Institution: University of Southampton		
Unit of Assessment: 20 Social Work and Social Policy		
Title of case study: 20-04 How Long Do We Live? Improving the life expectancy estimation in English Life Tables 17 for better social policy		
Period when the underpinning research was undertaken: 2009 – 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:**
Jakub Bijak Jason Hilton	Professor of Statistical Demography Lecturer in Social Statistics and Data Science	February 2009 – present January 2016 – present
Period when the claimed impact occurred: September 2015 – December 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Novel methods for estimating mortality, developed at the University of Southampton, underpin the latest decennial life tables: the English Life Tables No. 17 (ELT 17). Being a core component of UK official statistics, published by the Office for National Statistics, the English Life Tables provide a snapshot of a country's mortality experience and are seen as robust indicators of the health of the nation, life expectancy trends and age-specific mortality patterns. Using an innovative approach to life expectancy estimation, the research has had an instrumental impact on UK policy and practice. The new methods used in ELT 17 have strengthened government policymaking around social security and health and social care provision. They have also enabled insurance companies and pension providers to make more accurate assessments of actuarial risk. The research was key to the award of the 2020 ESRC Celebrating Impact Prize for Outstanding Public Policy Impact.

2. Underpinning research

Since its inception in 2009, the University of Southampton's ESRC Centre for Population Change (CPC) [**G1**] has become a world-leading demographic research centre, establishing itself as an international authority on population change, being at the forefront of methodological innovation in statistical demography. A key pillar of CPC research activity over this period has been to develop robust methods for estimating current, and forecasting future, populations - with a focus on the UK [**3.1, 3.2**]. These estimates and forecasts underpin many areas of social policy and planning, from pensions and national healthcare systems, to business decisions, including insurance pricing.

One of the individual demographic processes the CPC has been leading on is human mortality – how long people in the UK can be expected to live, how this will evolve over time, and how uncertain the estimates and predictions are [**3.3, 3.4, 3.5**]. Aside from being essential to the production of population statistics, mortality estimates and forecasts are of direct interest to public and private stakeholders seeking to make prudent yet efficient decisions in the fields of social security and healthcare provision, as well as life and health insurance.

Methodological research into mortality estimates and forecasts has been carried out since 2015 within the CPC Modelling strand, jointly led by Professor Jakub Bijak together with statistician Professor Peter W F Smith. The work was a part of ongoing research funded by the Office for National Statistics (ONS) on developing new life table estimation methods, first commissioned in 2014 and subsequently followed up by further research on methodology for setting future mortality assumptions [**G2**].

Within the CPC Modelling strand, the model development work was initially led by Professor Jonathan J Forster and Dr Erengul Dodd (UOA 10 Mathematical Sciences), with Dr Jason Hilton (who joined the group in January 2016) taking the lead role on a subsequent project [**3.4**]. The research conducted by the CPC makes substantial advances in the area with important policy implications. Naive estimates and forecasts of mortality rates may be unduly influenced by chance variations in deaths, particularly at the oldest ages where the populations involved are

small but growing. Estimates and forecasts of mortality rates must avoid these pitfalls. A failure to quantify the extent of possible under- or over-estimation of rates may leave governments and business unnecessarily exposed to mortality risks. The CPC work has demonstrated the importance of proper assessment of uncertainty of future population projections, which include mortality as their key component [**3.1, 3.2**]. In order to provide the stakeholders the best mortality estimates and forecasts, the variability of mortality needs to be properly calibrated for all different age groups, unlike in many state-of-the-art methods. To fill this gap, as part of the work for the ONS, flexible methods for estimating [**3.3**] and subsequently predicting future mortality [**3.4, 3.5**] have been developed.

The key methodological innovation of the approach proposed by the CPC team has been to allow mortality at different stages of human life to be described by different, but closely interconnected, models. This effectively combined two distinct approaches over different age ranges into a single life table estimate. By developing appropriate statistical methodology, the research team was able to integrate the two models in a smooth and coherent way. This allowed more fine-grained life expectancy estimation especially at the highest ages, with direct applications for social policy.

