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| **1. Summary of the impact**Research modelling the effect 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 on **the UK and international actuarial community** in three key areas:* Involvement with the actuarial community 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.
* Influencing UK and international health and social care policy makers.
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| **2. Underpinning research** Kulinskaya joined UEA in March 2010 as the *Aviva Chair in Insurance Statistics,* bringing with her expertise in health applications of multivariate statistical methods. Since 2014, Kulinskaya and co-authors 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. The 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,
* and integrate these individual survival effects to evaluate the 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],
* and 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 less than reported by previous studies. We also found that standard treatments of 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 to 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 complicated 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 the grant from IFoA [reference?]. Development of novel survival models and their application to NJR data was supported by ESRC BLG DRC grant [reference?]. |
| **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.01668471. Survival prospects after acute myocardial infarction in the United Kingdom: a matched cohort study 1987-2011

**Lisanne Gitsels, Elena Kulinskaya** & **Nicholas Steel** (**2017**) *BMJ Open* 7(1) DOI: 10.1136/bmjopen-2016-0135701. Optimal systolic blood pressure targets in routine clinical care

**Gitsels LA, Kulinskaya E., Bakbergenuly, I.** & **Steel N.** (**2018**) *Journal of Hypertension*, 2019, 37:837–843 DOI: 10.1097/HJH.00000000000019471. How Medical Advances and Health Interventions Will Shape Future Longevity

Sessional paper and presentation, IFoA, Edinburgh, June 25 2018**Gitsels LA, Kulinskaya E**. & **Wright N.**(**2019**) *British Actuarial Journal*, DOI: 10.1017/S13573217190000591. Calculation of changes in individual and period life expectancy based on proportional hazards model of an intervention.

Kulinskaya E., Gitsels, LA., Bakbergenuly, I. and Wright N.R *Insurance Mathematics and Economics* 2020, 93, 27-35  [https://doi.org/10.1016/j.insmatheco.2020.04.006](https://eur01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fdoi.org%2F10.1016%2Fj.insmatheco.2020.04.006&data=04%7C01%7CJ.Farrar%40uea.ac.uk%7C52140d480cfc4a0d217f08d8be0a3eb5%7Cc65f8795ba3d43518a070865e5d8f090%7C0%7C0%7C637468298494736951%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=iymtaE0UxaBukS4fu%2BA2mYaDdV7RHpOmbogCHNU9CXQ%3D&reserved=0)1. 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  |
| **4. Details of the impact** Our 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 the IFoA, UK’s only chartered professional body dedicated to the education, development and regulation of actuaries both in the UK, and internationally, representing and regulating over 30,000 members worldwide. This involvement 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).” [Source A]. Examples of our impact through the IFoA CPD programme 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 IFoA [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 IFoA, aimed at educating the actuaries in advanced statistical methods developed by the research team and their application, 83 attendees [Source B].
* We broaden access to our research findings through IFoA publications including the Actuary and the Longevity Bulletin [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 [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). [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 from our research to the actuarial community [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, 2019), Life Conference (2017), Royal Statistical Society (RSS) conference (2017, 2019) [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 from our research is to enable people with certain health conditions who had previously struggled to get insurance, to get insurance in the future. Our results on specific medical conditions and treatments have fed into and contribute 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.” [Source E]We have also 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 launch on September 3, 2020 there have been 813,000 visitors to the site, and 248,204 life expectancy calculations made [Source F]. The accompanying optional survey produces feedback and allows users to communicate what decisions the tool has influenced and therefore how much life expectancy gain the user may achieve. Specific feedback from two users shows that the My Longevity App is providing much-awaited 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.” [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**”, over 40 attendees[Source G]. The workshop explored how various wide scale medical advances or health interventions, for example changes in *National Institute for Health and Care Excellence* (NICE) guidelines, may change longevity and therefore necessitate changes in population projections, and hence a variety of policies and business models, from public health to pensions and insurance products. 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. [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) [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) [Source J]. |
| **5. Sources to corroborate the impact** [A] IFoA testimonial[B] Interaction with the IFoA through:**Presentations:**a) Webinar “Use of Big Health and Actuarial Data for Understanding Longevity and Morbidity” (13/06/2017) <https://www.youtube.com/watch?v=CHrCNb0Sj2w&list=PLTH4sS-tsiG8f13gGxrlO22NroLo44TdE&index=2> (461 views by 10/01/2020)b) Webinar “Use of Big Health and Actuarial Data for Understanding Longevity and Morbidity” (17/09/2018) <https://www.youtube.com/watch?v=Gq6w8Zkdp1Q&index=10&list=PLTH4sS-tsiG8f13gGxrlO22NroLo44TdE> (280 views by 10/01/2020)c) Presentation “How Medical Advances and Health Interventions Will Shape Future Longevity” at the Royal College of Physicians, Edinburgh (25/06/2018) <https://www.youtube.com/watch?v=cv0f9MMh_t4&feature=youtu.be> (181 views by 10/01/2020)d) Webinar “Use of Primary Health Care Records Data in Actuarial Research” (09/03/2021)**Dissemination via professional actuarial publications:**1. 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.

