



Institute
and Faculty
of Actuaries

Universe of Longevity Catalysts Call for Research

Part of the development of a UK population
Cause of Death Model by the Mortality
Research Steering Committee

5th February 2021

Universe of Catalysts

Authors and Contributors

Name	Role	Contribution
Caroline Roberts		Author

Reviewers

Name	Role	Review Scope
Sacha Dhamani Steve Bale Adrian Gallop		Feedback and comment

Contents

1	Introduction	3
2	Catalysts.....	4
3	Driver Groups	9
4	The impact of catalysts on driver groups	12
5	Call for Research.....	22

1 Introduction

1.1 Background

The Mortality Research Steering Committee (MRSC) has undertaken to produce a model that provides a method of deriving plausible population mortality improvement assumptions for the UK general population by looking at data showing deaths by cause, and then considering how these may change in the future as a result of longevity 'catalysts'.

There are vast numbers of different causes of death, which are recorded according to an International Classification of Disease (or ICD) code. The different causes of death will be grouped into different 'disease groups' for projection purposes.

In order to produce a projection of how mortality rates will change in the future for each cause of death, it is important to firstly understand what are the catalysts that have impacted mortality rates in the past before we can go on and produce a model of how the catalysts will have an impact in the future.

As a first stage of gaining understanding and knowledge of what these catalysts are and how they are expected to impact mortality rates, we are putting out a 'call for research'. We are asking people to identify and inform us of research on the effects of the different longevity catalysts that we have identified. We are looking for the research to provide some or all of the following pieces of information for various catalysts:

- What has been the historic impact of the catalyst and what change in trend has it driven and what is the time period over which the catalyst has exhibited the changes?
- What are the future expectations of the catalyst and how is it expected to change current and future trends?
- Which disease groups is the catalyst expected to impact, and what is the expected impact on the mortality rates?

1.2 Objectives

The aim of this paper is to firstly define a total universe of material catalysts that will cover all the elements that affect mortality, both past and future. These drivers cover:

- Politics and Economics
- Climate and Environment
- Medical Interventions
- Social Trends
- Technological Advances

The paper will then go on to describe which catalysts are expected to impact which of the disease groups. The final section sets out the help that the MRSC need with respect to identifying research that can be used as evidence to help parameterise the resulting model.

Speculations regarding novel conditions that may arise in the future as a result of existing or future catalysts are out of scope of the model and hence this paper.

2 Catalysts

This section sets out historical, current and future catalysts that are driving the changes in mortality rates. There is a separate section that considers the catalysts that have or may arise as a result of COVID-19.

2.1 Historical catalysts

These are assumed to be catalysts that are now so intrinsic to everyday life that they are no longer affecting observed mortality improvement – although the reversal of any of these catalysts are likely to have an impact. Only catalysts that have impacted mortality rates in the last 30 years are included.

Catalysts that Extend Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> • Benefits to ensure a minimum standard of living • Smoking banned in public places • Introduction of plain cigarette packing • Raising of the school leaving age (thus improving education levels)
Climate and Environment	<ul style="list-style-type: none"> • Smokeless fuel requirements in cities (thus reduced incidence of smog)
Medical Interventions	<ul style="list-style-type: none"> • Surgical techniques including: <ul style="list-style-type: none"> ○ Heart bypass ○ Transplant operations • Programme of vaccinations including <ul style="list-style-type: none"> ○ HPV • Introduction of Breast Cancer Screening in 1988 • AIDS Treatment
Social Trends	<ul style="list-style-type: none"> • Change in work patterns – general changes and specific change in the form of the reduction in the mining industry
Technological Advances	<ul style="list-style-type: none"> • Development of MRI

Catalysts that Reduce Lifespan

(None identified)

Category	Catalysts
Politics and Economics	
Climate and Environment	
Medical Interventions	
Social Trends	
Technological Advances	

