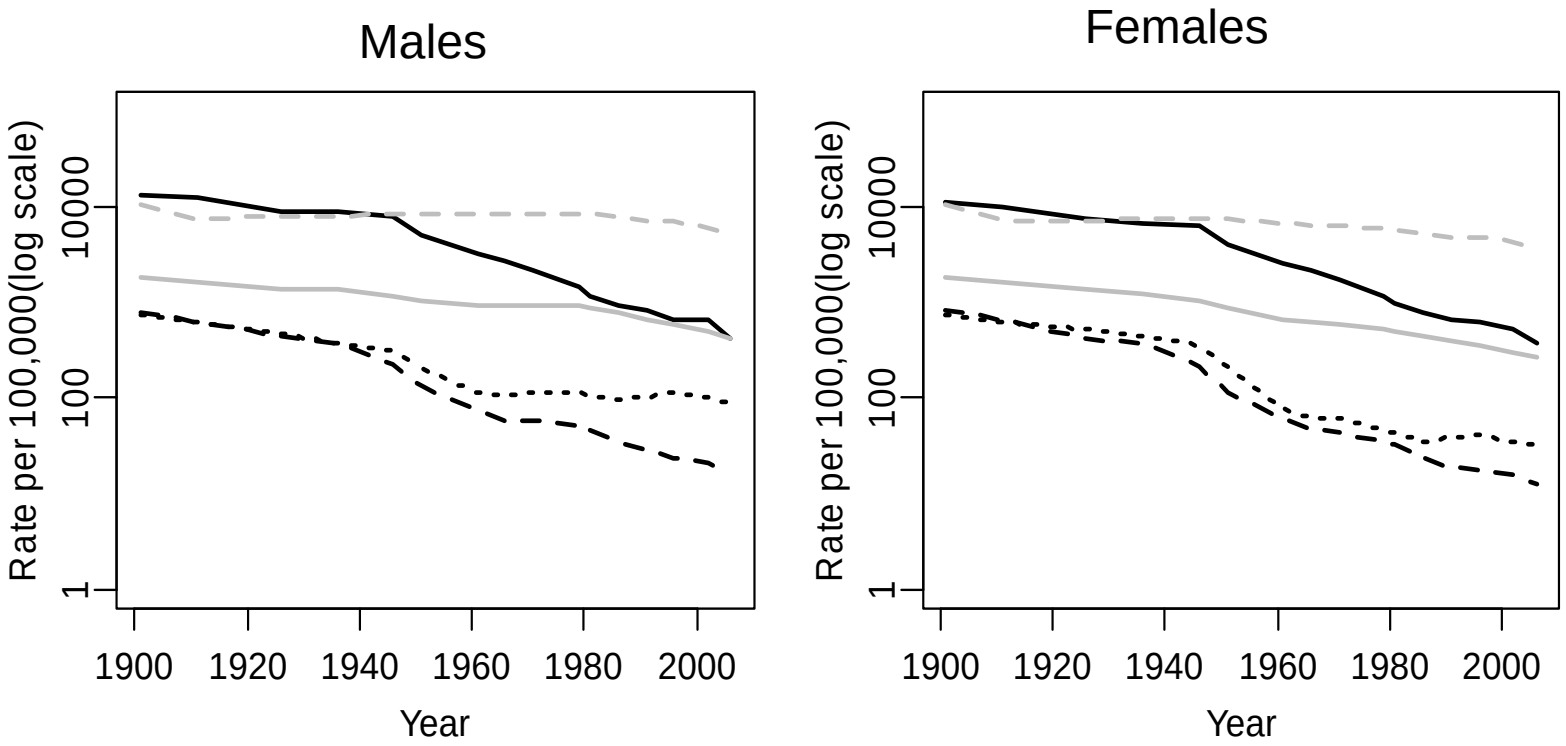
Directly Age Standardised All-Cause Death Rates for Ireland 1901 to 2006

- Significant decline in standardised death rates
  - Males ~ 69% drop
  - Females ~ 77% drop

- Relative risk for males and females:

