



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

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

Elena Kulinskaya (UEA)  
and Nigel Wright (Aviva)

Team: Prof Nick Steel (UEA), Prof Ruth Hancock (UEA), Mr Nigel Wright (Aviva)

Postdocs: Ilyas Bakbergenuly and Lisanne Gitsels;

PhD students: P. Chutoo, N. Akter and N. Ncube

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

17 September 2018

[www.actuaries.org.uk/arc](http://www.actuaries.org.uk/arc)





## Actuarial Research Centre

Institute and Faculty  
of Actuaries

**Disclaimer:** The views expressed in this presentation are those of invited contributors and not necessarily those of the Institute and Faculty of Actuaries. The Institute and Faculty of Actuaries do not endorse any of the views stated, nor any claims or representations made in this presentation and accept no responsibility or liability to any person for loss or damage suffered as a consequence of their placing reliance upon any view, claim or representation made in this presentation. The information and expressions of opinion contained in this presentation are not intended to be a comprehensive study, nor to provide actuarial advice or advice of any nature and should not be treated as a substitute for specific advice concerning individual situations. On no account may any part of this presentation be reproduced without the written permission of the Institute and Faculty of Actuaries.

# [www.bighealthactuarialdata.ac.uk](http://www.bighealthactuarialdata.ac.uk)

## Big Health Actuarial Data

The screenshot shows the website's navigation menu with 'Home' selected. Below the menu is a breadcrumb trail: 'Big Actuarial Health Data > Home'. The main content area is split into two columns. The left column features a large image of 'BIG DATA' in glowing blue letters over a globe and data stream, with a 'The Project' label. The right column has a 'Contact us' header, followed by contact details for the School of Computing Sciences at the University of East Anglia, including the address, phone number, and email. Below the contact info are the logos for the University of East Anglia and the Institute and Faculty of Actuaries.

Home Project Description The Team Publications Press Contact us


Big Actuarial Health Data > Home

**The Project**

**CONTACT US**

School of Computing Sciences  
University of East Anglia  
Norwich Research Park  
Norwich  
NR4 7TJ  
United Kingdom  
Tel: 01603 592300  
Email: [i.bakbergenuly@uea.ac.uk](mailto:i.bakbergenuly@uea.ac.uk)

**UEA**  
University of East Anglia

 Institute and Faculty of Actuaries



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# Quantifying longevity and morbidity changes

- Medical and social advances are the major drivers of longevity and morbidity changes. But how to quantify these relationships?
- In medicine, Randomized Control Trials (RCTs) are considered to be the gold standard.
- RCTs estimate the hazard or force of mortality in a (selective) sample of people and summarised over the observed (limited) time period.
- New health interventions are usually based on these estimated hazards obtained from clinical trials. A lengthy lead time would be needed to observe their effect on population longevity.



# Individual level data

- Our research uses The Health Improvement Network (THIN) primary care data to develop statistical models of longevity and morbidity.
- The advantage of using individual level medical data is that it is possible to model both the uptake of medical treatment and the effect of that treatment on longevity conditional on the individual sociodemographic and health factors instead of the aggregated profile.
- Survival models, usually the Cox's regression, are fitted to individual level data.
- The conclusions are generalisable to the general population.





# The Health Improvement Network (THIN) data

- Anonymised electronic primary care medical records (Vision)
- Data collection began in 2003 using Read codes
- 11 million patients, 3.7 million active patients
- 562 general practices, covering 6.2% of the UK population
- Diagnoses, prescriptions, consultations, postcode deprivation



Subset of THIN selected for our research:

- All patients born before 1960 and followed to 01.01.2017, this includes 3.5 million patients
- Social economic status variables such as Index of Multiple Deprivation (IMD), Townsend and Mosaic
- IMD: income, employment, health, education, crime, housing
- Townsend: employment, car ownership, home ownership, household overcrowding
- Mosaic: consumer classification based on demographics, lifestyles and behaviour of a person



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# Target conditions and interventions

The screenshot displays the 'Big Health Actuarial Data' website. At the top, there is a navigation menu with links for 'Home', 'Project Description', 'The Team', 'Publications', 'Press', and 'Contact us'. Below the menu, a breadcrumb trail reads 'Big Actuarial Health Data > Home > Current research'. The main content area features a grid of seven images, each with a corresponding label: 'Hypertension' (two people looking at a screen), 'Myocardial infarction' (a computer monitor showing a graph), 'Statins' (a rack of vials), 'Hormone replacement therapy' (a person in a lab coat), 'Stroke' (an anatomical model of a human head), 'Diabetes' (hands using a glucose meter), and 'Hip replacement' (a person holding a tablet displaying a hip scan).



