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Use of Big Health and Actuarial Data for understanding Longevity and Morbidity

Elena Kulinskaya and Nigel Wright

The **'Use of Big Health and Actuarial Data for understanding Longevity and Morbidity Risks'** research programme is being funded by the Actuarial Research Centre.

13 June 2017

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Use Of Big Health And Actuarial Data For Understanding Longevity And Morbidity Risks, ARC, IFoA 2016-2020

Consortium

University of East Anglia: School of Computing Sciences (CMP) and Norwich Medical School (NMS).

Aviva Life Plc.

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Aviva co-investigators

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Big Health Actuarial Data

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Big Actuarial Health Data > Home

This is the website of the research project on the Use Of Big Health And Actuarial Data For Understanding Longevity And Morbidity Risks. The project is funded by Institute and Faculty of Actuaries for 4 years from October 2016.

The main objectives of this project are the development of novel statistical and actuarial methods for modelling mortality, modelling trends in morbidity, assessing basis risk and evaluating longevity

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Spiegelhalter 2016....pdf

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Main objectives

Development of novel statistical and actuarial methods for:

- Modelling mortality
- Modelling trends in morbidity and uptake of health interventions
- Assessing basis risk
- Evaluating longevity improvement based on Big Health and Actuarial Data
- Tools to forecast longevity risk of a book

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Data

- The Health Improvement Network (THIN) data
  - Medical records from primary care
  - Representative of the UK when adjusted for deprivation
- All patients born before 1960 and followed to 01.01.2017, this includes 3.5 million patients
- Added various social economic status variables such as IMD and Mosaic
- Additional Actuarial Data

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Aim 1: Identification and quantification of the key factors affecting mortality/ longevity

We intend to have a target list of between 3-5 conditions or interventions.

Health conditions:

- Stroke
- Diabetes
- **…**

Health interventions:

- Statin prescription
- New blood pressure targets.
- …

Lifestyle factors

- obesity
- smoking.

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Poll 1: Where do you think the potential increases in longevity are:

- Diabetes **(15%)**
- Cancer **(44%)**
- Alzheimer's disease **(17%)**
- Stroke **(3%)**
- Heart disease **(19%)**
- Other **(2%)**

*** Results based on 117 participants during 17.00 – 18.00 webinar**

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Design and methods

- For each of these conditions we will design a population-based prospective cohort study using an appropriate extract of the primary care data.
- We intend to use a case-control design with cases matched with several controls from the same GP practice. This provides balanced and comparable cohorts of cases and controls and simplifies the study of comparatively rare conditions without loss of efficiency.
- The full list of relevant confounding variables will be established from medical literature such as systematic reviews, and from expert knowledge within the team, and then the subset of these variables to be adjusted for will be found through backward elimination.
- To account for the interdependence of patients from the same GP practice, multilevel modelling and multiple imputation will be used.

Aim 2. Modelling of temporal changes in the factors affecting morbidity and mortality

- Trends in the incidence and/or prevalence of particular medical conditions and/or lifestyle factors will also be obtained from the primary care data.
- This will enable us to establish patterns due to social or geographic inequalities, such as socio-economic status (SES), age or postcode lottery.
- For instance, the patients in the more deprived areas may be disadvantaged in regards to the latest interventions and/or public health campaigns at least initially. This will result in widening the gap in longevity between individuals from different backgrounds.
- Thus to be able to ascertain an effect on longevity of a population, we need to model the incidence of a condition or an uptake of an intervention over time in parallel to modelling mortality.

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Poll 2: How soon will the new medical breakthrough affect period life expectancy?

- 1-2 years **(6%)**
- 3-5 years **(31%)**
- 6-10 years **(39%)**
- 10+ years **(24%)**