2.2 Continuing catalysts

These are catalysts that are continuing to affect observed mortality improvement

Catalysts that Extend Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> • Sugar tax • Agreements to reduce salt and artificial trans-fats in processed food • Quality Outcomes Framework implemented across GP practices
Climate and Environment	<ul style="list-style-type: none"> • Reduced reliance on coal fired fuels • Measures to reduce pollution and carbon emissions, such as the introduction of the congestion charge in London and a move away from natural fuels to electric cars
Medical Interventions	<ul style="list-style-type: none"> • Drugs for treatment of cholesterol / hypertension • Use of diagnostic biomarkers • Cancer Medical Improvements: <ul style="list-style-type: none"> ○ Various screening programmes including cervical screening, mammograms, bowel cancer screening ○ Chemotherapy ○ Improved imaging techniques ○ Immunotherapy for use in liquid cancers • Transplant developments • Enhanced access to stroke services and brain health clinics • Cures for Hep C and HIV • CVD Medical Improvements: <ul style="list-style-type: none"> ○ Statins ○ CPR ○ Angioplasty and CABG ○ Implants such as LVADs
Social Trends	<ul style="list-style-type: none"> • Reduction in smoker propensity • Improving quality of diet and level of exercise
Technological Advances	<ul style="list-style-type: none"> • Development of vaping as an alternative to smoking • Wearable tech • Technologies that increase social engagement and reduce social isolation in the elderly

Catalysts that Reduce Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> • Introduction of austerity in 2010
Climate and Environment	<ul style="list-style-type: none"> • Increasing air pollution from increased use of diesel cars
Medical Interventions	<ul style="list-style-type: none"> • Antibiotic resistance
Social Trends	<ul style="list-style-type: none"> • Rising obesity and diabetes due to a combination of: <ul style="list-style-type: none"> ○ Reduced levels of physical activity due to increased car use ○ Increase in 'deskbound' jobs ○ Decline in home cooking skills ○ Highly processed foods are cheap (often cheaper than cooking from scratch) and readily available • Poor and high carbohydrate diets, possibly the cause of increase in NAFLD • Alcohol consumption and recreational drug use • Social Isolation
Technological Advances	<ul style="list-style-type: none"> • Too much 'screen time'

2.3 Emerging catalysts

These are catalysts that have occurred but are yet to be evident in the observed mortality improvement. In this section we consider catalysts which are not driven directly by the current pandemic related to COVID-19 (covered in section 2.5).

Catalysts that Extend Lifespan

Category	Catalysts
Politics and Economics	
Climate and Environment	<ul style="list-style-type: none"> Reducing air pollution resulting from the increased usage of electric cars Net zero carbon emissions by 2050 Implementation of The Paris Agreement
Medical Interventions	<ul style="list-style-type: none"> CRISPR Use of stem cell therapy for diseases of the nervous system such as Parkinson’s Disease Blood biomarker-based screening to identify cancer Use of metformin to reduce impacts of aging (depending on outcome of TAME trial)
Social Trends	<ul style="list-style-type: none"> Reduced levels of drinking amongst younger generations
Technological Advances	<ul style="list-style-type: none"> Remote access to health care and digital screening Further advancements and take-up of wearable technology

Catalysts that Reduce Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand Sustainable solution for social care (both adult and young people) not reached
Climate and Environment	<ul style="list-style-type: none"> Emergence of extreme temperature events including increase in UV radiation exposure from global warming
Medical Interventions	<ul style="list-style-type: none"> Increasing antimicrobial resistance
Social Trends	
Technological Advances	

2.4 New catalysts

These are catalysts that are expected to emerge over the next 5-10 years. In this section we consider catalysts which are not driven directly by the current pandemic related to COVID-19 (covered in section 2.5).