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# Poll 1

What do you think are the main causes of the apparent slow-down in mortality improvements over that last few years? (You can select more than one answer.)

- Diet/Lifestyle factors (obesity epidemic, substance abuse, etc.)
- Austerity (insufficient health/social care spending)
- Extreme weather (cold winters/hot summers)
- Antibiotic resistance
- Flu strains
- Previous drivers of improvements having run their course
- Other



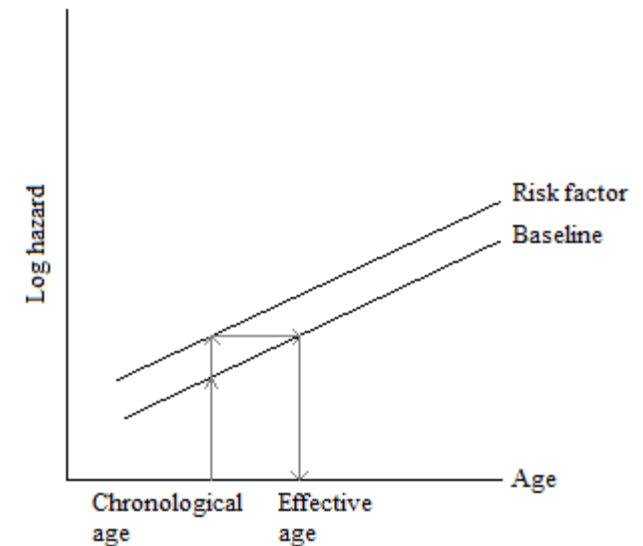
Actuarial  
Research Centre

Institute and Faculty  
of Actuaries



# Changes in individual and population life expectancy due to medical interventions

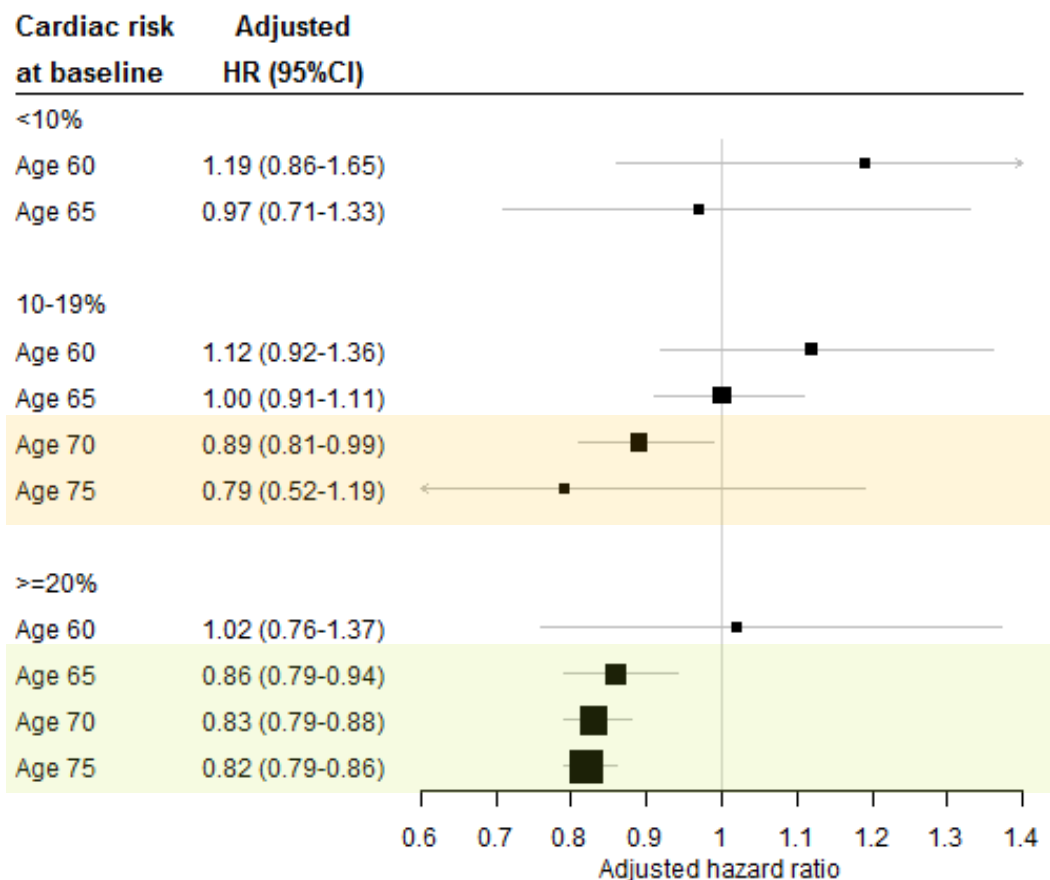
- We have developed methodology allowing to translate results from analyses of health care data, such as uptake of interventions and hazard ratios of death, into changes in individual and population life expectancy.
- For individuals, the hazard ratio of an intervention is translated into equivalent change in age using the Gompertz distribution [Brenner et al, 1993]. This is based on the definition of chronological and effective age [Spiegelhalter, 2016].
- This helps to explain consequences of conditions and lifestyle choices and can be used to nudge clients to pursue a healthier lifestyle.



