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Older Age Dynamics

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Agenda

- Background
- The datasets
- The models
- The results
- Comparing mortality measures

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Background

Setting the context for the analysis

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Background

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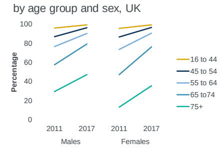
Older age health dynamics

- Current developing technologies will enable the insurers to track the health of their customers at older age continuously

Recent internet use in 2011 and 2017 by age group and sex, UK



Source: Office of National Statistics (2014)

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Objectives of this analysis

- Add evidence to current literature on older age dynamics
- Use English National Dataset to explore the interaction between the burden of disease and mortality in older age
- Support the debate on the benefits of continuous underwriting

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The Dataset

English Longitudinal Study of Ageing

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English Longitudinal study of Ageing

- ELSA is a longitudinal survey dataset for the study of:
  - health,
  - economic position, and
  - quality of life among the elderly.
- It was modelled after the Health and Retirement Study (HRS), a similar longitudinal survey dataset for the United States.

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ELSA sampling

- The technical details of this study are also available at the web site of the Institute of Fiscal Studies http://www.ifs.org.uk/elsa/

Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
3/2002 to 3/2003	6/2004 to 6/2005	5/2006 to 8/2007	5/2008 to 7/2009	7/2010 to 6/2011
Cohort 1		Cohort 3	Cohort 4	Cohort 1 Cohort 3 and Cohort 4 continued
50+ on 1 March 2002		50 to 53 1 March 2006	50 to 74 1 March 2008	
HSE 1998/1999 2001		HSE 2001 to 2004	HSE 2006	

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ELSA – reported diagnoses

- Pulmonary diseases (lung disease and asthma)
- Arthritis
- Cancer
- Neurological (Parkinson's, Alzheimer, dementia and senile)
- Cardiac diseases (Angina, hearth attack, congestive heart failure, heart murmur and abnormal heart rhyme)
- Stroke

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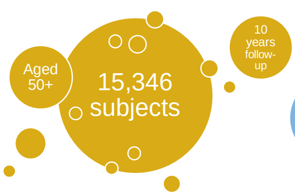
The analysis sample



Demographics	• age • sex, and • marital status
Socioe-conomics	• occupation • social class
Health related behaviour	• smoking • alcohol intake
Health status	• Functional health • Chronic conditions

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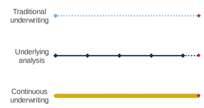
The models

Hazard model and multi-state actuarial model

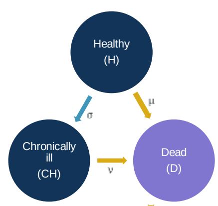
Proportional hazard model

- **competing risk cox proportional hazard model** was estimated using 10 years follow up on **mortality** between 2002 to 2012



Multi-state actuarial model

- The goal is to estimate **age-specific** transition probabilities among a sample of English older adults aged 50 to 90 at baseline in 2002
- A time-continuous inhomogeneous Markov chain was adopted
- Generalized linear models (GLM) were adopted for graduating both mortality and disability transition intensities



Markov process for transition probabilities

- The transition probability P_{ij} from state i to state j after t years from policy issue is defined by
  - $P_{ij}(t, t+\Delta t) = Pr\{S(t+\Delta t) = j | S(t) = i\} \quad , t \geq 0, \Delta t \geq 0, i, j \in \{N, FD, D\}$
- The instantaneous transition intensities are aged dependent and are assumed to be defined on compact intervals, and are defined by
  - $I_{ij} = \lim_{\Delta t \to 0^+} \frac{P_{ij}(t, t+\Delta t)}{\Delta t} \ , t \geq 0, i \neq j$
- Transition intensities were estimated from the data, the transition probabilities were derived using Kolmogorov differential equations (Haberman and Pitacco 1999)

Definitions of health states

- Reported chorionic diseases were used to define the state (CH).
- Pulmonary disease is used as an example to demonstrate the modelling.
- Moving from the state of healthy (H) to chronically ill (CH) was captured by the change in number of respondents who are diagnosed with the underlying chronic condition in six ELSA interview waves, between 2002 to 2012.
- Follow up on death data were available for the years 2002 to 2012

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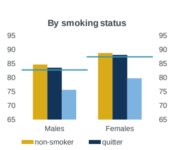
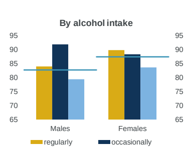
The results

