Things Fall Apart: The British Health Crisis, 2010-2020



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A thesis submitted for the degree of

Doctor of Philosophy in Geography and the Environment

January 2026

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ACKNOWLEDGEMENTS

This thesis was motivated by experiences that predate the formal start of this DPhil. As a GP, I saw the consequences of policy decisions that were defended, minimised, or ignored by those in positions of power, even as their effects were borne disproportionately by those often with the least voice. Seeing avoidable harm unfold in real time, alongside persistent denial of its existence, shaped the questions that drove this work and sustained my commitment to pursuing them with rigour and care.

I owe an immense debt of gratitude to my supervisors, Martin McKee and Danny Dorling. Their intellectual leadership has been matched by an exceptional generosity of spirit. Over the course of this DPhil, they have become not only mentors but friends, welcoming me into their homes and lives, from kayaking trips and election nights to even a visit in Kiribati. Their support has extended far beyond the academic, encompassing unexpected personal challenges as well as professional and personal milestones. Across time zones and continents, their constancy, kindness, good humour, and intellectual inspiration have been unwavering. I could not have hoped for more thoughtful, kind, or principled supervision.

I am grateful to the University of Oxford for providing the institutional home for this work. I also thank Kellogg College for its support during my time as a part time student, and for enabling me to spend a formative summer in Oxford. I am especially grateful to the Clarendon Scholarship team: without their generous support, none of this would have been possible.

This thesis is one part of a much wider body of work produced by researchers, clinicians, policy analysts, journalists, and community advocates who have

documented the same patterns of harm through different methods, disciplines, and forms of evidence. I am thankful to all those working in this space and insisting that uncomfortable findings be taken seriously. Taken together, their contributions make the evidence not merely compelling, but cumulative and difficult to dismiss.

I am grateful to many collaborators including Rob Aldridge, Rachel Burns, Theo Estrin-Serlui, Bob Klaber, Michael Marmot, Gerry McCartney, Parth Patel, Annabel Sowemimo, Matthew Wallace, David Walsh, and Claire Zhang. I am particularly indebted to Jon Minton, whose exceptional statistical insight, patient teaching, and clarity of thought shaped both the analytical approach of this thesis and my own development as a researcher.

Finally, I am extremely thankful to my family and my partner. My parents, Petria & Richard, my sisters, brothers-in-law, and niblings: Mel, Rich, Luca, Leo; Gem, Andy, Tommy, Joe and Marla. Their encouragement has been a constant source of strength. They have supported me unfailingly, celebrated progress at every stage, and listened with remarkable patience. My partner, Jeremy, has provided encouragement, belief in me during moments of doubt, and quiet confidence in the value of this work that has sustained me throughout. He has read drafts with care, acted as a trusted sounding board for arguments, and offered insight, perspective, and reassurance at exactly the moments they were most needed.

DEDICATION

This thesis is dedicated to the people behind the numbers. It is written in the conviction that evidence, assembled collectively and honestly, should not just inform debate but compel policy attention and action, making such experiences impossible to ignore, harder to deny, and placing responsibility on those with power to prevent avoidable harm.

Health statistics represent people with the tears wiped off

- Sir Austin Bradford Hill, epidemiologist.

ABBREVIATIONS

ASMR	Age-standardised Mortality Rate
BMJ	British Medical Journal
CI	Confidence Interval
DHSC	Department of Health and Social Care
DPhil	Doctor of Philosophy
DWP	Department of Work and Pensions
FLICC	Fake experts, Logical Fallacies, Impossible expectations, Cherry-picking, Conspiracy
GDP	Gross Domestic Product
GP	General Practitioner
HIC	High-income countries
HMD	Human Mortality Database
IMF	International Monetary Fund
IMR	Infant Mortality Rate
NCD(s)	Non-communicable Disease(s)
NHS	National Health Service
ONS	Office for National Statistics
PHE	Public Health England
PRS	Probationer Research Student
RCT	Randomised Controlled Trial
RQ	Research Question
SDH	Social Determinants of Health
SMR	Standardised Mortality Rate
UK	United Kingdom
WHO	World Health Organization

GLOSSARY

Table 1: Table of key terms and their definitions used in the thesis. Updated and adapted from Hiam et al., 2021.

Term	Definition
Austerity	A set of fiscal and policy measures that reduce government spending and/or increase taxes (Anderson & Minneman, 2014; McCartney, McMaster, Shipton, et al., 2022). In this thesis, austerity is treated as a sustained series of policies rather than a single event after 2010.
Age-standardised mortality rate (ASMR)	A mortality rate calculated by applying age-specific death rates to a standard population to allow fair comparisons (Eurostat, 2013).
Bradford Hill criteria	Criteria used in epidemiology to assess causal explanations for observed associations (Hill, 1965).
Cohort effect / Cohort life expectancy	A pattern arising from exposures shared by people born in the same time period; cohort life expectancy follows a birth cohort through time (Dattani, 2023; Hiam & Dorling, 2024).
Data artefact	An apparent trend produced by measurement and/or coding issues rather than true change.
FLICC framework	A framework of science denial tactics: Fake experts, Logical fallacies, Impossible expectations, Cherry-picking, Conspiracy (Cook, 2020; Diethelm & McKee, 2009; Zanartu et al., 2024)
Excess deaths	The difference between observed and expected deaths.
Golden Cohort	A generation born between 1925 and 1934 with unusually good mortality improvements until the 2010s (Goldring et al., 2011; Hiam & Dorling, 2024).
Life disparity (LD)	A measure of lifespan variation, representing the average remaining life expectancy at the ages when death occurs; effectively the average number of life years lost due to death (Vaupel et al., 2011).
Life expectancy	A statistical measure of the average number of years a person can expect to live at a given age, based on current age-specific mortality rates. Unless otherwise specified, life expectancy in this thesis refers to *period* life expectancy.
Life expectancy at birth (e_0)	The hypothetical average age at death if current age-specific mortality rates persisted throughout life.
Lifespan variation (LV)	A set of measures capturing heterogeneity in ages at death. Typically decreases as life expectancy rises, but changes in opposite directions can reveal shifts in mortality distribution. Used alongside life expectancy to capture inequality in survival (Hiam et al., 2021; van Raalte et al., 2018).

Period effect / Period life expectancy	A change in mortality that affects all age groups during a particular time window (for example, a severe influenza season or a policy reform). Period life expectancy reflects these conditions as if they applied throughout life.
Political ecology of health	How political and economic power shapes environments and vulnerabilities.
Precarity	Insecurity in income, housing, and services that heightens vulnerability to shocks and erodes the capacity to maintain health (McKee et al., 2017; Standing, 2011).
Proximate explanations	Immediate factors proposed to explain mortality change (e.g., influenza, cold winters, coding changes, cause-specific shifts, cardiovascular disease mortality improvements plateau).
Resilience	The capacity of people and places to absorb, adapt to, and recover from shocks.
Social determinants of health (SDH)	Conditions in which people are born, grow, live, work, and age that impact health and inequalities (Dahlgren & Whitehead, 1991; Marmot & Wilkinson, 2006).
Structural determinants and explanations	Upstream political, economic, and social processes that organise the distribution of resources, exposures, and power, shaping health outcomes and inequalities.
Triangle of Human Ecology	A framework linking population, habitat, and behaviour to explain how place and context shape health (Emch et al., 2017; Emch & Goel, 2025; Meade, 1977)

ABSTRACT

Since 2010, the United Kingdom has experienced an unprecedented slowdown, and in some groups a reversal, in life expectancy improvements. This thesis investigates the causes of this deterioration and examines why interpretations of the crisis diverged so sharply among public health experts and institutions. Using a mixed-methods falsification approach, it evaluates competing explanations by combining quantitative analyses of mortality trends with qualitative interviews and theoretical synthesis.

The empirical analyses demonstrate that the deterioration was real, substantial, and unevenly distributed. Paper 1 documents the timing and scale of the slowdown, showing worsening infant mortality rates, life expectancy, and widening inequalities between regions and socioeconomic groups. Papers 2 and 3 test commonly cited proximate explanations: influenza activity did not significantly increase during the period of decline, and even historically resilient birth cohorts experienced unexpected increases in mortality. Paper 4 situates the UK within international trends, showing that its nations showed a more severe “jump-then-fall” trajectory than comparator countries. Paper 5 examines expert interpretation, revealing how institutional norms, epistemic caution, and political sensitivities contributed to fragmented narratives and sustained weaker proximate accounts.

Synthesised through the innovative application of existing theoretical frameworks that integrate the social determinants of health, the Triangle of Human Ecology, and concepts of precarity and resilience, the findings show how austerity policies functioned as an ecological stressor. Austerity increased population vulnerability, degraded local environments and services, and disrupted behavioural and institutional pathways that had previously supported health and resilience. These

processes interacted to produce uneven and cumulative harm, explaining both the timing and social patterning of the mortality reversal.

The thesis concludes that austerity represents the most plausible structural explanation for the UK's lost decade of health improvement. It highlights implications for public health practice, the importance of engaging with the political determinants of health, and the need for spatial approaches in health geography. It also identifies outstanding questions and directions for future research.

Ethical Approval

Ethical approval was sought and granted for the qualitative interviews in Paper 5, as detailed in the publication. All other research papers used anonymised, publicly available data and did not require ethical approval.

Use of Generative AI

Generative AI (ChatGPT 5.1) was used to support the drafting of the framing chapters of this thesis by assisting with structuring, language refinement, and improving clarity of expression. All analytical content, interpretations, and arguments were generated by the author, and all AI-assisted content was thoroughly reviewed, edited, and verified by the author to ensure accuracy.

Generative AI was not used for any of the empirical research papers included in the thesis, nor for data analysis, coding, interpretation of results, or generation of academic arguments or evidence. All research design, analysis, and critical interpretation are the author's own work.

PART I: INTRODUCTION & LITERATURE REVIEW

1 INTRODUCTION

1.1 Britain's Lost Decade

In January 2024, the Office for National Statistics (ONS) published life expectancy figures for the United Kingdom (UK). Life expectancy for the 2020 to 2022 triennium (used by ONS to smooth annual fluctuations) had fallen for both males and females to the level of 2010 to 2012 (Office for National Statistics, 2024). Of course, this was in part due to the covid-19 pandemic, but Britain was an outlier among high-income countries (HICs) in falling so far behind (see Appendix 1). As Professor Sir Michael Marmot warned in 2020, "Britain has lost a decade" (Marmot, 2020). This reversal, hereafter referred to as the post-2010 health crisis, marked the end of decades of improvement in population health.

Writing in 2025, the country's health remains in crisis. Despite repeated warnings from public health scholars (Hiam, Dorling, et al., 2018a; Hiam, Klaber, et al., 2024; Marmot et al., 2020; Taylor-Robinson et al., 2019; Walsh & McCartney, 2024b), official discourse has been slow to acknowledge either the scale or causes of this crisis. Understanding the crisis requires attention to the determinants of health, which act at several levels, from proximate factors such as biological risk to distal influences, including the characteristics of the communities or political regimes in which people live. At the distal end of this spectrum, a growing literature links austerity policies to worsening population health (Alexiou et al., 2021; Hiam & Dorling, 2024; Lewer & Bibby, 2021; Marmot et al., 2020; McCartney, Walsh, et al., 2022; Rashid et al., 2021; Stokes et al., 2022), yet many continue to favour proximate explanations such as influenza, cold winters, or population ageing. The

persistence of these proximate narratives, despite mounting contradictory evidence and their inability to account for the crisis's breadth, timing, and distribution, motivates this thesis.

Indicator	Finding	Source(s)
Turning point	Life expectancy improvements stalled from 2010 to 2012, then reversed	(Office for National Statistics, 2024; Rashid et al., 2021)
Excess deaths	335,000 excess deaths in England, Wales and Scotland 2012-2019	(Walsh, Dundas, et al., 2022)
International ranking	The UK fell from the middle to the near bottom of the G7 life expectancy rankings. The UK was one of the very few countries that saw a fall in life expectancy to the 2010-2012 levels.	(Hiam et al., 2023a), Appendix 1
2014-2015 mortality spike	Largest year-on-year mortality increase since the 1960s; symptom, not cause, of crisis	(Hiam et al., 2017a, 2017b)
Geographical pattern	Most deprived areas experienced a) the greatest cuts and b) the greatest mortality deterioration	(Alexiou et al., 2021; Beatty & Fothergill, 2016; Gray & Barford, 2018)
Age groups affected	All ages are affected, across different causes	(Public Health England, 2018a)

Box 1: Key Markers of the UK's Health Crisis

1.1.1 A "Jump" in Deaths

Sitting in the consulting room of my primary care practice in London[a] in February 2016, I read a BBC News report of a large "jump" in deaths between 2014 and 2015, the biggest year-on-year rise since the 1960s, and the mortality spike noted in Box 1 (Mundasad, 2016). Public Health England (PHE) is quoted in the report, emphasising year-to-year fluctuations are expected, and that "In 2015, the monthly death figures suggest cold weather and flu may have played a part in the high numbers of deaths in the early part of the year". That proximate explanation did not

[a] The practice population was classified in the 2019 Index of Multiple Deprivation as in the most deprived deciles: https://data.cdrc.ac.uk/dataset/index-multiple-deprivation-imd (accessed 2 May 2024)

align with my clinical experience: as a practising GP[b], I had not seen an exceptional flu season, but I had seen the erosion of some community support, such as the closure of the Sure Start centre opposite the surgery and the cancellation of Meals on Wheels[c]. I remember the first time a patient asked for a foodbank voucher. I had never heard of it, but soon it became commonplace (and, subsequently, vouchers would no longer be required, given the scale of administrative work to meet the growing demand). This concerning trend was reflected nationwide (Loopstra et al., 2015; The Trussell Trust UK, 2023).

Further ONS data confirmed the 2014-15 mortality spike: age-standardised mortality rates (ASMRs) rose by 5.6% in 2015, with rises in deaths attributed to dementia, Alzheimer's Disease, and respiratory disease concentrated among older ages (Office for National Statistics, 2016c). Life expectancy at birth fell by 0.2 years for males and 0.3 years for females (Office for National Statistics, 2016c). In two linked papers that were published in 2017, we asserted that such an increase in mortality in a population could only be caused by a few factors: (1) data artefact; (2) mass in- or out-migration, causing the denominator to change; (3) a large scale environmental event such as a natural disaster or war; (4) a disease outbreak; and (5) breakdown of the health and social care system (Hiam et al., 2017a, 2017b). Some of these were easy to exclude. There was no significant natural disaster or war in the UK during that time[d]; no extreme winter; no significant change in how deaths were collected, coded and published (though we noted that changes in dementia coding

[b] I had been working in the NHS in that area of London since 2011, and in the GP practice since 2013.
[c] Sure Start centres were introduced to offer support to families with children under 5; Meals on Wheels provided meals delivered to a person's home.
[d] It should be noted that the deaths cause by the Grenfell Tower fire in London in June 2017 are reflected in analyses of differences in life expectancy by middle-layer super output area (MSOA) for that year. See Figure 2, Rashid et al. (2021).

likely increased its appearance as a cause of death, discussed in Chapter 2); and there was no evidence of a particularly lethal strain of flu or increase in flu deaths. By contrast, markers of NHS performance deteriorated substantially. We concluded:

> *Explanations presented up until now do not conclusively explain that rise [in mortality in England & Wales], but do provide serious cause for concern, with the deaths occurring in the context of massive disinvestment in both health and social care, and almost all NHS performance markers falling below their targets. The possibility that the cuts to health and social care are implicated in almost 30,000 excess deaths is one that needs further exploration.*

My colleagues and I highlighted that the mortality increase was recurring in 2016 and warned of the risk of continued deterioration. The Department of Health (now the Department of Health and Social Care, DHSC) responded dismissively, calling the work “a triumph of personal bias over research” (Forster, 2017). Subsequent data and analyses confirmed the change was not a one-off fluctuation but a reversal in long-standing trends (Hiam, Dorling, et al., 2018a; Hiam, Harrison, et al., 2018; Marshall et al., 2019; Public Health England, 2018a).

1.1.2 Not a One-off Phenomenon

Scepticism about our early findings was, to an extent, understandable: annual trends fluctuate. But as adverse trends persisted, the scepticism hardened into resistance that persisted despite accumulating evidence in support of our view (Hiam, McKee, et al., 2024). In 2018, a PHE report concluded: “The main findings suggest the overall slowdown in improvement [in mortality] is due to factors operating across a wide range of age groups, geographies, and causes of death” (Public Health England, 2018a). That breadth made any single proximate agent, such as influenza, an unlikely sole explanation or primary cause. In 2022, McCartney et al. synthesised competing hypotheses (see Table 2, Chapter 2).

I summarised the poor state of health in the UK in “Things Fall Apart” (Paper 1), showing multiple indicators worsening and inequalities widening (Hiam et al., 2020). By this point, the evidence was incontrovertible: the post-2010 deterioration in population health was real, sustained, and widespread. What remained less clear, however, was how these changes had arisen and why proximate explanations continued to dominate public and policy discourse despite their declining plausibility.

1.2 Problem Statement and Motivation

Despite extensive commentary, as of January 2026, few studies have systematically explored both proximate and structural explanations for Britain’s post-2010 mortality reversal, with the exception of the work of McCartney and Walsh, which primarily focused on Scotland but also wider trends in the UK (McCartney, Walsh, et al., 2022; Walsh & McCartney, 2024b). The persistence of proximate narratives, such as influenza, ageing, or data artefacts, has distracted us from achieving a good understanding of underlying structural change. This thesis addresses that gap by testing competing explanations against epidemiological standards, and by innovative use of a theoretical framework to understand how austerity reshaped the social, economic, and spatial conditions for health through its effects on the social determinants of health (SDH), the ecological relationships between population, habitat and behaviour, and the roles of precarity and resilience.

What remains contested is not whether the post-2010 deterioration occurred (Box 1), but why it happened. Two central questions, therefore, guide this thesis: first, what caused the reversal in the improvement of population health and life expectancy trends in the UK after 2010? Second, why did many experts and institutions resist structural explanations, favouring proximate accounts such as influenza? Together,

these questions aim to illuminate both the mechanisms of decline and the politics of its explanation.

In this thesis, I argue that the UK's post-2010 health crisis constitutes an exceptional case among HICs. Understanding its causes is not only of historical interest but of continuing policy relevance: it provides lessons for health system resilience, for governance in times of fiscal constraint, and for how evidence is mobilised or suppressed in times of political controversy. It also requires conceptual tools capable of linking macro-level policy choices to local, embodied health outcomes. This is an interpretive task undertaken through the integrated theoretical framework outlined in Chapter 3 and applied throughout the thesis.

1.3 Research Aims and Questions

The overarching aim of this thesis is to explain the reversal in population health improvements in the UK after 2010 and to understand how different explanations for this reversal were produced, contested, and sustained. To achieve this, it integrates quantitative, qualitative, and theoretical approaches to evaluate competing hypotheses and to apply a theoretical framework linking policy, place, and population health. A further aim is to provide a coherent interpretive lens, drawing on the SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience, to guide the synthesis of empirical findings.

Three interconnected research questions (RQs) guide the analysis:

RQ1: What happened to life expectancy trends in the UK after 2010, and what caused these changes?

This question is introduced in Chapter 2, which reviews the empirical evidence for stalling life expectancy and competing proximate explanations, and is examined

quantitatively in Chapters 4 (Paper 1), which document the timing, scale, and patterning of the mortality reversal using official data sources and comparative analyses.

RQ2: How well do commonly suggested proximate explanations, such as influenza, ageing, and other age- and cause-specific effects, account for these trends?

This question is explored in Chapters 2, 5 (Paper 2), and 6 (Paper 3) through systematic evaluation of the literature, mortality data, and cohort analysis. This question tests the plausibility of proximate factors using epidemiological reasoning and demographic methods.

The international comparative analysis in Chapter 7 (Paper 4) contributes to RQ1 and RQ2 by assessing whether the UK slowdown reflects broader international trends.

RQ3: How did expert interpretations of these trends vary, and why did some narratives persist despite mounting contrary evidence?

Investigated in Chapter 8 (Paper 5) through qualitative interviews with senior public health and policy experts, this question examines the social and institutional dynamics that shaped how evidence was interpreted and is further considered in the Discussion (Chapter 9), where these insights are integrated into the broader explanatory framework and literature.

Together, these questions progress from empirical documentation to causal evaluation, interpretive analysis, and theoretical synthesis. A mixed methods design triangulates mortality trends, expert narratives, and the integrated theoretical framework to enhance robustness.

This thesis treats austerity not as an assumed cause but as one hypothesis among several. Its analytical approach is falsification: it begins with competing explanations for the post-2010 mortality reversal and systematically tests whether proximate, demographic, or comparative accounts can account for the observed patterns. After evaluating and, where appropriate, rejecting these alternatives, the thesis considers whether austerity provides a more coherent structural explanation.

1.4 Methods and Thesis Structure

This thesis adopts a mixed-methods design that combines quantitative analysis of mortality trends, qualitative investigation of expert interpretations, and theoretical synthesis.

Quantitative analyses draw on official datasets from the ONS, the Human Mortality Database (HMD), and other published sources. Standard demographic and epidemiological techniques, including age-standardisation and cohort analysis, are applied to test candidate explanations and assess their plausibility against established causal criteria. Period life expectancy is used unless otherwise stated (see Glossary in Table 1). Qualitative research (Chapter 8, Paper 5) explores how experts understood and communicated these same trends through semi-structured interviews with senior figures in public health, epidemiology, and policy. The theoretical integration (introduced in Chapter 3 and synthesised in Chapter 9) innovatively applies existing theoretical frameworks to explain why austerity is the most plausible driver of the post-2010 mortality crisis, how it generated population-level harm, and why proximate explanations are insufficient.

It is important to clarify the different geographic contexts examined in this thesis. Much of the existing literature, as well as several datasets, focuses on England and

Wales. Where findings or data refer specifically to England and Wales, or to the UK, this is made explicit; Scotland is similarly identified where relevant. Northern Ireland is not examined separately due to data limitations and its relatively small population (~1.9 million).

1.4.1 Thesis Structure and Paper Integration

The thesis proceeds as follows, with the relationship between chapters and papers made explicit:

- **Chapter 2** reviews the literature on proximate explanations, such as influenza, ageing, coding artefacts, and cardiovascular disease slowdown, and introduces the empirical evidence for the stall in life expectancy improvements.
- **Chapter 3** situates the health crisis within broader theoretical debates, reviewing the literature on austerity and structural determinants and presenting the use of integrated existing theoretical frameworks, used throughout the thesis, to evaluate why proximate explanations fail and why austerity is the most plausible driver of the post-2010 reversal**.**
- **Chapter 4** (Paper 1) documents the British health crisis empirically, establishing the timing and magnitude of mortality change.
- **Chapter 5** (Paper 2) examines whether influenza can account for the mortality reversal, to test a prominent proximate explanation.
- **Chapter 6** (Paper 3) tests the demographic hypothesis through cohort analysis of the “Golden Cohort”, those born between 1925 and 1933, who were in their final years of life when austerity began.

- **Chapter 7** (Paper 4) evaluates whether the post-2010 slowdown reflects international trends or a return to normal after earlier gains, comparing the nations of the UK to similar European countries.
- **Chapter 8** (Paper 5) explores expert disagreement and the persistence of proximate narratives.
- **Chapter 9** (Discussion and Conclusions) synthesises the findings from Chapters 2-8, applying the integrated theoretical framework introduced in Chapter 3 to explain the mechanisms through which austerity reshaped the social, ecological, and institutional conditions for health, and to address the RQs.

Together, these chapters form a coherent programme of research that progresses from empirical documentation to causal testing, interpretive analysis, and theoretical synthesis. Short bridging sections between chapters clarify how each chapter builds on the previous one.

When multiple references are cited together, they are listed alphabetically by author. All references appear in the Bibliography on pages 215–242, except those cited within published Papers 1–5 and the Appendix, which are listed at the end of the relevant paper or appendix. Supplementary materials for each of the empirical papers are included in Part VI.

1.4.2 Justification of Format

This is an article-based DPhil comprising five main papers and accompanying framing chapters. All papers were produced during Probationer Research Student (PRS) and Doctor of Philosophy (DPhil) status, led by me, with co-author

contributions outlined in Appendix 2[e]. The framing chapters demonstrate coherence and unified contribution, fulfilling the School of Geography and the Environment's requirements.

1.5 Originality and Contribution

This thesis provides a comprehensive account to date of the UK's post-2010 health deterioration, drawing together official statistics, international comparisons, and original analyses to show that the slowdown in life expectancy was systemic rather than transient. It establishes that the reversal was not driven by demographic change or by proximate causes but by structural change, marking a rupture in the social and economic foundations of population health.

Analytically, it applies epidemiological criteria for causation to competing explanations, systematically ruling out proximate causes such as influenza, ageing, or a slowdown in the rate of decline in cardiovascular mortality, as well as international trend explanations, to demonstrate the limitations of prevailing interpretations. Collectively, these analyses identify austerity as the most plausible structural driver of the post-2010 mortality reversal (Box 1).

Theoretically, the thesis employs an integrative, place-based framework that bridges public health and health geography, linking precarity and resilience within the Triangle of Human Ecology and the SDH to explore how political and economic restructuring becomes embodied in place, producing uneven health outcomes across populations, habitats, and behaviours.

[e] A full list of publications since the start of the part-time DPhil in October 2019 is available in Appendix 3, with selected publications available in Appendices 4, 5 and 6.

Together, these contributions advance understanding of how macro-level policy change (specifically austerity) translates into embodied and spatially unequal health outcomes, and why proximate explanations fail to account for the timing, scale, and patterning of the UK's post-2010 mortality crisis.

1.6 Chapter 1 Summary and Next Steps

This chapter has introduced the UK's post-2010 reversal in life expectancy and population health, and some of the explanations advanced to account for it. Yet, despite extensive analysis and public debate, no consensus has emerged**.** Different institutions, researchers, and policymakers have attributed the same patterns to causes such as influenza, ageing, data artefacts, cause-specific changes, or socioeconomic conditions, often drawing opposing conclusions from similar evidence and data**.** This lack of agreement demonstrates the need for a systematic and transparent evaluation of competing accounts and for an approach that can distinguish between proximate and structural explanations.

Building on this, Chapter 2 begins the systematic evaluation by assessing whether proximate causes, such as influenza, ageing, cardiovascular disease plateauing, and others, can account for the post-2010 deterioration.

2 The British Health Crisis in Context: The Limits of Proximate Explanations

It is important to situate the post-2010 mortality reversal within the context of existing knowledge of health inequalities in the UK before the financial crisis and the subsequent imposition of austerity. By the early 2010s, a substantial body of evidence had established the strong and graded relationship between socioeconomic inequality and population health (Black & Townsend, 1984; Marmot, 2004; Marmot et al., 2010; Marmot & Wilkinson, 2006; Wilkinson & Pickett, 2009). As a result, by 2010, when austerity was implemented, much was known about the negative impact of inequalities on health, and the publication of *The Spirit Level* (Wilkinson & Pickett, 2009) dominated public health discourse. The 2010 paperback of the book brought renewed attention to the societal (including trust), health, and material consequences of inequality across HICs, including the UK, alongside the publication of the Marmot Review, *Fair Society, Health Lives* (Marmot et al., 2010). At that time, a significant concern within public health was the persistence of social gradients in health despite decades of policy attention, rather than an absolute deterioration in mortality outcomes. While the harms associated with inequality were well known, neither a sustained reversal of life expectancy trends nor the scale of mortality change that would emerge after 2010 was anticipated. Thus, the post-2010 experience represents both a continuation of known inequalities and a shift in population health trajectories that require explanation beyond those that dominated the pre-austerity period.

Before analysing the empirical findings presented in the five papers of this thesis, it is essential to establish what is already known about the UK's post-2010 mortality reversal and how it has been interpreted in the academic and grey literature. This

chapter provides that foundation by reviewing the evidence for deterioration and evaluating the proximate explanations most commonly advanced in public discourse, policy, and professional practice. In doing so, it clarifies why these explanations require systematic causal assessment and how they are empirically examined in subsequent chapters.

2.1 Introduction

In the years following 2010, as evidence mounted that life expectancy improvements in the UK had stalled and begun to reverse, a succession of explanations emerged to account for this unprecedented peacetime health crisis. PHE initially attributed the increase to severe influenza seasons and cold winter weather (Office for National Statistics, 2016a; Pebody et al., 2018). Demographers and epidemiologists highlighted an ageing population and the exhaustion of some health gains (Murphy et al., 2019) alongside plateauing improvements in cardiovascular disease mortality (OECD & The King's Fund, 2020). Politicians and commentators variously invoked population ageing, obesity, lifestyle choices, immigration, or data artefacts. Each explanation offered a seemingly plausible account of why the UK had lost its longstanding trajectory of health improvement.

However, the crisis deepened and broadened, affecting not only life expectancy but infant mortality (Taylor-Robinson et al., 2019), health inequalities (Marmot et al., 2020), and multiple indicators of population wellbeing (Hiam et al., 2020; Hiam, Klaber, et al., 2024). These diverse patterns increasingly strained the credibility of narrow proximate explanations (Hiam et al., 2020), and raised questions about whether any could plausibly account for the timing, magnitude, or distribution of deterioration. Even before the covid-19 pandemic began in 2020, the UK's health outcomes had diverged markedly from those of comparable HICs, despite similar

demographic transitions, disease burdens, and seasonal weather patterns (Ho & Hendi, 2018; Office for National Statistics, 2018). The continued repetition of multiple proximate narratives in the face of mounting contrary evidence suggests that something more fundamental was required: a systematic evaluation of proposed causes using established epidemiological criteria for causation.

This chapter provides that systematic evaluation using the Bradford Hill criteria, a foundational framework for assessing causation in epidemiology (Hill, 1965). Initially developed for evaluating the contribution of environmental exposures to disease outcomes, these criteria provide a framework for assessing whether proposed causes can account for observed health patterns at the population level, and have previously been applied to the association between austerity and poor health in the UK (Hiam, Dorling, et al., 2018b).

This chapter serves a dual purpose within the thesis. Empirically, it consolidates and evaluates the evidence base surrounding competing explanations, addressing RQs 1 and 2 by examining changes in UK health trends and the extent to which commonly proposed explanations account for these changes. Methodologically, it demonstrates why a process of elimination is required: only by systematically ruling out inadequate explanations can we narrow the field to those capable of explaining the timing, magnitude, spatial distribution, and persistence of Britain's health crisis. Three of these explanations, influenza, the ageing of the "Golden Cohort", and the hypothesis that the UK was merely "returning to normal" after a period of unusually rapid gains in life expectancy in the 1990s and 2000s, were sufficiently prominent to warrant dedicated empirical testing. These are examined in depth in Papers 2 (Chapter 5), 3 (Chapter 6), and 4 (Chapter 7), respectively.

This chapter's central contribution is to demonstrate that none of the commonly proposed proximate explanations can satisfy the epidemiological criteria for causation when applied to the UK's post-2010 health crisis. This systematic elimination narrows the explanatory field to structural determinants and justifies the turn to structural theoretical approaches explored in Chapter 3 and further developed in Chapter 9. By establishing what the crisis is not, this chapter creates the conceptual space for exploring what it might be: a consequence of the systematic restructuring of the social, economic, and institutional conditions that sustain population health.

This analysis also reveals something important about the production of knowledge in public health: how institutional incentives, professional norms, and political constraints can sustain inadequate explanations long after their empirical basis has been undermined. This dimension prepares the ground for Chapter 8's examination of expert disagreement (Paper 5) and the institutional conditions that shape public health discourse. Understanding why weak explanations persist is as important as understanding why they are weak.

The importance of this analysis extends beyond academic debate. The UK's post-2010 health crisis represents a significant peacetime reversal in population health in a HIC. Understanding what happened is essential for preventing it from happening again, in the UK or elsewhere. By applying standard epidemiological criteria to competing explanations, this chapter aims to move the debate beyond speculation toward evidence-based analysis that can inform effective policy responses. The systematic elimination of inadequate explanations is the first step toward identifying adequate ones.

2.2 Methods

2.2.1 Literature Search Strategy

A comprehensive literature search identified studies, reports, and analyses with two objectives: first, to establish what happened to life expectancy in Britain during this period; and second, to identify proposed explanations for the post-2010 mortality trends. Proximate explanations were synthesised from existing reviews (McCartney, Walsh, et al., 2022; Murphy et al., 2019; Public Health England, 2018a), including my own interviews with public health experts (Hiam et al., 2023b). Databases included PubMed, Google Scholar, and government repositories. Search terms combined mortality trend descriptors (for example, “life expectancy”, “excess deaths”) with geographical locators (“UK”, “England and Wales”, “Britain”) and specific explanations (“influenza”, “cardiovascular diseases”, “obesity”, etc.). Sources included peer-reviewed articles, government reports (ONS, PHE, Department of Health and Social Care), and think tank publications covering 2010-2024. These are summarised in Table 2.

2.2.2 Analytical Framework: Bradford Hill Criteria

The dominant explanations, defined as those given as main drivers in official discourse, e.g., from ONS, PHE, and other government agencies, were qualitatively evaluated against the Bradford Hill criteria for causation: strength of association, consistency, temporality, biological gradient, plausibility, coherence, experimental evidence, analogy, and specificity (Hill, 1965).

2.3 What Happened to Life Expectancy in the UK After 2010?

2.3.1 Mortality Trends in the UK, 2010-2020

By 2010, life expectancy in the UK had steadily increased over decades, albeit with some fluctuations. Figure 1 shows life expectancy at birth by sex for England and Wales from 1920 to 2020 (Human Mortality Database, n.d.). Rapid rates of improvement were observed in both sexes from the early 1970s, which halted in 2010, with declines in 2015 and again in 2020, the latter associated with the covid-19 pandemic. These aggregate measures hide significant disparities between groups, including by age and area of residence (Marmot et al., 2020).

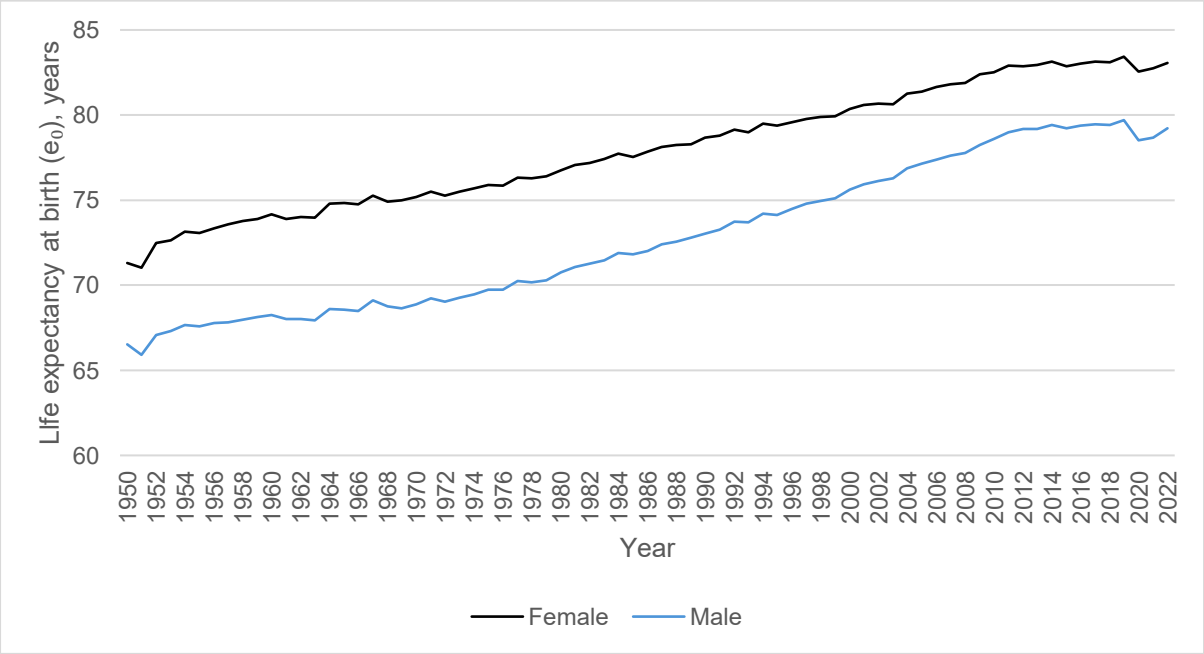


Figure 1: Life expectancy at birth (e_0) in years by sex for the population of England & Wales, 1950-2022. Source: Human Mortality Database, 2025

The magnitude and persistence of the UK's health crisis are evident when comparing predicted life expectancy with actual outcomes. Figure 2 shows how dramatically reality diverged from expectations after 2010 (Hiam & Dorling, 2022). The 2012 ONS projections, based on historical trends, anticipated continued steady improvements in life expectancy for both males and females. Instead, life expectancy stalled around

2014 and began to decline. By 2020, both male and female life expectancy had fallen below the levels recorded in 2014, representing not just a slowdown in improvement but a reversal. The gap between projected and actual outcomes widened progressively through the decade, with the divergence becoming apparent as early as 2012-2013, well before the covid-19 pandemic.

This pattern represents an unprecedented health crisis. The sustained nature of the divergence rules out temporary fluctuations or statistical artefacts. The consistency across both sexes suggests systemic rather than condition-specific causes. Most significantly, the timing of the divergence, beginning shortly after 2010, provides a crucial temporal anchor for evaluating proposed explanations. Any adequate causal account must explain not only why improvements stopped, but why they reversed so dramatically and persistently from around 2012 onward.

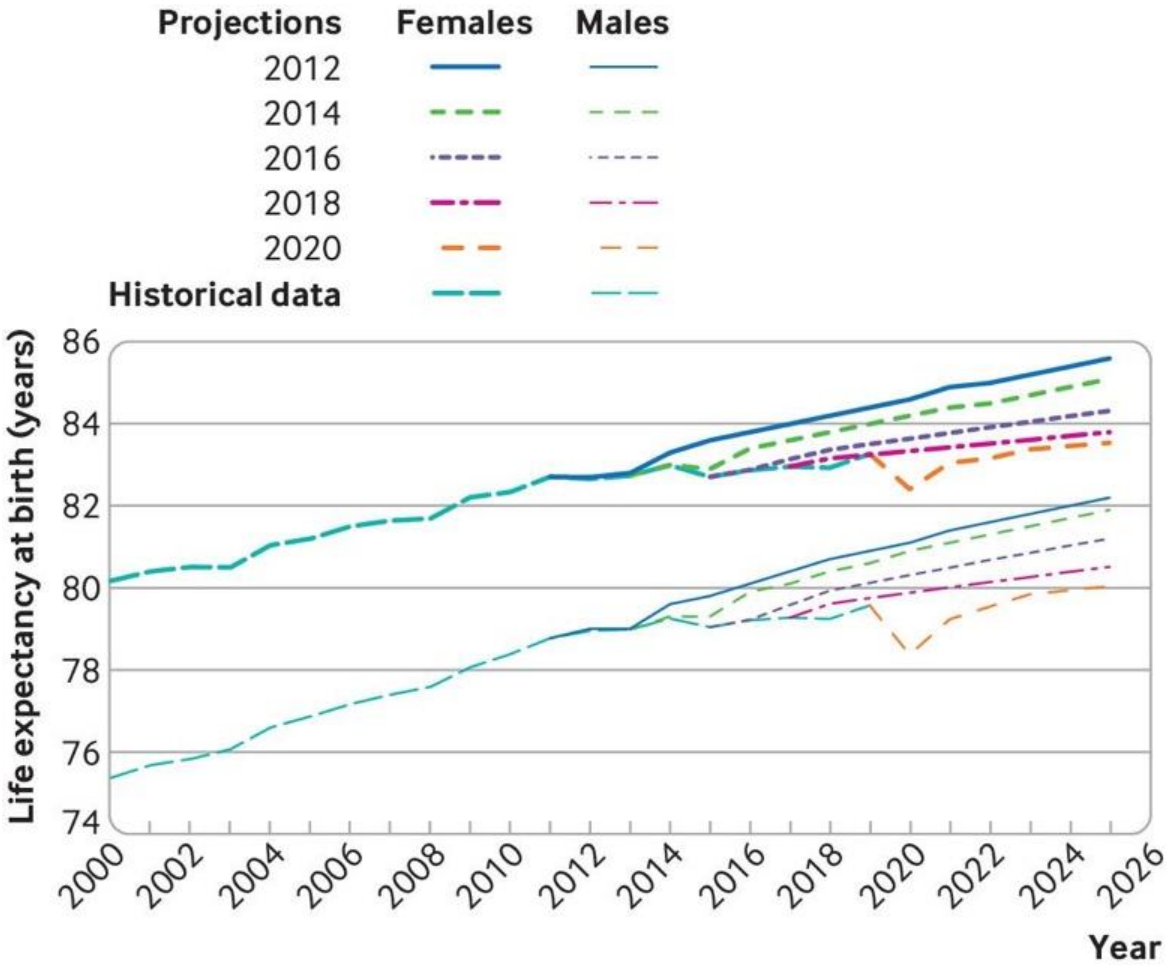


Figure 2: Projections of life expectancy at birth for males and females in the UK, 2012 onwards. The dotted lines show recorded historical data from 2000 to 2019, and the solid lines show the ONS annual projections from 2011 to 2025. Source: Hiam & Dorling, BMJ 2022

The scale of the crisis becomes even more stark when one considers that these projections were not ambitious targets but rather estimates based on historical performance. The post-2010 divergence, therefore, represents not just missed opportunities for health improvement but a fundamental rupture in the social and economic conditions that had previously sustained population health gains. As will be detailed further in Paper 1 in Chapter 4, the crisis did not just impact life expectancy, but multiple health indicators (Hiam et al., 2020).

2.3.2 International Context: The UK as an Outlier

Some observers claimed that the changes observed in the UK were observed across HICs and were not unique. Indeed, 2014-2015 saw declines in life expectancy across several HICs, but only the UK and a few other countries did not recover from this temporary setback (Broadbent et al., 2024; Ho & Hendi, 2018). Similarly, only very few countries fell back to levels of life expectancy in 2010-2012 following covid-19, one of which was the UK (Appendix 1). This international comparison is crucial for evaluating proposed explanations for the UK's health crisis. Ho and Hendi's analysis demonstrates that although several HICs experienced temporary declines in life expectancy in 2014-2015, most subsequently recovered (Ho & Hendi, 2018). The UK's sustained deterioration throughout 2020 makes it a clear outlier, even among countries that experienced initial setbacks (see Appendix 1).

Figure 3 reveals the UK's decline in international life expectancy rankings among G7 countries from 1950 to 2020 (Hiam et al., 2023a). After 2010, it is only one position above the bottom of the G7 rankings by 2020 due to the unprecedented decrease in life expectancy in the US (Venkataramani et al., 2021; Woolf & Schoomaker, 2019).

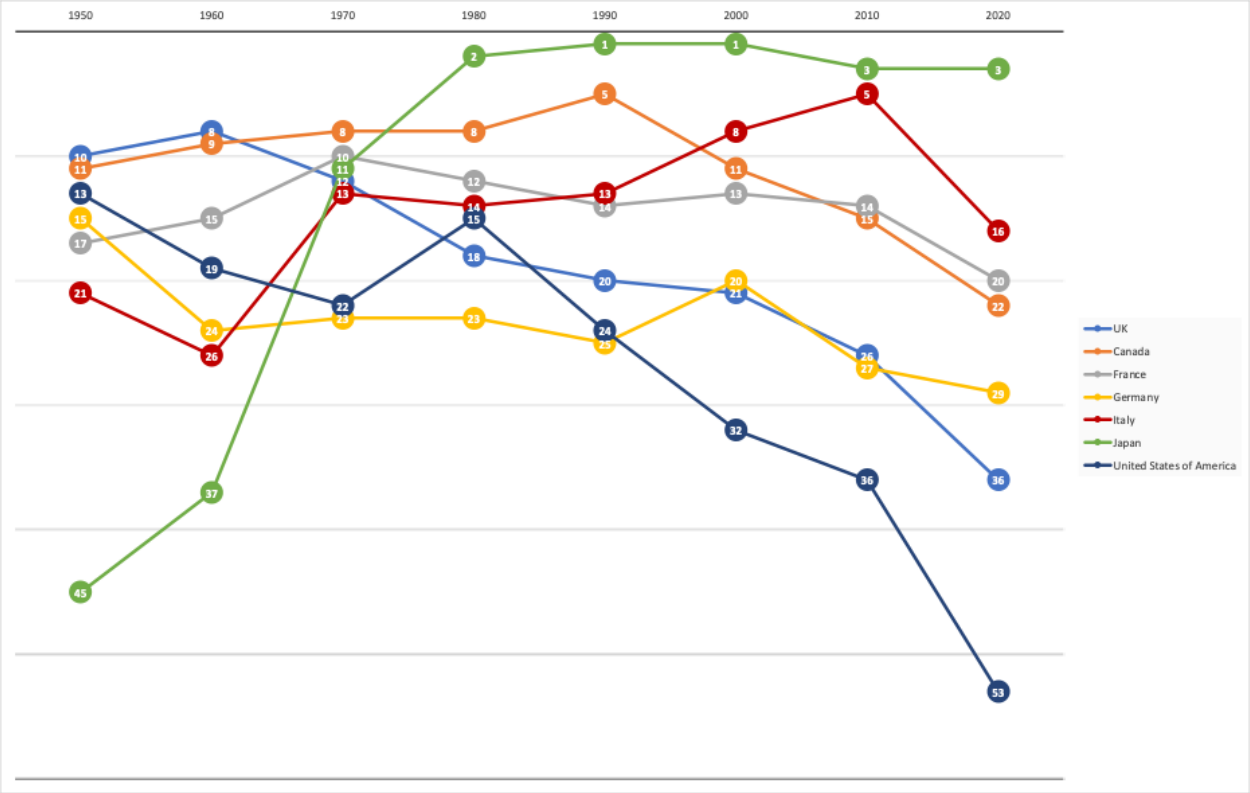


Figure 3: Countries of the G7's international life expectancy rankings, 1950–2020. Note: The data shown are the annual data for the corresponding year, not an average for the decade. Source: Hiam et al. 2023a

2.4 Timeline of Policy Changes and Health Outcomes

The timing and persistence of the UK's decline relative to its peers provides powerful evidence against explanations based on universal factors such as demographic ageing, influenza pandemics, or the limits of human lifespans. All G7 countries faced similar demographic transitions and seasonal health challenges, yet only the UK (along with the US) experienced sustained reversals. This divergence suggests that country-specific policy decisions, rather than universal demographic or epidemiological factors, drove the UK's exceptional deterioration.

2.5 Temporal Patterns: When did Health Trends Change?

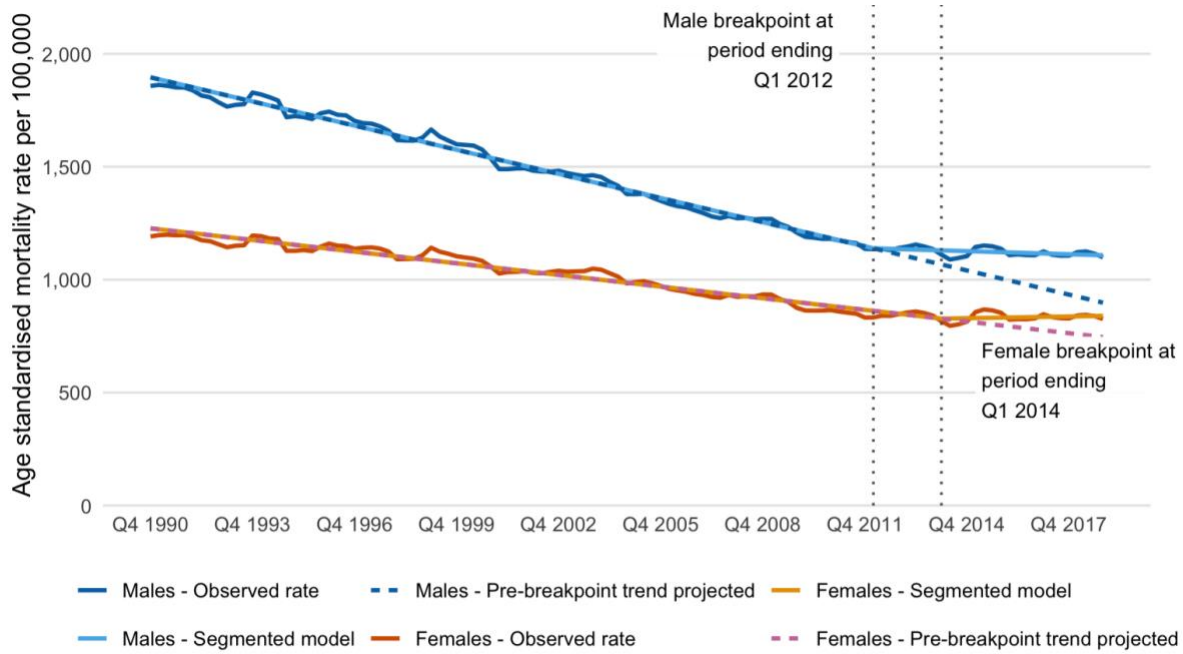


Figure 4: Age-standardised quarterly rolling annual mortality rates and fitted segmented model, by sex for all ages, England, 1990 to 2018, showing breakpoints for males and females in the early 2010s when a single breakpoint model is used. Reproduced from ONS data. Source: ONS, 2020

The temporal relationship between policy implementation and health deterioration provides important evidence for evaluating competing explanations. An ONS analysis of changing mortality trends identified statistically significant breakpoints in the early 2010s for both England and Wales, marking the point at which the long-term improvement in ASMRs began to slow dramatically (Office for National Statistics, 2020a). This pattern was consistent across England and Wales, for both sexes and all age groups, with variation in timing by specific age groups; the early 2010s marked the critical inflexion point when decades of mortality improvement stalled. The results for England are shown in Figure 4.

The timing is also significant when considered alongside the international context. As outlined, while 2014-2015 saw temporary life expectancy falls across multiple HICs, our research examined life expectancy improvements from 1980 at birth (e_0) and

aged 65 (e65) for England & Wales, Scotland, France, Germany, Italy, the Netherlands and Spain (Minton et al., 2023). We found that, while almost all countries examined experienced reductions in life expectancy gains, except for e65 in Italy, only in the British nations did gains stop completely or even decrease (Paper 4). Furthermore, the segmented regression showed a moderate annual increase during the 1980s and 1990s, an accelerated growth in the late 1990s and early 2000s, and a significant decrease thereafter for both sexes at both e_0 and e65. This means that, while the 1990s and 2000s saw unusually fast improvements, the fall in the 2010s was not “returning to normal” but a deterioration in rates of improvement. These findings are also relevant to the proximate explanation of the slowdown in cardiovascular disease mortality, explored in Section 2.5.

2.6 The Explanatory Landscape: Testing Proximate Causes

2.6.1 Introduction

Public bodies advanced several proximate explanations for the post-2011 slowdown in life expectancy. PHE and ONS suggested that the 2014-15 mortality spike was due to a particularly virulent flu season, and the circulating strain, influenza A (H3N2), "known to predominantly affect older people” (Office for National Statistics, 2016a; Pebody et al., 2018), and that this was also reflected across Europe (Molbak et al., 2015). In 2018, PHE’s Health Profile for England highlighted dementia and a slowdown in improvements in heart disease mortality as the two largest contributors to stalled gains, noting that rising dementia deaths alone offset life expectancy by 0.2 years in men and 0.3 years in women (Public Health England, 2018b). Alongside these disease-specific causes, others, including some politicians, have frequently invoked population ageing, arguing that Britain is simply reaching the limits of achievable health gains.

A synthesis of the academic and grey literature shows how these explanations have been framed and debated. Table 2 summarises the main proximate explanations identified in the literature and how they were presented in official or public discourse. These are reviewed in turn in the sections that follow.

The decision to apply the Bradford Hill criteria comprehensively to the first three explanations in the table (influenza, population ageing, and the slowdown in cardiovascular disease improvements) reflects their prominence in official discourse. Agencies such as the ONS, PHE, and DHSC repeatedly presented these factors as leading explanations for the post-2010 mortality slowdown. Applying all the Bradford Hill criteria to these dominant hypotheses enables a systematic and consistent evaluation of causality. In contrast, other proximate explanations—such as deaths of despair, obesity, and migration—have been less prominent in national policy documents or emerged later in academic debate. These are therefore assessed more briefly, drawing on targeted evidence to determine their plausibility with respect to the timing, scale, and distribution of the UK's health crisis.

Table 2: Summary of findings from the literature: proximate explanations commonly cited for the UK's post-2010 mortality slowdown

Explanation	Summary of findings from the literature
Influenza (severe seasons; vaccine mismatch)	Early analyses linked the 2014–15 mortality spike and later stalls to severe influenza seasons and low vaccine effectiveness (Office for National Statistics, 2016a; Pebody et al., 2018). Subsequent analyses showed that influenza deaths declined from 2001 to 2019, but could not account for the sustained multiyear deterioration.
Ageing/limits to gains	Commonly cited in policy debate (Murphy et al., 2019; UK Parliament, 2018) as evidence that Britain had reached longevity limits. The abrupt slowdown and continued improvements in similarly aged countries contradict this explanation.
Cardiovascular disease (CVD) improvements slow down	Improvements in CVD mortality plateaued in the 2000s (OECD & The King's Fund, 2020). Likely contributed to slower gains but cannot alone explain the timing or magnitude of the post-2012 reversal.
Dementia (coding and diagnosis changes)	The apparent rise in dementia-coded deaths during 2014–15 largely reflects coding changes and diagnostic incentives (Department of Health, 2015; Hiam et al., 2017b, 2017a; Office for National Statistics, 2016a). This is not sufficient to explain the broader decade-long stall.
Deaths of despair	Rising drug-, alcohol-, and suicide-related deaths (Camacho et al., 2024; Joyce & Xu, 2019; Walsh et al., 2021) contributed regionally but not enough to drive national trends; more likely to share structural causes.
Obesity (and metabolic risks)	Obesity prevalence rose steadily (Stiebhal, 2025), but obesity-specific mortality fell from 2004 to 2019 (Sophiea et al., 2024); the timing and magnitude of this decline were misaligned with the stall (Walsh, Tod, et al., 2022). 23/04/2026 18:23:00
Migration/denominator artefact	Suggestions that migration distorted rates are unsupported. Migrants to HICs have lower mortality (Hendi & Ho, 2021; Hiam et al., 2022), likely masking, not causing, the deterioration.

2.6.2 Influenza: Cause or Excuse?

Among proximate explanations, influenza has perhaps been the most consistently invoked by public bodies. ONS described the 2014-2015 increase in deaths as the greatest since the 1968 influenza pandemic, the flu vaccine "less effective" than in other years, and influenza described in public health reports and media as "the likely culprit" (Office for National Statistics, 2016a; Pebody et al., 2018; Wise, 2016).

Applying Bradford Hill Criteria

Table 3: Applying the Bradford Hill criteria to the influenza hypothesis

Bradford Hill Criterion	Assessment	Evidence
Temporality	X	Life expectancy slowdown began in 2012-13, before cited severe 2014-15 flu season
Strength of association	X	Flu deaths declined from 2001 to 2019, while overall mortality worsened (see Paper 2)
Consistency	X	The pattern is inconsistent across time periods and definitions
Biological gradient	X	No obvious dose-response: severe flu seasons ≠ worst mortality outcomes
Plausibility	±	Plausible for acute spikes, implausible for sustained multiyear trends
Coherence	X	Expected return to baseline in mild flu years did not occur
Experimental evidence	±	Previous pandemics (e.g., 1918, 1957, 1968) caused mortality spikes but not sustained trends
Analogy	X	Other seasonal infectious diseases do not show similar sustained patterns
Specificity	X	Mortality increases across multiple causes, not just respiratory

The influenza hypothesis fails to meet seven of nine Bradford Hill criteria, particularly with respect to temporality and strength of association (Table 3). Our detailed analysis (Paper 2) reveals that deaths from influenza and influenza-like diseases declined throughout 2001-2019, whereas overall mortality was stagnant or increasing (Hiam, McKee, et al., 2024). Even using the broadest definition of

influenza-related mortality, this inverse relationship persists, fundamentally contradicting the hypothesis that flu drove the UK's health crisis.

The persistence of the influenza explanation despite mounting contrary evidence raises important questions about institutional preferences for "safe" explanations that avoid political controversy. While seasonal flu may contribute to annual mortality fluctuations, it cannot account for the sustained, multi-year deterioration in UK population health documented in this thesis. Instead, as we concluded, influenza functioned more as an excuse than a cause, a convenient medical narrative that diverted scrutiny from structural drivers such as austerity (Hiam, McKee, et al., 2024).

2.6.3 Demographic Change: Ageing Population and Limit to Lifespan

During a 2018 debate in the House of Commons[f], the Conservative MP Robert Courts responded to concerns about a link between austerity and stalling life expectancy:

> *"Saying simply that necessary control of public spending leads to an increase in mortality… is too simplistic… life expectancy cannot be expected to increase forever. That is, of course, common sense… but the point bears repeating and remembering. For a number of reasons, we have had extraordinary success in increasing healthcare over the past few years, but we are now faced with the results of that—an ageing and increasing population, therefore with increased complexity of morbidity factors." (UK Parliament, 2018)*

The challenges of an ageing population have been a persistent theme in UK policy discourse, often framed as inevitably straining health and social care systems and slow improvements in population health outcomes (Government Office for Science, 2016; UK Health Security Agency, 2019). Proponents of this explanation, such as Mr Courts, argue that the UK's post-2010 mortality trends reflect the natural

[f] "Austerity: Life Expectancy" Volume 639: debated on Wednesday 18 April 2018

consequences of an ageing society reaching the limits of achievable health gains, while others argued that the stalling of mortality improvements is an artefact of population changes rather than evidence of real decline (Murphy et al., 2019; Public Health England, 2018a). As larger cohorts reach advanced ages, when mortality risk is highest, this argument suggests that overall population mortality rates will inevitably rise, creating the appearance of a health crisis where none exists.

The demographic explanation may have gained traction among policymakers because it implied that deteriorating health outcomes were unavoidable demographic consequences of health policy success rather than policy failures. It suggested that stalling in life expectancy reflected the natural progression of an ageing society and the exhaustion of potential improvements in health, rather than systemic problems requiring intervention. It was also propagated by initial analyses, including our own (Hiam et al., 2017b), examining crude mortality counts, which did not allow for population ageing, even though a population does not “suddenly” get very old.

Applying Bradford Hill Criteria

While population ageing creates predictable pressures on mortality rates, the timing and pattern of the UK's health crisis cannot be explained by demographic factors alone (Table 4). Techniques such as age-standardisation, applying actual mortality rates to a standardised population age structure, further dispel this possibility by showing that, even when ageing is accounted for, the trends persist (Office for National Statistics, 2024).

Additionally, other HICs with similar population ageing continued to experience health improvements throughout the 2010s, such as Japan and France (Hiam et al., 2021), while the UK's deterioration has affected all age groups, not just older people.

Table 4: Applying the Bradford Hill criteria to the ageing population and limits to lifespan

Bradford Hill Criterion	Assessment	Evidence
Temporality	±	Population ageing is gradual; mortality changes were abrupt after 2012
Strength of association	X	Other countries with similar ageing experienced continued improvements
Consistency	X	Inconsistent across age groups; for example, infant and working-age mortality also worsened
Biological gradient	±	Expected gradient exists, but timing and magnitude do not align
Plausibility	±	Plausible in principle, but inconsistent with abrupt slowdown and with limits not reached in peer nations
Coherence	X	Contradicts continued improvements in comparable-aged populations
Experimental evidence	X	International comparisons show that ageing alone is insufficient
Analogy	X	Other ageing societies (e.g., Japan, France) maintained health improvements
Specificity	X	Changes affected multiple age groups, not just older people

My analysis of the mortality improvements of the "Golden Cohort" (Chapter 5) provides further evidence against purely demographic explanations (Hiam & Dorling, 2024). This historically advantaged generation, born between 1925 and 1934, benefited from postwar social investments and demonstrated exceptional longevity throughout their lives. Yet even this resilient cohort experienced an unexpected increase in mortality after 2012, suggesting that structural factors overwhelmed its demographic advantages. The demographic explanation cannot account for why one of the most favoured generations in British history suddenly experienced accelerated mortality just as they entered their final years.

2.6.4 Cardiovascular Disease: A Slowing Success Story?

Another strongly supported argument was that the rapid improvements in cardiovascular disease mortality observed in the 1990s and 2000s plateaued, and that this slowdown accounted for the observed overall mortality changes. This was

repeatedly reported by government agencies, think tanks, and academics (Murphy et al., 2019; OECD & The King's Fund, 2020; Office for National Statistics, 2018; Public Health England, 2018a).

There is strong evidence that improvements in cardiovascular disease (CVD) mortality contributed substantially to rising life expectancy in the latter half of the twentieth century, driven by reductions in smoking, better diagnosis and treatment of hypertension, and advancements in medications such as widespread statin use (Unal et al., 2004, 2005). Furthermore, decomposition analyses show reductions in these gains as important contributors to changes in life expectancy (Public Health England, 2018a; Ramsay et al., 2020). This has led some to argue that, rather than a slowdown in life expectancy gains, the UK experienced a return to "normal" after an unusually rapid period in the 1990s and 2000s, attributable to advances in cardiovascular disease care.

However, this argument cannot entirely account for the observed change for several reasons. First, the stall in improvements in cardiovascular disease pre-dates the stall in improvements in overall life expectancy (McCartney, Walsh, et al., 2022). Second, regional analyses further complicate the picture: some areas with the highest post-2012 mortality deterioration did not have the highest burden of cardiovascular deaths, undermining the claim that CVD alone can explain the national stall (McCartney, Walsh, et al., 2022). Third, as highlighted in Section 2.4, international evidence indicates that other countries, such as France and Spain, maintained steady improvements in life expectancy throughout the 2010s and/or returned to previous rates of improvement (Minton et al., 2023). Finally, the marked social inequalities in deaths from cardiovascular diseases show that a limit of improvements has not been reached, indeed far from it, with people in deprived

areas four times more likely to die prematurely from CVD than those in the most affluent areas, associated with less access to healthcare, prevention, and a higher prevalence of risk factors (Fu et al., 2023; Public Health England, 2021). This suggests that, while CVD is clearly part of the story, structural drivers common across multiple causes of death must also be involved.

Applying Bradford Hill Criteria

Table 5: Applying the Bradford Hill criteria to the CVD slowdown hypothesis

Bradford Hill Criterion	Assessment	Evidence
Temporality	±	CVD mortality improvements slowed before 2012, but all-cause mortality stalled abruptly from 2012
Strength of association	±	CVD is a major cause of death, so slower improvements reduce life expectancy, but this is not sufficient to explain the overall magnitude
Consistency	X	Not consistent across regions or internationally; some countries with similar CVD patterns continued improving
Biological gradient	±	Plausible gradient with risk factors (e.g., obesity, diabetes), but timing/magnitude do not align fully
Plausibility	✓	Plausible that stalled CVD improvements contributed to stalled life expectancy
Coherence	X	Incoherent with worsening trends in infant and working-age mortality (e.g., deaths of despair) unrelated to CVD
Experimental evidence	X	International comparisons show that the CVD slowdown alone is insufficient to cause a national stall
Analogy	±	Similar stalling in the US is partly linked to CVD, but combined with other drivers (e.g., opioids)
Specificity	X	Deterioration affected multiple causes of death, not specific to CVD

The CVD slowdown hypothesis may have contributed to slower improvements, but cannot alone account for the timing, magnitude, or breadth of the stall (Table 5). It is best understood as a contributory factor: the stalling of improvements in cardiovascular mortality has likely contributed to the slowdown in life expectancy, but cannot alone explain its timing, magnitude, or breadth across age groups and causes. As we argue, Britain's trajectory reflects both unusually rapid improvements

in the 1990s and 2000s and an unusually sharp slowdown from 2012 onwards, from which it did not recover while other countries did (Minton et al., 2023). The CVD explanation may account for part of the former, but the latter requires recognition of wider structural drivers that acted across multiple disease categories simultaneously.

2.6.5 Other Proximate Explanations

Writing in 2025, with over a decade of data showing worsening health outcomes in the UK, it is more difficult to understand how other proximate explanations gained traction. For completion, these included: increased deaths from Alzheimer's Disease and dementia (referred to collectively as dementia, hereafter); increased rates of so-called "deaths of despair" (especially in Scotland); increased prevalence of obesity; and migration. These have been critically appraised elsewhere (McCartney, Walsh, et al., 2022). This section briefly summarises why these four additional explanations, dementia, deaths of despair, obesity, and migration, cannot account for the UK's mortality crisis.

a) Alzheimer's Disease and Dementia

Decomposition analysis showed that much of the increase in mortality between 2014 and 2015 was driven by an increase in deaths coded as due to dementia (Hiam et al., 2017a, 2017b; Office for National Statistics, 2016a; Public Health England, 2018a). However, this was, in large part, attributed to a data artefact due to a combination of rising diagnosis rates as part of the then Prime Minister's "challenge on dementia", which included financial incentives for GPs (Department of Health, 2015), changes in how dementia on death certificates was coded (Office for National Statistics, 2020b), and an ageing population living longer as mortality from other causes of death declined, coupled with challenges in the accuracy of dementia death reporting (Gao et al., 2018), and research showing decreasing age-specific dementia

incidence (Ahmadi-Abhari et al., 2017). In sum, as the age of the population has increased, so have deaths from dementia, but this increase occurred before the stalling that began in the 2010s and can only partly explain the overall changes seen in mortality.

b) "Deaths of Despair"

Deaths of despair had been rising in the US for over a decade, that is, deaths from suicide, drug and alcohol overdose, and alcohol-related liver disease, linked to "cumulative disadvantage" (Case & Deaton, 2015, 2017). In England, analysis found mid-age mortality began to increase in the early 2010s, driven by slowing improvements in cardiovascular disease mortality and an increase in deaths of despair (Joyce & Xu, 2019). As with many other causes of worsening mortality, there are significant inequalities in deaths of despair by region, with Camacho et al. finding between 2019 and 2021, the SMR of 25.1 in London compared to 54.7 in the Northeast of England (Camacho et al., 2024). Rather than driving the increase in mortality, these deaths are likely a consequence of deteriorating social circumstances. McCartney et al. highlight the rise in drug-related deaths in Scotland, specifically, as a cited cause of the slowdown in life expectancy improvements (McCartney, Walsh, et al., 2022; Walsh et al., 2021). However, they conclude: "the evidence suggests that both are likely to share a common underlying cause, rather than the former [increase in drug-related deaths] causing the latter [overall stalled mortality trends]". McCartney et al. also highlight the lower drug-related deaths in England & Wales and, as highlighted by PHE, that the worsening trends affected all age groups, and all-cause mortality (Public Health England, 2018a).

c) Obesity

The prevalence of obesity has increased markedly over recent decades. According to the Health Survey for England, the proportion of adults who were overweight or obese rose from 52.9% in 1993 to 63.9% in 2022 (Stiebhal, 2025), with regional inequalities (Office for National Statistics, 2025). Obesity is one of four key metabolic changes resulting from behavioural risk factors (tobacco and alcohol use, physical inactivity, and unhealthy diet) to cause non-communicable diseases (NCDs) such as cardiovascular disease and diabetes (World Health Organization, 2025). NCDs, in turn, are the leading causes of death in the UK, excluding the covid-19 pandemic years (Office for National Statistics, 2024).

It is therefore understandable to link rising obesity with worsening mortality. However, the evidence is mixed, and the relationship is complex. For example, Sophiea et al. examined trends in all-cause and cause-specific mortality by body mass index (BMI) in England between 2004 and 2019 and found that all-cause mortality rates decreased among people with obesity over the study period (Sophiea et al., 2024). Research by Walsh et al. suggests that some of the stalling in mortality improvements may be associated with rising rates of obesity, but the authors emphasised the hypothetical nature of the analyses and concluded that, even if correct, the majority of changes in mortality must be due to other factors (McCartney, Walsh, et al., 2022; Walsh, Tod, et al., 2022). The increase in deaths unrelated to obesity, and occurring across population groups, further undermines obesity as a key driver.

Attributing recent mortality trends to obesity also shifts attention from structural determinants to individual behaviour. There is extensive evidence regarding the “obesogenic environment” (Swinburn et al., 1999; The Lancet Public Health, 2025),

the role of environmental factors such as access to affordable healthy foods and green spaces in shaping both diet and physical activity, and this is a product of policy. Obesity is strongly tied to inequality: Pickett et al. found obesity to be positively associated with income inequality in HICs (Pickett et al., 2005), and lower socioeconomic status was associated with morbid obesity in the UK more than the US (Booth et al., 2017). In the UK, the Food Foundation's annual "Broken Plate Report" found that the most deprived fifth of the population in 2025 would need to spend almost half (45%) of their disposable income on food to achieve a healthy diet (The Food Foundation, 2025), making eating well unattainable for many. In this context, austerity, through reduced incomes, rising poverty, and cuts to public health and social safety nets, has made it increasingly difficult for large sections of the population to eat well, reinforcing the structural roots of obesity and widening health inequalities.

d) Migration

Another possible cause of data artefact or real impact on life expectancy that has been proposed is in- or out-migration because mortality rates and life expectancy calculations depend on accurate population denominators, and migration has sometimes been suggested as a confounder. However, this explanation is highly implausible. As McCartney et al. note, for migration to explain the observed stalling, the UK population would have to have been systematically underestimated across all age and sex groups (McCartney, Walsh, et al., 2022). This is an unlikely scenario, and one contradicted by cohort data, which show the same stalling trends without relying on denominator estimates.

There is also no evidence that inward migration would worsen the population's risk profile. On the contrary, migrants to the UK typically have lower all-cause mortality

than the UK-born population (Hiam, Minton, et al., 2025) and in other HICs, including the US and Australia, have been shown to contribute positively to national life expectancy (Ho & Hendi, 2018; Huang et al., 2023; Page et al., 2007; Wallace et al., 2022). If anything, healthy migrants may have masked even worse trends in the UK, as Ho and Hendi (2018) found in the US. In sum, while migration has been used rhetorically as a scapegoat for pressures on health and social care services, the evidence indicates that it is far more likely to have mitigated than caused the UK's worsening mortality outcomes (Hiam et al., 2022). My publications that contribute to the evidence on migrant mortality and life expectancy in England and Wales are included in Appendix 5 (Hiam et al., 2022; Hiam, Minton, et al., 2024, 2025).

2.7 From Proximate to Structural Explanations

Proximate explanations share several common shortcomings. The UK's health crisis has been multifactorial, with no single disease category, demographic group, or seasonal event capable of accounting for its scale. Even agencies such as PHE acknowledged that multiple causes were in play (Public Health England, 2018a), yet the persistence of proximate narratives obscured this point. The spatial and temporal patterns of deterioration also demand a structural account: the abrupt stall in improvements in the early 2010s coincided across regions and age groups, while the most deprived areas experienced the greatest harm (Marmot et al., 2020). This diversity of those affected, from infants to working-age adults to historically advantaged cohorts of older people, undermines any explanation tied narrowly to age or disease-specific causes. The evidence instead suggests that these varied outcomes share underlying drivers, meaning proximate explanations are best understood as manifestations of deeper processes rather than root causes.

Taken together, the evidence demonstrates that proximate explanations cannot account for the scale, timing, persistence, or geography of the UK's health crisis. Only one or more structural drivers align with the magnitude and distribution of observed harm. The persistence of proximate narratives despite weak empirical support reveals how public health debates often privilege "safe" technical accounts over politically uncomfortable structural ones. This asymmetry reflects more than analytical error: it exposes how standards of evidence are unevenly applied. Weak proximate causes are accepted with limited scrutiny, while structural determinants are held to impossible evidentiary thresholds, echoing the "impossible expectations" mechanism in science denialism (Cook, 2020; Diethelm & McKee, 2009).

2.8 Chapter 2 Summary and Next Steps

By systematically evaluating and eliminating proximate explanations, this chapter establishes the limits of individual-level, seasonal, and disease-specific accounts of Britain's post-2010 mortality reversal. The next chapter, Chapter 3, turns to structural explanations, reviewing the evidence on austerity and health and introducing the theoretical frameworks used throughout the thesis to interpret the empirical findings that follow.

3 Beyond the Individual: Structural Theories of the Health Crisis

3.1 Introduction

Chapter 2 demonstrated that the dominant proximate explanations for Britain's post-2010 health crisis, such as seasonal influenza, population ageing, and plateauing cardiovascular gains, cannot satisfy the criteria of causation (Hill, 1965). This chapter, therefore, turns from proximate to structural explanations, asking what political and economic forces were sufficient to produce such a rupture in long-term mortality trends.

The coinciding of reversal in population health with the UK's programme of austerity implemented after the 2010 general election, as outlined in Section 2.4, has led many researchers to identify fiscal retrenchment, here referred to as austerity, as the central structural driver of the reversal. A growing body of work documents how welfare reforms, cuts to local government, and reduced investment in health and social care undermined the infrastructures that sustain population wellbeing (Alexiou et al., 2021; Berman & Hovland, 2024; Darlington-Pollock et al., 2022; Gray & Barford, 2018; Hiam, Dorling, et al., 2018a; Hiam et al., 2017a; McCartney, McMaster, Popham, et al., 2022; Rashid et al., 2021). Yet this evidence remains contested, and some argue that the causal link is overstated. The first task of this chapter, therefore, is to review and assess the evidence base, examining the extent to which austerity can plausibly account for the observed mortality reversal.

The second task is conceptual. Even if austerity is accepted as a driver, it is not self-evident how macro-level policy choices become embodied as spatially uneven health outcomes. To address this, the chapter reviews existing theoretical frameworks, including the SDH, structural violence, syndemic theory, welfare state theory, and

psychosocial stress theory, before outlining the innovative use of a unified theoretical framework. Building on traditions in health geography and public health, the framework acknowledges place as an active determinant of health rather than a passive backdrop: national policies operate through institutions, infrastructures, and social organisation to shape exposure, vulnerability, and adaptive capacity.

In sum, this chapter asks not only what explains Britain's health reversal, but how to explain it. By reviewing the evidence on austerity and situating it within the broader theoretical landscape, it provides the analytical foundations for interpreting the empirical chapters that follow and for addressing the RQs.

3.2 Austerity as a Key Structural Driver

3.2.1 Timing and Policy Shock

As Figure 4 shows, the timing of health deterioration coincides with the implementation of the UK's austerity programme following the 2010 general election. The Conservative-Liberal Democrat Coalition government, elected in May 2010, moved quickly to implement what it termed "fiscal consolidation" in response to the 2008 financial crisis and rising public debt. This began with the June 2010 Emergency Budget, which announced immediate spending cuts of £6.2 billion, along with other measures including freezing child benefit for three years (Seely & Webb, 2010), followed by the October 2010 "Comprehensive Spending Review" that set out plans to reduce public spending by £81 billion by 2014-15, including £11 billion from welfare (HM Treasury, 2010). Key measures included welfare and social security reforms such as benefit caps, changes to disability assessments, the introduction of Universal Credit, and the "bedroom tax". These reforms (and those that followed post-2015) disproportionately impacted those in deprived areas and reduced

household incomes by £27 billion a year by 2015 (Beatty & Fothergill, 2016). Local government lost over half of its funding from 2010 to 2015, and, once again, the most deprived areas faced greater spending reductions (Gray & Barford, 2018). Non-education spending per council resident decreased by almost one quarter between 2009-10 and 2019-20 (Ogden et al., 2021), while spending on health (here referring to NHS England) reduced substantially, falling below the average spending annual increase for 1955-2019, as shown in Figure 5 (Hiam & Dorling, 2024; Institute for Fiscal Studies, 2021; Triggle & Butcher, 2020).

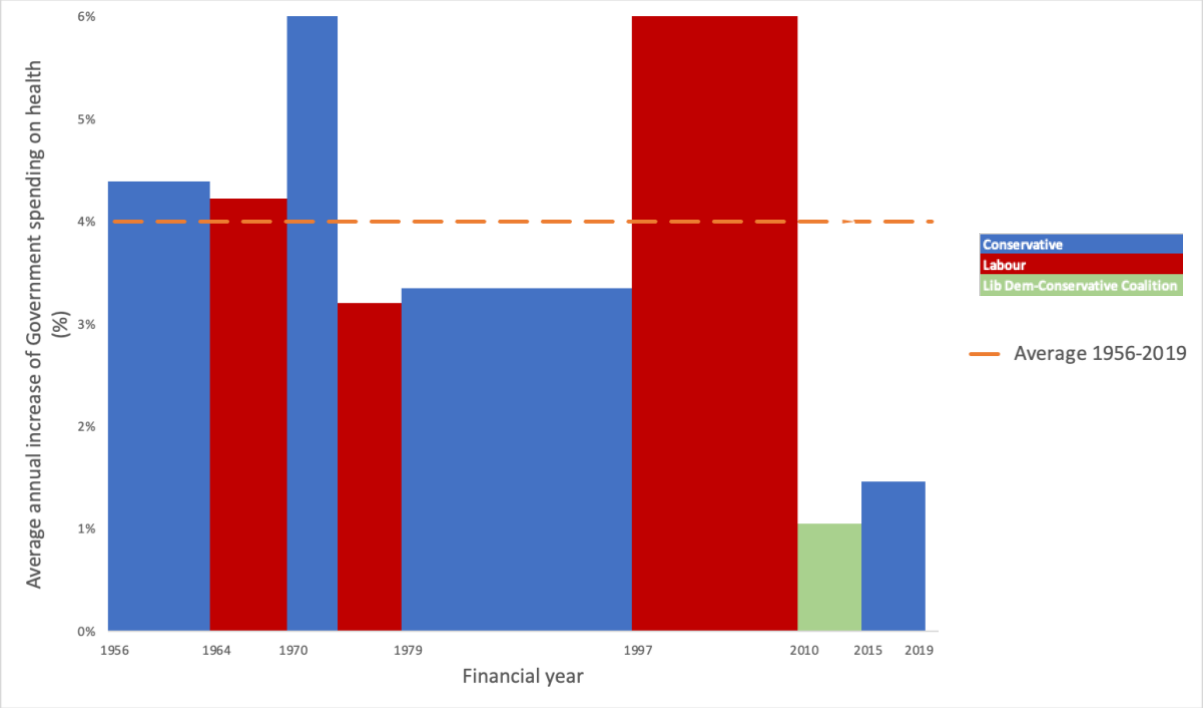


Figure 5: Average annual increase in government spending on health (NHS England), 1955–2019, based on 2019/2020 prices. Source: Hiam & Dorling, 2024.

These policy changes were implemented rapidly and simultaneously across multiple sectors, creating what some described as a "policy shock" to the systems supporting population health (Stuckler et al., 2017). The austerity policy interventions represented a clear departure from the post-war consensus on social protection and public investment. The temporal alignment between policy implementation and

health deterioration, combined with the geographic concentration of cuts in already disadvantaged areas, establishes austerity as a prime candidate explanation that merits systematic evaluation against epidemiological criteria for causation.

3.3 Austerity: The Emerging Evidence Base and Causal Assessment

As outlined in the introduction, the early publications I led with colleagues linking austerity to rising mortality and worsening health in the UK faced substantial critique, including the epidemiological objection that correlation does not imply causation. While austerity coincided with declining population health, this alone does not prove a causal relationship. However, demanding experimental proof sets an impossible standard for large-scale exposures such as austerity or climate change phenomena that cannot be randomised and whose effects are population-wide (see Chapter 9 for further discussion on the weaponisation of this in science denialism).

To address these critiques, in 2018, we applied the Bradford Hill criteria to evaluate austerity as a causal factor in deteriorating health (Hiam, Dorling, et al., 2018b). As Bradford Hill emphasises, none of the criteria provide “indisputable evidence”, but they help address the key question: “is there any other way of explaining the set of facts before us, is there any other answer equally, or more, likely than cause and effect?” (Hill, 1965). In 2018, we concluded that “to date, no alternative to austerity has been established as the reason for stalling life expectancy” (Hiam, Dorling, et al., 2018b).

Seven years later, with over a decade of data and a substantial expansion of the empirical literature since austerity was introduced, it is now possible to reassess this question systematically. This section therefore synthesises the current evidence base on the health effects of austerity across multiple indicators, drawing on both UK

and international studies, and re-evaluates the evidence against the Bradford Hill criteria.

3.3.1 The UK Evidence Base: Health Impacts Across Indicators

a) Excess Deaths and Life Expectancy

Research consistently links austerity in the UK to excess deaths and the stalling of life expectancy improvements from 2011 onwards, with declines in some populations (Walsh & McCartney, 2024b). Research examining life expectancy in 6791 communities in England from 2002 to 2019 found that before 2010, all but <1% of areas had continued life expectancy improvements for both sexes, but by 2010-2014 female life expectancy decreased in 5.2% of areas; and by 2014-19, this had risen to 18.7% for females and 11.5% for males (Rashid et al., 2021).

Between 2012 and 2019, there were an estimated 335,000[g] excess deaths across England, Wales and Scotland compared to previous trends, with those living in the most deprived areas most affected, and mortality among females worsening between 2010/12 and 2017/2019 (Walsh, Dundas, et al., 2022). Watkins et al. (2017) examined the impact of spending constraints in health and social care on mortality between 2010 and 2014 in England (Watkins et al., 2017). They found that the spending constraints were associated with an estimated 45,368 excess deaths (95% CI: 34,540-56,206). Other research estimated that there were 231,707 excess deaths in England between 2010 and 2018 relative to 2010 projections, occurring across 91% of local authorities, and mostly since 2014-2015 (Darlington-Pollock et al., 2022). These excess deaths were positively associated with austerity, with higher mortality in areas that experienced larger financial cuts.

[g] It should be noted the authors consider this figure a conservative estimate.

Indeed, the cuts in funding to local governments in England between 2013 and 2017 showed a dose-dependent effect on life expectancy at birth (e_0): each £100 reduction in per capita funding was associated with an average decrease in e_0 of 1.3 and 1.2 months for males and females, respectively (Alexiou et al., 2021). Furthermore, the authors found that because funding cuts were greater in more deprived areas, these areas were more affected, and the reduction in spending widened the gap in life expectancy between the most and least deprived areas by an estimated 3% (males) and 4% (females).

A review of life expectancy inequalities in England from 2001 to 2016 found the stalling of life expectancy improvements occurred along the social gradient, with stalls in the third, fourth, and fifth most deprived deciles for females, and declines in the two most deprived deciles, contributing to widening inequalities (Bennett et al., 2018).

b) Infant and Child Health

Measures beyond life expectancy have been impacted. Taylor-Robinson et al. (2019) found that the “unprecedented” rise in the infant mortality rate (IMR) in England disproportionately affected the poorest local authorities, widening the gap between the most and least deprived (Taylor-Robinson et al., 2019). The authors estimated that with each 1% increase in child poverty came an additional 5.8 infant deaths per 100,000 live births, and that rising child poverty could be linked to about one third of the increase in IMR between 2014 and 2017. These regional inequalities have persisted: Health Equity North found that the increase in IMR between 2021 and 2022 was driven primarily by infant deaths in the North of England (Akanni et al., 2024). Analysis in Scotland of live births between 1981 and 2019 found an increase in adverse birth outcomes from 2010 onwards, including low birthweight and preterm

birth, greater in deprived areas (Watson et al., 2024), consistent with European evidence showing a link between austerity and adverse birth outcomes (Rajmil et al., 2018, 2020).

Older children have also been affected, with a rising child death rate between 2021 and 2023, and stark regional inequalities (National Child Mortality Database, 2023). Children aged 5 years old in England are now shorter than their peers in comparable countries, with average height falling since 2013 (The Food Foundation, 2024). So severe are the changes in child health that the Academy of Medical Sciences described children under 5 years old as “betrayed”, citing the rise in children living in extreme poverty, and associated adverse health effects (Academy of Medical Sciences, 2024). Once again, the regional disparities are stark, with children living in the North of England more likely to be living in poverty than in other parts of the country (Barnes et al., 2022) .