*** Results based on 110 participants during 17.00 – 18.00 webinar**

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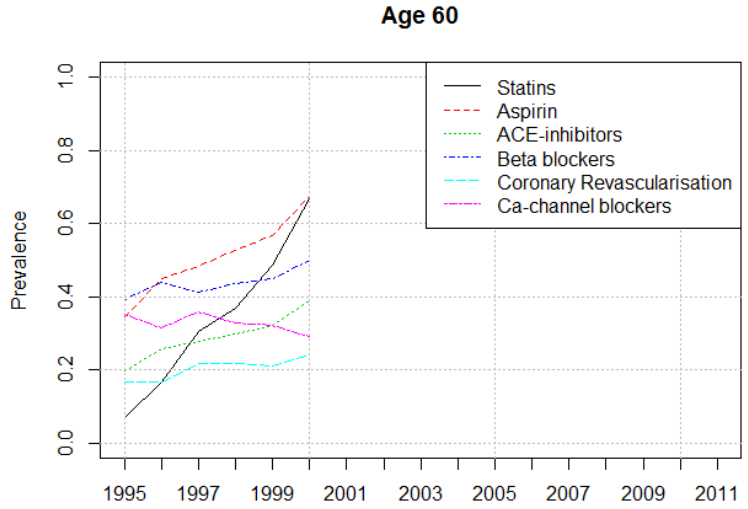
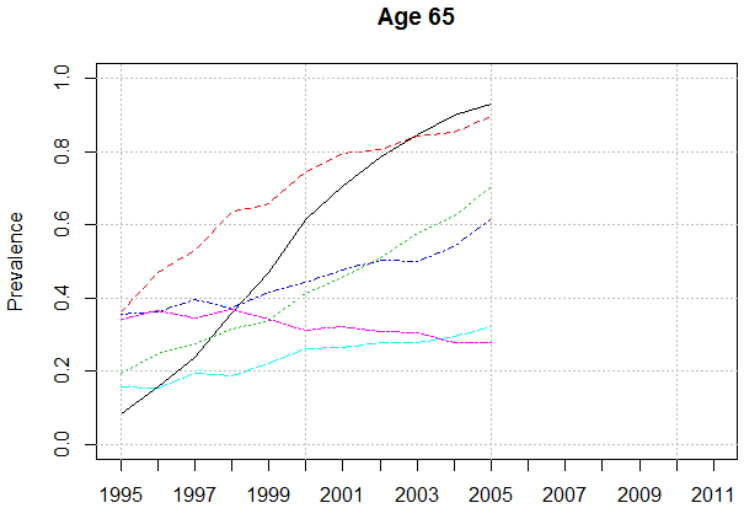
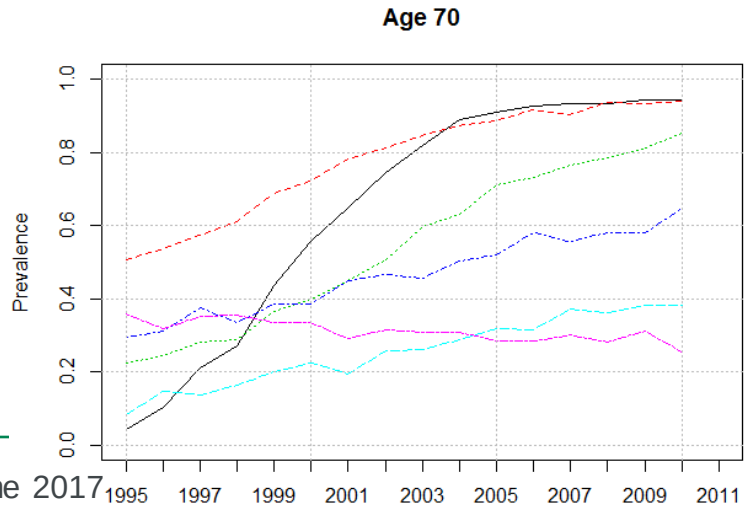
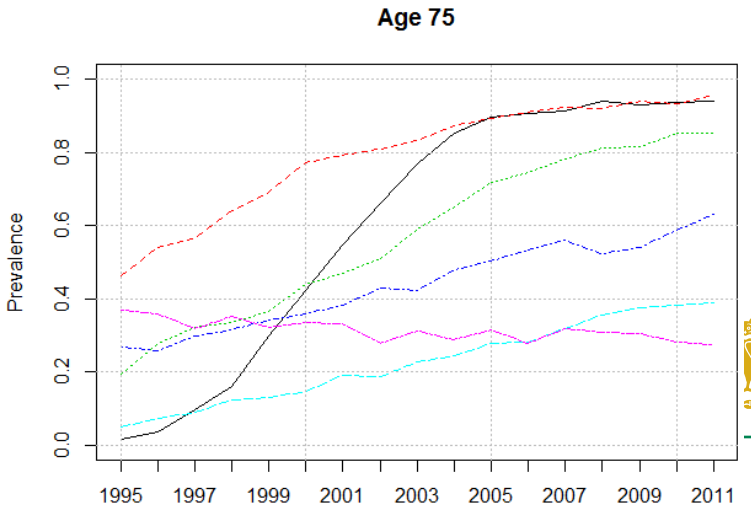
Prevalence of treatment by cohort's age in patients with a history of acute myocardial infarction









