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Critical illness insurance rates: are they changing over time and how?

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Work with
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SOCIETY OF ACTUARIES

Canadian Institute of Actuaries | Institut canadien des actuaires

www.actuaries.org.uk/arc

Modelling, Measurement and Management of Longevity and Morbidity Risk

- Major research programme funded by the Actuarial Research Centre of the Institute and Faculty of Actuaries running from 2016 to 2020

- Significant supporting funding from the Society of Actuaries and the Canadian Institute of Actuaries

- Themes
  - Development of new single and multi-population models for mortality and new sub-population mortality datasets
  - Drivers of mortality and cause of death analysis
  - Longevity risk management
  - **Stochastic models for critical illness insurance**

Outline

- Critical illness insurance
- Data
- Stochastic modelling
  - Delay time distribution (diagnosis to settlement)
  - Claim rates
- Claim rates comparison
  - Smoothed rates: 1999-2005 v 2007-2010
- Pricing rates

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Critical illness insurance

Critical illness: Policy description

- Fixed term policy, usually ceasing at age 65
- A fixed sum insured payable on the diagnosis of one of a specified list of critical illnesses
- Covers: Cancer; *Death*; Heart attack; Stroke; Multiple Sclerosis; Total & permanent disability; Coronary artery bypass graft; Kidney failure; Major organ transplant etc.
- Policies are often sold together with term or endowment insurance
- Benefit type: Full Accelerated (FA) or Stand Alone (SA)

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Data

Provided by the CMI Assurances Committee

Data

CII data supplied by CMI:

- 1999-2005
  - Details of policies inforce at the start and end of each year
  - 19,127 claims settled
- 2007- 2010
  - Grouped by various risk factors
  - 20,487 claims settled

Data:

- Claims
- Exposures
- Risk factors:

Risk factor (covariate)	1999 – 2005	2007 – 2010
Age (last birthday)	√	√
Gender	√	√
Smoker	√	√
Policy duration	√	√
Office	√	
Distribution channel	√	√
Benefit type (accelerated, standalone)	√	√
Benefit amount	√	√
Policy type (single, joint)	√	
Settlement year	√	√
Cause	√	
Product category		√
Date of diagnosis	√	

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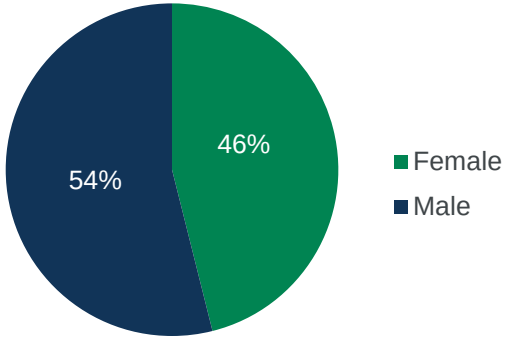
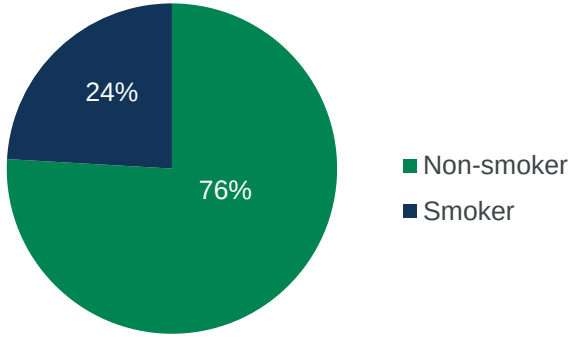
Data: 2007 - 2010