Notably, Norman et al. demonstrate that rising infant mortality, while a concerning and unequal trend, did not materially contribute to the stalling of life expectancy improvements (Norman et al., 2025). Using scenario modelling, they show that even an estimated excess of nearly 1,400 infant deaths between 2014 and 2019 produced negligible changes in life expectancy at birth (e_0). This indicates that changes in early-life mortality, although important, cannot account for the broader post-2010 mortality slowdown.

c) Cause-specific Morbidity and Mortality

Chapter 2 demonstrated that there were initial increases in mortality from certain diseases, which led to misattributed causality. As PHE highlighted, the increase in mortality was observed across causes, geographies, and age groups (Public Health England, 2018a). For example, there was a significant increase in reported mental

health problems between 2009 and 2013, with widening inequalities, especially by education level (Barr et al., 2015). The observed trends corresponded with increases in deaths from suicide (Walsh et al., 2021) as well as antidepressant prescribing (Cherrie et al., 2021), all linked to austerity cuts. As mentioned, deaths of despair increased, with regional inequalities (Camacho et al., 2024; Hiam, Dorling, et al., 2025). Opioid-related harm also rose: areas experiencing the deepest cuts to social care and housing recorded the largest increases in opioid hospitalisations and deaths, while social care and housing spending buffered the harms of unemployment on opioid mortality (Friebel et al., 2022).

Despite increased demand for mental health services during this period, there were severe cuts, including a rise in Mental Health Act detentions, reportedly due to a lack of community support (Cummins, 2018). The causes of this were multifactorial. In interviews in two towns in the North of England with high rates of deaths of despair, they found that austerity impacted not only through reduced access to mental health and substance use services, but through the loss of community institutions and youth services (Price, 2024). In addition, food insecurity, which rose in this period, was found to be linked to worsened mental health (Jenkins et al., 2021). Internationally within Europe, a 1% reduction in government spending was found to be associated with an increase in male suicide rates, which increased over the short, medium, and long-term (Antonakakis & Collins, 2015).

d) Health Inequalities

Across outcomes, austerity amplified existing inequalities (Marmot et al., 2020), in large part due to how austerity was implemented, with the largest financial losses seen in the most deprived areas (Beatty & Fothergill, 2016; Gray & Barford, 2018). Between 2011 and 2019, healthy life expectancy declined by 2 years, with a 3.5-year

decline in the 20% most deprived areas (Walsh, Wyper, et al., 2022). Localities experiencing the greatest welfare and local government cuts experienced the steepest deterioration in mortality (Alexiou et al., 2021). Health Equity North's 2024 analyses confirmed a widening North–South divide in both mortality and deprivation (Akanni et al., 2024; Health Equity North, 2024).

Populations already in vulnerable situations have been the most affected, including people with disabilities (Macdonald & Morgan, 2021), women (Rashid et al., 2021; Walsh, Wyper, et al., 2022), children in poverty (Rajmil et al., 2018, 2020), ethnic minorities (Marmot, 2022), and Northern and post-industrial communities (Health Equity North, 2024; Simpson et al., 2025).

e) The Unequal Geography of Austerity

The spatial distribution of austerity is also important to understanding its health impacts. National policies interacted with local socioeconomic, institutional and infrastructural contexts, producing highly uneven outcomes across the UK.

Financial Losses from Welfare Reform

The impacts of welfare reform, including benefit freezes, changes to tax credits and Personal Independence Payment (PIP), were unevenly implemented across the country. By 2016, the estimated loss per working-age adult ranged from £720 in Blackpool to just £190 in Cambridge (Beatty & Fothergill, 2016). These figures understate the disparity in relative terms: in 2016, £720 represented 4.1% of median gross annual pay in Blackpool (£17,630), while £190 represented just 0.7% in Cambridge (£27,157) (Office for National Statistics, 2016b). Figure 6 shows the substantial spatial variation in estimated loss arriving from welfare reform, including inequalities within metropolitan regions such as London.

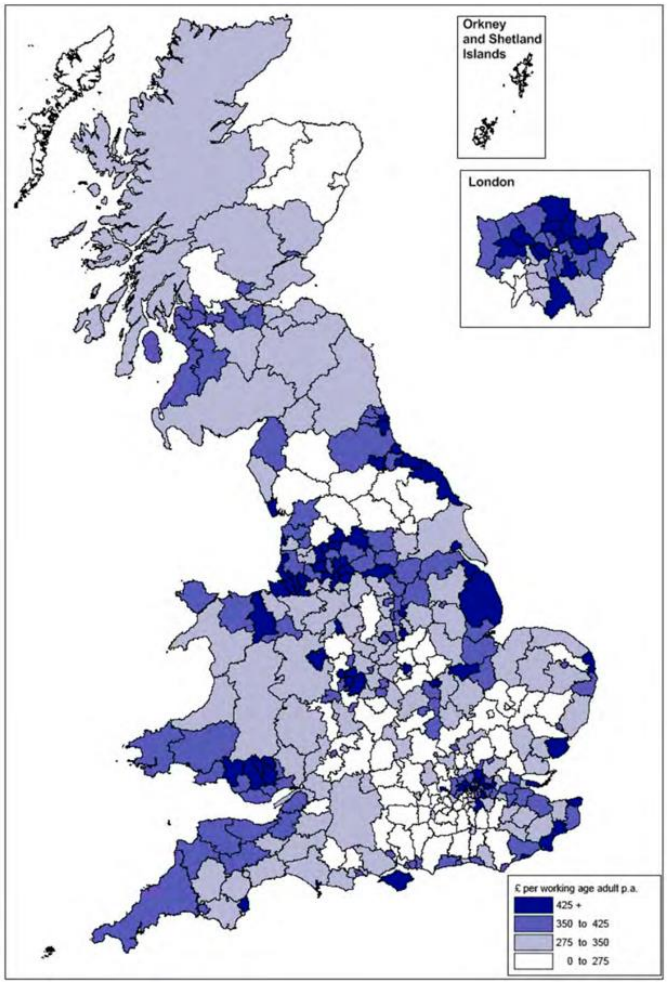


Figure 6: Estimated loss arising from welfare reform by March 2016, by district. Source: Beatty & Fothergill 2016, reproduced with their kind permission.

Diverging Health Outcomes

At the same time, regional inequalities in life expectancy and healthy life expectancy continued to widen (Marmot et al., 2020). Figure 7 compares life expectancy at birth for males and females in Blackpool and Cambridge from 2001 to 2023 (Office for National Statistics, 2024). While both areas have seen fluctuations, the widening gap coincides with spatially-linked financial losses attributable to austerity, lending weight to the case for causality.

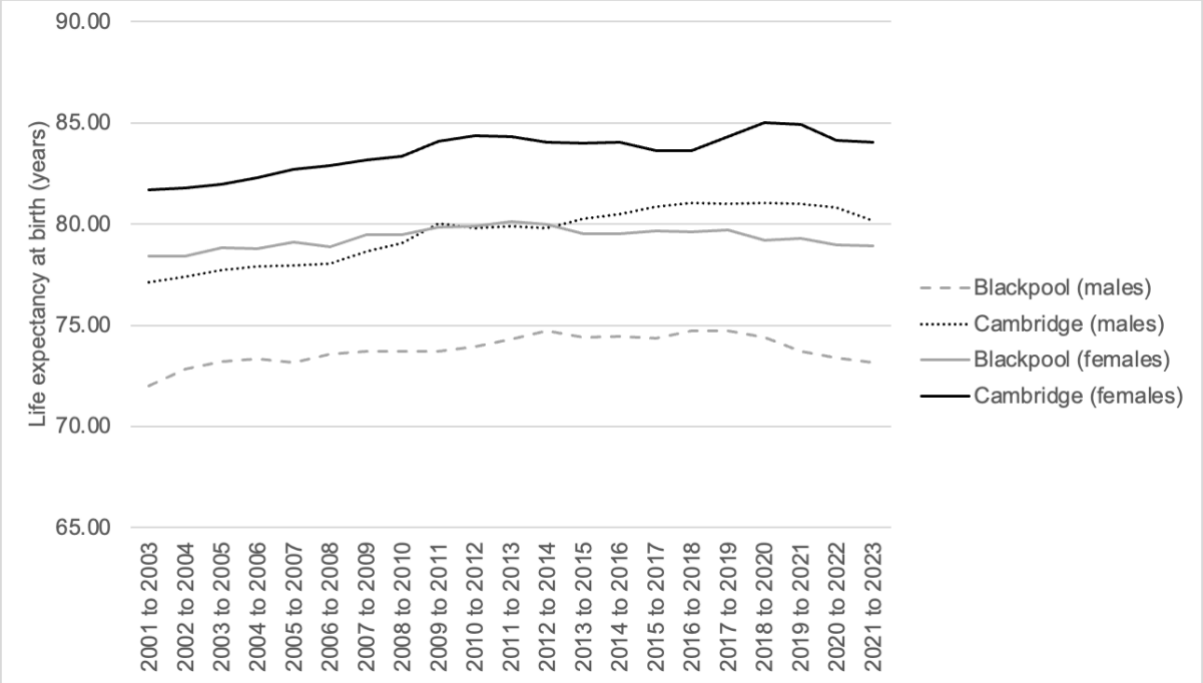


Figure 7: Life expectancy at birth in years for Cambridge and Blackpool by sex, 2001-2023. Source: ONS, 2024

f) International and Comparative Evidence

While the UK was not alone in imposing austerity, its approach was distinctive in its depth, duration, and reliance on spending cuts rather than taxation (Emmerson & Tetlow, 2015). Comparable countries in Europe also experienced adverse health trends following fiscal retrenchment (Stuckler et al., 2017), including a rise in unmet need for healthcare (Reeves et al., 2015), but in Europe, only Poland saw a fall in life expectancy back to 2010-2012 levels following the pandemic (Appendix 1). Cross-national comparisons, therefore, serve as quasi-experimental counterfactuals: while randomisation is impossible, differences in austerity intensity provide natural variation against which to test causal inference.

Rajmil et al. examined standardised mortality rates (SMRs) in 15 European countries between 2011-2015, stratifying the nations into high-, intermediate-, and low-levels of austerity (measured as cyclical adjusted primary balance using International Monetary Fund, IMF, figures) (Rajmil and Fernández de Sanmamed, 2019). They

found that while SMRs decreased across all nations between 2011 and 2014, in countries implementing high- or intermediate-level austerity, SMRs increased in 2015, whereas they continued to fall in countries applying little austerity. There was one notable exception: Germany, which was included as a country that had limited austerity but also saw an increase in SMR. Although the analysis did not adjust for demographic change or migration, the authors concluded that countries with deeper austerity experienced worse mortality outcomes.

Other research has found that austerity increased all-cause mortality by 0.7% across 28 EU countries between 1991 and 2013 (Toffolutti and Suhrcke, 2019), and it was associated with an increase in inequalities in self-reported general health, an effect that grew over time, from 2002 to 2015 in 25 European countries (van der Wel et al., 2018), and slower improvements in subjective health across age groups, where the UK was unusual in experiencing declines in subjective health, particularly among those aged over 65 (Franklin, 2017). Countries that implemented the largest spending cuts had a positive statistical relationship with the highest level of unmet health needs.

Collectively, these studies indicate that the magnitude of health deterioration correlates with the intensity of austerity, supporting the plausibility of a dose-response relationship. The UK's reversal aligns with an international gradient of harm, but stands out for its breadth, depth, and persistence of deterioration.

g) Systematic Reviews

The pattern observed across individual studies has been reinforced by systematic reviews (Broadbent et al., 2024; McCartney, McMaster, Popham, et al., 2022). Broadbent et al. reviewed seven international studies that met the eligibility criteria and found that six reported statistically significant associations between austerity and

adverse health outcomes (Broadbent et al., 2024). The researchers concluded that, while austerity policies were “consistently associated with adverse mortality outcomes”, the magnitude of this association was inconsistent.

McCartney et al. carried out a panel analysis of 37 HICs between 2000 and 2019, and found that austerity negatively impacted life expectancy, as well as other health outcome measures, when measured using three out of four definitions used (McCartney, McMaster, Popham, et al., 2022). Austerity was found to reduce the rate of improvement in mortality across all measures when the analysis was limited to economic downturns and economies not dominated by hydrocarbon production.

3.3.2 Synthesis and Causal Assessment: Bradford Hill Criteria

Although attributing health outcomes to economic policy can be challenging due to inconsistent definitions and overlapping policy effects (Anderson & Minneman, 2014; Matthay et al., 2022), drawing together the UK and international evidence allows austerity to be evaluated systematically against Hill’s nine criteria for causation (Hill, 1965).

As shown in Table 6, austerity satisfies seven of nine Bradford Hill criteria more convincingly than any competing explanation considered in Chapter 2. No single study is determinative, but the convergence of temporality, strength, consistency, and biological gradient, combined with plausible mechanisms and coherent cross-national patterns, meets the threshold for causal inference. Taken together, the evidence demonstrates that austerity provides a better empirical and theoretical fit to the UK’s post-2010 mortality trends than proximate causes reviewed.

Incorporating the spatial distribution of austerity deepens this assessment: the alignment between the geography of cuts and the geography of harm strengthens

the causal case and underscores the need to understand austerity as a structurally mediated and place-shaped exposure.

Table 6: Austerity and the Bradford Hill Criteria for Causation. Key illustrative references; not an exhaustive list.

Bradford Hill Criterion	Assessment	Evidence
Temporality	✓	Mortality stalls and life expectancy reversals followed within 2–3 years of the 2010 Emergency Budget and Comprehensive Spending Review (Hiam, Dorling, et al., 2018b; Steel et al., 2025)
Strength of association	✓	Areas experiencing the largest welfare, local government, and social care cuts saw the steepest deterioration in mortality, and the spatial distribution of financial losses closely aligns with the decline in life expectancy and healthy life expectancy across regions (Alexiou et al., 2021; Beatty & Fothergill, 2016; Marmot et al., 2020)
Consistency	✓	Findings reproduced across multiple datasets, age groups, and countries; corroborated in systematic reviews (Broadbent et al., 2024; McCartney, Walsh, et al., 2022; Public Health England, 2018a; Rajmil & Fernández de Sanmamed, 2019)
Biological gradient	✓	Dose-response evident: greater spending reductions linked to larger declines in life expectancy and higher mortality (Alexiou et al., 2021; Rashid et al., 2021)
Plausibility	✓	Mechanisms well established: reduced income, weakened public services, and constrained access to care increase exposure and vulnerability (Marmot et al., 2020; Stuckler et al., 2009)
Coherence	✓	Patterns align with deterioration in multiple social determinants (e.g., poverty, service capacity) and with observed geographic inequalities in harm (Beatty & Fothergill, 2016; Gray & Barford, 2018; Health Equity North, 2024)
Experimental evidence	±	Natural experiment analogies and policy comparison studies support causal inference but cannot isolate single policy effects (Walsh & McCartney, 2024b)
Analogy	✓	Similar mortality crises followed rapid retrenchment elsewhere (e.g., the post-Soviet transition and other European austerity measures) (McKee et al., 2012; Stuckler et al., 2017).
Specificity	±	Effects are broad and multisectoral, consistent with a structural determinant that acts through multiple pathways rather than a single disease process (Broadbent et al., 2023, 2024).

3.3.3 Political and Institutional Denial

Despite the accumulation of robust evidence linking austerity to the UK's post-2010 health crisis, acknowledgement of this relationship has remained politically fraught. Successive governments have repeatedly rejected any causal connection between fiscal policy and deteriorating health, with senior figures, including the architects of austerity, former Prime Minister David Cameron and former Chancellor George Osborne, continuing to publicly deny that austerity contributed to worsening health (Sparrow, 2023).

This silence extended beyond politics. Public agencies and professional bodies have often favoured depoliticised or ostensibly "technical" explanations, such as those explored in Chapter 2, which obscure questions of accountability and delay recognition of structurally patterned harm (Walsh & McCartney, 2024a).

The persistence of such narratives illustrates how power, ideology, and institutional incentives shape both what counts as evidence and which explanations are deemed legitimate. This epistemic asymmetry, scrutinising structural causes to impossible standards while accepting proximate ones at face value, recurs throughout the thesis and is revisited in Chapters 8 and 9. As later chapters discuss, this reluctance to name austerity's health consequences exemplifies a wider pattern of institutional denial and discursive containment, leading Walsh and McCartney to invoke Engels' term "social murder" in their book examining the health crisis (Walsh & McCartney, 2024b). Together, these dynamics highlight why structural determinants must be made visible if population health is to recover.

3.3.4 Conclusion

A comprehensive body of evidence demonstrates that austerity policies implemented following the 2008 financial crisis have had profound and measurable negative impacts on population health across HICs, with particularly severe effects observed in the UK. These findings establish austerity as the most plausible explanation for the UK's post-2010 health reversal. Yet identifying causation alone does not explain how macro-level policies become embodied as unequal health outcomes.

Having reassessed austerity against the Bradford Hill criteria, this section establishes the empirical basis for a structural explanation. Explaining these patterned harms requires a theoretical framework capable of linking political and economic change to lived experience, social conditions and the spatial distribution of vulnerability. The next section of this chapter outlines the conceptual apparatus used throughout this thesis: an integrated framework that draws on the SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience. Together, these provide the analytic lens through which the empirical findings in Chapters 4–8 are interpreted and, ultimately, synthesised in Chapter 9.

3.4 Frameworks for Understanding Structural Determinants of Health

The second part of this chapter reviews theoretical approaches relevant to understanding how austerity produced the health impacts documented in Chapter 2. While each offers valuable insights, none alone provides a complete account of how macro-level fiscal retrenchment translated into the patterned, place-based harm documented in Chapter 2. This thesis instead uses a unified interpretative framework, outlined in Section 3.4.1. Section 3.4.2 then briefly reviews complementary theoretical perspectives, identifying their insights and limitations for explaining Britain's post-2010 mortality reversal.

3.4.1 A Unified Framework for Understanding Structural Determinants of Health

The evidence reviewed earlier in this chapter establishes austerity as the most plausible structural explanation for Britain's post-2010 health reversal. The key task is to understand how these policy changes produced varied health outcomes across people and places. To do so, this thesis draws on a unified theoretical framework integrating three complementary strands from public health and health geography: the SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience. Together, they provide the analytic lens through which the empirical chapters are read and guide the synthesis in Chapter 9.

This thesis does not claim to develop an entirely new theoretical framework. Instead, it integrates three established but typically siloed bodies of theory to create an analytical lens suited to the challenge of explaining spatially and temporally uneven population-level health change resulting from structural policy shifts. The contribution, therefore, lies not in theoretical novelty but in demonstrating how frameworks from different traditions (public health, health geography) can be productively combined, showing how this integration highlights mechanisms invisible to any single framework, and in applying this integrated lens systematically.

a) Social Determinants of Health (SDH)

The SDH framework provides the starting point for understanding how austerity policies reshaped population health. Dahlgren and Whitehead's (1991) "Rainbow Model" (Figure 8) conceptualises health as emerging from multiple concentric layers of influence, ranging from individual factors to macro-level conditions (Dahlgren & Whitehead, 1991). At its core lie individual characteristics such as age, sex, and constitutional factors. Surrounding this are successive layers of individual lifestyle factors**,** social and community networks, and living and working conditions, including

housing, employment, education, health care, and transport. The outermost layer comprises the general socioeconomic, cultural, and environmental conditions that shape the distribution of all other determinants. In their reflections three decades later, the authors reaffirm its value: it promotes multisectoral action, encourages a holistic view of health beyond individual diseases, and has provided a foundational framework for research on SDH (Dahlgren & Whitehead, 2021).

This thesis draws on the SDH framework not only in theory but also through applied policy work. I led a national analysis for the BMJ Commission on the Future of the NHS (full paper in Appendix 4), which reiterated that the UK's recent health deterioration cannot be understood, nor reversed, by focusing on the NHS alone (Hiam, Klaber, et al., 2024). The Commission argued that reversing population health decline requires sustained investment across the social determinants, particularly housing, education, employment, social security, and local government services. Austerity was identified as the central policy undermining these foundations. A decade of cuts across welfare, public health, and social care has been shown to erode the infrastructure necessary for health, widening inequalities and increasing demand on an already strained NHS.

Despite its strengths, the SDH model has some known limitations relevant to its deployment in this thesis. First, although often used to explain inequalities, it was not designed as an explanatory model of mechanisms. Instead, it catalogues determinants but does not specify how or why they interact to produce different outcomes. Second, it treats many determinants as relatively static layers rather than dynamic processes that vary across space and over time. Third, the model offers limited guidance for understanding how macro-level political choices, such as

austerity, are mediated through institutions and local environments to shape lived experience.

Therefore, in this thesis, the Dahlgren-Whitehead model serves as an essential catalogue of essential upstream determinants, such as income, education, housing, transport, and work, that is extended through a spatial and temporal approach. The Triangle of Human Ecology, described in the next section, provides this missing structure, situating the SDH layers within interacting domains of population, habitat, and behaviour, while the concepts of precarity and resilience introduce adaptive dimensions that help explain differential vulnerability.

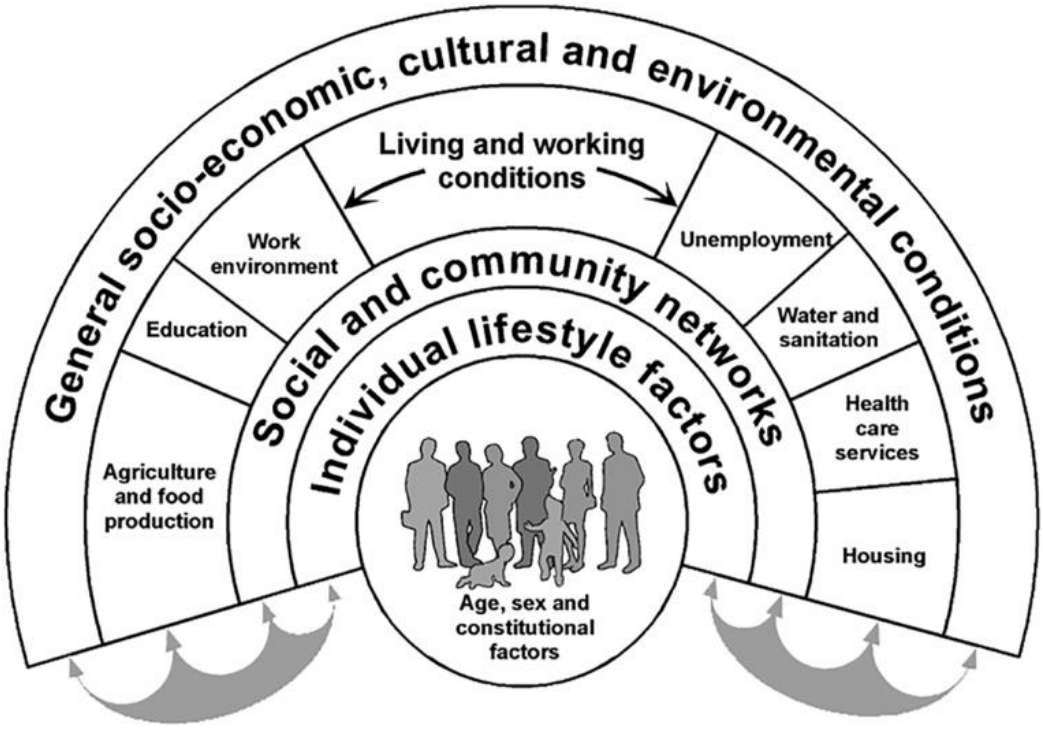


Figure 8: The "Rainbow Model" of the Social Determinants of Health. Source: Dahlgren and Whitehead, 1991

b) The Triangle of Human Ecology

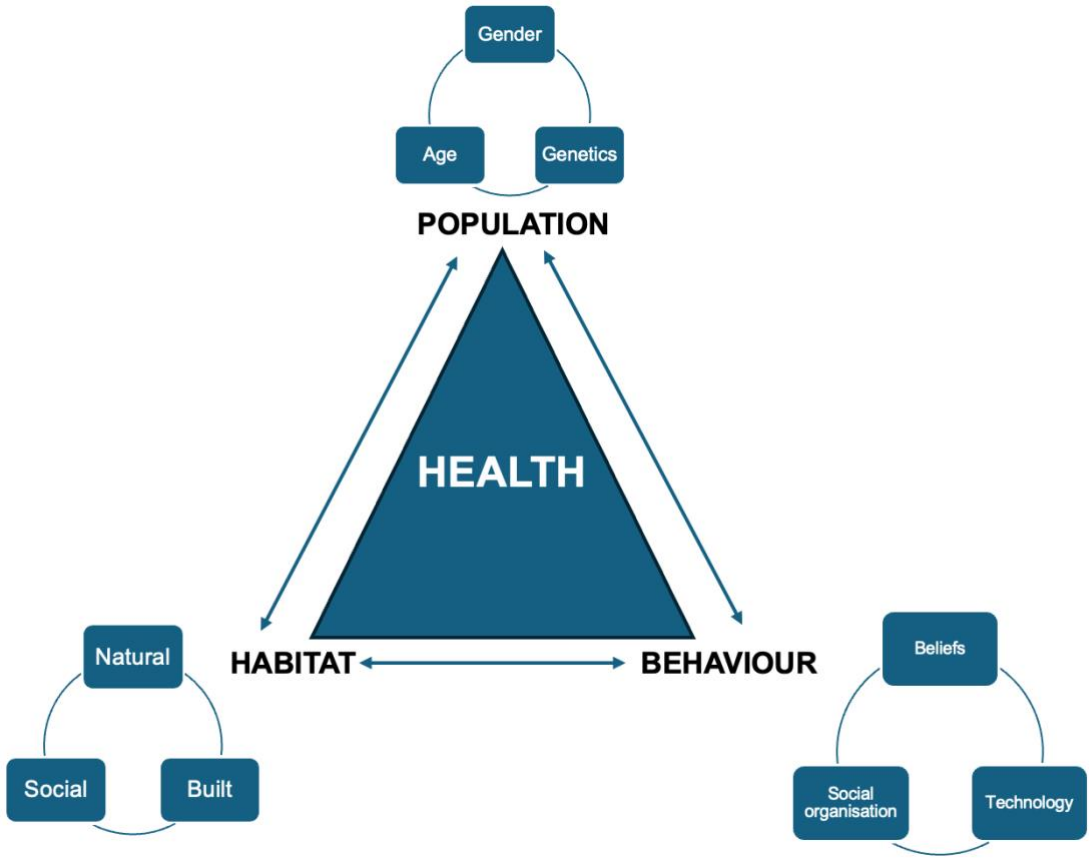


Figure 9: The Triangle of Human Ecology. Adapted from Emch et al. 2017; based on Meade 1977.

To extend the SDH framework, this thesis adopts the Triangle of Human Ecology (hereafter the Triangle) as its organising lens. The Triangle conceptualises health as emerging from interactions among three interrelated domains: population, habitat, and behaviour (Emch et al., 2017; Emch & Goel, 2025; Meade, 1977). It shifts attention from isolated risk factors to the relational dynamics through which people and places shape one another. Population refers to demographic characteristics, such as age, sex, and genetic susceptibility; habitat encompasses the natural, social, and built environments; and behaviour encompasses beliefs, social organisation, technology, and adaptive practices that shape health risks.

The value of the Triangle lies in its spatial and ecological orientation. It conceptualises health outcomes as the product of interactions between structural forces and local contexts, thereby explaining why the same national policy may produce divergent impacts across places. The model has been used extensively in health geography to analyse spatial variations in infectious diseases, environmental health risks, and chronic diseases (Emch & Goel, 2025; Kalipeni & Oppong, 1998; King, 2010; Messina et al., 2011; Nielsen et al., 2024).

For the purposes of this thesis, the Triangle functions not as an empirical hypothesis but as an organising lens. It provides the structure for examining how macro-level political choices translate into local ecologies; how policy decisions alter habitats through service provision and infrastructure; how these changes interact with population composition; and how behaviour is shaped by shifting constraints and opportunities. Its explanatory capacity is enhanced by incorporating the concepts of precarity and resilience, which introduce temporal and adaptive dimensions.

c) Precarity and Resilience

Precarity

Precarity refers to a chronic but dynamic condition of insecurity and marginalisation produced and sustained by political and economic systems (McKee et al., 2017; Standing, 2011). It introduces a temporal dimension to traditional approaches to social stratification, considering not only where someone sits on a social hierarchy but also how secure or precarious that position is over time. Across Europe, following the 2008 financial crisis, austerity intensified economic precarity (insecure employment, sanctions), housing precarity (overcrowding, homelessness), and food insecurity (growing reliance on food banks) (McKee et al., 2017). These forms of

insecurity interact and accumulate, transforming temporary hardship into structural vulnerability.

Within a human ecology framework, precarity disrupts relationships across all dimensions of the Triangle, heightening demographic susceptibility, degrading habitats, and constraining behaviour through reduced agency and opportunity (Figure 10).

Resilience

Resilience, by contrast, refers to the capacity of individuals, households, communities, and systems to absorb, adapt to, and recover from shocks while maintaining essential functions. In public health, resilience is increasingly recognised as a critical determinant of how populations weather crises, including economic shocks and disruptions to healthcare access (Castleden et al., 2011). Drawing on the Community Capitals Framework and UNDP's five-capitals model (Flora et al., 2018; United Nations Development Programme, 2018), resilience is conceptualised here as comprising: human capital (education, skills); social capital (trust, cohesion); economic capital (income, employment security); physical capital (built infrastructure); and natural capital (environment).

Crucially, resilience is not an intrinsic property of places or individuals but a relational one, shaped by historical investment, institutional capacity, and political choices. Precarity and resilience are therefore interdependent: increasing precarity erodes resilience, while strong resilience buffers vulnerability.

d) Innovative Use of Existing Theoretical Frameworks

The selection of these frameworks reflects the empirical requirements of explaining Britain's post-2010 mortality reversal. SDH is relevant because the crisis affects

multiple determinants simultaneously (e.g., income, housing, services), rendering a single-factor model inadequate; it provides a comprehensive catalogue of the factors that matter. The Triangle provides the relational structure that shows how people, environments, and practices interact, with effects that vary dramatically across places despite national policy. Finally, neither SDH nor Triangle alone captures the temporal dynamics by which the same shock produces different effects depending on prior conditions and cumulative exposure, nor the adaptive capacity of the population or community. Precarity and resilience add this dimension.

Across the domains of the Triangle, the SDH layers can be aligned with the dimensions. For example, in the population domain, baseline health, nutrition, and socioeconomic position shape susceptibility; in the habitat domain, housing, local services, and environmental context structure exposure and support; and in the behaviour domain, employment conditions, income security, and social organisation influence adaptive practices. Mapping precarity and resilience onto the Triangle of Human Ecology (Table 7, Figure 10) enables analysis of how structural shocks reorganise human ecologies across these three interconnected domains. The empirical chapters apply this framework, and Chapter 9 synthesises the evidence through it. Here, the aim is to set out the conceptual architecture guiding interpretation of the empirical findings.

This framework is summarised in Table 7, which illustrates how specific expressions of precarity and the capitals of resilience align with the domains of the Triangle, and in Figure 10, which visualises the interplay between precarity, resilience, and the Triangle.

Triangle Dimension	Precarity Examples	Mapped Capitals of Resilience
Population	**Food insecurity** impacts nutritional, immunological, and physiological status	*(No direct UNDP capital)*, but public health interventions (e.g., nutrition, immunisation) are noted as supporting population-level resilience.
Habitat	**Housing insecurity** with overcrowding, homelessness, and insecure tenancies. Also includes environment and services	**Natural Capital:** green spaces, climate. **Physical Capital:** housing, transport. **Social Capital:** trust, social cohesion, informal networks.
Behaviour	**Economic insecurity**: insecure employment, benefits sanctions; Behavioural aspects of **food insecurity**	**Social Capital:** social organisation. **Human Capital:** skills, education, health workforce. **Economic Capital:** income, savings, GDP. These influence employment capacity, agency, and coping strategies.

Table 7: Mapping Precarity and Capitals of Resilience across the Triangle of Human Ecology

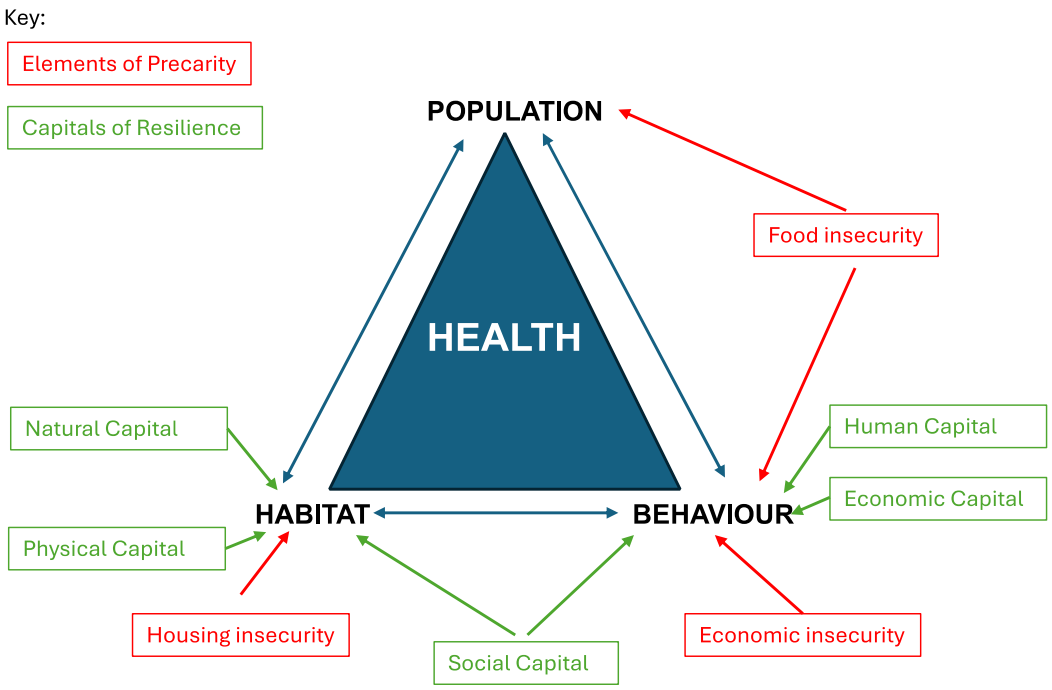


Figure 10: Integrated framework showing how precarity (red) and capitals of resilience (green) impact the different dimensions of the triangle of human ecology to influence health

3.4.2 Alternative Theoretical Frameworks

Although the unified framework outlined provides the primary analytic lens for this thesis, it sits within a wider theoretical literature that seeks to link the wider environment, inequalities and health. Austerity, as a multidimensional political, social, and economic phenomenon, has been explored through several related frameworks, each illuminating different aspects of the picture. In this thesis, these perspectives are used selectively to contextualise rather than replace the integrated theoretical framework outlined earlier in this chapter.

This section, therefore, reviews several complementary perspectives: structural violence, syndemic theory, welfare state theory, and psychosocial stress theory. Each contributes valuable insights into mechanisms of harm or adaptation, yet none integrates the multiple levels of population, environment, and behaviour through which structural forces such as austerity are embodied, nor does it fully explain their spatial patterning.

a) Structural Violence

The concept of structural violence**,** first introduced by Galtung and later developed by Paul Farmer in the context of HIV/AIDS, refers to social structures, economic, political, and cultural, that systematically prevent individuals from meeting their basic needs or realising their full potential (Farmer, 2004; Farmer et al., 2006; Galtung, 1969). Closely linked to issues of social injustice, inequality, and oppression, structural violence provides a powerful lens for understanding how institutionalised harm is embedded within political and economic systems.

Applied to austerity, the structural violence framework highlights how deliberate policy choices, including cuts to welfare, housing, and local government, translate

into premature mortality, lived insecurity, and reduced access to healthcare, disproportionately affecting people in vulnerable situations (Price et al., 2024; Sakellariou & Rotarou, 2017). Indeed, scholars have argued that austerity represents a form of neoliberal structural violence (Price et al., 2024; Sakellariou & Rotarou, 2017; Sparke, 2017). Sparke describes how the political economy of “fiscal discipline” and “market efficiency” becomes literally embodied as ill health, producing what he terms “biological sub-citizenship”: systematic disenfranchisement from the rights and protections that underpin full participation in social and biological life (Sparke, 2017).

However, while the structural violence framework offers a compelling moral critique of inequality and systemic harm, it provides limited analytical tools for tracing how such harms are produced or mitigated in specific contexts. Treatment of place and agency in the structural violence paradigm tends to be secondary, offering limited tools for identifying meso-level mechanisms or for analysing how harm and adaptation vary across place. In this thesis, an understanding of structural violence informs the moral and political framing of institutional harm but is extended through the integrated framework to examine how such violence is distributed, mediated, and sometimes mitigated by place-based capacities for adaptation and resilience.

b) Syndemic Theory

Syndemic theory examines how multiple diseases co-occur and mutually reinforce one another within populations experiencing structural inequality (Singer, 2000, 2009; Singer et al., 2021). It highlights the role of political-economic forces, such as poverty, racism, and marginalisation, in shaping health vulnerabilities, framing disease clustering and amplification as a biosocial process rather than a purely biological one. Initially developed by Singer in 1996 through research on intersecting

epidemics of infectious diseases (specifically HIV), the framework has since been applied to NCDs and environmental stressors, reflecting the broader social and political ecologies in which health is produced.

Singer et al. described syndemics as arising when adverse social conditions amplify disease clustering, interaction, and consequence (Singer et al., 2021). Singer also introduced the concepts of countersyndemics, in which protective factors mitigate harm, and ecosyndemics, which capture how environmental changes, such as global warming and human-made alterations to the physical environment, combine to create new vulnerabilities (Singer, 2009). The covid-19 pandemic has been described as a syndemic, a synergistic interaction between the virus and a high burden of NCDs, all occurring within and exacerbated by inequalities (Horton, 2020).

Thus, austerity can be understood as a generator of syndemic conditions. By weakening public health systems, increasing poverty, and eroding the SDH, austerity creates the context for mutually reinforcing crises of disease and deprivation. These processes exemplify what Singer terms syndemic vulnerability: feedback between biological susceptibility and social adversity, in which structural violence magnifies both illness and inequality.

While syndemic theory provides a valuable account of how social and political conditions shape the co-occurrence and interaction of disease, its analytical focus tends toward biomedical and epidemiological interaction and offers limited guidance on spatial differentiation or institutional mediation. It does not fully account for how place, policy environments, and collective capacity shape the distribution or moderation of harm. In this thesis, syndemic theory informs understanding of the compounding effects of deprivation and disease under austerity, but is extended

through a spatial framework that also attends to resilience, adaptation, and the capacities that buffer these biosocial shocks.

c) Welfare State Theory

Welfare State Theory, described by Esping-Andersen, offers a framework for understanding how states organise social protection and distribute welfare (Esping-Andersen, 1990). His influential model identifies the “three worlds of welfare capitalism”, dividing states into three regimes: Liberal, Conservative, and Social Democratic, each defined by varying degrees of decommodification, social stratification, and the role of the state, market, and family in welfare provision.

The framework is valuable for examining how different welfare state configurations shape population health, including in the context of austerity, where responses to the 2008 financial crisis and fiscal policy responses varied across HICs (Emmerson & Tetlow, 2015). However, some argue that public health research has relied too heavily on Esping-Andersen’s typology, despite extensive criticism and the development of alternative, potentially richer, welfare state models within social policy (Bambra, 2007). In addition, Bambra highlights that welfare regimes differ not only in cash benefits but also in the provision of public services, such as healthcare, education, and social care—key areas relevant to the erosion of welfare capacity and to austerity's impact on health.

Thus, while Welfare State Theory offers insight into institutional variation and its consequences, it remains too macro-level, static, and state-centric for the aims of this thesis. It pays little attention to the spatial and ecological mechanisms through which national welfare retrenchment is experienced, and how reductions in local government finance, service capacity, and community resources translate into uneven health outcomes across place.

d) Psychosocial Stress Theory

Psychosocial Stress Theory provides an account of how adverse social conditions, such as poverty, unemployment or precarious employment, and inequalities, can lead to chronic stress, which in turn adversely affects both physical and mental health. This pathway underpins the well-documented “social gradient” in health: people with higher social position tend to live longer and healthier lives than those in lower positions (Marmot, 2004).

This framework is relevant in the context of austerity, where economic insecurity, welfare cuts, and rising poverty have exposed large sections of the population to chronic stress and deteriorating mental and physical health (Cummins, 2018; Hiam, Klaber, et al., 2024; Marmot et al., 2020). These conditions contribute to increased cardiovascular and metabolic risk, as well as an increase in depression and anxiety, manifestations of allostatic load, the cumulative physiological impact from chronic stress, with the greatest burden in areas of higher deprivation (Delpierre et al., 2016; Kelly-Irving, 2019; Seeman et al., 2014).

However, while Psychosocial Stress Theory provides valuable insight into individual-level mechanisms linking inequality and health, it is limited as a structural explanation. Its analytical focus lies at the micro and interpersonal levels, emphasising physiological and coping-behavioural responses rather than the broader institutional and environmental contexts that generate and distribute (and sometimes mitigate) stress. As such, it offers little guidance on how macro-level shocks, such as austerity, are mediated through place, or on how communities adapt, resist, or recover.

In this thesis, psychosocial pathways are treated as micro-level mechanisms situated within wider ecological and structural systems, rather than as a standalone

explanatory framework. They help explain how policy-induced insecurity becomes embodied, but they are insufficient on their own to account for the spatial patterning of harm and adaptation observed during Britain's austerity period.

3.5 Chapter 3 Summary and Next Steps

This chapter has demonstrated that austerity is the most plausible structural driver of the UK's post-2010 health crisis, satisfying seven of the nine Bradford Hill criteria more convincingly than any competing explanation. It then set out the unified theoretical framework used throughout the thesis, integrating the SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience to explore how macro-level policy decisions are embodied in unequal, spatially patterned health outcomes. Related theoretical frameworks can add dimensions to these primary approaches, and I have offered a short overview of the most relevant alternatives.

In Part II, the following five chapters present the empirical evidence. Chapter 4 documents the health reversal. Chapters 5 and 6 test key proximate hypotheses, specifically flu and demographic change, to evaluate whether they can account for the post-2010 mortality trends. Chapter 7 examines international comparisons to assess whether the UK's experience reflects a broader pattern or an outlier. Chapter 8 analyses how experts interpreted the worsening mortality trends and asks why proximate narratives persisted despite the accumulating evidence. In Part III, Chapter 9 synthesises these findings through a unified theoretical framework, explaining how austerity generated place-based health harm, why its effects were unevenly distributed across people and places, and what questions remain.

PART II: EMPIRICAL PAPERS

4 THINGS FALL APART: DOCUMENTING THE CRISIS, 2010-2020

4.1 Introduction

The first empirical chapter of the thesis addresses RQ1 (*What happened to life expectancy trends in the UK after 2010, and what caused these changes*?). Rather than offering an explanation, the chapter's aim is diagnostic: to establish the scale, timing, and characteristics of the UK's health reversal after 2010. It defines the crisis that the thesis seeks to understand. Building on the analysis in Chapter 2, which ruled out proximate causes, this chapter documents the crisis those explanations failed to account for.

The main paper presented here is Things Fall Apart: The British Health Crisis 2010–2020 (Hiam et al., 2020). It demonstrates that gains in life expectancy, consistent over many decades, stalled sharply after 2010 and began to reverse for some groups. It documents rising infant mortality and widening inequalities, especially in more deprived areas. The analysis shows that these changes marked a fundamental break from historical progress. The paper, therefore, plays a foundational role in this thesis. It defines the problem that the structural frameworks introduced in Chapter 3 are designed to explain. Following the main paper, the chapter highlights additional empirical studies conducted during the DPhil.

4.2 Paper 1: Things Fall Apart: The British Health Crisis, 2010-2020

British Medical Bulletin, 2020, **133**:4–15
doi: 10.1093/bmb/ldz041
Advance Access Publication Date: 27 March 2020

Invited Review

Things Fall Apart: the British Health Crisis 2010–2020

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Received 4 November 2019; Revised 4 November 2019; Accepted 9 December 2019

Abstract

Background: A very large number of studies have reported a stalling of health improvements in the UK since 2010.

Sources of data: Almost all relevant data are produced by the Office for National Statistics and other national statistical agencies.

Areas of agreement: There has been a dramatic slowdown in life expectancy and diverging trends in infant mortality in the UK as a whole and England and Wales, respectively.

Areas of controversy: Many commentators are loath to describe the falls in life expectancy as actual falls or to ascribe blame to the political situation in the UK.

Growing points: Health trends in the UK are worrying and raise important questions about government policies.

Areas timely for developing research: These findings point to a need for greater investment in research on the political determinants of health, on the timely detection and interpretation of evidence of worsening health, and on how political and policy processes respond to such findings.

Key words: life expectancy, austerity, infant mortality, health outcomes

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Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned;
The best lack all conviction, while the worst
Are full of passionate intensity.
—Yeats, 1920.

Introduction

One hundred years ago, Yeats wrote that 'Things fall apart' in his poem 'The Second Coming'. Written in response to turmoil across Europe, including in his native Ireland, it has often been invoked in writings about societal decline. In 2016, it seemed particularly apt in the UK when, by a small majority, the British population opted for a future outside the EU, beginning a process that, so far, has created almost 4 years of political gridlock in which a barely functioning parliament has been unable to tackle mounting and increasingly severe social, economic, housing and health problems. An analysis published a few months after the referendum found that Yeats' poem had been quoted more often in the first part of that year than in any of the previous 30.[1]

There is no doubt that the UK has faced many problems in recent years, including political crises and relative economic decline. But are things really falling apart? In this paper, we argue that there is considerable evidence that they are, with profound consequences for the future of the UK. Our assessment is based on an examination of what is happening to the health of the British population. Since the middle of the 18th century, the health of the British people has been improving. Yet in recent years infant mortality has risen overall (most markedly in England and Wales), life expectancy fell everywhere in 2015 and appears now to have stalled, health inequalities have widened and access to healthcare has worsened. History tells us that this should be a matter of great concern. One of the first indicators that a state is failing has been stagnating or worsening health. In the early 1980s, few observers of the USSR believed that it was in decline,[2] but those who studied health data challenged this consensus when they found an unexpected rise in infant mortality.[3] In the 21st century, worsening health in the USA has been associated with a loss of faith in traditional institutions.[4]

In the remainder of this paper we review the evidence that causes us so much concern. An explanatory note is required. While aggregate data for the UK are supplied to international agencies, such as the World Health Organisation (WHO) and the Organisation for Economic Co-operation and Development (OECD), the more detailed data used in this paper are often published separately for England, Scotland, Wales and Northern Ireland.

A picture of health?

From the end of the Second World War, people living in industrialized countries enjoyed sustained and substantial health improvements. This changed in 2010. In some, the pace of improvement slowed markedly and, for certain groups, actually worsened. Several recent analyses have identified the UK as among the worst affected in major industrialized countries; only the USA had a worse record.[5] A very recent study comparing progress in life expectancy in the UK with 22 high-income countries found that while the figure for men in the UK tracked the median in the comparator countries between 1970 and 2010, females followed a similar trajectory but at a lower level and both diverged downwards from 2011 onwards.[6] In other words, while health has suffered in many countries in recent years, the UK and the USA, both countries that experienced major political shocks in 2016, stand out from the rest.

Markers of population health

Infant mortality

The infant mortality rate (IMR) had been improving steadily in England and Wales until 2014 when it went into reverse (Fig. 1). Using the most recent data, the Office for National Statistics (ONS) reported

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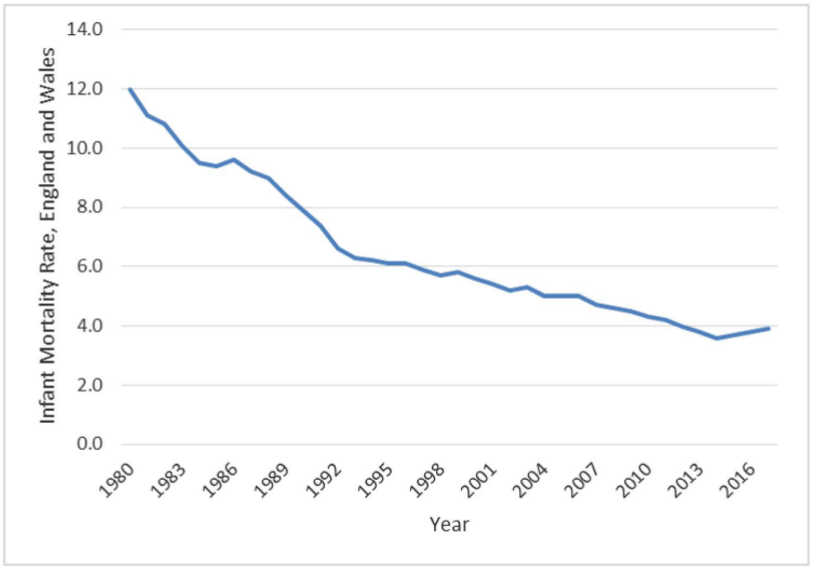


Fig. 1 Infant Mortality Rate, England and Wales, 1980–2017.
Source: ONS

that it increased from 3.8 deaths per 1000 live births in 2016 to 3.9 in 2017.[7] It had fallen to 3.6 in 2014. Annual fluctuations are expected but this is the first time in over a century that it has risen for 3 years in a row.[8] The ONS also reported that each of these annual rises has been statistically significant. Between 2014 and 2017, there were 570 more infant deaths than would have been expected given previous trends.[9]

Some of this increase seems likely to be due to an increase in very premature live births that survived only briefly,[10] perhaps reflecting changes in recording, but a regional analysis points to a more worrying development as (with the exception of improvements in Scotland, see in this section) the rise in infant mortality has been higher in the poorer regions and countries of the UK. In the most deprived areas, babies were almost twice as likely to die within their first year of life (5.2 deaths per 1000 live births) than those in the least deprived areas (2.7 deaths per 1000 live births).[11]

A detailed analysis by local authority in England found that IMRs continued to decline at the same rate in the most affluent ones but actually worsened in the poorest. The authors estimated that approximately one-third of the overall increase in IMR is estimated to be attributable to child poverty.[9] Had all local authorities improved to the extent of the most affluent, this would have compensated, at least in part, for the changes in very premature live births. Furthermore, in 2015, 2016 and 2017, IMRs recorded in Scotland were 3.2, 3.3. and 3.3, respectively, per 1000 births, having been 3.6 in 2014.[12] In England and Wales they had risen from 3.6 (in 2014) to be 3.7, 3.8 and 3.9, respectively.[13] Had England and Wales enjoyed the improvements that Scotland enjoyed, then the numbers of infants that would not have died would have been 349, 348 and 407 in those 3 years, or 1105 in total. These figures are not precise, so it is best to say ~1000 more infants died in England and Wales in 2015–2017 than would have done had IMRs fallen there

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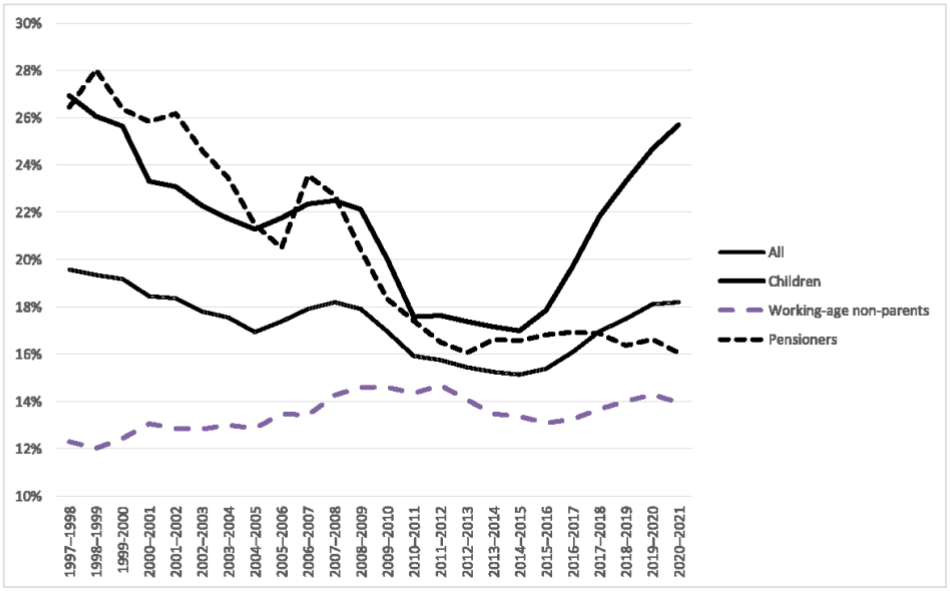


Fig. 2 Relative poverty rates by household types in the UK.
Source: Browne, J. and Hood, A. (2016) Living Standards, Poverty and Inequality in the UK: 2015–16 to 2020–21, Report 114, London: Institute for Fiscal Studies, figure 3.9, http://www.ifs.org.uk/publications/8171
Note: Incomes measured before housing costs have been deducted. Relative poverty is <60% of median household income in the current year. Pensioners are those aged ≥65. Projection uses the IFS tax and benefit microsimulation model.

as they fell in Scotland. In 2018 Scotland's IMR fell again to 3.2. No figure for England and Wales was available for 2018 at the time of writing.

Child poverty has risen markedly in the UK, with over 1 in 4 of all households with children expected to be in poverty by 2020 (Figure 2).[14] This is a reversal of the progress made before 2010, when just over 1 in 6 of such households experienced poverty, as assessed by the Institute for Fiscal Studies.[15] This is to a considerable extent a consequence of cuts or freezes in benefits and tax credits affecting households with children in England. In contrast, the Scottish government has concentrated on reducing child poverty rates and infant mortality there fell sharply after 2010. However, the Scottish population comprises only 8% of the population of the UK so this cannot compensate for the deterioration elsewhere in the UK.

These developments mean that the UK as a whole now has one of the worst IMRs in Western Europe, falling behind the EU average of 3.6 per 1000, and ranking 25th of the 42 countries with available data for 2017.[16] This is a marked change since 1990 when the UK had the seventh best neonatal mortality record in Europe and was even better, relatively, before that.[17]

Life expectancy

Life expectancy at a given age is one of the most widely used summary measures of population health. These data are published annually by ONS and recent trends in the UK have generated considerable controversy, initially as to whether the falls observed were only a transient phenomenon and, once it was clear that they were not, what the causes were. More detailed analyses reveal that life expectancy

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Table 1 Life expectancy at birth for males and females, 2014 and 2018

	Life expectancy at birth				Change 2014–2018			
	2014		2018		Years		Days of life	
	Men	Women	Men	Women	Men	Women	Men	Women
England	79.51	83.23	79.55	83.20	0.04	−0.03	15	−11
Northern Ireland	78.61	82.38	78.84	82.44	0.23	0.06	84	22
Scotland	77.32	81.34	77.05	81.01	−0.27	−0.33	−99	−121
Wales	78.79	82.61	78.23	82.19	−0.56	−0.42	−205	−153
UK	79.25	82.99	79.24	82.93	−0.01	−0.06	−4	−22

Source: Authors' calculations using ONS (2019) Single-year life tables, the UK: 1980–2018, released September 25, 2019, for the UK and all its separate countries: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/datasets/singleyearlifetablesuk1980to2018

at aged 75 and 85 years for women and 85 years for men has actually declined,[18] as it has for women at birth in the most deprived areas of England and Wales.[19] Other analyses that examine the four countries separately show that life expectancy at birth has fallen for men and women in Scotland and Northern Ireland, and recent comparisons of 24 high-income countries showed mean improvements in life expectancy in 2012–2016 were smallest among women (<2 weeks/year) in Northern Ireland, Iceland, England and Wales and the USA, and among men (<5 weeks/year) in Iceland, the USA, England and Wales and Scotland.[20] As Table 1 in this paper shows, life expectancy for the UK as a whole in 2018 remained below the level it had reached in 2014 for both men and women, but only by a few days for both. The falls before 2018 were much larger, with some recovery seen in 2018.

The latest national life tables, with data averaged over 3 years, show a very slight improvement when the year 2015 is not included, but the slowdown remains apparent (Fig. 3),[7] and the data for individual years (Table 1) uses ONS data released in September 2019 that shows that for the UK as a whole life expectancy for both men and women in 2015, 2016, 2017 and 2018 was always below than that reported in 2014.[7] A better comparison would be between what life expectancy should have been in 2018 if the historic trend prior to 2010 had continued, but as yet there is no widespread agreement on what that should have been. Figures for 2019 will be released by ONS in September 2020.

As with infant mortality, the UK has also fallen down the European rankings for life expectancy at birth for men and women combined from 13th place in 2009 to 19th in 2017.[21] The corresponding ranks for males were from 10th in 2009 to 14th in 2017, and for females from 21st to 22nd. Life expectancy at aged 65 years has fallen from 12th to 17th, males from 8th to 11th, and females from 17th to 21st. Hardly any of this fall in the ranking for the UK in life expectancy is due to the rise in infant mortality as, thankfully, IMRs, although rising, remain low enough not to significantly influence overall life expectancy. The falls in the UK life expectancy seen since 2014 for the population as a whole, and early for elderly women are almost entirely due to rising mortality rates in old age. However, rising mortality at younger adult ages from some causes has also played a part, as we now describe.

Deaths of despair

Case and Deaton, writing about the USA, coined the term 'deaths of despair' due to drug and alcohol overdoses, suicides and alcohol-related liver disease.[22] They described this phenomenon as 'unique' to the USA, offsetting reductions in deaths from other causes.[22, 23] It is now apparent that the UK is also affected.[24] Although deaths from cancer and heart disease in England have fallen between 1993

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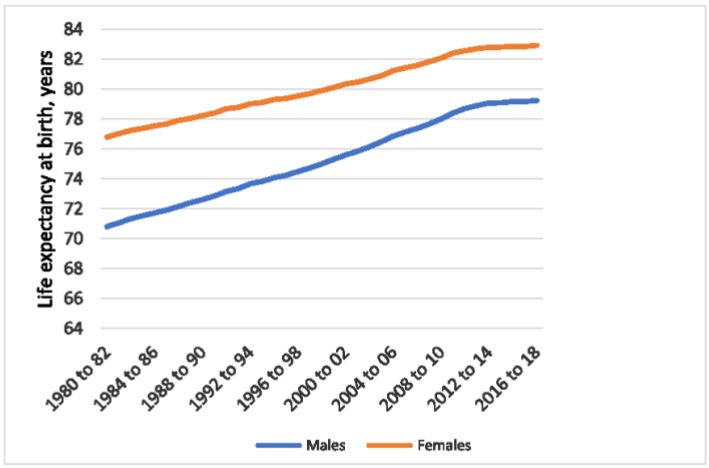


Fig. 3 Life expectancy at birth for males and females, the UK, between 1980 to 1982 and 2016 to 2018.
Source: ONS.

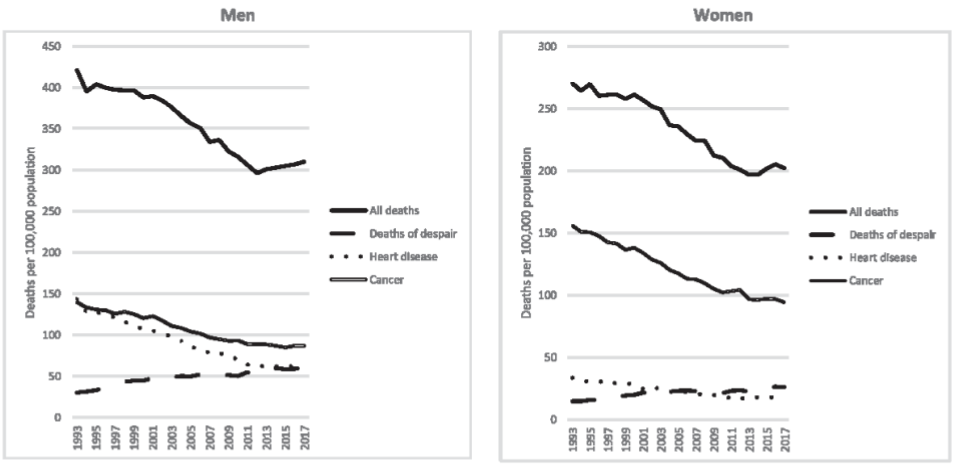


Fig. 4 Middle-age mortality, aged 45–54, in England 1993–2017.
Source: Joyce R, Xu X. Inequalities in the twenty-first century. 2019. https://www.ifs.org.uk/inequality/wp-content/uploads/2019/05/The-IFS-Deaton-Review-launch_final.pdf (28 October 2019, date last accessed).
Note: Authors' use ONS mortality data, and Case and Deaton's 2015 and 2017 classification of 'deaths of despair'.

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and 2017, deaths of despair have increased, contributing to a rise in all-cause mortality in those aged 45–54 years (Fig. 4).

Although it is difficult to ascertain the numbers of people who are homeless and 'rough sleeping' precisely, it is clear that deaths among them have risen substantially. According to the government's own statistics, there has been a dramatic upsurge in rough sleeping since 2010: 4677 people were found sleeping rough on a single night in autumn 2018, 2909 (165%) more than autumn 2010.[25] An estimated 726 people who were homeless died in 2018—the highest year-to-year increase since the ONS time series began, a rise in 1 year of 22%.[26] Alarmingly, two in five of these deaths were due to drug poisoning (294 deaths), an increase of 55% since 2017. These figures are likely to be underestimates due to the narrow definition of homelessness and the existence of 'hidden homelessness'.[27] Poor access to health care is also a major issue for people who are homeless, with a recent analysis of hospitalization records finding that nearly 1 in 3 deaths of people who are homeless were due to causes amenable to timely, effective healthcare.[28] In more affluent English cities, such as Oxford, deaths occurring while homeless became the main reason why mortality rates were higher than the national average; deaths while homeless explained the majority of geographical variations in mortality in the city by 2016.[29] In one electoral ward in Oxford, 88% of all deaths in 2014–2016 at ages under 65 were of people who were homeless. This was the highest proportion since comparisons began in the 1990s and was the highest number of homeless deaths in Oxford ever recorded.

Finally, mortality rates have also risen among young people aged 20 to 24 years in the UK between 2013 and 2016.[30]

Health inequalities

"The UK is the world's fifth largest economy, it contains many areas of immense wealth… It thus seems patently unjust and contrary to British values that so many people are living in poverty"—UN Special Rapporteur, Professor Philip Aston.[31]

Health inequalities have widened in the UK. The gap in life expectancy between the most affluent and most deprived increased between 2001 and 2016, and since 2011, female life expectancy has not only stalled in many areas but has reversed in the two most deprived deciles.[32] Deaths from cardiovascular causes, alcohol and drug misuse among 25- to 44-year-olds have risen in the north compared to the south.[33] However, within the south, deaths have risen in more deprived wards of otherwise affluent cities, as the above-mentioned example from Oxford illustrates, where health inequalities within the city have widened considerably in recent years to reach their widest for at least 30 years.[29] The same is the case in London, Bristol and is likely to be the case in some smaller southern English cities.

A vicious cycle?

Many aspects of the worsening health described above have be linked to austerity. Since 2010 funding for the National Health Service (NHS) has failed to keep pace with demand, and fallen considerably behind previous levels, even when compared to the Conservative government of 1978–79 to 1996–97, and well below the average of the last 60 years.[34] The UK has also fallen behind on health care capital spending, resulting in a fall of 3% in its value from 2000 to 2017, while this has risen in most other European countries.[35]

While this has, ultimately, been a political choice, a country facing economic decline faces constraints on the choices it can make. There is now extensive evidence that improved health of individuals and populations contributed to economic growth, through mechanisms such as increased labour force participation and productivity.[36] Conversely, worse health risks creating a downward spiral. A recent WHO Health Equity status report notes how: '…a 50% reduction in inequities in life expectancy between social groups would provide monetized benefits to countries ranging from 0.3% to 4.3% of gross domestic product (GDP)'.[37]

There is also growing recognition that worsening health threatens social cohesion,[4, 38] so the finding, from the European Quality of Life Surveys in 2016,

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that 29% of UK residents felt there was 'a lot of tension' between the poor and rich, compared to 17% in 2007 is especially concerning.[39]

A hostile environment

There are widespread concerns that the political discourse in the UK since 2016 has also undermined social cohesion, with large increases in reports of racially motivated incidents.[40] One manifestation of this discourse is the way in which politicians have spoken about migrants. In 2011, future Prime Minister, then Home Secretary, Theresa May declared her plan to create a 'really hostile environment for illegal immigrants'.[41] At least since the early 1970s, mainstream politicians had avoided words such as these.

The growth of xenophobia has had consequences in many sectors, but the NHS has been especially affected, for example with increasing racial abuse directed at ethnic minority healthcare workers.[42] It has impacted especially severely on some patients seeking NHS secondary care, such as an undocumented migrant or a person who is homeless, who must now pay upfront the full cost of their healthcare or face refusal of treatment if they cannot prove entitlement.[43] As a result, the NHS is now regressing in its commitment to Universal Health Coverage.[44,45]

The negative consequences of these restrictive measures have been widely documented, from cancer patients refused treatment,[46] mothers going without antenatal care, the impact on healthcare workers themselves[47] and the Windrush scandal, where people fully entitled to care, some who had worked many years in the NHS lacked necessary documentation.[48] Although NHS England guidance is clear that anyone in England can register and consult with a general practitioner (GP) without charge, research shows this is far from the case. The most recent data from the charity Doctors of the World UK found almost one-fifth of attempts to register patients were wrongly refused, with lack of proof of ID or address as the main reason.[49] Such barriers disproportionately affect vulnerable groups, and these findings are echoed by research exploring the experience of homeless people, some of whom are now being denied access to both primary care and mainstream services.[50] Given one-third of deaths among the UK homeless could have been prevented with treatment,[28] these barriers to healthcare are extremely concerning.

Does the UK risk becoming a failed state?

If worsening health is an early sign of national decline and, ultimately, crisis, as it was in the Soviet Union, then the UK has problems. Life expectancy is stagnating and, for some, worsening, infant deaths are rising in the poorest areas, and the UK is joining the USA in experiencing an upsurge in 'deaths of despair'. And there are many other worrying signs. For example, in 2016, the WHO declared the UK had eliminated measles, but revoked this assessment in August 2019.[51] It is very likely that this is, to some extent, a consequence of the ill-fated 2013 health system reorganization in England, which fragmented public health capacity.

This bleak assessment is supported by the US research organisation Fund for Peace. Its Fragile States Index (FSI) calculates a score of fragility for all UN member countries where sufficient data are available.[52] In 2019, out of 178 countries, the UK was the fourth 'most-worsened', after Venezuela, Brazil and Nicaragua.[52] (Fig. 5) shows the UK trajectory since 2006—the higher the score, the more fragile the state, the score can rise to a maximum of 120 for a completely failed state.

Before the May 2015 general election, when the Conservatives won an outright majority, Ipsos MORI reported the top three issues voters reported as influencing their voting decision were the NHS (47%), the economy (35%) and education (24%).[53] Asylum and immigration was 5th at 19%, and Europe/EU did not feature (at 7% it was just below their 8% cut-off line). A national poll taken just before the referendum on June 23, 2016 put immigration as the main political issue, at 48%, and NHS/hospitals/healthcare had fallen to 37%.[54] These changes are captured in the Fragile State Index's

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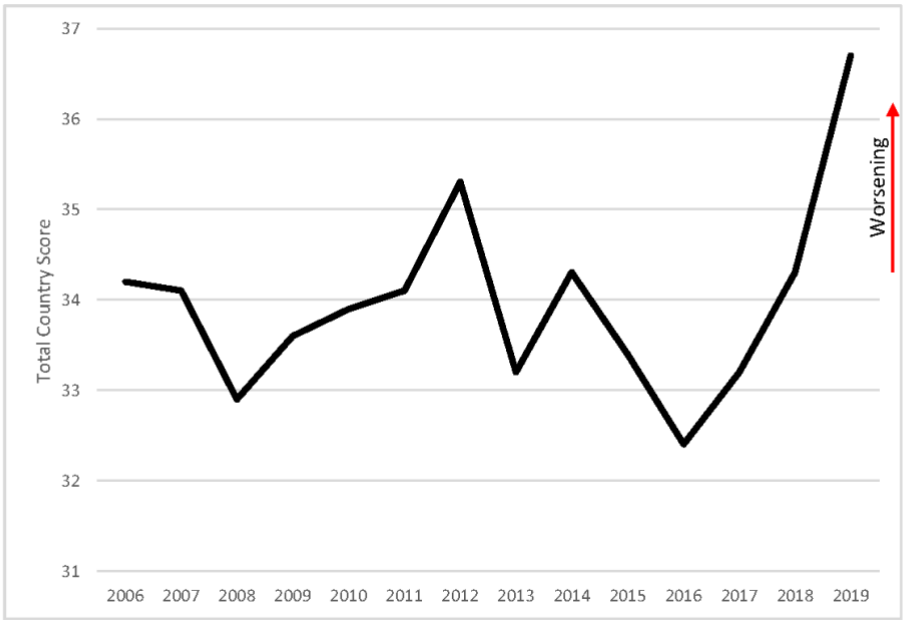


Fig. 5 Overall trend, UK, 2006–2019.
Source: Fund for Peace. Fragile States Index 2019, available at: https://fundforpeace.org/2019/04/10/fragile-states-index-2019/

marker of cohesion, entitled 'group grievance', which 'focuses on division and schisms between different groups in society', where the UK score increased from 4.1 (maximum 10, with 10 being the worst) in 2010 to 6.4 in 2019.

In December 2019 the UK had its third general election in four years. It took place against a backdrop of a criminal investigation of 'Vote Leave', in which the Prime Minister played a major role, reports of suppression of a report describing Russian interference in UK politics, and concerns about whether electoral law is fit for purpose.[55] Given these concerns, the failing health outcomes, and deteriorating position internationally, at what point would the UK be considered a failed state?

Conclusion

One of the primary responsibilities of a government is to protect its population, whether from external aggression or from disease. Since 2010, successive UK governments have clearly failed in their duty. As history shows, deteriorating health is often the first sign of an impending societal and political crisis. Indeed, this seems to be happening in front of our eyes even now, in the USA, where life expectancy declined in each of the 3 years after 2015.[56] Americans who felt 'left behind' have flocked to Donald Trump, providing a receptive audience for his attacks on the institutions of government.[57] Meanwhile, in the UK, newspapers pillory those same institutions, such as parliament and the judiciary, labelling them as 'enemies of the people'.[58]

Yet many of those who are most receptive to these messages are the victims of policies implemented by the politicians who espouse them. In 2018, the UN special rapporteur on extreme poverty concluded a visit to the UK by saying that 'Poverty is a political choice' and that 'Austerity could easily have spared the poor, if the political will had existed to do so'.[31, 59]

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Scotland chose to reduce child poverty and its infant mortality continues to fall, now to a level lower than in England and Wales.

The evidence we have reviewed has convinced us that things are indeed falling apart in the UK. But this is not inevitable. The government could act urgently if it wished to but it must first accept that there is a problem, then implement wide ranging changes to improve health, wealth and social well-being for all, while never forgetting the lessons of history.

Acknowledgements

We are grateful to Xiaowei Xu, Andrew Hood and other colleagues at the Institute for Fiscal Studies (IFS) and the team at the Fund for Peace for allowing inclusion of their work.

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4.2.1 Summary of Supplementary Empirical Work

Additional analyses conducted during the DPhil further reinforce the patterns described in this chapter and deepen the empirical foundation for the thesis (papers available in Appendix 4). Comparative work (Paper 4) demonstrated that the UK's post-2010 mortality slowdown was more severe and sustained than in comparable HICs (Minton et al., 2023), while the analysis shown in Figure 3 reveals a steep decline in the UK's international standing since the 1950s (Hiam et al., 2023a). Other studies highlighted worsening internal inequality in mortality outcomes, particularly among working-age adults (Hiam et al., 2021), and rising social disconnection, as reflected in the growing number of people found decomposed after dying alone (Hiam, Estrin-Serlui, et al., 2024). An editorial analysis showed that UK life expectancy projections had been repeatedly revised downwards since 2010, in contrast to historical trends and international comparators (Hiam & Dorling, 2022). It argued that this should have triggered greater scrutiny and political urgency and warned that failing to explain and address this shift risked accepting declining health as the new normal (Figure 2). In addition, the BMJ Future of the NHS Commission paper called for the NHS and wider society to act on the SDH, identifying structural drivers as central to reversing widening inequalities and deteriorating outcomes (Hiam, Klaber, et al., 2024).

Together, these studies reinforce the diagnosis of a sustained national health crisis and provide converging evidence that its causes are structural rather than demographic or cyclical. By drawing on international comparisons, rising internal inequalities, and overlooked indicators of social breakdown, this body of work, published alongside the main papers included in this thesis, challenged conventional explanations and underscored the need for a broader structural account.

4.3 Chapter 4 Summary and Next Steps

The analyses in this chapter show that, after 2010, health in the UK worsened across multiple indicators. Life expectancy gains slowed or reversed, inequalities widened, and markers of social distress and institutional strain became increasingly visible. Interpreted through the integrated framework introduced in Chapter 3, the trends documented here indicate early pressures across several dimensions of the Triangle. Population-level vulnerability was amplified among older adults and disadvantaged groups; habitat conditions deteriorated in areas experiencing rising deprivation and instability; and behavioural and institutional pathways became more fragile as pressures on services mounted. These shifts suggest reduced community resilience and heightened exposure to stressors, underscoring the need to examine which proximate explanations can plausibly account for the observed trends.

These developments establish the empirical contours of the emerging health crisis and highlight the need to investigate its drivers. The following chapters examine whether proximate explanations can account for these patterns. The next chapter, therefore, tests one such explanation: influenza.

5 Investigating Proximate Causes: Influenza, cause or Excuse?

5.1 Introduction

This chapter presents an empirical study examining whether influenza accounts for the post-2010 deterioration in mortality trends. As outlined in Chapter 2, influenza was among the most frequently cited proximate explanations by government departments and public bodies, particularly in relation to the mortality increases observed in 2014–15. These claims framed the health crisis as the result of seasonal flu fluctuations rather than emerging structural pressures. The integrated framework in Chapter 3 demonstrates how proximate shocks can interact with underlying population, place and institutional conditions. This chapter, therefore, evaluates whether influenza, as a short-term, but potential widespread, biological stressor, could plausibly account for the patterns of mortality deterioration described in Chapter 4. It addresses RQ2 (*How well do commonly suggested proximate explanations, such as influenza, ageing, or other age- and cause-specific effects, account for these trends?*) by analysing whether influenza contributed meaningfully to the patterns of worsening mortality. Drawing on detailed ICD-10 coded mortality data for England and Wales from 2001 to 2019, the paper evaluates several definitions of influenza burden, including expanded categories designed to account for potential under-recording on death certificates.

5.2 Paper 2: Influenza: Cause or Excuse? An Analysis of Flu's Influence on Worsening Mortality Trends in England and Wales, 2010–19

British Medical Bulletin, 2024, **149:**72–89
https://doi.org/10.1093/bmb/ldad028
Advance Access Publication Date: 15 January 2024

OXFORD

Invited Review

Influenza: cause or excuse? An analysis of flu's influence on worsening mortality trends in England and Wales, 2010–19

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Received 8 August 2023; Revised 20 October 2023; Accepted 27 October 2023

Background: England and Wales experienced a stagnation of previously improving life expectancy during the 2010s. Public bodies cited influenza as an important cause.

Sources of data: We used data from the Office for National Statistics to examine mortality attributed directly to influenza and to all influenza-like diseases for the total population of England and Wales 2010–19. Several combinations of ICD-10 codes were used to address the possibility of under-counting influenza deaths.

Areas of agreement: Deaths from influenza and influenza-like diseases declined between 2010 and 2019, while earlier improvements in mortality from all causes of death were stalling and, with some causes, worsening. Our findings support existing research showing that influenza is not an important cause of the stalling of mortality rates 2010–19.

Areas of controversy: Influenza was accepted by many as an important cause of stalling life expectancy for much of the 2010s, while few in public office have accepted austerity as a key factor in the changes seen during that time.

Growing points: This adds to the mounting evidence that austerity damaged health prior to COVID-19 and left the population more vulnerable when it arrived.

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Areas for developing timely research: Future research should explore why so many in public office were quick to attribute the change in trends in overall mortality in the UK in this period to influenza, and why many continue to do so through to 2023 and to deny the key role of austerity in harming population health.

Key words: mortality, influenza, life expectancy, austerity

Introduction

The problem: long-term improvements in mortality stopped in the UK in the 2010s

All social groups in England and Wales experienced a long period of increasing life expectancy until the second decade of the 21st century,[1–3] a trend mirrored within Scotland and Northern Ireland, albeit not as favourably in recent decades. Life expectancy, the most widely used summary measure of a population's mortality experience, shocked observers when its long upward trend slowed markedly shortly after 2010 (Fig. 1). Period life expectancy at birth, the most common version, is the average number of years a person born in a given year could expect to live based on the mortality rates of people dying in that year—it is not a prediction of how long they will live, which is unknowable as it is in the future. Mortality rates and life expectancy go hand in hand: if mortality rates increase, life expectancy improvements will reverse. Recent gains in life expectancy even reversed in some groups, such as those living in poorer areas.[4,5] This slowdown was also witnessed throughout the rest of the UK. Although we focus on England and Wales, some other European countries also saw slowing life expectancy improvements. However, the situation in the UK was more severe and prolonged than elsewhere in Europe, similar to what was observed in the USA.[2,6,7] For comparison, between 2010 and 2021, UK life expectancy at birth increased by 0.5 and 0.3 years for women and men, respectively. In contrast, the corresponding figures in Sweden were 1.4 and 1.6 years; in France, they were 0.8 and 1.4 years; and in Germany, one of the poorest performers in continental Europe, they were 0.6 and 0.7 years.[8]

Life expectancy tends to fluctuate yearly, especially in countries with small populations where the impact of relatively few deaths can be significant. In contrast, a non-trivial change in a large country like the UK usually has an identifiable cause. For instance, life expectancy in England and Wales fell by 0.45 years between 1950 and 1951 and 0.37 years between 1967 and 1968. These decreases coincided with what was considered an influenza epidemic and a confirmed influenza pandemic, respectively.[9] While there is ongoing debate about the exact causes of the high death toll in 1950/51, which was much higher than in other countries, the impact of the 1968 influenza pandemic is uncontested. The underlying upward trend in life expectancy has been attributed to reduced risk factors, especially for smoking-related cancers and cardiovascular diseases. This decrease in risk reflects improved living conditions and, particularly since the 1960s, advancements in the effectiveness and coverage of healthcare (The wider range of factors that may explain most of the overall trends in life expectancy are beyond the scope of this paper.).[10,11] While there is some debate about the detailed explanation of these improvements,[12] health overall in the UK was improving. There was a widespread, albeit implicit, assumption that this would continue. However, something changed in 2012. Unlike the previous years mentioned, this was not a one-off decline but a shift in the longer-term trend.

What is already known about the changes in mortality?

Public health experts began raising alarms in the mid-2010s.[13] Two separate analyses using 3-year

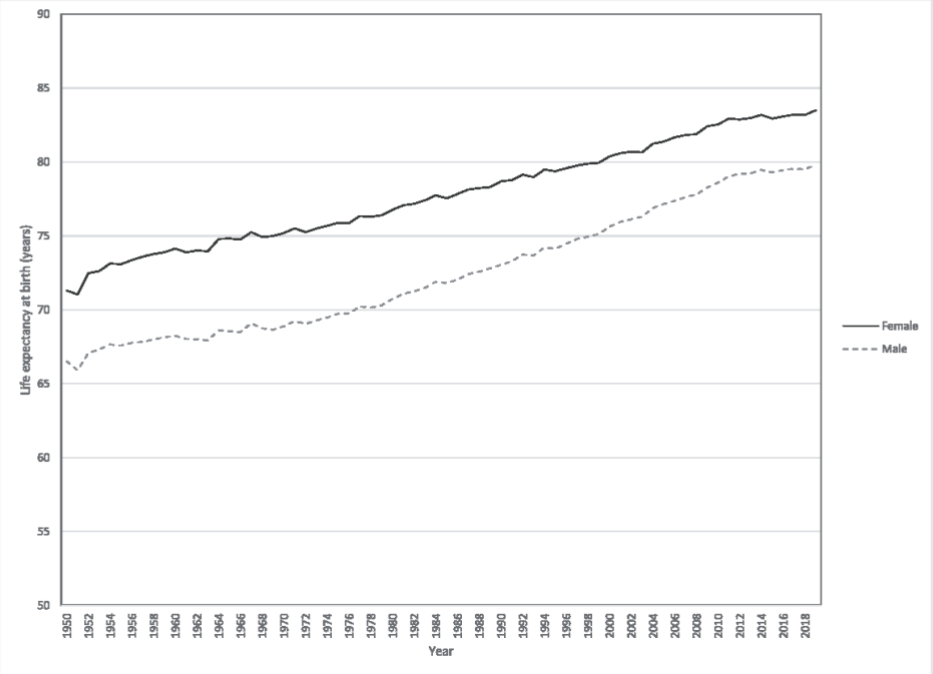


Fig. 1 Life expectancy at birth by sex, England and Wales, 1950–2019. Source: Human Mortality Database, 2022. Note: The axis does not start at 0.

and annual life expectancy data from the Office for National Statistics (ONS) revealed a drop in life expectancy for females aged over 85 years. Specifically, from 2012–14 to 2013–15, there was a decrease of 0.04 years (based on 3-year data),[3] and from 2014 to 2018, there was a decline of 0.03 years for women in England (based on annual data).[14] Initial concern arose from the observation that more older women were dying in the UK in 2012 than in previous years, after accounting for changes in the size of the population at risk.[13] This excess mortality was initially attributed to an 'unusually prolonged influenza season in England [in 2012-2013]' by Public Health England (PHE), now part of the UK Health Security Agency (UKHSA).[15,16] One study published in 2016 used a geographical analysis to link worsening old age mortality between 2007 and 2013 to austerity, but it received little attention.[17] It was not until the significant year-on-year increase in mortality between 2014 and 2015, described by ONS as the greatest increase since the onset of the influenza pandemic of 1968,[18] that a broader circle of researchers began to take note.[19]

At first, the increase in deaths between 2014 and 2015 was seen by many as a one-off blip, including by the Department of Health.[20,21] We explore these responses in more detail in the discussion. Provisional analysis by ONS revealed that most of the increase in 2015 occurred at the beginning of the year, coinciding, as the authorities at the time emphasized, with 'peak in flu activity for the 2014/15 season'.[18] The view then was that what was being seen could be attributed mainly to a particularly bad influenza season, detailed in publications by both the ONS and PHE, who wrote that the circulating strain—influenza A(H3N2)

subtype—was 'known to predominantly affect older people'.[1,15,18,22,23] PHE also pointed to an ageing population with higher levels of multi-morbidity and suggested that, even if many deaths in older people were not directly attributed to influenza, it was a factor contributing to their earlier deaths, thus contributing to the overall slowdown in improvements in life expectancy. However, it should be noted that deaths in older populations contribute less to overall life expectancy than those in younger populations. A senior official at PHE said, 'A range of factors can push up the number of deaths in older people in a particular year. An outbreak of influenza can have a big impact, especially on those who are most vulnerable or experiencing other illnesses, such as dementia... An increase in deaths will generally lead to a decrease in life expectancy that year, but we have seen these annual fluctuations before and the overall trend has remained positive'.[23] The title of another paper, analysing this increase, included the phrase 'influenza the likely culprit'.[24] An official from the ONS said 'A major cause behind the rise was the influenza virus, with estimates showing that the influenza vaccine was not as effective this winter compared to previous years'.[25,26] This explanation was contested by some others, including the three authors of this paper, who questioned whether deaths directly or indirectly due to influenza at that time could account for more than a small fraction of the observed increase in overall deaths.[27] The chief executive of a charity representing older people said 'Even discounting the impact of the flu, the figures are still far higher than in the previous year'.[28] Unfortunately, none of the concerns raised gained traction with those in authority, including the government and most of the leading think tanks close to the government.[29]

Advocates for the major role of influenza could highlight its contribution, along with other respiratory diseases, to the declines in life expectancy in several European countries in 2014/15.[1,30,31] However, the following year (2015/16), the UK and USA were the only countries not to see substantial gains in life expectancy in an analysis of 18 high-income countries, suggesting that other factors were at play.[6] Others contended that what transpired in England and Wales could be anticipated, given the unusually rapid improvements in the first decade of the 21st century. In other words, the rate of progress was returning to 'normal' after exceptional acceleration due, in part, to reductions in cardiovascular disease mortality.[32–34] However, a review of a longer time series found that while the first decade of the 21st century was unusual, the slowdown in the second decade saw rates of improvement fall below previous levels, with some rates turning negative.[35]

In summary, by the latter part of the 2010s, it became clear that the 'spike' in deaths in 2014–15 was part of a longer-lasting stagnation and, for certain groups, marked a reversal in mortality trend improvements.[36,37] Over time, the argument that austerity measures have had a detrimental effect on health has gained traction.[2,4,5,35,38–44] This includes research that has shown how the increase in excess mortality at local authority level correlates with the impact of welfare reforms (cuts), but not deprivation (poverty)[43], and an association between reductions in funding allocations by central government and adverse changes in life expectancy,[5] also noting that the reductions were greatest in the most deprived areas.