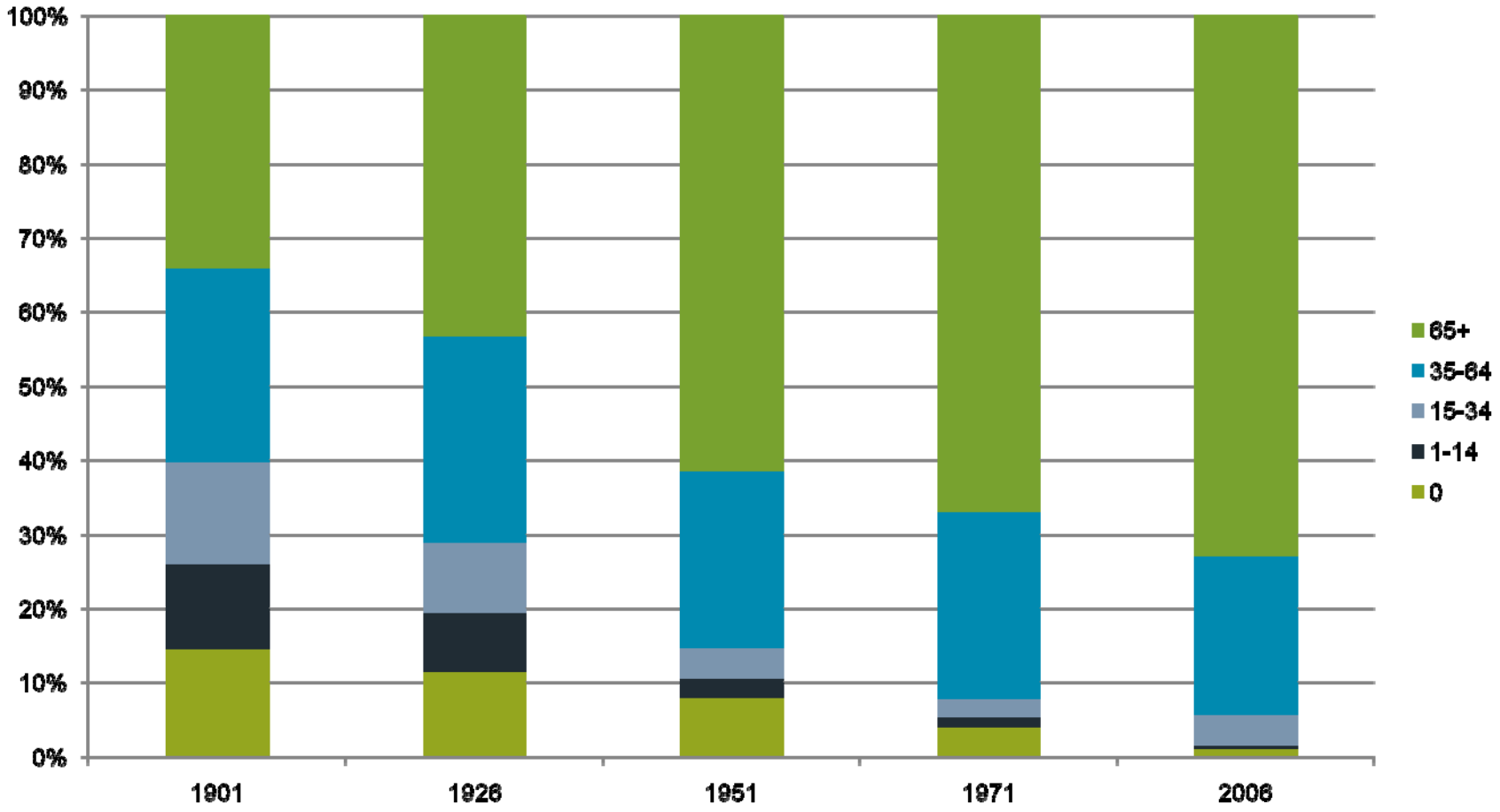
Age	1901	1926	1951	1971	1981	2006
0+	1.00	1.05	1.17	1.40	1.52	1.40
0-64	1.02	1.00	1.21	1.57	1.72	1.63
65+	0.98	1.09	1.15	1.33	1.44	1.34

