

Institut für Finanz- und Aktuarwissenschaften, Universität Ulm

# Longevity Risk in the United Kingdom

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# Prologue

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- Jennifer Stover collects £12,500 after winning a bet that her mother-in-law would live to 100.
- She placed a bet of £100 at 100-1 odds 11 years ago, and a year later staked another £50 at 50-1 odds.
- Her mother-in-law, Rosalind, celebrates her birthday at a party paid for with the winnings.

Source: BBC News, 4<sup>th</sup> November 2004.

# Prologue—odds

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- The bookmaker used a survival probability of 1%.
- He should have used a figure five times greater: 5.48%.

Source: Own calculations using 1992–1994 GAD interim life table for females in England and Wales.

# Life-expectancy calculations

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- They must!
- And here's why...

# Financial significance of life expectancy

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- Following its first mortality analysis for a decade, British Aerospace announced a £2.1bn increase in pension liabilities (17%)<sup>1</sup>.

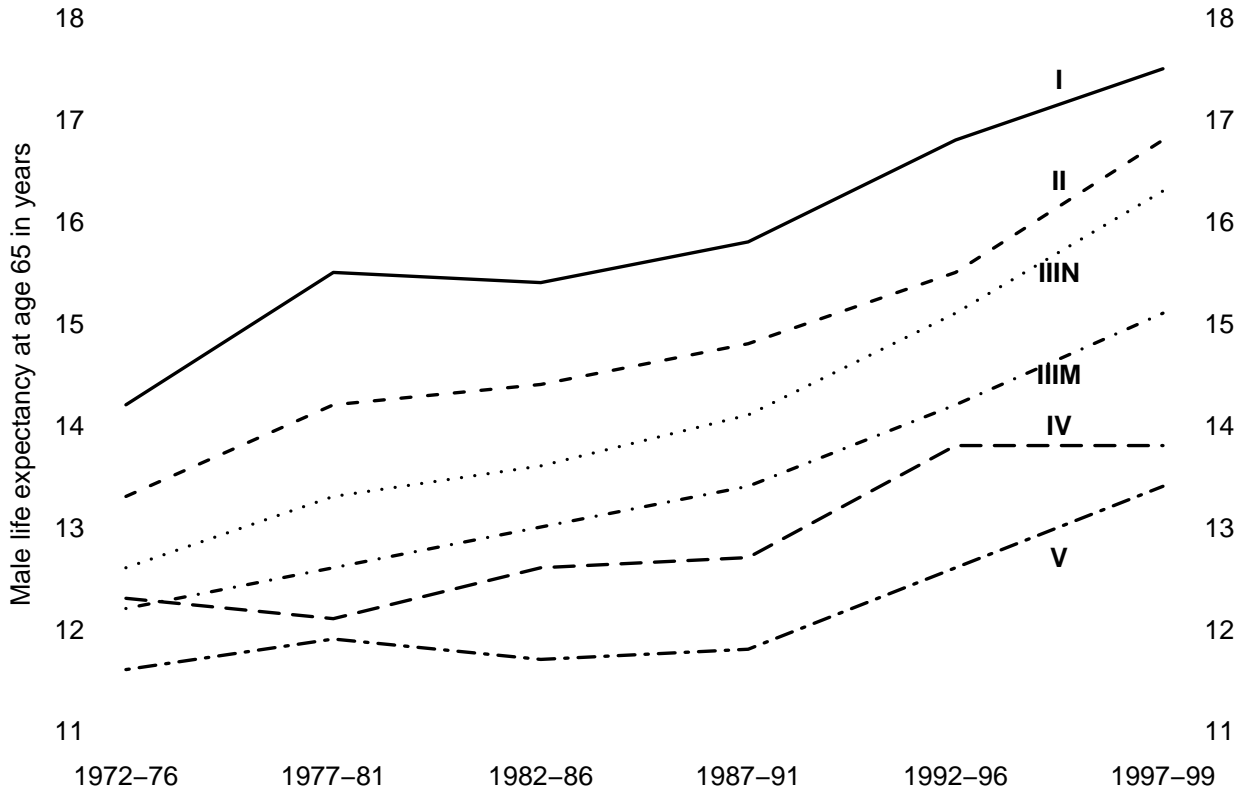
# Financial significance of life expectancy

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- Following its first mortality analysis for a decade, British Aerospace announced a £2.1bn increase in pension liabilities (17%)<sup>1</sup>.
- Following the adoption of International Financial Reporting Standards (IFRS), British Airway's net assets fell from £2.7bn to £1.4bn as the pension-scheme deficit came the balance sheet<sup>2</sup>.