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# Survival prospects associated with statin prescription and changes in effective age



Adjusted for sex, year of birth, socioeconomic status (Mosaic), diabetes, high cholesterol level, blood pressure regulating drugs, body mass index, smoking status, and general practice.

## Change in effective age based on the UK life tables of 2010-12 (ONS, 2017).

Age	QRISK2: 10-19%	QRISK2 ≥20%
65	0.00	-1.51
70	-1.17	-1.86
75	-2.36	-1.99



Actuarial Research Centre  
Institute and Faculty of Actuaries

# Calculating an effect on population life expectancy (LE)

- Period life expectancy  $e_x$  at age  $x$  is a weighted average of component LEs, of people with different risk profiles, with the weights defined by the prevalence  $p$  of the risk factor of interest and/or the uptake of relevant intervention.
- Splitting the overall LE into these components allows to estimate hypothetical changes in life expectancy at the population level at different scenarios.



# Period life expectancy for people with or without statin prescription

Sex	Period life expectancy	Age 70 (95% CI)	Age 75 (95% CI)
<b>Men</b>	National	14.45	11.11
	Prescription	15.14-15.17	11.79-11.81
	No prescription	13.15-13.38	9.66-9.84
<b>Women</b>	National	16.67	12.92
	Prescription	17.34-17.36	13.86-13.87
	No prescription	15.92-16.03	11.92-12.01

Note: statins prescription for both primary and secondary prevention of cardiovascular disease (CVD). Estimates of prevalence of CVD and survival benefits of statins given CVD are obtained from our previous published work (Gitsels et al, 2017).



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# Statins and increase in period life expectancy

- The increase in life expectancy from 1987 to 2010 in women was 2.7 and 2.2 years at ages 70 and 75 and in men 3.7 and 2.8 years at ages 70 and 75.
- Statins contributed to 72% (60-88%) of this increase in life expectancy at age 70 and to 54% (41-68%) of this increase at age 75.
- At 100% uptake, life expectancy of women aged 70 or 75 would be increased by 0.7 or 1.0 years; expectancy for men aged 70 or 75 would be increased by 0.8 years.



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries



# Questions

# Comments

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



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# Example 2: Would intensive systolic blood pressure control increase longevity?

- SPRINT trial reported considerable survival benefits of intensive systolic blood pressure (SBP) lowering below 120 mmHg.
- Adverse Renal Outcome was one of the main adverse effects, with the odds raised threefold in patients without Chronic Kidney Disease at baseline.
- The American Heart Association changed its hypertension guideline on the basis of SPRINT results (Whelton et al, 2017).
- The primary objective of our study was to investigate the survival benefits of intensive SBP lowering in UK primary care and to compare them to SPRINT results.



# Study design

- The sample included 54,683 patients from THIN (50-90 yr) who were treated for hypertension between 2005 and 2013 and followed-up to 2017.
- Group 1: patients with SBP>140 mmHg (SBP1) which was lowered to less than 120 mmHg; 19,756 (36%) patients.
- Group 2: SBP>140 mmHg lowered to 120-140 mmHg; 34,927 (64%) patients.
- Time interval: 2 weeks to 6 months + new prescription.