Catalysts that Extend Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> Government intervention to make lifestyles healthier through better diets and more exercise. Achieved through a combination of reward and tax
Climate and Environment	<ul style="list-style-type: none"> Government intervention to deliver the Paris Agreement Ban on the sale of new diesel / petrol cars by (2030)
Medical Interventions	<ul style="list-style-type: none"> Polypill that aims to deliver multiple benefits such as lowering blood pressure and cholesterol Development of a universal flu vaccination (effectively simultaneously targeting every form of flu including new strains) Amyloid-targeted therapies and other medical advances in respect of Alzheimer's and dementia Advancements in senescence (anti-aging) Barrett's oesophagus screening Immunotherapy for use in solid cancers Personalised medicine for better targeted genetic screening and treatments Therapies emerging from anti-aging research Potential sources of novel therapeutics from microbiome research
Social Trends	<ul style="list-style-type: none"> Widespread move to a Mediterranean style diet high in fruit and vegetables
Technological Advances	<ul style="list-style-type: none"> Artificial intelligence to aid in the diagnosis of conditions Organ regeneration Use of nanotechnology Cheap and widely available genome sequencing Use of technology to monitor health in the home (specifically for the oldest ages)

Catalysts that Reduce Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> Increasing wealth disparities
Climate and Environment	<ul style="list-style-type: none"> Over-population Increase in infectious/tropical diseases (e.g. malaria) from rising temperatures
Medical Interventions	
Social Trends	
Technological Advances	<ul style="list-style-type: none"> Effect of robotics leading to un-employment

Universe of Catalysts

2.5 Catalysts that are a result of COVID-19 pandemic

Arguably the COVID-19 pandemic is a disruptive event and a number of catalysts have arisen and are arising which would not have occurred if the pandemic had not happened. Note that these are kept separate for the purpose of this document as potential impacts are still emerging. However many of these catalysts will be able to link back into the current and emerging catalyst sections earlier in this document.

Catalysts that Extend Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> • Introduction of laws to tackle obesity e.g. ban on multi deals on junk food • The increased focus on the NHS means the government increase funding for the NHS • The poor response to the pandemic in care homes leads to pressure for the government to increase funding in adult social care
Climate and Environment	<ul style="list-style-type: none"> • The increase in homeworking leads to falls in pollution • Less demand for overseas travel leads to less air travel and less pollution • Government actions to re-boost the economy focus on 'green' initiatives
Medical Interventions	<ul style="list-style-type: none"> • Greater investment in vaccine research • Greater provision of ventilator equipment
Social Trends	<ul style="list-style-type: none"> • Increased handwashing • Better awareness of transmission of disease which could influence future flu pandemics e.g. importance of social distancing, wearing of masks • Increased uptake of flu vaccinations • More awareness over impact of unhealthy lifestyle leading to falls in obesity and prevalence of diabetes • Increased homeworking leads to better work / life balance • Continuation of a 'sense of community' leading to less social isolation
Technological Advances	<ul style="list-style-type: none"> • GPs continue to make use of technology for appointments, resulting in greater capacity and efficiency • Shift in work-life patterns (increased working from home)

Catalysts that Reduce Lifespan

Category	Catalysts
Politics and Economics	<ul style="list-style-type: none"> • Impact of recession historically has led to falls in longevity improvements • Government cuts deficit through falls in spending on NHS and social care
Climate and Environment	<ul style="list-style-type: none"> • Increased car use due to fears over using public transport
Medical Interventions	<ul style="list-style-type: none"> • Lockdown leads to delayed screening and diagnosis of diseases, especially cancer, which leads to a poorer outcome • Delays in treatment such as chemotherapy leads to falls in longevity improvements and earlier deaths • Survivors of COVID-19 have long last health conditions
Social Trends	<ul style="list-style-type: none"> • Falls in charitable donations means less research takes place • Increase in depression and mental illness • Increase in alcohol consumption/recreational drug use
Technological Advances	<ul style="list-style-type: none"> • Increase in cyber-crime and fraud?

3 Driver Groups

Deaths are categorised by cause of death according to the International Categorisation of Disease (ICD) and each cause of death has an ICD code. Due to the large number of categories, in order to be able to build a model that projects numbers of deaths by cause the deaths must be grouped. The categorisation of these 'driver' groups are described in this section.

3.1 All Disease Groups

Causes of death will be divided into 11 driver groups. These groups and the main causes of death included in the group are set out in a table on the following page (see section 3.2 for an explanation of the classification of cancer).