What is unknown or contested?

Despite the wealth of evidence linking austerity to worsening health outcomes, some seek to explain the observed effects as largely, or almost entirely, due to influenza—an increasing body of research has challenged this particular viewpoint.[40,41,45–47] This includes decomposition analyses that show influenza per se did not contribute significantly to the deteriorating trends in life expectancy. Yet, influenza continues to be invoked to explain why the UK fares so poorly compared to neighbouring countries.[1,37,48,49] A PHE review of mortality trends in England presented age-standardized mortality rates and decomposition analyses of selected causes of death from 2001 to 2016 for both sexes, showing large and relatively continuous improvements in mortality rates from influenza and pneumonia.[1] Despite this contrary evidence, the report stated that 'there is a

considerable body of evidence, both for England and across Europe, besides what is reported here, which provides evidence that respiratory diseases, including influenza, are leading contributors to levels of excess mortality in recent winters'. To date, this appears to remain the official view. Ramsay et al. performed decomposition analyses in Scotland using data up to 2017. While they noted an increase in deaths due to influenza and respiratory causes in the most recent years, they also demonstrated that this increase made only a small contribution to the stalling of life expectancy improvements.[45] Furthermore, their analyses showed that mortality had worsened across various age groups and causes of death, leading them to conclude that it is unlikely one 'single factor' could explain the change in trends.[45] Even if influenza was responsible for the observed changes, the question remains as to why the UK seems to experience higher mortality levels during epidemics than other countries. The COVID pandemic may provide insights, including the exclusive focus on influenza in preparedness exercises.[50,51] Given a novel virus in a population not previously exposed, the immediate cause among those so affected was the SARS-CoV-2 virus, poverty and service provision played an important role in mortality risk.[52]

What this paper adds

This paper aims to contribute to the existing body of evidence for England and Wales by (a) adopting a broader perspective on influenza-related deaths and (b) extending the time series up to 2019, before the onset of the COVID-19 pandemic in 2020. Finally, it seeks to understand why influenza was widely accepted as the primary cause of the observed changes and why there was, to a large extent and remains to be, an official denial of the role of austerity.

Methods

We use publicly available ONS cause of death (by ICD-10 code) data and mid-year population estimates to describe patterns of age/sex standardized death rates from 'influenza' between 2001 and 2019 for England and Wales treated as a single geographical area. The ICD-10 codes for influenza alone are insufficient to ascertain the true number of influenza deaths, given that not everyone with influenza will be tested and it may be a contributory factor to a death from other causes. Consequently, we follow conventional practice in combining the codes for influenza (J09–J11) and pneumonia (J12–J18).[53,54] Second, we use a bespoke dataset, i.e. a user-requested dataset from the ONS (The dataset includes numbers of deaths due to and involving influenza or pneumonia by 5-year age group for England and Wales, 2001–21.), which includes both deaths *due to* and *involving* influenza and pneumonia (The ONS describes this difference as: 'We use the term "due to" a cause of death (e.g. influenza) when referring only to deaths with that underlying (main) cause of death. We use the term "involving" when referring to all deaths that had the cause mentioned anywhere on the death certificate, whether as an underlying cause or contributory factor' (ONS, 2022).).[55] Third, we include additional analyses to broaden the classification to include other codes that might capture influenza deaths. These are shown in Table 1, henceforth referred to as 'influenza and influenza-like disease'. Finally, to account for the changing population composition, we calculated age-standardized mortality rates and ratios using the European standard population.[56]

Data availability

No new data were generated or requested as part of this manuscript. All data analysed are publicly available from the ONS at the given references.

Results

Mortality from influenza (ICD-10 codes J09-J11 inclusive)

Figure 2 shows the age-standardized mortality rate (ASMR) per 1000 people per year where influenza is directly coded as the underlying cause of death (ICD-10 codes J09-J11). This shows that influenza deaths were low until 2017, rose in 2018 and

Table 1 ICD-10 codes used for a broader analysis of 'influenza and influenza-like disease'

Code	Description
J09–J18	Influenza and pneumonia
J40	Bronchitis, not specified as acute or chronic
J41	Simple and mucopurulent chronic bronchitis
J42	Unspecified chronic bronchitis
J44	Other chronic obstructive pulmonary disease
J47	Bronchiectasis

remained higher than in 2019. This relatively high level of mortality from influenza coincides with the lowest all-cause age–sex-adjusted mortality in England and Wales on record (see Fig. A and Table B in the supplementary material for additional information).[57]

Mortality from influenza and pneumonia (ICD-10 codes J09–J18 inclusive)

Next, we present mortality from influenza and pneumonia, where either term was listed as the main *or* contributory cause of death (The ONS describes this difference as: 'We use the term "due to" a cause of death (e.g. influenza) when referring only to deaths with that underlying (main) cause of death. We use the term "involving" when referring to all deaths that had the cause mentioned anywhere on the death certificate, whether as an underlying cause or contributory factor' (ONS, 2022).). These bespoke data were not available disaggregated by sex. Figure 3 shows deaths per 1000 population (calculated using the mid-year population estimates by single year of age for England and Wales) from 2001 to 2019. It demonstrates a sustained downward trend, most obviously in the oldest age groups. Although the largest fall is for the oldest groups, when the graph is drawn on a log scale, in which equal vertical distances between lines represent equal percentage changes (see Fig. F in the supplementary material), this fall was similar in relative terms across all age groups. Figure 3 also demonstrates that 2019 saw the lowest number of deaths involving and due to pneumonia and influenza for those aged 70 and over. Conversely, this corresponds with a period of higher mortality in quarter 4 of 2019 in England compared to the previous five years for men and for all years except 2017 for women (see Table C and D and Figs G and H in the supplementary material and the work of Li et al. on the likely rise of influenza in late 2019 and early 2020 in the UK).[58]

Mortality from influenza and influenza-like disease (ICD-10 codes)

To further compensate for undercounting of influenza deaths, we present the data on trends in mortality rates from influenza and influenza-like disease using all the ICD-10 codes listed in Table 1, from 2001 to 2019 by age group and sex (Fig. 4). There was a spike in deaths in 2015 in both sexes in age groups 80–84 and 85+. However, this can be seen as causing only a small perturbation in overall influenza declines over this period in older age groups, among whom overall mortality was stagnating or worsening. At younger ages, the rate of decline either plateaued or transiently reversed. Still, the rates were so low that the small perturbation is unlikely to have had any significant effect on overall trends. Figure 4 also shows that the 2018 and 2019 increases in deaths directly attributed to influenza (Fig. 2) were not part of a wider increase in deaths from all influenza-like diseases (see Figs B to E in the online supplementary material for the longer-term trends).

Age-standardized mortality rates for influenza and influenza-like disease

Figure 5 combines the age-specific data in a summary age-standardized mortality rate, presenting trends in males and females from all influenza and

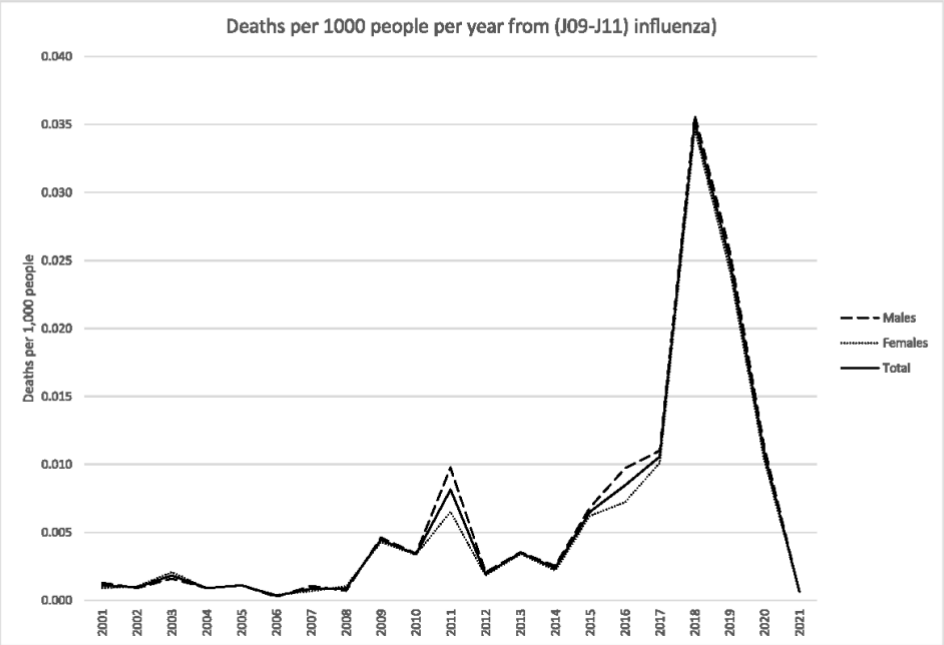


Fig. 2 Mortality from influenza (J09, J10, J11) per 1000 people, 2010–21, in England and Wales, directly standardized to the 2013 standard European population.

influenza-like disease. The increase observed in 2015 represents an increase of 12 deaths per 100 000 men and 11 per 100 000 women. Figure 2 reveals that <0.5 deaths per 100 000 deaths were directly attributable to influenza in most years between 2001 and 2021. In 2018 and 2019, it was slightly higher than 2 deaths per 100 000 people per year. A further important observation is that there were 79 male deaths and 60 female deaths per 100 000 in 2021 when almost no influenza virus was circulating in England and Wales. This helps to confirm what many people working in this area have long known: that the large majority of deaths falling within this broader category are not, in fact, due to influenza.[59]

Discussion

Areas of agreement

We demonstrate an overall decline (an improvement) in mortality in older age groups from influenza in both sexes from 2001 to 2019 in England and Wales, in contrast with the concurrent stalling of improvements and worsening of all-cause mortality. This is consistent with existing research critically appraised in McCartney et al.'s 2022 report, which concluded that 'influenza is unlikely to have been an important cause of the stalled trends in mortality improvements'.[40] McCartney et al. cited existing decomposition analyses showing that influenza and pneumonia made minimal and/or positive contributions,[1,45,47] that the stalling impacted all ages (not just older groups as would be expected with influenza mortality)[1,45] and that there was no increase in GP consultations for influenza-like illness or hospital admissions due to influenza.[1,60] Analyses up to 2017–18 reported that, while variation over time in influenza did contribute to annual fluctuations in mortality, its impact and that of other respiratory infections during the period in question was no greater than in

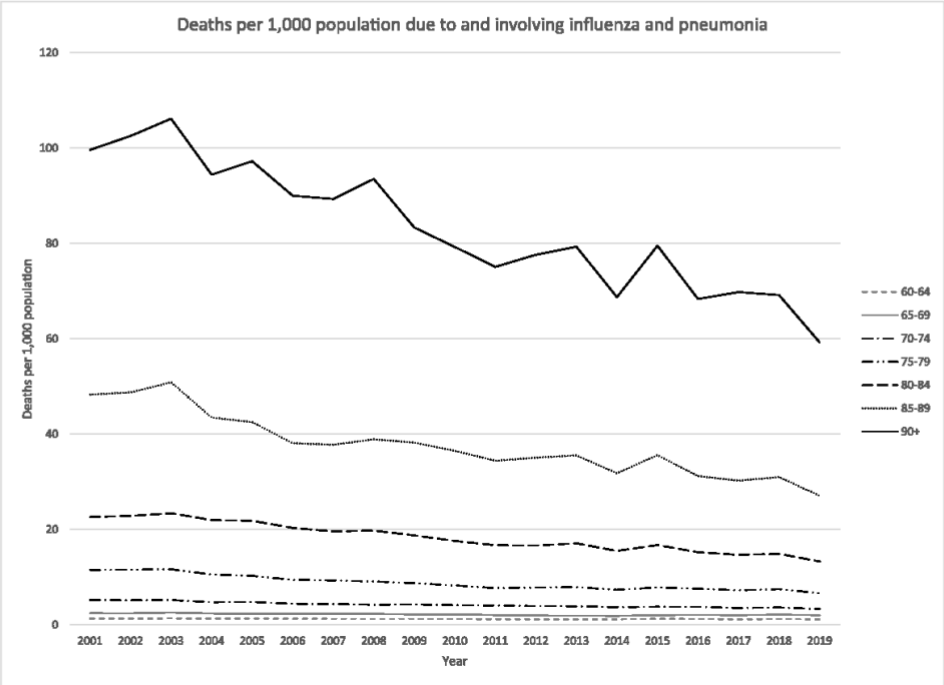


Fig. 3 Deaths per 1000 population due to and involving pneumonia and influenza by 5-year age group, England and Wales, 2001–19. Source: ONS, 2022.[55]

previous periods and should not impact longer-term trends.[27]

Strengths and weaknesses of the study

This study reports new analysis of the most recent data and we go beyond existing evidence, countering the claim that influenza played a significant role in the stagnating trends in mortality seen in England and Wales in the second decade of the 21st century. It is known that narrow codes—i.e. J09–J11 only—will undercount influenza deaths. Figure 2 highlights that when a new strain of influenza appears and is detected by analysis of viruses in hospitals, that is then reflected in the increased use of particular ICD-10 codes resulting from the change in notifications on death certificates. For example, in the UK in 2009, the code J09 was first used to code deaths when a new strain of influenza—H1N1—was detected (H1N1 caused the so-called swine influenza pandemic, which the World Health Organization (WHO) defined as taking place between June 2009 and August 2010, after which it became endemic and was given its own ICD10 code, J09, which had not been used in the UK before that date.). Although the number of deaths was extremely low, it might account for the slight reported overall rise in 2009 and 2012 because of improved virological surveillance and thus better identification of cases and because more testing was being done in the light of knowing about the new strain.

We extend beyond existing analyses focusing on deaths due to influenza and pneumonia to include those involving related diseases. The limitations

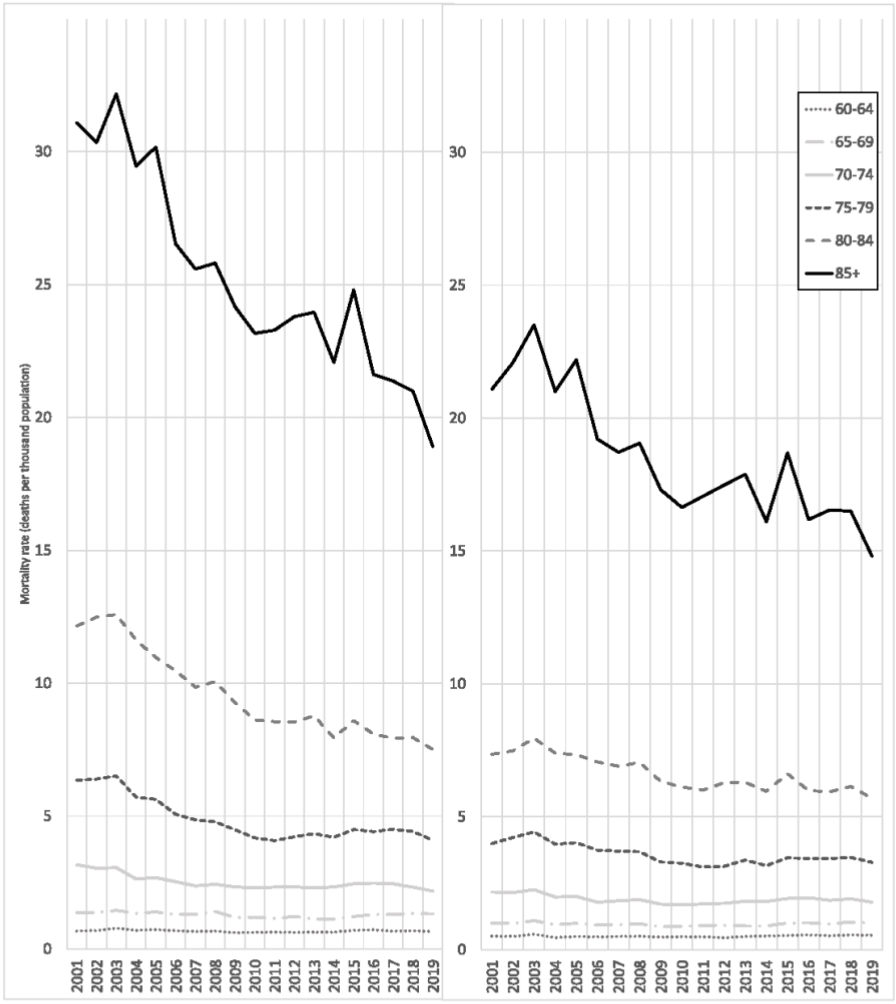


Fig. 4 Mortality rate (deaths per 1000 population) from influenza and influenza-like disease 2001–19 by age group for males (left) and females (right), England and Wales

lie within the challenges of assessing influenza deaths, which are well established. Underreporting of deaths from influenza is widely acknowledged, yet overreporting is not,[1,40] and an important limitation is that, despite the mitigations outlined in the results and methods section of this paper, some deaths involving influenza might still have been missed while others that should not have been included may have been. Including pneumonia could overestimate influenza deaths. Pneumonia is a far more common recorded cause of death than influenza,[55] and most deaths from pneumonia are not caused by or involve

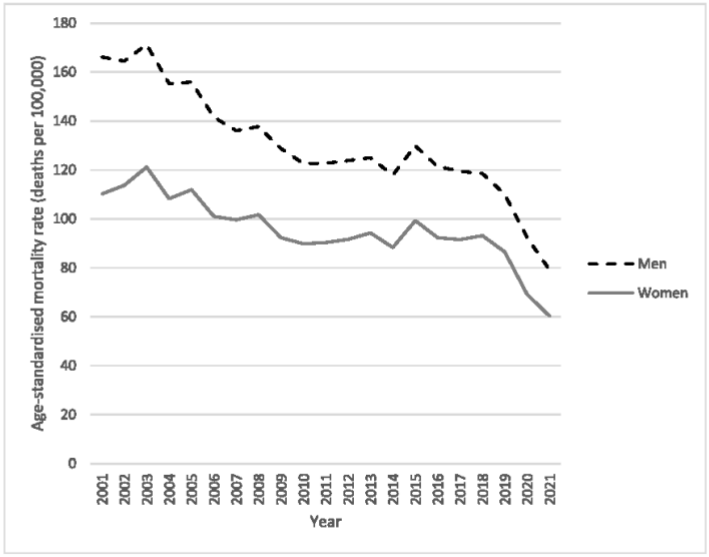


Fig. 5 Age-standardized mortality rate, deaths per 100 000 population, for influenza-like disease, males and females in England and Wales 2001–21. Note: deaths due to the spread of Sar-CoV2 are not included.

influenza. Furthermore, many other commonly circulating respiratory viruses will contribute to these figures.

A further limitation is that deaths from other diseases, particularly cardiovascular disease and dementia, both of which increased during the period in question, could have been expedited by a person also suffering from a respiratory infection, including, but not limited to, influenza, and these would also not have been captured.[40,61] The link between acute respiratory infection and cardiovascular disease mortality has long been established,[61–64] with an increasing understanding of the causal pathways involved.[65] However, there is no clear evidence that specifically implicates influenza as the most often involved infectious agent.[12] Similarly, while influenza is not known to cause dementia, individuals living with dementia are more susceptible to poor outcomes from respiratory infections. Yet, the extent to which a respiratory infection might provoke deaths from cardiovascular disease or dementia/Alzheimer's disease remains unknown. Conversely, a small study conducted in two teaching hospitals in New York City, USA, retrospectively reviewed all deaths with pneumonia or influenza as the cause of death and found that more than one-third were, in fact, due to heart disease or dementia/Alzheimer's disease.[66]

Areas of controversy

Our review of the data up to 2019 is consistent with existing evidence that influenza was not the primary, or even an important, explanation for the stalling life expectancy in England and Wales from 2012 onwards. This leads to the critical question: why were so many experts across government, public health bodies and think tanks so quick to accept influenza as the leading cause of the changes in mortality and so slow to change their minds when confronted with information to the contrary? We surmise that there are, at least, three possible explanations: first, a longstanding tendency to use influenza as, in effect, a default explanation when

deaths increase; second, a reluctance to engage with the political choices that lead to poor health; and third, the active promotion of competing narratives.

Influenza as a default explanation when deaths increase

Why did many experts accept influenza as the cause of worsening mortality? Historically, there is a precedent for misattributing a substantial rise in deaths to influenza. Ascribing excess mortality, especially at older ages, to influenza was commonplace after 1889.[12] After an influential working paper was published by Serfling in 1963,[67] this tendency became systematized, and influenza began to be blamed for most excess deaths each winter. Attempts to assess the 'virulence' of different circulating strains of influenza and their impacts on the population were, and often still are, based on overall rises in winter mortality.[68,69] Over time, the identification and increased understanding of many more viruses has shown that many are implicated in respiratory disease—not just influenza.

There were influenza pandemics in 1918/19, 1957, 1968 and 1977 and smaller ones (There was probably at least one pandemic between 1919 and 1957, but our means of detecting the influenza virus were in their infancy then, with the virus only having been identified in the 1930s.).[70] In between the pandemic years, there was a tendency to ascribe excess winter deaths to influenza. One example is London in 1952 when influenza was initially blamed for a large rise in mortality. While this is understandable given there was what was thought to have been an influenza epidemic in 1951,[71] but with the benefit of hindsight, as far as we can currently ascertain, the 1952 rise in mortality in London was caused mainly by what has been called the 'great smog'.[72,73]

The argument linking recent mortality patterns to influenza draws extensively on two data sources, EUROMOMO and FLUMOMO.[30,74] These report weekly trends in excess mortality across selected European countries. However, both measures have important limitations. EUROMOMO presents the Z scores for data on all-cause excess deaths scaled by their standard deviations. If the natural variability of death rates is lower in one country than another, then this could exaggerate excess mortality compared to what would be seen using P scores, as is done by the Financial Times, so, strictly speaking, the measures are not comparable across countries.[75] FLUMOMO considers any deviation from baseline to be due to influenza or extreme temperatures, but it has been argued that it excludes other important variables.[76]

The tendency to ascribe excess winter deaths to influenza is not helpful. It diverts attention away from the danger of actual pandemics of new strains or the return of an older strain to a young population without immunity. It also diverts attention from other respiratory diseases—had modern medical techniques not existed in 2020, it is possible that the COVID-19 pandemic would have been called an influenza pandemic.

Insufficient caution is applied in attributing deaths to influenza without microbiological evidence to support it. It is noteworthy that the UK surveillance system did not detect any significant changes in influenza between 2010 and 2022 (See Figure 22 available at: https://www.gov.uk/government/statistics/annual-flu-reports/surveillance-of-influenza-and-other-seasonal-respiratory-viruses-in-winter-2021-to-2022#microbiological-surveillance (accessed 19 June 2023)).[77] Given the evolving nature of respiratory viruses and the crumbling of an under-funded, over-worked health service, this will become increasingly important in both planning and decision-making, mainly come winter 2023/24 and the winters that follow in the UK with its severely depleted public health and care services, and officials still all too willing to blame 'the flu'.

A reluctance to engage with political choices that lead to poor health

Writing in 2023, there remains a need for acceptance of the negative impacts of austerity. This study contributes to the existing evidence by refuting claims that influenza is one of the main causes of the deterioration.[27,40,45,47] On their own, the observed changes in cause-specific mortality that we have described do not allow us to invoke austerity as playing a role, but nor do they allow us to exclude it—that requires

other evidence.[78–81] It is, however, intuitive that anyone already living in deprived circumstances will be at greater risk from health and social care cuts, as laid bare by the COVID-19 pandemic,[52] and this would also likely be the case if an actual influenza pandemic or epidemic took hold and then rapidly spread across the country. As the health services already cannot cope in most winters, an influenza pandemic could be devastating. This is especially the case given an ageing and increasingly impoverished population suffering from the effects of cost-of-living crises, including not being able to heat many homes. Misattributing rising mortality to influenza could have unforeseen detrimental effects in the event of an actual influenza pandemic.

It is difficult to justify the almost total rejection by Conservative politicians of the idea that austerity played a role. Yet this is what has happened. In 2017, in response to our publications examining potential causes for the 2014–15 rise in mortality, including influenza, and calling for urgent investigation into the link between health and social care cuts,[19,20] a Department of Health spokesperson said 'This report is a triumph of personal bias over research – for two reasons. Every year there is significant variation in reported excess deaths, and in the year following this study they fell by nearly 20,000, undermining any link between pressure on the NHS and the number of deaths. Moreover, to blame an increase in a single year on "cuts" to the NHS budget is arithmetically impossible given that budget rose by almost £15bn between 2009-10 and 2014-15'.[21] That publication was met with criticism and scepticism by others, perhaps appropriately given the focus on one year-on-year change.[82–84] However, there was a growing realization that what had just occurred was more serious than first realized and represented the early stage of a reversal of the previous long-term improvements.[85] Nevertheless, the architects of austerity (including the current Conservative government) still do not appear to accept that it had any adverse health impact.[86]

In 2022, Walsh et al. published research linking 'over 330,000 excess deaths in Great Britain' to austerity.[87,88] This was debated in the House of Lords in early 2023, with the then parliamentary under-secretary of state at the Department of Health and Social Care, Lord Bethell. While Lord Bethell did acknowledge that the rate of improvement of life expectancy had stalled, when asked '. . . [if the government] accepted that austerity policies since 2010 was a significant cause. This argument was rejected by Lord Bethell'.[89] The debate went on: 'Lord Kirkhope of Harrogate (Conservative) asked the government what it thought the explanation was for this change, querying whether it might be the result of a change in the methodology used to assess life expectancy or a result of changing social habits among the population. Lord Bethell said the reasons for the change were complex and that he could not give an answer that addressed every element of this problem. However, he said behaviour was a factor, noting the high levels of obesity in the UK'.[89] One study that has looked at this in detail finds that, at most, 20% (male) and 35% (female) of the stalling mortality between 2017 and 2019 could be attributed to obesity, and these figures are likely overestimates.[78] Moreover, evidence links austerity, specifically cuts to early childhood services, to increased childhood obesity in England.[90] This denialism of the effects of cutting public health and social care services can also be seen in how the advocates of austerity have refused to accept that it played a role in the UK's poor response to the COVID pandemic despite the extensive evidence to the contrary.[91]

A frequent rebuttal to research linking austerity to worsening health outcomes is an epidemiological one—asserting that observational longitudinal data cannot provide evidence of causality. This argument was used in published criticisms of a 2017 paper linking health and social care cuts with 120 000 excess deaths.[92,93] While this point has merit, the criticism is weakened by study after study reporting the same findings despite using different data and approaches and by how many of the studies invoking austerity are very robust, employing panel regression methods to account for time-invariant confounding, series of sensitivity analyses and checking for possible confounding by using different measures

of austerity.[2,38,39] The evidence invoking influenza is also observational, but that has not prevented it from being used. This suggests that different evidence thresholds are being applied to other hypotheses, suggesting that personal, ideological or institutional biases towards 'safer' and 'depoliticized' explanations may play a role. We have also shown previously how the argument invoking austerity meets Bradford–Hill's criteria for causality.[94] This begs the greater question: at what point does the evidence for the cuts have led to shorter lives become overwhelming?

Many public bodies still refuse to accept the negative impacts of the cuts on health. Influenza, then, may perhaps be considered a convenient and well-tested excuse for an increase in deaths. A concentration on influenza as a possible cause for worsening mortality provides an off-the-shelf excuse for governments wishing to divert attention from things they can more directly control.

Active promotion of competing narrative

We have shown how faced with clear evidence of worsening health linked to austerity, politicians and others were promoting a competing narrative that emphasized a mixture of artefact and influenza. This was largely successful, and, until relatively late in the day, there was little serious discussion about the austerity causing earlier deaths issue in policy circles. How did this narrative take hold?

Narratives are powerful storytelling tools that shape how policymakers and the public perceive and understand certain issues. They are established and maintained in several ways. The first is the framing chosen for the issue.[95] In this case, it was a frame that included artefact and influenza and which excluded austerity. Other examples in public health include how problems arising from consumption of harmful substances, like tobacco[96] or gambling,[97] are framed by their producers as a matter of individual responsibility so as to exclude measures such as restrictions on marketing or availability from the policy discourse. The second is the media. With a few exceptions, the British print media is unsympathetic to anything that would increase the state's role (pejoratively referred to as the 'nanny state')[98] or the taxes paid by its readers. The third is the role of advocacy groups and interest organizations. Although their activities usually take place in the shadows (a rare exception was the attention they attracted as advocates of the short-lived and catastrophic policies of Prime Minister Liz Truss in 2022), their influence is substantial. A cluster of well-connected organizations, co-located at 55 Tufton Street, London and a few nearby addresses,[99] have mounted sustained attacks on critics of austerity, even though these critics include Nobel laureates and United Nations Special Rapporteurs.[100] Importantly, there was no strong countervailing narrative from the leading health thinktanks. This is unsurprising as they had been unwilling to take a firm stance over the introduction of the 2012 NHS 'reforms' in England, now widely accepted as having been misguided, even by the then Prime Minister, David Cameron, in his memoirs.[101] However, such public bodies and some academics face a difficult balancing act. They may depend on access to ministers, access that can easily be cut off should they be seen to be critical. They may depend on government funding, sponsorship or approval to do their work. As a 1993 paper noted, 'Think tanks face tactical dilemmas when pressing their views on Britain's comparatively closed system of government, in particular their choice between insider and outsider forms of persuasion; the tension between proximity to ministers and intellectual autonomy; and their advantages to politicians as deniable sources that can float new ideas, which can be counter-balanced by politicians' fluctuating appetite for radical ideas'.[102] Future research could usefully explore the role that these factors played in promoting influenza in the face of growing evidence that challenged it.

Unanswered questions and future research

Influenza did not cause the stalling and worsening mortality trends in England and Wales from 2012 onwards, which continue to the present day. Given the evidence of the greatest impact of austerity on those living in deprived areas,[4,5] a next step will be

to examine these trends by deprivation decile. Future research may also explore why so many people in such high positions of authority were so quick to attribute the change in overall mortality trends to influenza and were slow to correct this later and why, to this day, the negative impacts of austerity on health, not least on pandemic preparedness, are not accepted by its architects, nor by so many of those who have followed them,[86] and why so many people in England and Wales have stood by and watched this failure of government and public health unfold.[103]

Supplementary material

Supplementary material is available at *British Medical Bulletin Journal* online.

Acknowledgements

We are grateful to the two anonymous reviewers of a previous iteration of this paper who helped us substantially improve it and were generous with their advice and comments, and the three referees who helped immensely on commenting on the final iteration. We are sorry we cannot thank them by name, as they have contributed to the paper considerably!

Author contributions

Lucinda Hiam (Conceptualization, Investigation, Project administration, Writing– original draft, Writing– review & editing), Martin McKee (Conceptualization, Investigation, Methodology, Supervision, Writing– review & editing), Danny Dorling (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing– review & editing)

Conflict of interest statement

The authors have no pertinent commercial or other sources of funding either for their own research or for any work in their academic departments or colleges that they know of that could influence the view expressed here.

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5.3 Chapter 5 Summary and Next Steps

Influenza did not play a significant role in the UK's post-2010 deterioration in mortality. Across multiple coding definitions, influenza-related deaths remained low, declined overall, and did not exhibit the temporal or social patterns necessary to account for the shift described in Chapters 2 and 4. This undermines claims that flu was a principal cause of the slowdown and reinforces the argument developed in Chapter 2 that proximate explanations are inadequate.

Viewed through the integrated framework, these findings indicate that an acute pathogen shock does not align with the aspects of the population, habitat, and behavioural dimensions that were deteriorating during this period. Influenza did not meaningfully interact with underlying social determinants or increase population precarity, further supporting the conclusion that the mortality changes observed require explanation beyond proximate biological factors.

By ruling out influenza, this chapter extends the process of elimination set out in Chapter 2: it tests a prominent proximate explanation and shows that it is insufficient. This establishes the groundwork for Chapter 6, which examines a second major non-structural hypothesis concerning whether demographic ageing and cohort effects can account for the observed trends before turning to structural mechanisms in later chapters.

6 The Golden Cohort: Testing the Demographic Hypothesis

6.1 Introduction

This chapter presents the third empirical paper in the thesis. It addresses RQ 2 (*How well do commonly suggested proximate explanations, such as influenza, ageing, or other age- and cause-specific effects, account for these trends?*) by examining whether demographic factors, specifically cohort effects, can account for the mortality trends or whether structural explanations remain necessary. It focuses on one of the most historically advantaged generations: the so-called "Golden Cohort" born between 1925 and 1934 (Goldring et al., 2011). This generation benefited from a unique combination of early-life investments and postwar welfare expansion and has long been associated with exceptional longevity. Yet, as the paper shows, even this resilient generation experienced a marked and unexpected rise in mortality from 2012 onward. Drawing on economic, social, and epidemiological insights, the analysis demonstrates that the deterioration in their health outcomes cannot be attributed to demographic inevitability or ageing alone. This offers an opportunity to test whether demographic dynamics alone could explain the emerging crisis or whether other components of the wider dimensions of the Triangle were implicated.

In doing so, this chapter extends the process of elimination established in Chapter 2, testing whether cohort ageing could explain the crisis before, in later chapters, turning to the structural mechanisms introduced in Chapter 3.

6.2 Paper 3: The Rise and Fall of Britain's Golden Cohort: How the Remarkable Generation of 1925–1934 had their Lives Cut Short by Austerity

REVIEW OF SOCIAL ECONOMY
https://doi.org/10.1080/00346764.2023.2300007

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The rise and fall of Britain's Golden Cohort: how the remarkable generation of 1925–1934 had their lives cut short by austerity

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ABSTRACT

The British born between 1925 and 1934 experienced exceptional improvements in their annual mortality; earning them the title 'the Golden Cohort'. They were the goldilocks generation; almost all too young to fight in WWII, but the right age to benefit from food rationing; too old to be hit by 1980s youth unemployment, and the right age to benefit from increased health and social care spending of the late 1990s and early 2000s. This group has befuddled demographers for many years, and as recently as 2014 it was predicted that their golden luck would continue. However, using the latest data from the Human Mortality Database, we show how the Golden Cohort's luck changed in 2012 when their outstanding health record was reversed, cutting short most of their remarkable lives. This change coincides with the introduction of austerity in 2010, consistent with the evidence on the harms of austerity in Britain.

ARTICLE HISTORY Received 16 May 2023; Accepted 22 December 2023

KEYWORDS Life expectancy; Austerity; Golden cohort

1. Introduction

There is something unusual about people born in Britain between 1925 and 1934. The men and women born in that decade were children during the time of the Great Depression and in the wake of World War I (WWI). Yet, for almost all their lives, they consistently benefited from better mortality improvements than those born before and, curiously, after them. This earned them the collective name 'the Golden Cohort' (Easton, 2011; Goldring et al., 2011; Murphy, 2009).

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Supplemental data for this article can be accessed at https://doi.org/10.1080/00346764.2023.2300007

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For most people, Britain in the years 1925–1934 was not a place of health and prosperity. In adulthood, the Golden Cohort did not start out at an easy time in British history. As adults, they lived in a country that was losing its empire and becoming poorer in relation to other Europeans. As children, most of them lived in poverty which had deepened in some key ways in the previous three decades (Seebohm Rowntree, 1941). They were not especially healthy as young adults, and often smoked, but *something* about this group resulted in their health continuing to improve from early on at rates unrivalled by those born both before them, and after them.

The Golden Cohort may partly just have been lucky. They lived, in their adulthood, through what was the most prolonged period of peace to have occurred across most of Europe for many centuries. They avoided pandemics that came far less frequently for them than such diseases had for earlier generations. They lived through some of the most equitable and progressive eras in British history. When, in the 1980s, there was mass unemployment, it mainly affected people younger than them. When health and social care spending rose greatly after 1997, it mainly benefitted them. Their good fortune had been 'golden'. However, in this paper we argue that the Golden Cohort, who had been so lucky for so long, encountered extremely bad luck in old age. As a group, they had their lives cut short by a government-imposed policy—austerity. This so badly affected enough of this cohort to alter their collective outcomes in a way we can now see as having been startling, and which perhaps we should have better monitored at the time. Austerity measures, which were introduced in the UK in late 2010, have now been widely linked to rapidly worsening health in the British population, a trend which began long before the COVID-19 pandemic had emerged. Some of those who suffered most were the group who had been called golden.

The Golden Cohort were well into their Golden years of life—in their 70s and 80s—when the impacts of 2010 austerity began to take effect, around 2012 onwards. Here we compare the trends in mortality improvements for them with other people born a little earlier and later than those ages. We show that austerity was most damaging for those who were oldest and had by then the least power to fight it.

We begin by exploring the story of the Golden Cohort throughout the twentieth century, their more recent history from 2000 onwards, and then turn to consider the years of austerity from 2010 until the present day in depth (these austerity years are not yet over). We end with their experience of the COVID-19 pandemic and, now in the mid 2020s, how the very few that remain, but also and in summary, how their children, grandchildren and great grandchildren are today being affected by the cost-of-living crisis coupled with continued austerity in Britain.

2. The cohort effect

2.1. What is the 'cohort effect'?

The term 'cohort effect' refers to a factor which specifically affects a group who were influenced by something in their shared past. Cohort effects can be revealed through variations in one or more characteristics over time, such as age at onset of a disease being seen among a group of individuals (a cohort) who share a defining experience. This experience can include events around their year of birth (such as being born in famine, or when an infectious disease was highly prevalent) or years of a specific exposure such as to smoking or radiation (Jacob & Ganguli, 2016). However, definitions vary, including its attribution as a non-statistical descriptive term specifically to the observed trend of the Golden Cohort (also referred to as the Golden Generation) (Murphy, 2009; Murphy & Richards, 2010; Willets, 2004; Willets, 1999). Some demographic and actuarial intricacies of the definition can be found in the references provided for Murphy and Willets, for example, at the end of this paper.

In their 2023 paper, Jones et al. demonstrated that graphical visualisations: '… are more effective than the HAPC [a statistical] model for the exploration of the data' when exploring cohort effects (Jones et al., 2023). The authors provide a clear explanation of the 'identification problem' – that when considering the three interacting factors of age, period, and cohort 'there is a problem that by knowing two variables we can perfectly predict the other: age equals period minus cohort, so the three variables have only two degrees of freedom'. What this means is that it is possible, although often unlikely, that what appears to be a *cohort* effect is a series of unrelated *period* effects that influence people at a series of different ages. A good example of a clear *cohort* effect is the long term effects of being in utero during the 1817 hunger crisis in Switzerland (for those born in 1818), and similarly being in utero when the Spanish Flu was at its worse, in 1918 (Matthes, 2023). There is much speculation of possible cohort effects of the 1918 flu. However, sometimes when these appear to be found, they may in fact be of something that affected an earlier cohort, but only appear around, for example, at age 30. Thus, what looks like a cohort effect that begins in 1918 may have begun earlier (Blanchard et al., 2020). For the Golden Cohort, as we discuss further later on, they may well be an example of the combination of benefitting from only tangentially related period and age effects, for example being old enough to benefit when health spending increased in the New Labour years (Section 3.4).

2.2. The Lexis diagram or 'heat maps'

One way to identify and visualise a cohort effect is to produce a graphical visualisation, often thought of as a 'heat map', but in demography more formally called a Lexis Diagram (or 'surface'). These diagrams show age in years on the

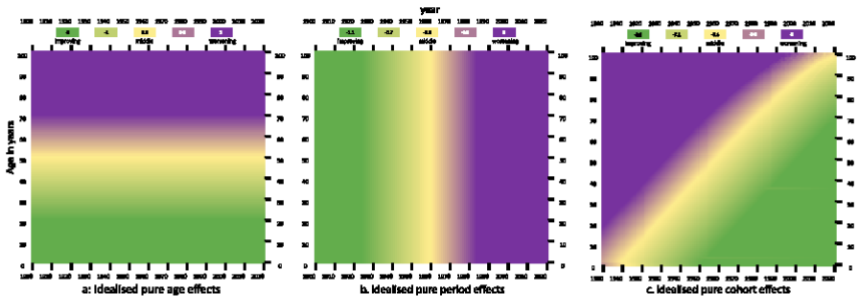


Figure 1. Idealised illustrations of Lexis diagrams showing 3 different types of cohort effects: 'Ideal' age-, period-, and cohort effects on the Lexis surface. Adapted from Rau et al., 2018.

vertical axis and time in calendar years on the horizontal axis, and the coloured squares within them can show a rate for that age/year group, or, if the Lexis diagram is of change over time, then each square can represent the rate of change in mortality rate relative to the rate the previous year for any age/sex group. For example, the change in mortality of a 65-year-old in 2020 is the percentage point change in the proportion of the relevant population that died in 2020 relative to those of that age who died in 2019. Often separate diagrams are drawn for men and women as both their mortality rates and what influences those rates can vary so much.

Figure 1 is adapted from 'The Lexis Diagram' by Rau et al., and demonstrates how the Lexis surface should look for age-, period- and cohort effects (Rau et al., 2018). Figures 1(a,b) show how a Lexis surface would look with 'pure' age or period effects. If this were for mortality, it would imply that either only age or only the time period were impacting the outcome (deaths). Figure 1(c) highlights what we are interested in—a pure cohort effect. Birth cohorts move along the 45-degree line — each 1-year increase in time corresponds with a 1-year increase in age. The diagonal line from bottom left to top right therefore represents a group of individuals born at the same time who have their own specific mortality outcomes across the time period. These are idealised illustrations, as we will see when looking at the real Lexis diagrams of mortality in England and Wales.

2.3. The golden cohort

Figure 2 shows Lexis diagrams for males and females from 1913 to 2008, reproduced with kind permission from an Office for National Statistics (ONS) paper exploring the phenomenon of the Golden Cohort in 2011 (Goldring et al., 2011). Along the horizontal axis is the year the data refer to, and on the vertical axis is the age of the population being examined. The colours correspond to the annual percentage change in mortality rates where dark, medium, and

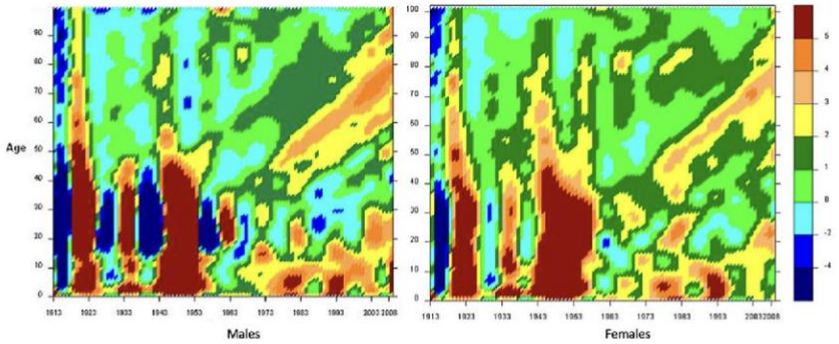


Figure 2. Annual percentage change in smoothed mortality rates, England and Wales, 1913–2008 using three year rolling averages, males (left) and females (right). Source: Goldring et al., 2011. Note: an increase in the rate is a decrease in mortality. Reproduced with kind permission of the authors at ONS.

light blue represent a negative change, i.e. a worsening of mortality compared to the previous year, and yellow, orange, and red represent improvement in mortality. Light green shows no change, and dark green, represents the modest improvements.

For some major events, the same changes can be seen in both the Lexis diagrams of males and females. For example, the dark blue stripe in the mid-late 1910s corresponds with World War One and the Spanish Flu pandemic. The second blue stripe from the left corresponds with the Great Depression—the period during which the Golden Cohort were born— and shows a greater worsening of mortality for males than females. Wages fell after 1921 and did not return to the level there were then until 1931. However, in that year unemployment benefits were cut by 10% and that life-line for those in great destitution was not restored until 1934 (Dorling, 2023b). Geographical health inequality in the UK was higher in the 1930s than at any time afterwards (Dorling, 1995). The effects of these circumstances and the political decisions made in these years can be seen in the colours in the Lexis diagram for men between ages 20 and 40 especially. The third blue stripe from the left again is dominant for males in the 1940s, coinciding with WWII, with a lighter blue (i.e. less negative change in mortality) being seen then for females. The red/brown high improvements in the mid-1940s to mid-1950s in both sexes likely represent fewer men dying from war injuries, the creation of the NHS, the welfare state, the new availability of antibiotics, and the onset of vaccination campaigns, with substantial improvements then seen at younger age groups; but also a remarkable fall in the frequency and severity of what people at the time called flu-like diseases (which peaked in Britain in 1951).

There are other features in the Lexis diagrams in Figure 2 that can be picked out, but the key tell-tale sign of a cohort effect is in both Figures: the golden/orange stripe for both males and females around age 40 years old in

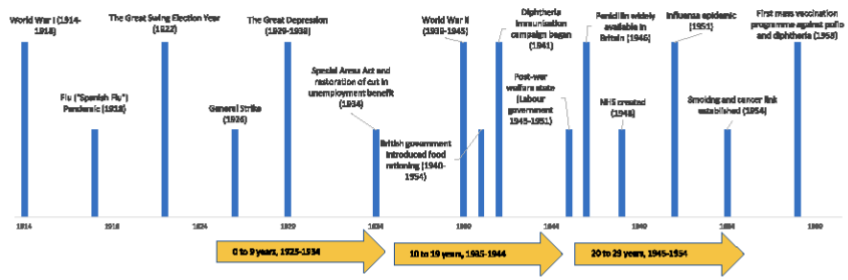


Figure 3. Timeline of selected events from 1914 to 1959 and corresponding age of the Golden Cohort. Adapted from: Goldring et al., 2011.

Note: the height of the bars is for illustrative purposes only.

the late 1970s that continues diagonally up and right from the late 1970s/early 1980s all the way through to 2008 (the end of the timeline). What this very important line represents is a group of people born between 1925 and 1934 having better mortality improvements than all those born around them. This line is the mark of the Golden Cohort on the Lexis surfaces of England and Wales.

3. The rise of the golden cohort, 1925–1934 to 2010 (birth to aged 76–85)

3.1. The early years: 1930s–1960s (birth-aged 16–25 years)

The Golden Cohort lived through, and for the small minority that remain, continue to live through, significant widespread events that impacted on the health of the population in Britain in both positive and negative ways. Figure 3 shows a selection of significant events from 1914 to 1959 (Goldring et al., 2011). These include events with a positive impact on health such as the creation of the NHS, immunisation campaigns, and the growing availability of antibiotics. However, there are also substantial 'unhealthy' events including two World Wars and the Great Depression, as well as the widespread uptake of smoking which peaked in the 1950s, and then declined gradually thereafter.

3.1.1. Rationing

Rationing was an evidence-based, equitable programme that fed *all* children equally (and was not quite as generous to adults). Research carried out between 1937 and 1939 resulted in the later war-time ration being set high for children (and their mothers) (Milne, 2022). It was fortunate that, in 1936, work at the Rowett Institute in Aberdeen, building on earlier work in the 1920s and early 1930s, had discovered just how important nutrition was for growing children: 'So great was the interest in the 1936 study that the Carnegie Trust

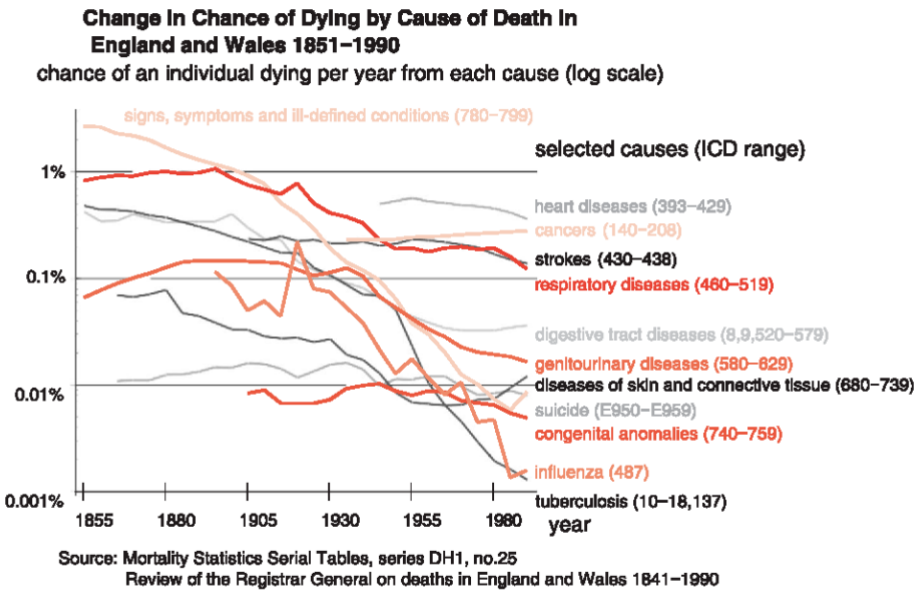


Figure 4. Change in chance of dying from select diseases (by cause of death), England and Wales, 1851–1990. The graph shows the chance of an individual dying per year from each cause (log scale). The numbers in brackets are the International Classification of Disease (ICD) codes that were used by the 1980s. The Registrar General attempted to match, as closely as he/she could, to these from earlier decades. Source: Dorling 1995

gave the Rowett a grant of £15,000 to carry out a more detailed study. More than a thousand families, including 3,000 children, took part across Scotland and England between 1937 and 1939. Detailed information was gathered on the socioeconomic status of each household and diet and analysis of data from the Carnegie survey was in progress at the Rowett when war broke out. Lord Woolton, Minister for Food, used these results to develop his wartime food rationing policy, which included special measures to safeguard the health of mothers and children' (Milne, 2022).

Thus, unlike the children who lived through the First World War, the Golden Cohort benefitted from both better knowledge of what food children needed and a government policy in 1939 to feed them well at low cost to their families. A further huge benefit was in the change over time in our ability to deal with disease. Death in childhood from disease had been common before this cohort were born, but saw rapid changes in their early years (Figure 4), (Dorling, 1995) in large part due to the introduction of immunisations and antibiotics.

3.1.2. Immunisations and antibiotics

As children and young adults, the Golden Cohort experienced some of the most important developments in medicine. As shown in the Timeline,

Diphtheria immunisation and penicillin became available in 1941 and 1946. The latter was especially important to these children's life chances, who were aged between 12 and 21 when it first became widely used. Tuberculosis (TB) was the leading single cause of death in the UK overall until 1880, and in age groups between infancy and 50 years old for both sexes until the late 1940s (Office for National Statistics, 2017). In 1948, when the Golden Cohort were between 14 and 23 years old, the first medical clinical trial of treating pulmonary TB with an antibiotic—streptomycin—was published (Leeming-Latham, 2015). This was followed by the introduction of safer combinations of chemotherapy treatments which saw mortality from TB rapidly decline, and case notifications falling due to a combination of decreased infectious contacts and improved social and economic conditions (Glaziou et al., 2018; Leeming-Latham, 2015; Public Health England, 2013). The BCG vaccine against TB was also introduced during this period, entering the UK immunisation schedule in 1953. However, while the BCG vaccine reduces chances of suffering from the most severe forms of TB, such as tuberculous meningitis in children, it is less effective in preventing pulmonary TB. The effect of that immunisation on the overall spread and prevalence of TB is limited, meaning it played a lesser role in mortality reduction (NHS, 2019).

3.1.3. Education, employment and housing

The Golden Cohort entered the workforce, often at age 14 or 15 (sometimes earlier, only very rarely later), at a time when jobs were plentiful and when choice over what work to do was increasing. Although the younger among them benefitted from free secondary education due to the Butler Education Act of 1944, almost none of them went to university (less than 1%). As young adults in the late 1940s and 1950s, most of them lived at home with their parents, who were mostly in work (although many women did not work at that time). A narrow majority of children at this time in the UK lived in council housing at some point in their childhood (Pearson, 2016). This was a huge improvement on the slum or poor standard of housing that most British children had mostly grown up in during the 1920s.

3.1.4. Birth of the NHS: when the Golden Cohort was aged 14–23 years

On the 5th July 1948, the National Health Service (NHS) took over from the existing structures of charity hospitals and other mostly private services. It was founded on key principles: that provision would be based on clinical need, not ability to pay; that it met the needs of everyone; and that it was free at the point of delivery, funded by national taxation. Before the NHS, the vast majority of the people of Britain had lived in fear that they, or any member of their family, could without notice be faced with the catastrophic costs of disease and/or disability, or simply be unable to pay for medical care. The NHS was one of the first universal health care (UHC) systems in the world, and as with other universal

reforms it was formed in the wake of crisis (Hiam & Yates, 2021). It transformed health care in Britain. The Secretary of State for Health and founder of the NHS, Aneurin Bevan, wrote in his seminal book, *In Place of Fear*: 'The essence of a satisfactory health system is that the rich and poor are treated alike, that poverty is not a disability, and wealth is not advantaged' (Bevan, 1952). In adulthood, the Golden Cohort would not know the risk of financial ruin that ill health could bring, or the fear of simply not being able to access care at all, the worry that almost all of their parents had endured.

3.1.5. 'Never had it so good'

By the late 1950s, Prime Minister Harold Macmillan told the people of Britain that they had 'never had it so good' (Hennessy, 2007). Globally, the UK was among the best in the world for life expectancy at birth. Worldwide it ranked at 7th for most of the 1950s (the six countries above it were, in total population size, much smaller than the UK was, even with all their populations combined). The UK continued to be positioned in or around the top 10 until the 1970s, during and after which it began to fall down the ranks (Hiam, Dorling, et al., 2023a). In 2022, it was ranked 29th.

3.2. The working years: the optimism of the 1960s (aged 26–35 years)

3.2.1. The number of the Golden Cohort

In mid-1961, the Golden Cohort comprised almost six million people, at this point with slightly more males than females as more boys are born and the cohort was too young to have suffered many war deaths (Figure 5) (Office for National Statistics, 2021). The years that followed were no less remarkable than those which had just passed in terms of the social and economic changes seen across the UK, as the timeline from 1960 to 2020 shows (Figure 6).

3.2.2. Income inequality

Figure 7 shows income inequality in the UK from 1910 to 2019 (Dorling, 2013). The Golden Cohort were born into rapidly falling inequality and lived through most of the best years for equality in the UK, when this measure continued to fall most steeply. Unlike so many of their parents, and an even larger proportion of their grandmothers (for whom it was the most common job), they did not have to 'go into service', and by the time that the overall British social and economic situation began to deteriorate again, in the very late 1970s, they were insulated from the immediate effects. Figure 8 shows a measure of income inequality—the Gini Coefficient—for Britain from 1961 to 2020 (Institute for Fiscal Studies, 2022). The graph shows the rise in inequality that began at the end of the 1970s, and just how good the 1950s and 1960s were when the Golden Cohort were in their late 20s and 30s. Note that these different figures highlight different aspects of inequality trends. The overall Gini coefficient

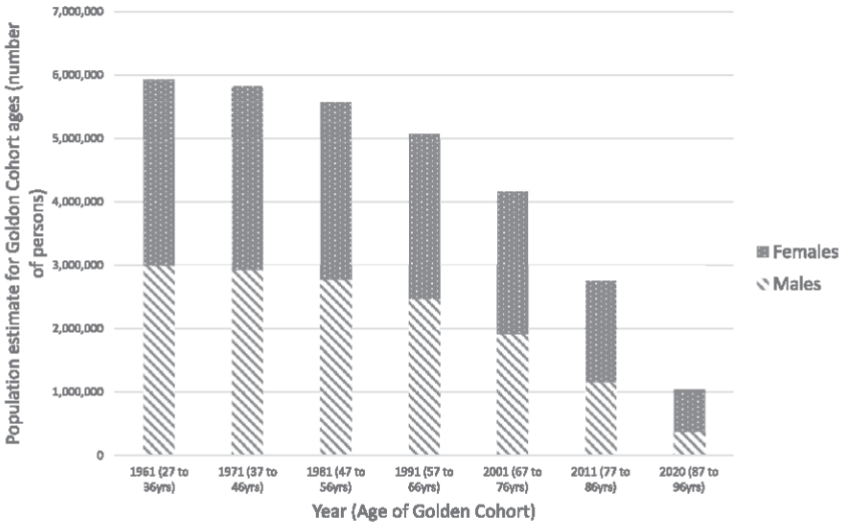


Figure 5. Population estimates for the Golden Cohort, England and Wales, by sex, from mid-1961 to mid-2020.

Note: for mid-2020 the group comprises those aged 87–89, and all over 90 years. Source: Authors' calculations using ONS population estimates.

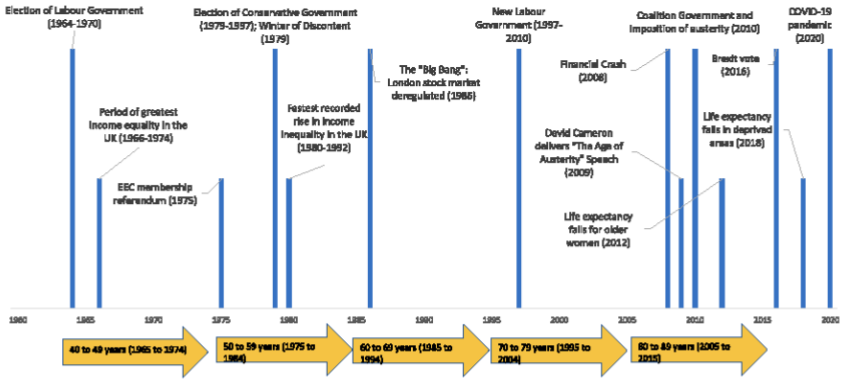


Figure 6. Timeline of selected events from 1960 to 2020 and corresponding age of the Golden Cohort.

Note: the height of the bars is for illustrative purposes only.

plateaued after the 1990s (Figure 8), but the very richest of all continued to take more and more for two more decades (Figure 7). Increasingly the growing take of the richest was at the expense of those in the middle of the income distribution and harmed overall public expenditure. However, before the impact of that became apparent, people in the middle thought they were doing well, not

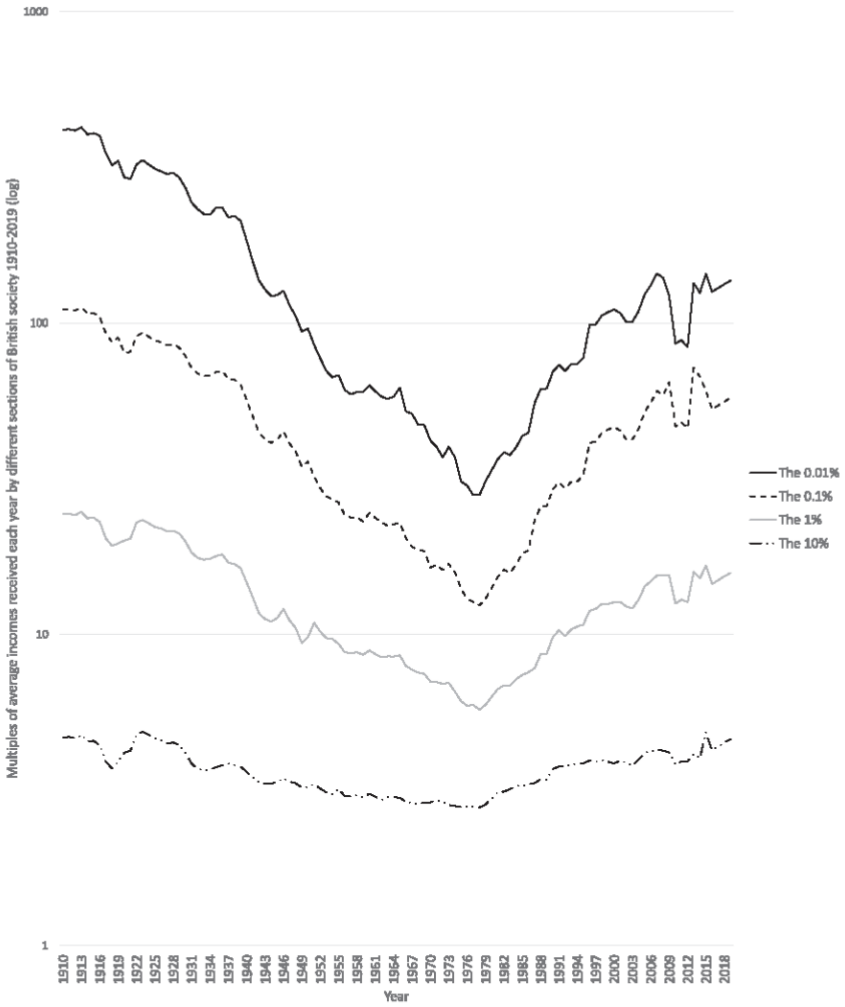


Figure 7. Income Inequality in the UK, 1910–2019. Sources: Pre-tax national income share including pension income, individuals over age 20 from listed sources: (Atkinson et al., 2017; Brewer, 2019; Dorling, 2013; Shine & Webber, 2019)

least in terms of becoming rich themselves (or so they thought) as the value of the homes most of them had purchased appeared to rise rapidly.

3.2.3. Home ownership

The Golden Cohort were the first generation to strike housing gold. They were the first cohort to escape private landlords and have high home ownership. Figure 9 shows the proportion of people in the UK who, at any point, lived in a home owned outright or mortgaged by date (horizontal axis, from 1982 on left, to 2012) and by their age (vertical axis, from 17 years old at top to

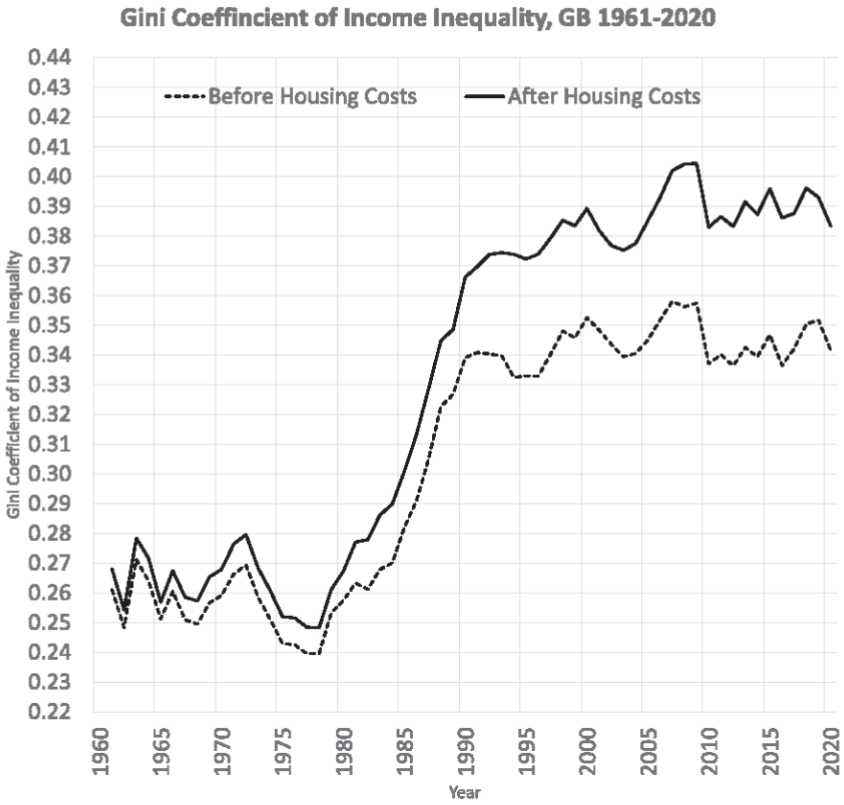


Figure 8. Gini Coefficient of Income Inequality, Great Britain 1961–2020. The range of the Gini Coefficient is 0 (zero) to 1, where 0 reflects total equality and 1 maximum inequality. Thus, the higher the Gini Coefficient, the greater the inequality. Source: IFS (2022) Living standards, poverty and inequality in the UK.

90) (Dorling, 2015). In 1982, the Golden Cohort were aged between 48 and 57 years old. Green and blue boxes represent high ownership (greater than 75%). The chart shows the beginning of a golden generation of high homeownership for those born between 1925 and 1934, which maximised for those born in the in 1950s (although that group had to pay far more to secure a home with a mortgage). Later born cohorts did not do so well and were also threatened with unemployment, which was especially frightening if you had a new mortgage and knew there was not enough council housing should you fail to pay the mortgage. When employment became much less secure during and following the oil shocks the 1970s, people (including many new homebuyers) began to strike.

3.2.4. The strikes of the 1970s

The 1970s saw a multitude of strikes take place, including the UK miner's strike of 1972 (as the Conservative government was holding miners' pay down

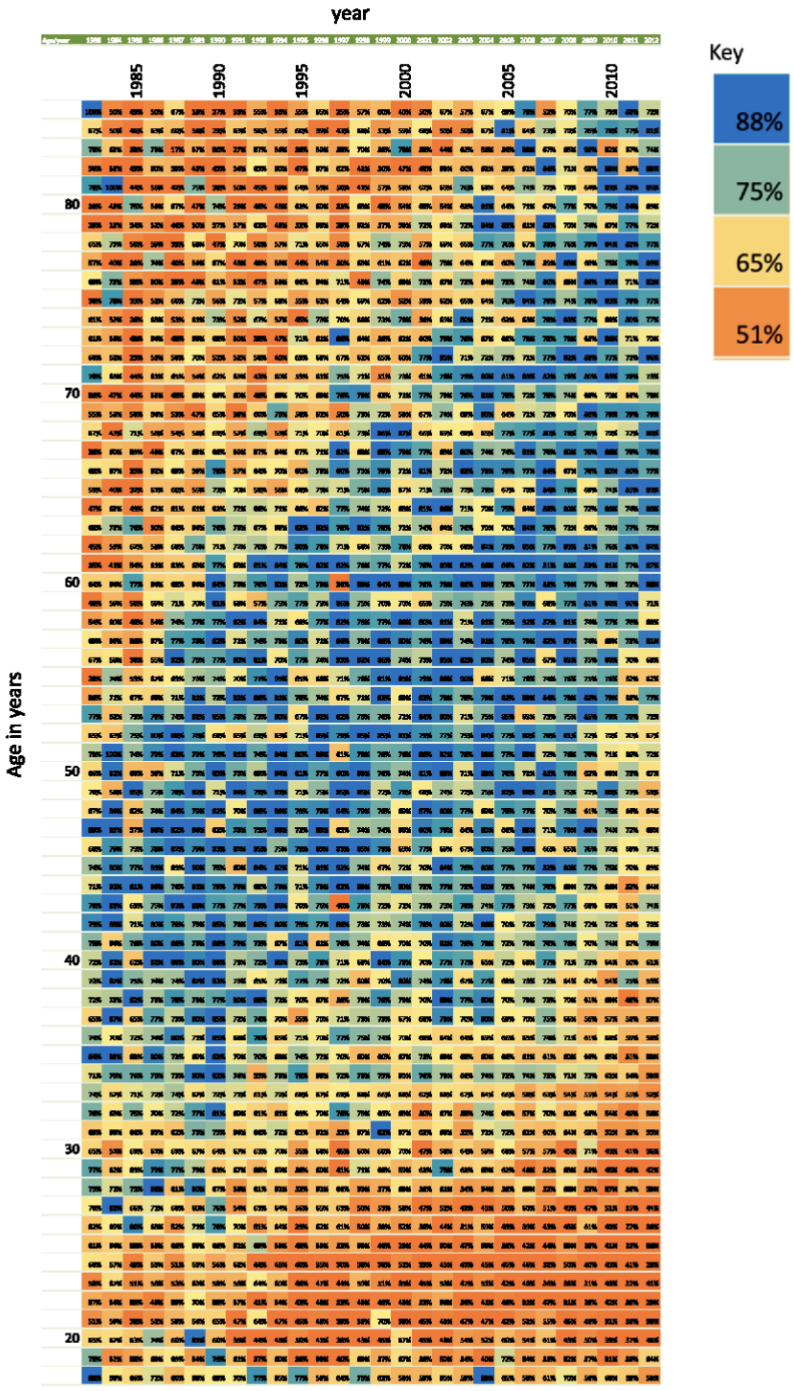


Figure 9. The proportion of people in the UK who live in a home owned outright or mortgaged by year and age. Source: Dorling, 2015.



Figure 10. Number of working days lost due to labour disputes, 1925–2022. Source: ONS 2015, (Office for National Statistics, 2015) ONS 2023 (Office for National Statistics, 2023)

compared to that of other workers and in the 1960s) and the Winter of Discontent in 1978/79 (when mass unemployment was beginning). Despite this substantial industrial action, still far fewer working days were lost than in the 1920s (Figure 10) (Office for National Statistics, 2015, 2023), Furthermore, the strikes of the 1970s failed to galvanise the population as a whole and, in how they were portrayed by the newspapers and TV, may have even increased the size of the 1979 landslide victory for Margaret Thatcher and the Conservative Party, which had promised to restrict the power of the trade unions (Office for National Statistics, 2015).

Those striking in the 1970s may have believed that eventually their day would come. The strikes of the 1920s were successful, but not immediately, only in the medium-and long-term, in contributing to equality growing both at the time and afterwards[1] (Darvos et al., 2023). In the short-term, the general strike of 1926, which lasted nine days, was seen as a defeat. However, as the graphs of income inequality above show, it was part of what it took to help maintain the momentum that had only just begun in the early 1920s towards greater and greater income equality for the next five decades. After 1926, successive governments were aware that a general strike was possible—before 1926 it was something that could only be imagined.

[1] At the time of writing in 2023, substantial strike action which begun in 2022 is continuing across the public sector. The impact remains to be seen, and the level is much lower than that seen in the 1970s.

3.2.5. The austerity of the 1980s

Following the optimism of the 1960s, and the strikes of the 1970s, the new Conservative government of 1979 immediately introduced severe austerity on much public spending which continued for many years, that harmed the old, the poor and the young the most. The Golden Cohort were not greatly harmed by the austerity of the 1980s, as they were almost all in work, despite unemployment for people younger than them. In the worst years of the early 1980s, 2 million people aged under 25 were out of work and had signed on the dole (Dorling, 1995). Widespread use of the dole had last been seen in the 1930s. Poverty rose greatly, but not so much for the lucky Golden Generation. At this point, they were still young enough not to be too reliant on health care, which was not well funded in the 1980s. Britain saw the greatest increase in income inequality experienced in Europe in the 1980s (see Figure 8); but this was not the personal experience of the majority of the Golden Cohort, who were mostly in work and approaching retirement.

3.3. The retirement years: 1985–1995 (women aged 60), 1990–2000 (men aged 65)

Retirement came for the women in this cohort at age 60 (in the years 1985–1994) and for men usually at age 65 (1990–1999). With the election of a New Labour government in 1997, which stuck to Conservative spending plans for their first two years, the increase in health and social care funding (see Section 3.4) that came from 1999 onwards benefitted the Golden Cohort considerably. A large majority of this cohort retired while still living in homes they now owned outright, in contrast to previous generations of older people who had often spent their final years in abject poverty (Townsend, 1963). Poverty was not a common experience for this Golden Cohort, although for those whose parents were still alive, they were often poorer older pensioners. However, poverty was rising again among younger generations.

3.4. The New Labour years: 1997–2010 (aged 63–72 to 76–85 years)

3.4.1. Health and social care investment

The New Labour years of health and social care investment came as the Golden Cohort entered the older years of their lives, and thus when they might have been needing such services the most. Health care and social security spending in pounds (GBP, £) per person to 2019–2020 prices from 1955 to 2020 are shown in Figure 11 (Institute for Fiscal Studies, 2023). Figure 11 reveals that spending on both health care and social security increasing from 1999[2] to 2010

[2] New Labour kept its promise to not increase spending for the first 2 years of government following the election.



Figure 11. Health and Social Security spending per person in £ to 2019–2020 prices, 1955–2020. Source: IFS data. Grey vertical line represents financial year 2010–2011.

(the grey vertical line marks the 2010–2011 financial year). What happens after 2010 is discussed below, in Section 4.2.

3.4.2. Health inequalities strategy

New Labour's 'English health inequalities strategy' from 1999 to 2010 had the aim of reducing the gap in life expectancy between poor and affluent areas. Researchers found that the strategy was successful according to some measures. The time period of the strategy was associated with a reduction in geographical inequalities in the infant mortality rate (IMR) (Robinson et al., 2019) and, by some measures, in life expectancy (Barr et al., 2017), and the real-location of NHS resources to increase funding in deprived areas compared to the more affluent areas reduced inequalities from causes amenable to health-care, especially by increasing resources where fewer people survived into old age (Barr et al., 2014). However, other research using a different method of measuring health inequalities concluded that: 'When measured by the rela-tive index of inequality, geographical inequalities in age-sex standardised rates of mortality below age 75 have increased every two years from 1990–1991 to 2006–2007 without exception' so the reduction in geographical inequalities was not seen in those younger than the golden cohort (Thomas et al., 2010).

3.4.3. Cardiovascular disease mortality improvements

Another important factor of this period is the rapid improvements in cardio-vascular disease mortality. Between 1979 and 2013, total deaths from cardio-vascular disease decreased by 70% in the UK, with even larger improvements

in premature mortality (Bhatnagar et al., 2016; World Health Organisation, 2023). These improvements were reflected across many affluent countries, with advancements in diagnosis and management, and increasing recognition of prevention. In the UK, the rate of improvement has slowed since 2011 (OECD & The King's Fund, 2020), and this is further explored in Section 4.3. Recent work has suggested that factors not well understood before the onset of the 2019 pandemic might also have played a part in this global decline seen from the late 1950s through to its abrupt end in 2020 (Davey Smith & Dorling, 2023).

3.5. The beginning of the end

The Golden Cohort saw overall improvements year-on-year in their mortality from birth to 2010. This was not due to a period or age effect, but due to a series of social and economic events that occurred at just the times that benefitted them, such as war-time rationing and the birth of the NHS, or just at a time that they narrowly avoided adversity, such as the income inequality and unemployment of the 1980s. They were mostly too young to fight in WWII, too old to be hit by the worse effects of 1980s austerity, and just the right age to benefit from the late 1990s and early 2000s spending on health and social care.

State involvement in the lives of the Golden Cohort had been, on balance, positive up until this point. However, they entered the austerity years of the 2010s at just the wrong age: in their late 70s and early 80s, the ages when they would need the state to provide health and social care the most – and when, for many of them, it was no longer reliably there.

4. The austerity years, 2010 onwards (aged 76–85 onwards)

After the financial crash of 2008, much of life in Britain fundamentally changed. The election of the Conservative-Liberal Democrat coalition government of 2010 brought in the 'age of austerity', led by then Prime Minister David Cameron, with the aid of the deputy Prime Minster Nick Clegg and, crucially, the Chancellor, George Osborne. For the Golden Cohort, the state which had interfered to a remarkable level in their young lives had effectively walked out on them in their old age - especially for those in this group with great need due to ill health or disability. Here, we first examine what is meant by the often-used term 'austerity', we consider the existing evidence on the impact of austerity on life expectancy, and finally present our analysis of the impact of the austerity years on the Golden Cohort. Could the generation that survived World War II, rationing, economic decline, rising inequalities, and epidemics have had their lives cut short by government policy in the most dramatic and harmful of ways?

4.1. What is austerity?

'Austerity' originates from the Latin '*austerus*' meaning dry, plain, or harsh (Anderson & Minneman, 2014). Before World War II (WWII), the term was used

to describe physical conditions, not economic ones—only in the 1950s was 'austerity' used to describe economic policy, at which time it referred to post-War rationing with enforced decreased spending on household goods and on discretionary food, and continued substantial military spending. In its modern use, it refers to fiscal consolidation with spending cuts and/or increased taxes. However, many definitions exist, and this poses a challenge in research (see: Figure 3 in Anderson & Minneman, 2014 regarding different definitions of austerity; and Table 1 in McCartney et al., 2020 regarding different definitions used in health outcomes research) (Anderson & Minneman, 2014; McCartney et al., 2020).

4.2. Austerity in Britain

4.2.1. A tale of two austerity Britains

Under 1950s austerity, those living in poverty were still fed well because of rationing (see timeline). The 'Great Leveller' of war meant people did not have to witness the inequality of the affluent still being able to spend money (Scheidel, 2018). The recently established National Health Service meant people no longer lived in fear of the catastrophic financial cost of illness (Bevan, 1952). House prices fell, and housing became more affordable. By 1957, the Prime Minister Harold Macmillan could tell people they had 'never had it so good' (Hennessy, 2007).

The story of austerity in the twenty-first century is a very different one. In 2009, then leader of the opposition party David Cameron gave his now infamous 'age of austerity' speech at the Conservative party conference[3] (Evans & Walker, 2019; Summers, 2009). Due to the support of the Liberal Democrats, the Conservative-led coalition government of 2010 could implement austerity. This led to significant cuts in public spending, including on health and social care. In the 1950s, fear of healthcare costs had been alleviated thanks to the NHS. In the 2020s, following a decade of the twenty-first century austerity and the COVID-19 pandemic, more and more people began to turn to private health care, as the chronically under-funded NHS failed to keep pace with demand, with many if not most ill people now stating their health needs were not met (Hiam & Yates, 2022).

In contrast to the 'leveller' of food rationing, unprecedented post-war numbers of people in Britain have been forced into food poverty, with austerity policies linked to food insecurity and food bank use (Jenkins et al., 2021). Despite an open letter in 2014 from the Faculty of Public Health in *the Lancet* raising the alarm on rising food poverty (Ashton et al., 2014), with coverage citing John Boyd-Orr's role in the 'delivery of equitable nutrition' during

[3] David Cameron delivered his age of austerity speech on 26 April 2009. Excerpts available at: https://www.theguardian.com/politics/2009/apr/26/david-cameron-conservative-economic-policy1 (accessed 18th April 2023). In it, he asserts the answer is "delivering more for less".

the austerity of WWII into the 1950s (The Lancet, 2014), there was no government intervention. Subsequently, both food bank use and food insecurity continued to rise (Gorb et al., 2023), with the number of children living in food poverty almost doubling between 2022 and 2023 to 4 million (Butler, 2023). A survey in September 2022 by the Food Foundation reported 1 in 4 households with children had experienced food insecurity in the past month, increasing to 42.2% of households with 3 or more children (Godie, 2022). For older people, cuts to Meals on Wheels across local authorities left many in vulnerable situations going hungry several days a month or a week—this was further exacerbated by the pandemic (Camden Unison, 2011; Dickinson & Wills, 2022). Those 'Meals on Wheels' cuts began in 2011 and 2012 in many local authorities in the UK – from then on, for the frailest of the Golden Cohort, especially those living alone, simply feeding themselves often became much harder.

During the 2010s austerity, house prices rose sharply, out of step with the average salary, so an older person unable to access Meals on Wheels could appear to be wealthy but was increasingly hungry. The number of people rough sleeping in England rose by 74% from 2010 to 2022 (Department for Levelling Up, Housing and Communities, 2023), and those living in temporary accommodation have increased sharply (Shelter, 2023). The cost of living crisis gave rise to the choice 'heating or eating'—with older people disproportionately affected (Bullard, 2022).

4.2.2. Health and social care spending, 2010–2020

The impact of austerity on public spending has been severe. For example, in England, non-education spending per council resident decreased by almost one quarter between 2009–2010 and 2019–2020 (Ogden, K. et al., 2021), while spending on health (specifically NHS England) slowed substantially, well below the average annual increase for 1955–2019, as shown in Figure 12 (Institute for Fiscal Studies, 2023).

Another useful measure to compare spending over time is as per person, as shown in Figure 11 (Section 3.4). In the Figure, social security is shown as a total (all) and divided into pensioners and non-pensioners from 1978. It shows that for all health and social security spending there was a stall and decline since 2010, except for the uptick in 2020 for health spending due to COVID-19. It is noteworthy that the 2020 spending increase includes a reported £15 billion 'wasted' on unused COVID supplies (Hall & Campbell, 2023), £37 billion over two years on a track and trace system which did not deliver on in its objective of preventing a further lockdown (UK Parliament Public Accounts Committee, 2021), and beyond. The Figure also shows that the suggestion pensioners were protected from austerity is not apparent when it comes to spending per person, with a clear decline in social security seen.

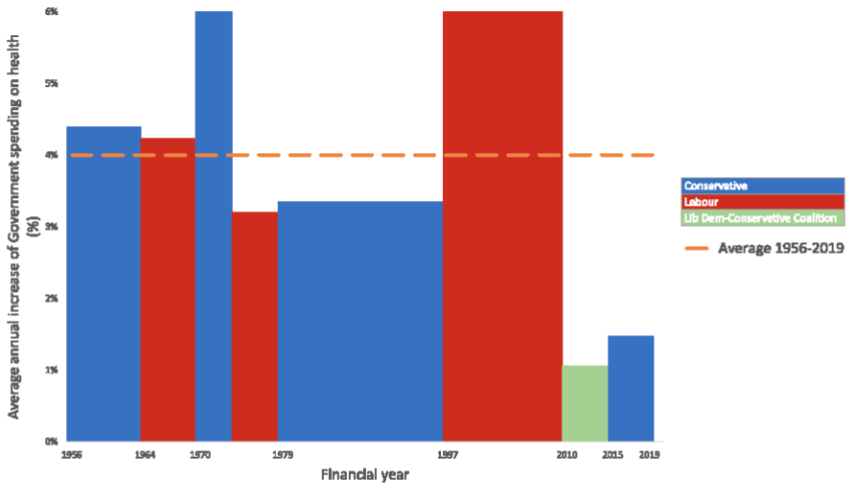


Figure 12. Average annual increase in government spending on health, 1955–2019, based on 2019/2020 prices. Source: authors' calculations based on IFS spending composition sheet (Institute for Fiscal Studies, 2023) adapted from the BBC graphic (Triggle & Butcher, 2020)

4.2.3. Austerity elsewhere in Europe

Austerity measures were implemented across Europe following the 2008 financial crash, with cuts to public spending in many countries (McKee et al., 2012). However, the UK saw the deepest cuts. Figure 13 shows public spending as a percentage of GDP from 1980 (the earliest available data) to 2019 using IMF data for five comparable Western European countries: France, Italy, Spain, Germany, and the UK. While the UK had seen an increase in public spending from the mid-late 1990s to 2010, at points catching up with Spain and edging closer to post-unification Germany, in 2010 it entered austerity from the lowest position and had the greatest reduction in spending from 2010 to 2019 at 5.9%. In comparison, France and Italy saw a reduction of 1.3% in public spending from 2010 to 2019, Germany 3% and Spain 4%. Other countries, such as Finland, increased the proportion of their GDP spent on the public good during and after the crash as a response to its effects.