# Results (to appear in Journal of Hypertension)

- SPRINT: the intensive treatment had a hazard ratio (HR) of 0.73 (0.60, 0.90) compared to standard treatment:
  - a decrease in effective age of 3.4 to 3.6 years.
  - AHA Guidelines: boost to the life expectancy in the US?
- THIN: the intensive group had significantly increased HR of 1.35 (1.14, 1.27):
  - an increase in effective age of 1.7 to 1.8 years.
- In both studies, more than 2 blood pressure lowering drugs, and increase in dosage (THIN) further significantly increased the hazards of mortality and the hazard of adverse renal outcomes.



# Poll 2

Thinking about the possible ‘stalling’ of mortality improvements, what would you expect life expectancies to do in the next 5-10 years?

- Start to decrease
- Remain level
- Increase more slowly than the 2000-2010 rate
- Increase at about the 2000-2010 rate
- Increase faster than the 2000-2010 rate

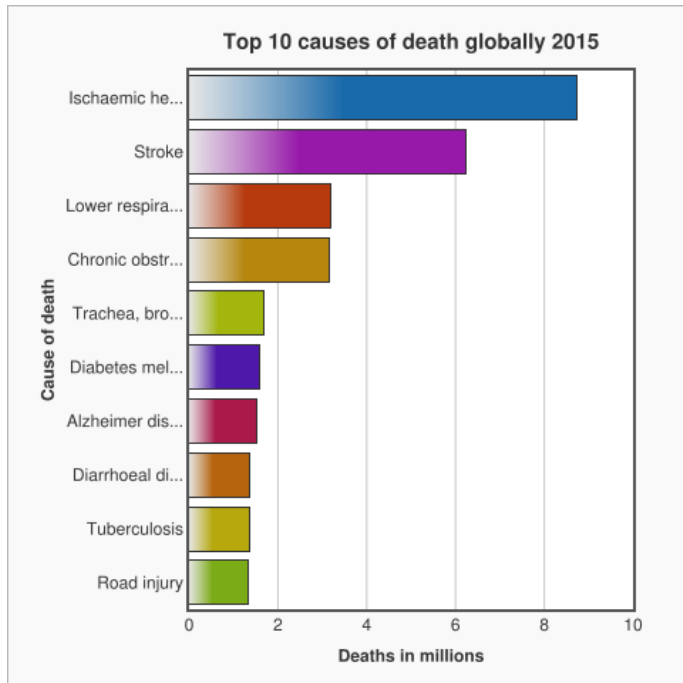


Actuarial  
Research Centre

Institute and Faculty  
of Actuaries



# Data selected for other target conditions and interventions



## Big Health Actuarial Data

Home Project Description The Team Publications Press Contact us

Big Actuarial Health Data > Home > Current research

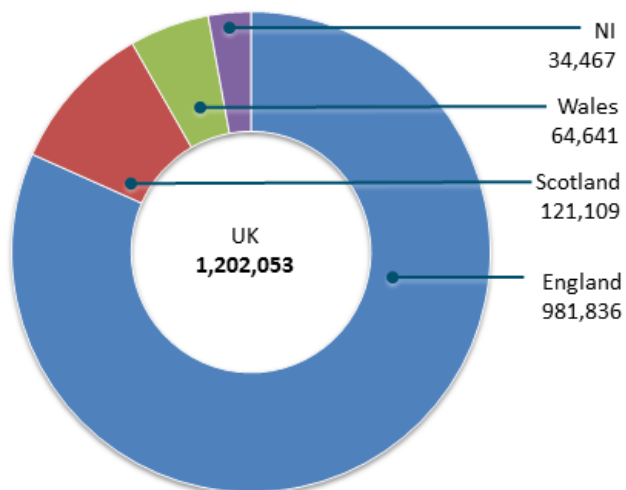
- Hypertension
- Myocardial infarction
- Statins
- Hormone replacement therapy
- Stroke
- Diabetes
- Hip replacement



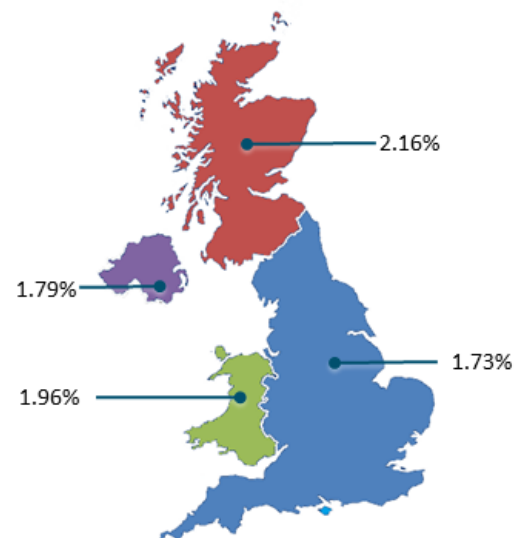
**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# PhD Study 1: Morbidity and Longevity after Stroke



Reference: Health and Social Care Information Centre.  
Quality and Outcomes Framework (QOF) – 2014-2015.