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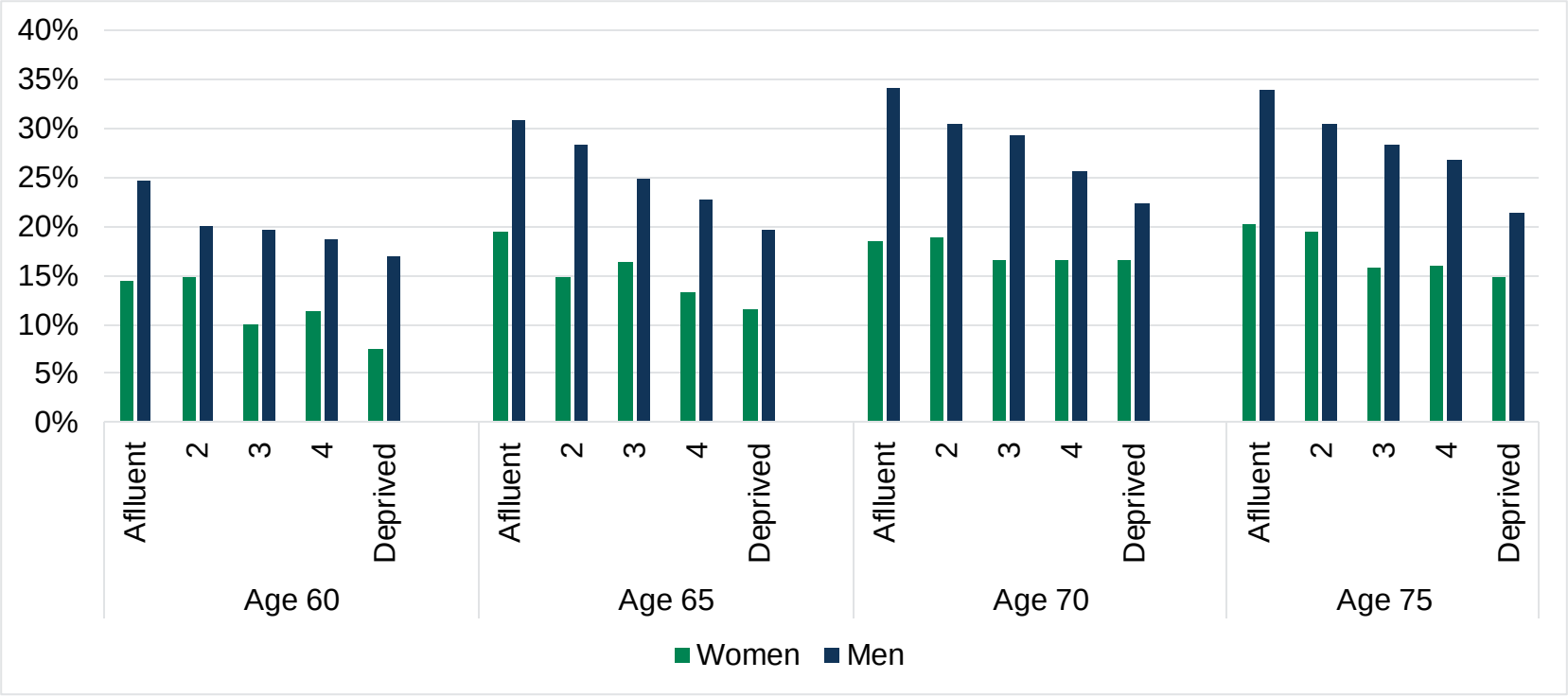
Example: Coronary Revascularisation given IHD



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Aim 3. Evaluation of plausible scenarios in mortality trends due to particular medical advances or lifestyle changes on the population of insureds

As often happens with the existing portfolio of insured lives, the minute health details of a life are not available. Instead, the interest lies in the mortality trends of the whole book.