Source: <sup>1</sup>British Aerospace: 2004 preliminary results, page 25. <sup>2</sup>British Airways: Release of Financial Information 2004/5 under IFRS, page 3.

# Retirement life expectancy by socio-economic group



Source: ONS Longitudinal Survey.

# Mortality improvements

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# Mortality improvements

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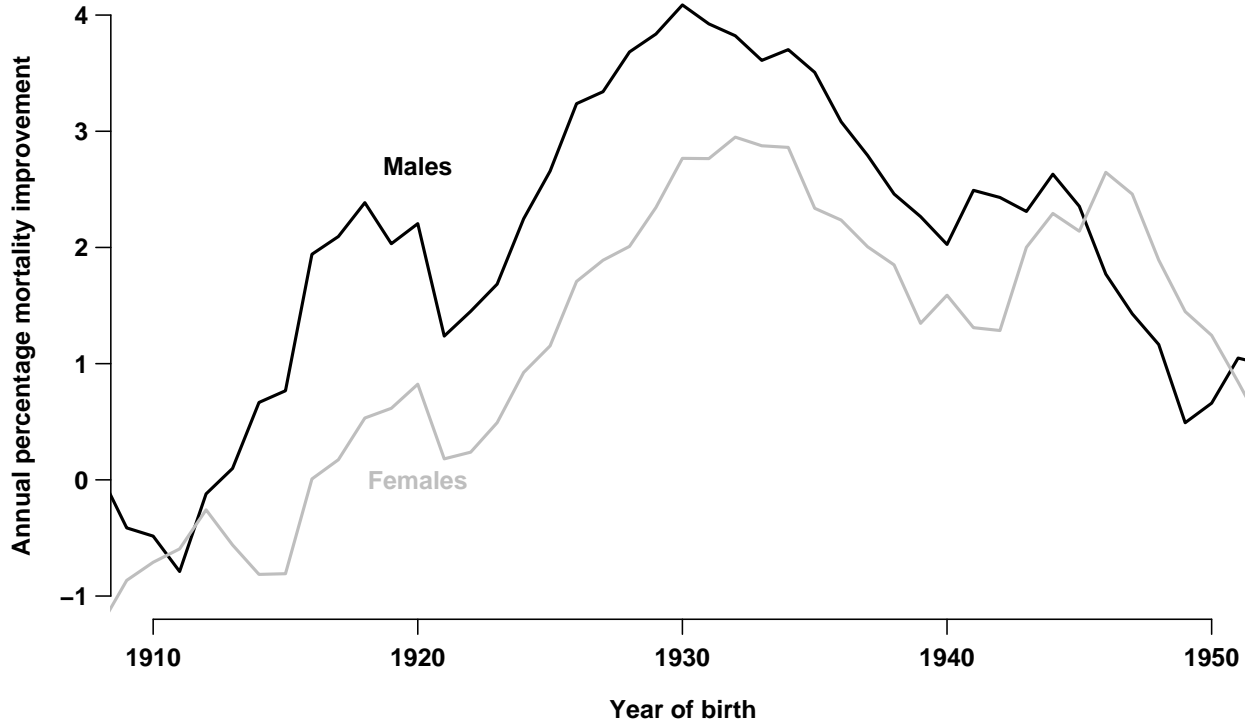
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- Improvements strongly related to year of birth, or *cohort*.
- For more details, see Willets (2004) and Richards and Jones (2004).

# Mortality improvements by year of birth

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Source: Own calculations with GAD interim life tables for 2000–2002 and 2001–2003.