# Stroke study: brief description

(PhD student Padma Chutoo)

- The study is designed to model the impact of ischaemic stroke and transient ischaemic attack (TIA) on longevity and morbidity risks. The data is based on the UK THIN database.
- The study period is from 2004 up to 2017.
- Selection of cases: patients who have had the ischaemic or transient ischaemic attack type of stroke for the first time after 2004.
- Exclusion criteria: prior major cancers, dementia, heart failure, chronic kidney disease stages 3+ and haemorrhagic stroke.
- 83,379 cases were matched to 236,687 controls by practice, age and sex.
- The primary outcome is all-cause mortality. The secondary outcomes are further strokes, dementia, heart failure, myocardial infarction, pulmonary arterial disease.
- Variables of interest:
  - Antihypertensives, Anticoagulants, Lipid regulating drugs, Asthma, Atrial Fibrillation, Chronic Kidney Disease, Coronary heart disease, PAD, Hypothyroidism, COPD, Diabetes, Hypercholesterolemia, Hypertension, Depression, and Socio-economic status.



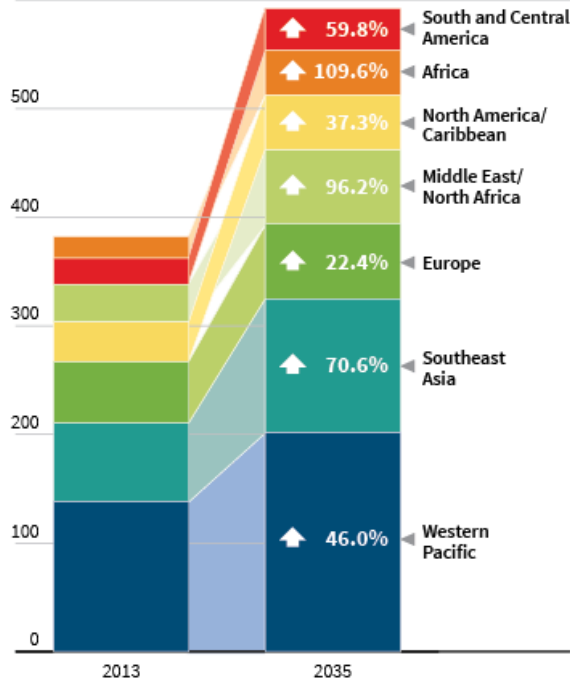
Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

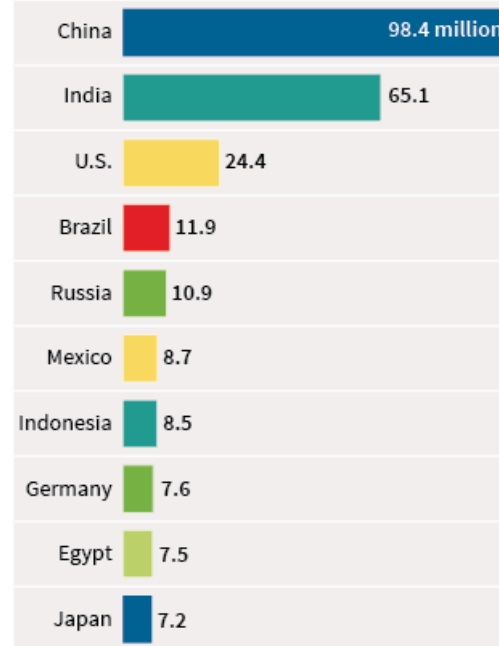
# PhD Study 2: Diabetes Mellitus Type 2

## World diabetes cases expected to jump 55 percent by 2035

Current and projected cases of diabetes by region  
600 million



Top 10 countries by number of people with diabetes in 2013, ages 20 to 79



Source: International Diabetes Federation

S. Culp, 12/11/2013

REUTERS



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# DM-II study: brief description