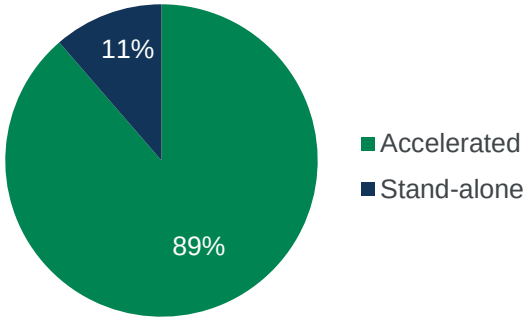
Gender



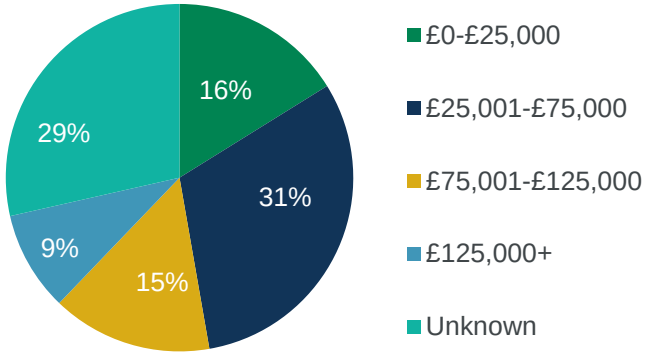
Smoker Status



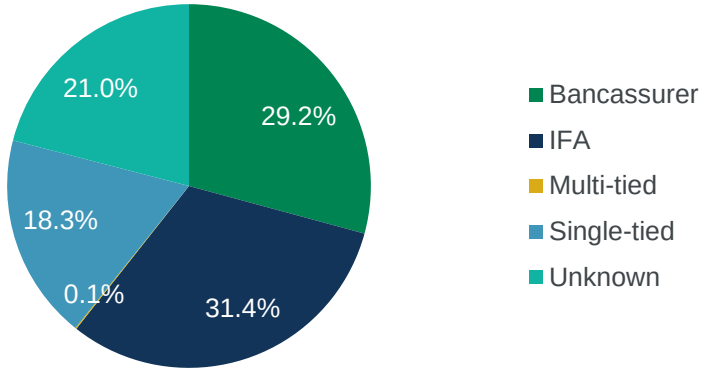
Benefit Type



Sum Assured



Distribution Channel



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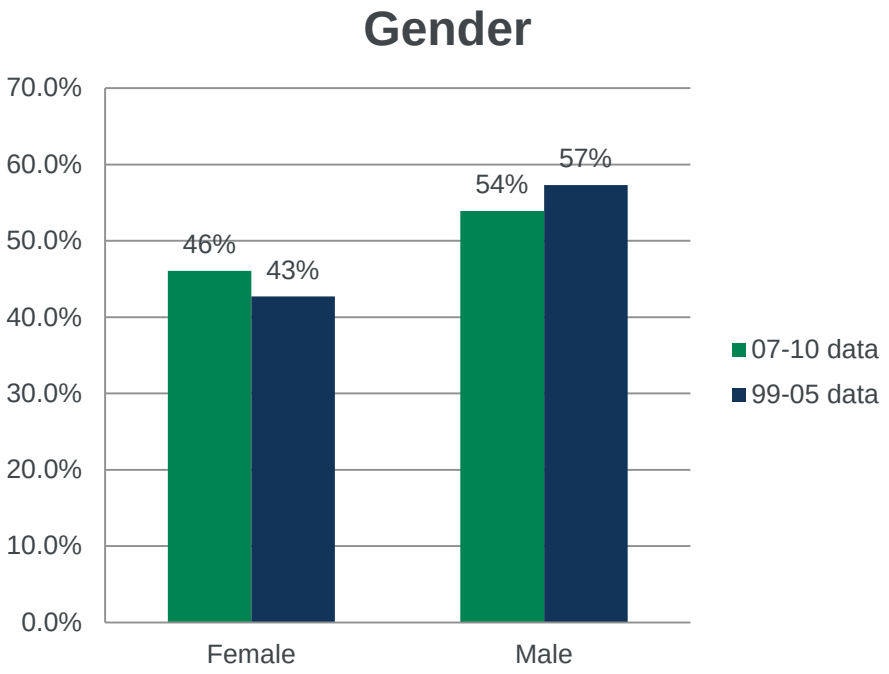
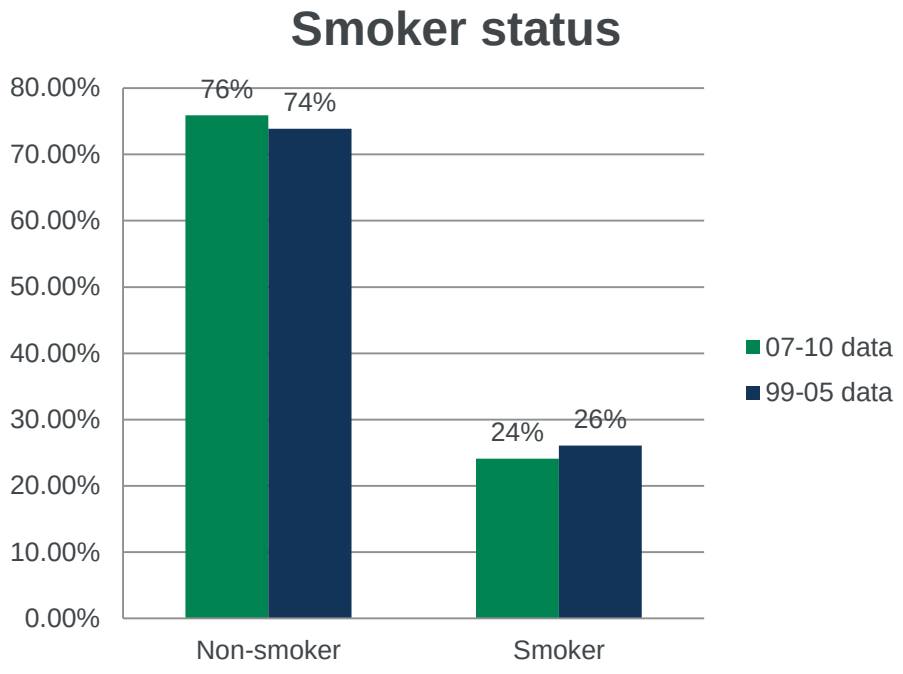
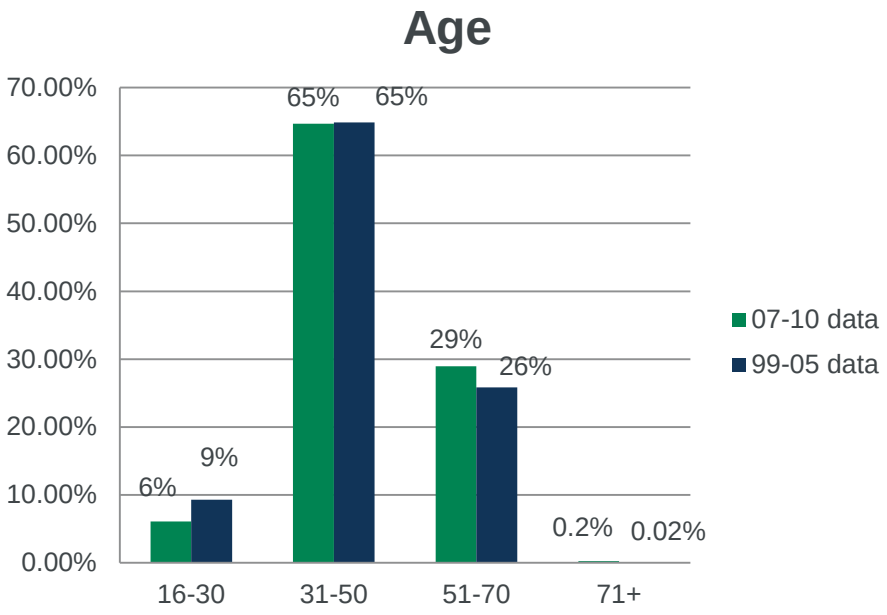
Data: 2007 – 2010 v 1999 – 2005

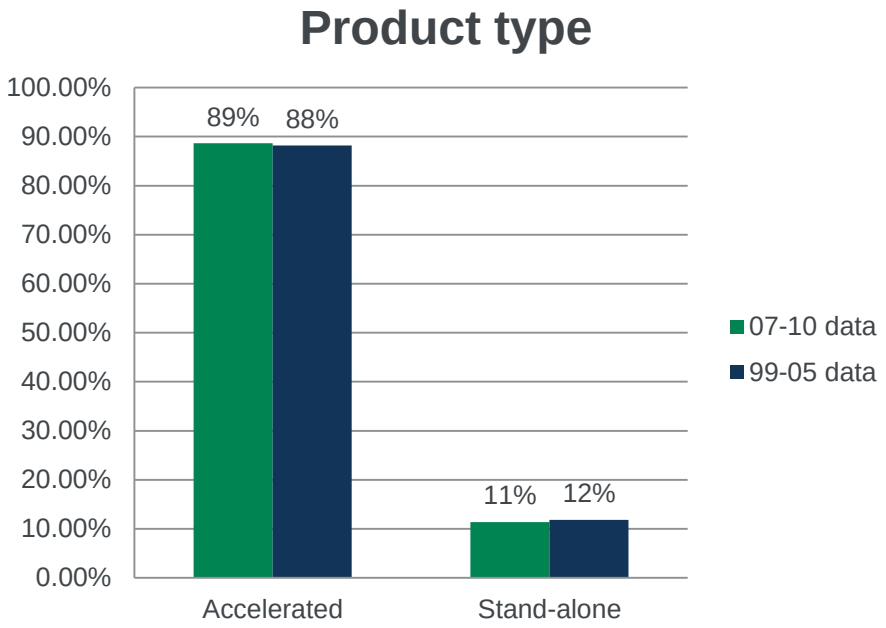




- Distributions very similar between 2007 – 2010 & 1999 – 2005
- Slightly higher proportion of **F** and **NS** in 2007 – 2010