4.3. Austerity and mortality

Life expectancy in the UK since 2010 follows a similar pattern to that of health spending (Figure 11). After decades of improvements, with some fluctuations, life expectancy improvements halted in the years that followed 2010, before falling for some groups, beginning with older women in 2012 (Hiam et al., 2020). A plethora of evidence has linked the cuts to public services through austerity with the increase in deaths and the subsequent stall in improvements in life expectancy seen throughout the UK, with some groups and communities

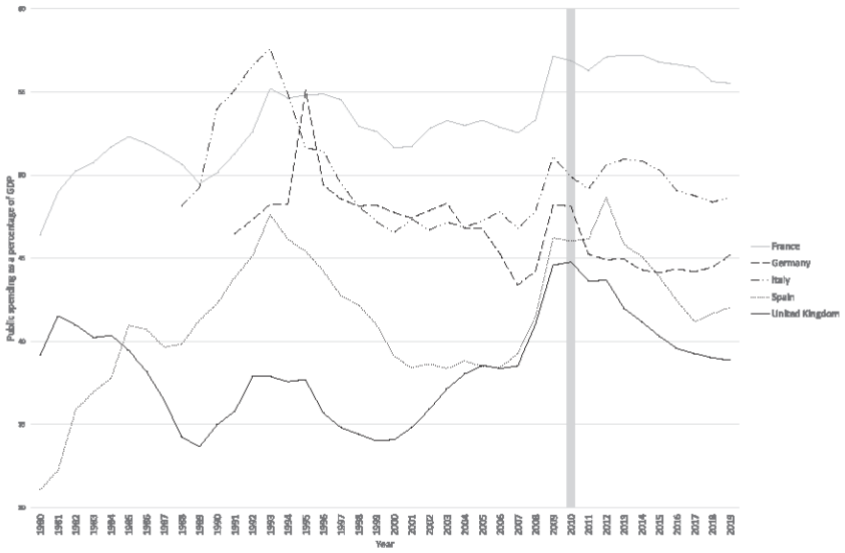


Figure 13. Public spending as a percentage of GDP from 1980 (or earliest available) to 2019 in 5 European Countries. Source: International Monetary Fund, World Economic Outlook Database, April 2021.
Note: Axis does not start at 0.

seeing their life expectancy fall earlier than others, beginning first with older women in 2012 (first identified and released as a media story in early 2014), followed by others subsequently (Alexiou et al., 2021; Bennett et al., 2018; Darlington-Pollock et al., 2022; Hiam et al., 2020; Hiam, Harrison, et al., 2018; McCartney, McMaster, et al., 2022; Rashid et al., 2021; Walsh, Dundas, et al., 2022). A 2023 analysis from the *Economist* suggested, that of 700,000 'additional deaths' in Britain between 2012 and 2022, 250,000 additional deaths were specific to problems in Britain, and not explained by an overall slowdown in life expectancy across Europe nor by the COVID-19 pandemic (The Economist, 2023). The change has been so stark that the ONS have had to repeatedly revise their population projections downwards (Figure 14) (Hiam & Dorling, 2022), and pension companies have made great adjustments to their expectations.

4.3.1. Other explanations cited for worsening mortality

The stalls in mortality improvements have invited much speculation since they were first highlighted in the 2010s. These trends of stalling life expectancy improvements occurred long before COVID-19. They occurred in the absence of mass-migration, data artefact, large-scale environmental event, or any other disease pandemic. Following the 2015 spike in annual mortality, many, including Public Health England (PHE), attributed the spike in mortality to influenza

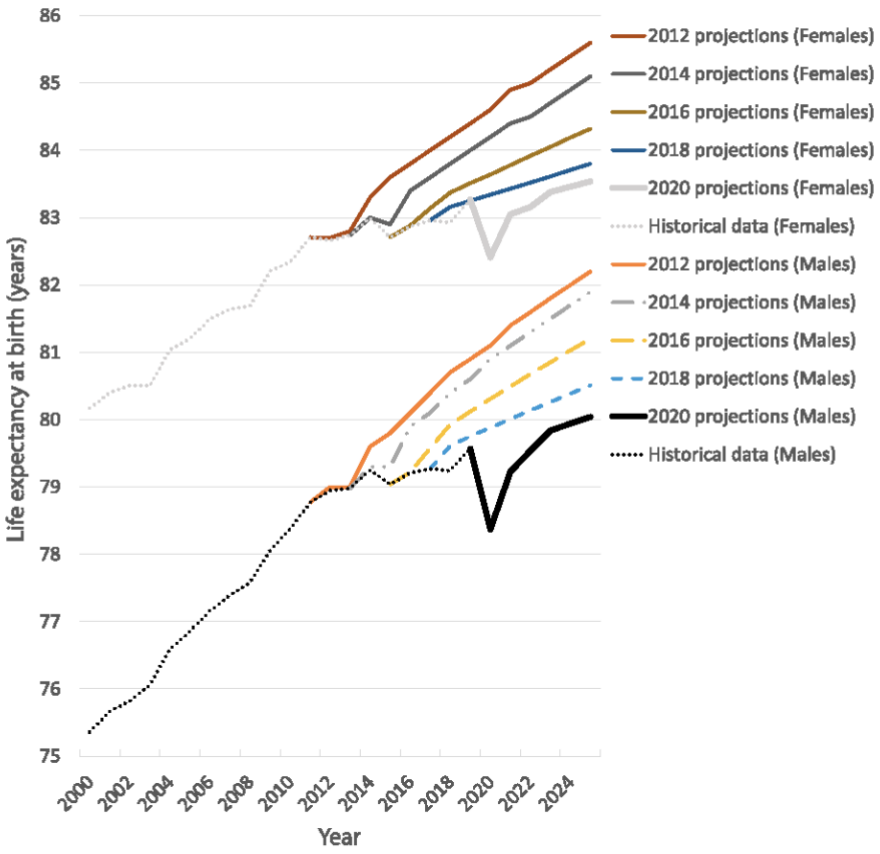


Figure 14. Projections of life expectancy at birth for males and females in the UK, 2012 onwards. The dotted lines show the actual recorded historical data from 2000 to 2019, and the solid lines show ONS projections made every year from 2011 to 2025. Source: Hiam and Dorling, BMJ, 2022.

and cold winters, whilst highlighting the subsequent decrease in mortality in 2016 (Baker et al., 2018). While 'flu may have played a small role in the winter mortality spike in 2015, both in the UK and other European countries (Molbak et al., 2015), it does not explain the ongoing trends and slowdown of life expectancy improvements over time, nor the falls for some groups, nor why life expectancy in the UK in 2016 was lower than it had been in 2014, and why it continued to be lower in 2017 and 2018 than in 2014 (for both women and men) (McCartney, Walsh, et al., 2022; Hiam et al., 2024).

Such was the interest and, at points, controversy, that in 2018 PHE published a report investigating some of the many explanations (Public Health England, 2018). In it, they reported that measurement artefact and migration were unlikely to have played a role, but they suggested that a combination of ambient temperature, influenza, increasing mortality rates from dementia,

slowdown in previous improvements in cardiovascular disease mortality rates, widening health inequalities, cohort effects, and possibly health and social care spending all required further investigation.

Five years later, with more data to analyse, the evidence has shown some of these explanations to be implausible (McCartney, Walsh, et al., 2022). The possibility of the stall in improvements post-2010 being a return to normal improvements after an unusual period of improvement due to declining cardiovascular disease mortality could be an important factor (OECD & The King's Fund, 2020), but analysis has shown the post-2010 rates have not returned to 'normal', but to a lower level, suggesting it is, at best, an incomplete explanation (Minton et al., 2023). The role of flu has often been over-emphasised in the period after the last serious global pandemic (1968–1970) (Hiam et al., 2024). Deaths are usually attributed to influenza without testing for the virus, and mostly among the very elderly. Comparisons of rises in mortality between countries in Europe in winter suggests that there are other social and economic factors that matter more, such as public spending on health care and more equitable socioeconomic circumstances (Healy, 2003).

Deaths from dementia and Alzheimer's disease increased in the past decade, and contributed to the spike in mortality 2014–2015 (Hiam et al., 2017; Office for National Statistics, 2016), fell in 2019, and increased in 2020 (Figure 15) (Office for National Statistics, 2020, 2022). However, these data should be interpreted with caution, as outlined by the ONS, as a result of data artefact due to a change in the way causes of deaths were coded between 2011 and 2014, which resulted in an increase in dementia coding; an ageing population surviving other causes of death; and the measures put in place as part of the 'Prime Minister's Challenge' (Department of Health and Social Care et al., 2015) which included a target of diagnosing two thirds of people estimated to be living with dementia, alongside financial incentives for GPs offered between October 2014 and March 2015. Figure 16 shows a clear impact of this with a jump in dementia prevalence between 2014 and 2015 (NHS Digital, 2022).

Recent research has shown earlier increases in obesity rates in England and Scotland may have played a role in the stalling (Walsh, Tod, et al., 2022), though the role of the obesogenic environment and social determinants of health could still be linked back to austerity. There are some who have suggested that it is the demise of the Golden Cohort that has been a factor in stalling life expectancy (Wilson & Coghlan, 2018), which we aim to explore further.

4.3.2. International trends

Finally, many argue that these changes were seen across many high-income countries (HICs). Indeed, many countries in Europe experienced both austerity (see Figure 13) and adverse impacts on health (Stuckler et al., 2017). However, there are challenges with attributing health outcomes to changes in economic policy due to: variable definitions (Anderson & Minneman, 2014)

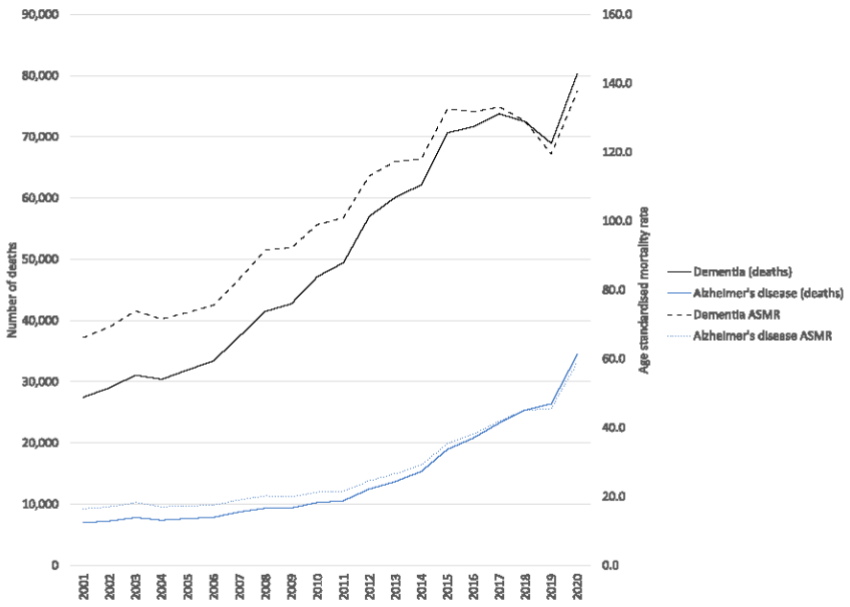


Figure 15. Deaths and Age Standardised Mortality Rates (ASMR) for Dementia (black lines) and Alzheimer's disease (blue lines) in England and Wales, 2000–2020. Source: ONS

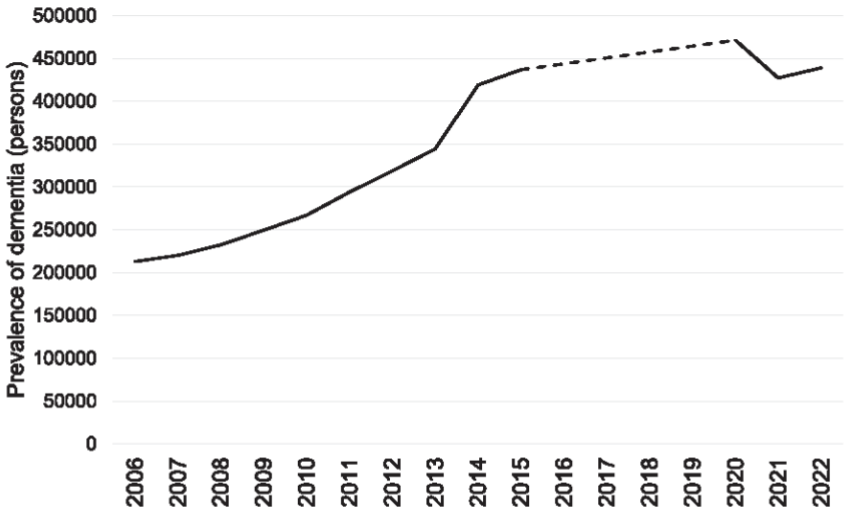


Figure 16. Prevalence of dementia over time (estimated). Note missing data for 2016–2019 (dashed line). England, 2006–2022. Data for 2020–2022 are from January and February. Source: NHS Digital, 2022.

(see Section 4.1), the co-occurrence of policies making it difficult to evaluate effects (Matthay et al., 2021), and the challenges of causality (Hiam, Dorling, et al., 2018).

Few studies internationally have explored the impact of austerity on health outcomes. For example, researchers examined standardised mortality rates (SMRs) in 15 European countries between 2011 and 2015, stratifying the nations into high-, intermediate-, and low-levels of austerity (measured as cyclical adjusted primary balance using IMF figures) (Rajmil & Fernández de Sanmamed, 2019). They found that while SMRs decreased for all nations between 2011 and 2014, in countries implementing high- and intermediate-levels of austerity, SMRs increased in 2015, while mortality rates summarised in that way continued to fall where there was little austerity. There was one notable exception: Germany, which was included as a country that had limited austerity but also saw an increase in its SMRs.

Other research has found that austerity increased all-cause mortality by 0.7% across 28 EU countries between 1991 and 2013 (Toffolutti & Suhrcke, 2019), and that it was associated with an increase in inequalities in self-reported general health, an effect that grew over time, from 2002 to 2015 in 25 European countries (van der Wel et al., 2018), and slower improvements in subjective health across age groups. The UK was an exception in what was then the EU-28, with all age groups experiencing a fall in subjective health, in particular the population aged over 65 (Franklin, 2017). Countries that had the greatest spending cuts had a positive statistical relationship with greatest level of unmet health needs.

In contrast with the support for other causes, such as flu, which have become weaker with time and more data (Hiam et al., 2024), the evidence linking austerity and poor health in the UK is becoming increasingly robust as more studies are being released in the current decade (McCartney, McMaster, et al., 2022; McCartney, Walsh, et al., 2022). Research in 2021 linked austerity to excess deaths due to cuts in local government funding (Alexiou et al., 2021), excess deaths in older adults and widening inequalities for younger populations (Darlington-Pollock et al., 2022), not just to stalls but to absolute declines in life expectancy in an increasing number of communities (Rashid et al., 2021), and widened inequalities impacting the most deprived deciles, with declines in life expectancy in the two most deprived deciles for women in 2018 (Bennett et al., 2018).

Furthermore, while other high-income or affluent countries did see stalls in improvements in life expectancy between 2014 and 2015, research has shown of 18 Organisation for Economic Cooperation and Development (OECD) countries, only the US, where life expectancy is falling, and in the UK, was there no recovery in 2015–2016 with any of the 'robust gains' found elsewhere (Ho & Hendi, 2018). Of course, a comparison of rates of improvement depends on the time periods being compared. However, research examining different

time periods have also concluded the same: Fenton et al. found the smallest improvements in life expectancy in Iceland, USA and UK nations when comparing 5-year time periods from 1992 to 2016 (Fenton et al., 2019), while Leon et al. found that from 1970 to 2016 while many affluent countries saw slowed increases since 2011, England and Wales performed the worst (Leon et al., 2019).

4.3.3. Lack of consensus

It may be that in the future when you are reading these words history may appear more clear, but it is important to note that in 2023 the link between austerity and flatlining life expectancy improvement remained a contested one, with a lack of agreement not only among politicians, but also among public health experts (Hiam, Dorling, et al., 2023b). There were those who asserted that it cannot be proven that austerity has caused harm to health, as it is impossible to analyse the impact of no austerity compared to austerity. However others suggested that is reasonable to draw conclusions with the use of the mounting evidence and plausibility, along with other criteria for cause and effect (Hiam, Dorling, et al., 2018). Finally, we explore further by asking: 'Could some of the key answers to settling this lack of consensus lie with the fate of the Golden Cohort?'

4.4. Austerity and the Golden Cohort

By mid-2011, 2.7 million of the Golden Cohort remained alive, now with substantially more females than males (see Figure 5). The Golden Cohort continued to see remarkable mortality improvements up until 2008 compared to those born both before and after them (Figure 2). Here we present the latest available data on the mortality improvements of this generation in recent years, to explore what happened to the Golden Cohort in the 2010s when austerity came into effect. At the beginning of the decade, the Golden Cohort were aged between 76 and 85 years old. Statistically, there were few years of life left for this remarkable generation. Yet, as we demonstrate, over time, those few years became even fewer, as they began to die at a faster rate the cohorts born before them had. In short, the Golden Cohort in its final years was shattered. What we find is that the trend shown in Figure 14 was caused to a disproportionate degree by what happened to the Golden Cohort in those years – a period effect.

4.5. Data sources and methods

We use publicly available data from the Human Mortality Database (HMD) for 1900–2020 for males and females for England and Wales. We have triangulated these data with that provided by the ONS and the results coincided exactly or varied minimally (e.g. by 1 year)—we present the HMD data here as it

has a slightly different definition and allows for international comparisons. First, we show an updated Lexis diagrams to demonstrate the cohort effect outlined in Section 2 (seen up to 2008 in Figure 2). Next, we look in more detail at the change in life expectancy improvements, presented as descriptive graphs.[4] The data used are available in an open repository available at: https://ora.ox.ac.uk/objects/uuid:17917e56-0965-49bc-9fb2-70bbd97529bc.

4.6. Results

4.6.1. Lexis diagrams (or heat maps)

We present Lexis diagrams similar to those in Figure 2 with some key differences. First, we have used the latest data up to 2020 (from 1900). Second, we use HMD data for the *civilian* population of England and Wales. This means the deaths of soldiers during the two World Wars are excluded, though the wider impacts of the wars can still be seen. Third, the data are not smoothed. Finally, the colours are different. Here, purple represents worsening mortality, and green improving mortality, measured as the annual percentage change compared to the 3-year rolling average. The Golden Cohort are highlighted with the two red lines—born between 1925 and 1934. These are presented for females (Figure 17) and males (Figure 18).

Figure 17 shows the annual percentage change in female mortality rates from 1900 to 2020 (increase in mortality in purple, decrease in mortality in green). The same trend of mortality improvements (green) shown in Figure 2 are replicated here up to and beyond 2008, continuing for 2010 and 2011. At 2012, for the older members of the cohort, these change to purple (worsening/increasing mortality), and do not return to green again. For the younger members of the cohort, first the mortality improvements slow, before also declining, and by 2014 the Golden Cohort for the first time since 1942 has declining mortality across almost all ages. Looking beyond the Golden Cohort, the purple squares (worsening mortality) around 2014 are visible in a vertical stripe across almost age groups and continue for the subsequent years for many (a period effect, see Section 2.2). This is continued, and for some, worsened, in 2020, when the COVID-19 pandemic hit.

Figure 18 shows the same for males from 1900 to 2020. It is important again to note here these data are for the civilian population, though men decommissioned from fighting became civilians and many were very badly injured, and some did not survive their wounds. This shows a similar pattern to females, with many good years of improvement after WWII (green), but, in contrast to females, more varied experiences in middle age though still better than generations either side. As shown in females, for males these trends of consistent

[4] We do not use statistical analysis as the possible identification of cohort effects is "not a statistical issue" – it cannot be done through statistical methods (See Murphy 2009).

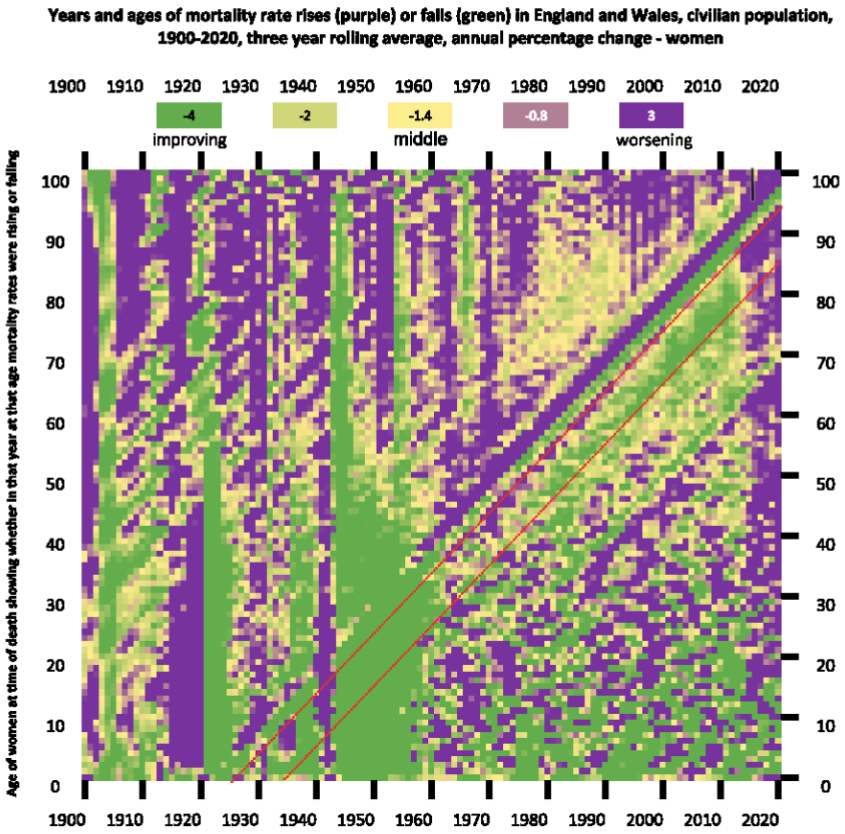


Figure 17. Annual percentage change in female mortality rates in England and Wales, civilian population, 1900–2020 (3-year rolling averages – comparing the three year period up to the year shown with the three years immediately prior to those three years – so the 2020 column is the average annual change in mortality between 2015–2017 and 2018–2020).

mortality improvements continue post-2008 into 2010 and 2011 but in 2012 and the subsequent years mortality improvements stall and, for some ages, reduce. As for females, a similar period effect is seen across many years at this period (2012–2014 onwards), and the impact of the 2020 COVID-19 pandemic clear.

Another consistent finding in both Figures is an apparent cohort effect seen of those born around 1918–1919—a purple stripe from the late 1950s onwards. This is consistent with the impact of those born to mothers who had influenza in 1918 while pregnant (see Section 2.1) and may be one reason the Golden Cohort did so much better than the generation born just before them.

A key finding in both Lexis diagrams is that while the Golden Cohort have had a remarkable lifetime of mortality improvements, it has not always been

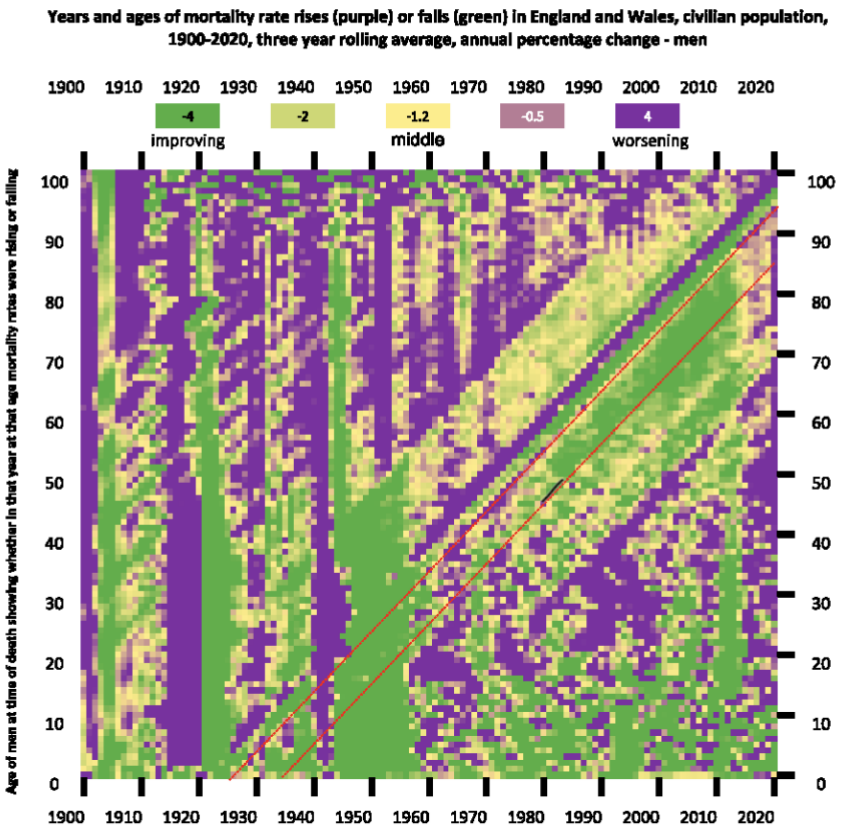


Figure 18. Annual percentage change in male mortality rates in England and Wales, civilian population, 1900–2020 (3-year rolling averages).

the case. This is important as it suggests what is being seen is not a 'birth cohort effect', but a series of economic and social events, as outlined in Section 3, that for them were often very beneficial to their health and, consequently, their lower mortality.

4.6.2. Changes in life expectancy at different ages

It is clear from the Lexis diagrams that the Golden Cohort saw an unusual and large number of years of improvement compared to those born before and after them (the green squares) for almost all their lives until 2012. To examine this in more detail, and their later years, we next compare life expectancy at ages 55, 65, 75, 85, and 95 (denoted 'e55, e65' etc.), for females and males in England and Wales from 1978 to 2020. Figure 19, below, includes five lines. Each line shows the annual change in life expectancy for people of that age group. To be precise over our definition of change: the three-year average life

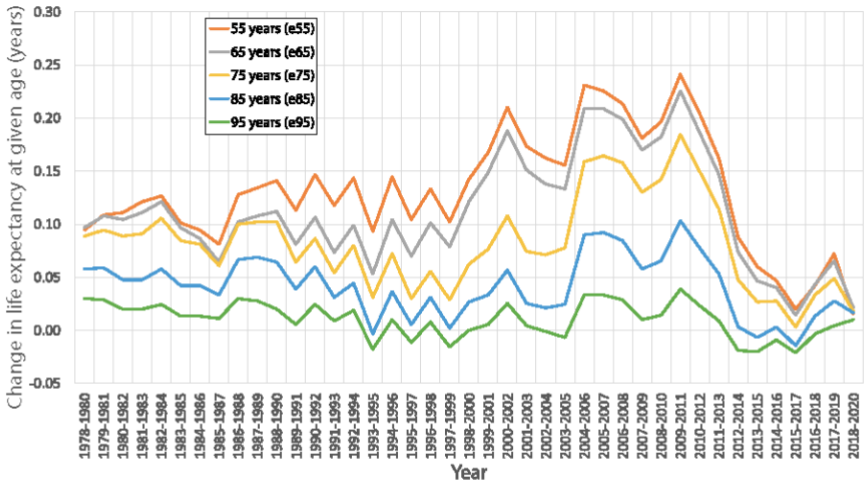


Figure 19. Changes in period female life expectancy in years by age in England and Wales 1978–2020.

expectancy up to any year is compared to the three-year period immediately before and the change is reported as an annual rate of change (in years).

An example: in 2009–2011 women aged 55 had a life expectancy of 29.34 years. The equivalent figure for 2006–2008 was 28.63 years. The difference between those two numbers is 0.71 years over a three-year period. Dividing that by three, to determine an annual rate of change, we see that life expectancy for women of these ages was rising at 0.24 years per year; an extra 86 days of life gained, each year, in just three years (on average). The highest point in the graph above is that example, 0.24 years. After 2009–2011 the line for those aged 55 decreases very substantially in a fall that, except for briefly in the depths of WWII in 1942, is without precedent. Figure 19 does not include 1942, but that fall is visible in the Lexis diagram for women (Figure 17).

The next graph (Figure 20) shows the change between age groups. It can be thought of as showing a 'difference in difference' or the difference between two measures which are themselves calculated as differences between two points in time.[5]

Taking the same example as before, we are now comparing that figure of 0.24, which is almost a quarter of a year gain for women aged 55 in 2009–2011, with the figure for the average annual improvement for women aged ten years older, 65. For women aged 65 years, their life expectancy improved by 0.22 years in those three years. The difference between 0.24 and 0.22 without

[5] This can be difficult to understand. It only becomes easy to understand with practice, but it is not complex. It is the simplest way to understand how underlying trends themselves are changing. So please bear with us!

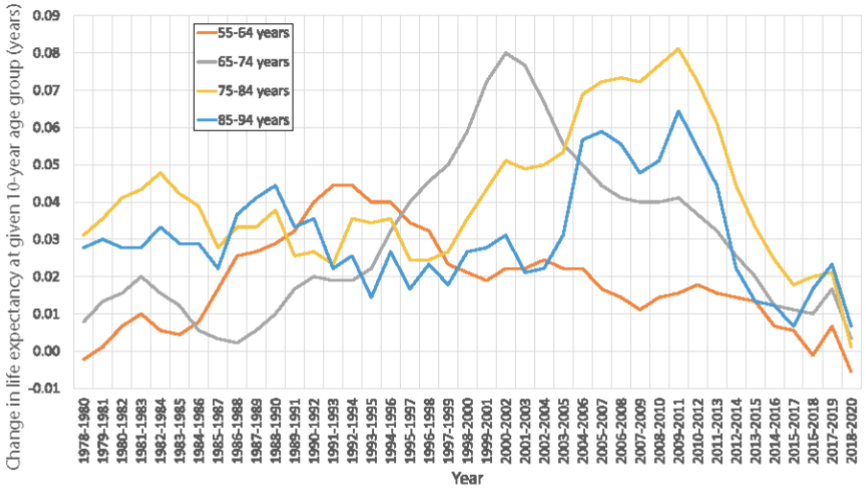


Figure 20. Change in period life expectancy for women between 10-year age group, in years, England and Wales, 1978–2020.

rounding is a little less than 0.02 years. Thus, the gap in the size of the improvements between these two age groups was positive. The younger women were gaining fractionally more years of life than the older women over this time. The trend for this difference in the rates of improvement between these two age groups (55 and 65) is shown by the orange line in Figure 20. We can see that the 55–64 line had been falling since 1992–1994. The Figure also shows the trends for the other three ten-year age gap differences. If, as a reader, you are new to this way of thinking then it can be at first complex to understand, but understanding these differences in difference graphs is key to knowing what happened and precisely when it happened and to who.

When we look at the change in life expectancy between the 10-year age groups for women, some clear distinctions stand out. Life expectancy at ages 55–64 improved most quickly in 1991–1995 (when the Golden Cohort were aged 57–66). It rose by around 0.04 years and then fell—it has not reached the same level since. At ages 65–74 years, life expectancy improved most quickly in the years 2000–2002 (the Golden Cohort were aged 65–74) at 0.08 years a year, and since then has fallen until a recent uptick (just before the pandemic began). At ages 75–84 years, improvements peaked in 2009–2011 at 0.08 years before falling every year since, quite sharply. That is when the blue line in Figure 20 also falls as those aged 85+ also see their fortunes change quickly then.

The fall in the grey line (65–74 years) could represent the unusual ageing effect of a 'golden cohort', and the fall that follows the peak in that line could be suggested to be due to their passing through the ages, rather than austerity, and perhaps an unusual number of them having lived to reach old age and

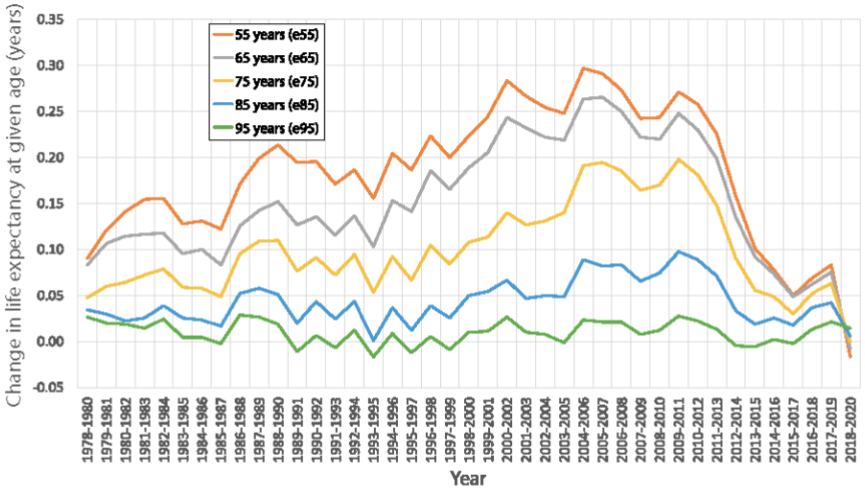


Figure 21. Change in period life expectancy for males by age, in years, England and Wales 1978–2020.

there being more 'weaklings' amongst the survivors. However, life expectancy at ages 85–94 years does not continue the trend seen every decade before it. Instead, it improved most quickly first in 1988–1990, possibly suggesting an earlier golden cohort, but then the next peak rise was 2005–2007 at 0.06 years. It peaks again in 2009–2011 and then falls sharply, at a similar rate to the 75–84 years group, before briefly increasing from 2016 onwards. So, there are several things going on earlier that are complex, and very probably no 'weaklings'. However, after 2011, all four lines in Figure 20 crash down together – in sync in a way and forming a pattern that is not at all complicated. For men, as we show next, the pattern is even clearer.

We will not be going into as much detail in our description of Figure 21 as we did for its equivalent Figure 19 for women. Instead, we simply point out that they show very similar patterns. One day someone might be interested in studying the small differences between them, but for now it is not those small differences that matter most. What matters most is that for men after the worse years of the 1980s, the lines in Figure 21 are all generally rising (i.e. life expectancy is improving), least quickly for those of older ages, but still rising. Those improvements peak just before the year of the banking crisis of 2008, but do not end then. All five lines begin to fall immediately after 2011.

What do we see when we consider the 'difference in difference' graph for men (Figure 22)? Again, it is very similar to that for women (Figure 20). In general, the four lines representing the four 10-year age groups were rising from the late 1970s onwards with a couple of dips in the economic recessions of the 1980s and early 1990s, and the grey line (65–74 years) begins to fall earlier.

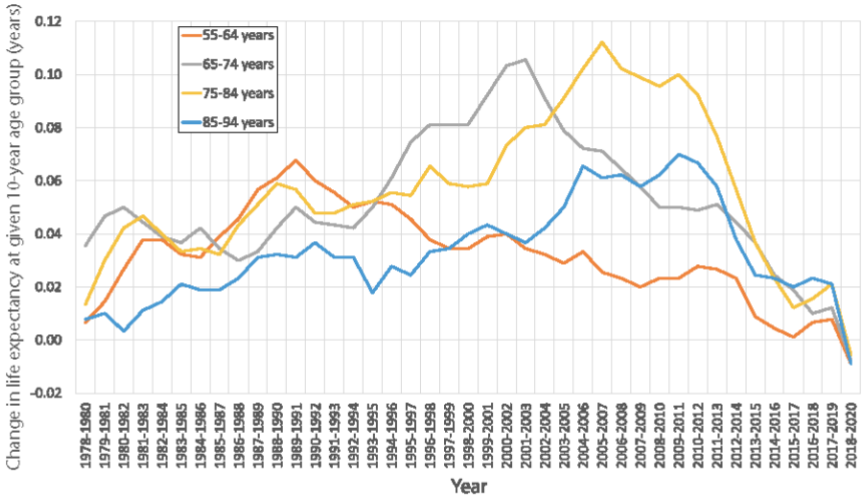


Figure 22. Change in period life expectancy for males between 10-year age group, in years, England and Wales 1978–2020.

This is the improvement for the generation who are a little younger than the Golden Cohort. It did not continue to improve as quickly – an interesting but, in the grand scheme of things, minor detail. Again, all four lines begin to fall after 2011: exactly when the adult social service visits were being cut, the meals on wheels were ending, the health budget was being squeezed – exactly when you would expect if austerity were as deadly as COVID-19 to the very elderly. In fact, it is only just possible to see the influence of the pandemic in the last data point on Figure 22. One could speculate that this may be because compared to austerity it was a less important event as here it is just contributing to part of the 2018–2020 three-year average that forms the basis of the calculations that produce Figure 22.

4.6.3. Raising the alarm

Looking at these figures, and many before them, it is difficult to understand why no action was taken and why no outrage was seen. We now turn to what was happening in those early years of the changes, 2012–2015, that might have meant that these trends were not noticed by enough people at the time, when the lines were going in the wrong direction, and when the evidence existed to show that they were – as early as in February 2014 (Dorling, 2014). Many, as outlined in Section 4.3, were comfortable to follow alternative explanations for what was happening (Hiam et al., 2024). The general view was that a combination of flu, a bad winter, and an ageing population had meant more people were dying. This referred, in particular, to the 2014/2015 mortality spike, which was easy for some politicians to brush away as a blip. For those

working in health care, it was clear it was not. Our first research published on that spike suggesting austerity could be playing a major role was dismissed by the Department of Health and Social Care as 'a triumph of personal bias over research' (Forster, 2017). A similar response has persisted from the government to multiple studies (highlighted above) showing the link between austerity and poor health with increasing veracity.

During those early austerity years, political attention was elsewhere. Europe and migration slowly climbed to the top of the agenda, and UKIP performed well at the 2014 elections. David Cameron promised an EU referendum in the 2015 manifesto, and won a majority which saw that promise enacted.

4.7. Brexit, 2016 (aged 82–91 years)

Six years into austerity came the referendum for the UK to leave the European Union (EU), known ubiquitously as Brexit. This was the second time the Golden Cohort had voted on Britain's relationship with Europe. In 1975, 65% of registered voters turned out to vote in the United Kingdom European Communities membership referendum (or EEC membership referendum). More than two thirds of them voted to 'stay joined' including over 70% of the Golden Cohort[6] (Andrew, 2017). By 2016, the Golden Cohort switched and voted for Brexit, with 64% of those aged 65 years voting to leave the EU (Moore, 2016). The impact of Brexit on health is beyond the scope of this paper, but those who voted for it were more likely to be older, more impacted by austerity, and, according to research, be from areas with worsening mortality (Koltai et al., 2020), echoing what had been seen in the USA with voting for Donald Trump (Bor, 2017). Poor health may have been a factor in the vote for Brexit, and it is clear Brexit is bad for health (Fahy et al., 2019).

4.8. 'Things fall apart': 2020 onwards (aged 86–95 years to present)

Life for the Golden Cohort has not improved in the years since austerity began in 2010. The enactment of Brexit in January 2020 was followed swiftly by the first lockdown due to COVID-19, which began on 23rd March 2020. The COVID-19 virus, like the subsequent cost-of-living crisis, and NHS crises which continue to this day, disproportionately impact older people. For those member of the Golden Cohort who remain, these years have failed to meet the expectations of demographers, who predicted their Golden luck would continue (see Figure 14 in this paper, and Figure 1 in the Appendix) (Hiam & Dorling, 2022; Nash, 2016), and the state has failed to meet the expectations of those individuals and their families, as it had in the past. Detailed information about these years can be found in the Appendix.

[6] For the 1975 referendum, they were aged 41–50 years, and 73% of those aged between 46 and 64 years voted in support of *staying* in the EEC (Andrew, 2017)

5. Conclusion

The Golden Cohort saw remarkable improvements in their mortality over many decades – probably greater than ever experienced by any cohort born in the UK before. It is unlikely this was due to something special about the time they were born, 1925–1934, which were not prosperous years in Britain and when economic inequality was very high. They were born in the aftermath of the devastation of WWI, during the time of the Great Depression, and with a second World War on the horizon. They were born at a time without routine immunisations, antibiotics, or a National Health Service. They were born at a time of the dole, of poverty, and of great hunger. Yet, their early years saw remarkable social and political change. The introduction of wartime rationing, focused on equality, meant they ate well—regardless of their background—for more of them throughout a formative part of their childhood than children ever had before. The 'Great Leveller' of war is sometimes said to have led to a time of income equality, affordable housing, of social cohesion, and to the creation of the NHS (Scheidel, 2018). However, most of the equality secured between 1918 and 1974 had already been achieved by 1939—it was just not realised at the time (Dorling, 2023a). Medical discoveries in immunisations and antibiotics saw dramatic falls in causes of death such as tuberculosis, and these discoveries could not have efficiently been implemented without public sector support. In short, governments of different political parties in the 1920s and 1930s intervened with policies that impacted positively on health, housing, and education, in ways which transformed the early years of this cohort, and later meant that they entered adulthood, for most of them, in a time when full employment was being secured largely through post-war government determination.

When the good times of the 1950s, 1960s and early 1970s ended, at first this cohort were sheltered, and isolated from initial harm. Through the turbulence of the 1970s and 1980s, the Golden Cohort were largely protected—the majority being homeowners in more secure forms of employment, with little exposure to the severe economic chaos that a large minority of adults suffered. By the time of their retirement, health and social care spending increased to keep pace with demand and, as a result, inequalities narrowed and health improved.

In this paper we have demonstrated how sharply the situation changed in 2010. The Golden Cohort were trailblazers of mortality improvements. The fall in improvement in life expectancy among and between age groups is dramatic and seen first in 2012. For the Golden Cohort, the state, which had supported them in their childhood and other eras of their lives to remarkable effect, abandoned them in their final years.

One key difference between their early years and the years of austerity from 2010 onwards is that they had played no part in influencing the state as



Figure 23. Percentage of people who identify as a Conservative party supporter, 1983–2020. Reproduced with kind permission of Duffy and Stoneman. Source: Are millennials really killing the Tory Party? (Stoneman & Duffy, 2023). using British Social Attitudes Survey data.

children. In fact, the youngest of the Golden Cohort turned 18 in 1952—the year Queen Elizabeth II came to the throne; and so, had approximately 21 opportunities in their lifetimes to vote on national issues. They were able, and most of them did, vote in 18 General Elections between 1955 and 2019, in two referendums on Britain's place in Europe, and in one referendum on potentially changing the voting system to a more democratic one.

By 2023, the surviving members of the Golden Cohort had lived through (and continue to live in) a global pandemic, since 2021 a cost-of-living crisis so stark that people in modern day Britain were forced to choose between 'heating and eating', and a health and social crisis so entrenched that public satisfaction with the health service has fallen to the lowest levels since records began (Morris et al., 2023). The Golden Cohort identified as Conservative supporters for much of their lifetimes (Figure 23) (Stoneman & Duffy, 2023), and, perhaps surprisingly, the support by most of them for the party of austerity rose substantially during the austerity years including the last election of 2019, where they voted overwhelmingly for a continuation of the then Government, and, by proxy, for Brexit (Dorling, 2020). It would not be hard to argue that this cohort did not vote for options that, in the long run, ensured the best possible final years of their own lives, let alone the future of the next generation.

Writing in 2019, we quoted Yates' famous poem 'The Second Coming' when assessing the state of health in the UK—when he wrote on how 'Things Fall Apart' (Hiam et al., 2020). We documented rising infant mortality rates, poverty,

falling life expectancy, and widening health inequalities, concluding that the countries of the UK could be on their way to becoming a failed state. We could not have imagined the years that have followed, but certainly the markers we examined have, sadly, all worsened with other impacts now seen, such as reports in 2023 describing that children in the UK 'raised under austerity' are, in terms of height attained, shorter than their European counterparts (Hill, 2023). Thus, while the impact of austerity has not only affected those towards the end of their lives, for the Golden Cohort, these years further exacerbated a significant change in outlook. With the Conservatives still in power at the start of 2024, and the Labour Party now appearing to support austerity, there is little to suggest that outlook will suddenly change. Certainly not in time to aid the final few survivors of the Golden Cohort. Now, writing four years later in 2024, we end with a few of the lines of another famous poet, W.H. Auden, concerning history repeating. The Golden Cohort were born into poverty, relieved by intervention, yet, ended their days mostly in austerity. Auden was 20 years senior to this cohort. In 1939 in 'September 1st' he wrote:

The enlightenment driven away,
The habit-forming pain,
Mismanagement and grief:
We must suffer them all again.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article's supplementary materials.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Acknowledgements

The authors are extremely grateful to the production team for their work on producing the paper, the reviewers and editors who helped improve the paper in its earlier versions, and the colleagues at the ONS who kindly permitted the re-production of Figure 2.

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6.3 Chapter 6 Summary and Next Steps

Even Britain's most resilient cohort experienced unexpected increases in mortality after 2012, a generation historically buffered by early life advantage and welfare expansion. This undermines explanations based on demographic inevitability and signals the presence of wider systemic forces.

Through the lens of the integrated framework, the deterioration observed within the Golden Cohort suggests that pressures were emerging across multiple components across the Triangle. Individual resilience, derived from favourable early life conditions, was no longer sufficient in the face of changing habitat conditions and increasingly strained behavioural and institutional pathways. This combination points toward wider structural stresses and increased precarity, rather than demographic dynamics, as the source of the mortality shift.

The next chapter examines a final cited explanation: first, the UK was not an outlier; many HICs experienced the same health crisis; and second, it was a "return to normal" in mortality improvements that had seen unusually rapid increases in the 1990s and 2000s.

7 International Context: Testing the "Return to Normal" Hypothesis

7.1 Introduction

This chapter presents the fourth empirical paper in the thesis. It examines whether the slowdown in mortality improvements observed since 2010 represents a UK-specific deviation or a wider HIC trend. As outlined in Chapter 2, one of the most persistent counterarguments to structural explanations is that the UK was not an outlier, and that the apparent deterioration reflected a broader shift across Europe and a return to long-term, slower improvement rates after the unusually rapid gains of the 1990s and 2000s.

This chapter evaluates that claim directly. Using HMD data, the analysis compares annual changes in life expectancy from 1980 to 2019 in England and Wales and Scotland with those in five other large Western European countries. By extending the time series back to 1980 and applying segmented regression models with up to two breakpoints, the paper tests whether Britain's slowdown was a deviation from normal improvement rates or a reversion to them.

The integrated framework emphasises the importance of understanding how population, place and institutional environments evolve over time. Framing Britain's experience within an international context, therefore, helps identify which elements of this wider system were uniquely under strain in the UK and whether the deterioration in mortality reflected national conditions rather than shared international demographic or epidemiological pressures.

By situating the UK's mortality trends within a wider European context, the chapter continues the elimination strategy developed in Chapter 2 and built on in Chapters 5 and 6. Having shown that proximate causes such as influenza (Chapter 5) and

demographic composition (Chapter 6) do not account for the mortality crisis, this chapter examines whether international convergence can.

7.2 Paper 4: Slowing down or returning to normal?

British Medical Bulletin, 2023, **145**:6–16
https://doi.org/10.1093/bmb/ldac036
Advance Access Publication Date: 25 December 2022

OXFORD

Invited Review

Slowing down or returning to normal? Life expectancy improvements in Britain compared to five large European countries before the COVID-19 pandemic

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Received 28 July 2022; Revised 3 November 2022; Accepted 8 November 2022

Abstract

Introduction or background: Life expectancy is an important summary measure of population health. In the absence of a significant event like war or disease outbreak, trends should, and historically have, increase over time, albeit with some fluctuations.

Sources of data: Data were extracted from the human mortality database for life expectancy at birth and age 65 years from 1980 to the latest available year for England & Wales, Scotland (Great Britain), France, Spain, Italy, the Netherlands and Germany.

Areas of agreement: It is well established that life expectancy improvements in Great Britain have stalled in recent years, and that a similar stalling was seen in other high-income countries during the mid-2010s.

Areas of controversy: The significance and causes of the slowdown in improvement in life expectancy in Britain are disputed. First, was Britain's slowdown in progress in life expectancy in the 2010s a deviation 'from' earlier sustained improvements or simply returning to normal (slower)

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improvement rates following faster gains in the 2000s? Second, did other European countries have slowdowns comparable to that in Britain?

Growing points: Life expectancy, as a summary measure, conceals inequalities. Other measures, such as lifespan disparity, complement it in understanding changing trends. While annual fluctuations in life expectancy are expected, continued stalls should raise concern. The three British nations examined were the only ones among these European countries to experience stalling of life expectancy gains in both sexes.

Areas timely for developing research: While it is clear that Britain is making less progress in health than similar countries, more research is needed to explain why.

Key words: life expectancy, public health, austerity

Introduction

'Even with coronavirus out of the picture, Britain is the sick man, woman and child of Europe'.[1] Richard Horton wrote these words in 2020, when the Global Burden of Disease study placed the UK close to the bottom of European rankings. In 2019, before the pandemic, we said much the same.[2] Pointing to stalling life expectancy, rising infant mortality, widening inequalities and difficulties in accessing healthcare, we recalled Yeats' words from 1919, 'things fall apart'.[3]

More than 2 years on, the world has changed in ways few could have imagined. While the full impact will not be known for some time, death rates from COVID-19 have been higher in the UK than in many comparable countries.[4] There are many reasons, but several commentators have argued that the poor health of the British population prior to the pandemic may have left them more vulnerable.[5–7] This seems plausible. The average annual gain or improvement in life expectancy in the UK in the 2010s, from around 2012–14, was lower than the late 1990s/2000s.[8] This fact is not controversial. What is controversial is what this slowdown in life expectancy gains represents. First, was the UK an outlier or following a trend in comparable European nations, and second, when did it diverge, a key question in understanding the reasons for any divergence.

Before we explore these areas further, a note on terminology. We use the term 'slowdown' throughout this paper in its literal meaning of the rates of improvements in life expectancy at birth slowing down or declining. We refer to 'stalling' also in its literal meaning of 'to stop making progress' i.e. when there is no improvement occurring.

Some have highlighted that the UK's fall in the European rankings could be partially attributed to the 'catch up' by ex-Soviet states and Eastern European countries recovering from the trauma of the 1980s and 1990s, and that the same patterns (or at least similar) have been seen in other Western European countries.[9–11] This would suggest wider factors were at play. Indeed, the stalling of life expectancy improvements in the UK in the 2010s was seen in some other Western European countries, although it was more marked in the UK than in other countries, except the USA and, depending on the comparison, Iceland. This conclusion is reached consistently by studies examining different periods and selections of high-income countries.[10,12–14] However, few studies have compared countries after 2016, and especially, the 'good' mortality year, 2019, before COVID-19, which was seen by some

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Table 1 Two interpretations of a finding that there was slowdown/stalling of life expectancy trends in the 2010s/2020s as compared with the 2000s

Interpretation	Improvement in life expectancy in late 1990s/2000s	Slowdown in life expectancy improvements in 2010s
A	Normal	Slowdown from normal trend
B	Exceptionally good/atypical	Slowdown to/return to normal trends after atypical 2000s

as a positive sign for the UK. This initial sign of encouragement was tempered by news from the Office for National Statistics that those living in the most deprived areas of England had a decrease in life expectancy, not only between 2015 and 2017 but also in 2018–2020.[15] While it is possible that this could also have happened in other European countries at that time, it has not yet been reported.

These worrying developments were especially alarming as they followed a period when the UK had experienced rapid reductions in mortality, with the improvement from 2001 to 2011 noted as 'the highest since records began in 1841'.[9] Explanations, not mutually exclusive, that were offered included reductions in cardiovascular disease mortality, increased funding of the NHS and possibly a 'healthy migrant' effect.[9,16,17] As a result, it may be that the appearance of a slowdown is not as concerning as it first appears, with rates of improvement in fact returning to normal following an unusual period of improvement period in the 2000s.[11]

In terms of the significance of the slowdown itself, initially the controversy arose over the possible 'over-interpretation' of earlier breaks in trend.[18] Early studies, including our own, focused on the 2014–15 increase in mortality in the UK, when the increase in deaths was the largest seen for almost 50 years, subsequently reflected in the increase in age-standardized mortality rate (ASMR).[19,20] However, annual fluctuations are to be expected, and an apparent break in trend might have been due to a single bad winter year around 2014–15, especially given the common use of 3-year smoothed data, or a particularly bad influenza season.[21,22] However, while certainly relevant at that time, the likelihood of a one-off 'bad year' has decreased as additional data have been added, showing that the slowdown in improvements has remained.[8] This has led commentators to argue that austerity policies imposed following the 2008 financial crash resulting in significant public spending cuts were a potential causal factor, both in the UK and other European countries—which mostly suffered less because they had smaller finance service sectors.[20,23–28]

The remaining controversy is whether the slowdown in life expectancy improvements in the UK was a slowdown from 'normal' improvement rates, suggesting that the 2000s trends were 'typical' (interpretation A), or a slowdown to 'normal' improvement rates (interpretation B), suggesting that the 2000s trends were 'atypical' (in a positive way in that life expectancy improvements were higher than the long term 'normal' trend). Table 1 summarizes these two positions.

Most previous research has looked at data series from 2000s onwards, and/or identifying a single break point (BP) in trends.[10,11] While useful, this has two important limitations. First, it is impossible to distinguish between the two interpretations without longer-term data. Second, earlier models, which constrained the analyses to a single breakpoint, do not allow alternative solutions with multiple breakpoints that would differentiate between the two interpretations. To address these limitations, we extend the range of years for analysis back to 1979 and in our analysis allowed up to two BP ('double hinged') models. This enables us to assess whether the slowdown is better interpreted as (a) a fall from normal, (b) a return to normal or (c) a combination of the two.

In this paper, we look at England and Wales and Scotland, so refer to 'Britain' rather than 'the UK', which includes Northern Ireland, from hereon. We address three issues: First, we seek

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to determine which of our two interpretations is correct. Was Britain's slowdown in progress in life expectancy from around 2013 a deviation 'from' earlier sustained improvements (interpretation A) or a correction following gains in the 2000s returning 'to' normal (slow) improvement rates (interpretation B)? Second, have other European countries seen slowdowns comparable to that in Britain? Third, if a significant change in trends occurred, when did it happen?

Methods

Data

We extracted publicly available data from the Human Mortality Database (HMD)[29] via the R package HMDHFDplus[30] to compare changes in life expectancy at birth (e_0) and age 65 (e_{65}) for Britain (England & Wales, treated as one population, and Scotland), France, Italy, Spain, Germany (Germany exists as three datasets in the HMD: Total Germany (DEUTNP) from 1991, East Germany (DEUTE) and West Germany (DEUTW).) and the Netherlands. We do not include Northern Ireland as it is a separate entity in the HMD and has a population too small for robust results with the analyses used. The nations selected for comparison are the five largest, by population size, in western Europe and therefore most directly comparable with Great Britain.

Synthetic Germany

We produced a 'Synthetic German' population with data for East and West Germany for years before reunification to allow comparison. We estimated that this could be produced using a weighted average of 20% East Germany and 80% West German life expectancy trends (details in Appendix 1 (All Appendices available online at: https://github.com/JonMinton/change-in-ex/blob/main/appendices/main.md)).

Analysis

We analysed trends in annual rates of change in life expectancy from 1980 to 2019 (or the latest available year) for the selected nations. For both annual changes in e_0 and e_{65} we add smoothed trendlines to the data series calculated using loess (locally estimated scatterplot smoothing),[31] to see whether these trendlines are rising or falling over time, and whether they vary between populations.

We then compare three model specifications for representing life expectancy against time for each population: (a) linear trend over time (no breakpoint); (b) a segmented model specification with a single breakpoint; (c) a segmented model specification with two breakpoints. The one and two breakpoint models are calculated using the segmented package in R.[32,33] As highlighted, most previous breakpoint analyses have used shorter data series and/or have only looked for a single breakpoint.[10,11] These two factors combined preclude separating the two interpretations in Table 1. For each population we identify which of the three models has the best penalized model fit as determined by Bayesian Information Criteria (BIC).[34] The first differences of the predicted values of best performing models are then calculated and plotted against the first differences in the observed values (i.e. annual changes in life expectancy from the previous year), and presented on the same scale and for the same populations as the loess smoother curves.

The loess method is continuous by design and only produces smooth curves that vary continuously over time; the breakpoint models are discontinuous by design and, once differenced, are represented as a series of horizontal lines whose intercepts vary after compared with before the breakpoint years. However, suppose there are genuine changes over time in the trends in life expectancy change for a population. In that case, both approaches should produce qualitatively similar shapes, with either upwards or downwards changes in trends apparent at similar times.

All code used in the analyses is available online at Github (Available at: https://github.com/JonMinton/change-in-ex (accessed 15 March 2022)). An R shiny app was built to compare the results of different possible modelling approaches (Available at: https://datascapes.shinyapps.io/compare_cps_and_bps/ (accessed 13 June 2022)).

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Results

Change in life expectancy in these nations

First, we compare the annual change in e0 and e65 for the nations from 1980 to the latest available year by sex (Fig. 1a and b). Trends are reported in Appendix 2.

The dots in the figures show, for each year, how life expectancy compared to the previous year. (For example, 1980 shows the life expectancy in 1980 minus the life expectancy in 1979.) The horizontal line indicates no change from the previous year, with points above the line indicating an increase in life expectancy and points below a reduction from the previous year. All values are converted to weeks per year.

There is considerable variation in these values, with some individual years having life expectancies almost a year higher than the previous year (France, Italy), and others more than half a year lower than the previous year (Scotland). Indeed, the level of variation in changes in life expectancy from the previous year is even higher than would be expected if the data were purely random, and instead the time series 'oscillates' slightly, as discussed in Appendix 3.

The smoothed trendlines indicate that for e_0 (Fig. 1a), the average change became negative by 2019 in England & Wales, and in Scotland; but for all other populations considered the trends have reduced but remain positive. However, the exact position of the lines through the points depends not just on the data, but also on modelling parameters used by the loess algorithm (We have used the default values of these parameters.). This means we cannot definitively conclude that the life expectancy trend fell in these UK nations, whereas merely 'stalled' in the comparator nations; however, the trendlines are indicative of a more severe decline in gains in these UK nations than the comparators.

Another feature in the trendlines is that, for several populations, the line moved upwards slightly during the 2000s or thereabouts, before falling again afterwards. This 'bump' is most apparent for the Netherlands, but also present for England & Wales. This is consistent with the thesis that the 2000s may have been a period of unusually rapid improvement, and so not an ideal 'baseline' period against which to compare the more modest gains in life expectancy (or declines in life expectancy) which occurred during the 2010s. Again, the exact shape of the curve depends on modelling parameters, and so is not definitive evidence that life expectancy trends over this period were exceptionally high.

Segmented regression approach using annual data

The locally estimated scatterplot smoothing (LOESS) smoothed trendlines indicated a more severe decline in trends for England & Wales, and for Scotland, than for the other comparator nations. They also indicated that the 2000s had somewhat elevated trends, though not to the same extent as the Netherlands. However, the curves produced from the loess method are dependent on modelling parameters as well as the data itself. Next, we assess if similar findings are identified using a different method. We present these for all nations at e_0 (Fig. 2a) and e_{65} (Fig. 2b).

For England & Wales, for both e_0 and e_{65}, a two breakpoint model was selected for both males and females. Like the loess smoother, this identified the 2000s has having a somewhat increased trend, then a decline from around 2013. Unlike with the loess smoother, the final trend value was still positive rather than negative but is more modest than for most comparators. In summary, it shows a moderate annual increase throughout the 1980s and 1990s, a greater increase throughout the late 1990s/early 2000s, and then a consistent and severe decrease after around 2012.

For Scotland, two breakpoint models were selected for e_0 trends for males, and both sexes for e_{65}; for e_0 females a single breakpoint model was selected. All models identified a break after 2010, and a reduced rate of improvement thereafter. For e_0, the life expectancy trends after 2010 are negative, with declines of around 1 or 2 weeks per year indicated.

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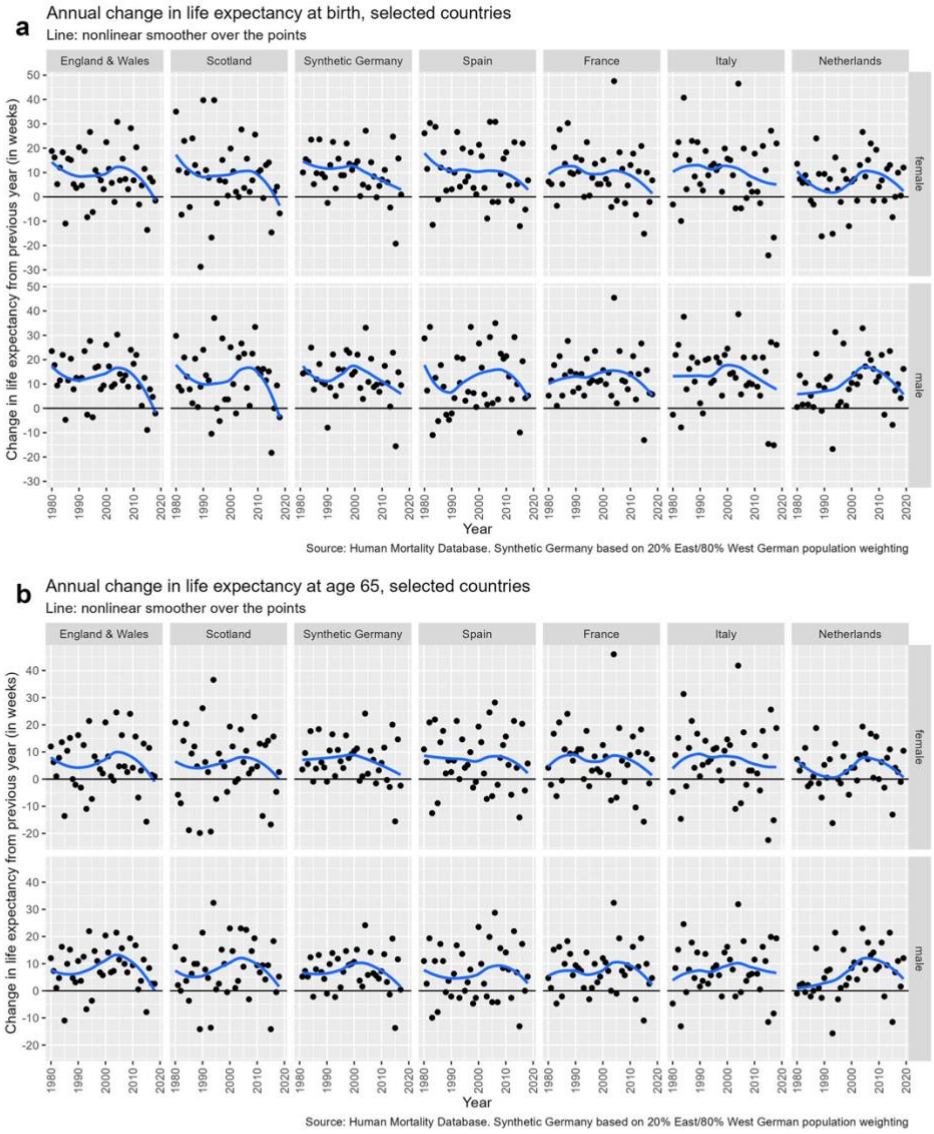


Fig. 1 Observed (points) and predicted (lines) annual changes in life expectancy at birth (a) and age 65 years (b); loess smoother approach

For other nations, two or one breakpoint models were selected in most cases, though the best performing models for e_{65} for Italian males had no breakpoints (i.e. standard linear regression), indicating continual annual gains in life expectancy of around 9 weeks per year. The Netherlands is notable

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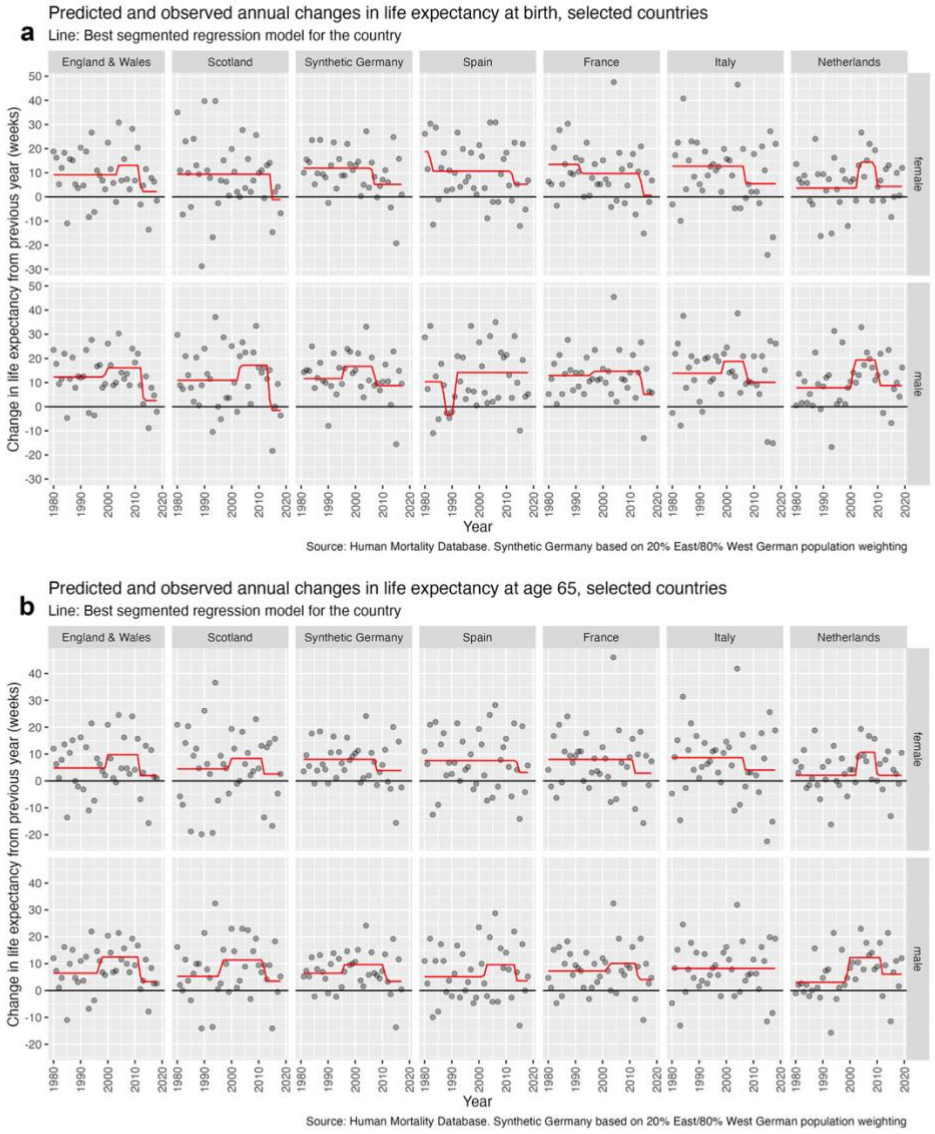


Fig. 2 Observed (points) and predicted (lines) annual changes in life expectancy at birth (a) and age 65 years (b); segmented regression approach

in that the 2000s were associated with substantial increases in trends, which then declined from the late 2000s/early 2010s. However, the post-2000s declines were not to levels appreciably below those in the 1980s and 1990s. For males, instead, they appear somewhat higher than these initial values.

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Conversely, however, the rates in the 1980s and 1990s in the Netherlands were somewhat below those observed in UK and other comparator nations. Further analyses of the other nations are available in Appendix 4.

Discussion

Main findings

In this paper, we asked whether the changes in trends in e_0 seen in Britain in the early 2010s represented a slowing of what were 'normal' improvement rates in the first decade of the 21st century or a reversion to 'normal' rates after a period of better than expected performance (Table 1), whether these changes occurred in other European countries in the same way, and if changes in trends did occur, when they happened. We studied e_0 and e_{65} from 1980 to the latest available year for England & Wales, Scotland, France, Germany, Italy, and Spain.

First, while almost all countries experienced a reduction in annual average life expectancy improvements, for both ages and sexes over the years examined, except for e_{65} in Italy, only in British nations did average improvements stop completely and/or decrease for both sexes. However, while this is an obvious cause for concern in the UK, there are no grounds for complacency in the other countries. Second, for England & Wales, we present evidence that the two apparently 'competing' interpretations of life expectancy trends are both correct: i.e. that it is simultaneously true that the late 1990s and 2000s were a period of unusually rapid average improvements in life expectancy, and that after around 2012 there has been a severe stalling of annual gains. Third, the Netherlands has previously been highlighted as a country that experienced a similar pattern to England & Wales,[17] and the lowest improvements at both e_0 and e_{65} for the countries examined (Appendix 2). However, the breakpoint analysis suggested that, for both women and men in the Netherlands, the increase in life expectancy over time accelerated slightly and then decelerated slightly around the years 2000 and 2010, respectively; in the 2010s it rose just as quickly as it had been rising in the 1980s and 1990s. Thus, when the time period is extended beyond the year 2000, it appears that there was not a slowdown in rates of improvement comparable to that in the UK in the Netherlands.

It is important to put improvements in the 1990s and 2000s into a longer international context. By 1998, the ASMR from coronary health disease in men in England & Wales had fallen to 250 men per 100 000 per year; down from a peak above 500 per 100 000 in the 1970s. The rate for women was already much lower but also halved. The improvements in the 1990s and 2000s were a continuation of these trends, as reported by Lawlor *et al.*[35] These trends were seen across many countries. In the USA, the rate for men fell from over 500 in the 1970s to under 150 per 100 000 men per year by 2010, as shown by Blanchard *et al.*[36] The same patterns were seen in Spain, Italy and France in a comparative study that did not include Germany.[37] It is highly probable this occurred in Germany as well. Thus, the greater slowdown in Britain after 2010 was not because it had unusually high rates of heart disease. Rates had already fallen substantially by the year 2000.

Our findings, based on a data series starting 1979–80, strengthen the evidence base supporting the stalling life expectancy hypothesis, because most previous analyses used data starting in the early 2000s and/or a single breakpoint. Without the longer time series here, it would not have been possible to discount the possibility that any breakpoint identified around 2010/12 represents a return to earlier more modest improvement, rather than the emergence of a new trend of unusually low longevity gains. There are some limitations in this approach, as outlined in Appendix 4. However, collectively the results provide good evidence that England & Wales experienced a substantial stalling in annual mortality improvements after around 2012, as well as fairly good evidence that the Scottish population may have experienced a decline as or more severe contemporaneously. For Scotland, the segmented regression approach implies that life expectancy has fallen, rather than simply stalled, in recent years; however, there is greater discordance between

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the results of the segmented and changepoint approaches, and smaller population size for Scotland compared with England & Wales, suggests the estimates for Scotland may be less reliable than those for England & Wales.

The analyses also reveal some similarities and differences between England & Wales and other European nations. In particular, England & Wales was not unique in the finding that the segmented regression approach identified both a period of increased followed by a period of slower improvement in life expectancy. When looking at trends in life expectancy at birth, this jump-then-fall pattern is seen in Italy, Germany (synthetic) and to a lesser extent France for males, though not for females. When looking at comparable trends in life expectancy change from age 65, a jump-then-fall pattern is evident in Spain, France, Germany, for males only. Among females, the fall component was seen in Germany, Spain, France and Italy, but the jump component in males was not; this appears to be the case both for trends in life expectancy from birth and from age 65.

Though the presence of a fall component—i.e. a reduced rate of improvement starting in the late 2000s or early 2010s—was identified in these other European nations as well as England & Wales, where the extent of the recent fall appears to be more uniform across population subgroups, more consistently identifiable using the two methods applied here, and more severe than in the other European comparator nations. Within Scotland, despite a smaller population and greater discordance between the segmented and changepoint methods, there are indications that life expectancy may be falling, rather than simply 'stalling', with the trend in annual changes in life expectancy from birth being negative for both males and females. (It should also be noted that, for females, the French trends from birth are also close to zero.)

In summary, it appears that patterns in life expectancy change over time are not qualitatively dissimilar in England & Wales (and Scotland) as compared with other European nations, but are quantitatively dissimilar in terms of both the increase in rate of improvement in trends during the late 1990s and 2000s, and the severity of the fall in improvement in trends seen since around 2012. Put more simply, it appears that what has occurred in England & Wales has also occurred in other European nations, only more so. This suggests that factors specific to England & Wales (and with more uncertainty, Scotland too) may have exacerbated the international factors behind a general slowdown in improvements in life expectancy in these affluent European states.

Limitations and strengths

These analyses have important strengths. First, the HMD provides robust comparable data. Second, we cover a longer period than previous research and include annual changes. Third, we could select multiple breakpoints, using two separate methods.

However, there are also limitations. The data conceal large variations within countries, whether geographic, ethnic or social. Life expectancy is a summary measure and can miss important information, such as increasing death rates at certain ages in the UK, detected initially by other methods.[38] In addition, readers should consider our results alongside previous analyses conducted into this topic, and consider the extent to which differences in data and methods used, as well as in interpretation of results, may explain any discordance in conclusions drawn by different researchers. Finally, we cannot attribute causality.

Future research

This research adds to the evidence base by firstly, extending the period examined, and secondly, by using models assessing for more than one (or no) breakpoints in trends. However, by using annual changes the models pick up particularly good or bad years in terms of high or low mortality (e.g. cold weather, bad flu seasons). Future research could take paired years to limit this artefact.

More countries could be examined, including the 18 OECD countries Ho and Hendi examined, and in particular the USA—whose life expectancy fell for 3 years after 2015.

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Disaggregating the data by deprivation may also be revealing, as would the inclusion of Northern Ireland, one of the poorest parts of the UK. More insights into differences in access to health and social care may also further help explain some of the trends.

Examining the impact of the trend on COVID-19 outcomes and whether higher death rates prior to the pandemic left fewer frail people available to die matters. In contrast, the remarkable record of mortality improvement in old age in Italy prior to the onset of the pandemic could have contributed to more deaths in the pandemic. Migration might also matter,[16] especially as many young Europeans returned to their home countries during the pandemic, exacerbated by Brexit in the UK.

Conclusion

All the countries examined were affected by the international financial crisis of 2008 and its aftermath, but each experienced different rates of slowdown in health improvements. The countries of the UK were most affected. A slowdown in the rapid decline of mortality from heart disease in the 1980s and 1990s may have contributed to the changes observed, but this should not explain trends since 2000. The onset of the pandemic in Europe in early 2020 complicates comparisons but as COVID-19 deaths fall, the underlying trends will likely re-emerge. Understanding these differences is now even more important; as we were completing this paper a new analysis showed that the UK was the only one of 38 industrialized nations where the loss of people of working age from the labour force had not recovered.[39]

Data availability

All data used are publicly available from the Human Mortality Database. All analyses and code are available at: https://github.com/JonMinton/change-in-ex.

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7.3 Chapter 7 Summary and Next Steps

This chapter assessed whether the UK's mortality slowdown reflected a common European pattern or a return to longer-term trends. The paper showed that, although many nations experienced some deceleration after 2010, Britain's trajectory was distinct. Only England & Wales and Scotland saw improvements stall or turn negative for both sexes. While some other countries saw a "jump-then-fall" pattern, with unusually rapid gains in the late 1990s and 2000s, followed by a sharp and sustained reduction in improvement rates after 2012, the UK was distinct in the severity. Both interpretations of the trend are therefore true in the UK: the 1990s and 2000s were exceptionally good, and the 2010s exceptionally bad. This cannot be characterised as a "return to normal" or reversion to trend.

These findings indicate that the UK's mortality crisis cannot be attributed to international convergence or statistical artefact. Instead, Britain diverged in both the magnitude and persistence of its slowdown, consistent with pressures emerging within the UK's dimensions of the Triangle. Differences in population vulnerability, habitat conditions, and the resilience of behavioural and institutional dimensions may help explain why Britain's trajectory diverged from that of countries with similar demographic and epidemiological profiles.

The next chapter examines how these trends were interpreted within the public health community, including why proximate explanations persisted and why structural interpretations were contested, and asks how expert narratives shaped understanding of the UK's emerging mortality crisis.

8 When Experts Disagree: Constraint and Fragmentation in Public Health

8.1 Introduction

This chapter presents the fifth and final empirical paper of the thesis, which contributes to RQ3 (*How did expert interpretations of these trends vary, and why did some narratives persist despite mounting contrary evidence?)* by examining how public health experts interpreted the causes of the UK's post-2010 mortality slowdown. Based on semi-structured interviews conducted between November 2021 and January 2022 with senior national-level experts, the paper examines why no single explanatory narrative emerged despite growing concern about life expectancy trends. While some interviewees identified austerity as a plausible driver, others cited explanations such as influenza, demographic factors, or data issues.

As established, these proximate explanations cannot account for the crisis's scaling or timing. This chapter, therefore, asks why such a narrative persisted in public discourse despite weak empirical support. The findings suggest that expert interpretations were shaped not only by the strength of available evidence, but also by perceived professional expectations around neutrality, the contested nature of evidence standards, and the challenges of communicating structural or politically sensitive arguments in public.

Such constraints are not unique to the UK context but reflect a wider dilemma in public health: how political context, institutional norms, and professional cultures shape the framing of health crises. The analysis also draws on critical literature, notably Walsh & McCartney's book 'Social Murder', to contextualise these constraints as forms of epistemic and institutional precarity, conditions under which

structural (and politically sensitive) causation becomes difficult to name. The integrated framework highlights how institutional environments can shape the visibility of structural drivers.

8.2 Paper 5: When Experts Disagree

Public Health 214 (2023) 96–105

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Themed Paper – Original Research

When experts disagree: interviews with public health experts on health outcomes in the UK 2010–2020

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ARTICLE INFO

Article history:
Received 31 July 2022
Received in revised form
7 October 2022
Accepted 21 October 2022
Available online 16 December 2022

Keywords:
Public health
Health inequalities
COVID-19
Social determinants of health

ABSTRACT

Objectives: To ascertain the views of public health experts on adverse trends in life expectancy across England and Wales over the past decade, causal factors, possible solutions, and their opinions about how the prepandemic situation influenced the UK's COVID-19 response.
Study design: Semistructured, in-depth interviews.
Methods: Nineteen public health experts were identified by purposeful sampling and invited to take part via e-mail. Sixty-three percent responded and participated ($n = 12$), six females and six males. Interviews took place via Microsoft Teams between November 2021 and January 2022. Interviews were transcribed and analysed using thematic content analysis.
Results: There was no consensus on the significance of the stalling and, at some ages, reversal of previous improvements in life expectancy between 2010 and 2020. Explanations offered included data misinterpretation, widening health inequalities, and disinvestment in public services, as well as some disease-specific causes. Those accepting that the decline was concerning linked it to social factors and suggested solutions based on increased investment and implementing existing evidence on how to reduce health inequalities. These interviewees also pointed to the same factors playing a role in the UK's poor COVID-19 response, highlighting the need to understand and address these underlying issues as part of pandemic preparedness.
Conclusions: There was no consensus among a group of influential public health experts in the UK on the scale, nature, and explanations of recent trends in life expectancy. A majority called for implementation of existing evidence on reducing inequalities, especially in the wake of COVID-19. However, without agreement on what the problem is, action is likely to remain elusive.
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Introduction

Trends in population health provide a means to track societal progress and life expectancy at birth is among the most widely used measures. It has some limitations; when reported as a single national measure, it provides no information on geographic or social inequalities. However, it does enable comparisons between countries and over time. Life expectancy has increased considerably since records began in 1840, albeit at different speeds and with some fluctuations, and substantial events such as both World Wars and the 1918 flu pandemic (Fig. 1).[1,2]

In the 2010s, the long-term improvements began to stall.[3] Although the upward trajectory continued, improvements were among the smallest among high-income countries (HICs).[4] The scale, significance, and causes of this have been disputed. Explanations proposed include particularly cold winters or severe flu; that fluctuations are to be expected and are no cause for alarm; the apparent slowdown is a consequence of rapid improvements in the first decade of the 21st century; and the impact of austerity policies in the 2010s and associated cuts to health and social care budgets (Box 1).[5–7]

The last of these interpretations is especially controversial. Deaths at older ages made important contributions to slowed progress in life expectancy but some have highlighted that old-age pensions were relatively protected. Yet, this only provides a partial picture, as there were cuts to other benefits meaning the average UK pensioner saw a real terms weekly income (after housing costs) increase of £12 between 2010 and 2020, an increase of just £1.71 a day.[8]

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https://doi.org/10.1016/j.puhe.2022.10.019
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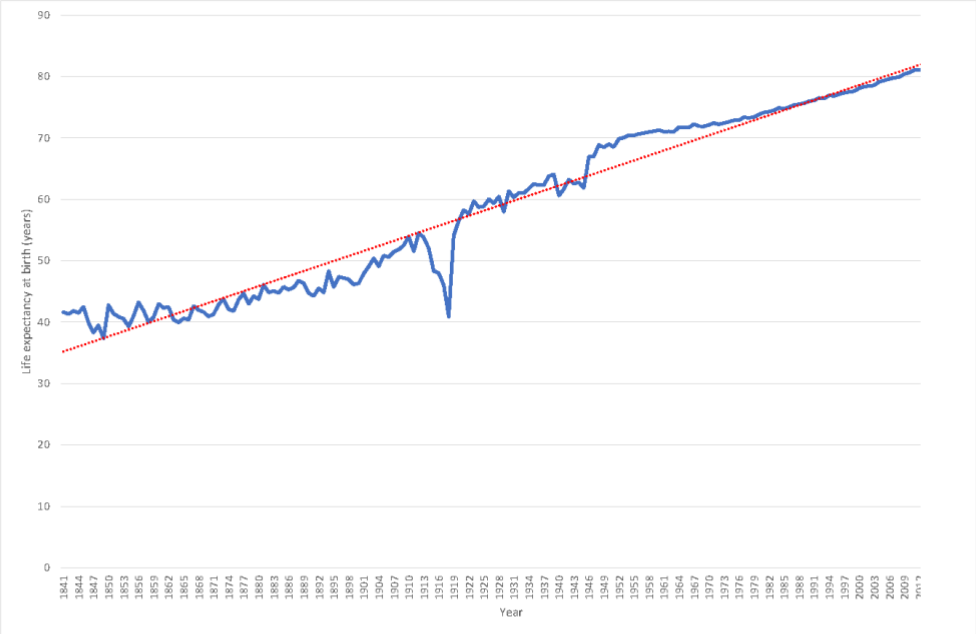


Fig. 1. Life expectancy at birth in England and Wales, both sexes, 1840 to 2020. Source: Human Mortality Database. Note: Blue line shows the value, red dotted line shows the linear trend. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

While all of these explanations likely play some role, consensus remains elusive, as does agreement on appropriate policy responses. This is problematic in a country facing a cost of living crisis and will be a barrier to preparation for a future pandemic. The UK's poor outcomes during the COVID-19 pandemic, despite its scientific capacity, have been linked by some to deteriorating health in previous years.

We asked public health experts in the UK what they thought about this issue. They have all written or spoken about it, in public statements that cover the range of views set out above. However, given the experience of the pandemic, their views may have changed, or they may now be able to express views that they could not previously, for example, due to holding official positions. We adopted a qualitative approach to discover why consensus has been elusive and, potentially, to propose further research on previously overlooked topics. Additional background material is available in Appendix 1.

This paper builds on previous work on the interface between research and policy,[9 12] in particular in the contested area of health inequalities, an issue at the heart of the right-left political divide in many countries, and where views on solutions diverge, ranging from redistributive taxation to the 'trickle down economics', exemplified by Liz Truss, the current British Prime Minister.[13,14]

Methods

Participants

We sought individuals with relevant professional and scientific expertise who had commented publicly on this issue. This was not a huge public debate so the pool of potential invitees was small. As we sought to include a diversity of opinions, we used purposeful sampling. We emailed 19 experts, enclosing a participant information sheet and consent form. Twelve (63%) responded and were interviewed: six females and six males; seven did not respond (Appendix 2). Interviewees represent a diverse group of experts in the most senior positions from academia, government, civil service, medical journals, and non-governmental organisations with experience in economics, public health, and/or public policy. All gave written consent and agreed to the use of anonymised quotes.