(PhD student Njabulo Ncube)

- The study is designed to model the impact of diabetes mellitus II (DM-II) on longevity and morbidity risks. The data is based on the UK THIN database.
- The study period is from 2004 up to 2017.
- Selection of cases: only DM-II cases diagnosed from 2004 and who had no other severe conditions diagnosed before DM-II diagnosis date were included.
- 138 979 cases were selected and matched to 299 429 controls by practice, age and sex (matching ratio 1:3).
- The primary outcome is all-cause mortality. The secondary outcomes are amputation, cognitive impairment, CKD 3-5, heart failure, myocardial infarction, pulmonary vascular disease, stroke, cancer and dementia.



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

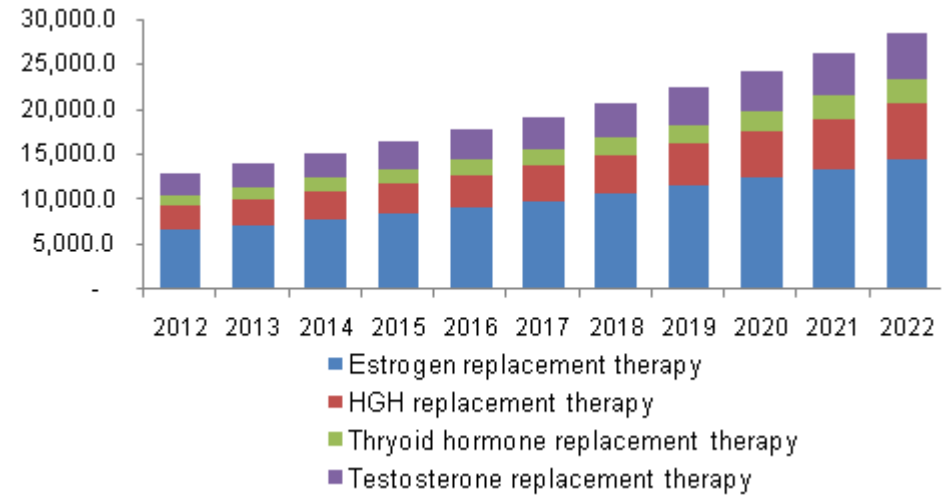
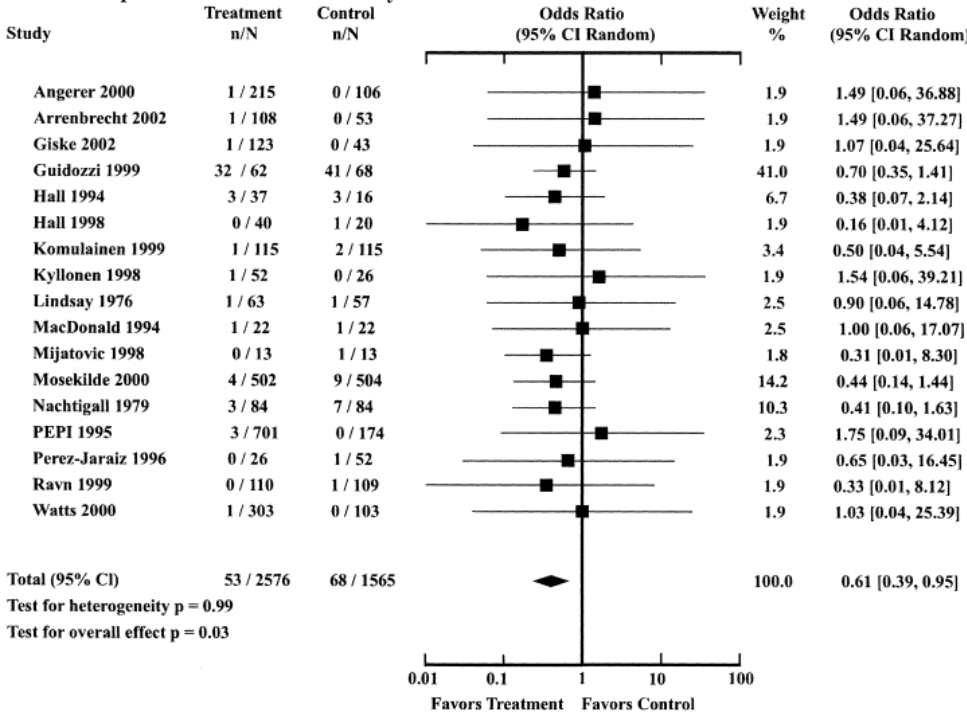