Data: 2007 – 2010 v 1999 – 2005





- Lower proportion of **age 16-30** in 2007 – 2010
- Stand-alone only ~ 11% of claims data

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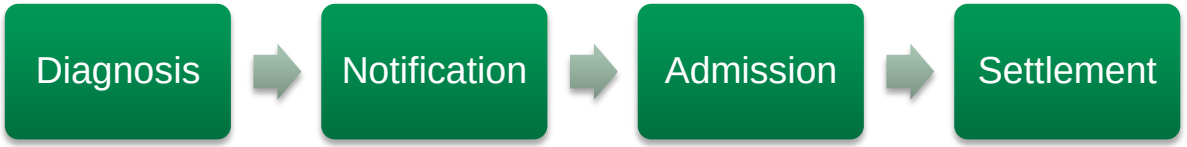
Modelling

Mostly Bayesian stochastic

Stochastic modelling

- Estimation & smoothing of CI diagnosis rates
  - how do these depend on **risk factors?**
- Diagnosis is the **insured event and there is a delay between diagnosis** and **settlement**



- The **exposure corresponds to claims settled, not to claims diagnosed**
- **This can lead to biased rate estimates;** need to adjust it
- Also take into account uncertainty

Stochastic modelling
Delay time distribution (1999-2005)

- Diagnosis date not always recorded or available
  - 18% diagnosis dates missing
- Observed data: mean delay 185 days; sd 263 days
- Fit a delay distribution (GB2 in Bayesian GLM-type setting):
  - *F*(*d*; *x*, *z*) = *Pr*(claim diagnosed age *x*, risk factors *z*, will be settled in *d* days)

$D_i \sim \text{Generalised Beta2}(\alpha, \tau, \gamma, s_i)$

$$f_D(d_i) = \frac{\Gamma(\alpha+\gamma)}{\Gamma(\alpha)\Gamma(\gamma)} \frac{\tau (d_i/s_i)^{\tau\gamma}}{d_i\,[1+(d_i/s_i)^{\tau}]^{\alpha+\gamma}}$$

$$E(D_i) = \exp(\eta_i) = \exp\left(\beta_0 + \sum_{j=1}^{8} \beta_j z_{ij} + \beta_{9,k} + \beta_{10,l}\right)$$

with s_i given as function of $\eta_i, \alpha, \tau, \gamma$.

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Stochastic modelling
Delay time distribution (1999-2005)

- Most factors significant:
  - Policy duration, amount, death: **shorter delay**
  - Single life, stroke, multiple sclerosis: **longer delay**
- Non-recorded **diagnosis dates estimated through delay distribution *F*()**
- Data (exposures) adjusted to allow for non-settled claims

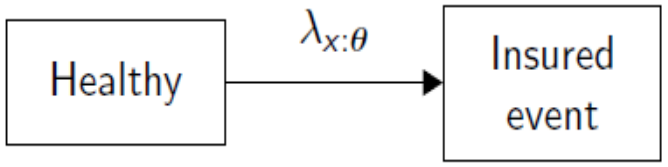
$$E^*(u; x) = E(u; x) \times F(t\text{-}u; x)$$

Stochastic modelling
Delay time distribution (2007 – 2010)

- Diagnosis date **not available**
- Assume similar delay distribution
- Match claims with common characteristics (age, policy duration etc)
- Adjust exposures as in earlier data

Stochastic modelling: Claim rates

Model:



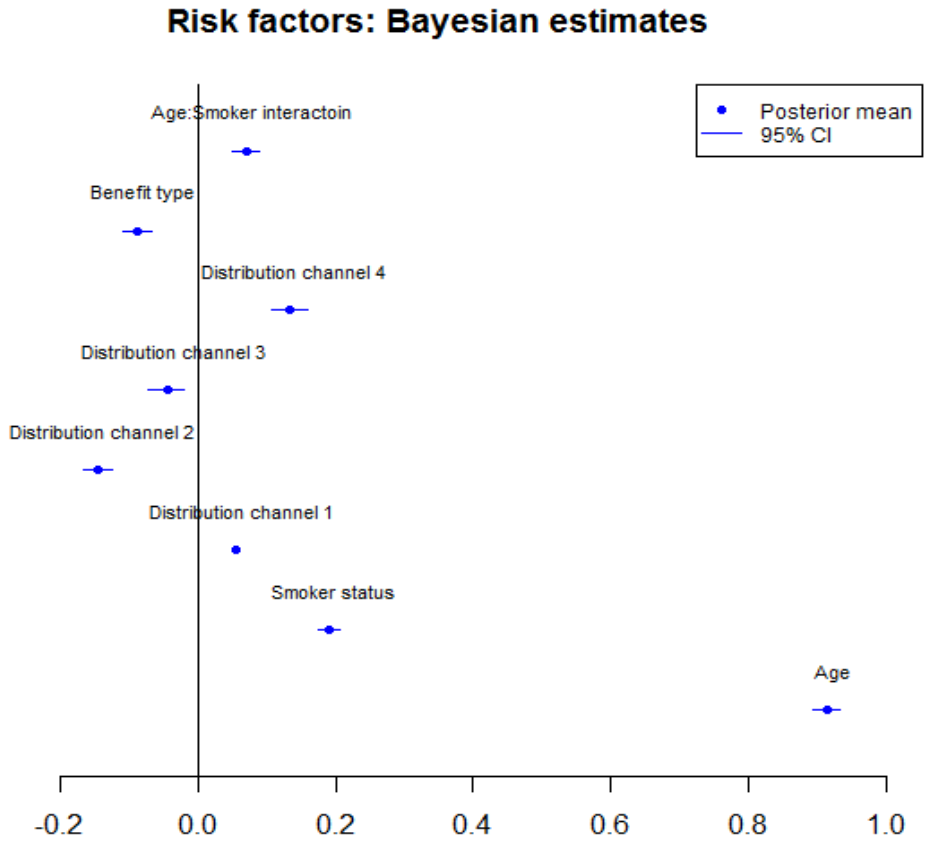
Fit Bayesian model:

Adjusted exposure

$$N^{(j)}(x;\theta) \sim \text{Poisson}\left(\lambda^{(j)}_{x;\theta} \int_{u=0}^{4} E(u:x;\theta)\, F^{(j)}(4-u:x;\theta)\, du\right)$$

- $\lambda^{(j)}_{x,\theta}$: **diagnosis (claim) rate** for cause *j* at age *x* with risk factors θ

Stochastic modelling:
Risk factor estimates for claim rates (2007 – 2010)



Perform variable (factor) selection

Selected model includes:

- ✓ age (older ↑)
- ✓ smoker status (S ↑)
- ✓ distribution channel
- ✓ benefit type (stand-alone ↓)
- ✓ age x smoker

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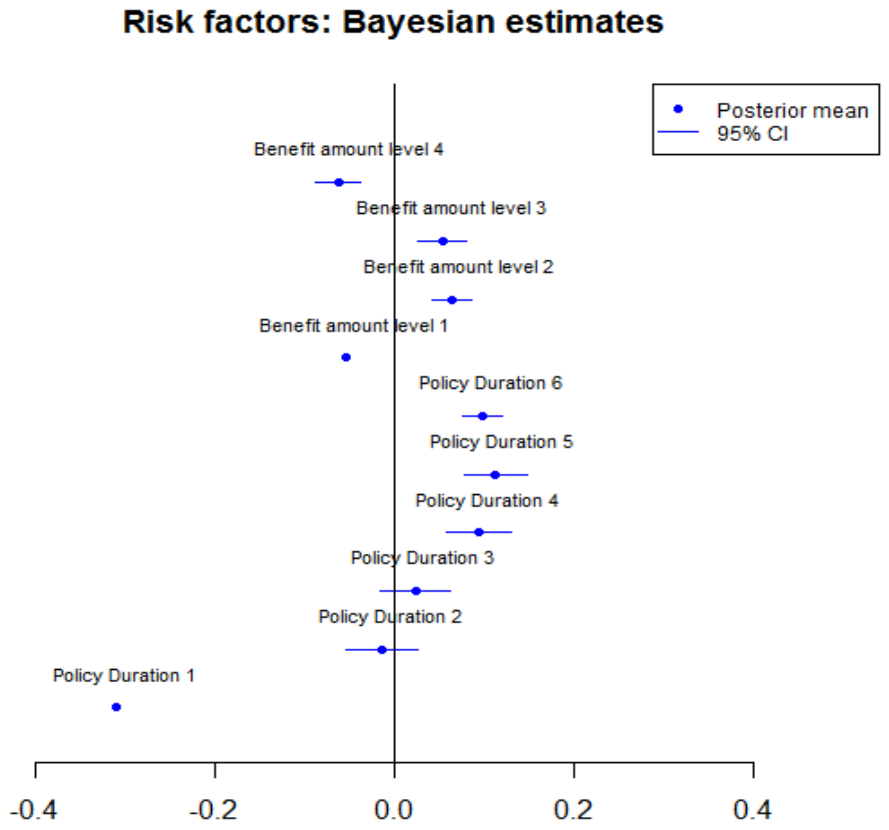
Stochastic modelling:
Risk factor estimates for claim rates (2007 – 2010) cont.



Selected model includes:

- ✓ policy duration (longer ↑)
- ✓ benefit amount (mid ↑)

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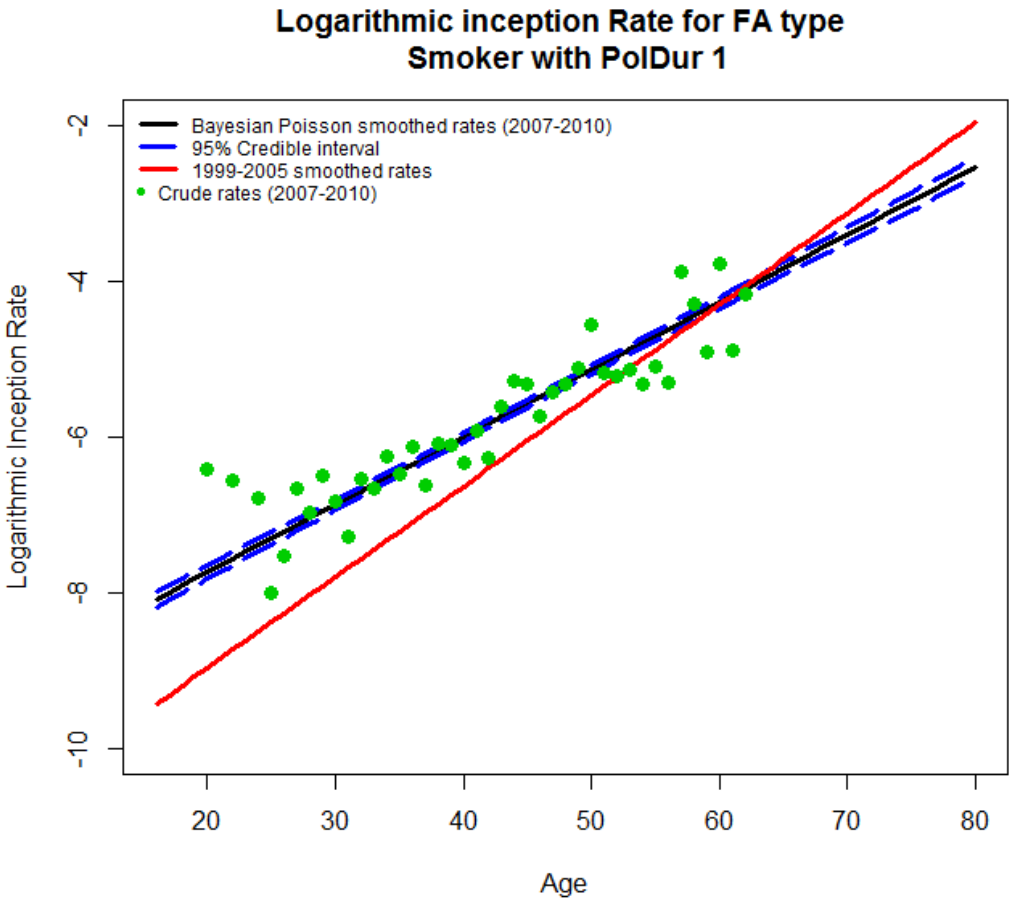
Claim rates

