The Actuarial Profession
making financial sense of the future

Pensions conference 2010 – Workshop session A
Daniel Ryan

How long are we going to live?

Insights on the past and future

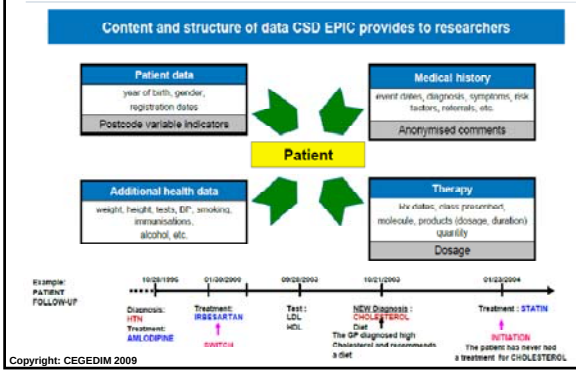
Breadth of current longevity models

- Extrapolative
  - analysis of historical all-cause mortality experience
  - project past trends on deterministic/stochastic models
  - no explicit constraints placed on model
- Targeting
  - expert opinion or historical trends
- Explanatory
  - cause-specific mortality
  - disease diagnosis, interaction and subsequent death

Fundamental importance of time

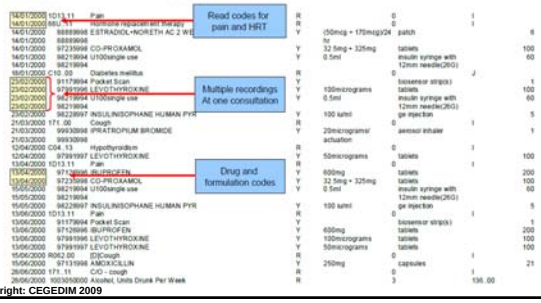
- Extrapolative models allow the user to overlook significance of different time periods
- Clear horizons that separate informed opinion from guesswork
- Short to medium term (c. 10 years)
  - predictive scenarios based on clinical guidelines, current treatments & experience in other countries
- Long term
  - historical analysis (adjusted OR unadjusted)
  - impact of changes over short to medium term
  - amenable mortality
  - future advances for particular diseases

The Health Improvement Network data



THIN extract from specimen medical record

- All consultation events are recorded by Doctor in Vision system using Read codes (standardised clinical terms) and drug codes from Multilex and BNF coding systems
- Below is extraction from medical history of chronological events for a 65 year old female with diagnosis of Diabetes and Hypothyrodism



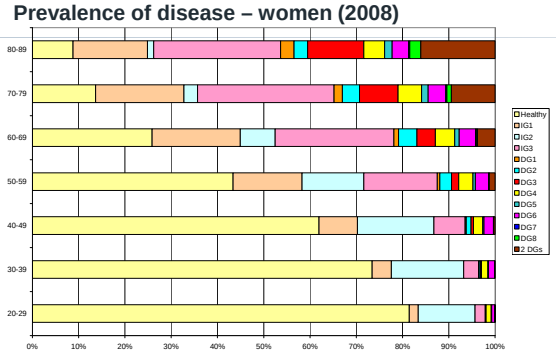
Disease-based mortality models

- Extension of impaired life annuity concept
- Multi-state model of all-cause mortality
- Remote access or dataset from General Practice Research Database (“GPRD”) or The Health Improvement Network (“THIN”)
  - identify new disease from “healthy” population
  - track development of subsequent disease
  - track deaths from individuals with prior history of disease
- Two potential approaches to derive future mortality

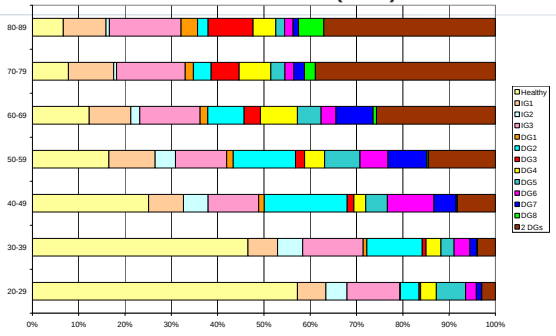
Framework of TW_DBMMv2.x(y)

Disease Groups	Diseases considered
Minor Group 1 (IG1)	atherosclerosis, cardiac arrhythmias, cardiomyopathy, diabetes, hypercholesterolaemia, hypertension, transient ischaemic attacks, valvular disease
Minor Group 2 (IG2)	benign neoplasms, malignant skin cancers other than malignant melanoma
Minor Group 3 (IG3)	epilepsy, motor neurone disease, MRSA, multiple sclerosis, osteoporosis, osteoarthritis, rheumatoid arthritis
Principal Group 1 (DG1)	stroke
Principal Group 2 (DG2)	cancers of breast, cervix, larynx, prostate and uterus, plus malignant melanoma
Principal Group 3 (DG3)	aneurysms, ischaemic heart disease, heart failure
Principal Group 4 (DG4)	chronic obstructive pulmonary disease, pneumonia and tuberculosis
Principal Group 5 (DG5)	cancers of colon, ovary, rectum and urinary system, plus oral cancers, leukaemias and lymphomas
Principal Group 6 (DG6)	Crohn's disease, gastric and duodenal ulcers, clostridium difficile infection, ulcerative colitis, and kidney and liver disease
Principal Group 7 (DG7)	cancers of brain, lung, oesophagus, pancreas and stomach, and multiple myeloma