Co-morbidity and frailty are a separate driver group. Old age, 'senility' or 'frailty of old age' can be given as the sole cause of death in some limited circumstances. However, the death certificate may mention old age or frailty as a contributory cause, especially if it explains the severe effect of a condition that is not usually fatal.

Universe of Catalysts

Driver Group	Main Causes of Death Included
Coronary Heart Disease	<ul style="list-style-type: none"> • Coronary heart disease • Peripheral arterial disease • Rheumatic heart disease
Stroke	<ul style="list-style-type: none"> • Stroke • Transient Ischaemic Attack • Subarachnoid Haemorrhage
Cancer – Unmet need	<ul style="list-style-type: none"> • Lung cancer • Pancreatic cancer • Oesophageal cancer • Brain Tumours (including meningioma)
Cancer – Obesity Related	<ul style="list-style-type: none"> • Breast cancer • Colorectal cancer • Uterine cancer • Thyroid cancer • Gallbladder cancer • Myeloma • Kidney cancer • Liver cancer • Ovarian cancer
Cancer – Smoking Related	<ul style="list-style-type: none"> • Cancers of the mouth (including Pharynx & Larynx) • Nasal and paranasal sinus cancer • Bladder cancer • Cervical cancer • Acute myeloid leukaemia (AML) • Stomach cancer
Cancer – Other	<ul style="list-style-type: none"> • Hodgkin’s Lymphoma • Malignant Melanoma • Prostrate • Testicular • Acute lymphoblastic leukaemia (ALL) • Non-Hodgkin’s Lymphoma
Respiratory Disease – smoker related	<ul style="list-style-type: none"> • Chronic obstructive pulmonary disease (COPD) • Bronchial Disease • Emphysema
Alzheimer’s and Dementia	
Diabetes and Obesity	
Co-Morbidity/Frailty	
Other	<ul style="list-style-type: none"> • Parkinson’s Disease • Liver disease • Pancreatitis

3.2 Categorisation of Cancer

There are a number of ways that deaths from cancer can be grouped and our objective is to have a small number of groups, but to group cancers in such a way that each cancer in that group will be impacted by the catalysts in a similar way.

Cancer Research UK (CRUK) has identified 4 cancers of ‘unmet need’¹. Lung, pancreatic, oesophageal cancers and brain tumours share poor five-year survival rates and have realised only limited improvement in the past decade. Therefore these 4 cancers have been grouped together to reflect late diagnosis, poor survival rates and limited catalysts likely to improve death rates in the short term (although having been identified by CRUK as a key priority may increase the likelihood of improvements in the medium to longer term). Note that lung, pancreatic and oesophageal cancers are also strongly related to smoking.

Aside from medical advancements (which are likely to impact cancer across the board), the main risk factors for cancer are smoking and obesity. The CRUK website lists the cancers that are linked to smoking² and obesity³ and these lists have been used to create the related cancer groups.

Kidney, liver, stomach, colorectal and ovarian cancers are linked to both smoking and obesity. In order to determine the most appropriate groups for these cancers, the research paper “The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015” by Brown et al⁴ has been referred to. As this paper describes, “Population attributable fractions (PAFs) were calculated for combinations of risk factor and cancer type with sufficient/convincing evidence of a causal association”. For the five cancer types that had both smoking and obesity as risk factors, they were assigned to the group that had the highest PAF associated with it. Hence kidney, liver, colorectal and ovarian cancers are assigned to the obesity related group and stomach cancer is assigned to the smoking related group.

The remaining cancers are grouped together as ‘other’. Typically these cancers are highly treatable with a better outcome than many other forms of cancer.

¹ <https://www.cancerresearchuk.org/funding-for-researchers/our-research-strategy/tackle-cancers-with-substantial-unmet-need>

² https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/smoking-and-cancer/how-does-smoking-cause-cancer?_ga=2.64751151.166144606.1606476040-1378006154.1606476040

³ https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/obesity-weight-and-cancer/does-obesity-cause-cancer?_ga=2.64751151.166144606.1606476040-1378006154.1606476040

⁴ Brown, K.F., Rumgay, H., Dunlop, C. *et al.* The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. *Br J Cancer* **118**, 1130–1141 (2018). <https://doi.org/10.1038/s41416-018-0029-6>

4 The impact of catalysts on driver groups

This section combines the previous 2 sections by describing for each of the driver groups which catalysts have had, and are expected to have, the greatest impact.