Directly Age Standardised All-Cause Death Rates by Broad Age Group



Age 0 _____ Ages 1-14_ _ _ _ Ages 15-34 …….
Ages 34-64 _____ Ages 65+ _ _ _ _

Proportion of Deaths by Broad Age Group - Males



Relative All-Cause Mortality Risk

	Northern Ireland		England & Wales	
	Males	Females	Males	Females
1901	-		0.94	1.11
1911	-		0.90	1.04
1926	0.89	0.90	0.92	1.10
1936	0.92	0.92	0.97	1.17
1951	1.02	1.07	1.01	1.24
1961	0.97	1.04	0.97	1.16
1971	0.95	1.06	1.02	1.17
1981	0.97	1.02	1.09	1.14
1991	1.03	1.03	1.10	1.08
2002	1.04	1.00	1.09	1.00
2006	0.94	0.95	1.03	0.97

Relative All-Cause Mortality Risk

- Relative mortality of Irish males:
  - good over most of 20th century
  - deteriorated towards the end of the 20th century
- Relative mortality of Irish females:
  - poor over most of 20th century
  - improved towards the end of the 20th century
- Ireland experienced significant improvements in relative mortality in early years of 21st century.

Cause of Death 1926 - 2006

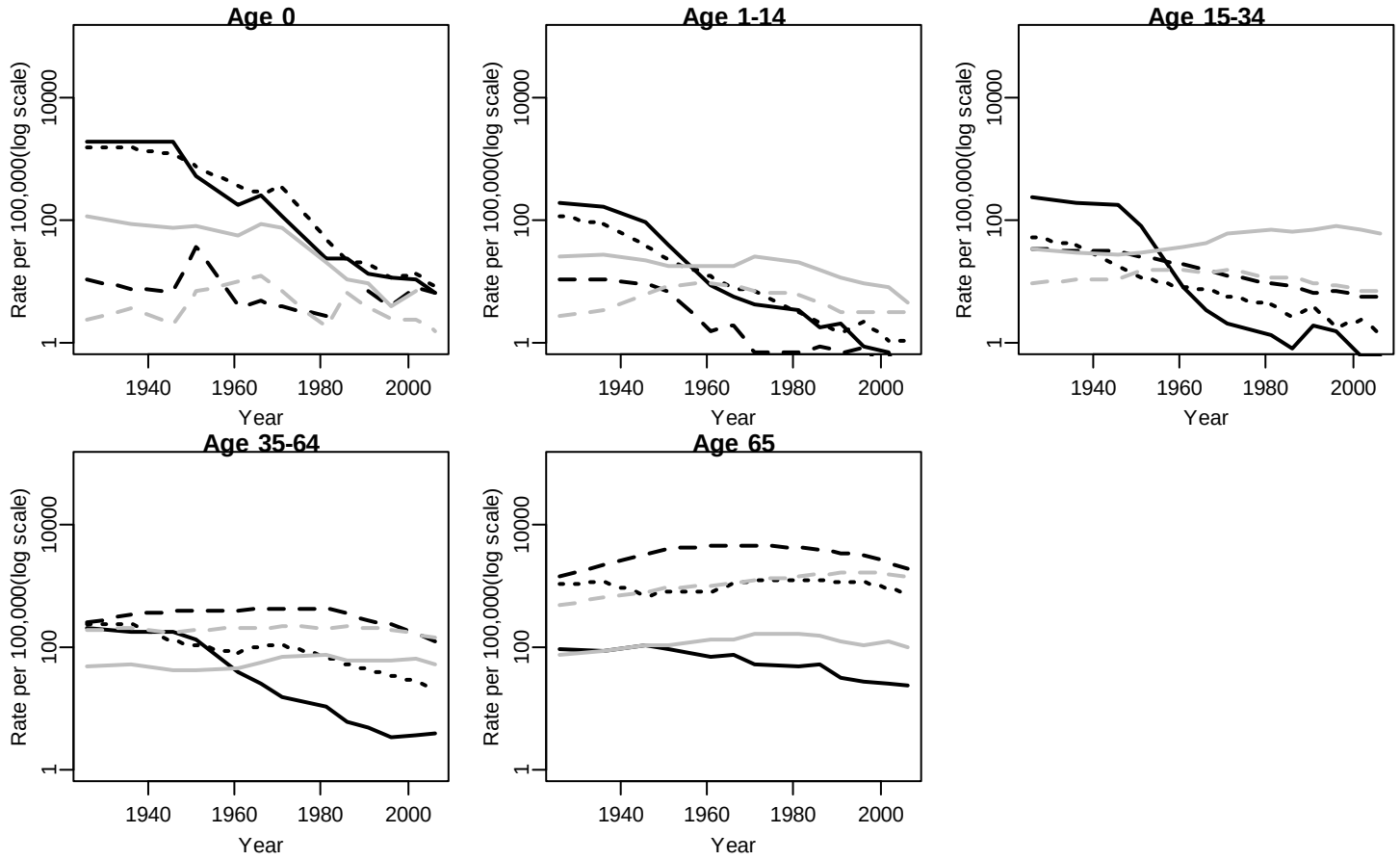
- Five major causes of death analysed:
  - Infectious Diseases - External Causes
  - Circulatory Diseases - Cancer
  - Respiratory Diseases
- Grouping by WHO ICD (International Classification of Diseases) Codes.