Disease-based mortality model
Prevalence of disease – women (2008)



Disease-based mortality model
Distribution of deaths – women (2008)



Holistic view of future longevity

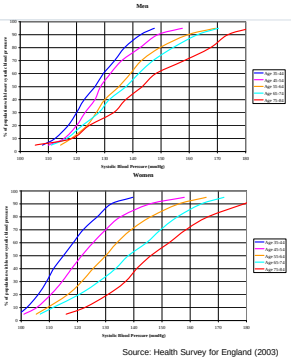
- Longevity projectionists – Vaupel/Bongaarts
  - projection of trends without deconstruction
  - no imminent sign of limit to life expectancy
  - future medical advances expected to be as significant as historical advances
- Longevity realists/pessimists – Olshansky
  - question lack of explanation from projectionists
  - stress ageing process as separate from disease
  - no current treatments for ageing process
- Recent convergence on potential scenarios of increases in life expectancy of 7 years by 2050

Predictive scenario on impact of treatment

- National Institute for Clinical Excellence (NICE)
  - Technical Appraisals
  - Clinical Guidance
- TA 176 – cetuximab for combination first-line treatment of KRAS metastatic colorectal cancer by blocking EGFR
  - metastases restricted to liver and unresectable but primary tumour resectable and patient fit enough for surgery
- Target population: 1,402
- Cost per QALY: £30,000
- Total annual cost: £18.8 million
- Average increase in “healthy” life expectancy: 5.3 months

Predictive scenario based on clinical guidelines

- Systolic blood pressure target guidelines:
- Quality Outcome Framework
  - 150mmHg
- Joint British Societies 2
  - 130mmHg
- AHA Strategic Impact Goal through 2020
  - 120mmHg
- Promotion of combination therapy (CG 34)



Source: Health Survey for England (2003)

Fundamental importance of time

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- **Long term**
  - **historical analysis (adjusted OR unadjusted)**
  - **impact of changes over short to medium term**
  - **amendable mortality**
  - **future advances for particular diseases**

Long-term mortality improvements in CMI Mortality Projection Tool & ONS 2008 projections

- International historical analysis
- Mortality improvement differentials
  - CMI Permanent Assured Lives and CMI Pensioners in UK
- Development of expert opinion for different assumptions in census analyses.
- Relevance of cohort mindset of ONS when developing mortality improvements led to cohort features despite experts' comments.

Origins and uses for amendable mortality

- Deaths occurring before age 75 in diseases regarded as amenable.
- Would include breast cancer, colo-rectal cancer, leukaemia, ulcers and hypertensive diseases
- Key work in recent decades by Nolte & McKee
  - "Measuring the health of nations"
- 43% and 38% reduction in amendable causes of death for men and women respectively over period 1993 to 2005.

Cumulative improvements to mortality predicted over 2008-2020 for ages 70-74

Disease Groups	Male lives	Female lives
Healthy	13.1%	13.1%
Minor Group 1 (IG1)	14.5%	15.3%
Minor Group 2 (IG2)	-3.1%	11.2%
Minor Group 3 (IG3)	12.2%	12.2%
Principal Group 1 (DG1)	16.9%	16.7%
Principal Group 2 (DG2)	30.8%	32.7%
Principal Group 3 (DG3)	18.7%	18.9%
Principal Group 4 (DG4)	9.7%	8.0%
Principal Group 5 (DG5)	23.3%	24.4%
Principal Group 6 (DG6)	12.7%	12.8%
Principal Group 7 (DG7)	12.0%	9.7%
Principal Group 8 (DG8)	12.2%	16.8%
All lives	21.3%	19.5%

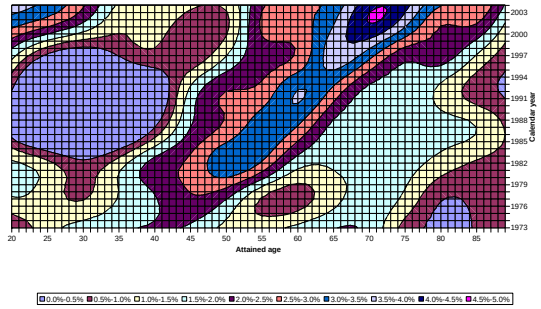
Long-term trends in non-smoker mortality
Data sources

- UK Doctor's Study & American Cancer Society – Cancer Prevention Study (2)
  - Excess mortality of smokers over never smokers
  - Reduction in excess mortality for ex-smokers
- General Household Survey
  - Annual survey covering smoking & other behaviours
  - Published data for proportions of smokers, non-smokers and ex-smokers for relatively wide age groups
  - Time Series Dataset includes 800,000 interviews over the period 1972 to 2004
- ONS mortality experience
  - Deaths and population exposure by sex and individual age from 1971 up to age 89