Smoothed estimates, intervals

Claim rates

2007-2010 v 1999 – 2005, Accelerated, Smoker, Pol Duration 1



- Model fits crude rates (2007 – 2010) well
- 2007 – 2010 rates significantly higher
- Gap widens at younger ages

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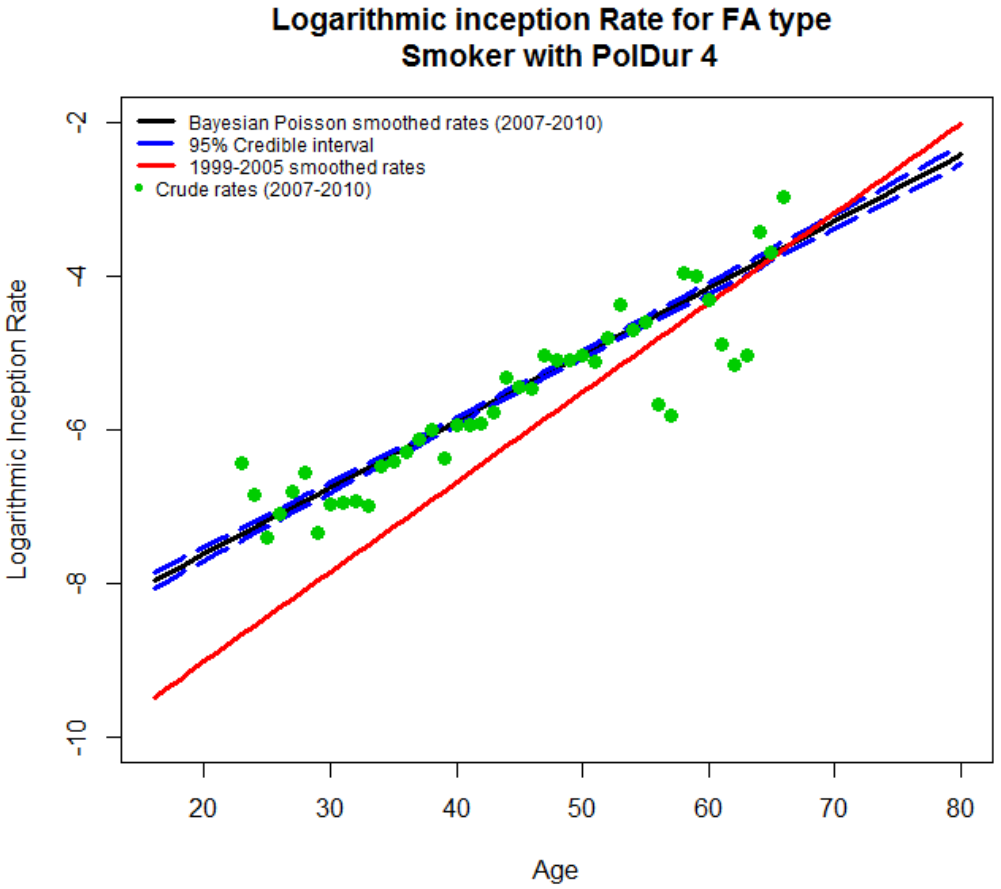
Claim rates

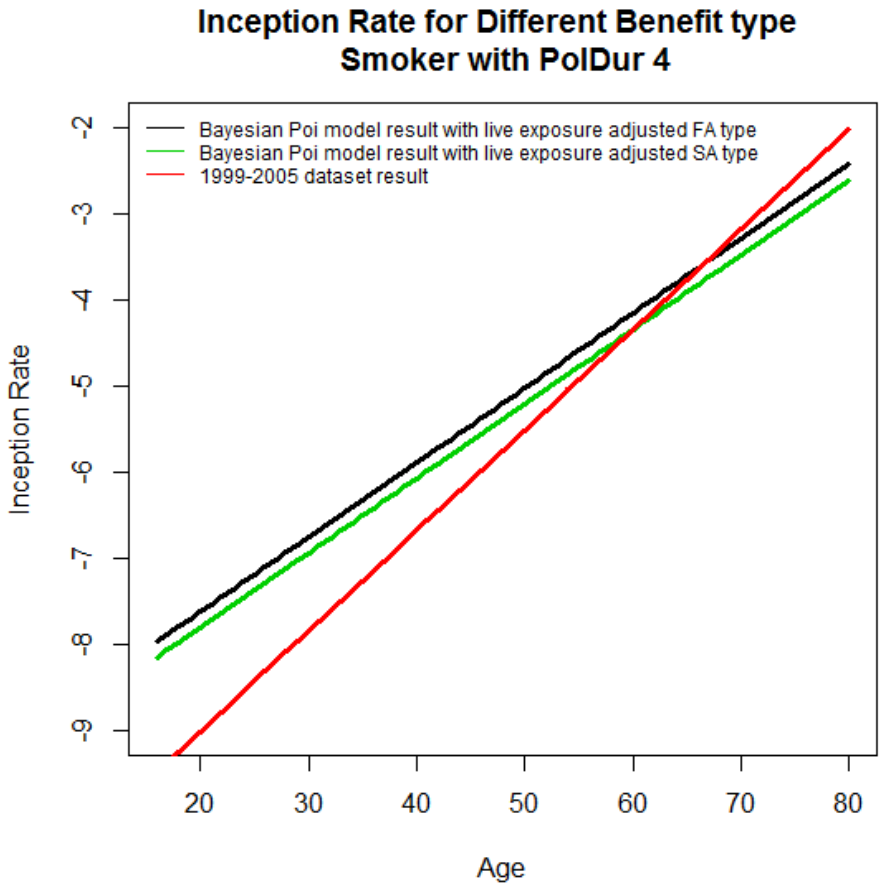
2007-2010 v 1999 – 2005, Accelerated, Smoker, *Pol Duration 4*



- Again, 2007 – 2010 rates significantly higher
- Rates higher than for Pol Duration 1