Data collection

One of us (LH) conducted semistructured, in-depth interviews between November 2021 and January 2022 via Microsoft Teams.[42] The semistructured interview guide (Table 1) was agreed by the research team, informed by the existing literature and areas of divergence. These questions were shared with participants before the interviews, which were recorded and transcribed following University guidance.[43] Interviews varied from 20 to 60 min. Transcriptions were not returned to participants and there were no repeat interviews.

Analysis and findings

We report our findings according to the consolidated criteria for reporting qualitative research (COREQ).[44] Coding of the data was done by one coder (LH), and the data managed with NVivo software, using thematic content analysis to identify emergent themes.[45] Following Braun and Clarke, this involved six steps.[46] First, familiarisation involved transcribing the interviews, making initial notes, and combining interview responses by question (1–4).

Box 1
What is already known on this topic.

Mortality rates in England and Wales began to increase for some groups after 2015;[15,16] infant mortality rates rose, disproportionately in the most deprived areas of the country,[17] and working-age mortality increased, mirroring the rises in 'deaths of despair'[a] seen in the USA.[18–20] The initial 'blip' would soon become an overall slowdown, with longstanding progress in life expectancy reversing in some groups, widening overall inequalities.[22] While other HICs experienced increased mortality at some times in this period, especially in 2014–15, the UK, along with the USA, has emerged as an outlier in the decade since 2010.[23–26]

The deterioration in health affected more than one group, more than one measure, over more than year. Indeed, a 2018 Public Health England (PHE—now the UK Health Security Agency or UKHSA), report concluded 'The main findings suggest the overall slowdown in improvement [in mortality] is due to factors operating across a wide range of age groups, geographies, and causes of death'.[27] It listed as potential causes a combination of ambient temperature, influenza, increasing mortality rates from dementia, slowdown in previous improvements in cardiovascular disease (CVD) mortality rates, widening health inequalities, and cohort effects.[b,27–29] However, it included little mention of the policy of austerity pursued since 2010, with accompanying cuts to public services and, especially, health and social care[30–32] even though there is an increasing body of national and international evidence pointing to it playing a role.[7,21,33–41]

Second, coding was undertaken within NVivo, highlighting sections of text in the transcription of each interview within the questions and creating codes that described the ideas or content. The codes were added to or new ones developed as this process continued. Using NVivo, the data were then grouped by code to explore the main findings and recurring ideas. Third, a series of themes was generated from the codes, with most codes combined into one of a series of overarching themes. Fourth, we compared the themes to the raw data to check for omissions and ensure that themes were representative. Fifth, we defined and named the themes, attempting to ensure the names helped us understand the data and were themselves understandable. Finally, the account was written up. Although the interviews were informed by the literature and debates about the phenomenon being studied, the approach taken was inductive, allowing themes to emerge from the interviews following initial open-ended questions in the interview guide.

Results

Fig. 2 shows the six themes and sub-themes that emerged from the data[c]. Many of the sub-themes are cross-cutting. For example, the role of inequalities was raised by experts in all six themes.

[a] The term 'deaths of despair' was originally used to describe rising mid-life mortality in the USA due to suicide, drugs, and alcohol-related disease.

[b] Cohort effects refer to 'factors that may affect people born or experiencing a situation at a particular time' (PHE, 2018). One example is historical trends in smoking prevalence.

[c] While an inductive approach was used overall, specific prompts on 1) the role of austerity and 2) the role of migration were used, providing two preconceived themes based on the literature and research questions

Table 1
Interview questions.

Question	Prompts
As you know, life expectancy improvements have stalled in England and Wales in recent years. How would you describe these changes?	
What do you think are some of the causes?	Has austerity played a role? Has migration played a role?
If there is a problem, what solutions might there be?	
What impact did the trends leading up to 2020 have on the COVID-19 pandemic in the UK, if any?	

Interpretation of changes in life expectancy

Experts varied widely in their overall view of the changes, from describing the slowdown in improvements in life expectancy as 'unprecedented' and 'shocking', to consistent with trends seen in other HICs, or due to misinterpretation of the data. The range of views can be seen in the quotes in Table 2.

Causes of change in rate of improvements

Data misinterpretation

Two experts highlighted the importance of caution in interpreting the data and argued that some commentators had: a) focussed disproportionately on the year-on-year increase in mortality in 2014–15; b) ignored the dramatic improvements in mortality in the first decade of the 21st century (2000–2010) which may have given the appearance of a slowdown in subsequent years; c) used inappropriate and/or selective period and country comparisons (Table 3).

Changes in mortality from specific diseases

Most experts emphasised disease-specific factors, such as increasing obesity, flu epidemics, increased use of dementia codes, drug-related deaths, and changes in CVD mortality, although there were some areas of discordance. For example, there was marked disagreement about the importance of improvements in CVD outcomes before 2010 (Table 4).

Most also pointed to factors that would account for changes in outcomes of certain diseases, such as health behaviours, which in turn are shaped by, for example, the obesogenic environment, while growing social isolation was raised as contributing to worsening outcomes from dementia. In all of these discussions, the role of inequalities was widely accepted and seen as something that could be addressed.

Quote 1	'Lifestyle is another issue. We know that we have a a sick environment, an obesogenic environment. You only have to look at the data on smoking in the most deprived areas … You know people who feel that they've got no hope … they're living in an obesogenic environment in poverty. They're smoking. Many of them are drinking, and we know that drugs of addiction are steadily going up, so it all comes together.' -Expert 10

Limit of human lifespan

One expert (Expert 8) asked whether we were reaching the limit of human life expectancy, although highlighting that this could not apply to the UK given other countries were clearly doing better, such as Japan.

Complex and uncertain

Of those who thought there was a problem, there was agreement that it was unlikely that there would be one single explanation.

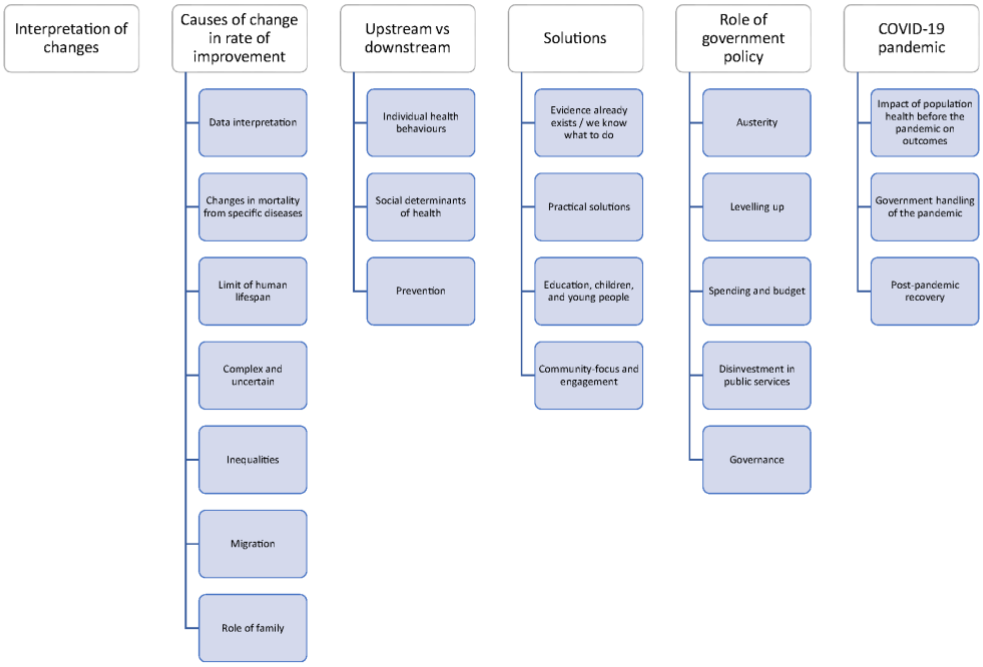


Fig. 2. Map of key themes and sub-themes.

Quote 1	'Almost certainly this is multifaceted and the search for simple solution answer is probably wrong … this is more complex than austerity and it's more complex than winter. Both might be important.'- Expert 2
Quote 2	'I can't give you a definitive single, overarching answer 'cause I don't think there is one … I think it's a combination of a lot of things … I don't think one reason represents even 50% of why it's happened' – Expert 8

Inequalities

Almost all experts (11 of 12) agreed that widening inequalities were likely to be important, both to explain what had happened and to develop responses. Several highlighted gender inequalities and differences in access to health care, citing the inverse care law,[47] and noting how not everyone was affected to the same extent. However, one expert felt the data on inequalities had been misinterpreted (Table 5).

Migration

The experts were unanimous that migration was unlikely to have had a substantial impact but if it did, it would likely be positive. One expert suggested that, going forward, the return of older British migrants from countries such as Spain following Brexit may impact adversely on the figures.

Quote 1	'I mean if [migrants] are any part picture they're probably a positive part, and they're probably a very small part of the picture anyway' – Expert 3

Quote 1	'I can't quite quantify to what extent it impacts of life expectancy but I do think it's worth mentioning is that families in this country a lot smaller than they used to be … It's partly to do with the way we live house households or smaller … You don't quite see generations of people living in the same households as such, and so I think there's a much greater reliance on the state for health care and social care really so.' – Expert 8

Role of family

One expert pointed to the changing role of the family and the implications for state support.

Social determinants of health

Most (11 of 12) raised the social determinants of health as a cross-cutting theme, especially in relation to the pandemic. The impact of poverty on health was raised frequently (Table 6).

Living and working conditions

Experts argued that inequalities in housing, environments, and labour impacted on health, especially during the pandemic (discussed further under theme six: COVID-19 pandemic; Table 7).

Access to health care services

Inequalities in access to health care services and a need to shift to community-focus and user-led interventions were raised as both a problem and a solution (Table 8).

Table 2
Quotes on the theme 'interpretation of changes in life expectancy'.

Quote 1	'I would describe these changes as completely shocking and a real wake up call … Life expectancy is one of the key sort of 'canary in the coal mine' statistics in public health' – Expert 3
Quote 2	'I would describe it as dramatic … it's pretty dramatic to get the break in the curve [of life expectancy improvements] … If it were the case that this was the result of government policy? That's pretty powerful. Wow … So it was dramatic and close to unprecedented' – Expert 7
Quote 3	'I think it's appalling … you can't just dismiss it because it's happened so specifically and differently in places in the UK compared to elsewhere' – Expert 12
Quote 4	'I think it's probably less substantial than is often portrayed … It's not the sort of catastrophe and cataclysm that sometimes is portrayed' – Expert 4
Quote 5	'I think it's disappointing to have seen it stall, but it's not unique to England, or indeed the UK' – Expert 6
Quote 6	'… those slowing down trends were observed in many countries, so the UK wasn't alone in that. But what did make the UK stand out was of course especially as our life expectancy didn't compare very well anyway, particularly for women. We really are the bottom compared to all West European countries'. Expert 9
Quote 7	'Looking at the confusion, I think that much of the discussion was based on the 2014–2015 period, which … slightly distorted the discussion … So if we're … looking at their side, the first decade of the 21st century and the second decade the 21st century, then there was quite a substantial change. We've had a very, very high rate [of improvement] and then followed by a rather low rate and therefore the difference is quite substantial' – Expert 4
Quote 8	'The trend in life expectancy has stalled, as I would describe it … from 2010 for both males and females … and most ages … I don't think it's fallen in the true sense of the word. And I think it would be a little bit overzealous to say it's fallen … it's certainly not growing, that's for sure' – Expert 8

Table 3
Role of data misinterpretation.

Quote 1	'It could be partly artificial … the same thing you could interpret in different ways … the difference between 2014 and 2015 was because 2014 was the lowest ever recorded winter excess mortality, which drives the whole process … you pick the time and what deciles and ignore everybody else you can … selectively choose bits which are perhaps more consistent with ideas about what ought to have happened rather than the what did happen.' Expert 4
Quote 2	'It does depend [a] bit on which time period you use and … which comparison period use for this whole baseline as well … you might find one analysis Iceland is worse, or you might find the USA is worse or England worse, just depending on exactly the time bounds … but the truth is that there's the overall pattern can't really be hidden that lots of high-income countries have seen this stalled trend'. – Expert 5

Solutions

Evidence already exists/we know what to do

Most experts believed that solutions already exist, especially concerning inequalities, arguing that 'we already know the answers' (Expert 3) and that the government could make a difference reasonably quickly by tackling the social determinants of health through a range of policies (Table 9).

Practical solutions

Some experts pointed to specific, practical solutions, for example highlighting the failure to prioritise prevention, with one calling for a ring-fenced NHS prevention budget (Expert 1) and making general practice lines freephone (Expert 2).

Table 4
Quotes demonstrating the differing opinions on the role of CVD mortality.

Quote 1	'The [improvement in] cardiovascular diseases slowed … what is that explaining? That's just a description. Even if it were correct, it's not explaining anything unless you say … it's all downstream.' – Expert 7
Quote 2	'Clearly the slowdown in cardiovascular disease mortality has played a big role. Now some of that could be due to austerity, because there were very significant cuts in public health budgets, we know that. But equally that is being seen across some European countries as well.' – Expert 9
Quote 3	'A great majority of the reduction in improvement between the first and second decades was due to changes in in CVD. I mean, in the UK it's something like the first decade CVD dropped by a third. In the second decade it dropped by 4% that's using Global Burden of Diseases data …' – Expert 4
Quote 4	'there are proposals around having run out of new interventions in relation to cardiovascular disease, which again I don't think are particularly plausible, but particularly because the most deprived groups have seen the worst trends and they're still not getting through and accessing all of the benefits that those treatments can offer, and so you would, in a sense, expect inequalities and those deaths to have narrowed rather than widened if there wasn't a sort of ongoing chain of health care interventions coming through as it were.' – Expert 5

Table 5
Quotes on inequalities.

Quote 1	'… if it's [life expectancy] going to stall then it needed to stall for everybody in the exact same way. But it didn't, so that for me is why there's an issue. That's why we need to start asking questions of why it happened' – Expert 12
Quote 2	'COVID, of course globally has amplified inequalities … our inequalities were widening anyway … so you know we're looking at a magnified effect.' – Expert 9
Quote 3	'So we've got inverse care law writ large in that at the moment getting the types of services which are more empowering so I think things like so all that's going on with mental health services with peer to peer and early intervention' – Expert 2
Quote 4	'[inequalities got] smaller after about 2002/3 and increased again after about 2012, so it's consistent with saying that New Labour's policies to reduce health inequalities worked. And when those policies were reversed, it took a couple of years, but … health inequalities started to increase again.' – Expert 7
Quote 5	'I think there's been a lot of confusion about … inequality in that decade … people have said that inequality increased. That's not how I read the evidence.' – Expert 4
Quote 6	'Ah well, it's increasing inequalities isn't it? … it's unfair that money makes money and those without can't. And health allows you to live a good life and stay healthy. Unhealth stops you from staying healthy. So the division starts with the inequalities and gets ever greater.' – Expert 10

Table 6
Quotes on the social determinants of health.

Quote 1	'To tackle the social determinants of health at their most upstream level and manifestation. To tackle poverty, to tackle inequality, to tackle deprivation.' – Expert 3
Quote 2	'At any point to suggest that individuals are only responsible for their health whilst also living in a structure that means they are more likely to have poor health outcomes, less likely to be able to afford a decent home, buy good food, all of those things that may make you healthy, is just ridiculous.' – Expert 12

Education, children, and young people

Approximately half of the experts called for investment in education, children, and young people, citing the negative impact of cuts to Sure Start centres, to education, and of austerity more broadly on child poverty and child health (Table 10).

Table 7
Quotes on living and working conditions impact on health.

Quote 1	'there is a convergence of evidence around poverty and declining … circumstances for choice … and empowerment of people so you know they're increasingly boxed in to less and less income … and that makes healthy choices very difficult. And also I think the nature of work is important. I mean, these are the wider determinants, but if people have two or three jobs just to keep going and most of the poverty is in work … ' – Expert 6
Quote 2	'… housing needs to move towards passive house standards for housing and ecologically, sustainable and affordable heating systems with adequate room and no damp, etc. And with housing being available according to needs, and not just about what you can afford.' – Expert 5

Table 8
Quotes on access to health care services.

Quote 1	'We don't have progressive health services. We don't look at equity of access, we look at equity of offer, so the fact that every woman in certain age groups is offered screening breast and cervical, we get a big tick. But actually for many of these women, should we be actually trying to reach them in different ways … the poor areas have much longer waiting lists, much more unmet health need, so they have bigger needs.' – Expert 10
Quote 2	'… we probably need to look hard about whether or not we just skew more of our [NHS] resources to areas of unmet need and a richer understanding of unmet need' – Expert 2

Table 9
Quotes on evidence already exists sub-theme.

Quote 1	'The increase in social and economic inequalities? … [People say] there's nothing to be done because we don't understand the causes … well in my view we know a great deal. We know what to do.' – Expert 7
Quote 2	'That means rapid recognition of how everything is is connected … don't just publish a report that says 'oh social determinants of health' actually carry through with that ….listen to the evidence' – Expert 12
Quote 3	'… people arguing for more research and I'm thinking, we may not know everything about everything, but we know enough to make a difference now … it's deeply frustrating. We've got evidence on what works … we've trialled some of these things.' – Expert 9
Quote 4	'You might choose to be blind to the evidence that's out there but you had to choose to be blind … we had had in this country [a] series of health inequalities Government commissioned reports here. The Black report, the Acheison, the Marmot review coming out in 2010 that all said the same thing'. – Expert 3

Community-focus and engagement

One (Expert 2) argued for co-creation of solutions with affected communities. Another (Expert 11) called for integrated health services, closing the gap between primary and secondary care (Table 11).

Governance

One (Expert 1) highlighted the need for 'smart governance', without which policies would be ineffective (Table 12).

Prevention

A majority argued that solutions should focus on prevention, with greater NHS spending and wider public health measures such as addressing the obesogenic environment (Table 13).

Role of government policy and spending

Austerity

Views on the role of austerity were divided. Some saw the slowdown as 'not a surprise given what was going on in the economy and policy arena' (Expert 3), and the 'marked change in policy approaches in 2010' (Expert 12). However, not all agreed, for example, one noted noting how the changes were driven mainly by worsening mortality in older people, who were 'protected in the main from the force of austerity by the triple lock in place … the simple austerity argument doesn't quite cut it' (Expert 2). Another saw the austerity arguments as 'very unconvincing' (Expert 4). One argued for cautious interpretation when comparing to other European countries in Southern Europe (Expert 5) (Table 14).

Table 10
Quotes on education, children, and young people.

Quote 1	'Invest, reduce child poverty, invest in early child development, reverse the cuts in spending on education per pupil. 8% cut in education per pupil from 2010. And these were amazing, regressive cuts in funding to local government.' – Expert 7
Quote 2	'I don't want to say spend more on the NHS, because that's the easy thing to say. I would actually say if I had to choose where to spend money … I'd probably choose to spend it on the on the education system rather than the health system … I do think the education system is an absolutely crucial instrument to protect and advance health.' – Expert 11

Table 11
Quotes on community focus and engagement.

Quote 1	'Some communities have very high levels of community assets which people can draw on, other communities have much lower levels of community assets and so almost public services have to work a lot harder to fill some of those gaps … there is something there for our conceptualisation of unmet need being not just clinically-led but also thinking about what are the resources and the assets in the community and are there people in communities where there are less of those assets? … Community activities that progressively build the confidence in people … like social prescribing but we don't want to medicalise' – Expert 2
Quote 2	'… having these palaces of high tech medicine in our hospitals and general practice separated from each other in the rigid way we have and public health too … I don't think that's the that's necessarily at all the best way … How do you provide integrated care for local communities?' – Expert 11
Quote 3	'I don't think consultants should be locked in hospitals all the time they need to be getting out into communities. But equally, GPs shouldn't just be in the community … we need to get these consultants out of hospitals … the community is where it's at and just waiting people for people to come into out patients is crazy.' – Expert 11

Table 12
Role of governance.

Quote 1	'Our health inequalities targets, for instance, everybody signed up to them blindly for the last 30 years, and they've got worse. So the issue isn't commitment, the issue isn't metrics, the issue isn't signing up to it. The issue is delivery and governance.' – Expert 1
Quote 2	'One of the things we need is smart governance. We can't just act on the supply side to this solution, which has been one of our problems. What we need is to work on the demand side and actually get the public to be saying 'why aren't you doing this' to the politicians who then say to the system managers, 'Why aren't you doing this?' And … the public get this, and and the system managers get it, but they seem to be caught in a stagnant position of being able to unable to address it. It's not that people don't get it 'cause they health services full of really smart people' – Expert 1

Levelling up

Some of the experts raised the Government's 'levelling up' agenda, emphasising it was unclear about what it meant while stressing the need for action across government. One said it was a positive move from a 'deeply Conservative government' (Table 15).

Table 13
Quotes on prevention as a solution.

Quote 1	'I think obesity rates reflect the obesogenic nature of society. So that's because people make profit from unhealthy foods and from transporting us around to out of town shopping centres and out of town entertainment places. So we need to redesign our urban realm. We need to re-design our food systems that to prioritize health and taste, frankly. In doing so, we can support health and and support people to be a healthy weight because it's actually incredibly difficult to maintain a healthy weight in that context of obesogenesis.' – Expert 5
Quote 2	'If someone is seriously ill and in front of you, it might have been better to spend the money preventing them. But by the time you see them, it's too late so you're primary duty is to fix them … and the problem with that is the NHS will continue to be increasingly unsustainable because all the time you are allowing the exacerbation of risk into health conditions into the need for treatment and if you just spend the money at the treatment end of that cycle all the time that budget will the demand the need will get bigger and bigger and bigger.' – Expert 1
Quote 3	'I think there needs to be a much more renewed and invigorated push on public health and prevention. We've neglected that much too long.' – Expert 9

Disinvestment in public services

Many saw a need to address disinvestment in public services and, especially, in health protection and health and social care (Table 16).

COVID-19 pandemic

Disinvestment in public services 'which was done in a regressive way' (Expert 7), including declining health protection and an 'overstretched' health care system before 2020, were cited as important in the poor COVID-19 pandemic outcomes. These have been explored under the theme 'role of government policy'.

Table 14
Examples of different views on the role of austerity.

Quote 1	'Those changes in life expectancy are rooted in the austerity economics that result from 2010 … it is to do with increasing poverty, increasing inequality, increasing deprivation, and the chronic stress related to those things. And that's it really. And and I think what happened to the Social Security system is a really key part of that … those changes are due to deliberate economic policy that was adopted in the face of world leading expert economic opinion on what should happen following the global financial crisis. You know it's completely and utterly unnecessary to adopt austerity economics at that time. But it was it was a chosen policy because it fit with the neoliberal ideologies and ambitions of the coalition, and then and then the Conservative governments, and about reducing the size of the state. So it was a quite cold eyed, deliberate political choice. And they knew that people would suffer.' – Expert 3
Quote 2	'So the other main one [cause proposed] has been that government austerity policies were responsible for it. Well, the problem there is that countries like The Netherlands which has identical mortality patterns in both decades to the UK had no austerity in the same sense. No reductions in it's sort of health service expenditure, etc. In fact, 18 of the 19 major established market economies actually had a lower mortality improvement in the second decade than in the first decade … all those different economies which have very different patterns of austerity and government policy, so again that I found that those arguments very unconvincing.' – Expert 4
Quote 3	'Glib statements about you know 'Southern European countries that did or didn't implement austerity during a particular period of time and look at their stats' I think at times have been quite unhelpful and perhaps not awfully well informed by what the actual experience of fiscal balance in government policy and economic policy has been' – Expert 5

Table 15
Example quotes on 'levelling up'.

Quote 1	'the whole 'Levelling up' agenda if it's to mean anything … needs to get a much more forensic look at what's driving inequalities across all dimensions and address them … whether it's public health prevention talk, addressing things like obesity. 'leveling up' this has got to be a cross government agenda.' – Expert 9
Quote 2	'… we've got the whole 'levelling up' rhetoric at the moment. Now that should be a surprise … because who would have thought you would hear that the those those those words coming from the mouth of a deeply Conservative government? It's how they got their large majority in the last election, and now they're really panicking about having something to show for it … so I think we will see some action around leveling up … I don't suppose we will see the kind of comprehensive policies that we need to see for true leveling up, but that rhetoric is at least there.' – Expert 3
Quote 3	'Like everyone else, I don't know what it [levelling up] is yet. I mean, and I think clever thing politically is it means what I want it mean to me. It means what you want it to mean to you. It's very clever. It's a slogan … '– Expert 10

Impact of population health before the pandemic on COVID-19 outcomes

Most experts felt that it was the *causes* of earlier adverse trends in life expectancy that were important. In particular, they highlighted the role of work and living conditions on outcomes (Table 17).

One expert suggested using previous trends to explore COVID-19 would be unhelpful: '… [COVID-19] is changing so rapidly that the idea that there would be any traction in trying to use sort of long term past trends … wouldn't be the most useful way of trying to proceed' (Expert 4).

Table 16
Quotes on the disinvestment in public services.

Quote 1	'… if you start with health and social care … we've been underfunding these services for for a long time now … we compare very badly with with Europe … there's only so far you can go with an overstretched NHS with cuts to public health and social care spending, So that has to be a starting point: if we want better health outcomes, we've got to start spending on it.' – Expert 9
Quote 2	'… just as during Second World War, we needed to spend a lot of money … and when we set up the health service, we decided to to to spend the money on that … Governments can spend on what they choose to spend and and it's not about there not being the money available … Money is just something that the government can create when it wants to to do the things it wants to do. There is a magic money tree.' – Expert 3
Quote 3	'Economic interventions are about a different purpose to the economy. So the economy should be designed and that the whole purpose of the economy should be about improving health, improving equity, achieving ecological sustainability, achieving social outcomes. It shouldn't be about economic growth and as long as we pursue economic growth and try to fix all the side effects of that, I think we're somewhat doomed to repeat the mistakes of the past.' – Expert 5
Quote 4	'All public systems that were that needed to be mobilized to respond effectively, to manage and prevent the worst effects of the pandemic had been disinvested in; That whole system of Health Protection was under invested in … local authority Public health services cut and Public Health England cut. So they were devalued, under resourced and not in a fit state to meet the challenge of a global pandemic' – Expert 1
Quote 5	'We went into the pandemic with very overstretched health and social care system which meant we were possibly on the back foot a bit … relative to many other Western countries, you know in terms of beds, doctors staffing all of that … So we went into the pandemic facing an overstretched NHS.' – Expert 9
Quote 6	'I found a lot of statistics alarming in the last year and a half, but the ones that really stuck out for me … was the excess mortality or people dying in their own homes … I think [its] symptomatic of a health care system which is struggling to cope.' – Expert 7

Table 17
Examples of quotes on the role of population health before the pandemic on COVID-19 outcomes.

Quote 3	'We weren't fast enough with our response around lock down and and protecting people. We certainly were hopeless about protecting people within our care homes … we had a worst pandemic than we need have done. It meant that more people were exposed to COVID than need be. More people got sicker from COVID than they need and more people died.' – Expert 3
Quote 4	'… the policies designed to stop the spread of that virus … were only gonna work for people who have a nice house, have a spare room that they can work in, don't actually have to leave the house, can afford to stock up on groceries, have the space to stock up on groceries … everything that happened that climate of austerity that responsiblisation of health that put that emphasis on the individual meant that of course COVID was going to be far worse in the UK than it was in other countries.' – Expert 12
Quote 1	'… what cardiovascular disease and diabetes meant during the pandemic … they were significant risk factors for adverse COVID outcomes. and I think these are the kinds of areas where there is some potential for relatively quicker wins. They remain massive problems in their own right … but with the right policies you can turn things round in these areas relatively quickly.' – Expert 9
Quote 2	'It's not an arguable case that we've been dealing with a syndemic. The evidence is very, very clear … not only do you have two biological epidemics coinciding, but you also have the biological overlaid on the social, so … you have these two epidemics on a on a gradient or pattern of poverty and inequality and that again does drives worse health outcomes' – Expert 11
Quote 3	'[people are living] in unfair circumstances … at their homes, their neighbourhoods, their working environments. So all of those things that mean you're already more likely to have poor health meant that you are more likely to die from COVID and then that became something that then explained it away 'oh don't worry actually they had an underlying health condition'. Our social structure meant they had an underlying health condition which meant they were more likely to die from a virus' – Expert 12
Quote 4	'People are working in warehouses … probably working in multiple places … on zero hours contracts they're probably traveling quite a way to get there … bunched together because they're trying to cut down their travel costs. They're good enough jobs, but they're unstable and insecure, and they have to work, so they go when they're sick and therefore they bring the infection back into their families.' – Expert 6
Quote 5	'… with such a hyper infectious disease in which household transmission seem to have played such an important part … the nature of housing … when people do the proper work on this, they'll see that the nature of countries housing circumstances probably had an enormous role' – Expert 2

Government pandemic policies/handling of the pandemic

Those who had a view on the pandemic response were unanimously negative suggesting more people died than needed and that the lockdown policies were regressive (Table 18).

The exception was the furlough scheme, about which all were positive. One said it showed what a government can do to improve population health (Table 19).

Table 18
Government pandemic response beyond the furlough scheme.

Quote 1	'We weren't fast enough with our response around lock down and and protecting people. We certainly were hopeless about protecting people within our care homes.' – Expert 3
Quote 2	'… the policies designed to stop the spread of that virus … were only gonna work for people who have a nice house, have a spare room that they can work in, don't actually have to leave the house, can afford to stock up on groceries, have the space to stock up on groceries … everything that happened that climate of austerity that responsiblisation of health that put that emphasis on the individual meant that of course COVID was going to be far worse in the UK than it was in other countries.' – Expert 12

Table 19
Quotes regarding the government's furlough scheme during COVID-19.

Quote 1	'… the furlough scheme is one of the most remarkable pieces of public policy ever. We reversed engineered the tax system in a week … so that was one bit that was good in a sea of stuff that was just awful.' – Expert 2
Quote 2	'… furlough and the boost to Universal Credit showed what governments can do, and those were two … unthinkable things prior to the pandemic … had they not been in place, things would have been so much worse and so it's interesting to see that happen, but also is sad to think … if we had the employment protection and the increase in Social Security prior to the pandemic, well that would have made a big difference to mortality pre COVID.' – Expert 5

Postpandemic recovery

Finally some, but not all, highlighted how the pandemic has exposed and amplified existing inequalities and could be a catalyst for change (Table 20).

Discussion

Main findings of this study

We asked 12 public health experts about recent slowing of improvement in life expectancy in England and Wales and what should be done. Six main themes emerged: meaning of the trends, their cause, the role of social determinants of health, possible solutions, the role of government policy, and the COVID-19 pandemic (Fig. 2).

There was no agreement about the meaning of mortality trends in England and Wales before 2020, consistent with disagreements in the current literature. Some saw them as 'shocking' and 'appalling', others as misinterpretation of data, and yet others as no different from what was happening elsewhere. One rare area of agreement was that migration had no significant impact but, if it did, it would be positive. This view is consistent with the literature from other HICs.[48 52] There was particular disagreement about the role of longer-term trends in CVD and austerity.

Most also agreed about the social determinants of health, pointing to existing evidence in the Marmot reports[3,53] and the earlier Acheson report in 1998 and the Black report in 1980.

Table 20
Postpandemic recovery quotes.

Quote 1	'I think the impact of the pandemic and everything that's gone before on inequalities will be extremely profound … It's the areas that were the worst off prior to the pandemic that then got hit. Not just directly in terms of the numbers of deaths from COVID and related effects. But you know all the built in effects, the children, the schooling, the lack of IT, the mental health issues, you know this is ….is a tsunami waiting to happen.' – Expert 9
Quote 2	'… unless you address chronic ill health and the growing unhealthy period of life that people lead and the issues of poverty and inequality … Unless you address those absolutely core to pandemic preparedness and the reasons why we've performed so badly as a country … You don't learn the lessons.' – Expert 11
Quote 3	'I am starting to hear people talking about 'How do we make sure that we don't go into the next problem in the same sort of parlous state?' because there was there was not a single public health professional or social epidemiologist or academic in this arena who was surprised by by what happened to us during COVID.' – Expert 3
Quote 4	'So there's an opportunity here to try and influence both policy, but also the big outfits in this country. The NHS, local government, but particularly philanthropy and other parts of the system that need to play in very actively if we are actually to build back fairer.' – Expert 6

Most also agreed that the UK entered the pandemic in an unhealthy state, consistent with other literature[54,55] but not everyone linked this to the slowdown in life expectancy improvements in the 2010s.

Implications of this study

Owing to the small number of experts interviewed, we cannot say particular views are generalisable to, for example, economists or demographers, academics or civil society experts, and it would be unwise to attempt to do so. However, what is concerning, is that without a public health community in agreement, political acceptance and action may remain unlikely.

The importance of understanding the causes and possible solutions of adverse changes to health outcomes has only heightened given the UK's poor performance in the COVID-19 pandemic. Some suggested that policies to put the UK back on its upward trend in life expectancy pre-2010 would only be possible once there was understanding and acceptance of the state of health at the onset of the pandemic.[56]

Limitations of this study

This study has limitations. First, there is inevitable selection bias; invitations were sent out by researchers who have written on this topic whose views may be unwelcome in some quarters. Second, while we sought a diverse range of opinions, we cannot ignore responder bias, as those who agreed may differ from those who did not. Third is interviewer bias, which is increased by having a single researcher (LH) conducting interviews, especially given her previous research on this topic, so themes were tested by discussion among the three authors in an attempt to address this.

Fourth, we did not seek to build consensus on the causes or solutions. For the latter, one option, undertaken with other contentious issues such as Brexit, would be a citizens' assembly.[57]

Finally, we cannot say why some experts in public health do not see the change in trends in life expectancy in the UK as not significant. Yet, without a shared understanding, we will struggle to propose solutions.[58]

Conclusion

Twelve influential public health experts varied in their view of the scale, nature, and causes of the stall of improvements in life expectancy in England and Wales in the 2010s. Those who felt there was a problem called for implementation of existing evidence to address health inequalities, acting on the social determinants of health, and investment in public services. However, without agreement about what the data tell us, it is difficult to see how policies can be enacted to improve health and reduce inequalities. This makes it difficult to agree what needs to be done and, while politicians must decide on policy, when experts disagree, change is less likely.

Author statements

Acknowledgements

We are extremely grateful to all the experts who took part in the interviews and consented to their quotes being used anonymously in the paper. We would like to thank the reviewers whose detailed and thorough reviews significantly improved the paper.

Ethical approval

Ethical approval was granted on 3 November 2021 from the University of Oxford Social Sciences ethics board, reference: SOGE 1A2020-205.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interests

No further competing interests declared beyond the reflexivity statement included in the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.10.019.

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8.3 Political Constraint in Public Health Discourse

The interview findings highlight a fragmentation in how the UK's mortality crisis was understood and communicated. Structural explanations, such as austerity, were seen as credible by some interviewees, yet were rarely prioritised publicly. This pattern aligns with broader critiques of the professional culture of public health. Walsh and McCartney explore how governments and agencies, including international actors such as the World Health Organization (WHO), responded to the life expectancy crisis (Walsh & McCartney, 2024a). They argue that public health actors often face systemic disincentives to name or challenge the political roots of health inequalities and describe how institutional expectations, the professionalisation of neutrality, and media framing all contribute to a constrained interpretive field in which technocratic or proximate explanations are favoured and structural political causes remain less prominent.

This analysis highlights that depoliticisation is not accidental but is embedded in the ways in which public health evidence is produced, disseminated, and acted upon. The result is a form of epistemic precarity: even when causation is well-founded, institutional norms can render it unsayable.

8.4 Chapter 8 Summary and Next Steps

Expert interpretations of the post-2010 mortality reversal were heterogeneous and often publicly cautious. Interviews revealed that while many experts regarded austerity as a credible driver, structural explanations were rarely foregrounded. Instead, proximate narratives, seasonal influenza, adverse winters, coding artefacts, or cohort ageing were repeatedly preferred in public-facing discourse. This pattern reflected not only evidential uncertainty but institutional and professional norms.

This chapter builds directly on the analysis in Chapter 2 of why weak, proximate explanations persisted. Recognising institutional constraints clarifies why proximate accounts persisted and shows the importance of an integrated account of how structural conditions, operating across the components of the human ecological system and the SDH, shape population vulnerability.

Having traced how proximate narratives endured and why structural ones were muted, the thesis now turns to the discussion, where these empirical and interpretive insights are synthesised and interpreted through the lens of the integrated theoretical framework.

PART III: SYNTHESIS & IMPLICATIONS

9 DISCUSSION: EXPLAINING A LOST DECADE

9.1 Introduction

The final chapter of this thesis synthesises the findings and how they help to explain Britain's post-2010 mortality reversal. The empirical analyses demonstrated that the deterioration was real, prolonged, and unevenly distributed across people and places. They also showed that commonly cited proximate explanations, such as influenza, demographic ageing, or a return to long-term trends, cannot account for the timing, magnitude, or geography of the crisis. Having evaluated and rejected these alternatives through a falsification approach, the thesis now turns to the structural explanation that remains: austerity.

The integrated framework introduced in Chapter 3 provides the interpretive structure for this synthesis. By examining dimensions of population, habitat, and behaviour, and by identifying the SDH operating within each of these, the framework offers a coherent way to understand how austerity reshaped ecological conditions for health. It also helps explain why the impacts were so uneven and why some communities were far more exposed than others.

This chapter proceeds as follows. Section 9.2 provides an overview of the main findings. Section 9.3 revisits the RQs and summarises how the empirical papers address them. Section 9.4 synthesises the empirical findings through the integrated framework to explain how austerity altered vulnerability, eroded resilience, and produced the conditions underlying the UK's lost decade of health improvement. Section 9.5 considers the contributions and value of the thesis, while Section 9.6 describes its strengths and limitations. Section 9.7 examines why structural

explanations were frequently marginalised despite accumulating evidence. The concluding sections outline implications for public health and health geography, remaining unanswered questions, and priorities for future research.

9.2 Summary of Main Findings

Austerity represents the most plausible and significant structural explanation for the post-2010 mortality deterioration, based on temporal alignment between policy implementation and health outcomes, spatial correlation between cuts and mortality worsening, dose-response patterns linking severity of cuts to health deterioration, systematic elimination of prominent alternative explanations, coherence with established understanding of SDH, consistency with theoretical frameworks linking political economy to population health, and comparative evidence showing UK divergence from peer nations.

The evidence presented meets the threshold typically used to inform public health action, stronger than speculation but acknowledging residual uncertainty. In Bradford Hill's framing, the question is not whether we have “indisputable evidence” but whether there is "any other answer equally, or more, likely than cause and effect" (Hill, 1965). The systematic evaluation across Chapters 2-8 suggests there is not.

9.3 Revisiting the Research Questions

This thesis addressed three RQs, progressing from description to causal evaluation and, finally, to interpretive analysis. Together, they establish what happened to population health in the UK after 2010, which explanations remain plausible after systematic testing, and why weaker accounts persisted despite growing contradictory evidence.

RQ1: What happened to life expectancy trends in the UK after 2010, and what caused these changes?

Chapter 2 and Paper 1 (Chapter 4) demonstrated that the post-2010 period marked a decisive break in the long-term trajectory of mortality improvement, and provided initial evidence on causation, showing that the timing, geography, and social patterning of the slowdown did not align with demographic ageing or single-cause effects, highlighting the need for further evaluation of commonly cited explanations.

RQ2: How well do commonly suggested proximate explanations, such as influenza, ageing, or other age- and cause-specific effects, account for these trends?

Chapters 2, 5 and 6 addressed this question directly. Paper 2 (Chapter 5) showed that influenza could not account for the magnitude or distribution of excess mortality. Paper 3 (Chapter 6) demonstrated that cohort processes, including ageing of the "Golden Cohort", also failed to explain the post-2010 reversal: even this historically advantaged generation experienced unexpected increases in mortality after 2012, inconsistent with demographic inevitability. Paper 4 (Chapter 7) extended this evaluation through international comparison, showing the UK exhibited a distinct "jump-then-fall" trajectory, with unusually rapid gains in the 1990s-2000s followed by an unusually sharp and persistent slowdown after 2012. This pattern was not replicated to the same extent in comparator nations.

Taken together, the analyses show that proximate and demographic explanations are insufficient.

RQ3: How did expert interpretations of these trends vary, and why did some narratives persist despite mounting contrary evidence?

Paper 5 (Chapter 8) examined how experts understood and communicated the mortality trends. Although many interviewees regarded austerity as a credible structural explanation, it was rarely foregrounded publicly. Instead, proximate narratives, such as influenza, cold winters, or coding artefacts, remained common in public-facing outputs.

9.3.1 Summary

Together, in answering the three RQs, the thesis shows how the UK experienced a genuine and internationally exceptional deterioration in mortality trends after 2010. Proximate, demographic, and comparative explanations cannot account for its defining features. At the same time, institutional constraints shaped public interpretation of the slowdown, sustaining narratives that obscured emerging structural harm. These findings establish the foundation for the synthesis that follows, which draws on the integrated framework to explain how austerity reshaped vulnerability across population, habitat, and behavioural dimensions.

9.4 Synthesising the Findings through the Integrated Framework

The integrated framework developed in Chapter 3 combines three strands of thinking, not in a novel framework, but in an innovative use of existing theoretical frameworks. In summary, first, the SDH provide the catalogue of factors that influence health beyond the individual. Second, the Triangle of Human Ecology provides a framework for interpreting health, with outcomes arising from interactions among population, habitat, and behaviour. Third, the concepts of precarity and resilience capture how people and places absorb or amplify structural shocks over

time. Taken together, these elements offer a way to interpret the empirical findings as the outcome of changing relationships between populations, their environments, and the practices and institutions that connect them.

9.4.1 Population

Within the Triangle of Human Ecology, the population domain refers to demographic characteristics such as age, sex, cohort, and underlying susceptibility (Emch & Goel, 2025; Meade, 1977). The literature review in Chapter 2 and analyses in Chapters 4, 6 and 7 showed that the post-2010 mortality reversal was not confined to a single age group or cohort, but affected multiple segments of the population, with especially sharp effects among older adults and people in more deprived areas (Hiam et al., 2020; Public Health England, 2018a). The Golden Cohort analysis revealed that even those born between 1925 and 1934, historically associated with exceptional longevity due to early-life advantage and post-war welfare expansion, experienced unexpected increases in mortality after 2012 (Hiam & Dorling, 2024). This indicates that the crisis cannot be reduced to demographic inevitability or the ageing of specific cohorts.

Using the SDH as a guide, the population domain highlights how demographic structures intersect with social position and prior life-course exposures. Groups already carrying a higher burden of disadvantage (for example, women in deprived areas, disabled people, and children in poverty) were more exposed to the consequences of austerity and less able to buffer its effects (Macdonald & Morgan, 2021; Rashid et al., 2021; Sakellariou & Rotarou, 2017; Taylor-Robinson et al., 2019; Walsh, Dundas, et al., 2022). In terms of the framework, austerity did not create demographic vulnerability, but it interacted with existing population structures in ways

that increased precarity and reduced the capacity of some groups to withstand further shocks.

9.4.2 Habitat

The habitat domain encompasses the natural, social, and built environments in which people live (Emch & Goel, 2025; Meade, 1977). This includes housing quality, neighbourhood infrastructure, local services, and the broader institutional landscape of welfare and local government. The evidence assembled in Chapters 2, 3, and 4 showed that austerity was geographically uneven: places facing the deepest cuts to local government, welfare, and social care also saw the largest declines in life expectancy and healthy life expectancy, and the greatest widening of inequalities (Alexiou et al., 2021; Beatty & Fothergill, 2016; Marmot et al., 2020; Rashid et al., 2021; Stokes et al., 2022).

Viewed through the SDH catalogue, the habitat domain demonstrates that austerity altered the environments that underpin community health. Reductions in local authority budgets affected social care, youth provision, housing support, transport, public health programmes, and other services that sustain everyday living conditions (Alston et al., 2021; Cattan et al., 2025; Department of Health, 2015; Rex & Campbell, 2022; Robinson & Sheldon, 2019; Wise, 2021). In many deprived areas, these cuts arrived on top of long-standing structural disadvantages, eroding the material and institutional resources that had previously supported resilience (Finch et al., 2025; Health Equity North, 2024). The result was an increase in place-based precarity: local systems had fewer tools with which to absorb economic shocks or protect residents from their consequences. Changes in high street environments reinforce this interpretation: research found that between 2014 and 2024, the most deprived neighbourhoods in England were more likely to gain health-harming

amenities such as fast-food outlets, gambling and vape shops, and to lose health-promoting ones such as supermarkets and public toilets, with particularly pronounced changes in Northern regions (Zied Abozied et al., 2026). These shifts illustrate how national political and economic decisions reshape local commercial ecologies, concentrating risk and reducing everyday resilience in already disadvantaged places.

The international comparisons in Chapters 2 and 7 reinforces this interpretation (Ho & Hendi, 2018; Minton et al., 2023; Office for National Statistics, 2018). If the slowdown had simply reflected shared demographic pressures or global changes, similar patterns would have appeared across comparable countries. Instead, Britain's distinctive "jump-then-fall" trajectory suggests that changes in habitat, including the way austerity was implemented across local environments, played a central role in shaping the mortality reversal.

9.4.3 Behaviour

The behaviour domain includes the beliefs, social organisation, technologies, and adaptive practices through which people interact with their environments and with institutions (Emch & Goel, 2025; Meade, 1977). In the context of the post-2010 mortality reversal, austerity reshaped these behavioural pathways in ways that made protective practices harder to sustain and increased the effort required to access support.

At the individual level, welfare reforms and administrative changes altered how people navigated benefits, housing support, and social care (Barford & Gray, 2022; Pearce & Kelly, 2025). New forms of conditionality, greater bureaucratic complexity, and reduced availability of local services meant that actions which previously

buffered hardship, such as seeking advice, engaging with community organisations, and accessing preventive or routine care, became more difficult to access or less effective (Price, 2024; Smith, 2023), and were disproportionately cut in deprived areas (Barlow et al., 2021; Robertson et al., 2017; Thomas, 2019). In health and social care, cuts contributed to rising waiting times and declining service capacity, which in turn affected help-seeking behaviours and increased unmet need (Hiam et al., 2017a; Reeves et al., 2015; Stuckler et al., 2017). These developments represent a form of behavioural precarity: individuals had fewer viable pathways to maintain health amid worsening material conditions.

A second aspect of the behaviour domain relates to institutional practices. As shown in Chapter 8, experts held divergent views about the nature and causes of the slowdown, reflecting epistemic caution, disciplinary differences, and the political sensitivity of structural explanations (Hiam et al., 2023b). These dynamics shaped how evidence was interpreted and communicated, narrowing the range of narratives that entered public discussion (Walsh & McCartney, 2024a). Analysis of these interpretive processes is developed in Section 9.6; here, their relevance lies in highlighting how institutional behaviour formed part of the ecological context within which the crisis unfolded.

Taken together, the behavioural domain shows that austerity not only altered environments and heightened demographic vulnerabilities but also disrupted the adaptive and institutional pathways through which individuals and systems respond to health risks. This contributed to reduced resilience across the human ecological system and intensified the effects observed in the population and habitat domains.

9.4.4 Austerity as a Systemic Shock and Ecological Stressor

When considered together, the population, habitat, and behaviour domains provide an integrated account of the UK's mortality reversal. Austerity acted as both a policy shock (Stuckler et al., 2017) and an ecological stressor: it interacted with existing demographic vulnerabilities, altered the environments in which people live, and constrained the practices and institutional pathways through which they seek and receive support. The SDH specify the channels through which these changes occurred, from income and employment to housing, local services, and access to care (Hiam, Klaber, et al., 2024; Marmot et al., 2020). The concepts of precarity and resilience help explain why the effects were so uneven, both socially and geographically. Pre-existing disadvantages in population structure, local conditions, and institutional capacity meant that some places and groups were far less able to absorb the shock than others.

Thus, the integrated framework does more than label austerity as a structural determinant. It clarifies how the crisis emerged from the interaction of population characteristics, environmental conditions, and institutional and behavioural practices, and why its consequences were concentrated in some communities. The mortality slowdown of the 2010s is thus best understood not as the result of isolated risk factors, but as the outcome of a reconfigured human ecological system under sustained political and economic pressure.

9.5 Contributions and Value of the Thesis

This thesis provides empirical, methodological, and conceptual value by systematically evaluating competing explanations for the UK's post-2010 mortality slowdown and interpreting the findings through an integrated theoretical framework.

9.5.1 Empirical Value

Empirically, the thesis offers an original and coherent account of the scale, timing, and distribution of the UK's mortality reversal. Paper 1 demonstrated that life expectancy stalled and, in some groups, declined, with declining health across a range of outcomes. Papers 2, 3, and 4 showed that widely cited proximate explanations of influenza, demographic ageing, or a return to long-term trends do not account for the observed patterns. The comparative analyses further established that the UK diverged from peer countries, indicating a domestic structural process rather than an international epidemiological shift.

These findings refine the understanding of the slowdown by demonstrating that it was both real and spatially patterned, and that its defining features are inconsistent with proximate, single-factor interpretations. The thesis, therefore, strengthens the empirical basis for considering structural explanations, particularly those linked to austerity and its uneven distribution across places and populations.

9.5.2 Methodological Value

Methodologically, the thesis demonstrates the utility of a mixed-methods, falsification approach for assessing population-level health change, where more traditional methods, such as a randomised controlled trial (RCT), are not feasible. Quantitative analyses employed demographic, epidemiological, and comparative methods to test alternative hypotheses against established criteria. This approach demonstrates how causal inference can be strengthened by explicitly evaluating competing explanations rather than relying on single indicators.

The qualitative research adds insight into how experts interpreted the same trends, revealing variation in causal reasoning, thresholds of evidence, and raised questions

of sensitivities around politically charged explanations. Integrating these perspectives with quantitative findings illustrates the value of combining empirical assessment with interpretive analysis when examining contested health phenomena.

9.5.3 Conceptual Value

Conceptually, the thesis contributes through its innovative use of existing theoretical frameworks, integrating the SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience. The framework provides a structured way of organising existing ideas about how population, habitat, and behaviour interact. Applied throughout the empirical chapters and synthesised in this discussion, it helps explain how macro-level policy changes, through austerity policies, reshaped the ecological conditions for health in ways that were uneven across people and places.

9.6 Strengths and Limitations

This thesis has several strengths, as well as limitations inherent to observational, population-level research.

9.6.1 Strengths

A core strength is the systematic, falsification approach used to evaluate competing explanations for the post-2010 mortality slowdown. By testing proximate, demographic, and comparative hypotheses before considering structural explanations, the thesis strengthens causal inference. The quantitative analyses draw on robust official datasets, long-term series, and international comparisons, enabling careful assessment of timing, magnitude, and geographic patterning.

The mixed-methods design is another strength. Quantitative work identifies the parameters of the crisis and evaluates alternative explanations, while qualitative interviews illuminate how experts interpreted the same evidence yet produced

divergent causal narratives. Triangulating across these perspectives provides a more complete understanding of both the empirical trends and the interpretive processes surrounding them.

Finally, the integrated theoretical framework provides a coherent framework for interpretation. It does not constitute a new theory but instead supports a coherent synthesis and exploration throughout the thesis.

9.6.2 Limitations

a) The Limits of Observational Evidence

The most fundamental limitation is one shared with all population-level policy research: the evidence is observational rather than experimental. No RCT assigned different austerity intensities to comparable populations. This creates three interrelated challenges that cannot be entirely overcome.

First, confounding. Multiple changes occurred in Britain after 2010 beyond austerity policies: the 2008 financial crisis continued to reverberate through labour markets and household finances; political discourse became increasingly polarised, culminating in the 2016 Brexit referendum, which introduced new sources of uncertainty including health impacts (Fahy et al., 2019); technological changes affected employment and social connection, with rising levels of isolation and loneliness, which are themselves bad for health (Naito et al., 2023; Wang et al., 2023).

The Bradford Hill criteria provide a framework for evaluating causation from observational evidence, and the falsification approach strengthens inference by systematically testing competing explanations; however, these methods establish plausibility rather than certainty. The evidence certainly meets the precautionary

principle threshold sometimes used in public health policy (Kriebel et al., 2001), but not the internal validity of RCTs.

Second, measurement heterogeneity in that “austerity” is not a single intervention but a complex package of policies implemented at different times, with varying intensity across places, and subject to modifications (Anderson & Minneman, 2014). Welfare reform included benefit caps, sanctions regimes, changes to disability assessments, and the rollout of Universal Credit, each with distinct mechanisms and timelines. Local government cuts affected services (social care, public health, housing, youth services) in varying combinations, depending on local priorities and starting points. NHS funding constraints manifested differently across commissioning areas and provider organisations.

This heterogeneity means the thesis cannot isolate the effect of specific policies from the broader package, nor precisely quantify the relative contribution of different austerity measures to mortality outcomes. The integrated framework attempts to address this by disaggregating mechanisms across dimensions (population, habitat, behaviour), and some of the literature has looked at specific correlations between local authority cuts and health outcomes (Alexiou et al., 2021; Friebel et al., 2022; Stokes et al., 2022). However, treating austerity as a single exposure limits the capacity for targeted policy recommendations. We can conclude that the package was harmful but cannot specify with precision which elements were most damaging.

Third, and finally, temporal complexity. The relationship between policy implementation and health outcomes involves multiple timescales. Some effects may be immediate (e.g., the effects of benefit sanctions on household income), while others operate over years (e.g., cumulative stress effects on cardiovascular health) or even decades (e.g., the effects of early-life poverty on child development).

Different pathways may have different lag structures, and effects may interact and compound over time.

This temporal complexity creates challenges for causal attribution. The deterioration began around 2011-2012, shortly after the implementation of the 2010 austerity measures, thereby satisfying the temporality criterion. However, explaining why mortality trends continued to worsen through 2019 requires invoking cumulative and persistent effects that are theoretically plausible but empirically difficult to demonstrate. The precarity and resilience concepts within the framework provide theoretical grounding for these lagged and cumulative effects, but the thesis cannot specify precise lag structures or quantify the extent to which the 2016-2019 deterioration reflects 2010-2015 policies versus more recent factors.

b) Study-specific Limitations

Each empirical paper also has limitations, including the reliability of the data used, the lack of disaggregation that can obscure inequalities in some interpretations, and the reliance on accurate ICD-10 coding and recording (Paper 2). Paper 3 examines a single birth cohort and cannot adjudicate among all demographic explanations. Paper 4 depends on model specification and data consistency across countries. Paper 5 reflects the views of a purposive sample of senior experts, does not include local practitioners or affected communities, and may reflect the interviewer's biases.

c) Thesis Limitations

At the thesis level, integrating quantitative and qualitative components involves interpretive judgement, and the focus on England, Wales, and Scotland limits generalisability to other settings. The integrated framework aids interpretation but is not exhaustive; other theoretical perspectives could complement the analysis.

Furthermore, alternative structural explorations are not widely reviewed and are beyond the scope of this thesis. As outlined above, other major political shocks during that period include Brexit, resulting changes in immigration, ongoing deindustrialisation and economic restructuring, and housing and affordability crises. However, one could argue that austerity amplified these effects through the mechanisms described in the integrated framework, affecting each component and dimension, increasing precarity, and eroding resilience.

d) Conclusion

These limitations mean that the thesis cannot claim to have proven that austerity caused the mortality reversal, in the sense of establishing causation with certainty. What the evidence does support is a more qualified but still substantive claim, as outlined in Section 9.2.

9.7 Why was Austerity Overlooked for so Long?

Despite increasing evidence that austerity was central to the post-2010 mortality slowdown, these explanations remained marginal in public-facing narratives. Insights from the interviews in Paper 5, alongside wider scholarship on uncertainty, denialism, and evidence politics, help explain why proximate accounts persisted, and structural interpretations struggled to gain traction.

9.7.1 Fragmented Interpretation and Political Sensitivity

The interviews showed that experts approached the slowdown from different vantage points, for example, disease-specific epidemiology, demographic trend analysis, inequalities research, or broader SDH frameworks (Hiam et al., 2023b). These differing interpretive orientations, sometimes reflecting different disciplines, shaped which explanations felt plausible. Structural accounts resonated more strongly with

those that foregrounded inequalities and social context, whereas others prioritised disease-specific or demographic reasoning. This fragmented interpretive landscape hindered the emergence of a unified explanatory narrative and created an environment in which proximate accounts continued to circulate even when they were inconsistent with the empirical pattern, thereby providing cover for politicians who may have preferred these explanations.

Public health institutions operated under structural and communication constraints, with organisational norms encouraging caution in relation to politically sensitive claims (Walsh & McCartney, 2024a). This analysis aligns with broader critiques of how mainstream public health conceptualises evidence, policymaking, and the role of politics (Kothari & Smith, 2022). Kothari and Smith argue that public health often adopts an apolitical, technocratic model of evidence-based decision-making that privileges epidemiological modes of inference and assumes a rational pathway from evidence to policy. This can obscure the political and ethical dimensions of structural determinants, such as austerity, and contribute to institutional discomfort with causal claims that cannot be demonstrated through experimental or quasi-experimental designs. As Kothari and Smith note, the sector's tendency to portray itself as value-neutral limits its capacity to recognise political determinants, challenge structural drivers of inequality, or enter debates where evidence and politics are intertwined. This reflects a form of institutional precarity, with reduced capacity to identify, articulate, and, as a result, respond to structural harm.

9.7.2 Denialism and Performative Doubt

The dynamics evident in the austerity debate align with the established phenomenon of science denialism, defined as the creation of a false impression of scientific controversy where none exists (Diethelm & McKee, 2009). Denialism has been used

by so-called “merchants of doubt” (Oreskes & Conway, 2022) to limit climate change legislation and argue for other harmful industries such as fossil fuels and tobacco. Diethelm and McKee describe strategies used to manufacture doubt, summarised as the FLICC framework (Cook, 2020; Diethelm & McKee, 2009): false experts, logical fallacies, impossible expectations, cherry-picking, and conspiracy-like framing.

McCartney and Walsh highlight how politically sensitive structural explanations are particularly vulnerable to dismissal through appeals to methodological purism or overemphasis on uncertainty (Walsh & McCartney, 2024a). This “performative doubt” is weaponised by certain actors, for their own gain, and often results in upstream determinants being subjected to disproportionate scrutiny relative to proximate explanations (Hiam, 2025)[h]. Within the austerity debate, the most prominent mechanism was impossible expectations: the imposition of evidential thresholds that no macro-level social policy could satisfy, while proximate explanations were rarely scrutinised to the same degree.

9.7.3 Summary

Amid an environment of entrenched science denialism and impossible expectations for evidence, structural explanations remained relatively invisible in public narratives, despite increasing empirical support. These processes form part of the behavioural and institutional pathways within the integrated framework and help explain not only how the mortality crisis developed but also how its causes became obscured within public discourse.

[h] The cited BMJ Opinion piece is one of a series I am writing as part of my Harkness Fellowship on reflections of the US health system. Those published to date are included in Appendix 6.

9.8 Implications for Public Health and Health Geography

The findings of this thesis have important implications for both public health practice and the discipline of health geography. By demonstrating that the post-2010 mortality slowdown reflects structural and ecological change rather than proximate or demographic fluctuations, the thesis underscores the need for approaches that can recognise, analyse, and respond to upstream determinants of health.

9.8.1 Implications for Public Health

For public health, the analysis affirms that health crises are both political and epidemiological events. The persistence of proximate narratives, despite weak empirical support, shows how institutional norms, epistemic caution, and political sensitivities can limit the visibility of structural and political determinants. This has consequences for accountability. When harm arising from policy is obscured, opportunities for prevention and correction are diminished. The findings highlight the need for public health institutions to develop clearer strategies for engaging with political determinants, including stronger capacities to synthesise observational evidence, articulate structural mechanisms, and communicate uncertainty without allowing it to be weaponised.

Failure to recognise upstream drivers narrows the scope of intervention. Changing high street environments, for example, show how national economic and regulatory decisions can translate into local health-harming and “addictive” environments, concentrated in deprived communities, further highlighting the need for public health to treat commercial and spatial patterns as political determinants rather than neutral backgrounds (Zied Abozied et al., 2026).

When health deterioration is attributed primarily to seasonal factors such as influenza or cold winters, ageing, or data artefacts, attention shifts towards surveillance rather than prevention and towards clinical services rather than social and economic policy. This thesis shows that such a shift misdiagnoses the problem and weakens the policy response. Addressing structural determinants requires public health to engage more confidently with political economy, to articulate the material and institutional conditions that shape vulnerability, and to advocate for environments that support resilience rather than erode it, moving beyond narrow hierarchies of evidence to recognise that policymaking is inherently political, value-laden, and shaped by power (Kothari & Smith, 2022).

9.8.2 Implications for Health Geography

For health geography, the findings validate the value of spatial and ecological analyses in understanding structural change. Aggregate health outcomes, like national life expectancy, obscure the profoundly uneven geography of austerity-related harm. By situating mortality trends within a theoretical framework linking population, habitat, and behavioural pathways, the thesis highlights how local environments, institutional infrastructures, and pre-existing inequalities mediate the effects of policy change. This affirms a central contribution of health geography: the exposure of geographies of vulnerability and resilience that are invisible in aggregate statistics.

The integrated theoretical framework also suggests opportunities for interdisciplinary development. Bringing political economy and ecological thinking into closer dialogue strengthens health geography's capacity to analyse how macro-level decisions are experienced unevenly across places. It emphasises that spatial patterns of harm are not just distributions but products of historically and politically constituted

environments. As such, the thesis contributes to ongoing efforts to conceptualise health as an emergent property of socio-spatial systems rather than an outcome reducible to individual behaviours or biomedical risk factors.

9.9 Unanswered Questions and Future Research

9.9.1 Unanswered Questions

Many questions remain unanswered. This section details some of the most important ones, but it is not exhaustive. First, as noted in the limitations, the extent of mortality deterioration attributable to austerity versus other factors remains unknown, and austerity is likely a mediator of other proximate factors (Broadbent et al., 2023). Linked to this, it is unclear which austerity policies mattered most, whether welfare cuts, for example, were more damaging than NHS underfunding, or whether local government cuts to social care had larger effects than cuts to public health services. An important question for future policy and public health interventions is which aspects of resilience were most effective in mitigating the harms of austerity and how these could be supported at the community level. Additionally relevant to policy is the question of how quickly mortality would improve if austerity policies were reversed, and, linked to that, whether there are some irreversible effects, for example, the impacts on children who have only known the austerity years. Of course, the counterfactual trajectory cannot be known, what would have happened to UK mortality trends in the absence of austerity, and whether the improvements of the 1990s and 2000s might have continued. These questions, and others, should inform future research into the harms of austerity and policy responses.

9.9.2 Future Research

The analyses in this thesis and unanswered questions above open several avenues for further research that would deepen understanding of structural health change and extend the integrated framework to other contexts.

First, there is scope for comparative work to develop and apply the integrated framework to other countries that have experienced austerity or similar forms of fiscal retrenchment. Cross-national analyses could clarify which features of the UK case are context-specific and which reflect broader mechanisms linking political economy to population health. Comparative subnational studies examining regions within countries under different policy regimes and modes of implementation could also illuminate how place-based resilience and precarity shape divergent trajectories.

Second, future research could develop more refined quantitative approaches for assessing macro-level structural change. These may include small-area longitudinal models, causal inference techniques adapted for policy evaluation, or mixed-methods designs linking administrative data with qualitative research on lived experience. This may help assess the magnitude of impact and identify which policies mattered most. There is also potential to extend the cohort analyses to additional generations or to incorporate morbidity and functional health outcomes alongside mortality.

Third, further work is needed to examine how public health institutions understand and communicate politically sensitive evidence. Building on the interview findings, research could explore organisational decision-making, the role of professional norms, and how institutional precarity affects the visibility of structural determinants.

Studies of communication strategies, for example, how to convey uncertainty without enabling denialism, would support more effective public health practice.

Fourth, and finally, the integrated framework itself could be tested and elaborated in different empirical settings. Applications to other domains of structural harm, such as climate change, housing insecurity, or labour market restructuring, may clarify how population, habitat, and behavioural pathways interact across contexts. There is also scope for integrating additional theoretical perspectives to strengthen the understanding of how structural shocks become embodied and spatially patterned.

9.10 Conclusion

This thesis set out to explain the reversal in population health improvements in the UK after 2010 and to understand why interpretations of this reversal diverged so sharply. By evaluating competing explanations and novel, integrated application of existing theoretical frameworks, it has shown that the post-2010 mortality slowdown was not the product of influenza, demographic ageing, or statistical artefact, nor a return to previous longer-term trends. Instead, the evidence indicates a structural rupture resulting from austerity policies that altered the ecological conditions for health across population, habitat, and behavioural domains.

The qualitative research recognises the disparate interpretations among experts, providing both questions and answers regarding why recognition of structural causation was slow to emerge. Epistemic caution, political sensitivity, fragmented interpretive cultures, and the dynamics of science denialism contributed to the persistence of proximate narratives even as the empirical case for a structural explanation strengthened. These interpretive processes form part of the behavioural

and institutional pathways that mediate how health crises are understood and acted upon.

The theoretical framework, which integrates SDH, the Triangle of Human Ecology, and the concepts of precarity and resilience, provides a coherent framework for interpreting these findings. It demonstrates that health outcomes arise from interactions between people, environments, and institutions, and that political choices operate through these interactions to shape vulnerability. When viewed through this ecological lens, Britain's "lost decade" becomes legible not as a collection of isolated trends but as a systemic consequence of policy-driven restructuring.

Recognising austerity as a structural determinant of health is not an endpoint but a starting point. It highlights the importance of political accountability, the need for public health to engage more directly with upstream determinants, and the value of spatial and ecological perspectives in analysing health. The findings also draw attention to the importance of evidence interpretation. When structural harms are obscured, opportunities for prevention are missed, and inequalities deepen.

Ultimately, this thesis supports the notion that population health is shaped not only by individual biology or behaviour, but by the political and economic environments in which people live. Understanding how those environments are produced and how their effects become visible or concealed is essential for preventing future crises and for rebuilding the institutional and material conditions that enable populations to thrive.

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PART V: APPENDIX

11 APPENDIX 1: LIFE EXPECTANCY IN 2020-2022 VS 2010-2012

To assess whether the UK's experience of life expectancy falling back to 2010–2012 levels was unusual, as suggested by the ONS data cited in the introduction, I undertook a comparative analysis using data from the Human Mortality Database (HMD). The analysis focuses on life expectancy at birth (e_0) across other high-income countries (HICs) available in the database.

For each country, life expectancy values for 2010, 2011, and 2012 were averaged to generate a baseline estimate for 2010–2012. The same approach was applied to 2020, 2021, and 2022 to produce a corresponding estimate for 2020–2022. The difference between these two period averages was then calculated and expressed as either a positive change (an increase in e_0 between 2010–2012 and 2020–2022) or a negative change (a decline). Countries with one or more years of missing data were excluded from the analysis.

Figure 11 shows the findings for total e_0 i.e. both sexes. The USA, Poland, England & Wales, Canada, UK total population and Scotland were the only countries to fall to or below 2010-2012 levels.

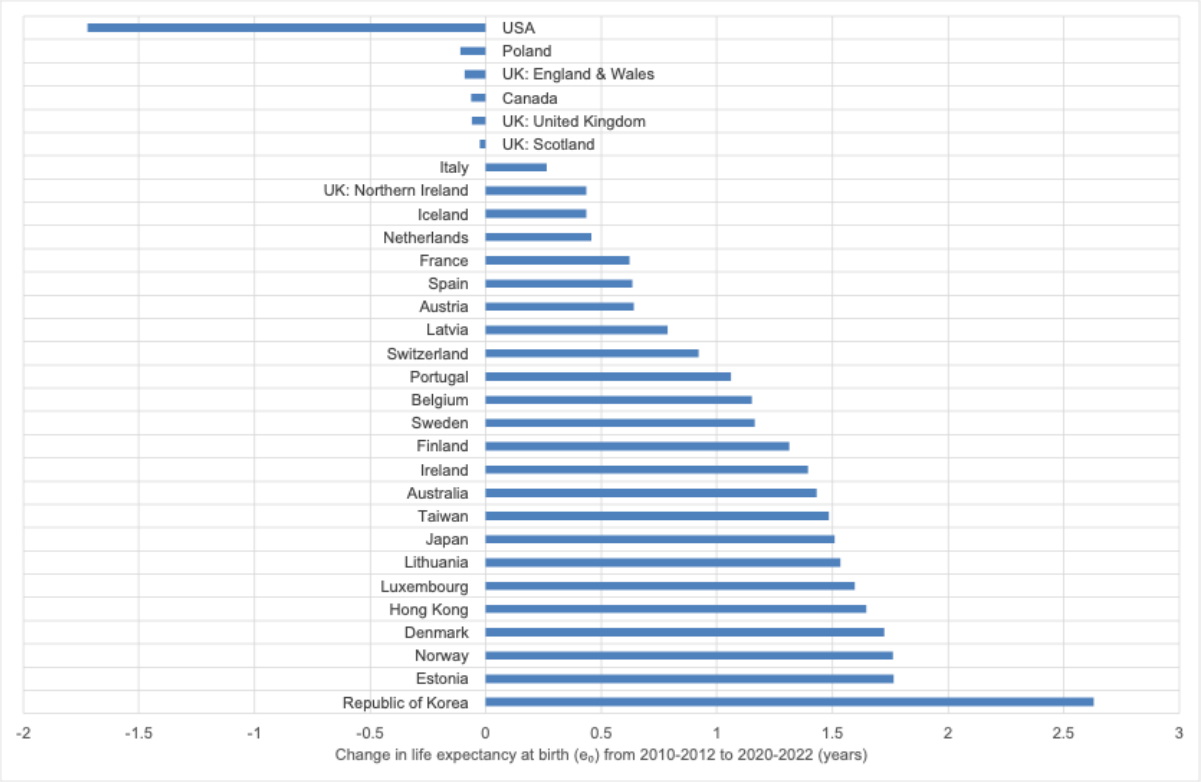


Figure 11: Changes in life expectancy at birth for both sexes from 2010-2012 to 2020-2022 in years in selected HICs. Data source: HMD

12 Appendix 2: Co-Authorship Statements

12.1 Co-authorship Statement: Paper 1

Lucinda Hiam conceptualised and designed the study, led the analyses, and wrote the first draft of the manuscript. Her co-authors and supervisors contributed through critical review and editing of the manuscript and by providing additional analytical input. Lucinda Hiam led the submission process and was responsible for responding to reviewers' comments and preparing the final version of the paper.

12.2 Co-authorship Statement: Paper 2

Lucinda Hiam led the conceptualisation of the study and was responsible for project administration, investigation, data curation, methodological development, and formal analysis. She wrote the original draft of the manuscript and led subsequent revisions. Martin McKee contributed to the conceptualisation and investigation, provided methodological input and supervision, and contributed to review and editing. Danny Dorling contributed to the conceptualisation, data curation, formal analysis, and methodology, and provided supervision, validation, and visualisation. All authors contributed to the review and editing of the manuscript.

12.3 Co-authorship Statement: Paper 3

Lucinda Hiam and Danny Dorling jointly conceptualised the study. Lucinda Hiam led the analysis and wrote the first full draft of the manuscript, with substantial intellectual input from Danny Dorling throughout the development of the paper. Data analyses were conducted collaboratively. Lucinda Hiam finalised the manuscript for submission, led responses to peer review, and prepared the final version for publication.

12.4 Co-authorship Statement: Paper 4

Lucinda Hiam conceptualised and designed the study and brought the research team together. She worked closely with Jon Minton to refine the methodology and analytical approach. Jon Minton conducted the statistical analyses with collaborative input from Lucinda Hiam. Martin McKee and Danny Dorling provided supervision and intellectual guidance throughout the development of the study. Lucinda Hiam wrote the first draft of the manuscript, led revisions in response to reviewer feedback, and prepared the final version for submission.

12.5 Co-authorship Statement: Paper 5

Lucinda Hiam conceptualised and designed the study and led the methodological development. She conducted all interviews and carried out the analyses. Lucinda Hiam wrote the first draft of the manuscript, including presentation of the results, before sharing it with co-authors for review and input. She then led revisions, responded to reviewers' comments, and prepared the final published version of the paper.

13 Appendix 3: List of Publications

The list below presents publications during my DPhil, from October 2019 to date of submission, in reverse chronological order (i.e. most recent first).

1. **Hiam L**, Minton J, Burns R, Aldridge RW. How does mortality compare between different countries/regions of birth for the population of England and Wales, 2007 to 2021? A descriptive, observational study. J R Soc Med. 2025 Dec 12:14107682513775 64. doi: 10.1177/01410768251377564.
2. **Hiam L.** US gun violence is a preventable health crisis. BMJ. 2025 Nov 21;391:r2465. doi: 10.1136/bmj.r2465. PMID: 41271241.
3. **Hiam L.** Waiting for America's healthcare revolution. BMJ. 2025 Nov 3;391:r2283. doi: 10.1136/bmj.r2283. PMID: 41184026.
4. **Hiam L**. Performative doubt and the fight for public trust BMJ 2025; 391 :r2077 doi:10.1136/bmj.r2077.
5. **Hiam L**. Political polarisation: an overlooked determinant of health. BMJ. 2025 Sep 5;390:r1858. doi: 10.1136/bmj.r1858. PMID: 40912725.
6. Morley J, Barry E, **Hiam L**. Can a digital NHS be equitable? BMJ. 2025 Jun 27;389:r1317. doi: 10.1136/bmj.r1317. PMID: 40578846.
7. McCartney G, **Hiam L**, Walsh D, Smith KE, Walsh D. UK welfare reforms threaten health of the most vulnerable. BMJ. 2025 Mar 25;388:r593. doi: 10.1136/bmj.r593. Erratum in: BMJ. 2025 Apr 2;389:r660. doi: 10.1136/bmj.r660.
8. **Hiam L**, Walsh D, McCartney G. Trends in UK mortality reflect a public health failure BMJ 2025; 388 :r525 doi:10.1136/bmj.r525
9. **Hiam L**. Book Review: Social Murder? The Effects of Austerity on Population Health in the UK. J Epidemiol Community Health Published Online First: 30 January 2025. doi: 10.1136/jech-2024-223593
10. **Hiam L**, Dorling D, McKee M. Changing suicide trends: A shift in regional disparities across the UK. Public Health. 2024 Dec 5;238:90-93. doi: 10.1016/j.puhe.2024.11.018. Epub ahead of print. PMID: 39642537.
11. **Hiam L**, Minton J, Burns R, McKee M, Aldridge RW. To what extent did mortality from COVID-19 in England and Wales differ for migrants compared to non-migrants in 2020 and 2021? A descriptive, observational study. Eur J Public

Health. 2024 Oct 16:ckae142. doi: 10.1093/eurpub/ckae142. Epub ahead of print. PMID: 39413439.

12. McKee R, **Hiam L**, Klaber B. Citizens' assemblies, health, and health policy. BMJ. 2024 Sep 5;386:q1886. doi: 10.1136/bmj.q1886. PMID: 39237302.
13. **Hiam L**, Dorling D, McKee M. Avoidable deaths have increased in the UK: the damning data political parties aren't discussing. The Conversation, July 2024. https://theconversation.com/avoidable-deaths-have-increased-in-the-uk-the-damning-data-political-parties-arent-discussing-234447
14. **Hiam L**. Action is urgently needed on the social determinants of health in the UK. BMJ. 2024 Jun 27;385:q1422. doi: 10.1136/bmj.q1422. PMID: 38936854.
15. Severoni S, **Hiam L**, Garry S. Climate change and health: displaced and migrant populations must be included. Lancet. 2024 Apr 20;403(10436):1537-1538. doi: 10.1016/S0140-6736(24)00243-5. PMID: 38642947.
16. **Hiam L**, Klaber B, Sowemimo A, Marmot M. NHS and the whole of society must act on social determinants of health for a healthier future. BMJ 2024; 385 :e079389 doi:10.1136/bmj-2024-079389
17. **Hiam L**, Dorling D. The rise and fall of Britain's Golden Cohort: how the remarkable generation of 1925–1934 had their lives cut short by austerity, Review of Social Economy, 2024 DOI: 10.1080/00346764.2023.2300007
18. **Hiam L**, McKee M, Dorling D. Influenza: cause or excuse? An analysis of flu's influence on worsening mortality trends in England and Wales, 2010-19. Br Med Bull. 2024 Jan 15:ldad028. doi: 10.1093/bmb/ldad028. Epub ahead of print. PMID: 38224198.
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21. **Hiam L**, Dorling D. The UK government has failed to act on extreme poverty BMJ 2023; 383 :p2638 doi:10.1136/bmj.p2638

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26. **Hiam L**, Yates R. Britain can afford the NHS—and it must to reduce fear during a period of crisis BMJ 2022; 379 :o2987 doi:10.1136/bmj.o2987
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28. **Hiam L**, Dorling D. A return to austerity is not inevitable, it is a political choice BMJ 2022; 379 :o2784 doi:10.1136/bmj.o2784
29. **Hiam L**, Patel P, Burns R, Orcutt M, Miller A, Rae M. "Hands up for our health" calls for suspension of NHS charging regulations. BMJ Opinion, October 2020. https://blogs.bmj.com/bmj/2020/10/06/hands-up-for-our-health-calls-for-suspension-of-nhs-charging-regulations/
30. McKee M, **Hiam L**. Britain's not working BMJ 2022; 378 :o1883 doi:10.1136/bmj.o1883
31. **Hiam L**, Mateescu I, Spiegel P. Improving access to contraception and abortion in Romania in the context of the conflict in Ukraine. Lancet. 2022 Oct 29;400(10362):1497-1498. doi: 10.1016/S0140-6736(22)01275-2. Epub 2022 Jul 8. PMID: 35817077.
32. **Hiam L**, Dorling D. The end of great expectations? BMJ 2022; 377 :e071329 doi:10.1136/bmj-2022-071329

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14 APPENDIX 4: ADDITIONAL EVIDENCE

This section includes selected additional publications during the DPhil which contribute to the overall thesis findings.

Check for updates

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Cite this as: *BMJ* 2022;377:e071329
http://dx.doi.org/10.1136/bmj-2022-071329
Published: 05 May 2022

The end of great expectations?

The pandemic inquiry must account for stalling life expectancy before the pandemic

Lucinda Hiam, Danny Dorling

Life expectancy at birth is a key summary measure of the health of any given population. Ideally, it should increase steadily over time in the absence of data artefact, mass migration in or out, or a large scale event such as war or natural disaster, disease outbreak, or societal collapse. Any break in the trend beyond isolated annual fluctuations should raise the alarm among health workers, policy makers, and the public.

The covid-19 pandemic has caused life expectancy to fall below predicted levels worldwide, including in the UK.[1] Part of this may have been inevitable given what we now know about this new coronavirus, but part could have been avoided. The inquiry into the UK government's handling of the pandemic is essential,[2] not least to provide answers to the tens of thousands of bereaved families who are rightly asking whether more could have been done to save their loved ones.

When the UK inquiry takes place—public hearings are likely to begin in 2023 (the Scottish government's inquiry may start in 2022)[3]—it must also consider what was happening in the UK before the pandemic began. This is essential to ensure that the population harms caused by covid-19 are measured accurately, taking full account of prevailing trends before the pandemic. By March 2020, decades of progress in improving life expectancy had already stalled, and for some groups, reversed. Women over 65 years old were the first to experience falls in their life expectancy.[4] In 2018, the UK's Office for National Statistics (ONS) reported a fall from 82.72 to 82.67 years for women of all ages between 2011 and 2012.[5] Subsequently, more groups and communities have experienced widening inequalities and declines in life expectancy,[6] including women at and below the second most deprived decile in the Index of Multiple Deprivation.[7] Most recently, life expectancy declined for people at and below the fourth most deprived decile between 2015-17 and 2018-20.[8]

In January this year, the ONS published an update of its regular life expectancy projections using the latest population estimates and data on life expectancy, up to and including 2020.[9] Figure 1 shows these and previous projections for both males and females in the UK.

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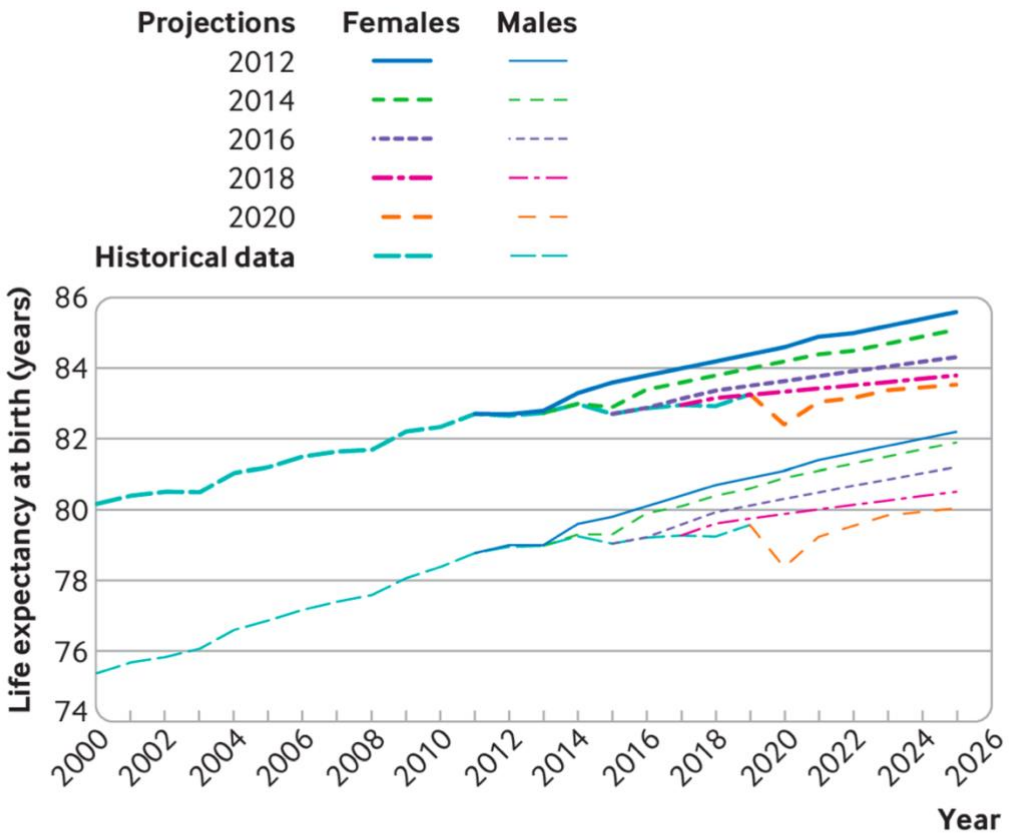


Fig 1 | Projections of life expectancy at birth for males and females in the UK, 2012 onwards. The dotted lines show the actual recorded historical data from 2000 to 2019, and the solid lines show ONS projections made every year from 2011 to 2025[9]

The recorded historical data, represented by the dotted lines, show that life expectancy fell for women briefly after 2011 and for both men and women more substantially after 2014, before rising above the 2014 levels in the year before the pandemic. Between 2012 and 2014, projected life expectancy for people in 2025 fell by 0.5 years for women and 0.3 years for men. Between 2018 and 2020 the same projections fell by 0.3 years for women and 0.5 years for men. In other words, the fall in projected life expectancy caused by the first year of the pandemic was comparable with a similar fall in the early 2010s.