To be able to provide this information, three components are required:

- established in Aim 1 model for survival differentials associated with a particular disease or intervention;
- developed in Aim 2 model for the incidence/ prevalence of this condition or uptake of this intervention over time,
- and the sufficient knowledge of the population to which it is desired to translate trends in longevity established in general population to be able to assess the basis risk.

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Aim 4. Tools to forecast longevity risk of a book

- We will develop an R package incorporating our models and providing analytical and graphical means to forecast longevity of a general UK population, and also of a population of a user defined composition under a number of scenarios for changes in disease incidence, health behaviours and treatments.
- This will be an open source software available from the project website along with an accompanying manual for its use.
- We also intend to develop teaching materials for the actuarial community on the modelling techniques used in the project, and the use of the developed R package. These materials will be available from the project website.

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Questions

Comments

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

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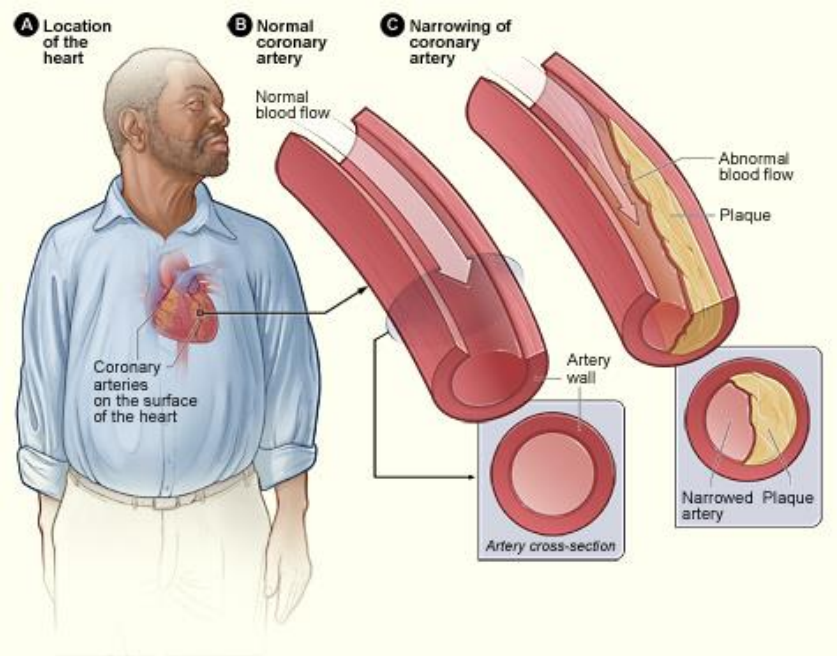
Case Study

Statins and Life Expectancy

13 June 2017

Cardiovascular disease (CVD)

- Disease of the heart or blood vessels, e.g. heart attack and stroke
- Leading cause of global and UK death: 33%
- Risk factors for CVD:
  - High blood pressure (hypertension)
  - Smoking
  - High blood cholesterol
  - Diabetes
  - Lack of exercise
  - Being overweight or obese
  - Family history / ethnic background