4.1 Coronary Heart Disease

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing Surgical techniques Development of MRI 	<ul style="list-style-type: none"> Drugs for treatment of cholesterol / hypertension Transplant developments CVD Medical Improvements Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking 		<ul style="list-style-type: none"> Government intervention to make lifestyles healthier Polypill that lowers blood pressure and cholesterol Mediterranean style diet Organ regeneration Use of nanotechnology
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Smokeless fuel requirements in cities Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation Wearable tech Agreements on food standards e.g. salt 	<ul style="list-style-type: none"> Remote access to health care and digital screening Wearable technology 	<ul style="list-style-type: none"> Personalised medicine Technology to monitor health in the home
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 	<ul style="list-style-type: none"> Reduced reliance on coal fired fuels Introduction of the congestion charge in London 		

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> Rising obesity and diabetes 		
Medium			<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.2 Stroke

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> • Smoking banned in public places • Introduction of plain cigarette packing • Development of MRI 	<ul style="list-style-type: none"> • Drugs for treatment of cholesterol / hypertension • Enhanced access to stroke services and brain health clinics • CVD Medical Improvements • Reduction in smoker propensity • Improving quality of diet and level of exercise • Development of vaping as an alternative to smoking 		<ul style="list-style-type: none"> • Government intervention to make lifestyles healthier • Polypill that lowers blood pressure and cholesterol • Mediterranean style diet
Medium	<ul style="list-style-type: none"> • Raising of the school leaving age • Smokeless fuel requirements in cities • Change in work patterns 	<ul style="list-style-type: none"> • Quality Outcomes Framework implementation • Wearable tech • Agreements on food standards e.g. salt 	<ul style="list-style-type: none"> • Remote access to health care and digital screening • Wearable technology 	<ul style="list-style-type: none"> • Personalised medicine • Technology to monitor health in the home
Low	<ul style="list-style-type: none"> • Benefits to ensure a minimum standard of living 			

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> • Rising obesity and diabetes 		
Medium			<ul style="list-style-type: none"> • Brexit – specifically effect on NHS staffing levels • Funding of NHS not increasing in line with demand 	
Low				

4.3 Cancer – Unmet Need

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing Surgical techniques Development of MRI 	<ul style="list-style-type: none"> Reduction in smoker propensity Development of vaping as an alternative to smoking Advancements in chemotherapy Improved imaging techniques 	<ul style="list-style-type: none"> Blood biomarker-based screening to identify cancer 	<ul style="list-style-type: none"> Barrett’s oesophagus screening Immunotherapy for use in solid cancers
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation 	<ul style="list-style-type: none"> Remote access to health care and digital screening 	<ul style="list-style-type: none"> Personalised medicine Government intervention to make lifestyles healthier Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 			

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High				
Medium			<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.4 Cancer – obesity related

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> • Surgical techniques • Development of MRI 	<ul style="list-style-type: none"> • Improving quality of diet and level of exercise • Advancements in chemotherapy • Improved imaging techniques • Various screening programmes 	<ul style="list-style-type: none"> • Blood biomarker-based screening to identify cancer • CRISPR 	<ul style="list-style-type: none"> • Immunotherapy for use in solid cancers • Widespread move to Mediterranean diet
Medium	<ul style="list-style-type: none"> • Raising of the school leaving age • Change in work patterns 	<ul style="list-style-type: none"> • Quality Outcomes Framework implementation 	<ul style="list-style-type: none"> • Remote access to health care and digital screening 	<ul style="list-style-type: none"> • Personalised medicine • Government intervention to make lifestyles healthier • Artificial intelligence to aid in the diagnosis of conditions • Organ regeneration • Use of nanotechnology • Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> • Benefits to ensure a minimum standard of living 			<ul style="list-style-type: none"> • Technology to monitor health in the home