This innovative approach was applied first to the English Life Tables No. 17 for 2010-2012 [**3.3**], published in 2015. These decennial life tables for England and Wales are official publications that have been produced by the statistical authorities after every census since 1841 (with the exception of 1941 when no census was carried out). The English Life Tables are designed to provide period life expectancy by age and single year of age in the three-year period around the census year. The new method developed by the University of Southampton team at CPC enabled the ONS to efficiently deal with the challenges posed by the sparse data in the oldest age groups. The approach, and its subsequent extensions to models for mortality forecasting, offers an elegant, integrated solution to many practical challenges posed by an ageing population and uncertain increases in longevity.

3. References to the research

3.1 Wiśniowski A, Smith PWF, Bijak J, Raymer J and Forster JJ (2015). Bayesian population forecasting: extending the Lee-Carter Method. *Demography*, 52(3), 1035-1059. https://doi.org/10.1007/s13524-015-0389-y

3.2 Shang HL, Smith PWF, Bijak J and Wiśniowski A (2015). A multilevel functional data method for forecasting population, with an application to the United Kingdom. *International Journal of Forecasting*, 32(3), 629-649. https://doi.org/10.1016/j.ijforecast.2015.10.002

3.3 Dodd E, Forster JJ, Bijak J and Smith PWF (2018). Smoothing mortality data: the English life table, 2010-12. *Journal of the Royal Statistical Society. Series A: Statistics in Society*, 181(3), 717-735. https://doi.org/10.1111/rssa.12309

3.4 Hilton J, Dodd E, Forster JJ and Smith PWF (2018) Projecting UK mortality by using Bayesian generalized additive models. *Journal of the Royal Statistical Society. Series C: Applied Statistics*. 68 (1) 29-49 https://doi.org/10.1111/rssc.12299

3.5 Dodd E., Forster J.J., Bijak J. & Smith P.W.F. (2020) Stochastic modelling and projection of mortality improvements using a hybrid parametric/semi-parametric age–period–cohort model, *Scandinavian Actuarial Journal*, https://doi.org/10.1080/03461238.2020.1815238

Grants and contracts:

G1 ESRC Centre for Population Change, consortium led by the University of Southampton (PI: Jane Falkingham); Phase I 2009–2013 (£5,388,177), and Phase II 2014–2019 (£5,388,048)

G2 University of Southampton – Office for National Statistics research contract: Provision of Research Services in Statistical Methodology, 2010-2015 (£1,060,865), 2016-2020 (£585,881)

4. Details of the impact

In our ageing society, the question ‘How long do we live?’ needs to be answered with confidence if increasingly complex policy and business challenges are to be met. CPC research into the design and implementation of a new method for life expectancy estimation has had a direct

impact on a key component of UK policy: the provision of new statistical insights into mortality patterns to inform better decision making. Published by the ONS, the CPC estimates have had a far-reaching, sustained impact on a broad range of end-users of mortality estimates and projections across the public and private sectors [**5.1**, **5.10**].

UK population statistics and the 'health of the nation'

The ONS took up the method proposed by the CPC team and made it the basis of the official English Life Tables No. 17. They were published on the ONS website (together with the accompanying methodology document), Gov.uk and the British Library website [**5.10**]. The Southampton research thus became a key part of UK official statistics, providing continuity to the series that has been ongoing since 1841, and thus being "of historical significance" [**5.1**], while providing a much-needed update to its methodological novelty and rigour, especially for old-age mortality.

In methodological terms, the ONS stated that the approach underpinning ELT 17 based on CPC research "provide[s] a better progression of mortality rates at [older] ages and, indeed, are the only officially published mortality rates by single year of age above age 99." [**5.1**] Thus, the decennial ELT 17 estimates offer a 'gold standard' benchmark for the annual life tables produced by the ONS to ensure they remain "fit for purpose" [**5.1**] – it is widely acknowledged, including by the ONS, that the latter "do not provide a good indicator of the levels of and trends in mortality rates at the very oldest ages", and so need verifying [**5.1**].

