Institution: University of East Anglia

Unit of Assessment: 11 – Computer Science and Informatics

Title of case study: Improved evaluation of longevity and mortality risks within the actuarial profession and insurance industry

Period when the underpinning research was undertaken: 2010 – 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s)	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Elena Kulinskaya	Professor in Statistics (Aviva Chair in Statistics)	2010 - to present
Nicholas Steel	Clinical Professor in Public Health	2004 - to present

Period when the claimed impact occurred: 2016 - 2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

Statistical modelling of the effects of medical conditions on longevity and mortality risk, by Professor Kulinskaya and her research group within the School of Computing Sciences at UEA, has had a direct and demonstrable impact in three key areas:

- Involvement with the UK and international actuarial profession has resulted in improved pricing and reserving within the insurance and pensions sector.
- Uptake of improved mortality and life expectancy projections by the leading insurance provider Aviva has resulted in wider access to insurance and pension products for people with impaired health.
- Influence on UK and international health and social care policy makers.

2. Underpinning research

Since 2014, we have developed a methodology for modelling the impacts of chronic medical conditions, medical advances and health interventions on longevity and mortality risks at both individual and population level. Our methodology is based on advanced methods of design and statistical analysis of the observational data from big health administrative databases, such as The Health Improvement Network (THIN) primary care database and the National Joint register (NJR). It involves the following steps:

- design a longitudinal case-cohort study with the appropriate cohorts of cases and their controls selected from the big administrative dataset
- build a sophisticated survival model enabling evaluation of survival benefits or harms of particular chronic health conditions, treatments and public health interventions
- integrate these individual survival effects to evaluate population effects.

This approach was applied to three important examples of implemented or potential health interventions:

- The survival benefits of statins at key retirement ages were established and published in 2016 [1].
- The effects of a number of medical interventions on survival after heart attack were published in 2017 [2].
- Optimal systolic blood pressure targets were evaluated and published in 2019 [3].

In [1], we demonstrated that the current internationally recommended thresholds for statin therapy for primary prevention of cardiovascular disease in routine practice may be too low and may lead to overtreatment of younger people and those at low risk of heart disease.

In [2], we quantified the hazards of death after myocardial infarction and found them to be lower than reported by previous studies. We also found that standard treatments using aspirin or ACE inhibitors may be of little benefit or even cause harm.

In [3], we compared intensive control of systolic blood pressure (SBP) at 120 mmHg (which is being implemented in the US) to standard control at 140 mmHg and quantified life expectancy implications of the two target SBP levels. We concluded that intensive treatment of SBP may be harmful in the general population in the UK.

Our novel methodology of integrating individual effects into population level longevity changes is presented in [4, 5]. This integration requires a combination of parametric assumptions about the underlying survival distribution, such as the Gompertz or Weibull distribution, with a survival model incorporating a number of modifiers. The latter can use a Cox's regression when the proportional hazards assumption is satisfied, but may require more sophisticated modelling of shape and scale parameters. This "double-Cox" model was developed in [6].

Our research on methodology of incorporating results of survival modelling into evaluation of longevity and its applications to UK life expectancy changes was supported by a grant from IFoA. Development of novel survival models and their application to NJR data was supported by an ESRC BLG DRC grant.

3. References to the research

(UEA authors highlighted in **bold**)

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

2] Survival prospects after acute myocardial infarction in the United Kingdom: a matched cohort study 1987-2011
Gitsels, L.A., Kulinskaya, E. & **Steel, N.**
(2017) *BMJ Open,* 7(1) DOI: 10.1136/bmjopen-2016-013570

3] Optimal systolic blood pressure targets in routine clinical care
Gitsels, L.A., Kulinskaya, E., Bakbergenuly, I. & **Steel, N.**
(2019) *Journal of Hypertension*, 37:837–843. DOI: 10.1097/HJH.0000000000001947

4] How Medical Advances and Health Interventions Will Shape Future Longevity
Sessional paper and presentation, IFoA, Edinburgh, June 25 2018
Gitsels, L.A**, Kulinskaya, E**. & Wright, N.
(2019) *British Actuarial Journal*. DOI: 10.1017/S1357321719000059

5] Calculation of changes in individual and period life expectancy based on proportional hazards model of an intervention
Kulinskaya, E., **Gitsels, L.A.**, **Bakbergenuly, I.** and **Wright, N.R**
(2020) *Insurance Mathematics and Economics,* 93, 27-35.
DOI: 10.1016/j.insmatheco.2020.04.006