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> • Increasing levels of obesity 		
Medium		<ul style="list-style-type: none"> • Poor and high carbohydrate diets • Alcohol consumption 	<ul style="list-style-type: none"> • Brexit – specifically effect on NHS staffing levels • Funding of NHS not increasing in line with demand 	
Low				

4.5 Cancer – smoking related

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing Programme of vaccinations including HPV 	<ul style="list-style-type: none"> Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking Advancements in chemotherapy Improved imaging techniques 	<ul style="list-style-type: none"> Blood biomarker-based screening to identify cancer 	<ul style="list-style-type: none"> Immunotherapy for use in solid cancers
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation 	<ul style="list-style-type: none"> Remote access to health care and digital screening 	<ul style="list-style-type: none"> Personalised medicine Government intervention to make lifestyles healthier Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 			<ul style="list-style-type: none"> Technology to monitor health in the home

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High				
Medium			<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.6 Cancer – other

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> • Surgical techniques • Development of MRI 	<ul style="list-style-type: none"> • Improving quality of diet and level of exercise • Advancements in chemotherapy • Improved imaging techniques • Various screening programmes 	<ul style="list-style-type: none"> • Blood biomarker-based screening to identify cancer • CRISPR 	<ul style="list-style-type: none"> • Immunotherapy for use in solid cancers
Medium	<ul style="list-style-type: none"> • Raising of the school leaving age • Smokeless fuel requirements in cities • Change in work patterns 	<ul style="list-style-type: none"> • Quality Outcomes Framework implementation 	<ul style="list-style-type: none"> • Remote access to health care and digital screening 	<ul style="list-style-type: none"> • Personalised medicine • Government intervention to make lifestyles healthier • Artificial intelligence to aid in the diagnosis of conditions • Organ regeneration • Use of nanotechnology • Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> • Benefits to ensure a minimum standard of living 			<ul style="list-style-type: none"> • Technology to monitor health in the home • Widespread move to Mediterranean diet

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High				
Medium		<ul style="list-style-type: none"> • Poor and high carbohydrate diets • Alcohol consumption 	<ul style="list-style-type: none"> • Brexit – specifically effect on NHS staffing levels • Funding of NHS not increasing in line with demand 	
Low				

4.7 Respiratory Disease – smoking related

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing 	<ul style="list-style-type: none"> Transplant developments Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking 		<ul style="list-style-type: none"> Government intervention to make lifestyles healthier Organ regeneration Use of nanotechnology Universal flu vaccination
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Smokeless fuel requirements in cities Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation 	<ul style="list-style-type: none"> Remote access to health care and digital screening Wearable technology 	<ul style="list-style-type: none"> Personalised medicine Technology to monitor health in the home
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 	<ul style="list-style-type: none"> Reduced reliance on coal fired fuels Introduction of the congestion charge in London 	<ul style="list-style-type: none"> Reducing air pollution resulting from the increased usage of electric cars Net zero carbon emissions by 2050 	

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> Rising obesity and diabetes 		
Medium		<ul style="list-style-type: none"> Increasing air pollution 	<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.8 Alzheimer's Disease and Dementia

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing 	<ul style="list-style-type: none"> Drugs for treatment of cholesterol / hypertension CVD Medical Improvements Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking 		<ul style="list-style-type: none"> Amyloid-targeted therapies Government intervention to make lifestyles healthier Polypill that lowers blood pressure and cholesterol Mediterranean style diet Use of stem cell therapy
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Smokeless fuel requirements in cities Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation Wearable tech Agreements on food standards e.g. salt Technologies that increase social engagement in the elderly 	<ul style="list-style-type: none"> Remote access to health care and digital screening Wearable technology 	<ul style="list-style-type: none"> Personalised medicine Technology to monitor health in the home Advancements in senescence Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 	<ul style="list-style-type: none"> Use of diagnostic biomarkers 	<ul style="list-style-type: none"> Reducing air pollution resulting from the increased usage of electric cars Net zero carbon emissions by 2050 	