Gitsels LA and Kulinskaya E. (2018) “Statins: figures on the pulse” *The Actuary* <http://www.theactuary.com/features/2018/08/statin-prescription-figures-on-the-pulse/>**IFoA technical workshop:** (filmed and available on YouTube). <https://www.youtube.com/watch?v=SwrfQ9y9zr4> <https://www.youtube.com/watch?v=25qa37Uxczk> **Presentations to the IFoA Health and Care Research Sub-Committee:**At the IFoA, London on 12 September 2018 and 24 October 2019[C] **Conference presentations**a) International Congress of Actuaries (Berlin, June 2018), b) International Biometric Society Conference (2018), c) International Society for Clinical Biostatistics Conferences (2017, 2019), d) Mortality and Longevity Symposiums (2016, 2019), e) IFoA Life Conference (2017), f) Royal Statistical Society conference (2017, 2019).g) IFoA Protection, Health & Care Conference(2019)h)The 2nd Insurance Data Science Conference (Zurich, Switzerland, June 2019)i) The Online International Conference in Actuarial Science, Data Science and Finance (OICA), 28-29 April 2020**Presentations to insurance and finance companies**a) Longevity Science panel at Legal and General (May 10, 2017)b) Aviva Life actuaries (18 October 2018)c) PWC pensions team (October 24, 2019) d) Just actuaries (24 February 2020)[D] mirror of UEA website <https://www.actuaries.org.uk/learn-and-develop/research-and-knowledge/actuarial-research-centre-arc/research-programmes/use-big-health-and-actuarial-data-understanding-longevity-and-morbidity-risks> [E] Aviva Testimonial[F] MyLongevity App, Google Analytics and feedback[G] One-day workshop entitled “The impact of medical advances and health interventions on longevity and population projections**”** 17 May 2018, available on YouTube at: <https://www.youtube.com/watch?v=cv0f9MMh_t4&t=9s>[H] Article by the IFoA President entitled ‘Big Health, Big Impact Big Data’ published in The Actuary magazine, July 2018 edition. [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 on [Advancing our health: prevention in the 2020s](https://eur01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.gov.uk%2Fgovernment%2Fconsultations%2Fadvancing-our-health-prevention-in-the-2020s%2Fadvancing-our-health-prevention-in-the-2020s-consultation-document&data=02%7C01%7Ce.kulinskaya%40uea.ac.uk%7C1391c14ee2ca48deb3f208d748f16e18%7Cc65f8795ba3d43518a070865e5d8f090%7C0%7C1%7C637058074595040924&sdata=xOdbooFOjI0ncIxkOYDc3sN7HVceoSmGirnSyC5B5Sc%3D&reserved=0), October 2019. |

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