# PhD Study 3: Hormone Replacement Therapy

Medscape® www.medscape.com

Mean age < 60 years

Hormone replacement and total mortality



North America hormone replacement therapy market share, by product, 2012-2022 (USD Million)

<https://www.grandviewresearch.com/industry-analysis/hormone-replacement-therapy-market>



Actuarial Research Centre

Institute and Faculty of Actuaries

Salpeter et al., J Gen Intern Med. 2004;19(7)

# HRT study: brief description

(PhD student Nurunnahar Akter)

- The study is designed to model the impact of hormone replacement therapy (HRT) prescription on longevity and morbidity risks. The data is based on the UK THIN database.
- The study period is from 1984 up to 2017.
- Selection of cases: women aged 46 years and above who received any kind of oral and transdermal HRT.
- Exclusion criteria: prior cancers, acute myocardial infraction (AMI), serious heart failure, stroke (except TIA), chronic kidney disease (CKD) stage 3-5, dementia, oophorectomy before age 45, premature ovarian insufficiency, premature menopause and surgical menopause before age 46.
- 117,627 cases were matched to 251,461 controls by GP practice and age.
- The primary outcome is all-cause mortality. The secondary outcomes are osteoporosis, dementia, cardiovascular disease, cancer and diabetes.



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# Poll 3

Please type in a key word (or expression) that represents the most important takeaway from this webinar in your mind.



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# Summary

- Estimating longevity risk and evaluating associated uncertainty is one of the main topics of concern to actuarial community.
- Modelling mortality experience in individual level health data from large health databases can:
  - Establish and quantify the drivers of changes in longevity
  - Help predict how these drivers may change over time
- The results can be translated into individual and population level life expectancy changes.
- Models that allow for differences in prevalence/treatments within the population can be used to transpose results to apply to a sub-population (of insured lives, for example).



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# Summary

- Changes in the prevalence of the risk factor of interest are reflected in the life expectancy at the population level, illustrating:
  - how much the risk factor of interest has already contributed to changes in past longevity improvements and
  - how continuing trends of the prevalence of the risk factor of interest can affect future life expectancy.
- These calculations can be informative for mortality projections of populations of insureds and pension schemes.



Actuarial  
Research Centre

Institute and Faculty  
of Actuaries

# Summary

Case studies presented here on:

- Statin prescription
- Intensive systolic blood pressure control

Outline of other target conditions and interventions for the project:

- Stroke
- Diabetes Mellitus Type 2
- Hormone Replacement Therapy



# Questions

# Comments

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



**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# References

- Brenner H, Gefeller O, Greenland S. (1993) Risk and rate advancement periods as measures of exposure impact on the occurrence of chronic diseases. *Epidemiol Camb Mass.* 4(3):229–36.
- Gitsels LA, 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
- Gitsels LA, Kulinskaya E, Steel N Survival prospects after acute myocardial infarction in the UK: a matched cohort study 1987–2011 *BMJ Open* 2017;7:e013570. doi:10.1136/bmjopen-2016-013570.
- Spiegelhalter (2016) How old are you, really? Communicating chronic risk through ‘effective age’ of your body and organs. *BMC Medical Informatics and Decision Making*, 16:104
- The SPRINT Research Group. A Randomized Trial of Intensive versus Standard Blood-Pressure Control. *New England Journal of Medicine*, 2015 373:2103-2116, DOI: [10.1056/NEJMoa1511939](https://doi.org/10.1056/NEJMoa1511939)
- Whelton PK, Carey RM, Aronow WS, Ovbiagele B, Casey DE Jr, Smith SC, Collins KJ, *et al.* *High Blood Pressure Clinical Practice Guideline*. *Hypertension* 2017; 00:e000-e000.







**Actuarial  
Research Centre**

Institute and Faculty  
of Actuaries

# The Actuarial Research Centre (ARC)

## A gateway to global actuarial research

The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' (IFoA) network of actuarial researchers around the world.

The ARC seeks to deliver cutting-edge research programmes that address some of the significant, global challenges in actuarial science, through a partnership of the actuarial profession, the academic community and practitioners.

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

[www.actuaries.org.uk/arc](http://www.actuaries.org.uk/arc)