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> Increases in prevalence of mid-life obesity and type 2 diabetes 		
Medium		<ul style="list-style-type: none"> Increasing air pollution Social Isolation 	<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.9 Co-morbidity / Frailty

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing 	<ul style="list-style-type: none"> Drugs for treatment of cholesterol / hypertension CVD Medical Improvements Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking 	<ul style="list-style-type: none"> Remote access to health care and digital screening 	<ul style="list-style-type: none"> Amyloid-targeted therapies Government intervention to make lifestyles healthier Polypill that lowers blood pressure and cholesterol Mediterranean style diet Use of stem cell therapy
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Smokeless fuel requirements in cities Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation Wearable tech Agreements on food standards e.g. salt Technologies that increase social engagement in the elderly 	<ul style="list-style-type: none"> Wearable technology Use of metformin to reduce impacts of aging 	<ul style="list-style-type: none"> Personalised medicine Technology to monitor health in the home Advancements in senescence
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 		<ul style="list-style-type: none"> Reducing air pollution resulting from the increased usage of electric cars Net zero carbon emissions by 2050 	

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> Emergence of extreme temperature events 		
Medium		<ul style="list-style-type: none"> Introduction of austerity Social Isolation 	<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand 	
Low				

4.10 Other

Extension of Lifespan

Impact	Historic	Continuing	Emerging	Future
High	<ul style="list-style-type: none"> Smoking banned in public places Introduction of plain cigarette packing 	<ul style="list-style-type: none"> Reduction in smoker propensity Improving quality of diet and level of exercise Development of vaping as an alternative to smoking 	<ul style="list-style-type: none"> Use of stem cell therapy 	<ul style="list-style-type: none"> Government intervention to make lifestyles healthier Polypill that lowers blood pressure and cholesterol Mediterranean style diet Use of stem cell therapy Organ regeneration
Medium	<ul style="list-style-type: none"> Raising of the school leaving age Smokeless fuel requirements in cities Change in work patterns 	<ul style="list-style-type: none"> Quality Outcomes Framework implementation Wearable tech Agreements on food standards e.g. salt 	<ul style="list-style-type: none"> Remote access to health care and digital screening Wearable technology 	<ul style="list-style-type: none"> Personalised medicine Technology to monitor health in the home Advancements in senescence Cheap and widely available genome sequencing
Low	<ul style="list-style-type: none"> Benefits to ensure a minimum standard of living 	<ul style="list-style-type: none"> Use of diagnostic biomarkers 		

Reduction of Lifespan

Impact	Historic	Continuing	Emerging	Future
High		<ul style="list-style-type: none"> Poor and high carbohydrate diets Rising obesity and diabetes 		
Medium		<ul style="list-style-type: none"> Increasing air pollution Emergence of extreme temperature events 	<ul style="list-style-type: none"> Brexit – specifically effect on NHS staffing levels Funding of NHS not increasing in line with demand Antimicrobial resistance 	
Low				

5 Call for Research

The aim of this section is to outline the research that will be needed to parameterise the model. Research is needed that will assess one (or more) of the longevity catalysts and provide some or all of the following pieces of information:

- What has been the historic impact of this catalyst and what change in trend has it driven? What is the time period over which this catalyst has exhibited the changes?
- What are the future expectations of the catalyst and how is it expected to change current and future trends?
- Which disease groups is the catalyst expected to impact, and what is the expected range of impacts on the mortality rates? These impacts may differ by:
 - Age
 - Time Period
 - Cohort (i.e. a combination of age and time period, say by considering people who are age 65 in 2020)
 - Gender

While an ideal piece of research will cover all of these elements, many pieces of research will only cover some of it. For example, annual statistics on smoking trends are available which will give the impact of the smoking ban catalyst, but won't give information on the impact on disease groups. Similarly, other research may describe the relationship between smoking and heart disease, but won't give information on smoking trends. However, it will be possible to combine sets of research and therefore the aim is to identify as much relevant research as possible, even if it doesn't cover all of these pieces of information.