Importantly, estimates of excess mortality linked to the pandemic compare mortality in 2020 and 2021 with a five year average—including the period between 2015 and 2019 when life expectancy was stalling. This distorted baseline (with higher mortality than might be expected historically) may lead to underestimation of the true excess mortality caused by covid-19. We should aspire to a higher level of population health than we had in 2015-19. Notably, the Institute and Faculty of Actuaries covid-19 action taskforce used 2019 alone as its baseline,[10] but even that number is lower than all of the four most recent previous ONS projections made for 2019.

Other high income countries also experienced falls or stalls in life expectancy between 2014 and 2015.[5 11] However, when trends for 18 Organisation for Economic Cooperation and Development countries were examined, researchers found that all countries except the US and UK recovered with "robust gains" in 2015-16.[11] The US is poor company to be in with regard to population health: life expectancy at birth there has declined annually since 2015, except for a small increase in 2019, with increasing inequalities in age at death.[12 13]

These latest ONS data suggest the UK was an outlier among comparable countries, with worsening population health in some years before covid-19.[5] ONS projections of life expectancy are likely to be revised down further when the 2022 based projections are published next year or in early 2024, as these will include far more complete data on covid-19 deaths in 2021 and 2022.

To be fully comprehensive, any inquiry into pandemic deaths must also investigate the underlying causes of the concerning trends in

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life expectancy over the decade before the pandemic began. Those same causes, which are presumably ongoing, probably exacerbated harms done by the pandemic and may continue to cause serious harm if they are not acknowledged and urgently tackled.

Competing interests: We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Commentary

The Royal Society of Medicine

Journal of the Royal Society of Medicine; 2023, Vol. 116(3) 89–92
DOI: 10.1177/01410768231155637

Falling down the global ranks: life expectancy in the UK, 1952–2021

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In 1952, when Queen Elizabeth II came to the throne, the UK had one of the longest life expectancies (as measured from birth) in the world, ranking seventh globally behind countries such as Norway, Sweden and Denmark.[1] Indeed, for many in Britain, the 1950s were a good time to be alive. The country was recovering from the devastation of the war, and Harold Macmillan, Prime Minister in the second half of the decade, famously told the people that they had 'never had it so good'.[2] Of course, not everyone was so lucky, with Blake's 'dark satanic mills' still dominating many communities experiencing deep poverty. But compared with many other countries, the prospects seemed good. A survey in the city of York found that poverty had almost disappeared there by 1950, although of course it was not entirely gone.[3] However, in marked contrast to the unemployment of the 1930s, the country was actively recruiting people from the Commonwealth to fill the many job vacancies.[4]

Objectively, Macmillan's comments seemed justified. One of the best measures of the progress of nations is the health of their people, and with life expectancy at an all-time high and, globally, higher than in many other countries, the UK was faring well. It can, of course, be unfair to compare countries without taking account of their initial circumstances. Most obviously, given a biological limit to longevity, countries that have already achieved long life expectancy have less scope to improve. However, while this may be an issue now, it was much less relevant in 1952 when life expectancy (both sexes) in the UK was only 69.5 years. The UK also benefitted from the legacy of wealth that came from possessing the largest empire the world has ever known. However, other major colonial powers, such as France, were also advantaged.

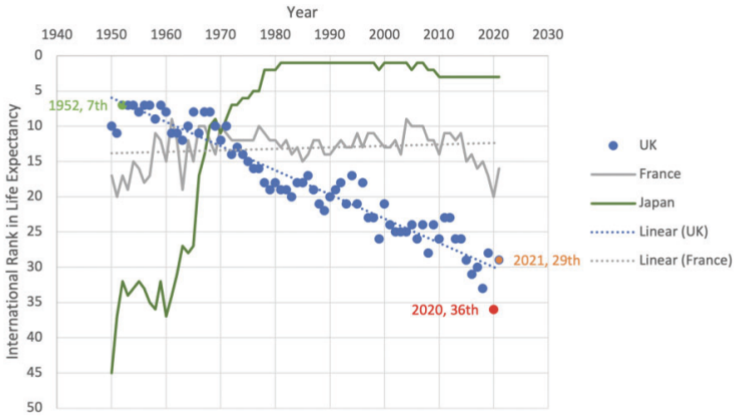
This favourable situation would not last. By the early 1960s, the UK was slipping down the global rankings in life expectancy (Figure 1). After particularly marked falls in the 1970s and 2010s, it had fallen to 36th place in 2020 (red dot) during the COVID-19 pandemic, just above the Maldives, Chile, Costa Rica and Thailand. In 2021, the UK's life expectancy rank rose seven places to 29th (orange dot), possibly linked to the arrival of vaccines against COVID-19 earlier in Britain than in the countries just above it. By rolling the vaccine out first to older people, who were especially likely to die from COVID-19, this may have provided a transient advantage before other countries caught up, but this is not yet clear. However, given the current challenges faced by the UK, there is no room for complacency. While life expectancy has increased in absolute terms over recent decades, other, now much more similar countries, are experiencing larger increases. It is hard to believe that the UK is facing diminishing marginal returns on its investment in health, while those other countries are at a point in the curve where returns are still much higher.

Some changes would have been expected in the decades from the 1950s until the present day. The post-war period saw remarkable economic progress in some parts of the world, such as Singapore, Hong Kong, South Korea and Taiwan giving rise to the term 'Asian tigers'. So, is what happened in the UK simply a matter of other regions catching up? Certainly, this is part of the explanation, but not all. We can illustrate this by looking at two other trendlines in Figure 1. Japan has made remarkable progress, coming from 45th position in the early 1950s to occupy one of the top three positions since the 1980s, and regularly holds the top position in global rankings. Yet, France, which in many ways is very comparable to the UK (including, as noted above, benefitting from having a global colonial empire), started well below the UK and has now surpassed it.

France and Japan, along with the UK, Canada, USA, Germany and Italy, are members of the 'Group of Seven' (G7). The G7 is a collection of

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Figure 1. UK rank in international life expectancy, 1950–2021, Source: UN Data, 2022.[1]



countries with advanced economies that represent about half of global economic output.[5] Figure 2 shows the rankings of the G7 countries at each decade from 1950 to 2020. Along with France and Japan, Germany and Italy have now surpassed the UK. In fact, the only G7 country to do worse than the UK is the USA. What has gone wrong?

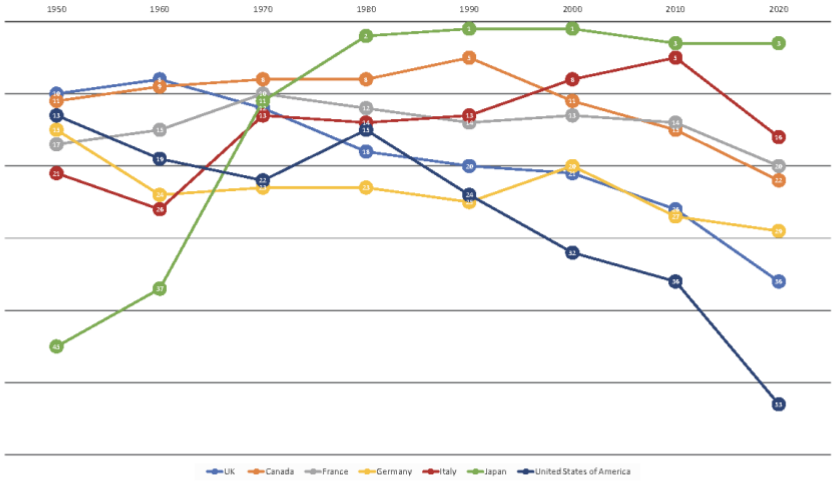
As always, the first question is whether we can trust the data. Vital registration has improved immensely over this time, especially in low- and middle-income countries. However, while caution would be needed in analysing the causes of deaths seven decades ago, with a few exceptions (such as in Korea during the war in the early 1950s), the countries at the top of the rankings have long-established systems for collecting demographic data.[6]

As far as we know, while these data are publicly available, the presentation, as rankings over seven decades, is new. This long-term perspective, with estimation of trends, overcomes the problem of short-term fluctuations of examining annual data. This is a particular problem in smaller countries but, even in larger ones, natural disasters or epidemics, for example, can produce quite substantial changes.

The relative decline of the UK portrayed in Figures 1 and 2 is stark. Yet, it may not be a surprise to scholars from some disciplines, such as political scientists and economic historians. In the international arena, Dean Acheson's 1962 observation that the UK had 'lost an empire and has not yet found a role' drew attention to the UK's loss of international influence after Suez.[7] Since 2016, when it voted to leave the European Union, the UK has found itself increasingly isolated, despite coining the slogan 'Global Britain'. For a long time it retained considerable soft power, taking advantage of the increasingly ubiquitous English language, but squandered this in the 2010s by disinvesting in its vehicles, such as the BBC and the British Council.[8] Economically, while it came out of World War II in a much better position than the nations it helped to defeat, a combination of complacency and lack of vision meant that it failed to achieve Germany's Wirtschaftswunder, or 'miracle on the Rhine'[9] and similar developments elsewhere. It was ill-prepared for the oil crisis of 1973, and by the end of the decade, the manufacturing industry was reduced to 3-day working.[10] With its large financial sector, it was also vulnerable when the 2008 financial crisis hit, exacerbated by a misguided policy of austerity that shut off the transient initial recovery, resulting in the average UK household having lower incomes in 2012 than in France or Germany,[11] paving the way for a decade in which health and the economy stagnated.[12,13]

Income inequalities rose greatly in the UK during and after the 1980s and that rise also saw an increase in the variation in life expectancy between different social groups. One reason why the overall increase in life expectancy has been so sluggish in the UK is that in recent years it has fallen for poorer groups, falling slightly overall between 2014 and 2018. According to the OECD, the UK is now the second most economically unequal country in Europe after Bulgaria.[14] Perhaps we should not be surprised to see that inequality reflected in such wide health inequalities and a declining overall position?

Figure 2. Countries of the G7's international life expectancy rankings, 1950–2020. Source: UN data, 2022.[1] Note: The data shown are the annual data for the corresponding year – not an average for the decade.



Given this history, we can begin to understand why the UK has done so badly. But it poses an obvious question. What comes next? The third Prime Minister of 2022, Rishi Sunak, inherited a country in crisis that was partly of his making as a former Chancellor of the Exchequer. Commentators are asking whether large numbers of people will have to choose between 'heating and eating' even after some bills have been capped. Yet, despite the scale of the crisis, the UK government treaded water during the summer and autumn of 2022, with the ruling party immersed in two destructive leadership campaigns. While politicians invoke global factors, especially the effects of the pandemic and the invasion of Ukraine, the reality is that, as in the 1950s, the country suffers from major structural and institutional weaknesses. Despite being much less reliant on Russian gas than countries such as Germany, energy prices have risen much faster, in part reflecting ill-advised closure of storage capacity and failure to regulate the market. Although, in theory, the country was second best prepared for a pandemic in the world, it experienced one of the highest death rates in 2020, with multiple policy failures.[15]

It is not the case that 'things can only get better'. There are many examples of once prosperous countries that experienced a long decline, such as Argentina in the 20th century.[16] Worryingly, at some point, countries can enter a vicious downward spiral, with worse health feeding into economic decline and vice versa. Meanwhile, a growing body of research is cataloguing how declining health threatens democracy itself.[17,18]

The UK is at a crossroads. The cost-of-living crisis means that 'business as usual' is no longer an option. But politicians have choices, and we can only hope they make the right ones, although events in and since October 2022 have so far provided little reassurance. As they move forward the data we present should give pause for thought.

In early 2023, both the establishment newspaper *The Times* and the fringe *Morning Star* ran near identical headlines: 'A&E delays are "killing up to 500 people a week"'.[19] In the short term, the government has an acute crisis to address. In the medium term, there is an economic malaise that makes it harder to address the short-term problems. At some point, it might be realised that proceeding along a particular path is slowly but surely resulting in the UK falling down the ranks. The headlines may be now, but the real causes would appear to have been decades in the making.

Declarations

Competing Interests: None declared.

Funding: None declared.

Ethics approval: Not applicable.

Guarantor: All authors.

Contributorship: LH had the initial idea for the paper which LH, DD, and MM subsequently contributed to equally.

Provenance: Not commissioned; peer reviewed by Mujahid Shaikh.

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Research

The Royal Society of Medicine

Journal of the Royal Society of Medicine; 2024, Vol. 117(5) 172–181
DOI: 10.1177/01410768231209001

A deathly silence: why has the number of people found decomposed in England and Wales been rising?

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Abstract

Objectives: The number of deaths occurring in private homes in England and Wales had been rising for years, increasingly rapidly from 2020. Media stories and research linked decomposing bodies found in private homes with pandemic-related social isolation. We aim to explore whether these incidents are one-offs or part of a wider trend.

Design: Descriptive analysis of publicly available Office for National Statistics (ONS) data.

Setting: England and Wales.

Participants: All residents of England and Wales, 1979 to 2020.

Main outcome measures: Using data from the Office for National Statistics, we calculate European Age Standardised Rates for deaths coded as R98 ('unattended death') and R99 ('other ill-defined and unknown causes of mortality') in the 10th version of the International Classification of Diseases (ICD-10), and the corresponding codes in ICD-9, by sex and age group from 1979 (when ICD-9 began) to 2020. These are proxy markers for deaths where decomposition precludes attribution of a specific cause at postmortem.

Results: While mortality from all other causes decreased from 1979 to 2020, the opposite was seen for deaths from R98 and R99 (or 'undefined deaths'), with men more affected than women. There was a sharp rise in these deaths in both sexes but in men particularly in the 1990s and 2000s, coinciding with a time when overall mortality was rapidly improving.

Conclusions: The increase in people found dead from unknown causes suggests wider societal breakdowns of both formal and informal social support networks. They are concerning and warrant urgent further investigation. We call on national and international authorities to consider measures that would make it possible to identify these deaths more easily in routine data.

Keywords

Pathology, public health

Received: 16th July 2023; accepted: 1st October 2023

Introduction

In July 2022, the British magazine *The Spectator* published an article 'The mystery of Britain's surging at-home deaths'.[1] It reported how deaths at home began to rise during the first year of the pandemic in 2020, and that this trend had continued into 2022. However, the rise in deaths at home pre-dates the pandemic. The Office for National Statistics (ONS) reports that the number of deaths occurring at home has been rising since 2007, with a sharp spike in 2020 due to the coronavirus disease 2019 (COVID-19) pandemic.[2] Excess deaths at home continued into 2022.[3]

The Spectator story coincided with other media reports of individual deaths. While the increase in deaths at home would not necessarily be a problem, the reported cases raised concerns that there may be a wider problem of growing isolation and lack of social support. For example, Sheila Seleoane, aged 58 years, died in a London social housing block in 2019 and was not discovered for over 2 years, by which point her body was severely decomposed. A subsequent investigation severely criticised her housing association for repeated failures to follow up on missed contacts.[4,5] Laura Winham, aged 38 years, was found 'mummified' in 2021, more than 3 years after she had died.[6] Her family blamed care and welfare services for neglecting her. There have been other anecdotal stories of this kind, which have suggested that the reduction in the availability of care and welfare services since 2010 may have contributed to the possible trend.

Against the backdrop of rising deaths at home, as well as growing evidence about the adverse consequences of a decade of austerity, there are concerns about whether those deaths of people found decomposed that have attracted media attention reflect a wider problem. Ideally, it would be possible to

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track trends in numbers of deaths found decomposing at home, but these data are not routinely coded in national statistics. Furthermore, the existing literature on deaths at home is largely focused on palliative care, recognising that, for many, a 'good' death at home is a desirable outcome. However, there are two studies, both from London, linking a significant increase of severely decomposed bodies since the beginning of the first lockdown to social isolation.[7,8] Neither looked at longer-term trends, so it is prudent to extend this analysis further back, especially as deaths at home had been increasing *before* the pandemic, and both deaths cited above were believed to have occurred before 2020, even if the bodies lay undiscovered during the pandemic.

In this exploratory article, we attempt to discover whether there was any increase in the number of people found to be in a state of decomposition at the time of postmortem over time from 1979 to 2020 in England and Wales. We suggest that if we find an increase in bodies found to be in a state of decomposition at postmortem, it would raise concerns about social isolation and neglect both after *and* before death and might be considered a proxy for a failure of society to safeguard its members.

Methods

As data for bodies found in a state of decomposition are not readily available, a proxy was developed (Box 1). We examined publicly available ONS data from 1979 to 2020. First, we calculate deaths at home in England and Wales from 2006 to 2021 as a proportion of total deaths by sex.[9] We used these years because data on place of death are not publicly reported prior to 2006, and cause of death by place is not reported by individual 10th version of the International Classification of Diseases (ICD-10) code.

Second, we extract deaths due to R98 and/or R99 (ICD-10) and equivalents in ICD-9 from 1979 to 2020 by 5-year age group and sex.[16,17] These data were extracted from all deaths, not deaths disaggregated by place of death (such as at home). However, most deaths that occur outside the home are in a hospital, care home or hospice environment and would therefore be extremely unlikely to end up in a state of decomposition with the R98/R99 code as they would either have a known diagnosis or undergo a postmortem. The very few others outside the home would, almost always, show evidence that could be used to ascertain the cause, such as major trauma causing fractures, or be found in circumstances that would indicate the cause, such as a body pulled out of the sea or being found wearing outdoor equipment on a mountain. In these cases, a cause of death should be able to be given, such as drowning, exposure or violence. Deaths that occur not-at-home, which lead to such severe decomposition that they are given a cause of death as 1a Unascertained, are likely extremely rare (and probably forensic/police cases).

Finally, using the European Standard Population 2013,[18] we calculate the European Age-Standardised mortality rates over time. We excluded all deaths under the age of 20 years due to changes in how

Box 1. Using ICD codes as a proxy for severe decomposition.

Evidence of decomposition is not routinely recorded nor shared in public records. Research during the pandemic found that 90% of postmortems that were recorded as '1a unascertained/unascertainable' were due to severe decomposition,[7] consistent with existing literature.[10] However, caution is required as studies examined small numbers (for example, 263 coronial autopsies were compared by Estrin-Serlui and Osborn; 55 of these were decomposed; and 9 certified as unascertained cause of death).[7] The ICD-10 codes R98 and R99 refer to unattended deaths and 'other ill-defined and unknown causes of mortality'.[11] If the number of severely decomposed deaths in the community were to increase, then the use of the codes R98 and R99 would most likely increase concordantly. It should be noted that well-defined sudden death syndromes such as sudden arrhythmic death syndrome (SADS) and sudden unexplained death in epilepsy (SUDEP) would not be included in these ICD codes as per ONS guidelines, with SADS routinely coded as R96, I49.9 or I46.1 and SUDEP as G40–41.[12,13] Therefore, we propose that the R98/99 codes may be used as a marker or proxy of (severe) decomposition. This will miss those decomposed but not so much as to prevent the pathologist and/or coroner determining a cause of death. For deaths prior to 2001, when ICD-10 was first used in the UK,[14] we identified the corresponding codes from ICDs 9a, 9b and 9c which are consistent (Table 1).[14–16] These will be referred to as 'undefined' deaths from here on.

At present, there is no ICD code for 'decomposed body'. While R98 and R99 codes are non-specific, we pose that these codes are the most likely way a '1a Unascertained' death would be coded. ONS have confirmed (personal communication 26 October 2023, included in Supplementary Appendix I) that the only code that can be applied when the cause of death is described as decomposed or unascertained is R99.[1] We have included R98 as the definition of it in ICD is quite specific for 'no cause could be discovered' which is suggestive of decomposition.

Table 1. ICD-9 and ICD-10 codes used for proxy described in Box 1 for 'undefined deaths'.

ICD version	Years	Code	Description	Includes
9a	1979–1984	798.9	Sudden death, cause unknown	Unattended death
		799.9	Other ill-defined and unknown causes of morbidity and mortality	Unknown cause
9b	1985–1993	798.9	Sudden death, cause unknown	Unattended death
		799.9	Other ill-defined and unknown causes of morbidity and mortality	Unknown cause
9c	1994–2000	798.9	Sudden death, cause unknown	Unattended death
		799.9	Other ill-defined and unknown causes of morbidity and mortality	Unknown cause
10	2001–2021	R98	Unattended death	Death in circumstances where the body of the deceased was found and no cause could be discovered; Found dead
		R99	Other ill-defined and unspecified causes of mortality	Death NOS; Unknown cause of mortality

ICD: International Classification of Diseases; NOS: not otherwise specified.

sudden infant death syndrome and sudden unexplained death syndrome were coded and recognised throughout the decades examined.

Results

Deaths at home 2006–2021

Figure 1 presents deaths aged 28 days and over at home as a proportion of all deaths from all causes by sex, 2006 to 2021 in England and Wales.[9] This shows a consistently higher proportion of total male deaths at home than women, with a slight narrowing of the gap during the first two years of the pandemic, increasing over time from 16% in 2006 to 21.4% in 2019 and 26.5% in 2021 for women, and from 22.4% (2006), 27.4% (2019) to 31% (2021) for men. When we disaggregate by age group, we see the highest proportion in those aged 15 44 years, followed by those aged 45 64 years.

Standardised mortality rates for 'undefined' deaths (R98/R99) and all other causes from 1979 to 2020 by sex

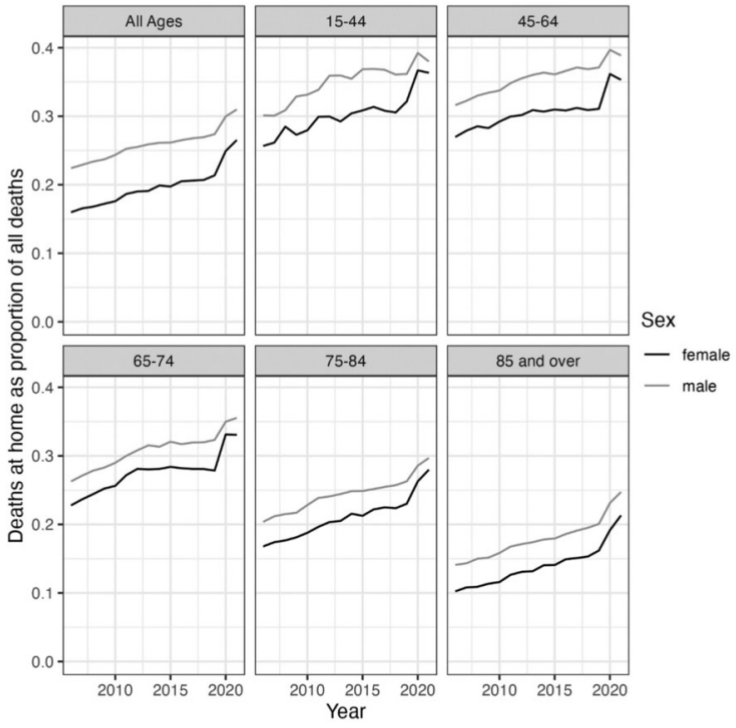
Next, we present age-standardised rates (ASR) of 'undefined' deaths (those coded R98 and R99 and ICD-9 equivalents) and all other causes of death by sex for England and Wales 1979 to 2020 (Figure 2). Please note, absolute numbers for these can be found in Table A and Figure C in Supplementary Appendix II. We indicate where the ICD version changed from ICD-9 to ICD-10 to highlight where we might expect to see any artefact due to the transition. For both sexes, the ASR for all other causes decreased steadily over time, with some fluctuations, until stalling after 2010 and increasing in 2020, when the pandemic began. The undefined deaths panel shows the opposite, with an increase for both sexes from 1979 to 2020. For women, the greatest increase is between the mid-1990s to mid-2000s, after which it stabilises. For men, there appear to be two periods of increase, first in the 1990s then again in the early 2000s. By the 2000s, the male rate is more than double the female rate. Note due to the small numbers, over-interpretation of the annual fluctuations should be avoided.

Standardised mortality rates by broad age group

Next, we explore ASRs by broad age group: working years (20 59 years), and older (60 years and over) (Figure 3). These shows similar patterns for both age groups, with a consistently higher rate for men than women (approximately three times as high).

We also present the same data indexed to 1980 (Figure 4). This makes it easier to see how relative trends in both undefined and all other causes of death have gone in very different directions. Caution is required in interpretation as it may give the impression that the two trends balance each other out. This

Figure 1. Deaths at home as proportion of total deaths, 2006–2021, by sex, England and Wales. Authors' calculations based on data from ONS 2022.[9]



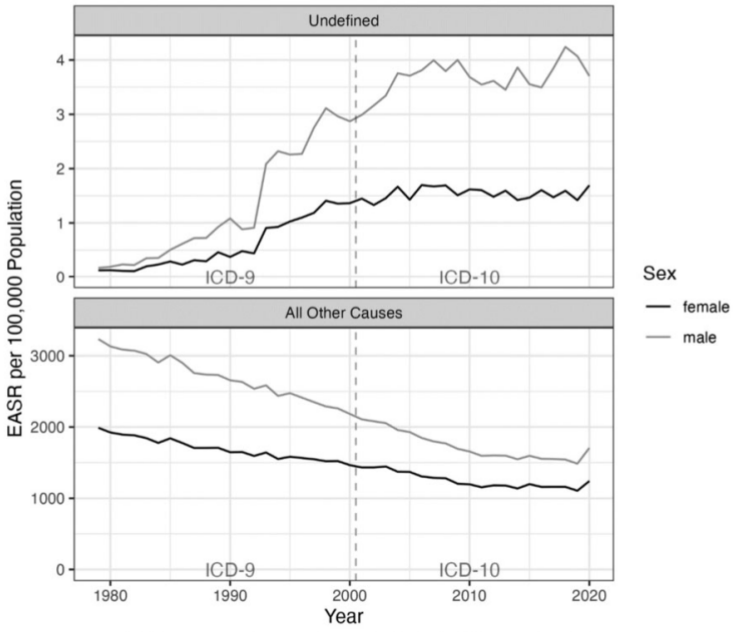
is incorrect, as undefined deaths are many orders of magnitude rarer than deaths from all other causes.

Discussion

Main findings of this study

We present preliminary findings analysing deaths of people likely to have been found decomposed, using a proxy marker of ICD codes.[2] We have argued that any increase in this measure can be considered as a proxy for long periods of neglect after death and that this, in turn, may be a proxy for prolonged neglect and social isolation before death. This may be a marker of breakdown in formal and informal social support networks. This said, it is important to acknowledge that decomposition is a complex process, caused by many individual and environmental factors, and the speed of it can vary greatly.[19] However, we focused on those deaths where decomposition has reached the stage where it was no longer possible to determine a cause of death. Our reading of the literature suggests that, except in exceptional circumstances such as a summer heatwave or a death in a very hot room, to reach severe decomposition would take some time and would strongly suggest that the deceased was extremely isolated in the perimortem period. Furthermore, while changes in variables such as medical conditions and ambient temperature do matter, on a large population scale, the most important factor that would affect decomposition is postmortem interval, while individual or environmental circumstances would likely be balanced over time. The average body mass index has increased in recent decades, and this can increase postmortem decomposition speed,[20] but this is unlikely to be as important a factor relative to the overall postmortem interval.

Figure 2. European age standardised rates for 'undefined' deaths (i.e. those coded R98/R99) and all other causes of death by sex, England and Wales, 1979 to 2020. Dashed vertical line indicates change in ICD version from ICD-9 to ICD-10 in 2001. EASR: European Age Standardised Rate.



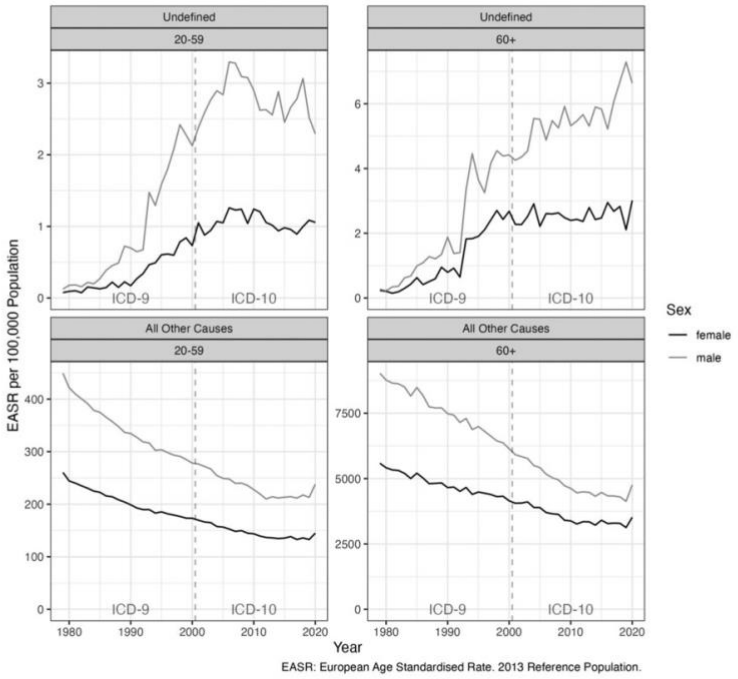
EASR: European Age Standardised Rate. 2013 Reference Population.

We were concerned that recent reports of people found decomposed could signify a longer-term trend that would point to growing failure of society to prevent people falling through the gaps in the welfare state during a prolonged period of austerity and becoming socially isolated. We confirmed that this increase has occurred, and over a prolonged period, the earlier part of which predates austerity. Interestingly, loneliness and isolation are often associated with ageing, as exemplified by National Health Service advice on countering it,[21] with a perception that older women are especially vulnerable, given their longer life expectancy than men. However, while we did find an increase in bodies found decomposed in older women, the rates increased at an even faster rate for both younger and older men, with a rapid increase in the 1990s and 2000s. The increase seen for both sexes in the 1990s and 2000s is particularly surprising given the substantial improvements seen in mortality during this period. There is some suggestion that these deaths may be more common in those born between 1975 and 1985 (see Supplementary Appendix II) but, if true, we can only speculate as to a reason.

What is already known on this topic

From 2012 onwards, trends in mortality worsened, a phenomenon that has been linked to the austerity measures implemented from 2010.[22 25] Initially, older age groups were most affected, with the first increase in mortality seen in older women in 2012, and soon after, more groups were affected with now widespread worsening of mortality outcomes for many groups. For example, an increase in mid-age mortality has been reported in the UK in recent years, in particular from so-called 'deaths of despair' (i.e. deaths related to drug and alcohol use, or suicide).[26,27] However, it important to note that, while the underlying social changes that give rise to these deaths may be similar to those studied here, in particular those that lead to greater social isolation, any

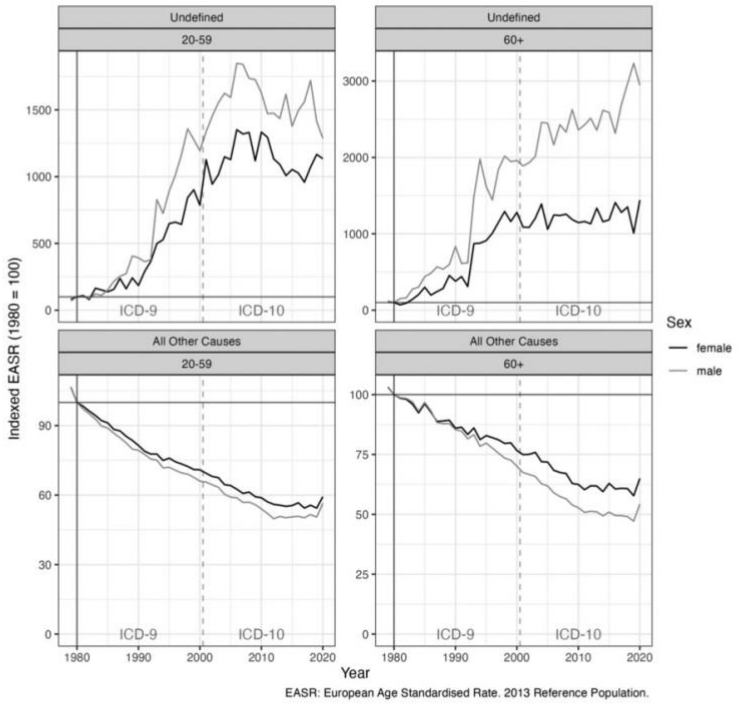
Figure 3. ASRs by broad age group (20–59 years, 60+ years) for men and women, 1979–2020, England and Wales. Dashed vertical line indicates change in ICD version from ICD-9 to ICD-10 in 2001. Note y axes are variable. EASR: European Age Standardised Rate.



substantial overlap is unlikely as, in most cases, a specific cause will be able to be allocated to these deaths of despair by means of toxicological detection of drugs or in overdose with suicidal intent, or from other evidence indicative of suicide. That said, the rise in these deaths could also be a reason for more deaths of men found at home, decomposed, who may have also been socially isolated.

Social isolation and loneliness are increasingly recognised as bad for health two 2023 meta-analyses found associations with an increased risk of all-cause mortality.[28,29] In the analysis of postmortem reports 'every markedly decomposed case that died at home lived alone'.[7] Data on people living alone in the UK between 1996 and 2021 show significant differences by age group and sex (see Figures D and E in Supplementary Appendix II).[30,31] At ages 25 44 years, almost double the number of men than women live alone, according to the latest data, but numbers in both sexes have decreased over time. At ages 45 64 years, the difference is smaller but remained by 2021, but while numbers of women were slightly higher until 2004, both have increased, with men diverging around 2007 after which there was a marked increase. At ages 65 and over, both sexes have seen an increase since 2014. However, here the gender difference is reversed, with a greater number of women living alone than men, although the data demonstrate that the ratio of men living alone relative to women has almost doubled in the 65 and over age group from 1996 to 2021.[30] This should be interpreted with caution as, first, these are crude numbers and do not take into account the population structure, i.e. there are more women than men in the older population (see population pyramid in Figure E in the Supplementary Material).[31,32] Second, men have lower life expectancy than women and, in a heterosexual marriage, the husband is less likely to be left alone than the wife due to the death of their spouse, as husbands usually die before their wives.

Figure 4. Indexed trends in EASRs (the year 1980 = 100) by broad age group (20–59 years, 60+ years) for men and women, 1979–2020, England and Wales. Dashed vertical line indicates change in ICD version from ICD-9 to ICD-10 in 2001. Note y axes are variable. EASR: European Age Standardised Rate.



This changing landscape of living arrangements could in part explain the rise in undefined deaths for both sexes, but specifically the accelerating rise in men relative to women. However, living alone is only one factor contributing to perimortem social isolation. Family, friend and local community social connections can also be expected to play an important role, but these factors are harder to quantify at the population level so data that might show any change in these parameters over time are sparse and fragmentary.

What this study adds

Using a proxy for severe decomposition, we have shown an increase over time among both sexes in 'undefined' deaths (which we propose as a proxy for found decomposed). In addition, it found that more deaths among men are coded 'undefined' than women in both working age and older groups, suggesting a higher rate of being found decomposed.

Limitations of this study

To our knowledge, the ICD-10 codes R98 and R99 (and equivalents) have not previously been used as a proxy for severe decomposition. These codes will miss those cases where the body is decomposed but with postmortem findings, which can still establish a defined cause of death (for example, as mentioned, in the study of postmortems before and after the pandemic lockdown only 16% of severely decomposed bodies had an unascertained cause of death).[7] Nonetheless, these ICD codes may still act as a reasonable surrogate given that, in the same study, almost all unascertained deaths did demonstrate severe decomposition. However, we cannot say with certainty that these codes are a good proxy for

advanced decomposition. There is a paucity in research describing exactly how often decomposed deaths lead to an unascertained cause of death, as the majority of deaths where bodies were found decomposed would still result in a cause of death being given. While the numbers are small in the limited existing research, and although we have demonstrated a possible relative increase in the frequency of unascertained deaths, the absolute number of decomposed bodies as a proportion of all deaths remains low, and so the number included in any potential further studies would be low, and further research in this area would be useful.

Severe decomposition or degradation of a body is the most likely reason for the final cause of death to be given as 'unascertained'. There may be rare exceptions, such as coronial or administrative issues, which can lead to an 'unascertained' cause of death, such as the body being repatriated following an autopsy abroad. However, pertaining to our findings of an increase in this proxy, it may be that more causes of death were reported as 'unascertained' in the past, and ICD-9 code 'sudden death, cause unknown' may have been used prior to the acceptance of conditions such as SADS or SUDEP. If sudden death syndromes such as these were previously coded as R99 and equivalents, we would have expected to see a decrease in deaths coded as 'undefined' over time, but we found the opposite, i.e., that deaths have increased.

Unanswered questions and future research

We are sharing these results in the hope of stimulating further research. Examples include whether there is a more suitable proxy for a body found in a state of decomposition, or whether our proxy is considered valid by experts in the field. We also hope to encourage others to report preliminary findings, and to raise the alarm about a possibly concerning trend that is challenging to investigate. Furthermore, future research may want to further explore the effects of living alone on mortality and, in particular, being found decomposed.

All bodies found in a state of decomposition should be referred for postmortem; however, research using coroners' reports is challenging, given variation in reporting across the country. Notably, the two cited studies were undertaken in an individual city.[7,8] Furthermore, we cannot easily link the anonymised, coded death data to compare to individual postmortem reports to validate whether the proxy is indeed appropriate.

Recording bodies found decomposing would be a useful addition to publicly available data. Thus, while recognising that the duties of coroners are strictly delineated in law,[33] we encourage the Chief Coroner of England and Wales, the Coroners' Society for England and Wales (and their counterparts in Scotland and Northern Ireland), to explore whether and how they might report whether the deceased was severely decomposed or not. This could permit decomposition data to enter public record and subsequently be coded and analysed by the ONS in a similar way to other mortality data such as cause of death and place of death. In the longer term, we would encourage the World Health Organization to consider adding a code to indicate advanced decomposition to the ICD, perhaps using the 'U' chapter, which allows for the adoption of new codes to address emerging concerns, as has been done with COVID-19 and vaping.[34]

Conclusion

Many people would be shocked that someone can lie dead at home for days, weeks, or even longer, without anyone raising an alarm among the community they live in. Being found decomposed after days, weeks, months or even years might indicate a high level of neglect, but this is speculative without further investigation. We share these inconclusive and preliminary results in the hope of encouraging others to take up this important topic, and we propose that future mortality data could include information about the severity of postmortem decomposition to enable further investigation into this topic.

Declarations

Competing Interests: None declared.

Funding: None declared.

Ethics approval: Ethical approval was not required as this article uses publicly available aggregate data.

Guarantor: JM is guarantor for the analysis.

Contributorship: LH had the idea for this article and discussed with the co-authors, producing the initial drafts. TES developed the 'proxy' marker of decomposition using ICD codes. JM carried out the data extraction, analyses and data visualisations. MM and DD provided expert advice and review throughout. All authors contributed and approved the final article.

Acknowledgements: We are grateful to all the reviewers for their constructive comments. We would like to extend our thanks to the team at the Office for National Statistics who responded extremely promptly and clearly to our queries via email, and gave permission for these to be published.

Provenance: Not commissioned; peer reviewed by Julie Morris and Benjamin Mazer.

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Notes

1. These deaths would then go to a coroner and an inquest held.
2. Details in Box 1 and Table 1.

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Research article

The Royal Society of Medicine

Journal of the Royal Society of Medicine; 2021, Vol. 114(8) 389–399
DOI: 10.1177/01410768211011742

What can lifespan variation reveal that life expectancy hides? Comparison of five high-income countries

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Abstract

Objectives: In most countries, life expectancy at birth (e0) has improved for many decades. Recently, however, progress has stalled in the UK and Canada, and reversed in the USA. Lifespan variation, a complementary measure of mortality, increased a few years before the reversal in the USA. To assess whether this measure offers additional meaningful insights, we examine what happened in four other high-income countries with differing life expectancy trends.

Design: We calculated life disparity (a specific measure of lifespan variation) in five countries – USA, UK, France, Japan and Canada – using sex- and age specific mortality rates from the Human Mortality Database from 1975 to 2017 for ages 0–100 years. We then examined trends in age-specific mortality to identify the age groups contributing to these changes.

Setting: USA, UK, France, Japan and Canada

Participants: aggregate population data of the above nations.

Main Outcome Measures: Life expectancy at birth, life disparity and age-specific mortality.

Results: The stalls and falls in life expectancy, for both males and females, seen in the UK, USA and Canada coincided with rising life disparity. These changes may be driven by worsening mortality in middle-age (such as at age 40). France and Japan, in contrast, continue on previous trajectories.

Conclusions: Life disparity is an additional summary measure of population health providing information beyond that signalled by life expectancy at birth alone.

Keywords

Health policy, non-clinical, public health

Received: 11th December 2020; accepted: 4th April 2021

Introduction

Life expectancy at birth (denoted e0) is an efficient summary of population health and how it changes over time. In the absence of extraordinary events such as wars, environmental disasters and pandemics e0 has trended steadily upwards in most populations in recent decades. Where it has fallen, other than transiently, it has often been associated with major crises, such as the AIDS pandemic, wars, famines or state collapse as in the ex-USSR.[1,2] While the eventual consequences of the COVID-19 pandemic remain unknown, the UK has experienced a fall in e0 of 0.9 and 1.2 years for females and males, respectively.[3] Given the long-term improvement in e0 prior to the pandemic in most high-income nations, any stalling in trends i.e. prolonged increases slower than the long-term average demand explanation. Identifying the cause of a falling e0 requires careful examination of mortality data by sex, age group and cause of death. This is especially important as improvements in some subgroups may, to some extent, compensate for declines or stalls in other subgroups. For example, in the 1980s, concern about the slowdown in what had, until then, been increasing life expectancy in countries of Central and Eastern Europe might have been greater if it had been widely recognised that continued mortality gains in infancy and childhood were obscuring worsening in adult mortality.[4] Thus, like any summary measure, e0 can conceal details with practical or policy importance, so there is a strong theoretical argument to look at other measures, in particular those capturing the distribution of mortality.

Lifespan variation is a term covering a class of complementary measures to e0 which measure the variability of age at death among individuals within a defined population.[5] Typically, as e0 increases, lifespan variation decreases; those countries with the highest e0 also have the lowest lifespan variation:[6] a phenomenon also observed in other primate species.[7] This is, in part, because the maximal attainable lifespan has changed little but death rates at younger ages have tended to fall. The measure of lifespan variation we use is life disparity, which measures the average gap between an individual's age at death and their remaining life expectancy at that age.[6] Some have argued that life disparity has a 'crucial' public health interpretation, not least because

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life disparity can differ between societies with similar life expectancies.[8,9]

One example is research by van Raalte et al., which showed that in the USA, where e0 increased by approximately 10% for men and 5% for women over 1980 2014, lifespan variation (measured as standard deviation) fluctuated then increased.[10] e0 in the USA then declined every year since 2015[11] driven by what have been termed 'deaths of despair',[12,13] from alcohol, other drugs and suicide.[13] Researchers concluded that had lifespan variation been monitored more closely, the mid-life mortality crisis in the USA could perhaps have been identified earlier.[10]

To see if lifespan variation might have been similarly useful in understanding the recent divergence of e0 trends in the UK, we extend the analysis of life disparity to four other high-income countries: the UK, where, like the USA, gains in e0 have trailed behind those in other industrialised countries[14]; Japan, which has seen sustained progress; and France and Canada, neighbours of the UK and USA, respectively, which lie in the middle. We ask whether e0 and life disparity in combination can (a) identify changes that could otherwise be missed and (b) detect changes in trends earlier.

Terminology

To ensure consistency and understanding of the terms used throughout this paper, Box 1 provides definitions from leading experts in the fields of demography and population health.

Box 1. Definitions of relevant terminology.

Term	Definition	Source
Age-standardised mortality rate (ASMR)	A mortality rate that can be calculated based on age-specific mortality rates for two or more populations, based on applying these populations' separate age-specific mortality rates to a common ('reference' or 'standard') population age-structure. A number of different standard age structures exist; the European Standard Population is one of the most commonly used.	Eurostat, 2013[15]
Life expectancy	A population-based statistical measure of the average number of years a person has before death. Life expectancies can be calculated for any age and give the further number of years a person can, on average, expect to live given the age they have attained. Life expectancy of a population at a certain point in time reflects the average number of years and individual would live if they faced during their entire life the current ASMRs, thus it gives the expected average length of life based on the current mortality pattern. Because age-specific mortality rates change over time, life expectancy does not accurately predict the actual number of years an individual will live.	Office for National Statistics (ONS), 2020[16] Smits and Monden, 2009[17]
Life expectancy at birth (e0)	Life expectancy at birth can be denoted as e0, life expectancy at 5 years old as e5, and so on. e0 is often simply referred to as life expectancy and is the most common metric of survival. It is the hypothetical average age at deaths given age-specific death rates in a given year.	Van Raalte AA et al., 2018[10]
Lifespan variation (LV)	Lifespan variation is a class of measures which calculate the amount of heterogeneity in age at death across all individuals in a population. LV can be measured by using an index of variation or inequality.	Seamen et al., 2019[5] Van Raalte AA et al., 2018[10]
Life disparity (LD)	Life disparity is one measure of lifespan variation, representing the average remaining life expectancy at the age when death occurs. It is a measure of life years lost due to death.	Vaupel JW et al., 2011[6]
Threshold age	Calculated from life tables, the 'cut-off' age where averting deaths before that age reduces LD, and averting deaths after it increases LD.	Zhang and Vaupel, 2009[18]

Methods

Data source

We extracted sex- and age-specific mortality rates from the Human Mortality Database (HMD) from 1947 until the latest available year (2017 or later) for the USA, Japan, UK, France and Canada, ages 0 100. HMD smoothes mortality rates at older ages (80+).[a] We present data from 1975 to the latest available year, unless otherwise stated. Ethical approval was not required.

Analytical approach

First, we report e0. Second, we measure lifespan variation using life disparity, replicating the method developed by Vaupel et al.[6] Box 2 provides an overview of this methodology, for which the full code and analyses undertaken can be found on Github.[b] Finally, we present trends in age-specific mortality to identify which age groups contributed to these changes.

Life disparity calculations. Life disparity (denoted $e^{\dagger}$) is defined as 'the average remaining life expectancy at the ages when death occurs'. It is calculated by summing age-specific contributions for all ages up to a maximum lifespan age (ω) which in our calculations is set to 100 years of age. These age-specific contributions are defined as the product of e_x and f_x, where e_x is defined as the remaining life expectancy at age x and f_x the life table distribution of deaths up to age x.[6] See the supplementary appendix in Vaupel et al. (2011) for a more complete definition. The values shown in the bottom row of Figure 1a and b are these age-specific contributions, $e_x f_x$, with selected values of age, x, on the horizontal axis. The values shown in the bottom row of Figure 2 are life disparity ($e^{\dagger}$), which is the sum of these age-specific contributions up to age ω. All calculations are based on period life tables.

Results

Figure 1a and b show the contribution of deaths at different ages to overall life disparity using the example of the USA and Japan, respectively, for 1947, 1975 and 2017. In each, the top panels show improvements in period survival by age over time, with age on the x axis and the proportion of people surviving to a given age on the y axis. Over time, as people live longer, the curve shifts to the right due to 'compression of mortality' or the 'rectangularisation' of the survival curve: mortality decreases are steeper at younger than older ages.[19,20]

The lower panels show the age-specific contributions to life disparity by deaths at different ages. Deaths in infancy and early childhood are on the left and those in adulthood on the right. In 1947, both by infant mortality and deaths throughout working and retirement ages were making an important contribution to life disparity, but the dramatic fall in deaths in children and, in Japan, people in their 20s, means that, by 2017, life disparity is largely due to variations in age of deaths at older ages. In 1975 and 2017, total life disparity was higher in the USA than in Japan, mostly due to the greater contribution from deaths at ages up to the mid-1970s in the USA. Put another way, in 1947, a higher proportion of deaths in Japan were in younger ages but by 1975, this had reversed.

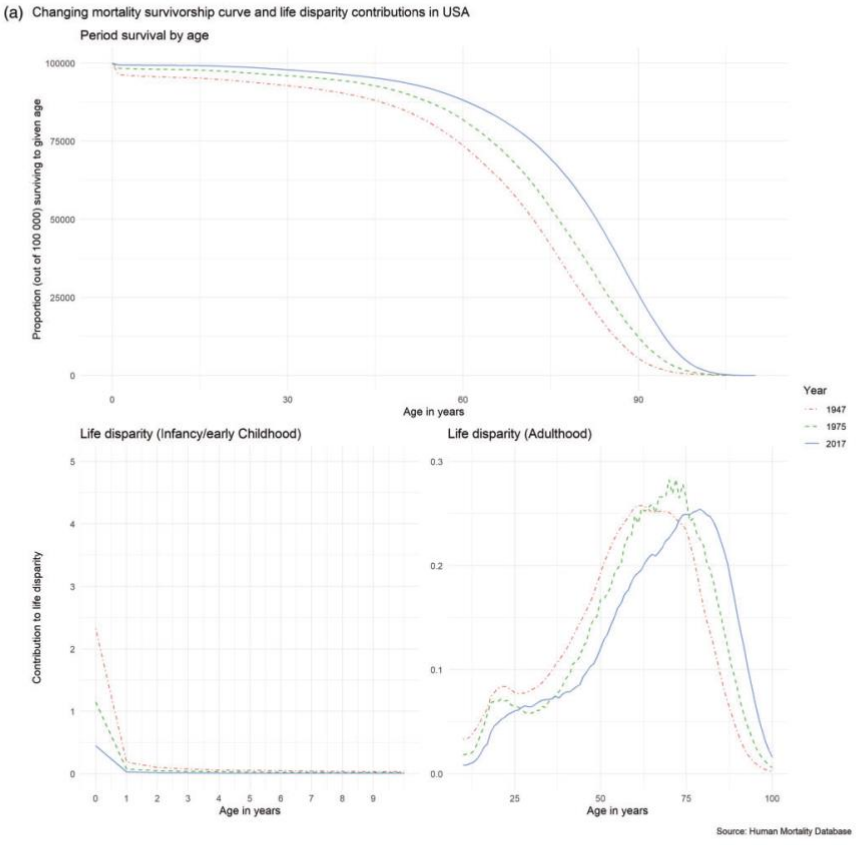
Life expectancy at birth (e0) and life disparity

Next, we present trends in e0 and life disparity for each country from 1975 to at least 2017. Japan has had the highest e0 for females since approximately 1980 and for males from 1975, improving annually, except for a brief fall after 2011 that coincided with the Tohoku earthquake and tsunami, when almost 16,000 people were killed on one day.[21] For females, the USA and UK consistently rank lower than the other countries, with stalling e0 from 2010 onwards. A similar pattern is seen for males, but with France following a similar trajectory to the UK. Canada shows steady improvements for both males and females, with a slight stalling seen for males in most recent years.

With life disparity, all countries demonstrate a downward trend between 1975 and 2000, albeit with a transient interruption among males in France and the USA in the 1980s and among females in Japan in the 1990s. Since 2010, life disparity has increased markedly in Canada and the USA, and slightly in the UK, also. In Japan, life disparity increased in 2011 for males especially, which may reflect the impact of the earthquake, before falling again.

Figure 3 zooms in on life disparity since 2000, since the majority of changes in e0 occur after 2010. Increases in life disparity in USA and Canada are clearer. The situation in the UK is less clear but for males there appears to be a divergence from the Japanese sustained downward trend, while for females they continue broadly in parallel, although care is necessary as there are fluctuations over time and changes in the UK after 2015 may reflect year-on-year variability.

Figure 1. (a) Changing mortality survivorship curve and contributions of deaths at different ages to life disparity contribution in the USA, 1947, 1975 and 2017. (b) Changing mortality survivorship curve and contributions of deaths at different ages to life disparity contribution in Japan, 1947, 1975 and 2017.

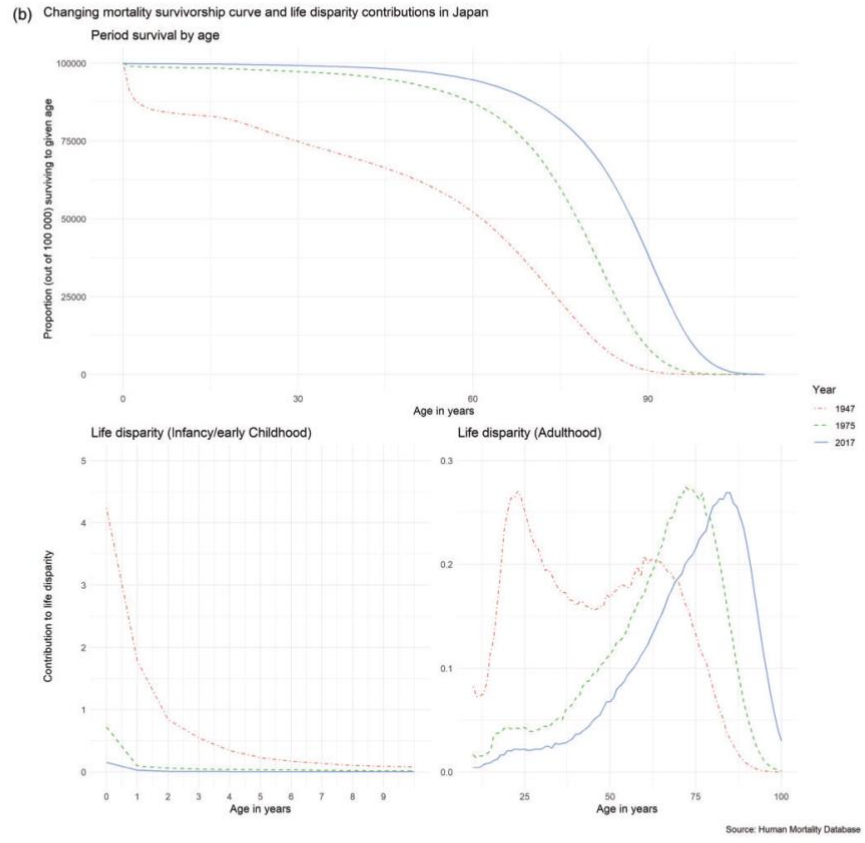


Probability of dying in the next 12 months

Deaths in which age groups are driving changes in life disparity? To answer this, we next examine 12-month death risks at birth, 40, 80 and 90 years of age (see White[22] and Christensen et al.[23]). In Figure 4, the *y* axis is on a log scale; a straight line means constant percentage rate reduction per year over time. For some countries/ages, such as older Japanese females, the series looks like a straight line, but for others it does not. Figure 4 shows a reversal of improving trends in mortality at age 40 years for all countries since 2010, more marked in some populations.

At under one year (age 0), previously declining trends slowed in the USA, UK, France and Canada, in females, and in males in the UK and France. However, at age 40 years, the USA, again with a markedly higher risk for both males and females, shows a clear increase since 2010, more so in males. In Canada and the UK, risk at age 40 years increased more recently. In France, trends continued downwards. At ages 80 and 90 years, the USA no longer has the highest risk; the UK does.

Figure 1. Continued.



Discussion

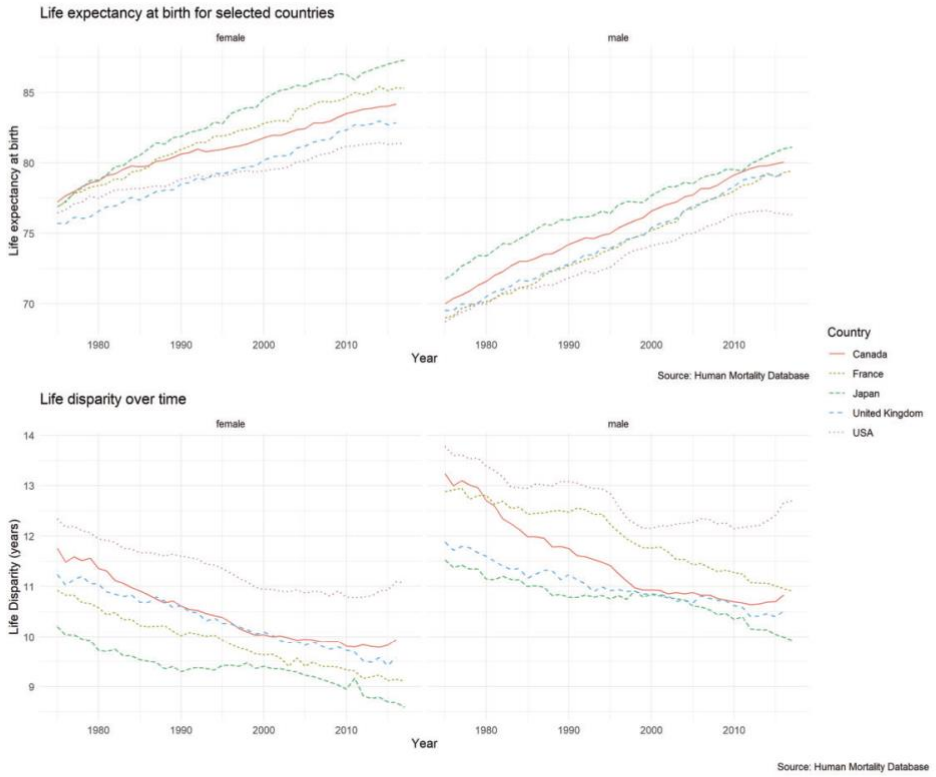
We asked whether lifespan variation, measured as life disparity, could (a) identify changes that otherwise would be missed and (b) detect changes in trends earlier, in the context of the recent divergence from earlier trends in e0 in five high-income countries, and thus whether life disparity should be considered alongside e0 in routine monitoring of population health. We found a deviation from earlier trends in the USA, UK and Canada in both e0 and life disparity, to varying degrees, but it is not clear that these were preceded by increasing life disparity in all cases. By contrast, existing trends largely held for Japan, and, to a lesser extent, France.

When mortality by age was examined, it seems the increase in life disparity in the USA and Canada may be driven by an increase in young- and mid-age mortality. This is consistent with theory and other evidence on how reductions in premature mortality contribute to the decreases in life disparity seen in many countries.[6,18]

What are the practical implications of our findings?

In the USA, we show that rising life disparity coincided with falling e0, with increases seen in young- and mid-age mortality, consistent with previous findings.[10] These findings occur in the context of the unprecedented reversal in e0 in the USA since

Figure 2. Life expectancy at birth (top) and life disparity over time (bottom), 1975–2017.



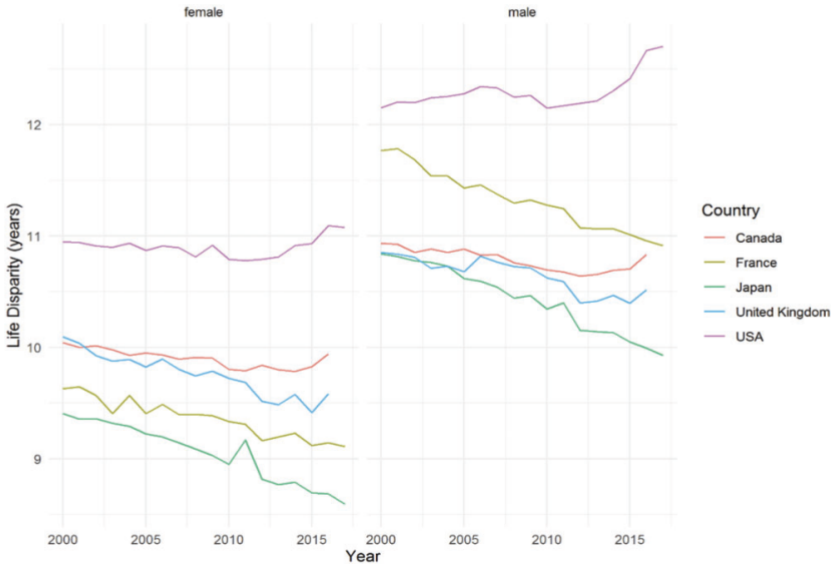
2015.[24] In the USA and, more recently, the UK, a rise in mid-age mortality from 'deaths of despair'[12,13,25] plus stagnating rates in improvements from cardiovascular disease moratlity[26,27] appear to be important contributors to stagnating and declining e0. US research suggests that these largely reflect 'worsening health among working-age individuals of lower socioeconomic status' consistent with evidence that increasing numbers of people are experiencing ever more precarious lives.[28]

Our findings are also consistent with evidence from Statistics Canada,[29] which found that while death rates were falling at older ages, at ages 20 44 years, especially among men, they were increasing. This was attributed largely to the opioid crisis which was afflicting several provinces.[30] Indeed, e0 for men fell in British Columbia and remained unchanged in Ontario, while it continued to increase in others.

An historical example of 'mortality crises' comes from the breakdown of the USSR in the 1990s in Central and Eastern Europe. Aburto and van Raalte found that changes in life disparity were greater than those in e0, with the changes in life disparity driven by increasing midlife mortality.[31] Furthermore, e0 and life disparity varied independently of each other. It may be that something similar is occurring in mid-life in the USA and Canada.

In contrast, except for when the earthquake struck in 2011, Japan continued to make good progress in both e0 and life disparity in the 2010s even during

Figure 3. Life disparity for females and males, 2010–2017.



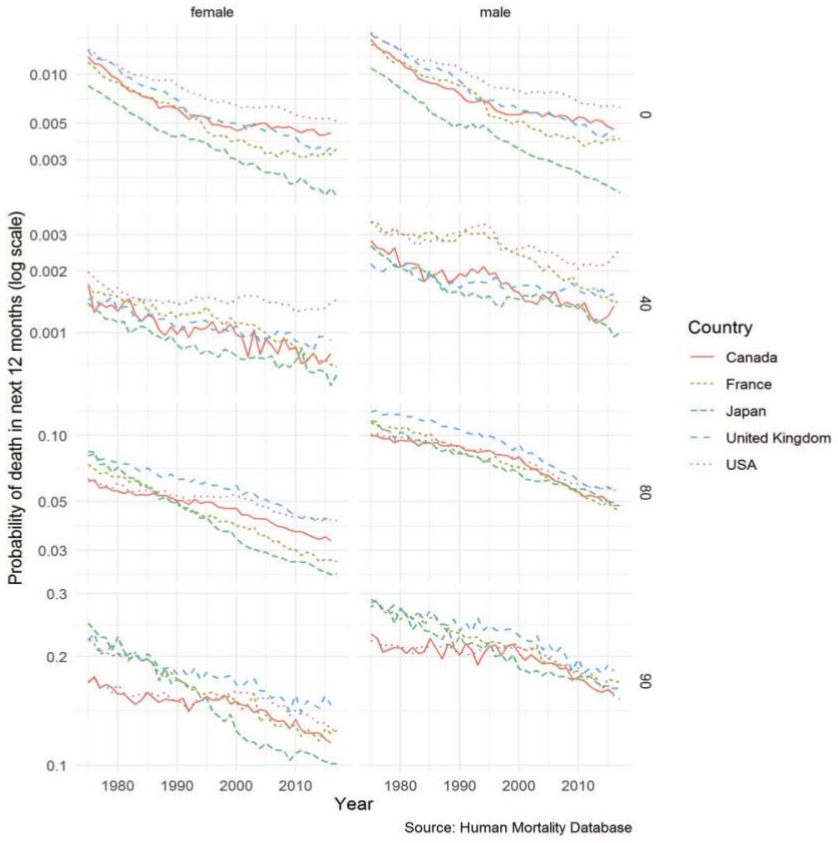
periods of long-term low economic growth, and health inequalities did not worsen.[32]

Can life disparity be used to detect changes in population health trends earlier?

We show increasing life disparity coincided with changes in e0, but cannot conclude that monitoring life disparity would have detected or predicted stalling and falling of e0 earlier in the countries examined. Indeed, existing research demonstrates that an increase in life disparity in isolation may cause a public health 'false alarm'. A study of two populations with increasing longevity, Japan and Hong Kong, showed that life disparity can increase where no adverse trends in mortality are occurring at any age, and while e0 continues to increase.[8] Conversely, analysis of the burden of COVID-19 on mortality in the UK found lifespan inequality decreased during the first year of the pandemic, while e0 also decreased.[3] In both examples, the utility of life disparity is as complementary to e0 a rising life disparity in the context of stagnating or falling e0 may indicate emerging public health challenges in a given population but a decreasing life disparity in isolation does not indicate a healthy population. In this respect, our findings support the emerging concerns about the situation in Canada.

The concept of the 'threshold age' is another measure which may complement the utility of life disparity in monitoring population health. The negative correlation between increasing e0 and reducing life disparity is typically due to progress in reducing premature mortality reducing deaths at older ages can increase life disparity,[6] as demonstrated in the Hong Kong example.[8] Zhang and Vaupel classified the different effects of 'early' deaths from 'late' deaths on life disparity, separated by the calculation of a 'threshold age' averting deaths before that age reduces life disparity, while averting deaths after increases life disparity.[18] Vaupel et al. show the 'threshold age' classifies deaths at late ages as premature or early: for example, in Japanese females, deaths up to the age of 85 years were considered premature.[6] While considering a death aged 85 years as premature may be counterintuitive for public health and policy makers, monitoring of the 'threshold age' through life tables may provide additional insights. In Hong Kong, life disparity increased alongside increased threshold age with no apparent slowdown in e0 gains.[8] By contrast, we show that in the USA, life disparity increased alongside slowdown and decreases

Figure 4. Probability of dying in the next 12 months by age in years, 1975–2017.



in e0. Thus, it may be that the threshold age in the USA also fell, in contrast to the increase in Hong Kong, and a rising life disparity in the context of stalling or falling threshold age may also indicate population health challenges.

We propose that future research could focus on the relationship over time between changes in life disparity, perhaps alongside stalling or falling threshold age, and in e0. If life disparity increases alongside falling threshold age, followed by stalling or declining e0, with a lag impact on e0, this may provide a warning of declining population health, itself often a marker of societal problems. This also gives caution to viewing e0 as a measure of population health in isolation while this is not a substitute for detailed demographic analysis, we suggest that life disparity does offer a simple measure that can provide useful information when undertaking international comparisons of trends over time.

Strengths and limitations of the study

The Human Mortality Database has rigorous data quality requirements and standardisation procedures and is widely accepted as reliable for international comparison.[33] The methods used to calculate life disparity and probability of dying at 12 months replicate those of experts in the field, and were checked against code supplied by one of the pioneers in using these methods.[6,22,23] We compared the countries with the best and worst rates of average annual increase in period life expectancy at birth, as identified by the

Office for National Statistics,[14] thus removing bias from country selection; comparison with geographically and politically similar nations demonstrated reversal of trends is not inevitable.

There are some limitations. For example, the UK is treated as a single entity, concealing differences between the devolved nations. Research comparing inequality in age of death in Scotland to England and Wales found Scotland had higher lifespan variation due to lower old age mortality and higher premature mortality.[34]

Furthermore, the data are aggregated, so it is not possible to examine differences by factors such as race, gender or the social determinants of health such as employment status. This is undoubtedly relevant: evidence from Denmark and Finland showed inequalities in improvements in lifespan variation, with stagnation in lower income quartiles and manual occupational classes compared to mortality compression, i.e. lifespan variation decreases among those in 'more favourable social positions'.[20,35] In addition, evidence from Europe shows those with lower educational attainment not only experience shorter life expectancies, but also greater uncertainty about the age they will die due to higher lifespan variation.[36]

Finally, examining five countries precluded considering each individual trajectory in depth, or exploring all fluctuations.

As such, future research might consider two broad areas. First, the development and testing of complementary measures to e0 for monitoring population health, as outlined above. Second, the public health and policy implications of the findings presented here at both international and national level in order to inform appropriate public health interventions and health policy.

Conclusion

The data presented here show trends in population health, measured as e0 and life disparity, in five high-income countries. They support the existing evidence that the worsening of e0 and life disparity in the USA and, of e0 in the UK, were not inevitable, and neither are continuing adverse trends. France and Japan both experienced periods of downturn but recovered and have been able to continue with improving trajectories in both e0 and life disparity. They also indicate that in those nations where e0 is stalling or falling Canada, the UK and USA rising mid-age mortality (such as at age 40) may be a key contributor. This highlights that when measuring the progress of nations, it is important to look not only at overall deaths but their distribution.

Life disparity can complement life expectancy at birth in monitoring population health, but should not be viewed in isolation.

Data availability

- Data are available in a public, open access repository.
- Data are available from the Human Mortality Database. See https://www.mortality.org/ (last checked 10 April 2021).
- Code and analyses used are available from GitHub. See https://github.com/JonMinton/rising_tide (last checked 9 March 2021).

Declarations

Competing Interests: None declared.

Funding: LH is in receipt of a Clarendon scholarship for her DPhil studies at the University of Oxford.

Ethics approval: Not required – data are aggregate, open access and non-identifiable.

Guarantor: JM.

Contributorship: JM conceived the idea for this paper and carried out all the data extraction and analyses. LH drafted the first version, with significant edits and input from JM and MM.

Acknowledgements: We would like to extend our gratitude to Dr Alyson van Raalte for providing expert review of the code used for the analysis, based on her pioneering work in this area, and to Prof Eric Brunner and Dr Julie Morris for their detailed and helpful reviews which enabled us to significantly improve the paper.

Provenance: Not commissioned; reviewed by Eric Brunner, Alyson van Raalte, and Julie Morris.

Notes:

a. Figure 7.1 of the HMD methods protocol outlines the use of the Kannisto–Thatcher method to smooth observed deaths rates for ages 80 and above. See www.mortality.org/Public/Docs/MethodsProtocol.pdf (last checked 8 March 2021).
b https://github.com/JonMinton/rising_tide (last checked 22 September 2020).

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Public Health 238 (2025) 90–93

Contents lists available at ScienceDirect

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Short Communication

Changing suicide trends: A shift in regional disparities across the UK

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ARTICLE INFO

Keywords:
Suicide
Mental health
England
Regional inequalities

ABSTRACT

Background: In 2023, suicide rates in England & Wales reached their highest levels since 1999. Despite changes in legal definitions and registration methods impacting trends, this increase reflects growing individual suffering. International comparisons suggest that while the UK saw a 12 % rise in suicide rates between 1999 and 2020, many other European countries experienced significant declines.

Methods: We used publicly available data from the Office for National Statistics on suicide rates from 1981 to 2023, by sex and geographical region in England & Wales. We conducted descriptive and statistical analyses with the Joinpoint regression programme to identify significant discontinuities in trends in suicide rates.

Results: In 1981, London had the highest suicide rates, but by 2023, it reported the lowest for both sexes, with declines of 51 % for men and 69 % for women. In contrast, the North East and North West now have much higher rates, particularly in men. Several regions have seen little improvement.

Conclusions: There are substantial regional differences in suicide trends in England. These are consistent with known social and economic changes and point to a need for whole of government responses.

1. Introduction

The August 2024 Statistical Bulletin from the Office for National Statistics (ONS) opened with a stark warning. In 2023, suicide rates in England and Wales reached "the highest rate seen since 1999".[1] For females, whose rates have consistently been much lower than males, one had to look back even further, to 1994, for a higher rate.[1]

Inevitably, caution is needed. These data relate to year of registration, not of death, and recorded suicides increased in 2018 following a change in the legal definition. Yet, notwithstanding these caveats, these numbers testify to widespread suffering among those who die from suicide and those left behind.

International comparisons are problematic due to extensive missing data and, especially, differences in reporting, some of which are cultural. So, comparisons of levels should be avoided, but comparing trends over time between countries creates fewer such problems. Data reported to WHO show a 12 % increase between 1999 and 2020 in the United Kingdom (UK) but falls in almost all EU member states for which complete data are available. For example, Spain, Denmark, and Finland, respectively, saw falls of 4 %, 35 %, and 45 %.[2] The exceptions are Greece and The Netherlands, with 12 % and 4 % increases respectively. The European experience thus indicates that the UK has been, with Greece (which also experienced deep austerity in the 2010s),[3] an outlier over the past two decades (see Figure A in Appendix).[4]

As with all large countries, England has great geographical diversity. During the past few decades, some regions have suffered greatly from deindustrialisation, especially in the north, while London has prospered. Given the well-established association between suicides and economic conditions, we ask whether there are differences in suicide trends in English regions.

2. Methods

We carried out descriptive and statistical analyses of publicly available ONS data on deaths from suicide from 1981 to 2023 in England and Wales, by sex and geographical region. There is considerable year-to-year variation, so it is important not to focus unduly on individual years but to look for underlying trends. Consequently, we used the National Cancer Institute's Joinpoint programme to identify trends and significant discontinuities in them. Briefly, this takes trend data and fits the simplest joinpoint model that the data allow, starting with the minimum number of joinpoints, which is zero where the trend is a straight line, and tests whether adding more joinpoints results in statistically significant improvements in fit, This is achieved using a Monte

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https://doi.org/10.1016/j.puhe.2024.11.018
Received 28 October 2024; Received in revised form 18 November 2024; Accepted 21 November 2024
Available online 6 December 2024
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Carlo permutation method. The user specifies the maximum number of joinpoints allowed; we selected four.

We used data on suicides from the ONS online resource by sex for all available years (1981–2023), and each standard region of England. We extracted the central estimates and upper and lower confidence limits, from which we calculated standard errors. We include key findings in the manuscript, with others in the Appendix.

3. Results

In 1981, the highest rates were in London, which remained in this top position for men until 1983 and for women until 1985. In 1981, the rate for men in London was 50 % higher than in the East Midlands, which had the lowest rate, with a similar gap for women between London and the West Midlands. Yet by 2023, London experienced the lowest rate for both sexes (consistently since 2019 for men and 2020 for women), with rates among men over twice as high in the North East than in London and, among women, almost three times as high in the North West. A closer inspection of the trends identified with Joinpoint shows that this reversal was largely due to fairly consistent declines throughout this period in London, of 51 % for men and 69 % for women, not seen elsewhere in the UK (Fig. 1). A few regions saw declines in the early 1990s but little subsequently, while several, including Wales, have seen no sustained improvement over the entire period. The recent worsening is concentrated in a few regions, especially the North East (Fig. 2) and North West (Fig. 3). As with the national data, these figures conceal differences that are only visible in more granular analyses. For example, some communities, such as certain coastal towns, have suffered even more.[5]

4. Discussion

In 1981, London had the highest rates for both men and women, but by 2023, it had the lowest rates, with declines of 51 % for men and 69 % for women. In contrast, regions like the North East and North West now have much higher rates, and some areas, such as coastal towns, have experienced even worse outcomes, reflecting uneven regional trends across the UK. This short report has many limitations. For example, it does not look at changes by age. The ONS data on suicides by age band.[1] show a change in age distribution that requires further analysis. In brief, in the early 1980s, the highest rates were among those aged over 50. These rates fell from the late 1980s and have remained low, but the decline was slower among those aged over 80. By the beginning of the 1990s, the highest rates were among those in their 30s and 40s but, by the 2010s, the highest rates had shifted to those in their 40s and 50s. Suicides among those in their 20s and 30s peaked in the early 1990s. While we have not explored these data here, by publishing these regional analyses, we hope to prompt further research into these concerning trends.

Given what is already known about the risk factors for suicide, further research could include a more granular analysis, including characterisation of the socioeconomic situation of those dying from suicide. A more detailed analysis could also look at the impact of different policies that fall within the umbrella of austerity, such as benefit sanctions, reduction in community services, the so-called "bedroom tax" (where those in social housing had benefits reduced if they had a spare room),[6] and cuts to support for families with more than two children.[7] It could also look specifically at the impact of deindustrialisation and the scale and nature of new forms of work, including the impact of precarious employment, recognising the complex relationship with gender and education.[8] Comparisons of what happened in Greece and the United Kingdom may be useful, given their shared experience of austerity following the 2008 global banking crisis, given that these two countries have both been economic and epidemiological outliers. Furthermore, future research could undertake focused comparisons of otherwise similar places that have fared better or worse, as well as detailed multimethod studies of places with common characteristics that have suffered the most, such as coastal towns.[9] These studies could be complemented by research on investment in and delivery of mental health services, noting the marked increase in mental health problems since 2010 linked to austerity.[10,11]

These changes occurred when the UK was experiencing remarkable social transformations, affecting the livelihoods of each region's population. In the 1980s, the Midlands and North experienced large-scale

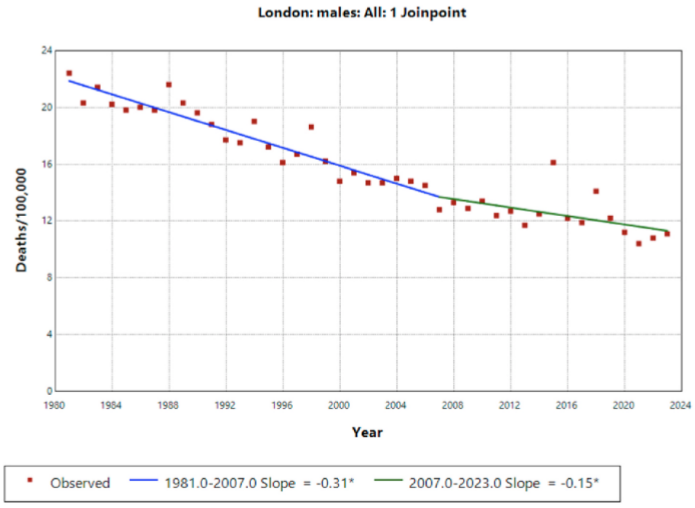


Fig. 1. Death rates from suicide of males in London, 1981–2023.

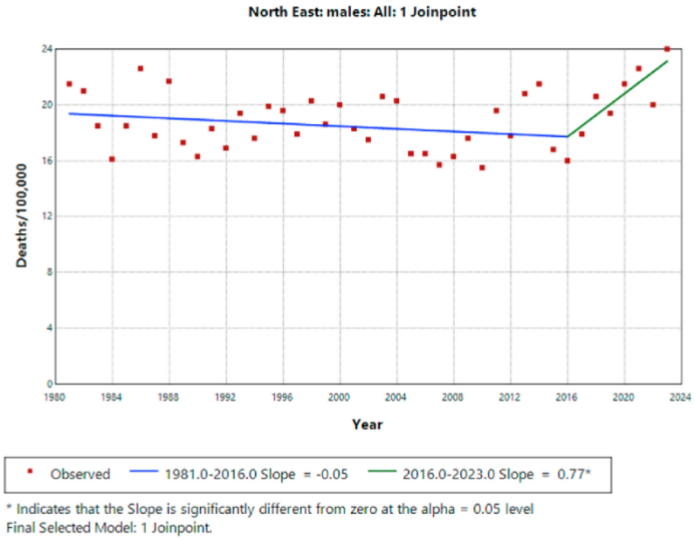


Fig. 2. Death rates from suicide for males, in the North East region, 1981–2021.

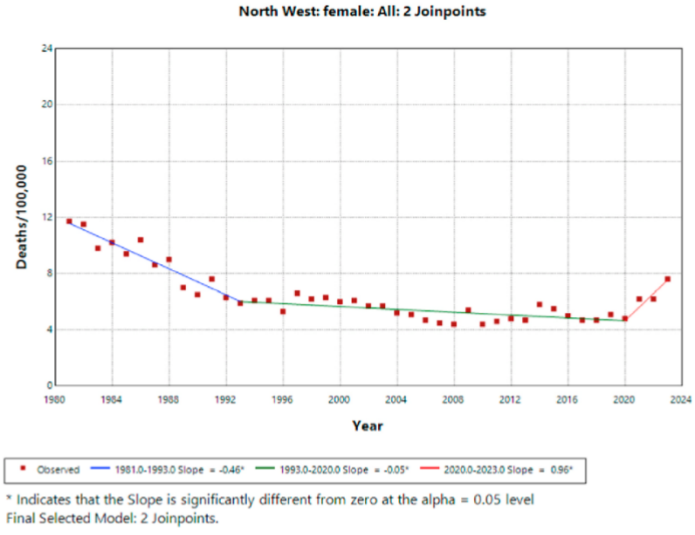


Fig. 3. Death rates from suicide for females, in the North West region, 1981–2021.

deindustrialisation, pre-dating rising "deaths of despair", including suicides.[12] Meanwhile, the "Big Bang" that deregulated the financial sector injected vast sums into London's economy, accompanied by extensive gentrification.[13] Every census taken since 1981 has shown an ever-increasing proportion of the country's university graduates living in London.

The global financial crisis was followed by austerity. Between 2007 and 2013 the suicide rate in England (all persons) increased from 9 to 10.6/100,000. Subsequently, wages, especially in the public sector, have lagged behind inflation, and the current 'real pay squeeze' has lasted longer than any seen in the 20th century while benefits have been cut. For many people, life has become much harder, while support systems they once might have relied on, especially in health, education, and youth services, have struggled to provide support.

Taken together, these policies have exacerbated existing regional inequalities. Now, the United Kingdom has a larger economic gap between its capital and other large cities than in any comparable European country. These problems are well known, partly because they have

important political consequences. The percentage of those voting who chose Leave in the 2016 Brexit referendum was greatest in those places that had experienced the greatest increases in suicides and drug-related deaths in the preceding years, and which transferred their allegiance, albeit transiently, to the Conservatives in 2019.

Taken together, these findings raise important questions for the newly elected Labour government that has inherited a large "black hole" in the public finances.[14] The regional differences highlight the importance of policies that achieve real "levelling up", and not those pursued by recent Conservative governments where, as the Institute for Government has noted, "repeated central government failures have thwarted efforts to reduce regional inequalities".[15] The new government must also take forward the previous government's 5-year suicide prevention strategy, where necessary, with additional funding that recognises how mental health services are now approaching collapse in many parts of the UK. As that strategy notes, action is needed in many sectors, addressing the social determinants of health.[16] However, there is also a clear synergy with its commitment to promote economic well-being. While all European countries experience job losses during recessions, some, such as Sweden, have succeeded in breaking the link between unemployment and suicide.[17] Others, such as Spain, historically did not. This difference has been explained, in part, by whether governments invested in measures that gave hope to those at risk of job loss, such as information, retraining, and support for those with disabilities. Even a relatively modest investment in these "active labour market" policies had a large impact.

Given the state of the public finances, there is a risk that the Labour government might emulate the Coalition government in 2010, imposing a new variant of austerity. History tells us that this would not only be bad for the economy but also for health.[18]

Author statements

Ethical approval

None required.

Funding

No additional funding was used.

Competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2024.11.018.

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Cite this as: *BMJ* 2024;385:e079389
http://dx.doi.org/10.1136/bmj-2024-079389
Published: 12 April 2024

THE BMJ COMMISSION ON THE FUTURE OF THE NHS

NHS and the whole of society must act on social determinants of health for a healthier future

Health is going in the wrong direction in the UK, and reversing the trend requires political and societal commitment to deal with the underlying causes

Lucinda Hiam, [1] Bob Klaber, [2,3] Annabel Sowemimo, [4] Michael Marmot[5]

The UK is facing a prolonged and serious health crisis. At a time when the future of the NHS is in jeopardy after over a decade of austerity, and with public satisfaction at an all time low,[1] it must pick up the pieces of failures across government. Attaining good health requires more than healthcare, and improvements in the provision of healthcare by the NHS alone is inadequate to address the health crisis—action is needed on the social determinants of health[2] (box 1).

Box 1: Definition of social determinants of health[3]

The social determinants of health are defined by the World Health Organization as: "the conditions in which people are born, grow, live, work, and age, and the wider set of forces and systems shaping the conditions of daily life. These forces and systems include economic policies and systems, development agendas, social norms, social policies, and political systems."

In this paper, we propose evidence based solutions to the worsening health and widening inequalities in the UK through action on the social determinants of health. (A separate article within the commission is focused on health equity.[4]) We first outline the problem of deteriorating health across the UK. We then provide an overview of the evidence, showing how action on the social determinants can improve health. We confront the challenging political nature of this area, including rebuttal of criticisms of interventions as actions of a "nanny state" and the neoliberal focus on individualism. Finally, we offer action focused solutions and recommendations on what NHS workers, leaders of NHS organisations and integrated care systems, and the government can do to urgently deal with the deteriorating health of the population.