Age at death





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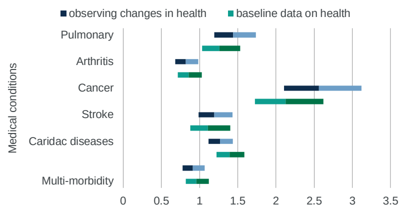
Mortality hazard ratios - compared with no medical conditions



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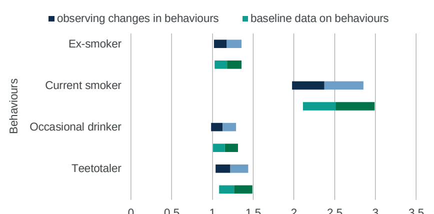
Mortality hazard ratios - compared with no smokers & regular drinkers



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Raw transitions counts and exposure years for pulmonary disease

	i_x = Number of transitions			e_x = exposure years	
Age band	σ: H → CH	μ:H → D	ν:CH → D	in state H	in state CH
50-54	53	6	8	7,140.1	1,110.8
55-59	107	57	23	14,648.9	2,549.8
60-64	114	90	36	13,651.8	2,665.2
65-69	122	124	55	11,396.9	2,529.6
70-74	80	176	88	10,244.4	2,319.5
75-79	85	273	118	8,055.5	1,878.7
80-84	49	346	118	5,719.3	1,239.0
85-89	24	363	95	3,295.8	617.1
90 and over	19	334	72	1,437.6	243.0
Total	**653**	**1,769**	**613**	**75,590.2**	**15,152.7**

Data from 10 years follow-up period between 2002 and 2012, of ELSA respondents for household residents aged 50 and over

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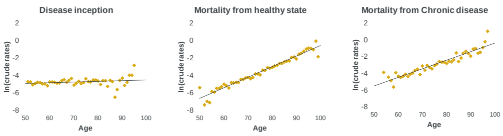
Testing linearity of the regressor η_x



- Generally linear patterns support the use of the proposed log transformation based on Poisson GLMs
- Mortality from CH state is higher than mortality from healthy at all ages

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Poisson GLM: Goodness of fit of the models

k	AIC	BIC	D	Dc	p-value
σ:H→CH	disease incidence				
1	**5.18**	**-126.98**	**41.48**		
2	5.20	-123.80	40.83	-0.65	0.421
3	5.22	-120.90	39.36	-1.47	0.334
μ:H→D	death from healthy state				
1	6.28	-115.03	53.43		
2	6.16	-118.40	46.23	-7.20	0.007
3	**6.06**	**-121.25**	**39.56**	**-6.67**	**0.010**
ν:CH→D	death from chronic illness				
1	**5.77**	**-87.32**	**81.14**		
2	5.78	-85.11	79.52	-1.62	0.203
3	5.78	-83.07	77.73	-1.79	0.181

- k denotes the number age related parameters.
- the use of cubic polynomial of age is statistically significant for mortality from healthy state, otherwise first order polynomial is sufficient

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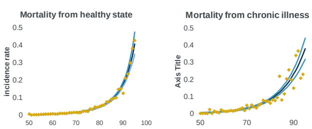
Graduated (smoothed) transition rates



- Not surprisingly mortality from pulmonary disease is higher than mortality from healthy state at all ages

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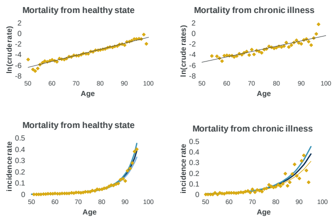
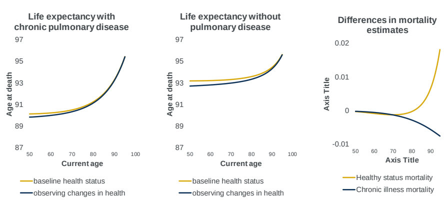
Traditional approach to underwriting



- Under this approach, transitions into chronic illness is not observed, and mortality is underestimated.

Comparison of mortality estimates



Summary

- Inequality in health between socioeconomic groups was more prominent when **changes in health and disability were allowed** in the model
- Taking into account changes in health and disability improves mortality prediction
- The accuracy of mortality prediction improves when using continuous underwriting approach
- The current model does not take account for the burden of disease

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Future research

- Investigate the inclusion of physical disability and cognitive impairments as measures of the burden of disease
- Examine interaction between different diseases (comorbidity)
- Use the Cognitive Functioning for Ageing Study (CFAS) as it covers older and more frail respondents
- Examine gender differentials, and other factors that affect mortality hazard rates

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Questions Comments

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