Claim rates

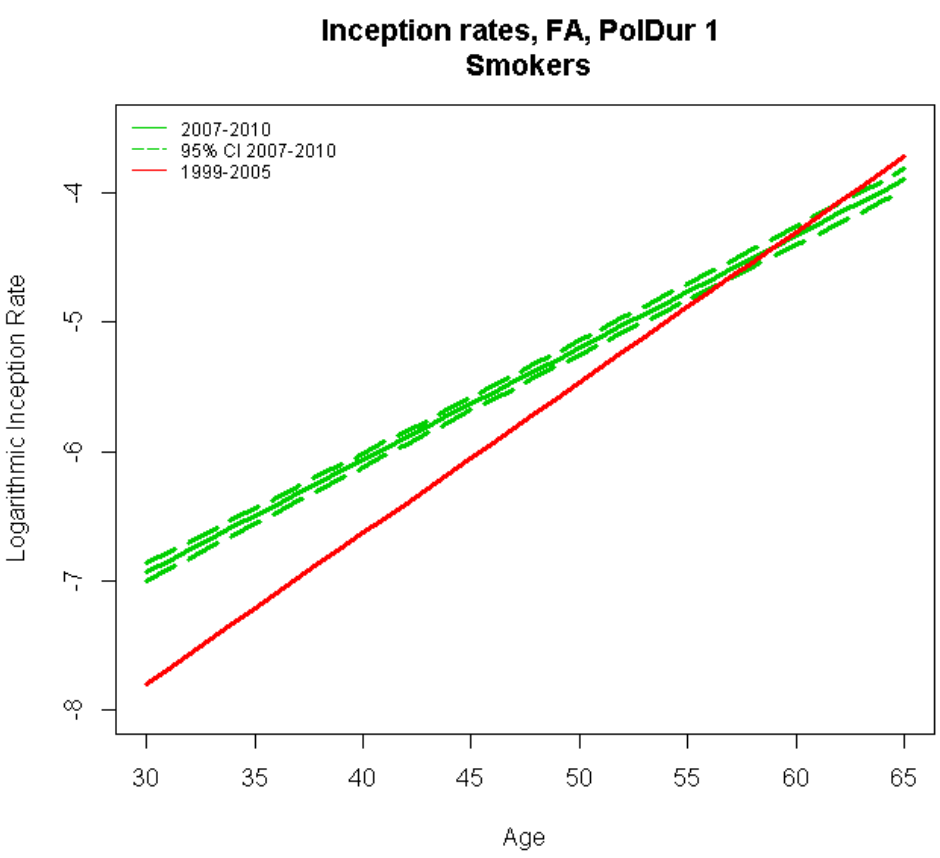
Accelerated v Stand alone (2007 – 2010) & 1999 – 2005

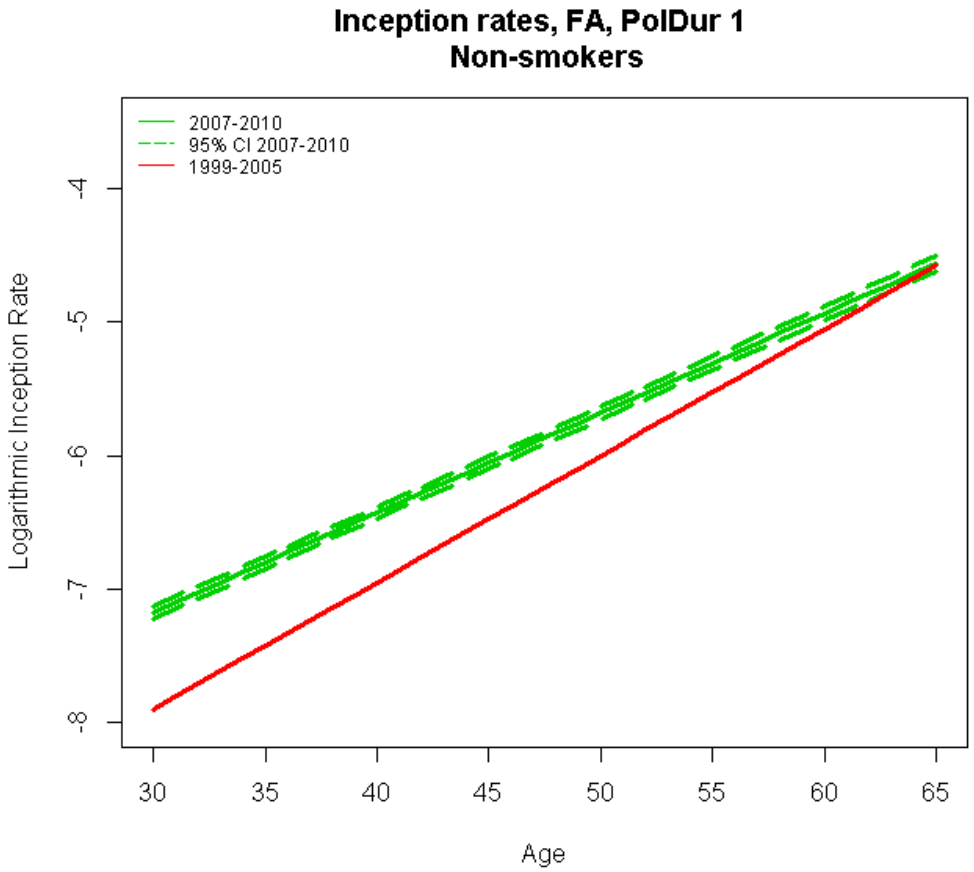


- Accelerated 2007 -2010 (black) higher than stand-alone (green)
- Both significantly higher than 1999 – 2005

Claim rates

Smokers & non-smokers (Accelerated, Pol Duration 1)