Directly Age Standardized Cause of Death Mortality Rates 1926 to 2006

Infectious **Circulatory** **Respiratory**

External **Cancer**

Trends by Broad Age Group - Males



Infectious_____ Circulatory _ _ _ _ Respiratory ---------
External _____ Cancer _ _ _ _

Trends by Broad Age Group

- Age Groups 0-34
  - Dramatic drop in deaths due to infectious diseases
  - External causes now primary cause of death for ages > 0
- Age group 35-64
  - Cancer primary cause of death by 2006
- Age group 65+
  - Deaths due to “ill-defined” causes distort trends in 1st half of 20th century
  - Circulatory disease primary cause of death by 2006

Relative Mortality Risk for Ireland and Northern Ireland - Males

	1951	1961	1971	1981	1991	2000
Infectious	1.33	1.35	1.24	2.14	1.98	1.83
Circulatory	0.90	0.88	0.88	0.94	1.01	1.10
Respiratory	0.90	0.85	1.04	0.96	0.88	0.90
External	0.80	0.86	0.91	0.89	1.00	1.20
Cancer	0.93	0.94	0.97	1.02	1.01	1.08
Ill-Defined	2.34	6.65	7.07	3.04	2.80	1.92

Relative Mortality Risk for Ireland and Northern Ireland - Females

	1951	1961	1971	1981	1991	2000
Infectious	1.56	1.68	1.30	1.60	2.31	1.65
Circulatory	0.92	0.94	0.97	1.01	0.99	1.06
Respiratory	0.99	1.03	1.32	0.97	0.84	0.81
External	0.86	0.77	1.01	0.87	1.01	1.13
Cancer	0.93	1.03	1.07	1.03	1.04	1.02
Ill-Defined	2.34	6.18	6.54	3.12	2.37	0.54

Relative Mortality Risk for Ireland and England and Wales - Males

	1951	1961	1971	1981	1991	2000
Infectious	1.76	1.60	1.79	2.31	1.37	0.99
Circulatory	0.88	0.99	1.04	1.14	1.11	1.21
Respiratory	0.76	0.64	0.91	1.01	1.39	1.10
External	0.70	0.75	1.30	1.52	1.40	1.48
Cancer	0.76	0.77	0.84	0.90	0.96	1.07
Ill-Defined	9.29	6.46	3.68	1.54	1.12	0.57

Relative Mortality Risk for Ireland and England and Wales - Females

	1951	1961	1971	1981	1991	2000
Infectious	2.61	2.21	2.06	2.04	1.25	1.04
Circulatory	1.01	1.13	1.17	1.21	1.10	1.18
Respiratory	1.17	1.05	1.22	1.05	1.45	1.04
External	0.73	0.66	1.10	1.22	1.26	1.32
Cancer	0.88	0.97	1.03	1.00	1.00	1.05
Ill-Defined	8.56	5.34	3.12	1.54	0.77	0.25

Irish Mortality in the 21st Century

- Irish mortality improvements at start of 21st century mainly due to drop in deaths from circulatory diseases.
- Drop in deaths from circulatory diseases can partly be attributed to government policy.
- Government policy likely to have a significant impact on future mortality improvements.

Mortality Projections

- Projection Methods
  - CMI – Continuous Mortality Investigation Bureau
  - CSO – Central Statistics Office
  - GAMs – Generalised Additive Models
- Irish Population Projections
  - GAMs
  - CSO
- Conclusions

Projection Method Overview

- CMI
  - Historical approach
  - Interim Tables
  - P-spline and Lee-Carter models
  - Mortality Projection Models
  - Library of Mortality Projections

- CSO
  - Targeting approach

Mortality Projections using Generalised Additive Models (GAMs)

- The basic form of a GLM is:

$$\eta = g(\mu) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_n x_n$$

where $\mu = E(y)$ and g is referred to as the link function.