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Primary prevention of CVD

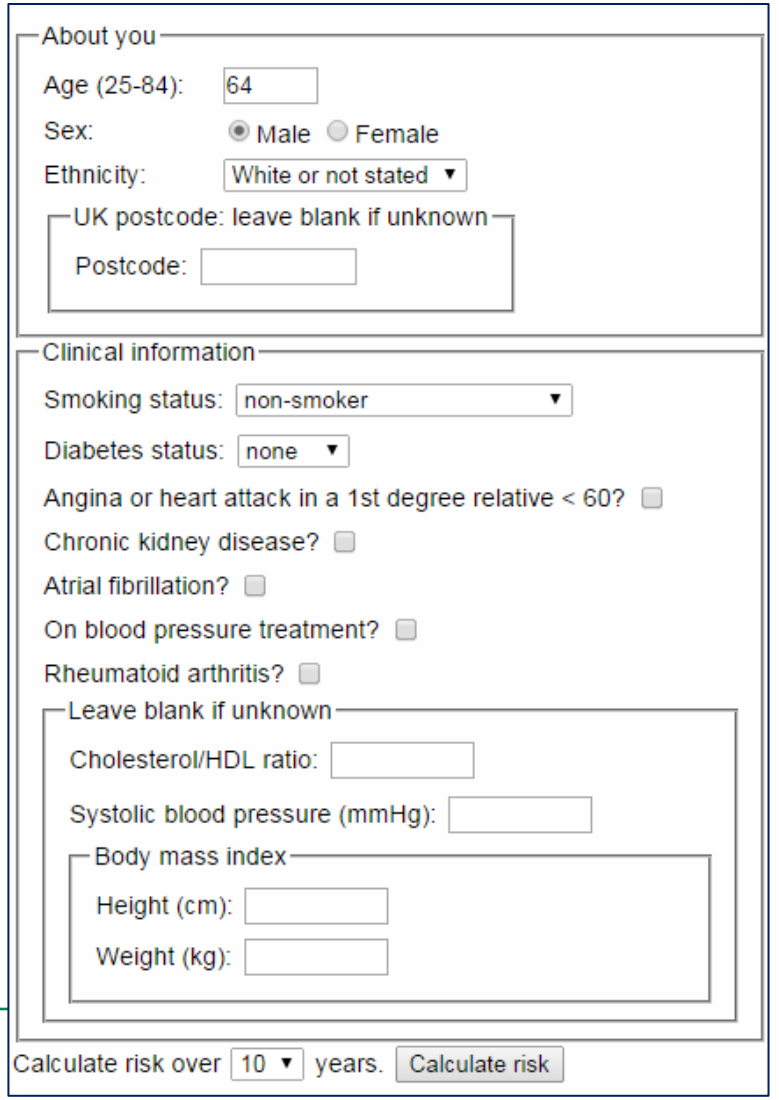
Primary prevention: no previous history of CVD

- Example: lipid-lowering therapy - statins

National Institute of Health and Clinical Excellence (NICE):

- *Offer atorvastatin 20 mg for the primary prevention of CVD to people who have a 10% or greater 10-year risk of developing CVD.*
- *Estimate the level of risk using the QRISK2 assessment tool*
- www.nice.org.uk/guidance/cg181/
- www.qrisk.org/2016/

Up to 17 million UK residents eligible for statins



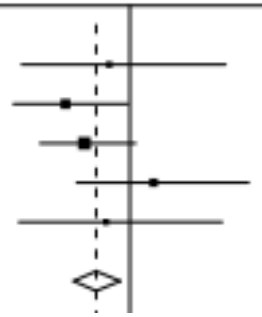
Previous research on effectiveness of statins

Meta-analysis of 27 randomised clinical trials by Cholesterol Treatment Trialists' (CTT) Collaborators, The Lancet 2015 (http://dx.doi.org/10.1016/S0140-6736(14)61368-4)

- Overall 9% relative reduction in all-cause mortality with statins

Webfigure 9: Effects on any deaths per 1.0 mmol/L reduction in LDL cholesterol at different levels of risk, by history of vascular disease and overall

5−year MVE risk at baseline	Deaths (% per annum) Statin/more	Control/less	RR (CI) per 1.0 mmol/L reduction in LDL cholesterol	Trend test
Participants without vascular disease				
< 5%	164 (0.38)	177 (0.41)	0.94 (0.71 − 1.26)	
≥ 5%,<10%	372 (0.77)	446 (0.93)	0.83 (0.69 − 0.99)	
≥ 10%,<20%	703 (1.99)	778 (2.19)	0.88 (0.76 − 1.02)	χ^2_1=1.57
≥ 20%,<30%	363 (5.13)	339 (4.73)	1.06 (0.86 − 1.32)	(p=0.2)
≥ 30%	192 (10.76)	192 (11.44)	0.94 (0.70 − 1.25)	
Subtotal	**1794 (1.33)**	**1932 (1.42)**	**0.91 (0.85 − 0.97)** **p= 0.007**	



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Research question

What is the survival benefit associated with statin prescription as primary prevention of cardiovascular disease for different risk groups at various ages in the general population?