# Possible causes of cohort mortality patterns

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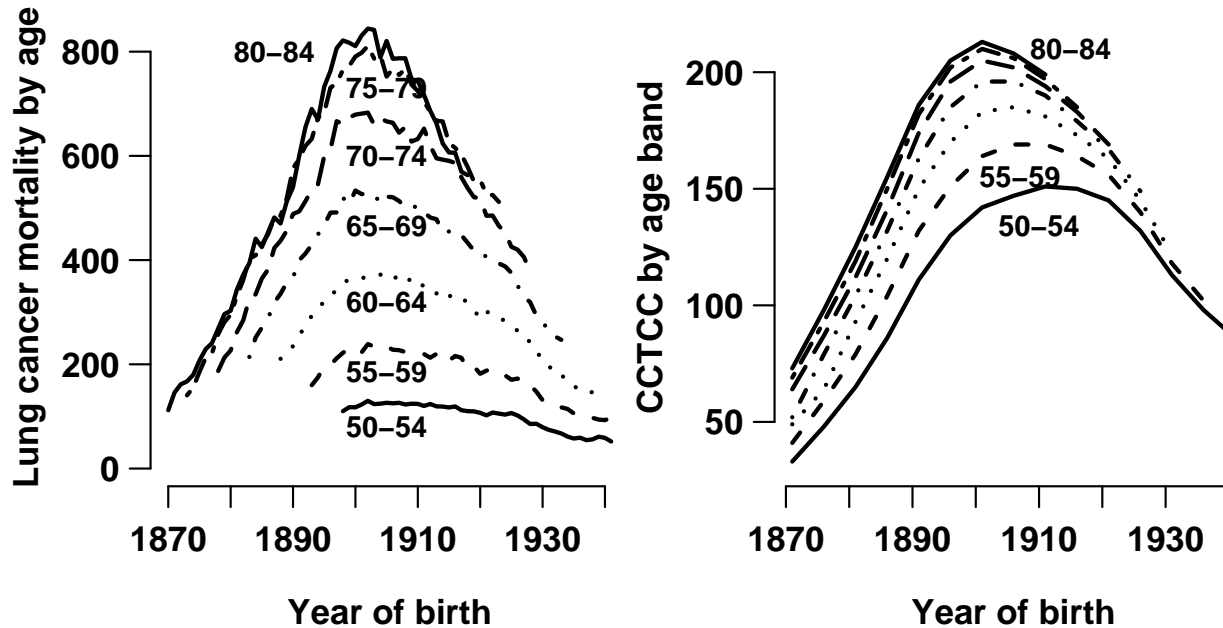
# Possible causes of cohort mortality patterns

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- Changes in smoking incidence.

# Lung-cancer mortality rates (left) and lifetime consumption of cigarettes (right) by year of birth

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Source: Lee et al (1990), Forey et al (1993) and ONS data.

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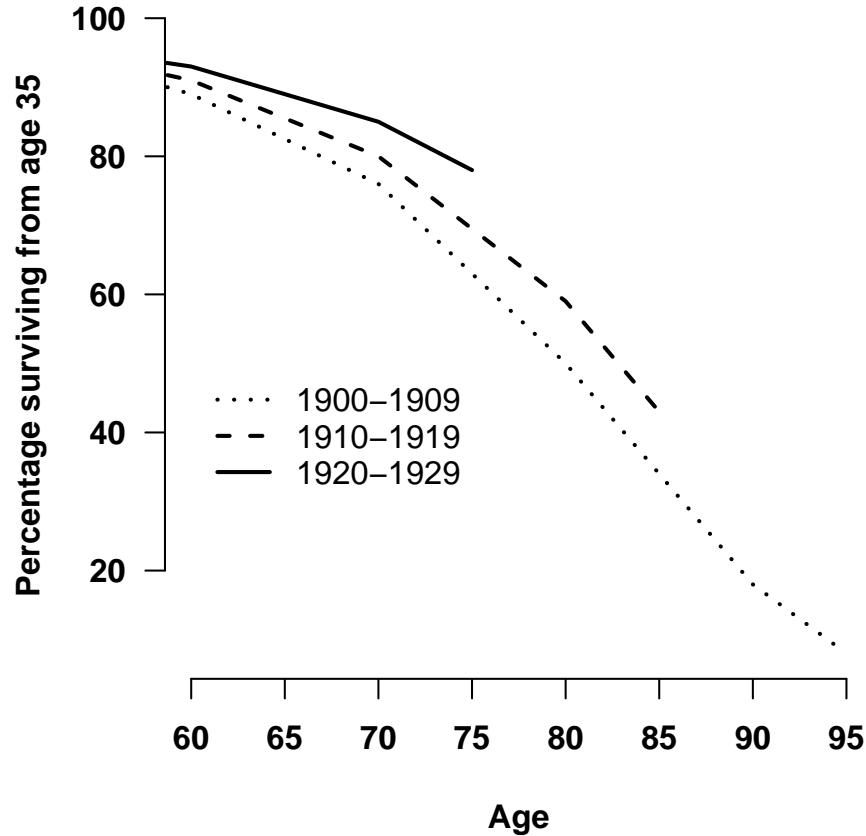
# Possible causes of cohort mortality patterns