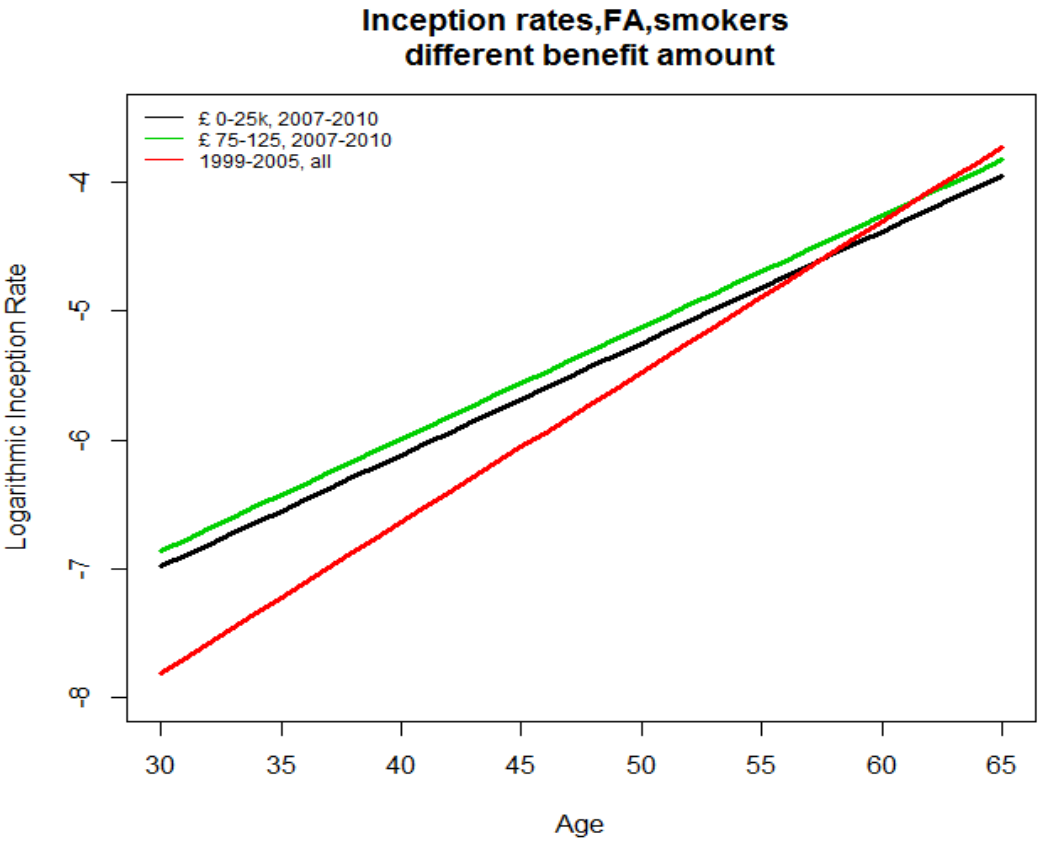




- 2007 – 2010 rates significantly higher, both S & NS

Claim rates

Different benefit amount (Accelerated, Smokers)



- 2007 – 2010 rates significantly higher, also for different amount

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Pricing

Pricing

Annual premium, paid at constant rate, n-year term:

$$\text{Net Premium} = \text{Benefit Amount} \times \frac{\int_{t=0}^{n} v^t \, {}_tp_x \, \lambda_{x+t} \, dt}{\int_{t=0}^{n} v^t \, {}_tp_x \, dt}$$

where

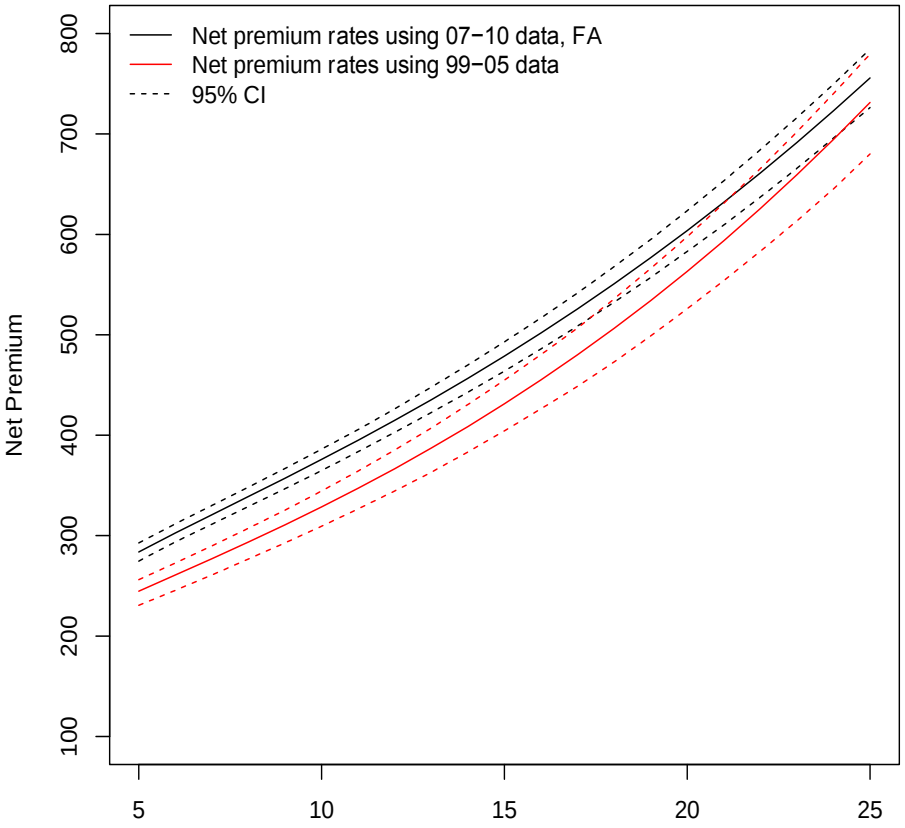
$${}_tp_x = \exp\left(-\int_{s=0}^{t} \lambda_{x+t} \, dt\right) \text{ and}$$

v is the discount factor.

Then bootstrap distribution of λs used to derive CIs for premiums.