Gitsels L.A., Kulinskaya E., Steel N. (2016) Survival Benefits of Statins for Primary Prevention: A Cohort Study. PLoS ONE **11**(11): e0166847. doi:10.1371/journal.pone.0166847

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Design and Data Selection

- Population-based prospective cohort study
- Restrictions data:
  - Medical records from 1987 to 2011 of people born between 1920 and 1940
- Target ages:
  - 60, 65, 70, and 75
- Exclusion:
  - Patients with a history of cardiovascular disease

- Incomplete records in BMI, smoking status, and risk of cardiac event were dealt with by multilevel multiple imputation using REALCOM-Imputation software

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Model specification

Cox's proportional hazard regression estimates the hazard λ_{ij} for patient *i* from GP practice *j*:

$$\lambda_{ij} = \lambda_0(t)\, Z_j\, e^{\beta X_{ij}}$$

where λ_0 = baseline hazard (function of time),
Z_j = shared frailty term on GP practice (constant),
β = coefficients (constant),
and X_{ij} = exposures, e.g. statins (constant).

Models specified:

- Ages: 60, 65, 70, and 75
- Risk groups:
  - Low <10% risk of cardiac event
  - Moderate 10-19% risk of cardiac event
  - High ≥20% risk of cardiac event

Cohorts' characteristics

Cohort	Number of patients	Number of deaths	Average follow-up time	Maximum follow-up time
Age 60	118,700	15,296 (12.8%)	12 years	24 years
Age 65	199,574	28,848 (14.5%)	10 years	24 years
Age 70	247,149	40,699 (16.5%)	7 years	21 years
Age 75	194,085	37,356 (19.2%)	6 years	16 years

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Distribution men and women across risk group

Cohort	Cardiac risk	Women % (Statins %)	Men % (Statins %)
Age 60	Low	83 (1.2)	16 (0.4)
	Moderate	16 (3.7)	78 (1.3)
	High	1 (11.9)	6 (5.2)
Age 65	Low	40 (2.2)	0 (0.0)
	Moderate	55 (7.4)	72 (3.2)
	High	5 (26.9)	28 (12.4)
Age 70	Moderate	80 (9.5)	17 (5.4)
	High	20 (28.2)	83 (17.4)
Age 75	Moderate	15 (4.6)	0 (0.0)
	High	85 (19.6)	100 (19.1)

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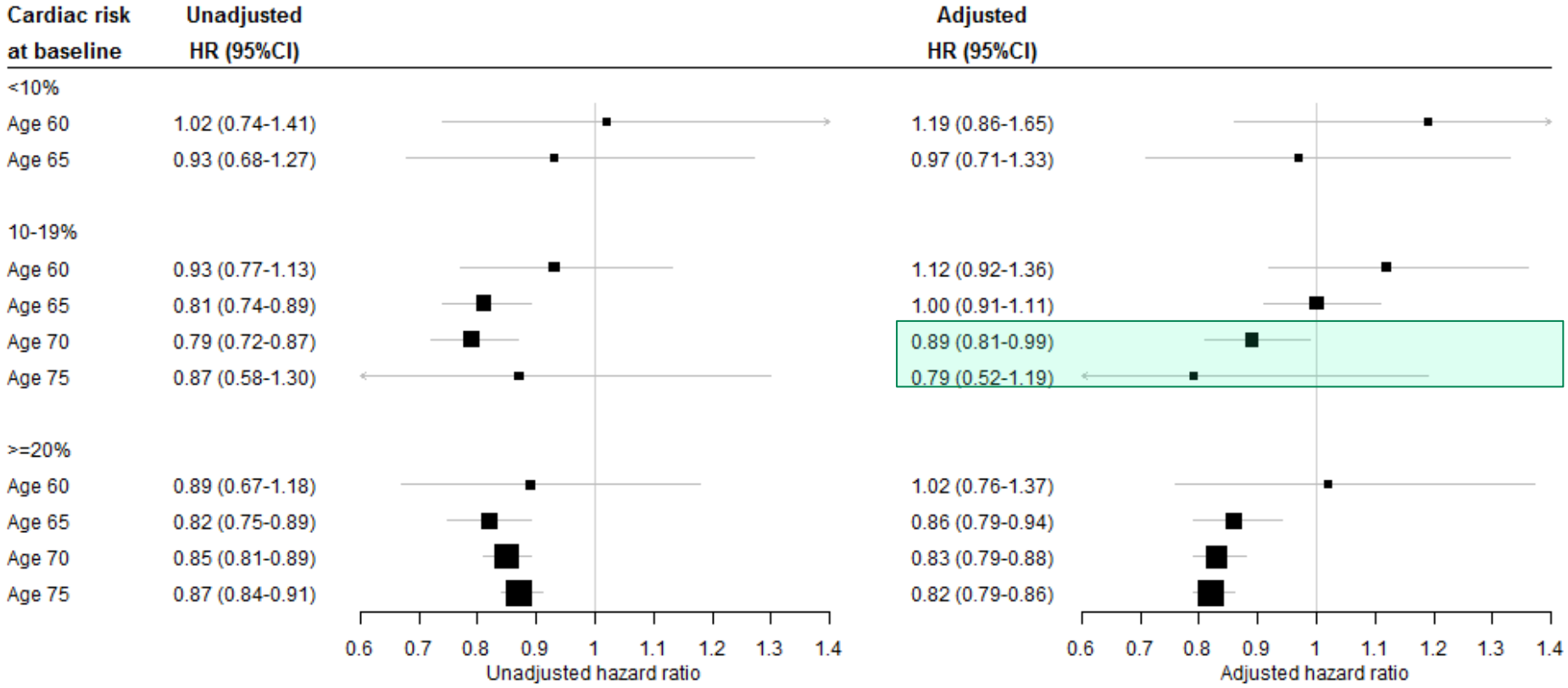
Hazard of mortality associated with statin prescription