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- Changes in smoking incidence.
- ... but this cannot be the whole explanation.

# Cohort survival curves for life-long non-smokers

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Source: Doll et al (2004).



# Possible causes of cohort mortality patterns

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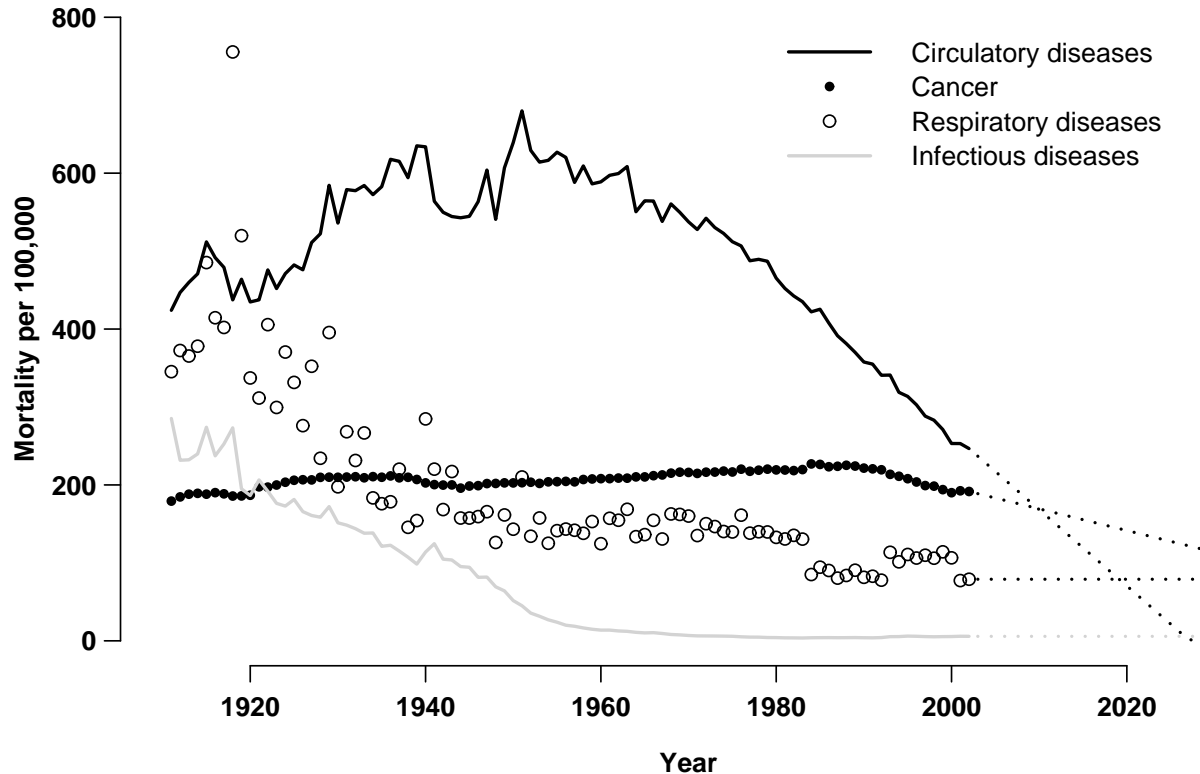
# Possible causes of cohort mortality patterns

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- Changes in smoking incidence.
- Early-life exposure to pathogens.

