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# Forecasting mortality, different approaches for different cause of deaths? The cases of lung cancer; influenza, pneumonia, and bronchitis; and motor vehicle accidents

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## The starting point

**Cause of death forecasts are increasingly important due to the implications of changing cause of death patterns for health and social care costs predictions as well as for their contribution to understanding the drivers of overall mortality change.**

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## Models

**In recent decades a range of methods for mortality forecasting has been developed**

- Lee-Carter (1992)
- Booth, Maindonald, and Smith (2002)
- Renshaw and Haberman (2006)
- Heathcote and Higgins (2001)
- Girosi and King (2008)

**including techniques for the estimation of uncertainty of forecasts**



## The problem

A large number of studies have examined differences among models forecasting overall level

**BUT**

Not many studies approach the problem of evaluating the appropriateness of specific forecasting models to specific cause of deaths. In other words, no systematic analyses have been developed to assign the best forecasting model to a specific cause of death.

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# The research question

**How far different causes of deaths need different hypothesis and methods of forecasting?**

**MODEL**

- Lee-Carter *(LC)*
  - Booth-Maindonald-Smith *(BMS)*
- Age-Period-Cohort *(APC)*
- Bayesian

**CAUSES OF DEATH**

- Malignant neoplasm of trachea, bronchus and lung *(Lung cancer)* (ICD10: C33-C34)
- Influenza, pneumonia, and bronchitis *(Influenza)* (ICD10: J10-J22 )
- Motor vehicle accidents *(MVA)* (ICD10: V02-V04, V09.0, V09.2, V12-V14, V19.0-V19.2, V19.4-V19.6, V20-V79, V80.3-V80.5, V81.0-V81.1, V82.0-V82.1, V83-V86, V87.0-V87.8, V88.0-V88.8, V89.0, V89.2)



# Data

- Twentieth Century Mortality database for England and Wales
- Twenty-first Century Mortality database for England and Wales
- 1950-2007
- Fit:1950-1977 obs. 1978-2007 est.
- Comparison basis: Mean absolute error *(MAE)*

  $|Obs(log(m))-Est(log(m))|$

## Assumptions (i)

- LC and BMS: No assumptions
- Bayesian: includes non-linear rates of increase in log-mortality -- important in cases where a linear trend fails to capture the influence of the factors that drive mortality down (or up) over time, but may at the beginning, drive mortality up (or down) over time.

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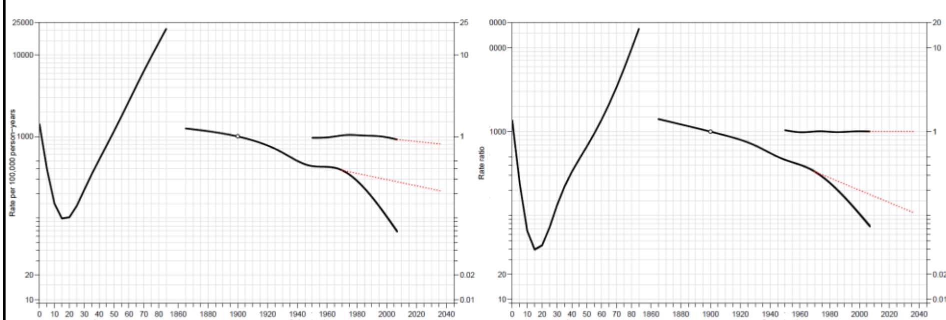
## Assumptions (ii)

- APC: Overall mortality fitted to period

Males | Females

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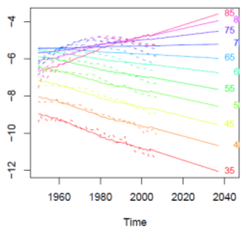
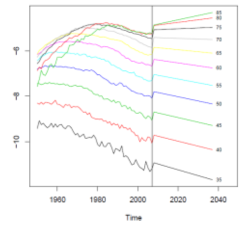
# Results – Lung cancer Males (35+)