The adjusted hazard ratios (HR) take into account sex, year of birth, postcode, diabetes, high cholesterol level, blood pressure regulating drugs, body mass index, smoking status, and general practice.

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Poll 3: By how much the next breakthrough will increase population life expectancy?

- Less than 1 year **(10%)**
- 1-2 years **(52%)**
- 3-5 years **(31%)**
- 5+ years **(6%)**

*** Results based on 105 participants during 17.00 – 18.00 webinar**

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Translating hazard of mortality to period life expectancy

- Using Gompertz law, the increase in annual hazard of mortality associated with ageing one year is approximately constant between ages 30 and 95.
- For England and Wales in 2010-2012, the increase in the hazard between those ages was approximately 1.1.
- A HR can be translated to the numbers of years gained in effective age as: log(HR)/log(1.1) ≈ 10*log(HR).

[Brenner, 1993 http://www.jstor.org/stable/3702276;
Spiegelhalter, 2016 DOI:10.1186/s12911-016-0342-z]

Period life expectancy increase associated with statins prescription

	QRISK2: 10-19%			QRISK2: ≥ 20%		
		Male	Female		Male	Female
Age	Effective age (years)	Period life expectancy (years)		Effective age (years)	Period life expectancy (years)	
65	0	0	0	-1.51	1.19	1.27
70	-1.17	0.85	0.93	-1.86	1.36	1.49
75	-2.36	1.53	1.74	-1.99	1.28	1.46

Change in effective age and period life expectancy based on the UK life tables of 2010-12 (ONS, 2016)