6] Risk-adjusted CUSUM control charts for shared frailty survival models with application to hip replacement outcomes: a study using the NJR dataset
Begun, A., Kulinskaya, E. & **MacGregor, A.J.**
(2019) *BMC Medical Research Methodology,* 19, 217. DOI: 10.1186/s12874-019-0853-2

Key Underpinning Funding

Project: Smart Data Analytics for Business and Local Government. (Co-I) Kulinskaya, E
Funder: ESRC BLG DRC award
Value: GBP1,233,622. Dates: Jan 2014 – Dec 2020

Project: Use of Big Health and Actuarial Data for understanding longevity and morbidity risks. (PI) Kulinskaya, E
Funder: Actuarial Research Centre, Institute and Faculty of Actuaries
Value: GBP790,537. Dates: 2016 - 2020

4. Details of the impact

UEA research has had impact in the following three areas.

1. Improved pricing and reserving within the insurance and pensions sector

We ensure that our research findings and methodologies are utilised by actuaries through our involvement with the Institute and Faculty of Actuaries (IFoA). This is the UK's only chartered professional body dedicated to the education, development and regulation of actuaries both in the UK and internationally. It represents and regulates over 30,000 members worldwide. Our impact generated with IFoA has primarily been through education and professional training. The Chair of the Research and Thought Leadership Board at the IFoA has stated:

> "*The research undertaken by Professor Elena Kulinskaya and her team at the University of East Anglia into understanding longevity and morbidity is a key component of our work to ensure that all members maintain their competence through a programme of Continuing Professional Development (CPD).*" [**corroborating source A**].

Examples of our impact through interaction with the IFoA include:

- Yearly webinars to actuaries in the UK and overseas where the key objective is to encourage a two-way dialogue and participation on the topics being researched. These events attract large actuarial audiences and are CPD accredited events for members of the IFoA [**corroborating source B**]. Two webinars created for the IFoA (2018 and 2019) were watched by 1,585 people with 1110 hours of CPD being recorded.
- On October 30, 2019, we provided a technical workshop at the IFoA, aimed at educating actuaries (83 attendees) in advanced statistical methods developed by the research team and their application [**corroborating source B**].
- We broaden access to our research findings through IFoA publications including the Actuary and the Longevity Bulletin [**corroborating source B**].
- To promote and embed our methods into actuarial practice, we were invited to participate in Working Parties by the IFoA, specifically the Working Party on Diabetes and the Working Party on Population Health Management. We also presented our results to the IFoA Health and Care Research Sub-Committee in 2018 and 2019 [**corroborating source B**].

To engage individual insurance and finance companies, we made a presentation to the Longevity Science panel at Legal and General (May 10, 2017), to Aviva Life actuaries (18 October 2018), to PWC pensions team (October 24, 2019) and to Just actuaries (24 February 2020). [**corroborating source C**]. Importantly, the Actuarial Research Council at the IFoA maintains a mirror of our UEA website to provide up-to-date and freely available information about our research to the actuarial community [**corroborating source D**].

A key mechanism for ensuring wider uptake of our research findings within the actuarial community has been presenting our findings at professional actuarial and statistical conferences, including International Congress of Actuaries (Berlin, June 2018), International Biometric Society Conference (2018), International Society for Clinical Biostatistics Conferences (2017, 2019), Mortality and Longevity Symposiums (2016), Life Conference (2017), Royal Statistical Society conference (2017, 2019) [**corroborating source C**].

2. Improved mortality and life expectancy projections resulting in wider access to insurance and pension products for people with impaired health

A key impact of our research is that it enhances the chances of people with certain health conditions, who had previously struggled to get insurance, of getting insured in the future. Our results on specific medical conditions and treatments have fed into and contributed to the underwriting of insurance longevity products in the following ways.

Aviva uses the results of our research in their underwriting, and our results help to quantify the

longevity assumptions necessary for numerous longevity and population projections. The importance to Aviva is confirmed in a letter from the Life Analytics Director:

> "*One of the risks that Aviva faces is the guaranteed income that Aviva promises to customers in annuity products. Our guarantee is based on an assessment of life expectancy and is underpinned by statistical models. Professor's Kulinskaya pioneering work on survival models and their linkage to individual and population life expectancy has provided Aviva with confidence that these guarantees are sound and robust.*"
> [**corroborating source E**]

We have developed a free "My Longevity" App aimed at both Insurance professionals and the general public which models the impact of lifestyle and health choices on life expectancy. Since its launch on September 3, 2020 there have been more than 800,000 visitors to the site, and more than 200,000 life expectancy calculations made [**corroborating source F**]. The accompanying optional survey produces feedback and allows users to communicate decisions the tool has influenced and therefore life expectancy gain for the user. Specific feedback from two users shows that the My Longevity App is providing long-anticipated answers to important societal questions:

> **"***As a kidney specialist writing medicolegal reports on Condition & Prognosis, I am often asked to give my opinion on life expectancy…. I have asked and asked statisticians if somehow I can manipulate risk ratios or hazard ratio data to give me amended life expectancy, and your paper is the first I have found to address this issue…. Your on-line calculator is amazing and just what everyone is looking for*."
>
> "*Congratulations on what is a great development. Very easy to use and a clear result!.... We are looking to help our potential customers / community members understand the biological age, health span and lifespan expectations and obviously your app would be an interesting tool that people could use plus there are some interesting developments that could be looked at.*"
> [**corroborating source F**]

3. Influencing UK and international policy makers

To engage in dialogue with public bodies and policy makers, in 2018 we organised a one-day workshop entitled **"The impact of medical advances and health interventions on longevity and population projections**", for over 40 attendees [**corroborating source G**]. The workshop explored how various wide-scale medical advances or health interventions, for example via changes in *National Institute for Health and Care Excellence* (NICE) guidelines, may impact on longevity and therefore necessitate changes in population projections. The consequent impact on a variety of policies and business models, from public health to pensions and insurance products was also covered. Invited stakeholders included: Office for National Statistics, Department for Work and Pensions, Department of Health, Government Actuary's Department, NICE, Royal Statistical Society, World Health Organization, World Bank, BPI Pension Trust, and, from within the IFoA: Steering Group members; Practice Board and Research Committee Representatives; Mortality Research Steering Committee; Relevant Working Parties; Policy and Public Affairs. An article written by Jules Constantinou, the IFoA President highlighted the success of the impact workshop and sessional. [**corroborating source H**]

In parallel, a high-level summary of our research findings was included in the IFoA's response to the LSE-Lancet Commission call for evidence on the future of the NHS (2018) [**corroborating source I**], and to the joint consultation between the Department for Health and Social Care and the Cabinet Office on *Advancing our Health: prevention in the 2020s* (2019) [**corroborating source J**].

5. Sources to corroborate the impact

[A] Testimonial letter from the Chair of the Research and Thought Leadership Board, Institute and Faculty of Actuaries, 12/01/2021

[B] Interaction with the IFoA through:

Presentations:

1) Webinar "Use of Big Health and Actuarial Data for Understanding Longevity and Morbidity" (13/06/2017) (461 views by 10/01/2020) Downloaded from YouTube and stored on file at UEA.
2) Webinar "Use of Big Health and Actuarial Data for Understanding Longevity and Morbidity" (17/09/2018) (280 views by 10/01/2020) Downloaded from You Tube and stored on file at UEA.

IFoA technical workshop:

3) Technical Workshop "Beyond Proportional Hazards" (30/10/2019) (87 views by 04/02/2021) Downloaded from You Tube and stored on file at UEA

Dissemination via professional actuarial publications:

4) Kulinskaya E and Gitsels LA (2016) Use of big health and actuarial data for understanding longevity and morbidity risk. *Longevity Bulletin by IFoA, Issue 9: Big Data in Health.* ISSN 2397-7213. Page 15 ff.
5) Gitsels LA and Kulinskaya E. (2018) "Statins: figures on the pulse" *The Actuary*

Presentations to the IFoA Health and Care Research Sub-Committee:

6) At the IFoA, London on 12 September 2018 and 24 October 2019

[C] Details of conference presentations, and presentations to individual insurance and finance companies

[D] Mirror of UEA website from actuaries.org.uk - accessed on 04/02/2021

[E] Testimonial from the Life Analytics Director of Aviva, 23/11/2020

[F] MyLongevity App (pages 1 – 2), Google Analytics (pages 3 – 5) and feedback (pages 6 -15)

[G] One-day workshop "The impact of medical advances and health interventions on longevity and population projections**"** (17/05/2018) (213 views by 4/02/2021) Downloaded from You Tube and stored on file at UEA

[H] Article by the IFoA President entitled 'Big Health, Big Impact Big Data' published in The Actuary magazine, July 2018 edition. Page 5 ff.

[I] IFoA's response to the LSE-Lancet Commission: the future of the NHS call for evidence, 30 July 2018.

[J] IFoA's presentation to the joint consultation between the Department for Health and Social Care and the Cabinet Office: Advancing our health: prevention in the 2020s, October 2019.