Although much of the evidence we draw on is focused on England, or England and Wales, we suggest that the overall findings and recommendations are relevant to all of the UK nations, and we emphasise where these might differ. Furthermore, throughout we highlight that health is inherently political, but it is not party political. Politicians from any party can choose to act on the ample evidence available to them.

The problem: why is action needed?

Among European countries, the UK is a relatively poor, sick country with some rich, healthy people.[5] Summary measures of the health of the population are going in the wrong direction for all four nations of the UK. The UK consistently ranks poorly for infant mortality,[6] and its global ranking for life expectancy has fallen, with only the US faring worse of the G7 countries.[7] The public health system in the UK has been decimated over the past decade,[8] particularly in England and Northern Ireland, with the unexpected abolition of Public Health England in 2020, and a 27% real terms per person cut to the public health grant since 2015-16,[9] with greater cuts in poorer areas of England. In contrast, both Public Health Scotland, reformed in 2019,[10] and Public Health Wales and are making progress in improving the health of the populations they serve.[8 11]

Shorter lives spent in poorer health

People in the UK are dying earlier. Life expectancy can be calculated at any age and provides an estimate of the average age a person would live if the current mortality rates were applied over their lifespan. Since 2010, the long history of improvements in life expectancy have plateaued and, for some groups, declined.[12-16] As of early 2024, the latest figures from the Office for National Statistics show that the combination of slow improvements for the past decade and the covid-19 pandemic have decreased overall life expectancy, returning to 2010-12 levels for women and below the 2010-12 level for men, and falling in all four nations for 2020-22 compared with 2017-19.[17] Furthermore, people are spending less of their lives in good health. *Health Equity in England: The Marmot Review 10 Years On* reported that healthy life expectancy has reduced for women since 2010, and the proportion of life spent in poor health has increased for both sexes.[14] A 2024 report found 9.6 million households are living on incomes below the minimum income standard and in some of the least well insulated, cold, damp homes in industrialised countries,[18] with negative consequences for the health of children and adults.[19]

The decline in health shows marked inequalities across factors such as ethnic group, race, sex, and deprivation, many of which intersect with each other. Life expectancy and healthy life expectancy are closely linked to deprivation: the greater the deprivation, the shorter the life expectancy. Those living in deprived areas spend more of their shorter lives in poor health.[14] This relation represents a social gradient: each increase in socioeconomic level results in an increase in health and lower mortality rates. *Health Inequalities: Lives Cut Short* found that that

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one million lives were cut short between 2011 and the start of the pandemic in 90% of areas in England.[20] Figure 1, from the *Marmot Review 10 Years On*, shows how deprivation and region overlap, with regional differences greater in the most deprived group (divided by deciles) than in the least deprived group.[14] In every region outside of London, life expectancy has fallen in the most deprived group.

Acknowledging the overlap and intersections in the groups affected is important. Those living in the most deprived areas are often affected by multiple factors, such as structural racism and the consequences of the climate emergency, and are often more likely to lack the resources to mitigate the subsequent health consequences.

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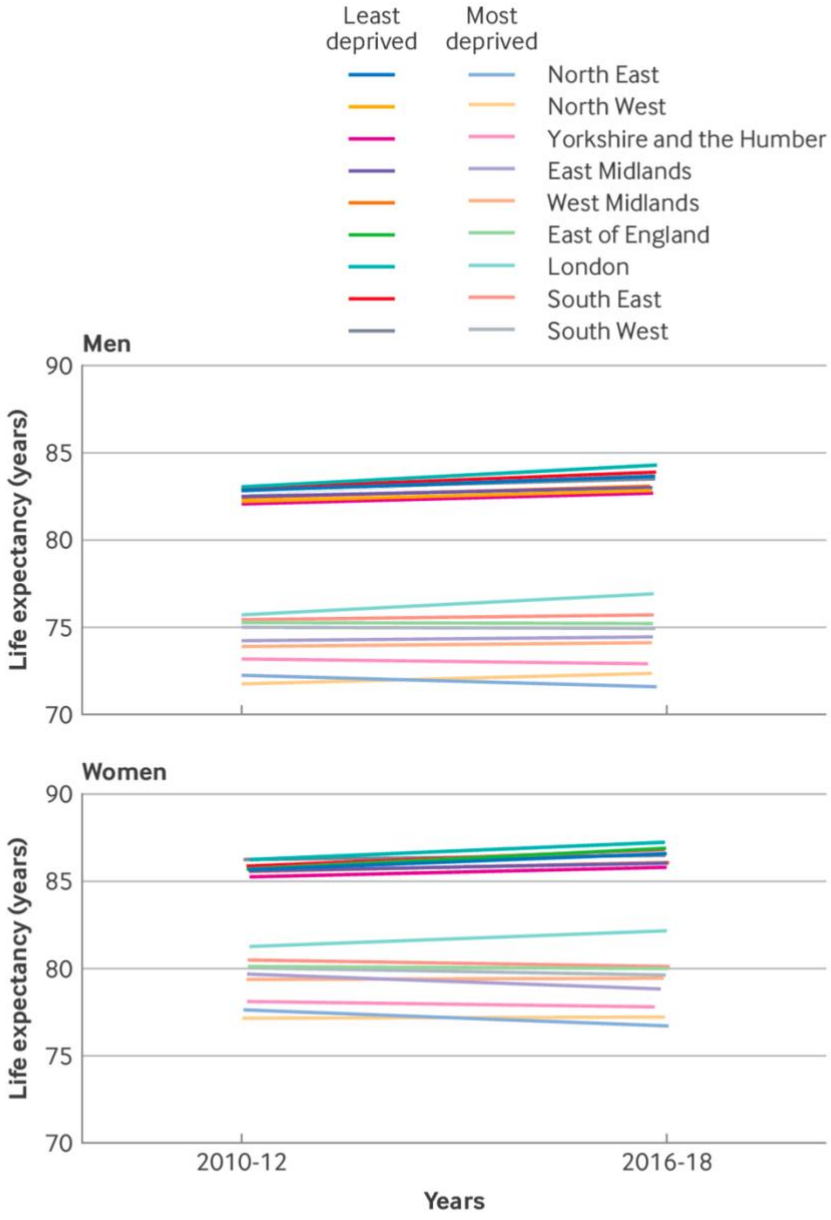


Fig 1 | Life expectancy at birth by sex for the least and most deprived groups in each region, England, 2010-12 and 2016-18[14]

Health is deteriorating from the cradle to the grave

Older women were among the first groups to have an unprecedented fall in life expectancy.[15 21] Older people have been particularly affected because of a greater reliance on a functioning health and social care system. The golden generation, those born between 1925 and 1934, saw remarkable improvements in mortality throughout

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their lifetimes,[22] but the remainder of their lives were cut short since 2010.[23] Over time, in more and more groups, health has worsened and lives have been shortened,[12 13] including a rise in deaths of despair in middle age, reflecting the US experience, of deaths from suicide and from causes related to alcohol and drugs.[24] These findings are reflected across Scotland,[25-27] and in Northern Ireland, life expectancy in men has been declining since 2016-18, with increased mortality in those aged 30-39 years making the greatest contribution.[28]

Of particular concern is the "appalling decline" in both physical and mental health of children aged <5 years, detailed in the 2024 report from the Academy of Medical Sciences. The report described children as being "betrayed" by a failure to be provided with a healthy start in life.[29 30] The accompanying statistics include that infant mortality increased between 2014 and 2017, with the UK ranking 30th out of 49 OECD (Organisation for Economic Cooperation and Development) countries; child vaccination levels are currently below WHO coverage targets; and a quarter of all children aged 5 years are affected by preventable tooth decay, the main reason for hospital admissions in children aged 6-10 years. These problems are entirely preventable and disproportionately affect the most deprived communities.

Figures 2 and 3 show that infant and child death rates increased between 2020 and 2023, with infant deaths almost three times as high for black/black British babies than white babies, and marked regional inequalities in child deaths.[31] Similar trends have been seen in the rates of stillbirths, with increasing rates linked to worsening areas of deprivation and ethnic groups.[32] Other inequalities in early child development exist: cognitive, linguistic, emotional, and behavioural.[14] These inequalities are important because they are correlated with behavioural problems in children and predict the subsequent development of health inequalities. Another marker of poor health in children in the UK is height. In 1985, the height of boys and girls aged 5 years in the UK was lower than in 68 other countries. Height in children aged 5 years increased more slowly in the UK than in many other countries. By 2019, in the UK, boys ranked 102 and girls ranked 96. The average height of children aged 5 years fell from 2015 onwards, suggesting that austerity, which began in 2010, might have had an effect.[33]

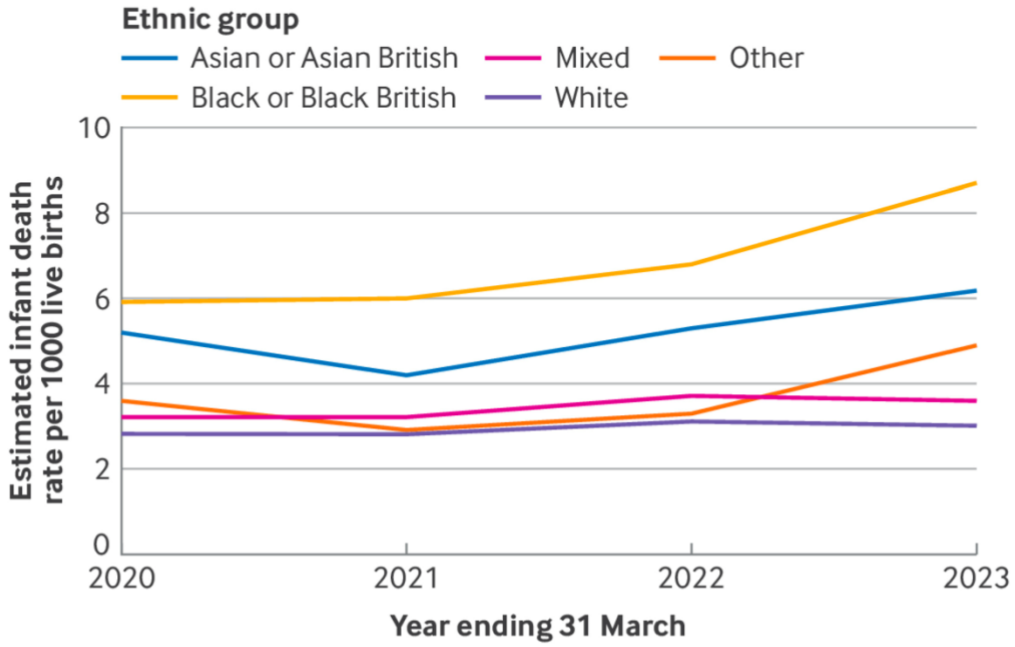


Fig 2 | Estimated infant death rate per 1000 live births by ethnic group[31]

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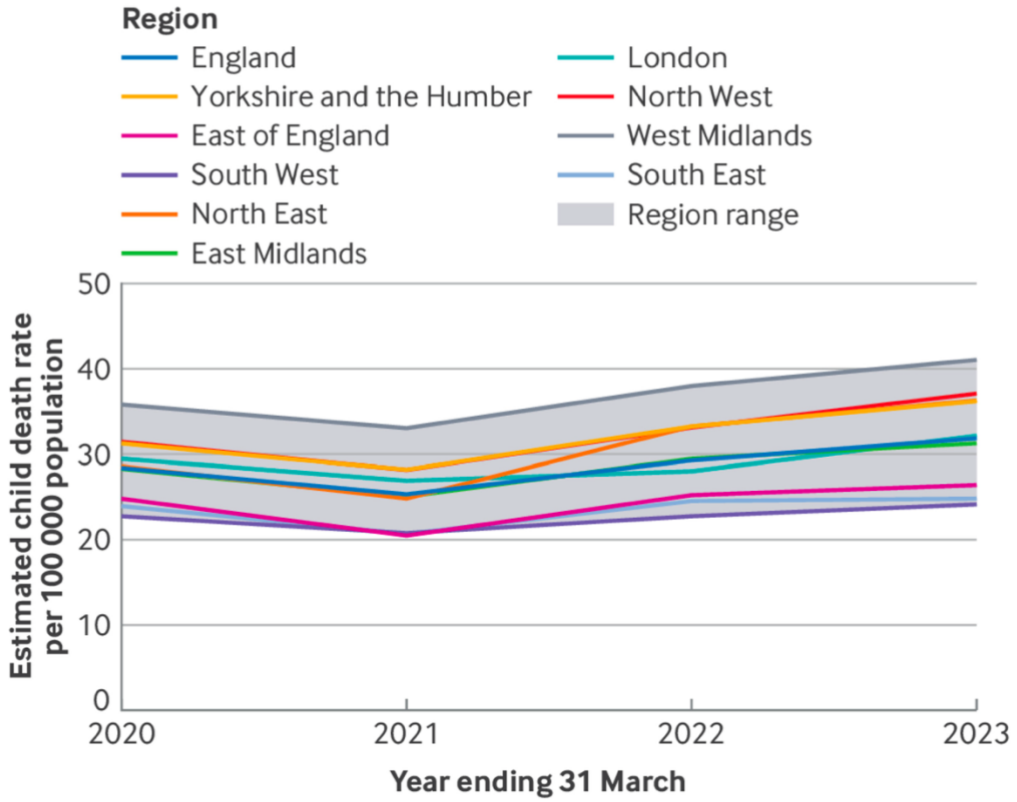


Fig 3 | Estimated child death rate per 100 000 population, by region. Population is children aged 0-17 years[31]

Rising poverty, worsening health

A wide body of evidence has indicated a link between deterioration in health in the UK and cuts in public spending through austerity policies introduced in 2010, policies that are continuing into 2024.[12 -14 23 25 34 -36] The effect of austerity on poverty in the UK has been so great that two successive United Nations special rapporteurs on extreme poverty have called on the government to take action on the problem.[37] The first, Philip Alston, visiting in 2018, called the policies of austerity "punitive, mean spirited, and callous" and the levels of child poverty both a disgrace and an economic disaster.[38] The second, Olivier de Schutter, visiting in 2023, commented that the warning signs his predecessor had given had not been acted upon, that universal credit was too low to protect people from poverty, and that "There's a huge gap, which is increasingly troubling, between the kinds of indicators the government chooses to assess its progress on one hand, and the lived experience of people living in poverty."[39] Currently, government policy does not provide enough money for people to live healthily.[40 41]

Evidence to support action on social determinants of health

Without a change in policy, there is no reason to think that the worsening trajectory of health in the UK will improve. Here, we summarise the key evidence on how action on the social determinants of health can improve the health of the population.

How do social determinants of health cause ill health?

The WHO Commission on Social Determinants of Health synthesised the evidence on social determinants of health.[42] Building on this global body of work, in 2010, *Fair Society Healthy Lives: the Marmot Review*, re-examined the evidence as it applied to England.[43] The review categorised the determinants of health inequality into six domains: early childhood, education, employment and working conditions, having enough money for a healthy life, environmental and living conditions, including housing, and health behaviours. *Health Equity in England: the Marmot Review 10 Years On*, published in 2020, indicated the health picture summarised above and showed worsening in most of these six domains, the likely cause of which was austerity.[14] Relative child poverty, after housing costs, increased from 27% to 30%, and 1000 Sure Start Children's Centres closed; spending on education per pupil was reduced by 8%; the gig

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economy increased; poverty increased, as summarised above; little was done to solve the housing crisis; and spending to improve the thermal property of housing was reduced. Looking at one key marker of future ill health, inequalities in childhood obesity increased.

Each of these domains was made worse by the pandemic and the cost-of-living crisis. For example, the Joseph Rowntree Foundation defined destitution as doing without two or more of six essential items: housing, heat, light, food, clothing, and toiletries.[44] In the UK in 2022, 3.8 million people, including one million children, were destitute. The figure for children increased by 2.9-fold since 2017. Food poverty and food insecurity rose, linked to austerity,[45 46] including for children, with the number of children in food poverty doubling between 2022 and 2023 to four million.[47] Between April 2022 and March 2023, the Trussell Trust's network of food banks delivered almost three million emergency food parcels (a 37% rise compared with the same period the year before); one million food parcels went to children.[48] The lack of these essential items will damage health and increase health inequalities. Living in these conditions has a huge social, emotional, and psychological effect, which will in turn affect mental and physical health.

Much has been reported on the commercial determinants of health.[49] A review of how industry can affect health and health inequalities summarised the evidence into three areas: employment and working conditions, unhealthy goods and services, and the wider effect on society and communities, including procurement, employment, and the environmental and social impact.[50] The 2010 Marmot review developed the concept of proportionate universalism: universal policies with effort proportional to need. Spending by local government in the decade after 2010 was regressive, showing effort inversely proportionate to need. The greater the deprivation of the area, the greater was the reduction in spending per person. Spending was reduced by 17% in the least deprived 20% of areas (quintile) and by 32% in the most deprived areas (quintile). Spending on adult social care was also regressive, with a reduction of 3% in the least deprived areas and 16% in the most deprived areas. Evidence indicated that the greater the reduction in local authority spending, the worse the mortality trends after 2010.[12]

Action on social determinants of health improves health

Recognising that the action needed to improve the health of the population is outside the provision of health services is not new, but some political factions reject such action, favouring an individualistic approach more consistent with a libertarian ideology. The great health gains made during the 19th and early 20th century were not because of the therapeutic revolutions of modern medicine but more a result of the sanitary and social reforms that provided people with better living conditions, such as uncontaminated food, clean water, waste disposal, improved housing, and education of children. The marked improvements in life expectancy in the 1940s and 1950s were thought to be a result of a combination of improved housing and nutrition after rationing during the second world war, which improved understanding of the importance of childhood nutrition, free secondary education for all (Butler Education Act of 1944), advancement of public health measures, including in sanitation and access to clean water, introduction of antibiotics and immunisations and, eventually, the introduction of the NHS in 1948. Although the NHS was established after the initial acceleration in improving life expectancy, substantial health gains have been made since, thanks to greater access to effective care that it enabled.

Politics of health

Given the repeated warnings and attention from international bodies,[37 39] why has the UK government failed to act on the social determinants of health? Here, we briefly outline what has been known for centuries: health is political.

Improving health is a political choice

Ten years ago, in 2014, experts wrote an open letter in the *Lancet* to the then prime minister, David Cameron, highlighting concerns about food poverty.[51] Since then (and before then), multiple reports, research papers, and editorials have called for government action on rising infant mortality rates, child poverty, and growing inequalities.[6 15 21 36 52] Many other reports on these problems exist, spanning over a decade, all indicating that the state of health in the UK in 2024 is not unexpected, has not happened without warning, and could feasibly have been prevented. More research is not needed; action is needed. Action to reduce poverty can be taken almost immediately. For example, the decision by the then chancellor, Rishi Sunak, to reverse the temporary increase of £20/week in universal credit during the covid-19 pandemic, which had helped 400 000 children out of poverty, returned the number of children living in poverty to levels before the pandemic of 4.2 million.[53] Notably, fewer children are living in poverty in Scotland than in England,[54] where child benefit payments for more than two children in a family have been maintained, and the Scottish child weekly payment was raised to £25 for any child aged <16 years in a household receiving benefits, a move the children's commissioner in Wales is advocating to replicate.[55 56] Child poverty in the UK is a political choice.

The economic decline of the UK, exacerbated by Brexit, must be confronted. The Institute for Fiscal Studies has forecast that real household disposable income will not return to pre-pandemic levels before the next election in 2024, after "another terrible decade" of poor economic growth.[57] The number of people signed off sick from work has tripled in the past decade, because Britain is sicker than it was a decade ago.[58] Investing in the social determinants of health will improve health, productivity, and thus economic growth. The move from health in all policies to health for all policies acknowledges that progress and improvement in health and health outcomes has substantial benefits for other sectors.[59] We cannot afford inaction.

We know what to do

Focused, evidence based recommendations exist on how to improve health in the UK. The 2010 Marmot review called for action on six policy objectives (the first six in box 2), and publication of a framework of indicators and economic analysis followed one year later.[43] *Inequalities in Health: the Black Report* was commissioned by a Labour government and published under Margaret Thatcher's Conservative government. The report detailed inequalities in poor health and mortality in Britain.[60] Similarly, the Marmot review was commissioned by a Labour government and published under the Conservative-Liberal Democrat coalition government. The coalition focused on implementing austerity, "doing more for less,"[61] and the recommendations were not acted upon.

Box 2: The Marmot principles

- Give every child the best start in life
- Create fair employment and good work for all
- Enable all children, young people, and adults to maximise their capabilities and have control over their lives
- Ensure a healthy standard of living for all
- Create and develop healthy and sustainable places and communities
- Strengthen the role and impact of ill health prevention

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- Tackle discrimination, racism, and their outcomes
- Pursue environmental sustainability and health equity together

From 2020 onwards, the covid-19 pandemic intensified and increased the existing inequalities. The UK fared comparatively badly, in part because of the condition of the country before the pandemic.[62 63] The *Build Back Fairer: COVID-19 Marmot Review* detailed short, medium, and long term actions needed on each of the six Marmot principles to reduce inequalities and improve health to build, or rebuild, a healthy society.[64] The profound effect of structural racism on the outcomes of covid-19 led to the addition of the seventh Marmot principle, and the eighth was added in consideration of the climate emergency (box 2).[65] These additional principles are based on empirical observation, but regrettably are often politically partisan. Although central government has failed to act on the robust evidence available, some local governments have acted decisively[66]; for example, Coventry and Manchester are Marmot cities, acting on the Marmot principles to improve health.[67 68]

Challenging individualism and the nanny state

Two related areas of political ideology, individualism and accusations of the nanny state, act as powerful rhetoric against public health interventions intended to improve the health of the population. Every day, people make decisions that affect their health and wellbeing, but not under conditions of their own choosing. The individualistic approach to health assigns blame to those who show behaviours associated with ill health, and is a convenient mechanism for those in and with power, and wider society, to abrogate responsibility for creating the conditions for a healthy society. Instead, those with the worst health are blamed for their conditions. For example, during the peak of the covid-19 pandemic, people from lower income households, frequently with frontline roles, were unable to work from home and had greater loss of income during quarantine when infected with the virus.[62 69] People infected with the virus, including those who died, were frequently blamed for not taking adequate precautions or having weaker immune systems or pre-existing conditions (also linked to deprivation) rather than the wider social context being acknowledged. The pandemic is just one example.

Low income, racial, and sex discrimination, commercial exploitation, poor housing (or lack of housing), and lack of access to high quality education are some of the social conditions that diminish the ability of people to live healthy and fulfilling lives. Action to improve these social and economic conditions can and will improve health and reduce the burden on healthcare.

If public health is seen as simply instructing people on how to behave, then accusations of the nanny state are understandable. But what is necessary for public health is ensuring that people have a roof over their heads, have sufficient money to buy food to feed their families, can afford heating when the weather turns cold, and can face the weeks and months without fear of eviction, which is different from instructing people on how to behave. Disputes at the margin, however, are inevitable. Some will see Prime Minister Sunak's ambition for a smoke-free generation as a bold step towards improving the public health (although a substantial health problem is looming from the growth in vaping, now shown to markedly increase risks of cardiovascular disease[70]). Others will see it as a step too far. We should see the key social determinants of health as the responsibility of government and other social actors, not simply individual responsibility. Asking individuals to make choices that their circumstances do not allow almost guarantees persisting health inequalities.

Weakening of the public health system across UK

Because of the political climate, at least in part, the public health system across the UK is now arguably weaker than at any point in history, going back as far as the 1870s, with substantial reductions to public health budgets and staffing levels. Northern Ireland and England have seen significant changes, with the functions of public health severely weakened at local, regional, and national levels.

In England, the abolition of the regional tier of government has seen the end of regional development agencies, regional assemblies, strategic health authorities, and government offices for the regions, among other subnational infrastructure. The abolition of regional emergency planning and response functions, which had worked effectively during crises, such as foot and mouth disease and the fuel tanker drivers' action, was a weakness in the poor response to covid-19 in the UK. The role of public health has been curtailed, with major reductions in resources and expertise, and changes in the role of directors of public health. The abolition of Public Health England and creation of the UK Health Security Agency as an executive component of the Westminster government's Department of Health and Social Care not only saw the disappearance of the term public health but cast the new and undefined function of health security as part of the country's security system. This change has been accompanied by attempts to replace the term health inequalities with the ill defined and obscure health disparities.

In Northern Ireland, local director of public health posts have disappeared entirely, and the public health function has been severely weakened. The absence of a functioning government for several years has created something that resembles a failed state.[71] The re-establishment of the Northern Ireland Executive offers a mechanism to begin to deal with these problems, and the current health minister is familiar with his brief. The legislative agenda is enormous, however, and health might not be a priority. Northern Ireland's unique position with regard to the European single market is a further advantage as it limits the ability of the government at Westminster to enact health damaging policies, such as relaxation of restrictions on harmful chemicals.[72] The Good Friday Agreement also offers opportunities to learn from and expand joint programmes with Ireland, where in marked contrast with the UK, life expectancy is improving.

Recommendations

Just as the health of people served by the NHS is determined by their economic and societal conditions, the future of the NHS is inextricable from the future of society and policies that provide for good health. Our recommendations focus on what the NHS can do in each of the four nations of the UK and what the whole of society can do, to act on the social determinants of health.

Restore, revitalise, and prioritise the public health system in the UK

We recommend urgent restoration of the public health system across all four nations of the UK. The evidence base for what needs to be done to improve population health continues to strengthen, as we have highlighted, even while the capacity in the UK to carry out the necessary actions to improve health is depleted. The deterioration in health and the social determinants of health, such as housing, have been accompanied by the dismantling and the imposed disorganisation of the public health system, particularly in England and Northern Ireland. Thus, we recommend that the government

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should restore the public health grant to at least 2015-16 levels[73] and re-establish Public Health England.

Dealing with the population health crisis in the UK requires urgent, in-depth consideration and substantial commitment to creating a system that can deliver all WHO defined essential public health functions. One way to engage in this task would be the formation of a cross party task force accountable for public health, enabling non-partisan consideration of the necessary actions. The task force should cover the whole of the UK and seek to learn from the positive experiences of public health structures in Wales and Scotland. Because of the long term nature of public health change, there would also be value in creating this cross party task force as a standing body so that it could review the implementation of its recommendations and measure the results.

Role of the NHS

The NHS is predominantly focused on providing clinical care and support to those needing treatment for health conditions. It is because of its role in the delivery of care that the NHS can do much more as both a health service provider and the country's largest employer[74] to ensure that fewer people are burdened with poor health and that many more enjoy healthy lives.

What individuals working in the NHS can do—Recognising that improving the social determinants of health will improve health, and thus reduce the burden on healthcare, those working in the NHS might consider the effect they can have as individuals. Box 3 shows some examples.

Box 3: Examples of actions on social determinants of health by individuals working in the NHS

As an individual healthcare worker

- Focus on co-production for service design, development, and evaluation.[75]
- Use clinical encounters with patients and their families to ask about, and listen to, some of the wider problems that might be affecting the patient's health.
- Consider if adaptations to how care is delivered could be helpful (eg, adapting the follow-up conversation to a time and method that saves travel and thus has less impact on time, carbon, and money), and fit around the patient's work (which might be paid by the hour or on a zero hours contract) and their children's schooling (education being a critical social determinant)?

As a community member

- Consider and mitigate for the effect of all activities on the environment, such as changing methods of travel, reducing waste, and switching off unused desktops/lights.
- Support initiatives on anti-oppression and raise awareness on how intersecting factors can worsen health outcomes.

As an organisation member

- Advocate for a more thoughtful, intentional, and effective organisation in its role as a partner in civil society (eg, explore the organisation's role in working with multi-agency partners such as housing departments of the local council, voluntary sector, public health teams, schools, and police).

As a member of the electorate

- Build knowledge on policies that can affect the social determinants of health, while supporting organisations and voting for policies that proactively deal with these concerns.

What the NHS can do as a health system—Leaders of NHS organisations and systems can act on the social determinants of health: firstly, as an employer, considering their staff as a key population; secondly, on staff recruitment, development, and training, working towards self-sufficiency in the workforce; thirdly, as important social partners within local communities; fourthly, as a procurer of goods in its supply chain; and finally, in reducing its environmental impact (box 4). These actions are linked to recommendations to enhance the NHS's role as an anchor institution (ie, an institution that can positively contribute to the wellbeing of the population it serves and the communities it is based in).[77] Healthcare leaders might draw inspiration from the East London NHS Foundation Trust, which is working with University College London Institute of Health Equity to become the first Marmot Trust, exploring how trusts can work upstream to tackle the drivers of poor health and implement the Marmot principles (box 2).[78]

Box 4: What the NHS can do as a health system

As an organisation or system that employs staff

- Build and maintain a workforce environment that is conducive to improving the health of patients, and protecting and enhancing the health of staff
- Ensure staff have the pay, conditions, and opportunities to learn and develop, and have inclusive working environments where they can thrive
- Take a proactive approach to workplace health and wellbeing
- Encourage an open and supportive culture for the early recognition and proactive management of mental health problems
- Ensure a continued commitment to educational programmes that raise awareness on how factors such as race, sex, sexuality, and deprivation can affect health outcomes

As an NHS workforce

- Work towards a model of workforce self-sufficiency for the UK
- Ensure adequate support structures are in place for international staff, because marked inequalities also exist in access to healthcare for staff and their families[76]
- Support local communities to explore the roles available in the health service, and support apprenticeship schemes in the NHS
- Increase training opportunities and skills development for all staff

As an organisational partner in civil society

- Learn from others, share and adopt ideas that improve health and care, and model broader civic responsibility
- Build relationships and partnerships with organisations (eg, local authorities, voluntary sector organisations, local businesses, sports club foundations, community groups, healthcare providers)
- Harness these relationships to work in multi-agency partnerships within a defined place, forming a strong collective power to tackle barriers to good health

As a procurer of goods and services

- Ensure contracted service providers have fair working conditions for their employees.
- Where possible, procure goods and services locally that benefit the community and minimise harm to the environment

As a sustainable healthcare system

- Continue to work to reduce the environmental impact, working in partnership with others on key concerns
- Continue progress towards the NHS becoming the world's first net zero health service

Role of policy makers

The health crisis cannot be solved by the NHS alone. Action on the social determinants of health requires changes in policies and

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political support from local and central governments. We know what to do. The political will to implement the recommended measures has, so far, been missing. The UK lost a decade between the government commissioned 2010 and 2020 Marmot reviews; the findings and recommendations were not acted upon by successive governments.[79] Since then, the covid-19 pandemic has worsened the crisis,[64] and life expectancy has regressed to 2010-12 levels.[17] Time is of the essence.

We are not recommending further reviews, research, or commissions; these processes would delay urgently needed action. Instead, from the Marmot reports,[14 19 43 64] we highlight three recommendations (box 5): implement policies to tackle poverty so that individuals and families can lead healthy lives; invest in housing that is compatible with good health; and prioritise children and young people. These recommendations are, of course, related. Reducing child poverty and improving child health will, in turn, improve the physical and mental health of families, strengthening the workforce and productivity, as well as reducing costs to the NHS. Although managing poverty does not level the social gradient, proportional universalism does, and a focus on housing and childhood can help deal with the gradient, as will further action on the Marmot principles (box 2). Similarly, by dealing with key policy areas, such as working and housing conditions, people experiencing intersecting factors are most likely to benefit, because the data consistently show that they are over-represented in these areas.

Box 5: Recommendations for the government[19 64]

Implement policies to tackle poverty so that individuals and families can lead healthy lives

- Ensure the national minimum wage and national living wage are sufficient to lead a healthy life
- Adopt more equitable redistribution of profits in companies to reduce in-work poverty
- Support the Joseph Rowntree Foundation and Trussell Trust campaign (Essentials Guarantee)[40] to raise universal credit to ensure that essentials are covered, with at least an annual review

Invest in housing compatible with good health

- Introduce schemes to increase the supply of affordable, good quality, sustainable housing (eg, by reform of the private housing market and by increased investment in building social housing)
- Commit to a 10 year retro-fit programme targeted to people on low incomes in energy inefficient housing, tackling both the negative effects of poor housing on health and the effects on the climate

Prioritise children and young people, giving every child the best start in life

- Reverse the deterioration in mental and physical health of children and young people, and improve levels of wellbeing from the current low rankings internationally, as a national aspiration
- Reduce levels of child poverty to 10% (comparable with the lowest rates in Europe)
- Prioritise reducing inequalities in early years development (eg, allocating additional spending to early years in more deprived areas)

Implement policies to tackle poverty so that individuals and families can lead healthy lives—Poverty causes poor health.[80] Treating people in a health service that returns them to conditions that are making them sick is futile. Policies to deal with poverty will, evidently, improve health.

Invest in sustainable housing compatible with good health—The standard of housing in the UK is poor, and homelessness is rising to record levels. Cold, energy inefficient homes cause poor health and cost billions a year, directly and indirectly, through costs to the NHS of associated health problems, energy bills, lost productivity from poor health, and carbon emissions.[19]

Prioritise children and young people, giving every child the best start in life—The government must act immediately to reduce child poverty and improve child health, with proportionate universalism, ensuring that those doing worst receive appropriate support. This approach requires acknowledgment of racial, ethnic, and geographical inequalities, as well as their interaction. In addition to the recommendations in box 5, the government should remove the two-child restriction on child benefit and benefit cap, increase child benefit for lower income families, and extend free school provision for all children in households that receive universal credit, as set out in the *Build Back Fairer* review.[64]

For any recommendations to be meaningful, an acknowledgment that the UK has a problem is crucial. Thus we call on the leaders of all political parties to recognise the scale of the problem and the need for action, and to commit to acting on the available evidence (box 6). Support for this initiative must come from an informed, unified general voting population, who are also considering those who cannot vote (eg, those who are too young to vote).

Box 6: Call for leaders of all political parties to acknowledge the problem and act on the evidence

- Austerity has harmed health, including through worsening of many social determinants of health, including housing, income, and education
- Action on the social determinants of health will improve health
- Inequalities are rising in the UK, based on factors such as deprivation, race, ethnic group, and sex, which overlap and interact

Conclusions

Improving the health of the population and reducing avoidable health inequalities must be a national priority. So strong is the evidence on social determinants of health that the health of the population is a good measure of how well society is meeting the needs of its members. If health inequalities are increasing, inequalities in society are increasing, and dealing with these inequalities is urgently needed. Action will include an NHS, free at the point of use, that delivers high quality care proportionate to need.

But much more will be needed. A common response is that we cannot afford such action—we argue, we cannot afford inaction. We call on all political leaders to acknowledge the problem and the urgent need for action on the social determinants of health. This action can be a story of hope: we can change the direction of health in the UK if we use the robust, broad evidence on how to act.

Recommendations

- Form a cross-party task force accountable for public health
- Re-establish Public Health England and restore the public health grant to 2015-16 levels
- Build and maintain a workforce environment in the NHS that supports action on the social determinants of health and that is conducive to protecting and enhancing the health of staff, as well as patients
- Implement policies to tackle poverty so that individuals and families can lead healthy lives
- Invest in sustainable housing compatible with good health
- Prioritise children and young people, giving every child the best start in life

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We thank Gabriel Scally for his significant contribution to the first iteration of the paper, including the section on the weakening of the public health system; Martin McKee for contributing on public health in Northern Ireland and providing further informal review and support in the final version of the paper; and Sophie Cook from *The BMJ* for her constant support throughout.

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Competing interests: We have read and understood BMJ policy on declaration of interests and have no interests to declare.

Provenance and peer review: Commissioned; externally peer reviewed.

This article is part of The BMJ Commission on the Future of the NHS (https://www.bmj.com/nhs-commission). The purpose of the commission is to identify key areas for analysis, lay out a vision for a future NHS, and make recommendations as to how we get there. *The BMJ* convened this commission, which was chaired independently by Victor Adebowale, Parveen Kumar, and Liam Smeeth. *The BMJ* was responsible for the peer review, editing, and publication of the papers of the commission. The BMA, which owns *The BMJ*, grants editorial freedom to the editor in chief of *The BMJ*. The views expressed are those of the authors and may not necessarily comply with BMA policy.

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15 Appendix 5: Evidence on Migration

During the DPhil, I have also pursued research on the impact of migration on life expectancy in the UK. Three publications related to this work are included below.

Journal of Public Health | Vol. 44, No. 4, pp. e499–e505 | https://doi.org/10.1093/pubmed/fdac013 | Advance Access Publication March 22, 2022

What can the UK learn from the impact of migrant populations on national life expectancy?

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ABSTRACT

Improvements in life expectancy at birth in the UK had stalled prior to 2020 and have fallen during the COVID-19 pandemic. The stagnation took place at a time of relatively high net migration, yet we know that migrants to Australia, the USA and some Nordic countries have positively impacted national life expectancy trends, outperforming native-born populations in terms of life expectancy. It is important to ascertain whether migrants have contributed positively to life expectancy in the UK, concealing worsening trends in the UK-born population, or whether relying on national life expectancy calculations alone may have masked excess mortality in migrant populations. We need a better understanding of the role and contribution of migrant populations to national life expectancy trends in the UK.

Keywords migration, public health

Introduction

Life expectancy at birth* is one of the most widely used indicators of the health of a population.[1] In the past decade, previous improvements in life expectancy in the UK have stalled and, for some groups, such as women in the most deprived deciles,[2] fallen.[3] The situation has worsened during the coronavirus disease 2019 (COVID-19) pandemic, with life expectancy in England falling by 1.3 and 0.9 years in 2020 for males and females, respectively.[4]

Interpreting changes in a summary measure such as life expectancy is complex. In part, any changes represent the net effect of rises and falls in deaths from different causes at different ages, reflecting both period effects and cohort effects, the latter with origins perhaps decades earlier.[1] We now have some potential explanations for trends before 2020, including the impact of austerity measures imposed since 2010 that have disproportionately affected older people,[5] interruption of long-term declines in cardiovascular disease mortality[6,7] and since 2020 the significant direct and indirect effects of the pandemic, the magnitude of which may not be known for some time. However, life expectancy may also be affected by changes in the composition of the population, for example when the health of those who migrate into and out of a country differs. Indeed, research in other high-income countries (HICs) has shown that migrants, with lower mortality rates, have positively impacted reported life expectancy.[8–11] Although this issue has received less attention, it is important that those formulating policy to improve population health understand how migration might impact measures used to track progress in health attainment.

The impact of migration on life expectancy is especially relevant to the UK, which has experienced relatively high levels of migration, in both directions, in recent years. Almost

* Here, we are referring to *period* life expectancy rather than *cohort* life expectancy. Period life expectancy is the number of years a newborn might be expected to live, on average, assuming the current death rates do not change. It does not consider future changes in mortality rates. Period life expectancies are used to compare trends over time, and the UK and other national life tables are period life tables for this reason.

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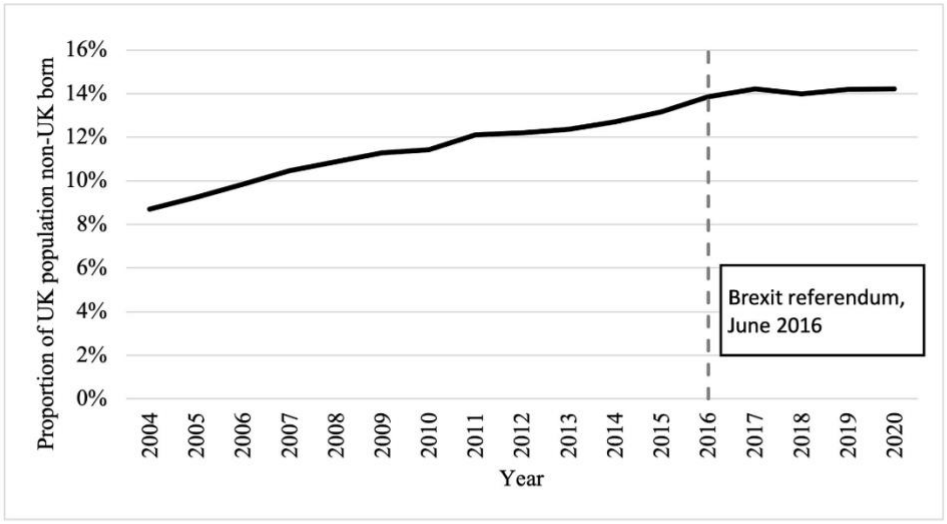


Fig. 1 Proportion of non-UK born population resident in the UK, 2004 to 2020. Authors' calculations based on estimates of non-UK born population in thousands resident in the UK and UK population mid-year estimates. Source: Office for National Statistics.

14% of the total UK population are migrants,[12] defined as any person born outside of and residing within the UK. However, a combination of Brexit and the impact of the pandemic has meant that migration patterns are changing. In these new circumstances, it is important to understand how migration has impacted on life expectancy in the past and how it might do so in the future.

Trends in migration in the UK

The UK's decision to leave the European Union (EU) in 2016 was, in part, driven by a desire to reduce immigration.[13] Loss of free movement meant EU citizens lost the right to move to the UK and also made it more difficult for older Britons to retire to the Mediterranean. Subsequently, travel restrictions imposed during the COVID-19 pandemic brought movement into and out of the UK to a virtual halt.[14] Figure 1 shows how the increase in the percentage of the resident UK population born outside of the UK has stalled since 2016.

How might migration impact measurement of a nation's health?

Before reviewing what is known, we should become familiar with terminology used in the area of migrant health (Table 1). Those who migrate tend to do so at young ages, and evidence suggests that they are often not just healthier than those they leave behind, the 'healthy migrant effect',[15] but also healthier than the native-born population in their country of destination, particularly those coming from regions such as North Africa, Asia and Southern Europe.[16] However, any such advantage tends to dissipate over time, with data from France and Scotland pointing to a phenomenon of 'levelling down'[17,18] as the accumulated disadvantage many migrants experience means that they often experience declining health over time compared with when they arrived in the country.[19]

Indeed, migrants may be more likely to live in more deprived areas, inner cities and in unsuitable, temporary housing.[20] Many may also be unemployed, underemployed or precariously employed with limited opportunities for upward social mobility. The situation is less clear for forced migrants (e.g. asylum seekers and refugees), in part because of data limitations.[16,21]

However, while forced migrants are significant in number globally,[22] in the UK they are few, contrary to the perception conveyed by the media and certain politicians. Indeed, in 2019, asylum seekers comprised only 6% of all migrants to the UK,[23] and 0.6% of the UK population.[24]

A further complication is 'salmon bias', where migrants return to their country of birth when faced with deteriorating health, thus removing them from the death statistics of their country of residence before they die.[25,26] Finally, it is

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Table 1 Key terms, their explanation and potential impact on national population health metrics

Term	*Explanation of term*	*Potential impact on population health metrics*
Migrant mortality advantage	People who migrate to HICs have lower mortality than the host population.[16]	Migration to a country may have a positive impact on its overall health outcomes such as life expectancy.
Healthy migrant effect	People who migrate may have a better health status compared with both their native population and to the new country of residence or host country population.[15]	People who migrate have better health outcomes due to selection processes at the time of migration. Potential cause of the migrant mortality advantage.
Salmon bias	'The compulsion to die in one's birthplace'[25] An out-selection effect relating to the return of some migrants (often frailer) to their country of origin in order to die in their birthplace.	Observed mortality levels of migrants are depressed because only the lower mortality of those migrants who remain in the host country is included in calculations of mortality. Potential cause of the migrant mortality advantage.
Data artefact	Issues relating to the inability of the data source to capture the mobility of migrants and/or their characteristics. For example, country of origin, age etc.	Observed mortality levels of migrants are lower than they would have been in the presence of perfect data. An artificial explanation of the advantage.
Health-mortality paradox	People who migrate may have lower mortality but worse health.[19]	While migrants may live longer, they may spend more time in poor health.

important to consider the accuracy of the data,[27,28] especially in a situation where government-imposed 'hostile environments', such as the use of barriers to accessing healthcare in immigration enforcement,[29] create powerful incentives not to be recorded.

Few studies have sought to quantify these complex effects.[9,16,30] An Australian study estimated trends in life expectancy at birth with and without the foreign-born population between 1981 and 2003, finding that the foreign-born population contributed almost half a year of increase for men, and a third of a year for women.[8] Migrants made a net positive contribution to life expectancy in three of four Nordic countries between 1990 and 2019—Denmark, Finland and Norway—with the effect growing over time.[9] The exception was Sweden, where the largest migrant group was from neighbouring Finland, who brought a higher mortality rate, and initially depressed national life expectancy. This highlights the need for country-specific analyses in the UK where previous work has provided many insights into the health of migrants, many with a mortality advantage. The large number of Irish migrants is a notable exception.[31] However, to our knowledge, no study has sought to estimate the combined impact of migration overall.

Life expectancy in the USA and the UK has followed similar trajectories in recent years, lagging behind other HICs.[32,33] Research has shown that the situation in the USA would have been even worse without migrants. Between 1990 and 2017, migrants to the USA added 0.94 and 0.83 years to male and female life expectancy, respectively, but not enough to compensate for the overall decline in life expectancy since 2015 driven by increasing mortality in the US-born population.[10] Remarkably, in 2017 life expectancy in migrants to the USA was 7 (men) and 6.2 (women) years higher than their US-born counterparts. Could a similar situation pertain to the UK?

Box 1. How might the age structure of international migrants determine their influence on national life expectancy?

The age structure of migrant populations in many HICs tends to be concentrated around young adult ages—the ages at which the majority of migrants arrive to live and work in the host country.

Although migrant populations are gradually ageing over time in HICs, they remain, on average, very young compared with native-born populations. The previous evidence, including from the UK, has demonstrated that while migrants often have lower overall mortality than native-born populations age-adjusted rates/ratios mask major variation in the mortality of migrants at specific ages. Mortality among migrants has been shown to be lower than the native-born population at young adult ages, increasingly similar to—or higher than—the native-born population at older adult ages, and elevated in infancy and childhood too.[34] What does this mean for the overall impact of migrants on population health metrics such as life expectancy, which are a product of mortality across the entire age range? If migrants *are* to positively influence national life expectancy, they have the greatest potential to do so at young adult ages where they comprise a larger share of the total population and have the largest mortality advantages over the native-born population. At very young and very old ages, where they comprise smaller shares of the total population but tend to have similar or excess

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mortality versus the native-born population, there may be a lack of, or counteracting, effect. In historical high-mortality settings, death at young ages had a larger effect upon life expectancy than death at old ages did. In today's HICs, however, mortality levels at young adult ages are very low already and, while changes in mortality at younger ages would have a substantial impact on life expectancy at birth, the scope for further large reductions in deaths in these ages is low.

How could this impact the UK?

Life expectancy at birth, as a measure of the progress (or regression) of nations, has the great advantage of simplicity. Like GDP as a measure of economic development, it captures trends in a single figure. Yet, in both cases this simplicity comes at a cost as it ignores some compositional issues. Apparent progress can conceal deterioration in the circumstances of some groups contributing to the summary measure.

This matters for both the migrant and the native-born population. If what has been happening in Australia and the USA has also been occurring in the UK then it suggests that the stagnating and, in some places, worsening life expectancy seen in recent years may have been even greater for the native-born population than believed at the time.

Conversely, any excess mortality among migrants may have suppressed what might have been even greater gains in national life expectancy in the UK. As found in Sweden, migrant groups from specific regions or over specific time periods could have had higher mortality than the native-born population.[9] Given the UK's consistent growth in life expectancy prior to the stalling seen in the last decade, it is possible that national life expectancy masked excess mortality in certain migrant populations over time; not knowing whether and to what degree this occurred limits public health and health and social care systems' ability to respond to the needs of migrant populations.

How can we improve understanding on the role of migrants in contributions to life expectancy in the UK?

Life expectancy in the UK was on a declining trend before the COVID-19 pandemic, performing worse than other HICs, with evidence of inequalities widening.[3,32] The road to recovery for the nation's health could benefit from better understanding of the role that migration plays in population health metrics, such as life expectancy, and in turn better inform the substantial investment in health and social care needed to reduce inequalities in health outcomes.[35]

Box 2. Actions to improve understanding of the role of migration on population health indicators

- Research the impact of migrants on life expectancy in the UK
- Record clearer indicators of migration indicators on death certificates e.g. country of birth instead of place of birth
- Avoid conflating ethnicity and migration
- Explore migration subgroups (e.g. labour migrants, forced migrants) and year of migration
- Link data from existing routine administration datasets
- Alongside mortality-based metrics, consider population health metrics that reflect how healthy migrants' lives are and how their well-being is affected by the wider determinants of health

A number of proposed actions are outlined in Box 2. Research is needed to investigate how migration influences indicators of population health. While publication of research on migration health in the UK has increased substantially in recent years,[21] to date there are no studies examining the impact of migrants on national life expectancy trends. This is, in part, due to the limitations of the available data. In contrast to countries such as Denmark and Sweden, the UK does not have a reliable national death register with country of birth or ethnicity recorded,[36] and relies on ethnicity data from the 10-yearly census to link to death records. Novel approaches such as data linkage of routine administrative datasets may provide more accurate data for analysis.[37] ONS recently produced experimental statistics on differences in life expectancy and mortality by ethnicity,[38] a methodology that should be further refined and developed to address its current limitations.[36,39,40] Furthermore, ethnicity and migration status are different concepts, and conflation must be avoided.

We have focused on the situation in the UK, where there is greater national surveillance and availability of routine data to conduct such research than many other countries. It is therefore necessary to recognize that this information can be exploited for purposes that undermine public health by those seeking to justify discriminatory policies, particularly for politically sensitive issues like migration. Public discourse and political rhetoric surrounding immigration in the UK is already replete with misinformation—researchers should engage proactively with policy-makers, the public and the media to ensure that sensitive findings are not misrepresented and do not undermine public trust in the benefits of collecting and using routine health data for the advancement of population health and well-being.

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Finally, while population health metrics based on measures of mortality, such as life expectancy, are important, so are measures of how healthy people's lives are. While migrants may live longer, some may spend more time in poor health (see Table 1).[19] Additionally, evidence on the negative health impacts of restrictive migration-related policies is well documented.[41] The conditions in which migrants live, work and socialize influence their health status, as do health behaviours and access to healthcare and preventative care. The former is well-researched in the UK; the latter less so. In the latter case, while many studies on behavioural risk factors disaggregate data by related variables such as ethnicity, revealing complex patterns further shaped by intersectional relationships,[42] few do so by migration status. A recent scoping review found that the literature on health of migrants in the UK is dominated by studies of infectious diseases and mental health, where structural risk factors dominate.[21] The interplay of these factors and how they impact on other national population health metrics like healthy life expectancy also warrants further investigation. The creation of the new Office for Health Improvement and Disparities (bringing together teams from the Department of Health and Social Care and the previous Public Health England) presents a unique opportunity to 'count migrants in' when generating and applying evidence appropriately to inform policy decisions to improve the nation's health.[43]

Conclusions

Improving life expectancy trajectories in the UK requires a significant step-change in economic and social policy, including a greater investment in public services. Alongside this, research is needed to examine the impact of migrant populations on population health metrics in the UK, and how a reduction in migration could affect future outcomes. Evidence from other HICs suggests that without migrants the UK's national life expectancy would be in a lower position than it currently is. In planning to 'build back better' following the pandemic, the generation of evidence and its application to policy-making must consider migrant health as a core component of the nation's health.

Funding

Matthew Wallace's involvement was supported by The Swedish Research Council for Health, Working Life and Welfare (Forte) under grant no. 2019-00603 'Migrant mortality advantage lost? Emerging lifespan inequalities among migrants and their descendants in Sweden'.

Conflict of interest

Claire Zhang works in the inclusion health team in the Office for Health Improvement and Disparities.

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The Royal Society of Medicine

Journal of the Royal Society of Medicine; 0(0) 1–11
DOI: 10.1177/01410768251377564

How does mortality compare between different countries/regions of birth for the population of England and Wales, 2007 to 2021? A descriptive, observational study

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Abstract

Objectives: To examine all-cause mortality differences among migrants from different countries/regions compared with native-born populations in England and Wales from 2007 to 2021 and assess whether migrant mortality patterns converge with or diverge from native-born trends over the study period.

Design: Descriptive, observational study analysing mortality trends over a 15-year period.

Setting: England and Wales, using national mortality records and Census data.

Participants: The study included all recorded deaths in England and Wales from 2007 to 2021, stratified by sex and country/region of birth.

Main outcome measures: European age-standardised rates (EASRs) and standardised mortality ratios (SMRs) for all-cause mortality, with and without COVID-19-related deaths. Linear regressions were used to assess mortality trends over time.

Results: Mortality patterns varied significantly by country/region of birth. While most migrant groups had lower mortality rates than the native-born population at the beginning of the study period, this advantage declined for many in recent years. Migrants from Ireland, Scotland and Northern Ireland exhibited consistently worse mortality outcomes. Excluding COVID-19 deaths, 14 out of 19 migrant groups retained a mortality advantage, though trends indicate substantial heterogeneity. Some migrant groups, particularly from North and Central America and parts of Europe, showed improving mortality rates, whereas others, such as those from Bangladesh, converged towards native-born mortality levels.

Conclusions: Despite lacking data on individual-level factors (e.g. duration of residence, socio-economic status and co-morbidities), this national-level study demonstrates important trends in migrant mortality. The findings highlight the urgent need for improved data to capture migration-related variables and enable a deeper understanding of the drivers behind observed trends. The decline in migrant mortality advantage over time for some groups highlights the importance of monitoring structural health inequalities and can inform targeted public health policies and more granular future research.

Keywords

Health inequalities, migrant health, mortality, public health, standardised mortality ratios (SMRs)

Received: 28th February 2025; accepted: 19th August 2025

Introduction

Between the 2011 and 2021 censuses the population of England & Wales (E&W) that were born outside of the United Kingdom (hereon referred to as 'migrants') increased by 2.5 million, making up 10 million (16.8%) of the population by 2021.[1] This period saw a growing number of policies embedding immigration control within public services, including the National Health Service (NHS), alongside shifts in mobility due to Brexit and the COVID-19 pandemic (although Freedom of Movement did not officially end until Brexit's implementation on 11 December 2020).[2,3] While overall numbers of migrants increased, there was a decrease in European Union (EU) migration, and an increase in non-EU migration.[4]

Migrants often face barriers to healthcare, discrimination, xenophobia and associated health harms.[5,6] Despite these challenges, evidence demonstrates that migrants from low- and middle-income countries experience lower mortality rates than native-born populations in high-income countries (HICs),[7,8] with migrants

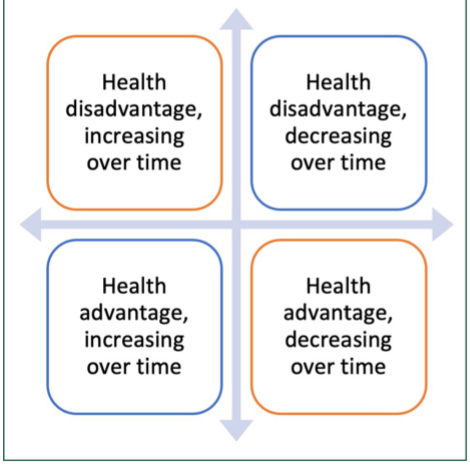
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contributing positively to life expectancy.[9–11] In the USA, immigration has mitigated some of the recent life expectancy deterioration and stagnation.[10] This 'migrant mortality advantage' is linked to the selective migration of healthier individuals.[12,13] However, exceptions exist, with mortality advantages and disadvantages varying by disease and country/region of birth.[14–17] For example, migrants from Ireland living in E&W[17] and those born in Finland living in Sweden[9] show higher mortality than the native-born population (or a health *disadvantage*).

The mortality advantage can diminish over time,[12,18,19] a form of 'levelling down', linked to negative acculturation in the country of residence (described as the 'selection-acculturation hypothesis')[12] and socio-economic challenges, including barriers to healthcare,[20] adoption of adverse health behaviours, poor housing and employment conditions, and the negative impacts of racism and xenophobia.[5] These social determinants of health may partially explain the worse outcomes some migrants experienced during the COVID-19 pandemic.[21]

Given the recent political and demographic shifts, this study examines two questions: (1) How does all-cause mortality vary among migrants from different countries/regions compared with native-born populations in E&W? (2) Are migrant mortality patterns converging with or diverging from native-born trends? We propose four scenarios for migrant health over time: a health disadvantage that (a) increases or (b) decreases over the years examined, or a health advantage that (c) increases or (d) decreases (Figure 1). While previous studies have explored some of these dynamics, they have often focused on shorter timeframes or specific groups. This study extends the analysis to 15 years (2007 to 2021), using annual mortality data by age, sex and country/region of birth for E&W to provide a more comprehensive understanding of long-term trends. This repeated cross-sectional approach is widely used in national mortality surveillance and while it cannot assess individual-level causality, it enables the detection of structural changes in mortality patterns over time. Our data do not include the length of time in E&W since migration, and thus the impact of negative acculturation cannot be assessed.

Figure 1. Four possible outcomes per country/region of birth when compared with the England & Wales-born population from 2007 to 2021.



Methods

Study design and setting

A descriptive, observational study of the population of E&W hereafter from 2007 to 2021 was carried out. The exposure was identified as the country/region of birth, as identified on the death certificate, and the outcome was annual mortality from all causes over the 15-year period. Notably, this is a repeated cross-sectional analysis, which observes population-level mortality trends over time without tracking the same individuals.

Data sources

This study used two data sources. Data were requested from the Office for National Statistics (ONS) for the number of deaths by country/region of birth, 5-year age band, sex and ICD-10 chapter from 2007 to 2021, based on vital registration data of deaths. The mortality data are subject to disclosure control and therefore not publicly available, but reported within the ONS guidance.[22] Second, for the total population, we used data from the last two censuses in 2011 and 2021, linearly interpolating for the years in between.[23] While this introduces some uncertainty, it is a commonly accepted method for national-level estimates and is used by statistical agencies such as the ONS and Human Mortality Database. These population estimates form the denominators for calculating age-standardised rates and standardised mortality ratios (SMRs).

Inclusion and exclusion criteria

The countries/regions of birth included were decided by (a) the available data from the ONS and (b) the 'matching' across the deaths and total population datasets (outlined below). Two countries/regions were excluded in line with disclosure control ('Africa NOS' and 'Asia NOS') due to

low counts.[22,24] Data cleaning was carried out to ensure consistent groupings of countries/regions of birth were applied between the datasets of the mortality and population data, collapsing populations to lowest common denominators where possible. Where a match was not possible, certain data that were disaggregated in one dataset, but not both, were excluded. For example, we were not able to disaggregate 'new EU' (i.e. those countries that joined after 2004) from total EU (i.e. all EU countries, including those that joined after 2004) in all datasets, and thus 'new EU' was excluded as an individual category, with EU as total included. In total, 20 countries/regions of birth were included (19 plus E&W born). Appendix I lists the countries included where a region is specified. People aged 20 years and over were included and standardised to the European age-standardised population (EASP), as outlined below. Those under 20 years old were excluded due to the low counts.

Analysis

Data preparation and analyses were carried out using R version 4.4.2.[25] First, we calculated the annual European age-standardised rates (EASRs) for all-cause mortality by the 20 country/regions of birth, including E&W, and sex, based on the 2013 EASP,[26] with 95% confidence intervals from 2007 to 2021. Recognising the impact of COVID-19 on mortality data from 2020 onwards, we then calculate the EASRs for all-cause mortality excluding deaths from COVID-19. As we are focused on the trends over time from 2007 to 2021, we used the data without deaths from COVID-19 for these analyses. We conducted a COVID-19-specific mortality analysis separately.[27] Second, we used the EASRs for all-cause mortality excluding COVID-19 to produce SMRs using the corresponding rates for each sex born in E&W as the reference population (i.e. SMR = 1) via the PHEindicatormethods package in R.[28] Analyses were conducted separately by sex, and 95% confidence intervals calculated using Byar's method in R.[29] Third, to further assess the relationship between SMRs for migrants and non-migrants over time, we used linear regressions to estimate the direction of trends in EASRs by the available country/region of birth compared with the E&W reference population between 2007 and 2021, reported with p values. The code for performing the analyses is available on request (note the mortality data are not available as these are subject to disclosure control).

Ethical approval

Ethical approval was not sought as the data are aggregate and anonymised. Data were handled subject to the disclosure agreement with ONS.

Results

European age-standardised rates by sex and country/region of birth, 2007 to 2021

All-cause mortality including COVID-19, 2007 to 2021. Figure 2 presents the EASRs for all-cause mortality by sex and country/region of birth for migrants from 2007 to 2021, with reference populations of those born in E&W shown as dashed lines. Ten of the 19 migrant sub-populations had lower EASRs than the E&W-born population, including in 2020 and 2021. However, for some groups, initial mortality advantages were lost by 2020–2021. For example, males from Central and Western Africa and both sexes from Pakistan and Bangladesh had initially lower mortality than E&W-born population, but by 2020 and 2021 their rates became higher. Bangladesh, in particular, experienced a notable 50% mortality increase from 2019 (Appendix I, Figure S1).

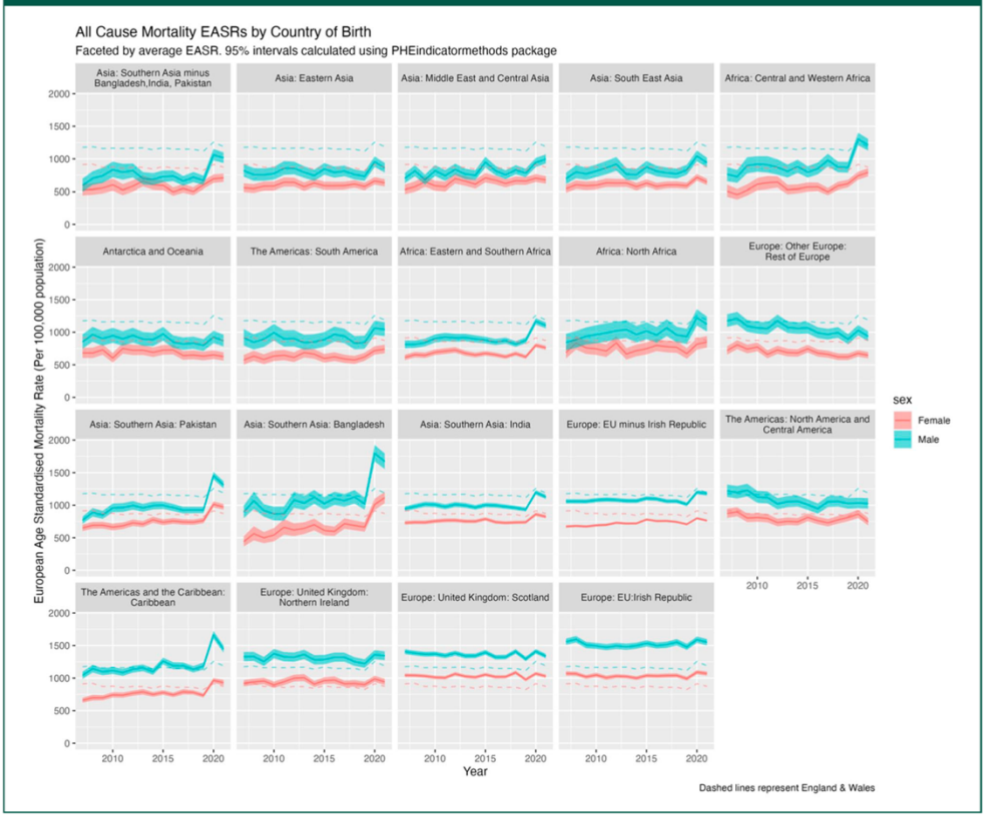
Migrants from Northern Ireland, Scotland and the Irish Republic had consistently higher EASRs than the native-born population throughout 2007 to 2021, without the pandemic-related uptick seen in other groups. Males from the Caribbean had similar EASRs to the native-born population until 2020–2021, when their mortality rates increased, while females from the Caribbean, initially lower, also converged with native-born rates. The varying impacts of COVID-19 mortality by the same regions/countries of birth are explored elsewhere.[27] Figure 2 shows diverging trends, with some migrant populations (e.g. North & Central America; European populations) showing improving mortality rates i.e. diverging from E&W-born up until 2020, while others, for example, Bangladesh, converged toward E&W reference populations.

All-cause mortality excluding COVID-19, 2007 to 2021. To explore the impact of COVID-19 on mortality trends, Figure 3 excludes COVID-19 deaths from the analysis in 2020 and 2021. Without COVID-19, 14 of the 19 migrant sub-populations had consistently lower EASRs than the native-born population. When compared with Figure 2, this suggests that increases in 2020 and 2021 for Central & Western Africa and Pakistan appear largely due to COVID-19 mortality, whereas for Bangladesh and the Caribbean, COVID-19 appears only a partial explanation.

Annual standardised mortality ratios by sex and country/region of birth, 2007 to 2021

All-cause mortality excluding COVID-19, 2007 to 2021. To examine trends over time, we focus on mortality excluding COVID-19 due to the unprecedented and unusual behaviour of the virus in 2020 and 2021. Results for

Figure 2. EASRs (per 100,000 population) for all-cause mortality (including COVID-19) by sex and country/region of birth for the population of England & Wales, 2007 to 2021, with 95% confidence intervals (shaded).



Dashed lines represent the reference population of males and females born in England & Wales.

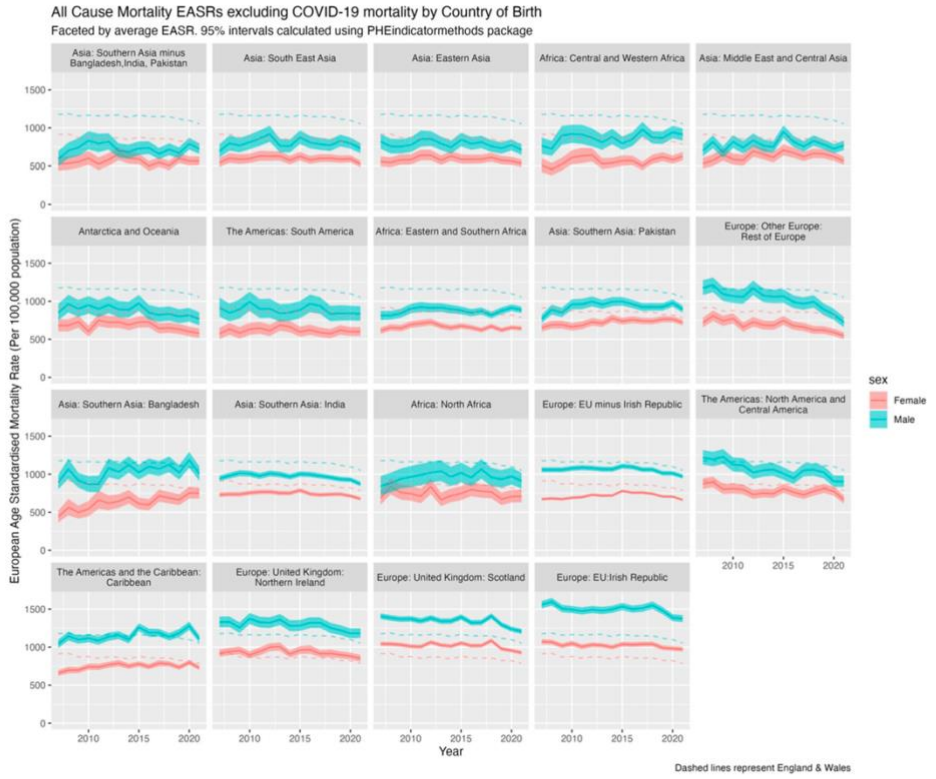
all-cause mortality SMRs, *including* COVID-19, can be found in Appendix I, Figure S2.

Figure 4 presents SMRs for all-cause mortality (excluding COVID-19) for the 19 countries/regions of birth compared with the native-born population (SMR = 1; shown with **black** horizontal line). The facets (subfigures) are arranged by average SMR, from most advantageous, that is, lowest SMR (<1) compared with E&W (Southern Asia minus Bangladesh, India, Pakistan) at the top left to most disadvantageous, that is, highest SMR (>1) compared with E&W (Irish Republic) at the bottom right. A SMR >1 indicates higher mortality than the E&W-born population, and a SMR less than 1 a lower mortality. Trends align with Figures 3 and 4, with some of the trends in mortality improving and diverging from E&W seen more clearly (prior to 2020 and 2021), for example, North & Central America and Rest of Europe, and converging of, for example, Bangladesh.

Regression of trends in SMRs between 2007 and 2021

The facet positions in Figure 4 that show the relative mortality (dis)advantage – that is, better or worse mortality than the E&W-born population – of each country/region of birth on average between 2007 and 2021, but do not tell us whether such relative (dis)advantages have changed over time. Figure 5 shows the linear regression of SMRs over time, indicating whether mortality

Figure 3. EASRs (per 100,000 population) for all-cause mortality excluding COVID-19 in 2020 and 2020-2021 by sex and country/region of birth for the population of England & Wales, 2007 to 2021, with 95% confidence intervals (shaded).



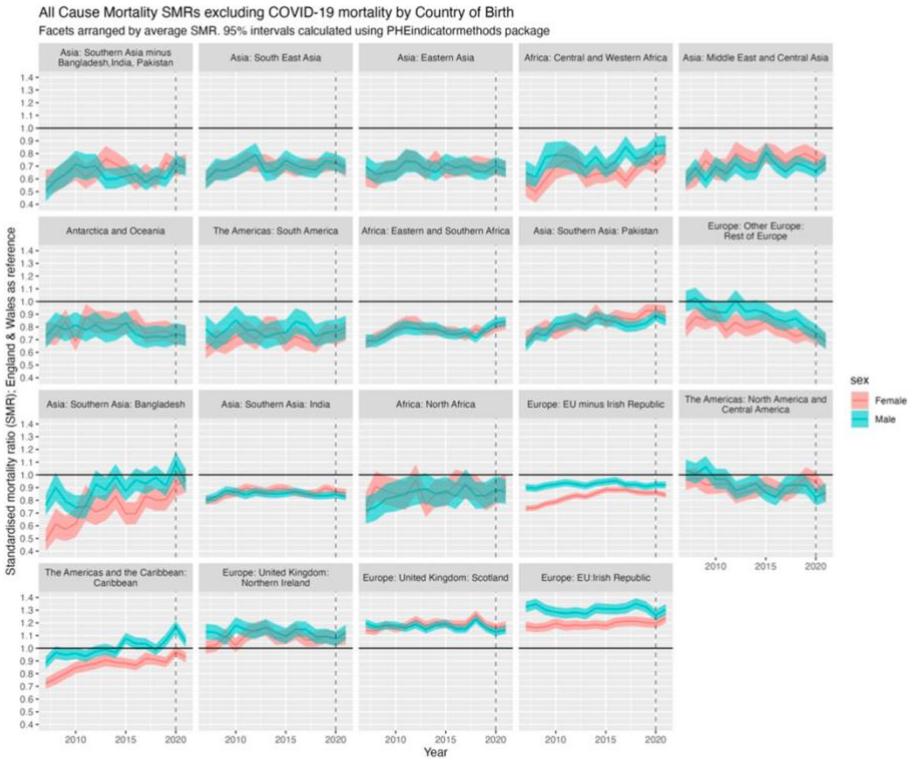
Dashed lines represent the reference population of males and females born in England & Wales.

advantages or disadvantages have increased or decreased. If the average SMR between 2007 and 2021 is below 1, then an upwards trend over time indicates the relative advantage compared with E&W-born has been decreasing (or worsening) over time, converging with E&W mortality; if the SMR is on average above 1, then the downwards trends indicate the disadvantage has been decreasing over time; and so forth. However, without the mean SMR, these results are difficult to interpret, as it is not clear whether there is a mortality advantage ($SMR < 1$) that is improving/worsening, or a mortality disadvantage ($SMR > 1$) that is improving/worsening. Thus, we present the slope coefficients for SMR trends and mean SMR against the slope coefficient for each/country region and sex in Section 2.2 of the Appendix.

Figure 6 categorises countries/regions into four broad trends: decreasing/worsening advantage, increasing/improving advantage, worsening disadvantage, and improving disadvantage. Most countries/regions of birth from 2007 to 2021 have seen the mortality advantage seen in 2007 decrease closer to that of non-migrants in later years.

The 2×2 typology presented here highlights systematic heterogeneity in migrant health trends and challenges assumptions of a uniform migrant experience. While statistical significance is noted (Appendix 2.2), the primary role of regression analysis is to conceptualise these

Figure 4. SMRs for all-cause mortality excluding COVID-19 in 2020 and 2021 by sex and country/region of birth for migrants compared with non-migrants for the population of England & Wales, 2007 to 2021, with 95% confidence intervals (shaded).



Horizontal **black** line at 1.0 represents the SMR of the reference population of males and females born in England & Wales.

variations rather than test specific hypotheses. Countries/regions without significant results ($p > 0.05$) are denoted in italics.

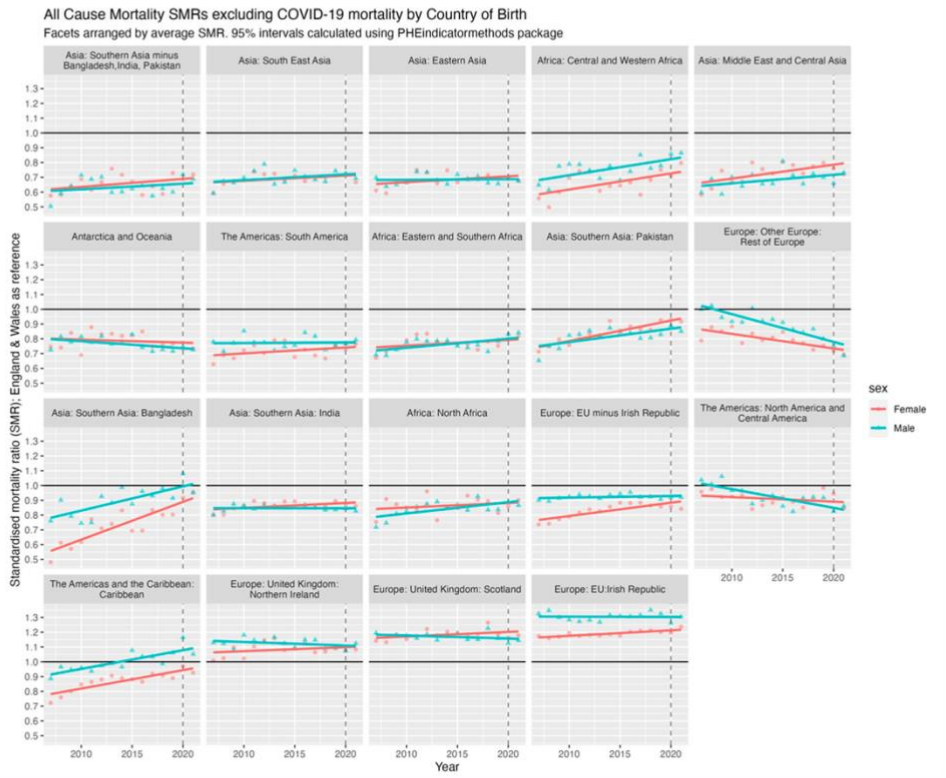
Discussion

Main findings of this study

We used ONS data to examine mortality differences by country/region of birth among the population of E&W from 2007 to 2021. This typology-based approach improves the interpretability of complex population trends and offers a structured framework for understanding which groups are gaining, maintaining or losing a mortality advantage. We explored how all-cause mortality varied among migrants from different countries/regions compared with native-born individuals and whether these mortality patterns converged towards or diverged from the native-born mortality over time. We found that 10/19 countries/regions of birth had lower EASRs than the reference E&W-born population over the study period, including during the COVID-19 pandemic in 2020 and 2021 (the divergence is explored in a separate paper).[27] Excluding COVID-19 deaths, 14/19 migrant groups had lower mortality than the native-born population. Exceptions included migrants from the Irish Republic, Scotland, Northern Ireland and the Americas & the Caribbean, with notable sex differences.

Over time, most countries/regions fell into the 'health advantage, decreasing' category, meaning any advantage found in 2007 was diminishing, or absent, by 2021. Three regions (rest of Europe (non-EU), Antarctica & Oceania and North & Central America) saw a mortality advantage

Figure 5. All-cause mortality SMRs excluding COVID-19 by country/region of birth and sex for migrants in England & Wales, 2007 to 2021, with linear regression lines. SMR for E&W shown as black line (=1). SMR <1, an upward trending line suggests a mortality advantage that is worsening, that is, converging with E&W; if SMR >1, a downward trend suggests a mortality disadvantage that is improving, that is, converging with E&W. Thus, further information is required for interpretation (see Table S1, S2, Figures S3, S4 in Appendix).



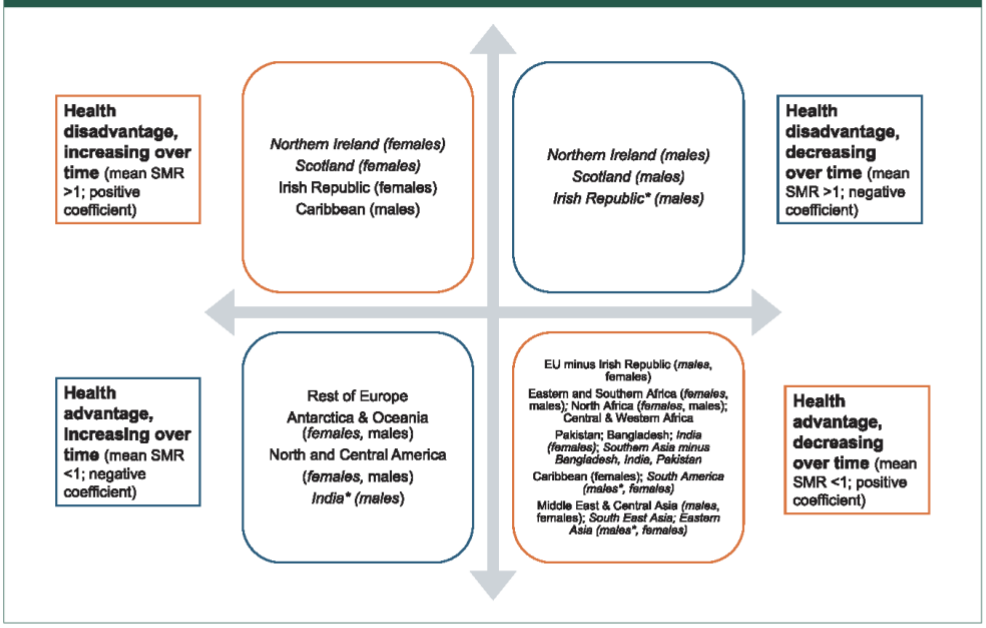
that increased over time, diverging further from E&W-born populations.

What this study adds to the existing literature

What is already known on this topic. As discussed in the introduction, migrants in HICs often exhibit a mortality advantage compared with native-born populations,[7,8] but this advantage can diminish over time due to socio-economic conditions, healthcare access barriers, negative acculturation and the negative impacts of racism and xenophobia.[5,6,12,18,19] Previous studies have examined specific migrant groups in both E&W and other settings,[9,15,17,24,30] but up-to-date exploration of long-term trends across multiple countries/regions of birth in E&W following the demographic and political changes outlined remain underexplored.

What this study adds. Using 15 years of mortality data in E&W, this study confirms evidence of the healthy migrant effect but shows it has weakened in recent years for most groups. The heterogeneity of migrants is evident. For example, migrants from Ireland, Scotland and Northern Ireland did not exhibit a mortality advantage, consistent with existing research on neighbouring countries in Europe.[9,17] These findings suggest further exploration is needed on factors such as socio-economic conditions and

Figure 6. Summary of linear regression of mean SMR from 2007 to 2021 and slope coefficient with England & Wales-born as reference population. Results are for both sexes except where sex differences were present, which are then indicated in parentheses; with those in italics not significant at the 0.05 level. Full results in Section 2.2, Appendix.



The asterisk * indicates coefficient 0.000 to three decimal places i.e. trend may be considered stable rather than increasing or decreasing.

health behaviours that could influence mortality patterns. Conversely, the three regions that saw a migrant mortality advantage that has increased over time suggest some groups may be benefitting from persistent protective factors. Sex differences in those from the Caribbean, Scotland, Northern Ireland and Ireland also warrant further study.

Limitations of this study

This study has several limitations, largely shaped by the nature of the available data. Migration-disaggregated national datasets are limited, and the absence of certain variables constrains interpretation. First, we lacked data on duration of residence, essential for examining the selection-acculturation hypothesis. As a result, the changes in mortality advantage/disadvantage over time, summarised in Figure 6, can neither support nor refute this hypothesis.[7,12,18] The likely bias from this is that our results may be over-estimating mortality rates for more recent migrants, who have had fewer years of negative acculturation and are still benefitting from the healthy selection bias, and under-estimating them for longer-term migrants, potentially subject to negative acculturation.

Second, population denominators for intercensal years were estimated using linear interpolation between the 2011 and 2021 censuses. While standard practice, this method does not capture year-to-year demographic shifts within the decade, such as annual migration flows, composition changes, or emigration, introducing uncertainty and potentially over- or under-estimating mortality rates, particularly for more mobile groups.

Third, the broad grouping of countries/regions may mask important inter- and intra-regional differences, likely under-estimating heterogeneity and obscuring particularly advantaged or disadvantaged sub-groups.

Fourth, we lacked individual-level data on confounders such as health co-morbidities or socio-economic position, limiting our ability to adjust for these factors or fully explain between-group differences. This likely results in some overestimation of the migrant mortality advantage if healthier or more advantaged individuals are overrepresented among migrants.

Fifth, the focus on adults aged 20 years and over and the exclusion of COVID-19 mortality may miss some differences in younger age groups and understate the pandemic's impact on migrant mortality patterns.

Sixth, we could not directly assess racial or ethnic disparities, which are known to significantly shape health

outcomes through structural racism, xenophobia and systemic inequalities.[5] This likely underestimates the impact of these structural factors on migrant health.

Finally, as the mortality of E&W nationally has worsened since 2010,[31] convergence of migrant mortality towards native-born levels may partly reflect a deterioration in native-born health, rather than improvements among migrants. Interpreting convergence as a positive trend should therefore be approached with caution.

Areas for future research

These findings open many avenues for future research. First, cause-specific analyses are needed to unpack the mechanisms behind the observed mortality trends. Disaggregating by cause of death will help identify whether changes are driven by, for example, chronic disease, external causes, or infectious disease, but must be interpreted in light of variation across age, sex and country/region of birth. Second, the development or linkage of individual-level datasets, including information on time since migration, socio-economic position and co-morbidities, is essential to assess the validity of the 'selection-acculturation' hypothesis and move from descriptive to causal analysis. Third, further research should investigate how structural factors, such as racism, xenophobia and immigration policies, interact with social determinants of health to shape migrant mortality. Previous research has shown that hostile environment policies, including NHS charging regulations, can have detrimental health impacts.[20,32,33] Notably, Scotland, Northern Ireland and Ireland, which had worse mortality than E&W, would not be subject to NHS charging regulations, suggesting a complex interplay of influencing factors, likely including the role of race. Racism is a fundamental determinant of health, creating structural barriers that lead to poorer health outcomes through limited healthcare access, environmental hazards and increased psychosocial stress.[5] The specific impacts of racism and xenophobia on migrant health are beyond the scope and design of this paper, and warrant further exploration in future research.

Fourth, identifying factors contributing to lower mortality in some migrant groups – such as dietary habits, social networks and educational status – could offer valuable insights for improving native-born population health. Finally, comparative studies across HICs with similar migrant populations could test the generalisability of these findings and inform international policy.

Implications for public health practice and policy

Most migrant groups have better health than the native-born population, but this advantage has reduced over the time examined. While we cannot infer individual-level trajectories or causation from this repeated cross-sectional design, the observed patterns offer a valuable signal of population-level change. As the study does not include time since migration, we cannot say this change is linked to negative acculturation, but we can comment on the change in population-level data at each year studied.