- The basic form of a GAM is:

$$\eta = g(\mu) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_m x_m + f_{m+1}(x_{m+1}) + ... + f_{m+n}(x_{m+n})$$

where as before $\mu = E(y)$ and f_{m+1}, …., f_{m+n} are smooth non parametric functions.

Mortality Projections using GAMs with thin plate regression splines

$$D_{x,t} \sim Poisson(E^{c}_{x,t}\mu_{x,t})$$

- 1–Dimensional GAMs:

  A+P: $\eta = \log(\mu_{A+P}) = \log(E^{C}_{A+P}) + f_A(age) + f_P(period)$

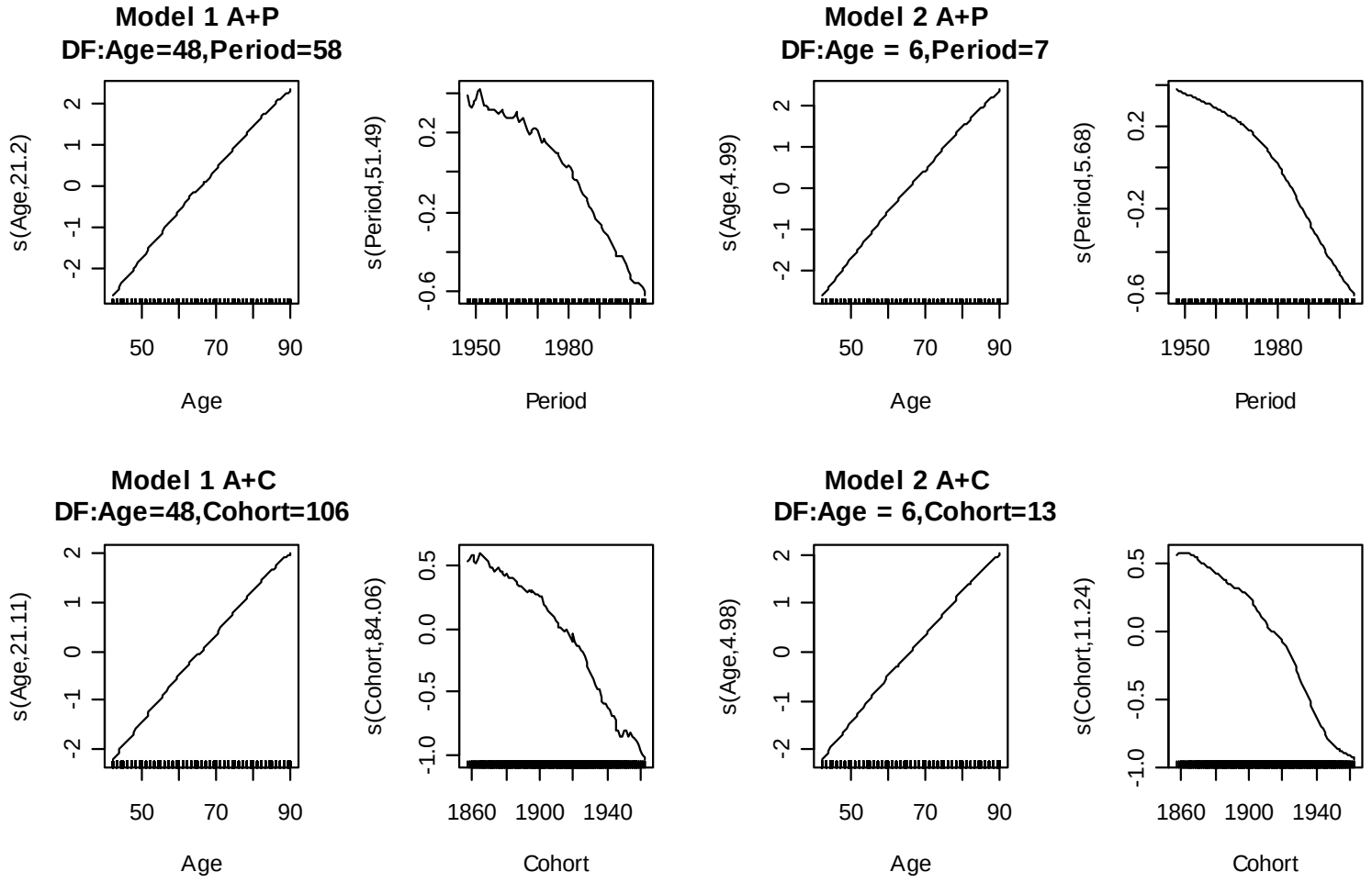
  A+C: $\eta = \log(\mu_{A+C}) = \log(E^{C}_{A+C}) + f_A(age) + f_C(cohort)$