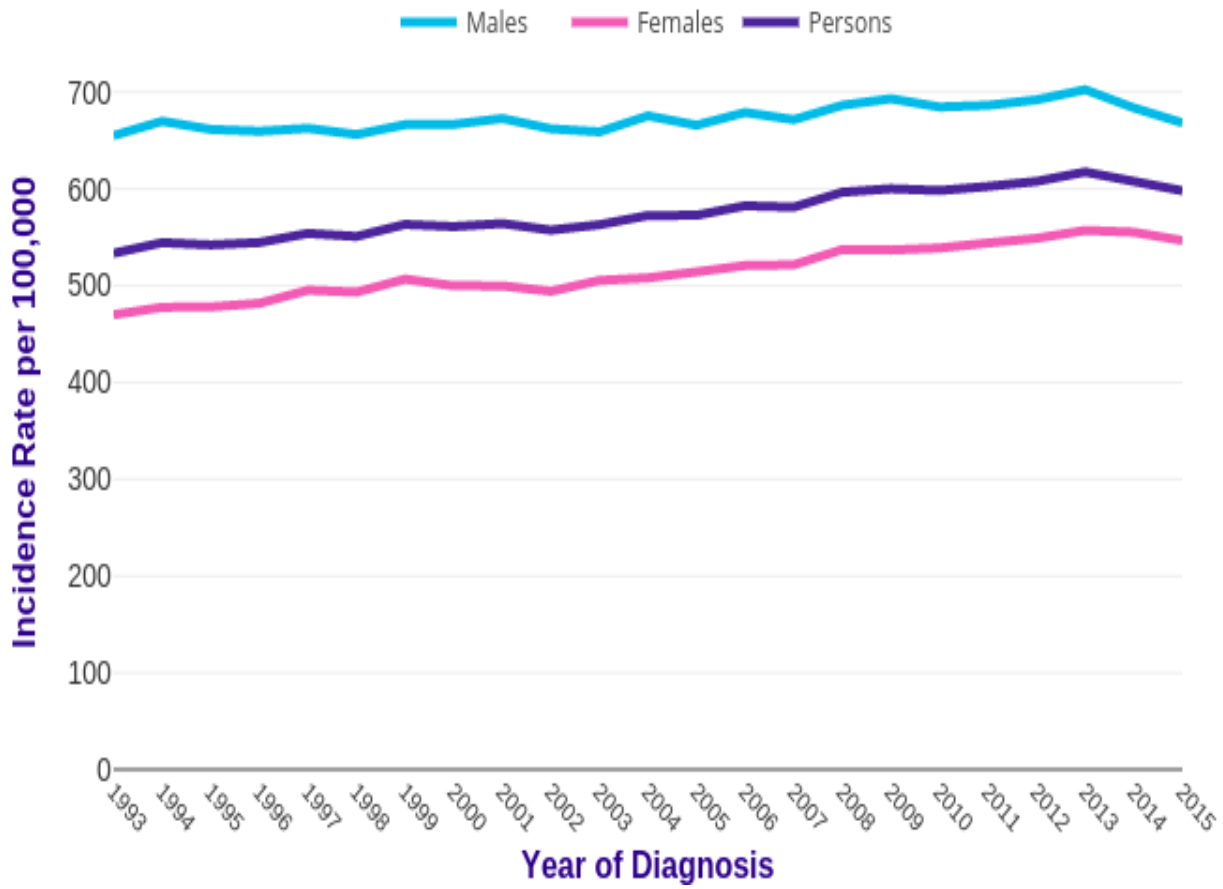
Pricing

All causes, Smoker, Age 40, Policy duration 0, Benefit amount £100k, i=3%



- Since 2007 – 2010 FA rates are higher than 1999-2005 combined rates, the net premium rates are also higher.

All Cancers Excluding Non-melanoma Skin Cancer (UK)



Source: cruk.org/cancerstats

In 1999-2005 dataset

- 49% of the claims were caused by cancer
- Death 17.6%
  Heart attack 11.6%
  CABG 2.1%

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Future trends of CII claims

- Cancer forms almost half of the CII claims.
  - Availability of screening (e.g colonoscopy, mammography)
  - Social/behavioural changes (e.g. obesity, alcohol consumption)
  - New treatments (e.g. targeted immunotherapy)
  - Statistical advances (e.g. use of big data, AI methods)

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Conclusions

Conclusions

- CII claimants distribution similar between 1999-2005 & 2007-2010

  (but not necessarily true for insured population)

- Time between diagnosis and settlement of a claim is important
- Claim rates (2007-2010) depend on a number of risk factors including:
  - age, smoker status, distribution channel, policy duration, benefit amount and benefit type
- Analysis suggests increase of CII claim and premium rates over time (1999-2005 v 2007-2010)
  - especially at younger ages

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Continuing work

- Fit more sophisticated Bayesian model to allow for more variation in rates (e.g. hierarchical, negative binomial)
- Use of population morbidity statistics
- Liaise with CMI for knowledge exchange on data, modelling
- Compare with CMI rates

Questions

Comments

The views expressed in this presentation are those of the presenter.

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Stochastic modelling: Delay time distribution

1999 – 2005 (cont.)

- Generalised Beta 2 distribution in Bayesian GLM-type setting

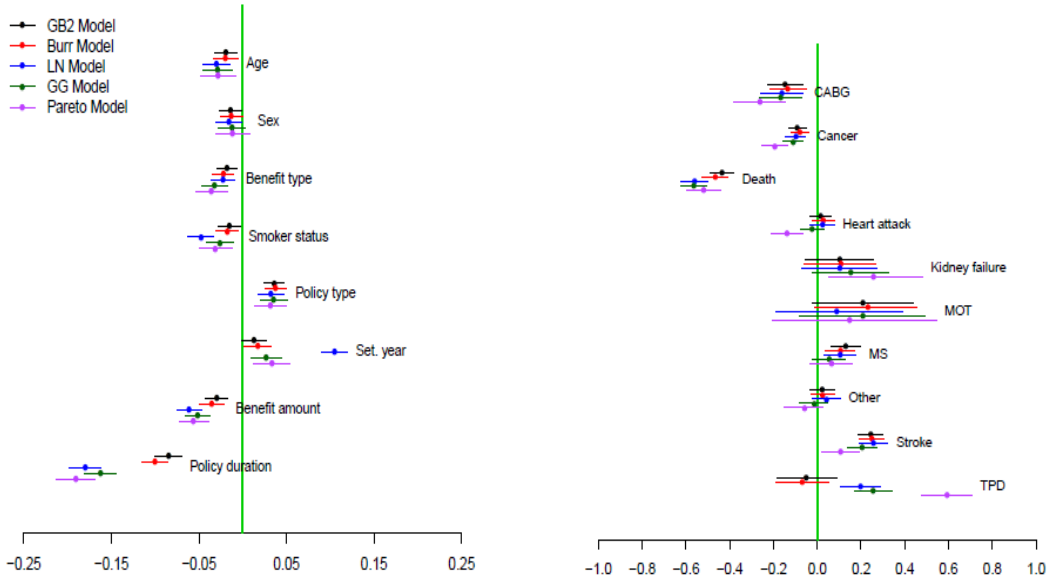

Figure: Posterior means (dots) and 95% credible intervals (bars) of β's.

Most factors significant:

- Policy duration, amount, death, CABG: **shorter** delay
- Single life, stroke, mult sclerosis: **longer** delay