# Mortality rates by broad cause of death

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Source: Own calculations using ONS data.

# Direction of future mortality improvements

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- Circumstantial evidence suggests improvements are *accelerating*.

# Direction of future mortality improvements

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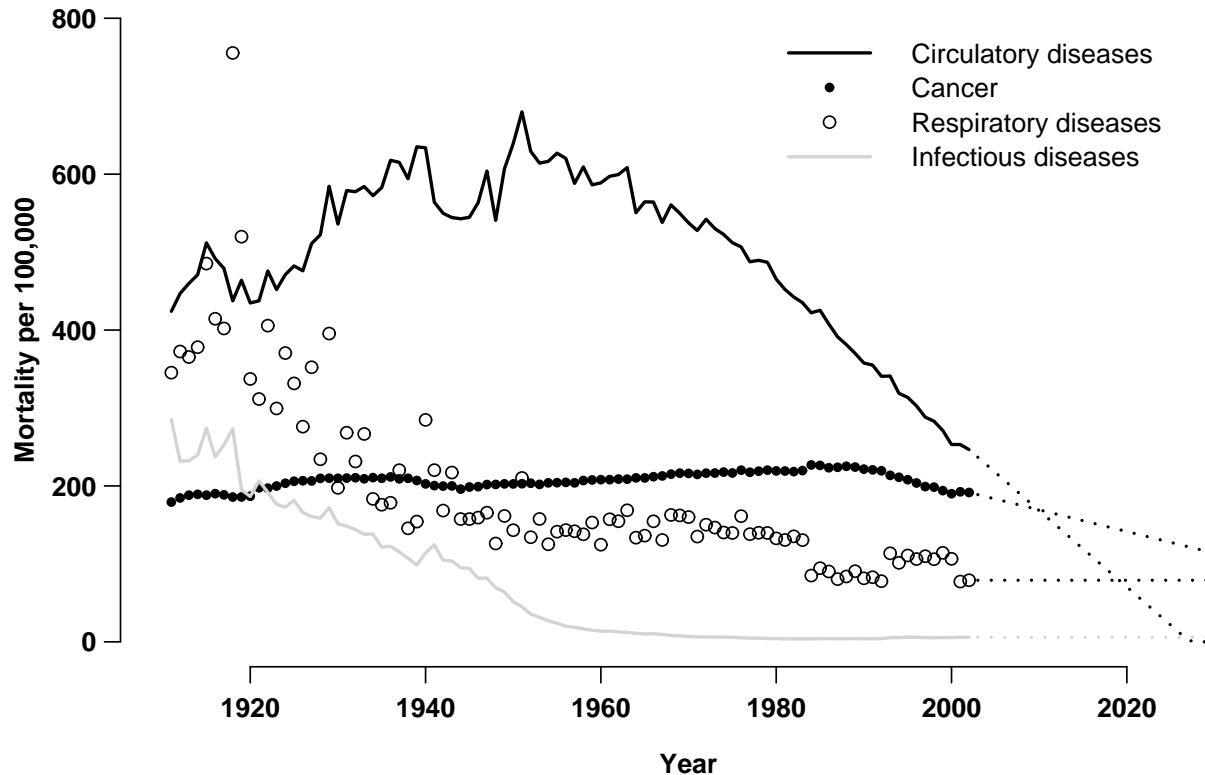
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# Direction of future mortality improvements

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- Circumstantial evidence suggests improvements are *accelerating*.
- Look again the pattern of mortality rates over the past century...
- ...and consider the implications of circulatory-disease mortality continuing its linear downward trend...