The Principal Methodologist at the ONS stated: "The decennial life tables provide insights into life expectancy trends and age-specific mortality patterns in the population over a long period of time. This makes them a valuable indicator of the health of the nation. They inform policy regarding state pension age, and they support the assessment of risk for life assurance and pension liability." [**5.10**] The publication of the ELT 17 resulted in widespread media coverage, including in The Guardian, The Telegraph, The Daily Mail and The Mirror [**5.10**]. The ONS wrote: "The press has focused mainly on the rising life expectancy at birth over decades, the comparison of mortality experiences between the UK and other countries, the narrowing gender gap in life expectancy and the possible effect of improving mortality on the state pension age. Each of these topics is a critical social policy concern and the decennial life tables are crucial to inform the debate." [**5.10**] The single document ELT 17 was "downloaded over 1,100 times in the first few months after release", with nearly 3,000 visits to the webpage over that period [**5.10**].

Ongoing collaboration between the ONS and the CPC has ensured continuing impact of our research on different aspects of mortality statistics. Most importantly, the ONS uses life tables to inform the assumptions of future mortality for the National Population Projections (NPP). Based on the ELT 17 work, the ONS commissioned a review of its NPP mortality assumptions, carried out by the CPC team in 2016-18. The NPP inform national policy, resource allocation and planning.

In November 2020, the impact of the CPC's work was recognised with an ESRC Celebrating Impact Prize for Outstanding Public Policy Impact. On the award of the prize, the UK's National Statistician said: "*Without this rigorous assessment and methodological progress, we don't have accuracy. And without accuracy, we are unable to efficiently plan for the future and govern effectively."* [**5.9**] Commenting that he had "*no doubt that the work of the CPC has had an impact on policymaking in the UK"*, he said CPC research had improved the measurement of mortality and provided "*vital socioeconomic evidence that will help our society to progress."* [**5.9**].

Public policy: social security and health and social care

Aside from the ONS, the key government users of the life tables and thus, more broadly, the resulting estimates and forecasts of mortality and life expectancy, are: HM Treasury, Department of Work and Pensions (DWP), Government Actuary's Department (GAD), Department of Health and Social Care (DHSC) and Health Authorities, and the National Records of Scotland, Northern Ireland Statistics and Research Agency and Welsh Assembly [**5.1**].

GAD, DWP and the Treasury use mortality estimates and forecasts chiefly to ensure the stability and resilience of social security and pension systems. GAD uses estimates of life expectancy to provide direct input into the national pension calculations [**5.2**]. GAD's work impacts, in turn, on

policy decisions taken by DWP [**5.3**, **5.11**]. The report in **5.2** was used by DWP to inform its review [**5.3**], published in July 2017, into the State Pension age, which announced a new timetable for the rise to 68 "to maintain fairness between generations in line with continuing increases in life expectancy". It cited ONS population data, including ELT 17 as "one of the key building blocks" [**5.11**].

The significance of ELT 17 for the formulation of pension policy is corroborated by DWP's Pensions Model Development and Forecasting Hub [**5.11**]. The Head of the DWP Hub wrote:

> *"This data influences Government decision-making about what age a State Pension and other related benefits can be paid, and … informs government forecasting and budgets for the welfare system and any costs and impacts on the people of the UK of changes to policy … The work the University of Southampton researchers have done and continue to do on improving accuracy of population estimates in relation to later life is therefore helping us to more accurately estimate the impact of policy changes, and hence improve decision-making."* [**5.11**]

Other policy applications range from national use (e.g. being used by Public Health England in their reports on life expectancy trends at the oldest ages [**5.5**]), to global influence through referencing by the World Health Organisation [**5.6** p32].