Research under the following categories is sought and if people are aware of any other research that doesn't fall under any of these categories then please highlight. Please email details of any research that you are aware of that can be used to research@actuaries.org.uk (putting for the attention of Caroline Roberts in the subject line).

Also, if this document has missed any material catalysts then please include this in your response and any associated research that you are aware of.

Universe of Catalysts

Longevity Catalyst Research Area	Includes (but not limited to)
Changes in smoking incidence and its impact on mortality	<ul style="list-style-type: none"> • Ban on smoking indoors • Introduction of plain cigarette packaging • Rising incidence of vaping
Changing levels of obesity and the impact on disease groups	<ul style="list-style-type: none"> • Introduction of the sugar tax • Education and government interventions • Falling levels of exercise and increased sedentary behaviour • Increased prevalence of highly processed foods • Increase of poor and high carbohydrate diets
Advancements in disease prevention	<ul style="list-style-type: none"> • Introduction of various screening programmes • Diagnostic biomarkers • Improved imaging techniques • Introduction of liquid biopsies • Introduction of Barrett's oesophagus screening
Development of cancer treatments	<ul style="list-style-type: none"> • Chemotherapy and future improvements in this treatment • Introduction of immunotherapy on both liquid and solid cancers • Development of CRISPR
Changes in air quality (both positive and negative)	<ul style="list-style-type: none"> • Reduction in coal fired heating and power stations • Changes in diesel car usage • Invention of the electric car and increased prevalence • Aim for net zero carbon emissions by 2050
Invention of surgical techniques and mechanical devices	<ul style="list-style-type: none"> • Transplant developments • Organ regeneration • Left ventricular assist device (LVAD) • Stem cell therapy
Drug developments	<ul style="list-style-type: none"> • Statins • Anti-biotic resistance • Universal flu vaccine • Developments in senescence • Amyloid-targeted therapies • Advancements in personalised medicine
Technological Advancements	<ul style="list-style-type: none"> • Impact of wearable tech on health • Artificial intelligence • Availability of remote healthcare (positive and negative impacts) • Use of nanotechnology • Cheap and widely available genome sequencing • Use of technology to monitor health in the home (specifically for the oldest ages)
Societal changes that impact mortality rates	<ul style="list-style-type: none"> • Austerity • Changes in funding of NHS • Changes in funding of social care • Increases in alcohol usage • Increases in drug dependency • Social Isolation • Brexit
Changes as a result of COVID-19	<ul style="list-style-type: none"> • Impact of COVID-19 on vaccine development

Universe of Catalysts

	<ul style="list-style-type: none">• Update of vaccination rates following COVID-19• Impact of COVID_19 on societal trends• Change in work-life patterns• Long term health impacts of Long Covid• Impact of delays in diagnosis and treatment of conditions such as cancer• Impact of falls in funding of research
--	--



Institute and Faculty of Actuaries

Disclaimer: The views expressed in this publication 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 publication 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 publication. The information and expressions of opinion contained in this publication 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 publication be reproduced without the written permission of the Institute and Faculty of Actuaries.

Beijing

14F China World Office 1 · 1 Jianwai Avenue · Beijing · China 100004
Tel: +86 (10) 6535 0248

Edinburgh

Level 2 · Exchange Crescent · 7 Conference Square · Edinburgh · EH3 8RA
Tel: +44 (0) 131 240 1300 · Fax +44 (0) 131 240 1311

Hong Kong

1803 Tower One · Lippo Centre · 89 Queensway · Hong Kong
Tel: +852 2147 9418

London (registered office)

7th Floor · Holborn Gate · 326-330 High Holborn · London · WC1V 7PP Tel: +44 (0) 20 7632 2100 · Fax: +44 (0) 20 7632 2111

Oxford

1st Floor · Park Central · 40/41 Park End Street · Oxford · OX1 1JD Tel: +44 (0) 1865 268 200 · Fax: +44 (0) 1865 268 211

Singapore

163 Tras Street · #07-05 Lian Huat Building · Singapore 079024
Tel: +65 6717 2955