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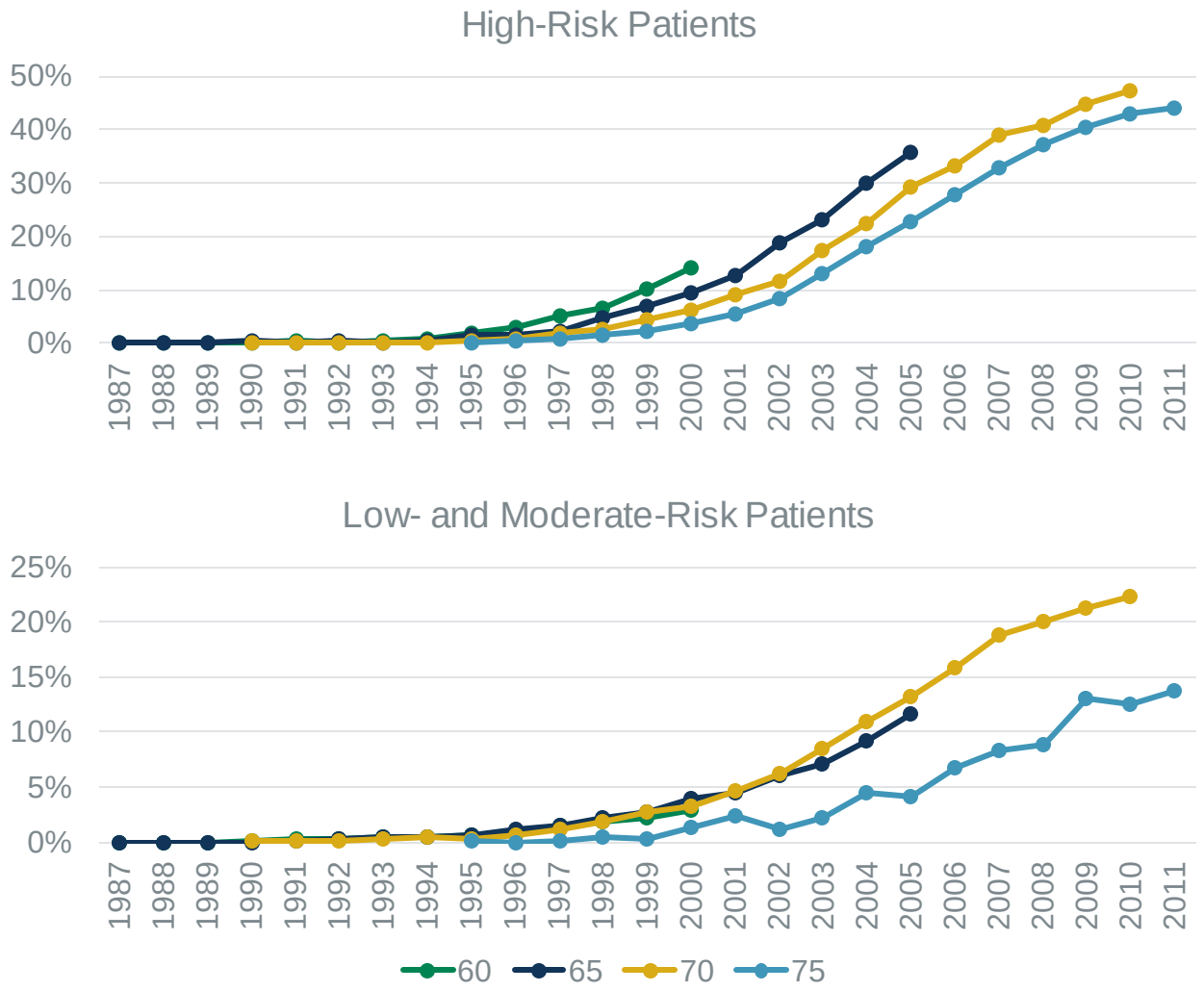
Statins prescription rate by age-risk group



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Actual increase in period life expectancy due to statins prescription

The prevalence of statins prescription in each sex-age-risk group:

2010	Men aged 70	Women aged 70	Men aged 75	Women aged 75
QRISK2:10-19%	18%	23%	N/A	13%
QRISK2≥20%	44%	54%	44%	42%

	Increase in life expectancy
• Men aged 70, 2010 prescription rates:	0.52 yrs
• Men aged 70, 100% take up:	1.27 yrs
• Women aged 70, 2010 prescription rates:	0.33 yrs
• Women aged 70, 100% take up:	1.04 yrs
• Men aged 75, 2010 rates vs. 100% take up:	0.56 vs. 1.28 yrs
• Women age 75, 2010 rates vs. 100% take up:	0.56 vs. 1.50 yrs

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Poll 4: Do you think the medical and lifestyle advances may counteract obesity epidemic?

- Yes **(58%)**
- No **(42%)**

*** Results based on 105 participants during 17.00 – 18.00 webinar**

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Questions

Comments

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

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Summary

- To establish the drivers of changes in longevity, and to predict how they may change over time we need to incorporate health-related trends and advances.
- Clinical trials deal with a selective population of patients, and usually are of short duration. Also are rarely interested in all-cause mortality.
- We need to use individual level health data found in large health databases, and to use sophisticated tools for modelling the mortality experience of participating populations.
- This involves resolving numerous ethical issues and also requires some time lag to be able to obtain sufficient population-based data.

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