Actuarial Research Centre
Institute and Faculty of Actuaries

HERIOT WATT UNIVERSITY

UNIVERSITY OF Southampton

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

Dr George Streftaris & Dr Erengul Dodd

Work with
Chunxiao Xie
.

11 May 2018

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

Actuarial Research Centre
Institute and Faculty of Actuaries

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)

Actuarial Research Centre
Institute and Faculty of Actuaries

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
  - 19,000 claims settled
- 2007- 2010
  - Grouped by various risk factors
  - 25,187 claims settled

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre Institute and Faculty of Actuaries

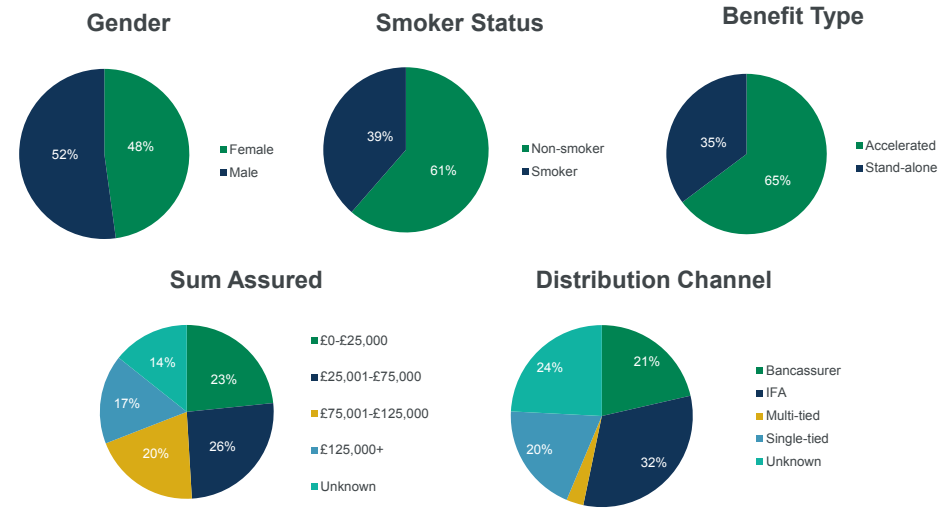
Data:

- 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	√	

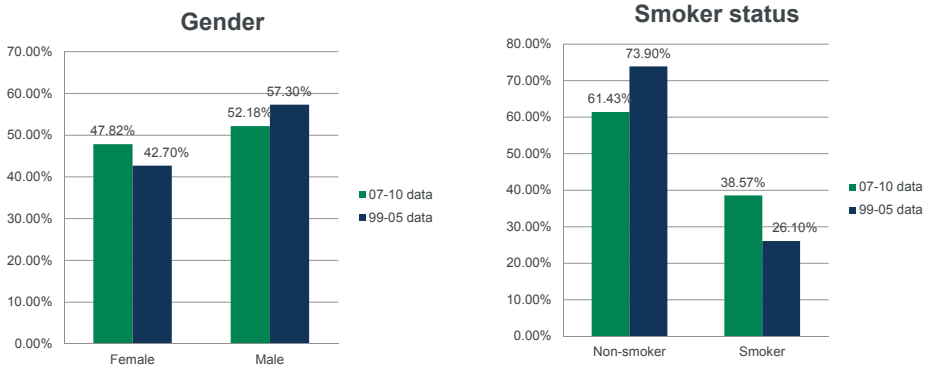
HERIOT WATT UNIVERSITY Southampton

Data: 2007 - 2010



HERIOT WATT UNIVERSITY | UNIVERSITY OF Southampton | Actuarial Research Centre, Institute and Faculty of Actuaries