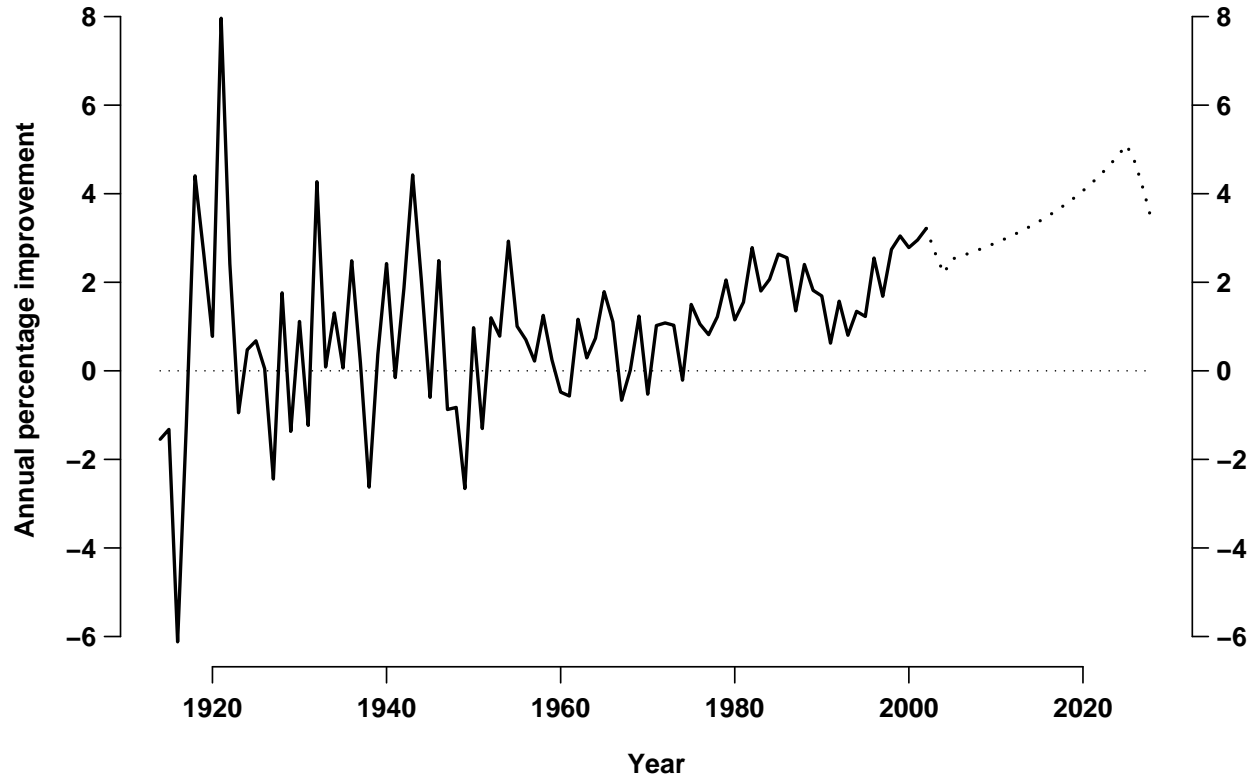
# Mortality rates by broad cause of death



Source: Own calculations using ONS data.

# Smoothed annual mortality improvement

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Source: Five-year moving average. Own calculations using ONS data.