- 2–Dimensional GAMs:

  AP: $\eta = \log(\mu_{AP}) = \log(E^{C}_{AP}) + f_{AP}(age, period)$

  AC: $\eta = \log(\mu_{AC}) = \log(E^{C}_{AC}) + f_{AC}(age, cohort)$

Smooth Functions
Choice of Degrees of Freedom

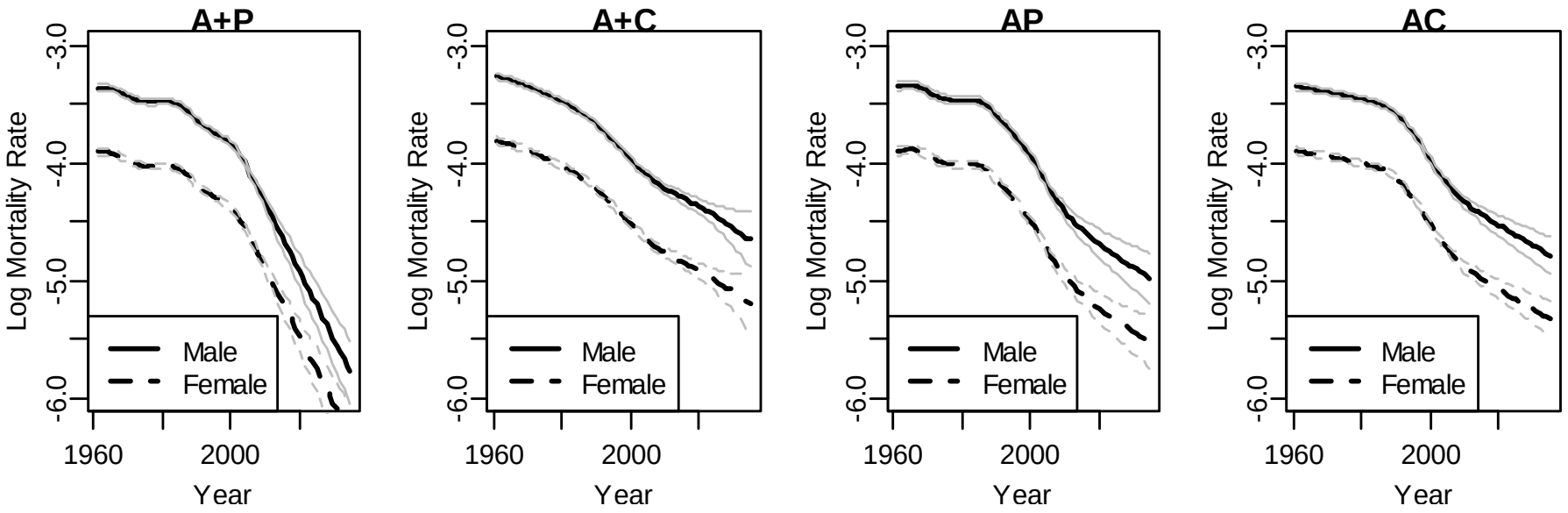


Mortality Projections using GAMs

- Advantages
  - intuitively simple
  - flexible mortality models without the need to specify detailed parametric relationships.

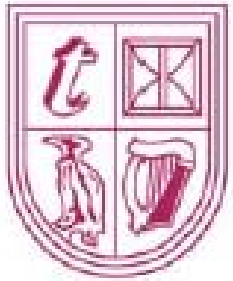
- Disadvantages
  - choice of model DOF
  - scalability

Irish Mortality Projections using GAMs



Conclusions

- Mortality improvements expected to continue.
- Due to uncertainty of future projections need to consider:
  - range of projection methods
  - range of projections
  - review regularly (consistent with past, international etc)
- Future work:
  - Mortality projections by cause
  - Impact of socio-economic status on mortality projections



Questions?