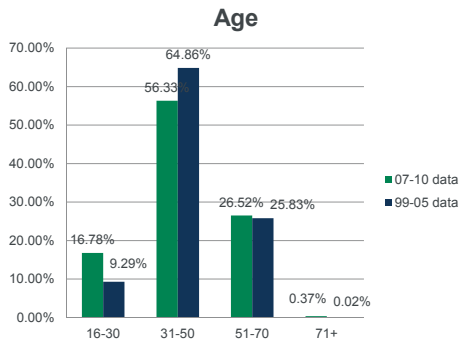
Data: 2007 – 2010 v 1999 – 2005

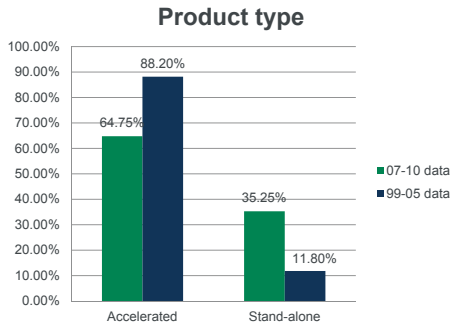


- Distributions more “even” in 2007 – 2010
- Higher proportion of **smokers** in 2007 – 2010

HERIOT WATT UNIVERSITY | UNIVERSITY OF Southampton | Actuarial Research Centre, Institute and Faculty of Actuaries

Data: 2007 – 2010 v 1999 – 2005





- Higher proportion of **age 16-30** in 2007 – 2010
- Higher proportion of **stand-alone** in 2007 – 2010

HERIOT WATT UNIVERSITY | University of Southampton | Actuarial Research Centre, Institute and Faculty of Actuaries

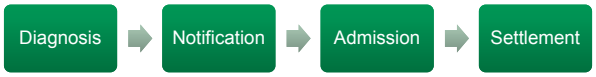
Actuarial Research Centre
Institute and Faculty of Actuaries

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

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre Institute and Faculty of Actuaries

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 $\eta_i, \alpha, \tau, \gamma$.

Actuarial Research Centre Institute and Faculty of Actuaries

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

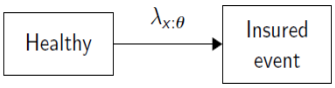
$$E^*(u; x) = E(u; x) \times F(t\text{-}u; x)$$

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:



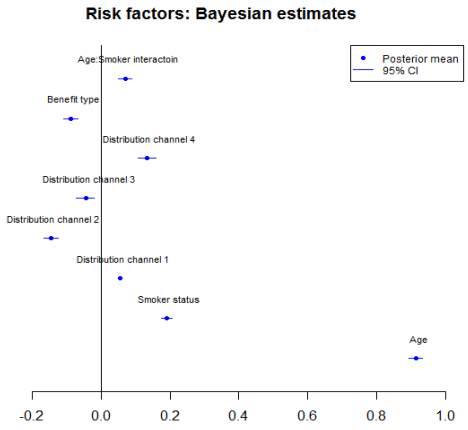
Fit Bayesian model:

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)

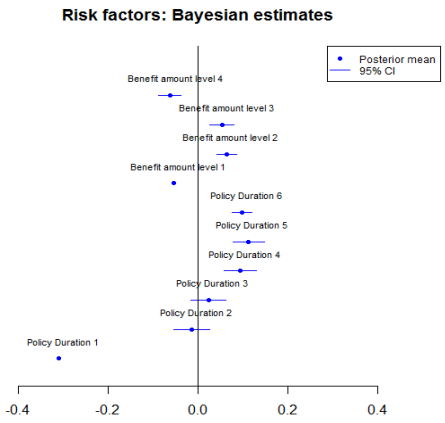


Perform variable (factor) selection

Selected model includes:

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

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



Selected model includes:

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

HERIOT WATT UNIVERSITY
UNIVERSITY OF Southampton
Actuarial Research Centre
Institute and Faculty of Actuaries

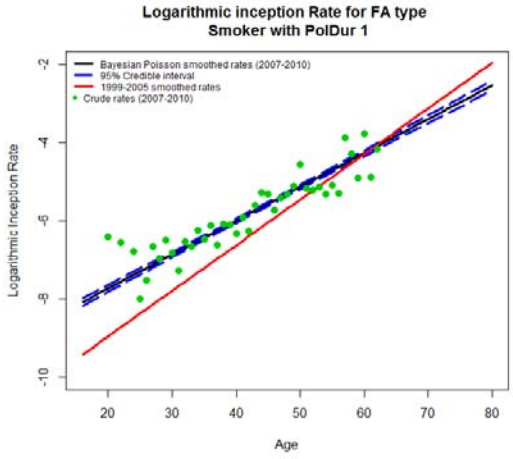
Actuarial Research Centre
Institute and Faculty of Actuaries