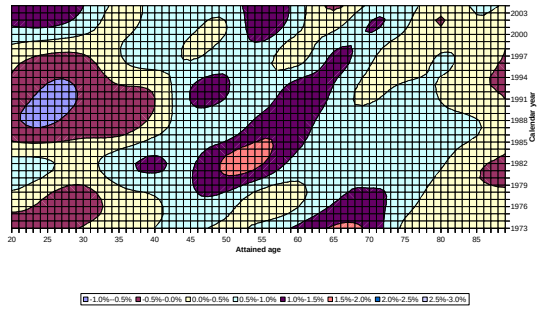
Long-term trends in non-smoker mortality
Model structure

- Population transition model using annual steps designed to derive non-smoker mortality rates from aggregate mortality rates
- Model tracks population exposures from age 20 for smokers, never smokers, former smokers by individual year since cessation up to 15 years & former smokers of 15+ years since cessation
- Resetting to annual population estimates with similar distribution for migrants and residents
- General Household Survey used to set starting distribution and then to validate model outputs
- EXCEL Solver applied to smoker cessation rates

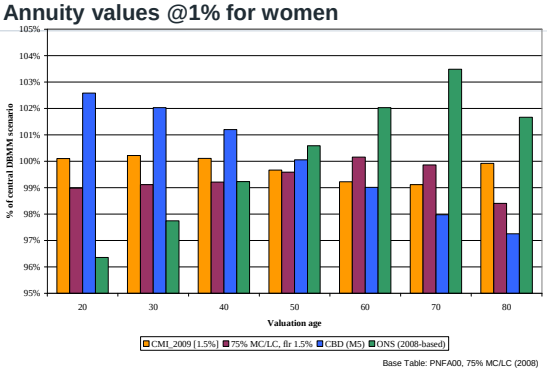
Contribution of changes in smoking prevalence
Male aggregate mortality improvements



Contribution of changes in smoking prevalence
Effect of changes in smoking prevalence (men)

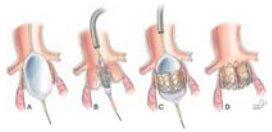


Comparisons of future assumptions
Annuity values @1% for women



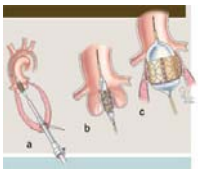
Base Table: PNFA00, 75% MC/LC (2008)

Future advances in treating circulatory disease – aortic valve replacement



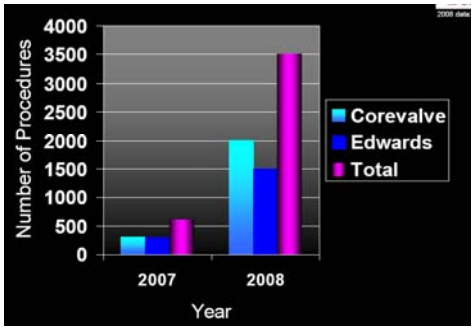
Trans-aortic

Trans-apical

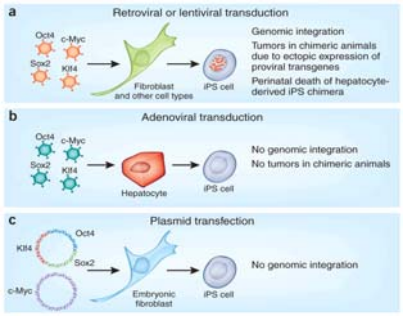


Patients with symptomatic aortic stenosis who have high risk for operative mortality or are “non-operable”

Future advances in treating circulatory disease – aortic valve replacement

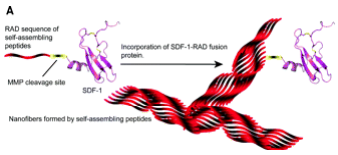


Future advances in treating circulatory disease – Induced pluripotent stem cells



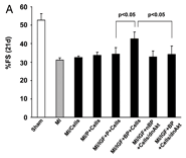
Stem cells derived from adult tissues such as skin fibroblasts

Future advances in treating circulatory disease – self-assembling nanofibres



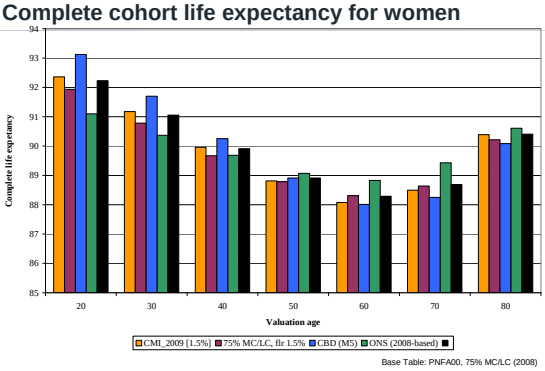
Segers / Lee
Circulation 2007

Improved function after MI



Davis / Lee PNAS 2006

Comparisons of future assumptions
Complete cohort life expectancy for women



Base Table: PNFA00, 75% MC/LC (2008)