The private sector: actuarial risk assessment

The life tables are widely used by insurance companies, the actuarial profession and financial advisors/consultants to assess risk for life assurance and pension liability [**5.1**]. In particular, the applications in the actuarial industry are of crucial importance, as they lead to more realistic and fairer pricing of life and health insurance products, such as life insurance policies or annuities. For the age range where the portfolio data of the insurance company lacks reliability, relevant population data is used to inform the graduation and close-off portfolio mortality tables at the oldest ages [**5.4**]. For example, the Continuous Mortality Investigation (CMI) of the Institute and Faculty of Actuaries, provides independent life tables for UK life insurers and pension funds. The CMI uses ELTs in their high age mortality research as these tables provide official figures for mortality by single year of age for the oldest ages. The old-age methodology that the CPC team developed in ELT 17 was cited in a 2015 report by the CMI's High Age Mortality Working Party [**5.7**], whose principal aim is to quantify the financial impact of mis-estimating old-age mortality and identify solutions to address it. Their follow-up report in 2017 compared their proposed method for high-age mortality projections with ELT 17, in effect using it to evidence the robustness of their approach [**5.7**].

Life tables also have an important role to play in reducing systemic risks within the financial system. ELT 17 has been used by financial organisations as a standard by which to assess their exposure to the risks associated with changes in mortality. For example, Healthy Investment is a UK-based mutual friendly society that provides ethical savings and investment products. Its 2018 accounting report demonstrates that it relies on ELT 17 to produce its long-term insurance and investment contract liability valuation assumptions [**5.8** p58]. Such calculations were requirements of the macro-prudential regulations set out in the Solvency II framework, the harmonised and robust regulatory framework for insurance firms in the EU.

In summary, the research on human mortality by UoS researchers within CPC has strengthened government policymaking around social security and health and social care provision. The research has also enabled insurance companies and pension providers to make more accurate assessments of actuarial risk, impacting on decisions around health insurance premiums, life insurance linked to mortgages and annuity rates. Better data has supported better decisions and through this has positively impacted upon people's lives across the UK and Europe.

5. Sources to corroborate the impact

Publications and reports:

5.1 Office for National Statistics (2015) Statistical bulletin: English Life Tables No.17: 2010 to 2012.https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/englishlifetablesno17/2015-09-01

5.2 GAD (2017) Periodic review of rules about State Pension age. Report by the Government Actuary. Government Actuary's Department, London (see chapter 5). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/603139/print-ready-periodic-review-of-rules-about-state-pension-age-gad-report.pdf

5.3 DWP (2017) Press Release: New timetable for State Pension changes to maintain fair and sustainable pension. Department for Work and Pensions, London. https://www.gov.uk/government/news/new-timetable-for-state-pension-changes-to-maintain-fair-and-sustainable-pension

5.4 Continuous Mortality Investigation (2017) High Age Mortality Working Party, Working paper 100: A second report on high age mortality. Institute and Faculty of Actuaries, London. https://www.actuaries.org.uk/documents/cmi-working-paper-100-second-report-high-age-mortality

5.5 Public Health England (2016) Recent Trends in Life Expectancy at Older Ages: Update to 2014. Public Health England, London. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/499252/Recent_trends_in_life_expectancy_at_older_ages_2014_update.pdf

5.6 WHO (2016 p32) WHO methods and data sources for life tables 1990-2016. World Health Organization, Geneva, http://www.who.int/healthinfo/statistics/LT_method.pdf

5.7 Continuous Mortality Investigation (2015) High Age Mortality Working Party, Working paper 85: Initial report on the features of high age mortality. Institute and Faculty of Actuaries, London. https://www.actuaries.org.uk/system/files/field/document/cmiwp85-v2.pdf

5.8 Healthy Investment (2019) Annual Report and Accounts 2018, https://www.healthyinvestment.co.uk/storage/2019/04/Annual-Report-and-Accounts-2018.pdf

5.9 Economic and Social Research Council (2020), Celebrating Impact Price 2020. ESRC, Swindon. https://esrc.ukri.org/files/research/celebrating-impact-prize/esrc-celebrating-impact-prize-2020/ (including corroborating comments from the UK's National Statistician).

User / beneficiary statements:

5.10 Dr Louisa Blackwell, Principal Methodologist, Demographic Methods Centre, Office for National Statistics

5.11 James Rees, Head of Pensions Model Development and Forecasting Hub, Pensions and Later Life Analysis, Department for Work and Pensions