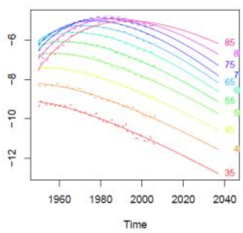
LC

MAE 0.88



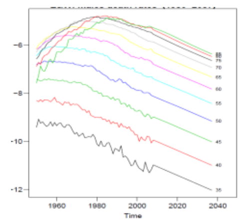
BMS

MAE 0.65



BAYESIAN

MAE 0.30

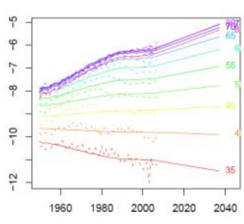


APC

MAE 0.27

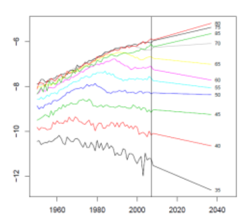


# Results – Lung cancer Females (35+)



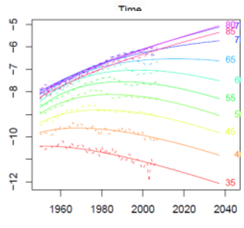
LC

MAE 0.45



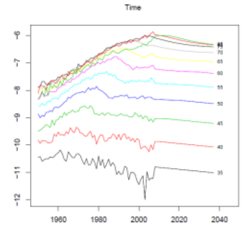
BMS

MAE 0.44



BAYESIAN

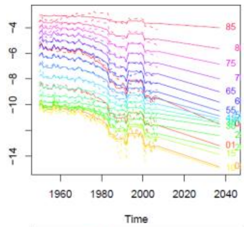
MAE 0.51



APC

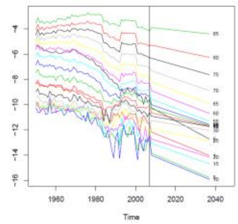
MAE 0.10

# Results – Influenza Males



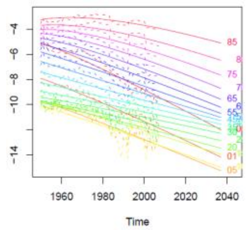
LC

MAE 0.80



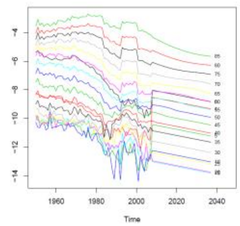
BMS

MAE 0.85



BAYESIAN

MAE 0.93



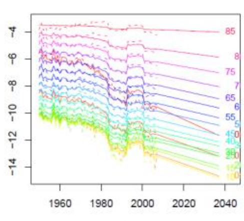
APC

MAE 0.93

MAE 35+: 0.70

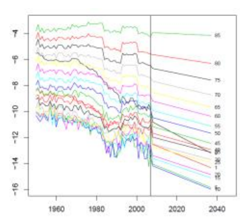


# Results – Influenza Females



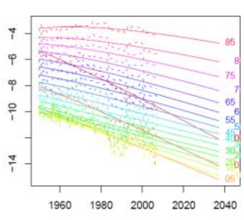
LC

MAE 0.63



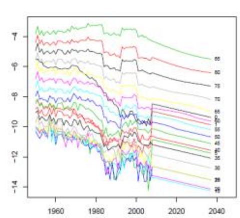
BMS

MAE 0.69



BAYESIAN

MAE 0.82

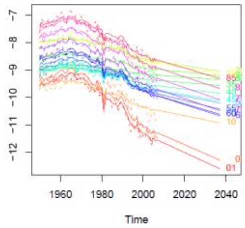


APC

MAE 0.82

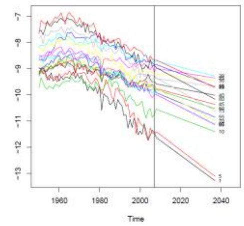
MAE 35+: 0.64

# Results – MVA Males



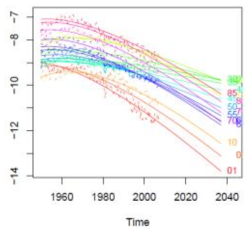

LC

MAE 0.65



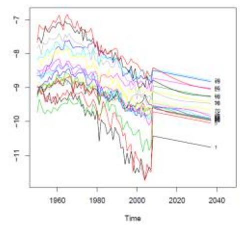

BMS

MAE 0.40




BAYESIAN

MAE 0. 41




APC

MAE 0.64

MAE 35+: 0.60

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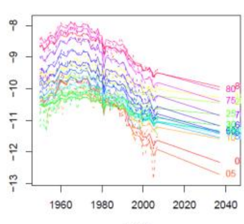
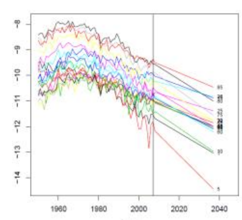
# Results – MVA Females