Claim rates

Smoothed estimates, intervals

Claim rates

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



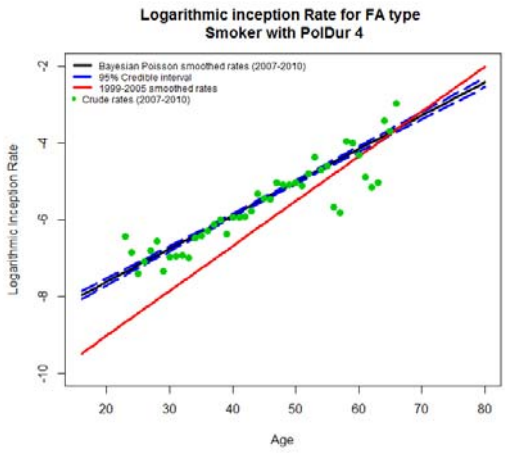
- Model fits crude rates (2007 – 2010) well
- 2007 – 2010 rates significantly higher
- Gap widens at younger ages

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

Claim rates

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



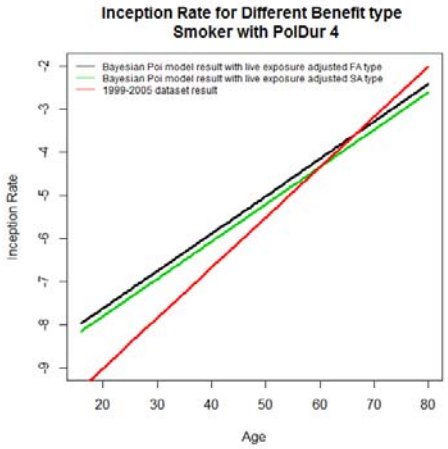
- Again, 2007 – 2010 rates significantly higher
- Rates higher than for Pol Duration 1

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

Claim rates

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



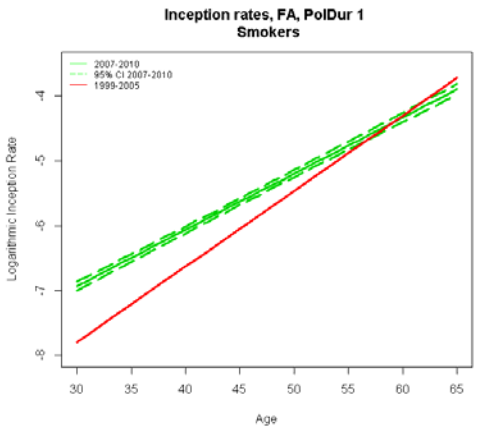
- Accelerated 2007 -2010 (black) higher than stand-alone (green)
- Both significantly higher than 1999 – 2005

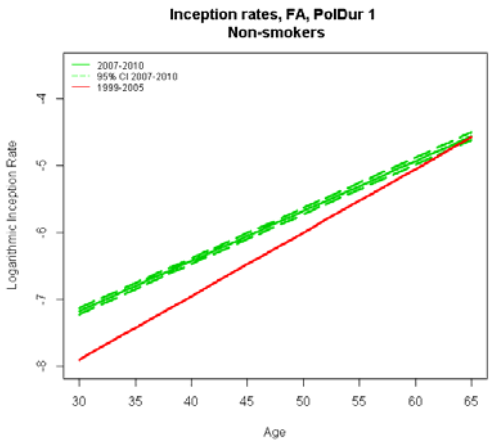
HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre Institute and Faculty of Actuaries