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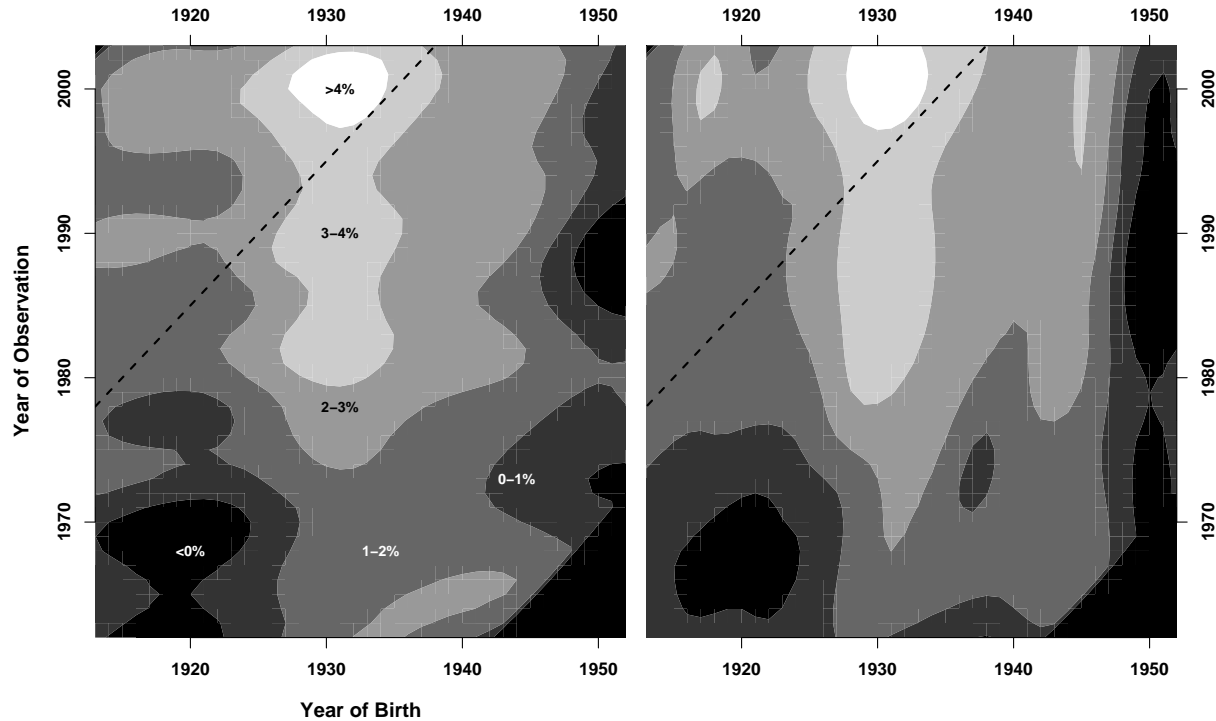
# Direction of future mortality improvements

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- For specific application to two-dimensional mortality data, see Durban, Currie and Eilers (2002).
- For application to mortality projections, see Currie, Durban and Eilers (2003) and CMIB (2005).

# Mortality improvements

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Source: Richards, Kirkby and Currie (2005). Male mortality improvements after smoothing mortality rates in two dimensions using penalised splines.

# Summary and questions

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- Mortality improvements vary by year of birth.
- They are driven by something more than just changes in smoking.
- The pace of mortality improvement appears to be accelerating.
- If so, then reserves for annuities and pensions are understated.
- Cohort effects would also appear to exist outside the U.K.

# References

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- CMIB (CONTINUOUS MORTALITY INVESTIGATION BUREAU) **2005** *Towards a stochastic methodology for mortality projection*, Working Paper 15
- CURRIE, I. D., DURBAN, M. AND EILERS, P. **2003** *Using P-splines to extrapolate two-dimensional Poisson data*, Proceedings of 18th International Workshop on Statistical Modelling, Leuven, Belgium, 97-102
- DOLL, R., PETO, R., BOREHAM, J. AND SUTHERLAND, I. **2004** *Mortality in relation to smoking: 50 years' observations on male British doctors*, BMJ 2004;328
- DURBAN, M., CURRIE, I. D. AND EILERS, P. **2002** *Using P-splines to smooth two-dimensional Poisson data*, Proceedings of 17th International Workshop on Statistical Modelling, Chania, Crete, 207-214
- EILERS, P. H. C. AND MARX, B. D. **1996** *Flexible smoothing with B-splines and penalties*, Statist. Sci. 11, 89-121.
- FOREY, B. A., LEE, P. N. AND FRY, J. S. **1993** *Updating UK estimates of age-, sex- and period-specific cumulative constant tar cigarette*

*consumption per adult, Thorax, 53, 875-878*

LEE, P. N., FRY, J. S. AND FOREY, B. A. **1990** *Trends in lung cancer, chronic obstructive lung disease, and emphysema death rates for England and Wales 1941-85 and their relation to trends in cigarette smoking, Thorax, 45, 657-665*

RICHARDS, S. J. AND JONES, G. L. **2004** *Financial aspects of longevity risk, SIAS*

RICHARDS, S. J., KIRKBY, J. G. AND CURRIE, I. D. **2005** *The Importance of Year of Birth in Two-Dimensional Mortality Data, Submitted*

WILLETS, R. C. **1999** *Mortality in the next Millennium, SIAS*

WILLETS, R. C. **2004** *The cohort effect—insights and explanations, British Actuarial Journal, Vol. 10, Part IV, No. 48*