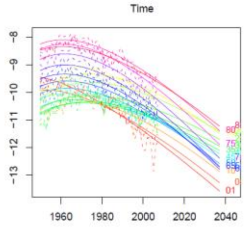

LC

MAE 0.90



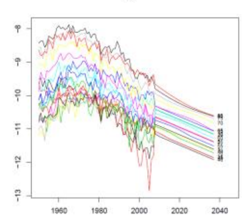

BMS

MAE 0.78




BAYESIAN

MAE 0.91




APC

MAE 0.96

MAE 35+: 0.89

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# Mean Absolute Error

| | All | | Lung | | IPB | | MVA | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| LC | 0.22 | 0.17 | 0.88 | 0.45 | 0.80 | 0.63 | 0.65 | 0.90 |
| BMS | 0.22 | 0.15 | 0.65 | 0.44 | 0.85 | 0.69 | 0.40 | 0.78 |
| Bayesian | 0.24 | 0.15 | 0.30 | 0.51 | 0.93 | 0.82 | 0.41 | 0.91 |
| APC | 0.53 | 0.47 | 0.27 | 0.10 | 0.93 | 0.82 | 0.64 | 0.96 |
| Bayesian (35+) | 0.19 | 0.11 | - | - | 0.70 | 0.64 | 0.60 | 0.89 |

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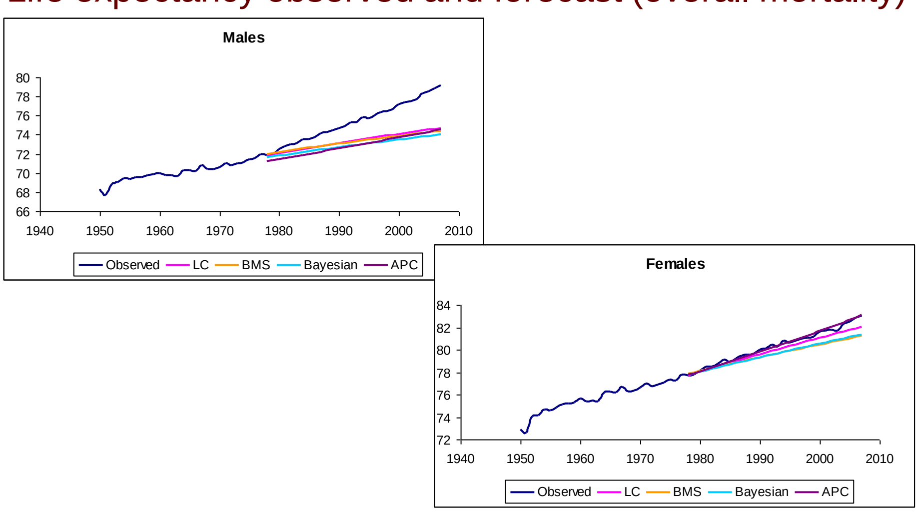
# Life expectancy observed and forecast (overall mortality)

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## Recommendations (i)

- LC and BMS based on the random walk with drift is a valid option for forecasting causes of death characterized by linear trends
- The same family of forecasting models better cope with “unpredictable” changes in trends. This is true for cause of deaths which are not driven by period or cohort effects (MVA) and also for cause of death which are characterized by unpredictable period effects (Influenza). This is due to the fact that the estimated “drift” is essentially the average over time which seems to mitigate possible, and unpredictable, changes over time, and consequently reduce the error.



## Recommendations (ii)

- Causes of deaths characterized by well-defined cohort effects, such as lung cancer need to be forecast using model which incorporate cohort factors. In such cases, the APC model tends to achieve the best result (MAE and ME).
- Even if the APC model includes the period effect, it doesn’t necessarily produce better forecasting results than the LC family methods. The problem in forecasting the future period effects is their unpredictability.
- The Bayesian model produce good forecasts however it never shows substantially better results than the others models discussed here.

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