Claim rates

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





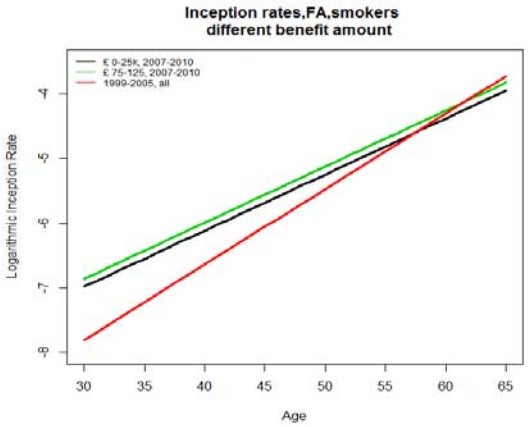
- 2007 – 2010 rates significantly higher, both S & NS

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre Institute and Faculty of Actuaries

Claim rates

Different benefit amount (Accelerated, Smokers)



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

HERIOT WATT UNIVERSITY
UNIVERSITY OF Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

Actuarial Research Centre
Institute and Faculty of Actuaries

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

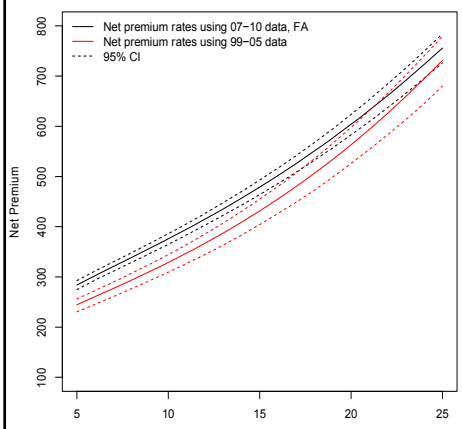
$${}_tp_x = \exp\left(-\int_{s=0}^{t} \lambda_{x+t} \, dt\right) \text{ and}$$

v is the discount factor.

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

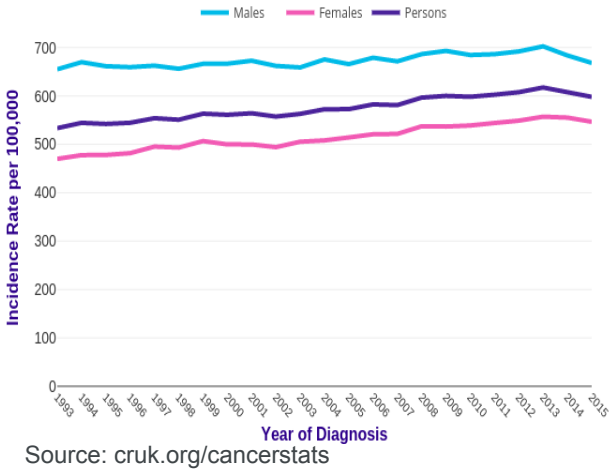
Pricing

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%

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

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)

HERIOT WATT UNIVERSITY Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

Actuarial Research Centre
Institute and Faculty of Actuaries

Conclusions

Conclusions

- Critical illness insured population distribution has some differences between 1999-2005 & 2007-2010
- 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 a CII claim and premium rates over time (1999-2005 v 2007-2010)
  - especially at younger ages

HERIOT WATT UNIVERSITY UNIVERSITY OF Southampton

Actuarial Research Centre
Institute and Faculty of Actuaries

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.

Stochastic modelling: Delay time distribution

1999 – 2005 (cont.)

- Generalised Beta 2 distribution in Bayesian GLM-type setting

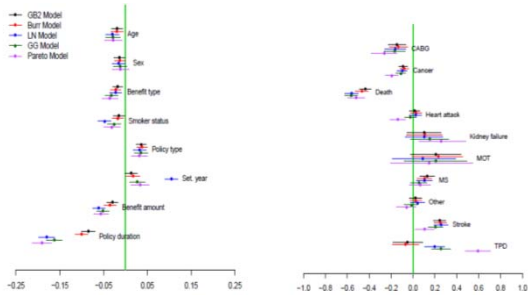


Figure: Posterior means (dots) and 95% credible intervals (bars) of β's.

Most factors significant:

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