The findings underline the need for targeted, community-led public health interventions to, for example, harness health benefits, where found, and to address the challenges migrants may face in areas such as accessing healthcare and poor housing. They also suggest the need to monitor how structural factors such as immigration policies, institutional racism or access to healthcare may contribute to the erosion of these advantages. Without understanding and addressing these underlying factors, strategies and interventions to mitigate migrant health disparities are unlikely to succeed.

Conclusion

Migrants make up a significant and growing part of the population of England & Wales. Our findings contribute to existing research by demonstrating substantial variation in mortality among migrant groups. While most groups had a health advantage in the initial years of the study period, this advantage diminished by the end of the period for many.

This study, while not longitudinal, offers a rare national-level view of long-term mortality trends by country of birth. It highlights key areas for public health action and future investigation, particularly the need to link individual-level data to understand the pathways underpinning observed changes. These findings emphasise the complex and challenging interplay between migration and health. Although we cannot attribute the observed convergence to negative acculturation due to the study design, the patterns are consistent with this phenomenon, reinforcing the need for targeted, community-led public health interventions to improve migrant health. Further research is needed to determine if – and why – the migrant mortality advantage diminishes with increasing time since migration. Such insights are vital to enable policymakers and healthcare workers to address these factors and improve outcomes for the whole population.

Declarations

Acknowledgements: We are grateful to the team at the ONS, who were generous with their time and support in providing the required datasets. We would like to thank Sarah Wild, who provided advice early in the conception of this work. The authors used ChatGPT (OpenAI) to refine the language of this manuscript. All intellectual contributions, analyses and interpretations remain the sole responsibility of the authors.

Data availability: The mortality data are subject to disclosure control and, therefore, not available. Census data are publicly accessible online. Code available on request to the authors.

Competing interests: None declared.

Funding: RWA was supported by a Wellcome Trust Clinical Research Career Development Fellowship (206602), which funded the data used in this analysis.

Ethics approval: The study uses anonymised, aggregate data and ethical approval was not required.

Contributorship: LH conceived the idea for the paper. JM carried out all analyses with input and review from LH, RB and RWA. LH drafted the manuscript with significant input from JM, RB and RWA. All authors approved the final draft.

Provenance: Not commissioned; peer-reviewed by Frank Lichtenberg, Zipporah Iheozor-Ejiofor, and Julie Morris.

Supplemental material: Supplemental material for this article is available online.

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Use of generative AI: Chat GPT was used to improve clarity and flow in sections of the manuscript. All content was reviewed, verified, and edited by the authors, who take full responsibility for the final version.

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European Journal of Public Health, Vol. 34, No. 6, 1149–1156
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https://doi.org/10.1093/eurpub/ckae142 Advance Access published on 16 October 2024

To what extent did mortality from COVID-19 in England and Wales differ for migrants compared to non-migrants in 2020 and 2021? A descriptive, observational study

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Abstract

Seventeen percent of people living in the UK are migrants. In high-income countries, migrants have been shown to have better all-cause mortality but worse mortality for some specific causes such as infectious diseases. This observational study aims to quantify the extent to which mortality from coronavirus disease 2019 (COVID-19) differed between migrants and non-migrants for the population of England and Wales, 2020-2021. We use Official National Statistics data to compare mortality from COVID-19 in 2020 and 2021 by country/region of birth, expressed as the standardized mortality ratio with those born in England and Wales as the reference population. Migrants from 17 of 19 countries/regions examined had higher mortality from COVID-19 than non-migrants. The highest mortality was those born in Bangladesh (females SMR = 3.39, 95% CIs 3.09–3.71; males 4.41, 95% CIs 4.09–4.75); Pakistan (females 2.73, 95% CIs 2.59–2.89; males 3.02, 95% CIs 2.89–3.14); and the Caribbean (females 2.03, 95% CIs 1.87–2.20; males 2.48, 95% CIs 2.37–2.60). Migrants born in Antarctica and Oceania (females 0.54, 95% CI 0.42–0.40; males 0.71, 95% CI 0.51–0.88), and North and Central America (females 0.95, 95% CI 0.80–1.11; males 0.85, 95% CI 0.72–0.99) had lower mortality than non-migrants. Most migrant populations had higher mortality from COVID-19 than non-migrants in England and Wales. Policy-makers must work to integrate migration status into routine data collection to inform future research and understand the causes of the inequalities seen.

Additional content

Additional content An author video to accompany this article is available at: https://oup.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=a7ba253d-03ff-4824-8134-b1f50181af79.

Introduction

It is now widely accepted that there were wide inequalities in outcomes of the coronavirus disease 2019 (COVID-19) pandemic. Yet, as the Pan European Commission on Health and Sustainable Development noted [1], in many European countries the scale and nature of these inequalities could only be guessed at. In particular, there was, and remains, a scarcity of information on mortality disaggregated by migration status, ethnicity, or nationality. There are two major reasons: First, the well-known definitional challenges with terminology in this area and, second, concerns regarding privacy of data sharing. Migrants may have lived in more than one country over their lifetime and include those residing in country A born in country B to parents from country A as well as those in country A born in country B where they had generations of ancestors. Furthermore, migration status is fluid and changeable, rather than a defined characteristic, and is likely to change over time, for example, in the context of asylum seekers and refugees. The related characteristics of ethnicity and nationality are similarly problematic. Ethnicity is a self-identified definition that is distinct from race and the recorded identity may, therefore, differ across data sets [2], while many people have multiple nationalities.

Privacy concerns regarding sharing of data on race, ethnicity, and migration status are often well-founded, such as in the UK where data sharing between the health and immigration services contributed to significant fears regarding accessing health care [3], as well as memories of historical abuses [4]. As a consequence, few European countries routinely disaggregate data by ethnicity, with Finland, Ireland, and the UK notable exceptions [5].

Of these three characteristics, ethnicity received most attention during the pandemic. In the UK, there were large differences in outcomes during the first year of the pandemic [6, 7], with changes noted over time and variant of the virus [8]. A meta-analysis examining associations between ethnicity and various outcomes of COVID-19 in the early phase of the pandemic found 58 studies, most from the USA, but 10 from the UK, two from Spain, and one from Italy [9] but, as noted, in many countries, any disadvantage by ethnicity is largely invisible in the data.

There is also some information on the situation that faced migrants in the initial stages of the pandemic in the UK, with substantially greater increases in mortality among those born in Africa, Asia, and the Caribbean [6]. These individuals are defined pragmatically as migrants as someone living in a country but born elsewhere, a definition that can be operationalized simply in datasets. While

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ethnicity may confer disadvantage due to factors such as discrimination, migrants may face additional challenges that accumulate before, during, and after their journey to a new country [10]. During the pandemic, migrants were soon identified as experiencing a toxic interaction of risk factors for infection [6, 11–14], including type of employment [15], living conditions [16, 17] such as high population density [14], barriers to accessing healthcare [18, 19], and, eventually, vaccination status [20]. For example, migrants are more likely to be in precarious employment, often public-facing with greater exposure to the virus [21], and without access to sick pay [15]. Like many airborne infectious diseases, COVID-19 thrives in crowded places, and migrants are more likely to live in overcrowded, multi-generational homes [16, 17].

Migrants, even when from the same country, are, however, an extremely heterogeneous group, reflecting factors including their age and social status at the time they left their country of birth, the conditions they experienced previously, their reasons for leaving, and their migration status. Thus, an economic migrant is likely to experience different health challenges from a refugee or asylum seeker. Nonetheless, migrants overall are often healthier than the host population in high income countries (HICs), a phenomenon known as the 'healthy migrant effect' [22], with 'atypically healthy' individuals more likely to leave their countries of birth [23]. This varies by factors including the country of origin, destination, reason for migration, and type of disease [22]. A systematic review found that while there was an overall mortality advantage among international migrants to HICs relative to their native-born counterparts, the opposite was seen with the infectious diseases and 'external causes' categories within the international classification of diseases version 10 (ICD-10) [24, 25]. The higher mortality from infectious diseases has been linked to several factors, including exposure to diseases like tuberculosis in the country of origin [26], as well experiences during the migration process and in the host country, such as barriers to accessing healthcare [10].

The countries of the UK had some of the worst outcomes in Europe in the first part of the pandemic and an ongoing official inquiry has revealed a severe lack of preparedness [27], exacerbated by sustained disinvestment in social safety nets [28]. We complement the existing literature from the UK [6, 29] with a study that analyses mortality from COVID-19 during 2020 and 2021 in England and Wales by country/region of birth using a unique dataset assembled by the Office for National Statistics (ONS) (health data systems are separate in the four countries of the UK). For context, at the 2021 Census, ten million people living in England and Wales were born outside of the UK, or 16.8% of the total population [30]. Our study is descriptive and thus we do not seek to explain these differences but hope that our findings will encourage others to do so.

Methods

Study design and setting

A descriptive, observational study of the population of England and Wales (E&W) between 2020 and 2021 was carried out. The exposure was country/region of birth, as identified on the death certificate, and the outcome was mortality from COVID-19 (ICD-10 codes U071, U072, U109) during the two-year period of 2020 and 2021.

Data sources

Two data sources were used. First, as part of a larger project, data were requested from the ONS for number of deaths by country/region of birth, 5-year age band, sex, and ICD-10 chapter from 2007 to 2021 for the population of E&W. Data on mortality from COVID-19 were available for 2020 and 2021, and for the analysis we summed the deaths over both calendar years as the pandemic did not begin on 1 January, and the acute phases of the pandemic occurred in waves across the two years. Because we are exploring and comparing the impact of COVID-19 on different migrant populations, we assert our estimates are not affected by summing the two years' data. These data are subject to disclosure control and therefore not publicly available, but reported within the ONS guidance. Second, for the total population, we used a custom dataset from the ONS providing the population of E&W by age, sex, and country/region of birth at the 2021 census (available online). Due to reference limitations, links to relevant sources and references for the data and methods are given in Supplementary Appendix II.

Inclusion and exclusion criteria

The countries/regions of birth included were based on (i) the available data from the ONS and (ii) 'matching' across the deaths and total population datasets (outlined below). Two countries/regions of birth were excluded due to low counts ('Africa NOS' and 'Asia NOS') that would have breached disclosure controls. Inconsistencies in data were reconciled where necessary. For example, we were not able to disaggregate 'new EU' (i.e. those countries that joined after 2004) from total EU (i.e. all EU countries, including those that joined after 2004) in all datasets and thus 'new EU' was incorporated within the larger EU category. Where appropriate, we made a very few other adjustments. For example, we treated the Irish Republic as a category separate from the rest of the EU as previous research has demonstrated a mortality disadvantage for migrants coming from Ireland [31]. We also included Scotland and Northern Ireland as distinct categories for the same reason. Supplementary Appendix I lists the countries included where a region is specified. All age groups were included and standardized to the European Standard population, as outlined below.

Analysis

Data preparation and analyses were carried out using the statistical programming language R. First, the sum of deaths from COVID-19 by each country/region of birth for all sexes and age groups for 2020 and 2021 were totalled and plotted alongside the sum of population from the 2021 Census for the corresponding country/region. Second, the crude death rates for the two-year period were calculated as a proportion of the sum of deaths divided by the population of E&W at the 2021 Census, presented as a percentage.

$$\text{Crude death rates} = \frac{\text{sum of deaths by country/region of birth in E\&W from COVID} - 19\ 2020 + 2021}{\text{total population for country/region of birth in E\&W at 2021 Census}}$$

Next, we calculated the Standardized Mortality Ratios (SMRs) of European Age Standardized Rates (EASRS), by sex and country/regions of birth (total = 19), as compared to the reference population of the corresponding sex, namely persons born in E&W (non-migrants). We used the 2013 European Age Standardized Population (EASP) to calculate EASRs for each sex/country-of-birth subgroup, and used Byar's method, implemented using R's PHEIndicatormethods package, to produce 95% uncertainty intervals for each EASR calculated. We converted EASRs into SMRs by simply dividing the EASR point and uncertainty estimates by the EASR point estimate for the reference population (those born in E&W), separately for both males and females.

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Ethical approval

Ethical approval was not sought as the data are aggregate and anonymized. Data were handled subject to the disclosure agreement with ONS.

Results

Descriptive analysis

At the 2021 Census, 81.6% of the population of E&W were native born (non-migrants). Figure 1 shows the remaining population, that is, those born outside E&W and termed here 'migrants', with population size in millions (black dots) and number of deaths from COVID-19 in 2020 and 2021 (red triangles) for each country/region of birth. The largest groups were those born in the EU (minus the Irish Republic), India, and Eastern and Southern Africa. Deaths from COVID-19 do not follow the same pattern, with India, Pakistan, the Caribbean and some other countries/regions clear outliers. Supplementary Fig. S1 shows that crude deaths from COVID-19 as a proportion of the population are higher than among those born in E&W for migrants from the Indian sub-continent and other parts of the UK, but lower among those from elsewhere. Supplementary Fig. S1 is reported for completeness only as the figures are unadjusted for age.

COVID-19 mortality relative risk by country/region of birth

The EASRs by sex for each country/region of birth are reported in Supplementary Appendix II (Supplementary Fig. S2). Here, in Fig. 2, we report the SMRs with 95% confidence intervals (CI), for females and males (for tabulated results see Supplementary Table S1). Figure 2 shows that, for both female and male migrants, only two

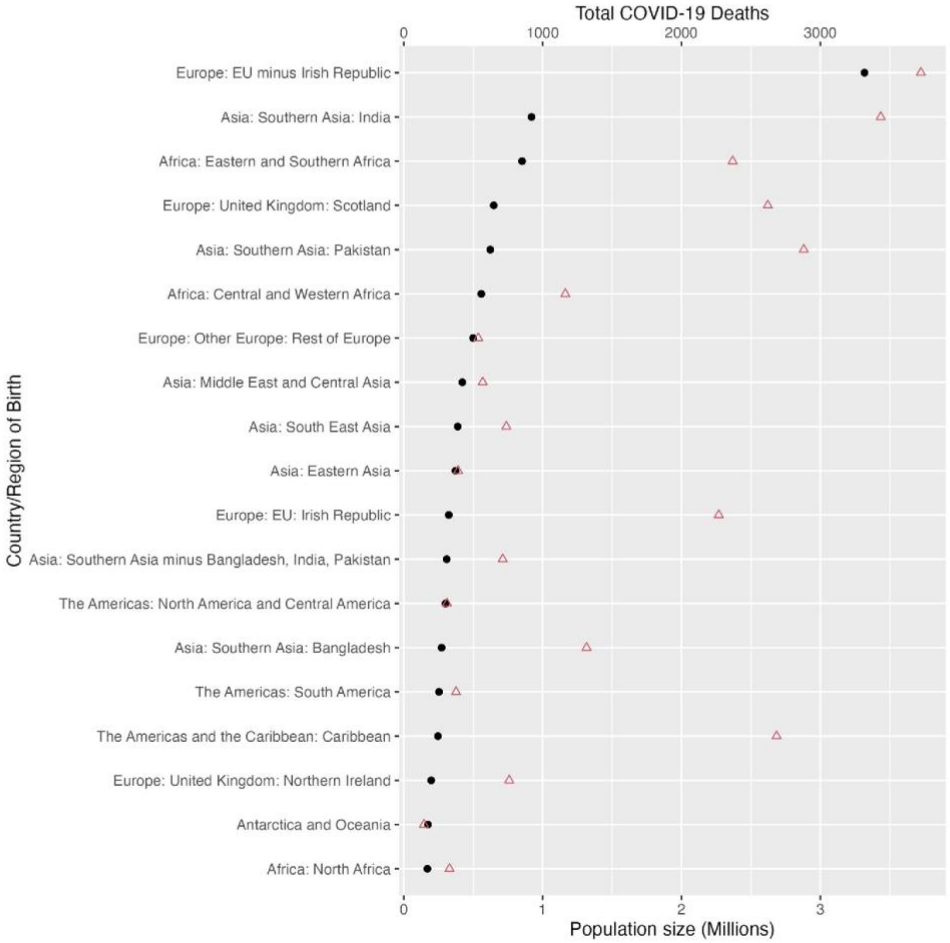


Figure 1. Population of migrants in England and Wales in millions, in descending order from highest to lower number (total persons, bottom axis, denoted by black dot) and deaths from COVID-19 (total persons, top axis, denoted by red triangle) by country/region of birth, excluding those born in England and Wales, 2020–2021.

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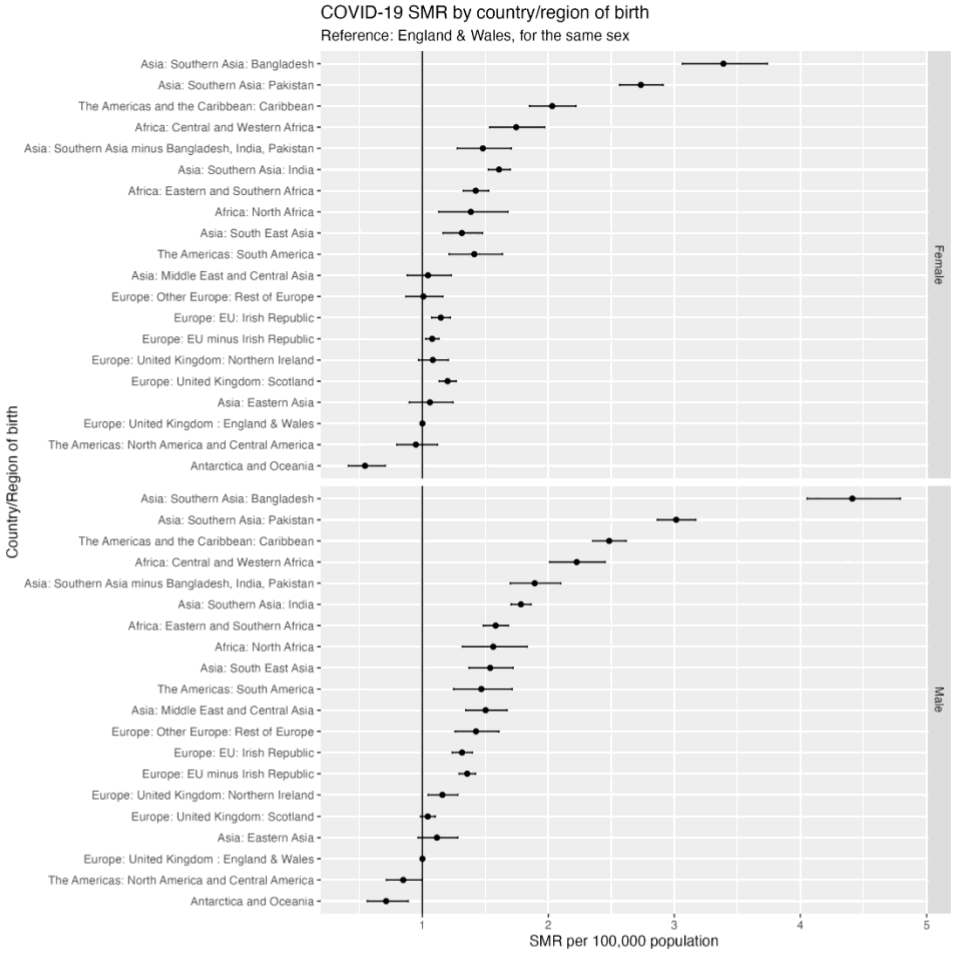


Figure 2. Forest plot showing SMR for COVID-19, population of England and and Wales, 2020–2021, by country/region of birth (top panel females, bottom panel males) with 95% confidence intervals. The vertical black line shows the SMR for female reference population is females born in England and Wales (SMR = 1); and male reference population is males born in England and Wales (SMR = 1).

countries/regions of birth (out of 19 total) had a lower risk of mortality from COVID-19 in 2020 and 2021 than the respective female and male E&W born reference population: Those born in Antarctica and Oceania (0.54, 95% CI 0.42–0.40 for females; 0.71, 95% CI 0.51–0.88 for males), and North and Central America (0.95, 95% CI 0.80–1.11 for females; 0.85, 95% CI 0.72–0.99 for males), noting for females born in Antarctica and Oceania the CIs include 1 so mortality is likely to be similar to the reference population (this is the name of a standard category used for many purposes in official statistics but no-one is actually born in Antarctica). Female migrants born in all other regions (17 of the 19) have a higher SMR than E&W born, with 95% CIs that included 1 for: those born in Northern Ireland, Eastern Asia, Middle East and Central Asia, and 'Rest of Europe' (non-EU countries). Similarly, male migrants born in all other countries/regions (17/19) have a higher SMR than non-migrant males, with 95% CIs that include 1 for two regions—Eastern Asia and Scotland.

For both female and male migrants, the countries/regions of birth with the highest SMRs were Bangladesh (3.39, 95% CIs 3.09–3.71 for females; 4.41, 95% CIs 4.09–4.75 for males); Pakistan (2.73, 95% CIs 2.59–2.89 for females; 3.02, 95% CIs 2.89–3.14 for males); and the Caribbean (2.03, 95% CIs 1.87–2.20 for females; 2.48, 95% CIs 2.37–2.60 for males).

The ranking of countries/regions of birth for SMR is similar for both sexes, but male migrants have higher relative mortality than female migrants except those born in Scotland where females had a higher SMR than males (1.20, 95% CIs 1.14–1.26 for females; 1.04, 95% CIs 0.99–1.09 for males), and North and Central America as listed above.

Choropleth of standardized mortality ratio results

Finally, we present two choropleths of mortality hazard from COVID-19 of the population of E&W for each sex and all ages between 2020 and 2021, where red shaded countries/regions indicate

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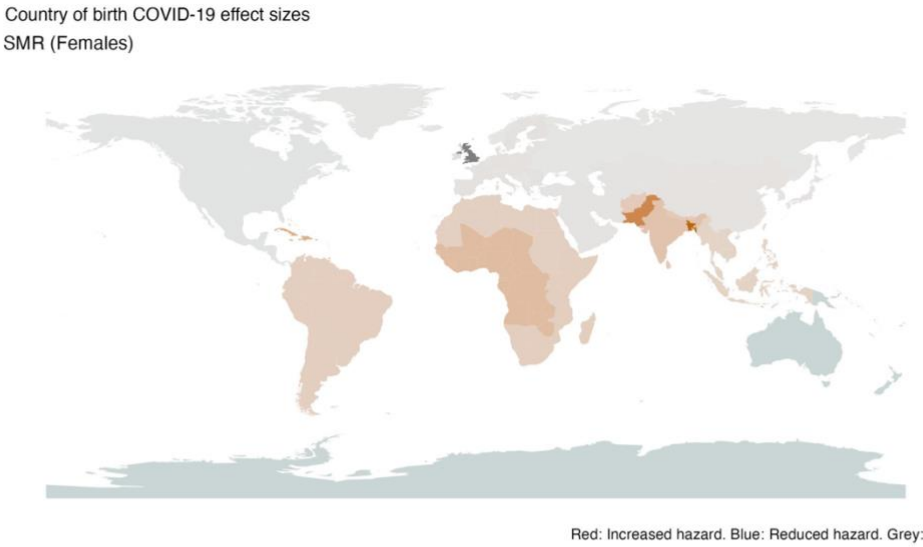


Figure 3. Choropleths showing SMR from COVID-19 for resident population of England and Wales from COVID-19, 2020–2021, by country or region of birth, for all ages for females. Countries/regions shaded red have higher SMRs than the reference population, and blue lower SMRs than the reference population. The darkness of the shade indicates how much higher (reds) or lower (blues) the SMRs are from the reference population, with darker shades indicating greater differences. The UK is combined for the purposes of the visualization and shaded grey as the reference population.

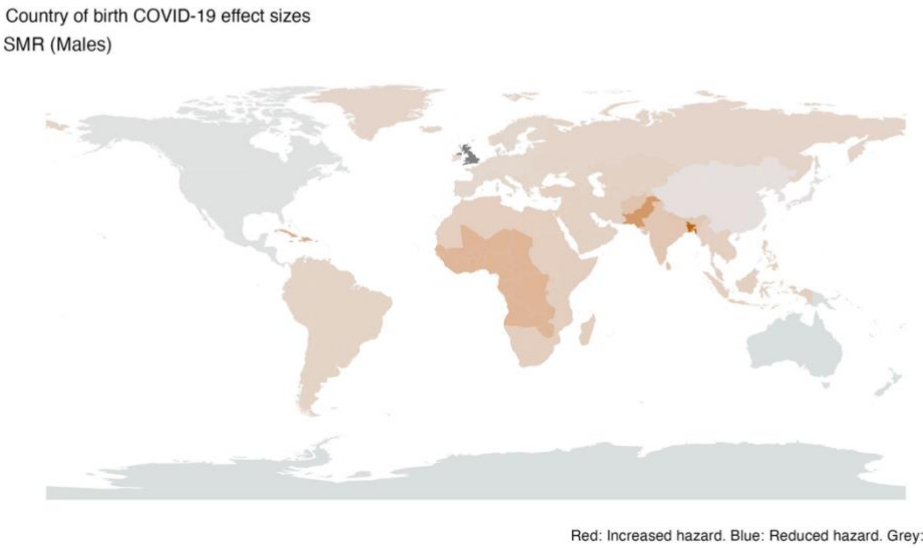


Figure 4. Choropleths showing SMR from COVID-19 for resident population of England and Wales from COVID-19, 2020–2021, by country or region of birth, for all ages for males. Countries/regions shaded red have higher SMRs than the reference population, and blue lower SMRs than the reference population. The darkness of the shade indicates how much higher (reds) or lower (blues) the SMRs are from the reference population, with darker shades indicating greater differences. The UK is combined for the purposes of the visualization and shaded grey as the reference population.

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a higher mortality hazard than the corresponding non-migrant reference population, and blue shaded countries/regions denote a lower mortality hazard (Figs 3 and 4). For the purposes of the visualization, we have included Greenland with Denmark (EU country), although acknowledge that Greenland left the EU in 1985. Comparing the two figures, the lower mortality for female migrants compared to male migrants is clear due to the darker shading in Fig. 4. For female migrants, the choropleth mirrors a map showing the Global North/Global South to some extent, but this is not the same for males with darker shading for Europe (though the decreased mortality for North and Central America is more pronounced for male migrants). The combination of some countries into one aggregate category could be distorting underlying inequities between countries. The limitations of this approach are explored further in the discussion.

Discussion

We compare mortality from COVID-19 between 2020 and 2021 in the migrant and native born population of E&W, disaggregated by sex. Migrants of both sexes had a higher mortality in 17 of the 19 countries/regions of birth examined, while female migrants from 13 countries/regions and male migrants from 15 countries/regions had higher mortality than their native born counterparts. Notably, these include migrants from Scotland, Northern Ireland, the Irish Republic, and the rest of the EU, who have moved from countries/regions that are very similar to E&W. Migrants from only two countries/regions had lower mortality—Antarctica and Oceania, and North and Central America.

Among both sexes, migrants born in Bangladesh, Pakistan, and the Caribbean had the greatest excess risk of mortality than non-migrants. Male migrants had a higher mortality than female migrants, except those from Scotland. Finally, the rank order of SMRs in each country/region of birth was similar for men and women. These findings are consistent with previous findings of a disproportionate increase in excess mortality among migrants, compared to non-migrants, in the first few months of the pandemic using 2014–2018 as the baseline [6]. Our findings expand upon this work with greater disaggregation by countries/regions of birth and over a two-year time period.

These findings contrast with the situation prior to the pandemic where the mortality advantage of migrants, particularly in HICs [22, 25], has actually contributed positively to population health measures such as life expectancy, seen in the USA and Nordic countries, and, potentially, in the UK [32–34]. Our findings are, however, consistent with the conclusions of a review by the OECD that identified many factors that increased the risks migrants faced in the pandemic, including of contracting the virus and dying [35].

Our study has certain limitations. The first relates to the categorizations of the countries and regions. For example, India, Pakistan, and Bangladesh are presented as single countries, while other large regions with diverse populations such as Central and Western Africa are combined. This prevents us from identifying intra-regional and inter-national differences. For example, the Antarctica and Oceania group is dominated by those from Australia and New Zealand who are likely to have much better outcomes than the much smaller numbers from Pacific Islands, given their experience when living in New Zealand [36]. Also, the various datasets are not always directly comparable. Thus, combining the "New EU" i.e. those countries with accession after 2004, with "Old EU" will have masked potentially important differences in the health status of more recent migrants from, for example, Romania and Bulgaria [37].

It is beyond the scope of this descriptive analysis to explain these findings. Rather, we report them to encourage others to probe the role of the multiple known risk factors that we could not account for, including social determinants of health such as housing and employment, and individual factors such as co-morbidities and vaccination status. In addition, by aggregating the two-year period (instead of looking by specific waves of infection), we cannot assess how the mortality rate changed over time, nor the effect of vaccination, specific communication campaigns, and other public health interventions. Thus, we could not detect phenomena such as the change in mortality by ethnicity with the Omicron variant reported by the ONS in 2023 [8].

We can, however, speculate that some reasons lie in the barriers many migrants face in accessing health care, poor living conditions, precarious employment, and low vaccination uptake. The precise mix is likely to vary given 'migrants' encompasses groups as diverse as those from Scotland and from Bangladesh, and includes some people whose situation places them at extremely low risk.

One particular issue that is affecting all groups other than those from the other parts of the UK and Ireland is the British government's 'hostile environment' for migrants, including the introduction of charging to access the National Health Service (NHS) for so-called 'overseas visitors' [38]. The hostile environment is a suite of policies introduced under Conservative Home Secretary Theresa May to make life as 'hostile' as possible for 'illegal immigrants' in the UK, to encourage them to leave, including restricting access to healthcare. Again, the most privileged may find this simply an inconvenience but, for many, it creates a fear of public services [39]. This may be exacerbated by structural and institutional racism [40].

Our findings support recommendations by Burns et al., based on their assessment of the UK's COVID-19 response [41]. These include action on the structural barriers and acknowledgement of intersectionality of other marginalized groups; improved data collection to include disaggregation by migration status; participatory approaches to public health campaigns, including co-design to with migrant communities; and universal access to healthcare for all people in the UK, regardless of migration status, with a legally enshrined firewall between immigration and health services.

Looking beyond the UK, our findings highlight the importance of monitoring health outcomes by migration status in other countries. The differences we have revealed add to the arguments set out in a recent review that confronts the excuses used for not doing so and provides a detailed agenda to implement the necessary systems, which must go beyond mortality data to include health information systems more generally [4]. This involves integrating refugee and migrant health data into national health information systems by establishing systems that can routinely collect, analyse, and share migrant health data while protecting data privacy, developing and using innovative privacy-preserving data linkage strategies, and enhancing and systematically using diversity-sensitive data collection strategies, including multilingual health surveys. Finally, all of this must take a participatory approach, engaging migrants in governance, data collection, analysis, and dissemination processes.

The limitations of our analysis point to areas for further research. One is to ask whether some of the social determinants of health, such as housing arrangements including multi-generational living, and associated mutual support, may be advantageous in 'normal' times but become disadvantageous during a pandemic [7]. Second, the considerable heterogeneity even among migrants from the same country invites more nuanced studies. Third, future research may explore the impacts of public health interventions such as vaccination on comparative mortality by migration status. In addition, further research in this area may help advance understanding of the 'healthy migrant effect'—an effect that was absent for most during the COVID-19 pandemic.

While this article may raise as many questions as it answers, without it, it is difficult to see how these further questions would ever be asked.

Acknowledgements

We are extremely grateful to the team at the ONS who were generous with their time and support in providing the required datasets.

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Author contributions

L.H. conceived the idea for the article. J.M. carried out and is guarantor for the analyses, with review from L.H., R.B., and R.W.A. L.H. drafted the manuscript with significant input from J.M., R.B., M.M., and R.W.A. All authors approved the final draft.

Supplementary data

Supplementary data are available at *EURPUB* online.

Conflict of interest: None declared.

Funding

R.W.A. was supported by a Wellcome Trust Clinical Research Career Development Fellowship (206602) which funded the data used in this analysis.

Data availability

The data underlying this article cannot be shared publicly due to being subject to disclosure control. The code use will be shared on request to the corresponding author.

Key points

- In some high-income countries, migrants have been shown to have worse morbidity and mortality from COVID-19 than non-migrants, despite better all-cause mortality outcomes.
- We explored mortality from COVID-19 over a two-year period of 2020 and 2021 for 19 country/regions of birth compared to those born in England and Wales and found migrants born in 17 out of the 19 country/regions of birth had higher mortality from COVID-19 than non-migrants.
- This study adds to existing evidence to demonstrate that urgent action is needed by policymakers to ensure all people in the UK have access to healthcare, address disinformation campaigns regarding migrants, provide migrant-sensitive and migrant-inclusive public health campaigns, and improve data disaggregated by migration status across Europe to ensure a better understanding of these issues.

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European Journal of Public Health, 2024, 34, 1149–1156
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16 Appendix 6: BMJ Columns

As part of a Harkness Fellowship from September 2025, I am writing a regular Opinion column for the BMJ. The first four entries are included here.

Check for updates

1 The Commonwealth Fund

Cite this as: *BMJ* 2025;390:r1858
http://doi.org/10.1136/bmj.r1858
Published: 05 September 2025

Political polarisation: an overlooked determinant of health

Writing from the US, Lucinda Hiam discusses how political polarisation is costing lives. When health becomes a culture war, evidence is ignored and public health suffers

Lucinda Hiam *UK Harkness fellow in health care policy and practice*[1]

Political polarisation is not just dividing societies—it is harming health and costing lives. In the US, political hostility towards public health reached a tragic milestone on 8 August 2025, when a gunman, reportedly distrustful of covid-19 vaccines, fired repeatedly at the US Centers for Disease Control and Prevention (CDC) headquarters, killing a police officer.[1 2]

This didn't happen in a vacuum. Health has always been political, but what's changed is how certain politicians have deliberately stoked division, seeded doubt, and dragged health policy into a culture war.

The politics of health were exemplified during the covid-19 pandemic, when some political leaders turned basic health measures, such as vaccination and mask wearing, into partisan symbols, exploiting life saving health policy for political gain. More recently, when Health and Human Services Secretary Robert F Kennedy Jr, whose vaccine scepticism has been a cornerstone of his career,[3] removed all members of the Advisory Committee on Immunization Practices, he further undermined established science, dismantling decades of expertise.[4] The assault on science continued this week when the newly appointed CDC director was "forced out" due to disagreements on RFK Jr's vaccine policy, followed by the resignation of four senior scientists.[5]

After the CDC shooting, political accountability was scarce. President Trump has reportedly said nothing publicly about the police officer who was killed protecting government workers.[6] RFK Jr offered brief condolences before returning to criticising the CDC's pandemic response, telling reporters that "public health agencies have not been honest."[4]

The harm of polarising rhetoric is reflected in the data. Polling reveals that fewer than half of Americans have confidence in the CDC and Food and Drug Administration (FDA) to carry out their responsibilities.[7] On vaccines, the partisan gap is stark: most Democrats trust government agencies to provide accurate information (70%); Republicans are more trusting of RFK Jr (73%) and Trump (74%) than the CDC (51%) or FDA (52%). When politicians are more trusted than scientific institutions on medical matters, the foundations of evidence based health policy are at risk.

The result is that health behaviours that should be guided by medical evidence become markers of political identity. In polarised societies, people don't just disagree, they view the other side as fundamentally wrong, dangerous, or untrustworthy.[8] That leaves little room for compromise or common ground, and no shared way forward.

When polarisation becomes a health risk

Just as poverty, housing, and education are recognised as key determinants of health,[9] we must now acknowledge that political polarisation belongs on that list.[8] When health behaviours are based on political identity rather than evidence, effective public health responses become extremely difficult, and health suffers. One clear example is vaccination. Credited with saving over 154 million lives since 1974,[10] vaccination has become a deeply contentious and polarised issue. In the US, partisan differences in the uptake of covid-19 vaccination and social distancing were linked to higher excess death rates in Republican counties.[11 12] And with measles cases soaring in the US, about one in five Republicans believes the vaccine poses greater risks than measles itself—a disease that has already caused three deaths in 2025.[13 14]

The US is not alone. Under Jair Bolsonaro's administration in Brazil, politicisation of the covid-19 pandemic and vaccines has been linked to reduced vaccine acceptance and broader setbacks to the national immunisation program: the so called "Bolsonaro effect."[15] Similarly, in Europe political polarisation has been linked to negative vaccine attitudes.[16] In England, the latest figures show that no childhood vaccination rate has met the 95% herd immunity threshold,[17] with noticeable inequalities in uptake,[18] while reports of anti-vaccine sentiment rise.[19]

The path forward

Where does this leave public health? Some argue that public health needs to be more political, and that its depoliticisation, focusing on individual behaviours instead of structural causes of poor health, is partly to blame for its current weaponisation.[20] Others highlight the urgent need to tackle misinformation, recognising that effective health communication must evolve beyond presenting facts and engage with the political and cultural context in which science is received.[21]

The path forward might not be clear, but it is urgent. Acknowledging the scale of the problem is a first step towards finding solutions. Scientists and public health leaders must strive to regain influence and trust,[22] recognising that in a polarised world, the messenger matters as much as the message.[23] We need to look for examples where health policies have succeeded despite political division, where trusted messengers have bridged partisan divides, and where shared values around health have transcended party lines. Success could come from unexpected alliances between those from, for example, professional, civil

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society and community groups, and local champions who can speak across the divide. Crucially, this requires defending and strengthening apolitical scientific institutions that can serve as sources of unbiased health information. The continuous degradation of agencies such as the CDC through political attacks, funding cuts, and leadership purges presents a substantial risk to public health. When scientific agencies lose their independence and credibility, societies lose their compass for navigating health crises based on evidence rather than ideology.

The CDC shooting serves as a tragic reminder that political polarisation has become a public health emergency. In an era of global health threats, we cannot afford to let political divisions undermine the institutions designed to protect us all. If we want healthier populations, we must treat polarisation itself as a risk factor. We must work together with patients and communities to build pathways that can move us beyond our differences, by using trusted messengers, collaborative approaches, and the defence of independent scientific institutions that serve the public good.

Competing interests: None declared.

Provenance and peer review: Not commissioned, not externally peer reviewed.

LH is a 2025-2026 Harkness Fellow based at Boston College and the Information Futures Laboratory at Brown University, supported by the Commonwealth Fund. The views presented here are those of the author and should not be attributed to the Commonwealth Fund or its directors, officers, or staff.

I thank my UK and US mentors (Profs Stefanie Friedhoff, Philip Landrigan, and Martin McKee) for their comments and feedback in preparing this piece.

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Cite this as: *BMJ* 2025;391:r2077
http://doi.org/10.1136/bmj.r2077
Published: 03 October 2025

Performative doubt and the fight for public trust

Writing from the US, Lucinda Hiam argues that public health must acknowledge uncertainty transparently, while unflinchingly confronting bad faith political figures who peddle lies and exploit mistrust

Lucinda Hiam *UK Harkness fellow in healthcare policy and practice*

In an interview during the final weeks of the Brexit campaign in June 2016, then Lord Chancellor Michael Gove famously said: "I think the people of this country have had enough of experts [from organizations with acronyms] saying they know what is best and getting it consistently wrong."[1]

Nearly a decade later, US Secretary of Health and Human Services Robert F Kennedy Jr echoed this sentiment in an interview in August 2025, saying that "trusting the experts is not a feature of science or democracy, it's a feature of totalitarianism and of religion."[2] This framing undermines valid scrutiny: science is organized skepticism, not blind trust. Yet these attacks land because they exploit genuine grievances with medicine and public institutions alongside manufactured suspicion. What we face is not ordinary doubt, but the deliberate weaponization of perceived uncertainty to undermine trust in expertise.

This performative doubt is part of the populist playbook, used by MAGA Republicans in the US and echoed globally. These soundbites are not isolated but are part of a harmful rhetoric that travels from political platforms; across borders[3]; and into schools, homes, and clinics.

This strategy of manufacturing doubt gains power by exploiting real experiences of neglect or harm to amplify baseless conspiracy. There are real, historical, and often entrenched reasons why these narratives against science and medicine resonate. Many communities have experienced damaging, dismissive, or discriminatory encounters with clinicians, institutions that can seem unresponsive and opaque, and the consequences of policies that privilege some over others. These experiences seed understandable mistrust.

Recognizing previous failures in science and medicine can help distinguish warranted doubt from the deliberate political tactic of manufacturing uncertainty, and explain why performative attacks on expertise find a receptive audience. Understanding the roots of skepticism is necessary, but it must be paired with a clear eyed view of how political actors exploit it to further their agendas.

Performative doubt is a form of science denialism, creating the false impression of scientific controversy where none exists.[4] This strategy is nothing new, it is often driven by people and organizations with vested interests seeking to obscure well established harms in areas such as climate change, tobacco, or industrial pollution, sometimes using so-called merchants of doubt—scientists willing to cast doubt on scientific consensus to advance and protect political or commercial interests.[5]

Understanding why doubt resonates and how it is deliberately manufactured could help clinicians, journalists, and the public recognize, pre-empt, and counter these manipulation strategies.[4 6] That also means calling out the peddlers of doubt directly: exposing their inconsistencies, opportunism, and bad faith. Many of these figures shift their arguments as evidence accumulates,[7] recycling disproven claims in new guises. Naming these contradictions shows that their aim is not to seek truth but to create confusion.

Performative doubt draws strength from two sources: real reasons for distrust and deliberate manipulation of that distrust by political and other public figures. Responding by simply asserting authority or ridiculing skeptics risks reinforcing mistrust. Effective countermeasures require more sophisticated approaches, and a wealth of literature exists on techniques for countering misinformation and disinformation.[8-10]

Alongside this, public health must embrace transparency with humility: show how guidance is made, and why it changes. Evidence evolving is science working exactly as intended, not a sign of institutional failure. Agencies must acknowledge uncertainty and errors with candor: all medical interventions carry risks and uncertainties and acknowledging these does not invalidate the wider evidence. Institutions must also engage with people whose experiences have fueled distrust, to listen and adapt. This openness and acknowledgment to trade off can show that science is self-correcting and fallible, and that integrity rather than perfection makes expertise credible.

Populist figures exploit existing grievances to erode trust in evidence. Public health must respond not with louder authority, but with openness, accountability, and engagement. Humility alone, however, cannot stop organized campaigns that weaponize doubt. Expertise must be shown to be rigorous and responsive. Failing to distinguish between warranted skepticism and performative doubt risks losing both public trust and scientific integrity. Public health must be ready to confront those who deliberately distort science, exposing their misrepresentations, holding them accountable, and showing that their rhetoric collapses under scrutiny.

AI use: ChatGPT was used in the preparation of this article.

Competing interests: None declared.

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Provenance and peer review: Not commissioned; not externally peer reviewed.

I thank my UK and US mentors (Stefanie Friedhoff, Philip Landrigan, and Martin McKee) for their comments and feedback in preparing this piece.

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Cite this as: *BMJ* 2025;391:r2283
http://doi.org/10.1136/bmj.r2283
Published: 03 November 2025

Waiting for America's healthcare revolution

Writing from the US amid a government shutdown, Lucinda Hiam asks why the world's most expensive health system still fails to deliver fair and universal access to care

Lucinda Hiam *UK Harkness fellow in healthcare policy and practice*

The Trump administration's unprecedented assaults on science, democracy, and human rights have shaken institutions to a degree not seen before. Yet, while politics may feel newly volatile, problems with the US health system feel stubbornly old.

As an outsider I've long found US healthcare baffling: a patchwork of public and private programmes, insurers, and employers that spend more money per capita on healthcare than any country in the world[1] but consistently deliver some of the worst health outcomes among high income countries.[2] The Commonwealth Fund's *Mirror, Mirror* report from 2024 ranks the US last among comparable nations on overall health system performance, using measures including access, equity, and outcomes.[2] These statistics are familiar, but after interacting with the health system myself I find it even more fragmented and confusing than I'd imagined.

I'm fortunate enough to have comprehensive health insurance while I'm in the US. Using it, however, is a bewildering maze of bureaucracy and barriers, with an incoherent rule book. Take emergencies, for example: you should call an ambulance, and if your case is later deemed life threatening or serious, the cost will be covered by the insurance. But there's a catch: it will be covered only if the ambulance that comes is "in network"—meaning that it's covered by your specific health insurance plan. But when you call 911 you can't choose the ambulance provider.

The incoherence of the health system isn't a problem just for those of us who are new to it. As a US health expert I spoke to recently explained, "I'm a nurse with a PhD in health policy, and I can't navigate my own healthcare."

History of failed reform

Healthcare reform in the US has been repeatedly attempted by Republicans and Democrats but usually ends in failure.[3] The Affordable Care Act (ACA), passed in 2010, was a rare exception.[4] It cut the proportion of Americans without health insurance from around 16% to under 9%, largely by expanding Medicaid and creating insurance marketplaces.[5] The ACA was no panacea, but it represented the most substantial progress in half a century.

That progress was fragile. During President Trump's first term, Republicans in Congress voted dozens of times to repeal the ACA. There was no credible replacement plan, and the effort finally collapsed with Senator John McCain's dramatic "thumbs down" on the Senate floor.[6] The law survived, but the symbolism was clear: health reform was a partisan identity test rather than a debate over policy.

Trump is again promising in the 2025 Federal Budget Reconciliation Bill (better known as the "One Big Beautiful Bill Act") a proposal that would result in millions of Americans losing health coverage without any serious alternative being offered—a major factor in the current US government shutdown.[7] Data suggest that Trump's voters are among those with the most to lose: more than three quarters (77%) of ACA marketplace enrolees live in states won by Trump in 2024, and 57% live in Republican held congressional districts.[8 9]

Even some conservative lawmakers have grown uneasy. Representative Marjorie Taylor Greene, a Georgia congresswoman and Trump supporter, warned that the bill could cause ACA subsidies to lapse, leaving tens of thousands of her own constituents at risk of losing coverage, including her "own adult children."[10] The data and Greene's warning both highlight the paradox at the heart of US health politics: policies championed by Republicans often threaten the very constituents they represent, highlighting the people harmed by polarised policy shifts.

Healthcare in any country is more than a policy debate—it's a test of national values. The US is capable of extraordinary care: world leading cancer outcomes, cutting edge research, and some of the best hospitals in the world. But access, not quality, remains the dividing line. As the influential Princeton economist Uwe Reinhardt asked nearly 30 years ago, "Should the child of a poor American family have the same chance of avoiding preventable illness, or of being cured from a given illness, as does the child of a rich American family?"[11] In most other wealthy nations, the answer has long been yes. In the US, the debate continues.

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Competing interests: None declared.

AI use: ChatGPT was used to improve readability. The research, analysis, and arguments were developed independently by the author.

Provenance: Not commissioned; not externally peer reviewed.

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Cite this as: *BMJ* 2025;391:r2465
http://doi.org/10.1136/bmj.r2465
Published: 21 November 2025

US gun violence is a preventable health crisis

America feels familiar to a British person—until it doesn't. Lucinda Hiam writes from the US, observing that nothing has felt more foreign than living in a country where the threat of gun violence is part of daily life

Lucinda Hiam *UK Harkness fellow in healthcare policy and practice*

The US is familiar in many ways. I grew up with its television shows, music, and movies. The language is the same, and the culture, at first, resembles the UK. Yet, as the BBC's former North America correspondent Jon Sopel observes in his book *If Only They Didn't Speak English*, a shared language can be deceptive, hiding political, social, and cultural divides beneath a surface of apparent familiarity.[1]

Nowhere is the illusion of familiarity more jarring than in the US's relationship with guns. I've lived in several countries outside the UK, including Kiribati, a remote Pacific island country of around 130 000 people. Yet nowhere have I felt as far from home as when I find myself wondering: is anyone here carrying a gun? It surfaces in unexpected moments: stopping at a highway gas station at night, walking through a shopping mall, or stopping for groceries. It's a quiet, background awareness—an understanding that guns are not an abstract policy issue here but a daily reality.

Evidence behind the unease

My disquiet isn't unfounded. The US has more guns than people: 120.5 guns per 100 people, which compares with 4.6 in England and Wales (and 0.8 in Kiribati).[2] It has more mass shootings than days of the year: as of 20 November 2025 there had been 324 days and 374 mass shootings.[3] Children and teenagers in the US are over 15 times more likely to die from gun related causes than their peers in 18 comparator high income nations from the Organisation for Economic Co-operation and Development.[4] Women in the US have some of the highest gun related mortality worldwide.[5] When disaggregated by state, US states have higher firearm mortality than most countries in the world, with higher rates in Mississippi, Louisiana, Alabama, and New Mexico than Guatemala, Mexico, or Honduras.[5]

Beyond the statistics are the human stories. Nelba Márquez-Greene is a gun safety advocate and community scholar at Yale University's School of Public Health. Her daughter, Ana Grace, was killed in the Sandy Hook Elementary School mass shooting in 2012 that claimed 26 lives, most of them children 6-7 years old.[6 7] After her daughter's murder people told her, "Now you have a platform." Her reply was, "I don't want a platform. I want a daughter."

Márquez-Greene shared this at a book launch for *In Guns We Trust* by the veteran journalist William J Kole.[8] In his book Kole explores America's relationship with guns, the constitutional second amendment "treated as if it were scripture," and the profound religious and cultural forces that sustain it. The book maps a landscape where guns are so deeply woven into national identity that they transcend policy debate, becoming articles of faith.

Kole contrasts the vast, unregulated toll of gun violence in the US with the UK's response to the massacre at Dunblane Primary School in 1996, where public outrage led to sweeping reform.[9] He suggests that the difference is not policy capacity but political will and national identity, which in the US is driven and reinforced by white evangelical Christians. Political will is also powerfully shaped by the National Rifle Association, one of the most influential lobbying organisations in US history. Its reach has been bolstered by decades of messaging that equates gun ownership with freedom and patriotism.

Gun violence is a public health crisis that falls heavily on children.[10] The US health and human services secretary, Robert F Kennedy Jr, has made children's health a central focus of his agenda. Yet the *Make Our Children Healthy Again* report published in October 2025 didn't mention firearms once, even though they are the leading cause of death in children aged 1-17.[11 12] This omission reveals how deeply political motivation overrides public health evidence. It's difficult to comprehend how a country that leads the world in medical innovation can remain inactive on a crisis rooted in preventable harm.

Beyond fear: rebuilding trust

Fear sits at the heart of this polarised issue. For many Americans, it's been weaponised and sustained by narratives that misrepresent guns as the solution to violence rather than its cause. Over time that fear has been amplified by politics, profiteering, and polarisation, stoked by racialised and antimigrant rhetoric, until it's become part of the culture itself.

The US seems unable, or perhaps unwilling, to protect its children from preventable injury and death. The problem isn't a lack of solutions. Reducing harm will require more than policy: it will require rebuilding trust and rethinking the national identity that has come to equate freedom with firearms.

Fear is a powerful force in public health and politics. It feeds polarisation, narrowing the space for trust and evidence. Re-establishing trust—in each other, in institutions, in shared facts—is essential if gun violence is ever to be treated as the preventable crisis it is, rather than accepted as an inevitable cost of constitutional freedom.

Competing interests: None declared.

Provenance and peer review: Not commissioned; not externally peer reviewed.

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PART VI: SUPPLEMENTARY MATERIALS

17 PAPER 1: THINGS FALL APART

There are no supplementary materials for Paper 1.

18 PAPER 2: INFLUENZA: CAUSE OR EXCUSE?

Supplementary material: Additional data on all-cause and flu mortality trends in England and Wales

Crude number of deaths (all causes) and age-standardised mortality rates over time

Figure A shows the total number of deaths (crude – absolute – the simple count, in grey) and the age-standardised mortality rate (blue line) for England and Wales, 1950 to 2019. It has been drawn using ONS data. The crude number of deaths per year had been steadily falling since the mid-70s, but rose in 2012.[1] The age-standardised mortality rate (ASMR), shows the annual rate of deaths adjusted so as not to be influenced by the ageing population, and reveals that mortality by this better measure also increased in 2012 and improvements stalled thereafter, being higher in 2015, 2016, 2017 and 2018 than in 2014. The lowest ASMR recorded was in 2019.

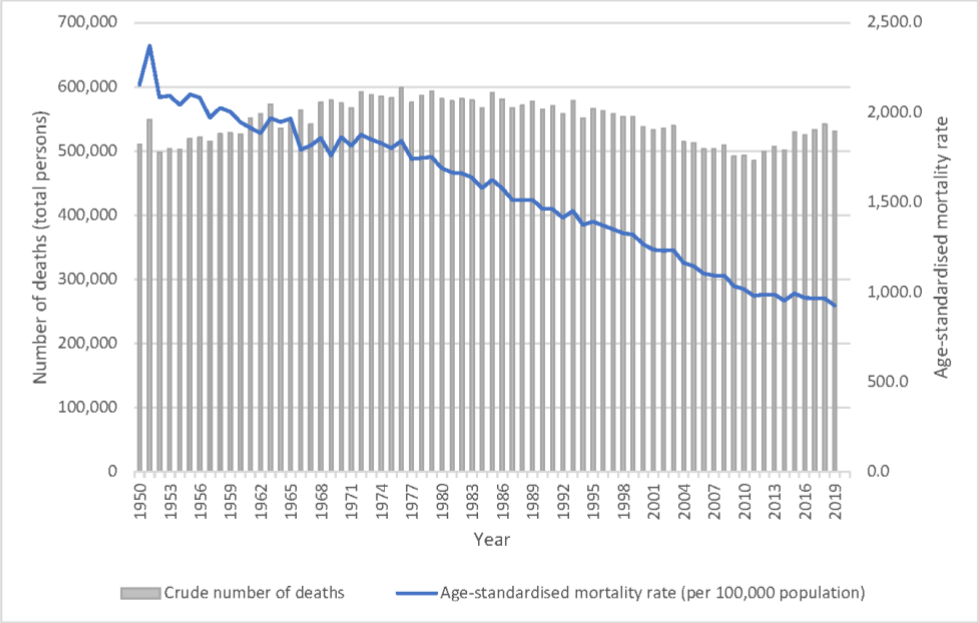


Figure A: Number of deaths and age-standardised mortality rates for total population, England and Wales, 1950 to 2019. Source: ONS 2021[1]

Influenza deaths and age-standardised mortality rates from influenza over time

International classification of diseases (ICD) coding changes over time. Figures B to E, below, show deaths directly coded as influenza, rather than the broader definition of influenza-like deaths, using the codes in Table A.

Table A: ICD codes for influenza 1901-2022 (narrow definition)

Year	ICD version	Code	Description
1901-1910	1	120	Influenza
1911-1920	2	10	
1921-1930	3	11	
1931-1939	4	11	
1940-1949	5	33	
1950-1957	6	480-483	
1958-1967	7	480-483	
1968-1978	8	470-474	
1979-2000	9	487	
2001-2022	10	J09-J11	

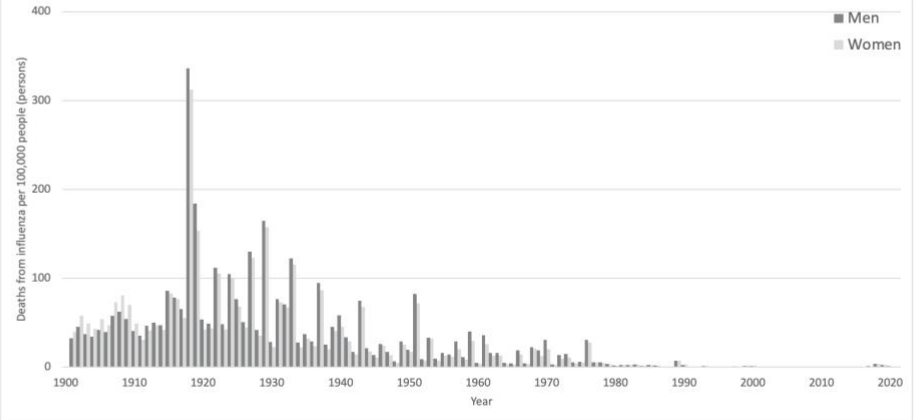


Figure B: Influenza deaths (narrow definition) age-standardised mortality rates for men and women. Source: Source: ONS 20th and 21st century mortality files and Human Mortality Database denominators, calculation by authors, and standardized to the 2013 European population.

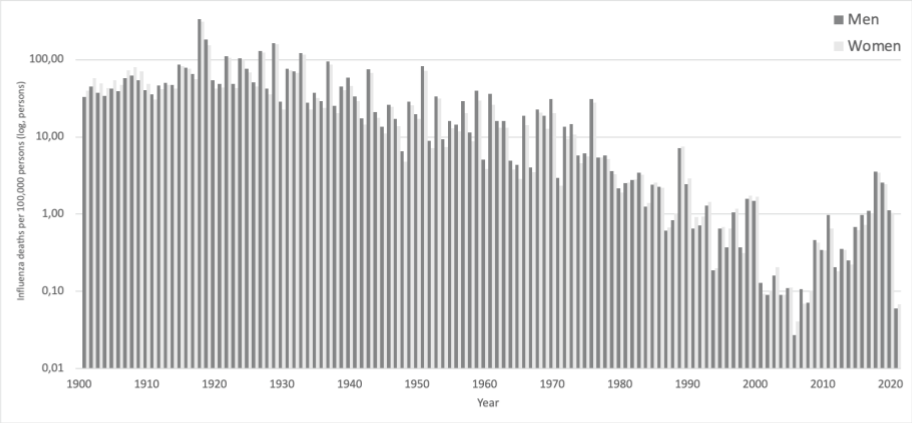


Figure C: Age-standardised mortality rates for deaths from influenza (narrow definition) per 100,000 persons, log scale. Source: As for Figure B

Figure C illustrates that while rates of influenza were increasing between 2007 and 2019, at most, the disease resulted in only 1 extra death per 100,000 people when the rates have been age-sex standardized, and thus influenza in these years could not make a significant contribution to overall mortality trends. Furthermore, as Figure 3 in the main paper illustrates, mortality from flu-like diseases defined more widely, which may have included undiagnosed influenza, was falling over this period.

Table B shows the crude rates of deaths from influenza directly (J09-J11) from 2010 to 2021.

Table B: Mortality from influenza (J09, J10, J11) per 100,000 people, 2010-2021, in England and Wales (not age standardized)

Year	Males	Females	Total
2010	32.3	32.3	32.3
2011	90.2	62.3	76.0
2012	14.8	14.7	14.7
2013	27.2	29.5	28.4
2014	21.3	20.0	20.6
2015	45.7	52.7	49.3
2016	81.2	66.9	74.0

2017	72.2	84.0	78.2
2018	247.3	294.5	271.2
2019	197.6	214.8	206.3
2020	81.7	90.3	86.0
2021	5.4	6.3	5.9

Note that the crude rates in Table B are not age standardized. They vary so much between years, and the age distribution of the population changed so slowly in these years, that such standardization does not alter them greatly apart from their magnitude (see Table 2 in the main paper where the age standardized rates are shown). In the past these rates have been published per million and without age standardisation (see Table 5 in Langford 2002, and Andrewes 1942).[2,3]

The two older publications produce a series of deaths per million which can now be extended to 2021, as shown in Figure D.

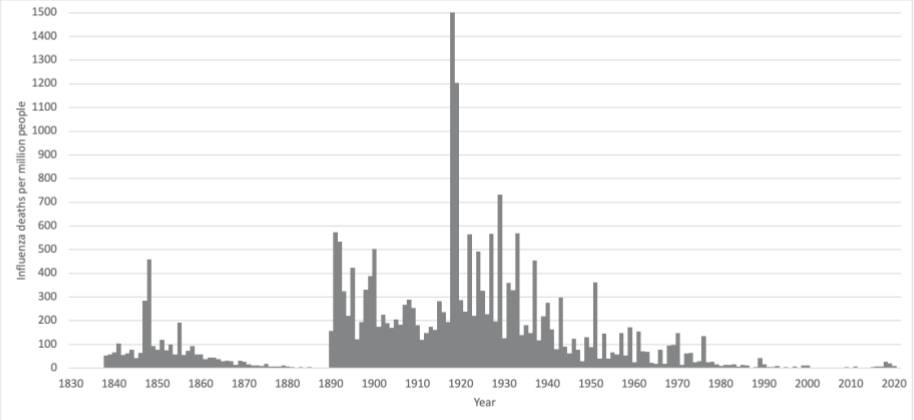


Figure D: Influenza deaths mortality rates per million for both sexes combined, England and Wales, 1838-2021. Source: As for Figure B with additional data from Langford 2002 and Andrewes 1942.

The longer-term trend in deaths solely attributed to influenza is clearer when plotted on a log scale (Figure E). Part of the fall in recent years (in the years since the 1950s) will be as more deaths are attributed to bronchitis and pneumonia, with no mention of influenza, but it is nevertheless interesting to see how similar the fall from 1838 to 1889 was as compared to that seen in more recent times. Drawn on a log scale in Figure E there appears to be a long term pattern to the supposed influenza

mortality rate – the basic rate at which people die from what their clinicians have through of as influenza over this very long period.

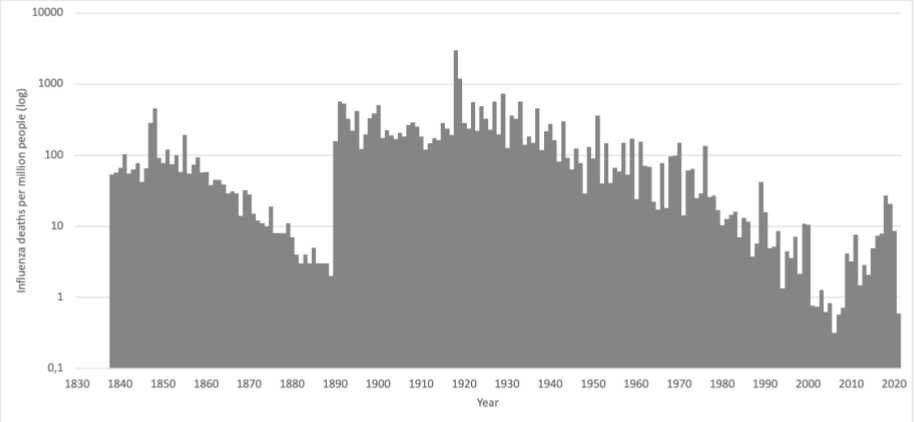


Figure E: Influenza deaths mortality rates per million for both sexes combined, England and Wales, 1838-2021. Source: As for Figure B with additional data from Langford 2002 and Andrewes 1942. Source: As for Figure B with additional data from Langford 2002 and Andrewes 1942.

Figure E shows again that the number of deaths attributed to influenza became too low in the period since 2010 to account for any non-trivial component of the overall rise in mortality in those years, and that this was a part of a long term downwards shift in the relative importance of influenza and what was thought to be a death associated with influenza across this time period in England and Wales. When not standardized by age, the rise is still only an extra 10 deaths per million, or 1 death per 100,000 people per year in 2018 and 2019.

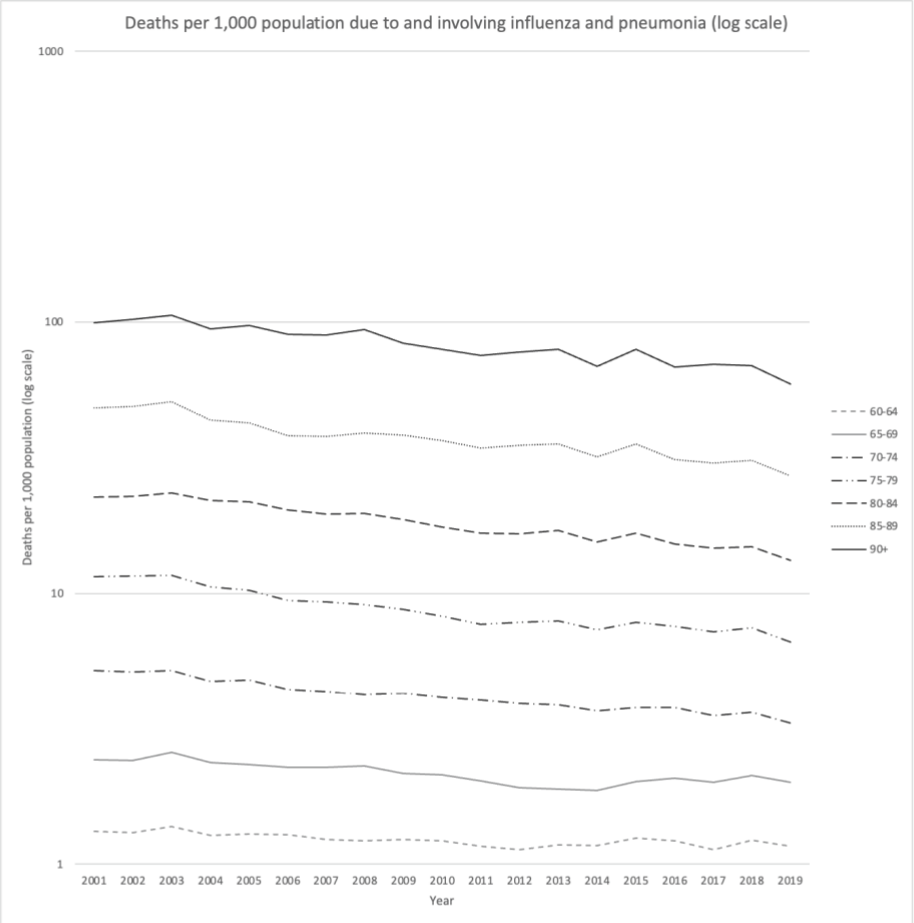


Figure F: Deaths per 1,000 population due to and involving pneumonia and influenza by 5-year age group, log scale, England and Wales, 2001-2019. Source: ONS, 2022

Figure F, which uses a log scale, shows how mortality due to and involving pneumonia and influenza declined overall between the years 2003 and 2019, with a very small temporary rise recorded for older people in 2015, but a flat-lining after 2014 for those aged 65-69. It is possible that the rise in 2015 was as much due to more mortality due to colder weather in January and February 2015 and the health services were extreme stretched at this time. However, the key message from this figure is that influenza cannot have contributed to the stalling and in some cases falling of life expectancy after 2014. It was simply too rare a cause of death – no matter how widely defined.

Excess mortality rates from all causes in England, 2019

Finally, Tables C and D below give the excess mortality rates for men and women respectively in Quarter 4 (Q4) 2019 as compared to Q4 in each of the previous five years by five-year age groups over age 70. These data are also taken from the ONS records.[4] Note these data are for England only at this point. These two tables C and D show that Q4 2019 was an unusual time, with higher mortality rates across all age groups as compared to the previous 5 years for men, and for all age groups and years except 2017 for women. Figures G and H illustrate those two tables graphically. It is noteworthy than in 2019 influenza-like deaths for both sexes in older age groups were at their lowest in the 21st century (Figure 3 in the main paper). Why did mortality rise in Q4 2019 for older men and women in England as compared to the same period in each of the last four years? Perhaps this finally was a little more influenza being prevalent as compared to 2014, 2015, 2016, 2017, or 2018? And maybe something else was in the air – a little earlier than was thought to have been the case? It is worth future researchers looking closely at this time period and the last few months of 2019 in countries across Europe for men and women of older ages and how they did in comparison to the final few months of the previous four years.

Table C: Excess all-cause mortality in Q4 2019, in England: Men, as compared to Q4 in each previous year. Source: Reference table A: Number of deaths by fiver-year age group and sex, England, Registered in Quarter 4 (October to December) 2014 to 2019, ONS 2020.[4]

Age	Q4 2014	Q4 2015	Q4 2016	Q4 2017	Q4 2018
70-74	17%	15%	10%	3%	2%
75-79	6%	9%	9%	7%	10%
80-84	5%	8%	7%	4%	8%
85-89	10%	13%	7%	5%	10%
90 +	18%	19%	11%	8%	13%

Table D: Excess all-cause mortality in Q4 2019, in England: Women, as compared to Q4 in each previous year. Source: As for Table C.

Age	Q4 2014	Q4 2015	Q4 2016	Q4 2017	Q4 2018
70-74	14%	15%	7%	5%	4%
75-79	4%	8%	6%	6%	10%
80-84	1%	5%	4%	4%	9%
85-89	0%	4%	0%	-1%	7%
90 +	4%	10%	7%	5%	12%

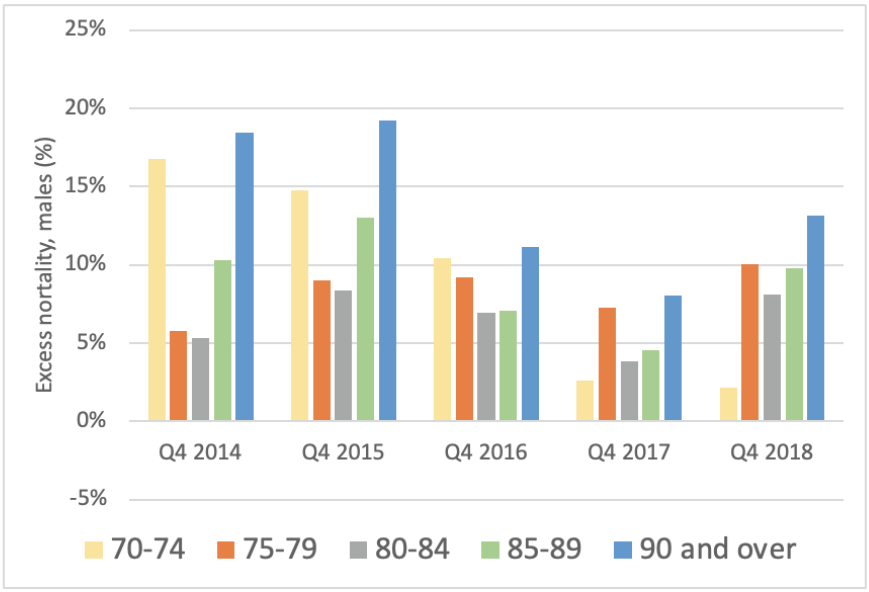


Figure F: Excess mortality for males in England by age in Q4 2019 as compared to each previous Q4, 2014-2019. Source: ONS

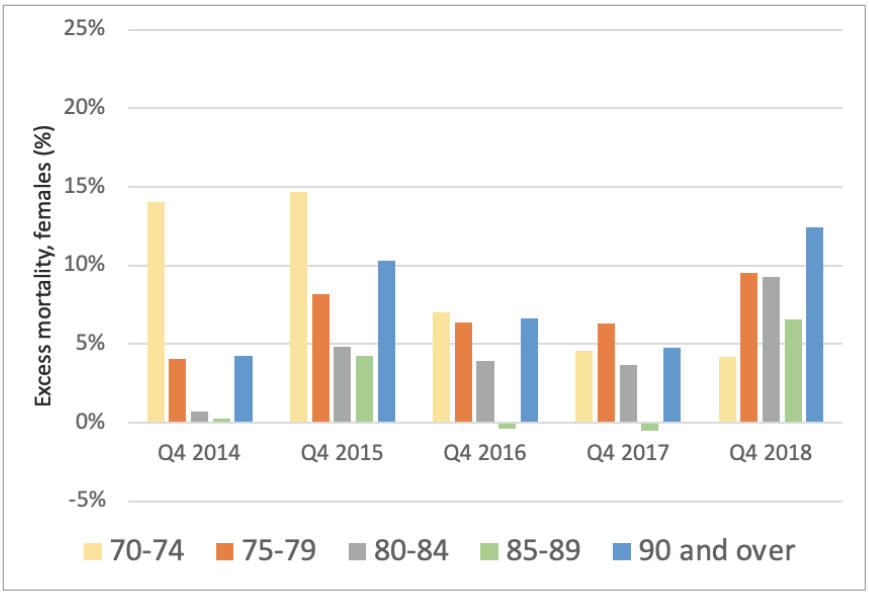
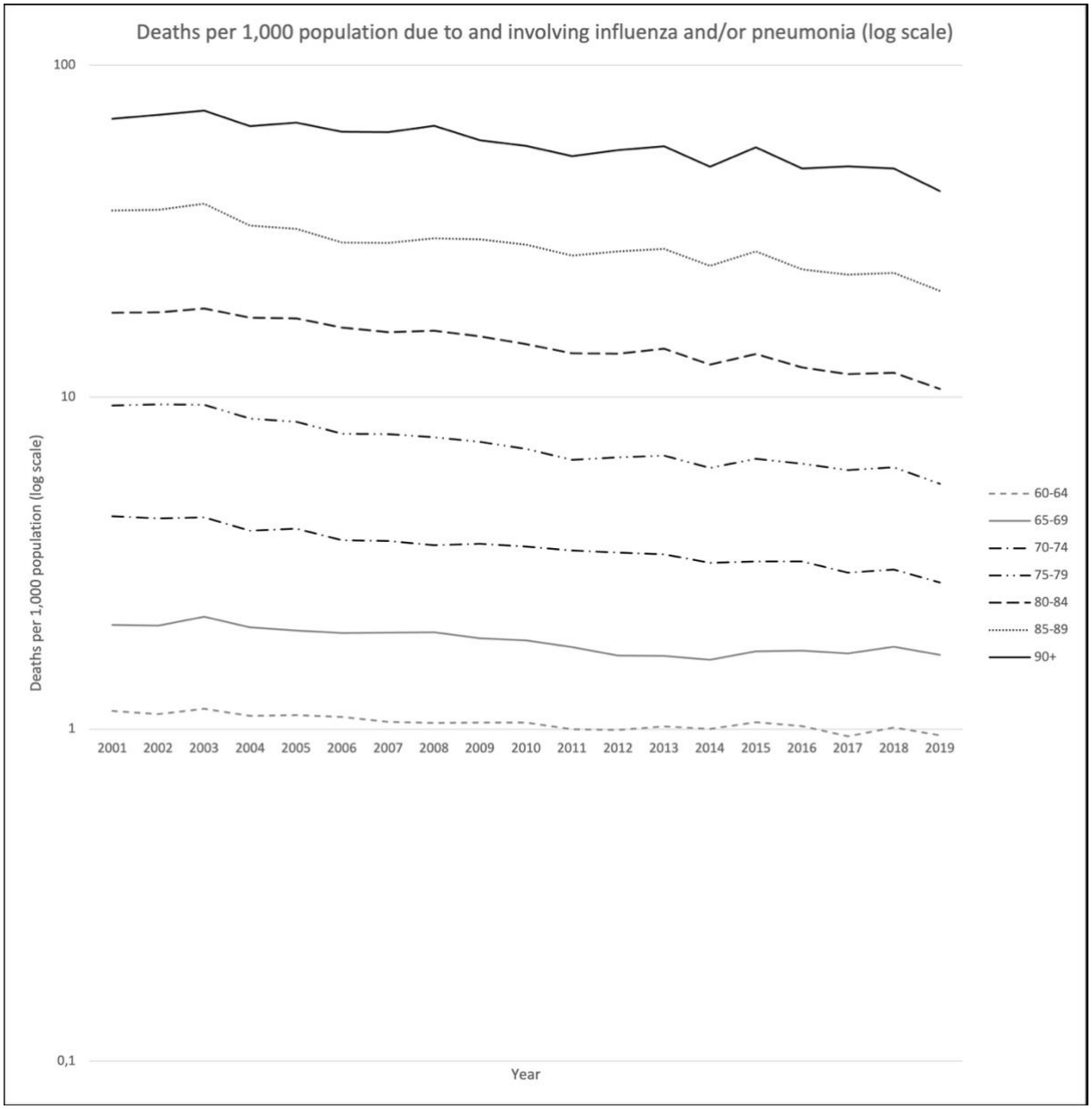


Figure G: Excess mortality for females in England by age in Q4 2019 as compared to each previous Q4, 2014-2019. Source: ONS

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Deaths per 1,000 population due to and involving influenza and/or pneumonia (log scale)
100
10
1
0,1
Deaths per 1,000 population (log scale)
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year
60-64
65-69
70-74
75-79
80-84
85-89
90+

19 PAPER 3: THE GOLDEN COHORT

THE RISE AND FALL OF BRITAIN'S GOLDEN COHORT: HOW THE REMARKABLE GENERATION OF 1925-1934 HAD THEIR LIVES CUT SHORT BY AUSTERITY

STATISTICAL AND FURTHER INFORMATION APPENDIX

1 "THINGS FALL APART": 2020 TO PRESENT (AGED 86-95 YEARS TO PRESENT)

1.1 The end of great expectations

In 2014, the ONS published historic and projected percentage change in smoothed mortality rates for males and females from 1962 to 2039 in the UK (Nash, 2016). These show that, even by 2014, it was assumed the Golden Cohort would continue to enjoy the same exceptional trends that they had for most of their lives (Figure 1). However, what later occurred in reality would lead the ONS to repeatedly revise their projections lower and lower as mortality worsened, losing many years of life (Dorling & Gietel-Basten, 2017; Hiam & Dorling, 2022).

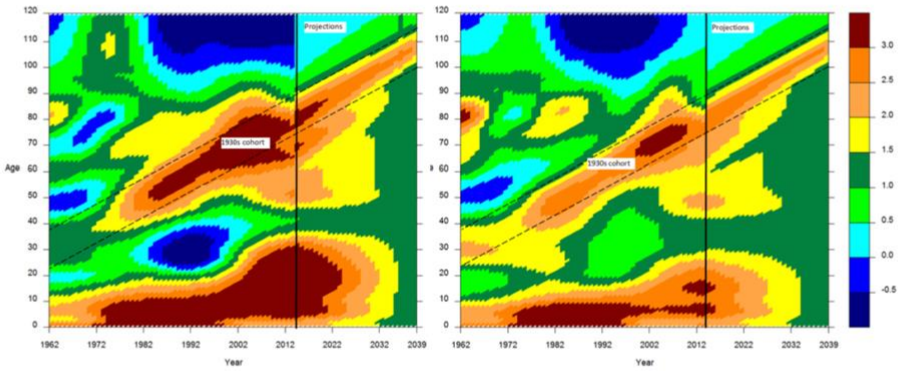


Figure 1a: Males

Figure 1b: Females

Figure 1: Historic and projected (in 2014) percentage change in smoothed mortality rates, males (left) and females (right), UK, 1962 to 2039. Source: Nash, 2016, ONS.

1.2 Brexit, 2020

Before the 23rd March 2020 when the first lockdown began in the UK, 2020 was already a momentous year (Clery et al., 2021, p. 36). The General Election in December 2019 had been called to "break the stalemate" of the parliamentary process for Brexit, which 3 years later was no closer to completion. At that election, 67% of those over 70 years old voted for the Conservatives (14% voted Labour, and 11% Lib Dem)(Skinner et al., 2019; Sloam & Henn, 2019), including the Golden Cohort, helping seal the fate of the Brexit deal. Figure 2

shows the breakdown of the vote in 2019 of the 66 million people in the UK, where 1 square represents 1 million people (Dorling, 2020).

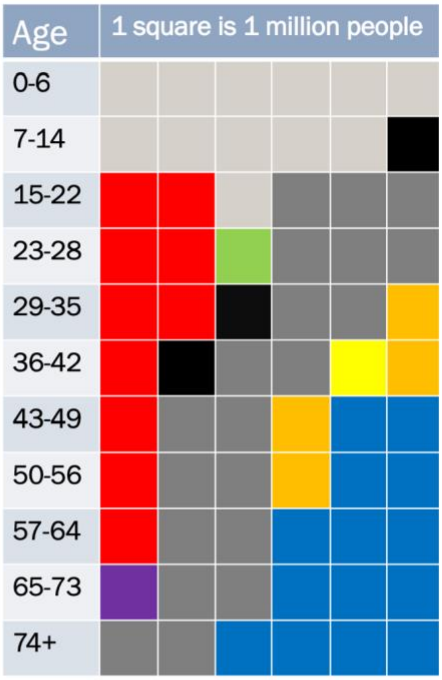


Figure 23 key

Group	Number of votes (millions)
Children (and UK citizens)	12
Voted Labour (203 seats)	10
Voted Conservative (365 seats)	14
Voted Liberal Democrats (11 seats)	4
Not UK Citizens	3
Voted in Northern Ireland (18 seats)	1
Voted SNP (48 seats)	1
Voted Green, Plaid or other (5 seats)	1
Did not vote including those eligible but not registered	20

Figure 2: Disaggregation of the UK population by age and vote in 2019 General Election. Source: Dorling 2020 using data from IPSOS and LSE (Skinner et al., 2019; Sloam & Henn, 2019)

The Golden Cohort's voting past, present and future

The Golden Cohort consistently voted throughout their lifetime. Analysis from 1964 to 2015 shows that from the age of 30 years, between 70% and 80% of them voted at General Elections (Gardiner, 2016). By comparison, around 50% of Millennials (born 1981-2000) voted at the 2015 election; less than 60% of Gen X (born 1966-1980), and just over 70% of Baby Boomers (born 1946-1965). Support for the Conservative party has been strongly linked to age with a generational gradient since at least the 1980s—when the annual British Social Attitudes Survey began to report (1983) (Stoneman & Duffy, 2023). Since at least the 1980s, the Golden Cohort (the pre-war born generation) have mostly identified as Conservative party supporters, and their support for that party grew substantially during the austerity years (Figure 3).



Figure 3: Percentage of people who identify as a Conservative party supporter, 1983 to 2020. Reproduced with kind permission of Duffy and Stoneman. Source: Are millennials really killing the Tory Party? (Stoneman & Duffy, 2023). using British Social Attitudes Survey data.

1.3 COVID-19, 2020

The Covid-19 pandemic began in the UK in 2020, when the Golden Cohort were aged between 86 and 95 years old. It quickly became apparent that the most important risk factor for death from the disease was age (Figure 4) (Office for National Statistics, 2022b). The next most important factor was sex – men died more than women.

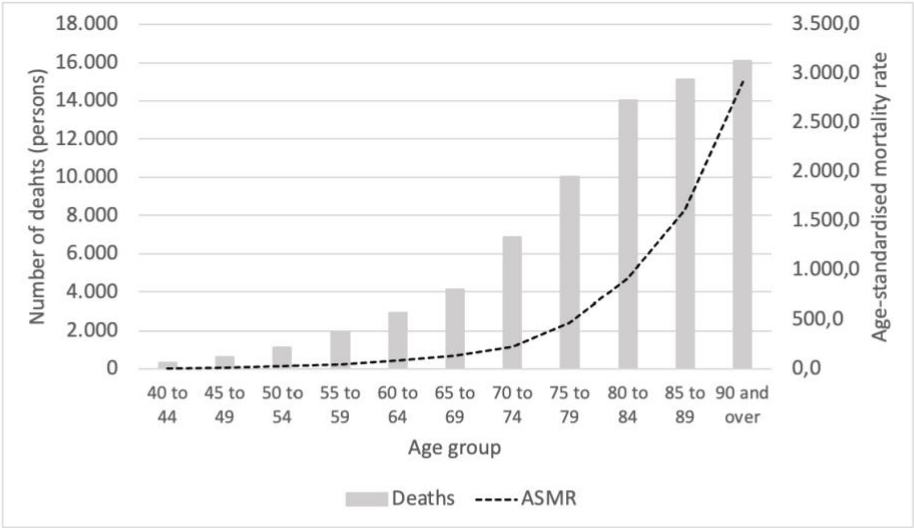


Figure 4: Deaths and age-standardised mortality rates (ASMR) for COVID-19, both sexes, from aged 40 years, England and Wales in 2020. Source: ONS

By the time of the 2021 Census[1], in England and Wales, less than 1 million of the Golden Cohort remained (956,674 people) (Office for National Statistics, 2022a). Many had been killed by the new disease. For those still living, COVID-19 remained a substantial threat. In 2021 36,641 deaths from the disease were recorded in those over 80 years of age, making it the 2nd highest leading cause of death after Dementia and Alzheimer's disease for all people in England and Wales (at 52,750 persons). This compared to 42,650 COVID-19 deaths in 2020 among members of the golden cohort (Office for National Statistics, 2022b). That toll was despite this age group being among the first to receive the COVID-19 vaccination, and by 2022, COVID-19 no longer featured among the top 5 leading causes of death for persons over 80 years old (Office for National Statistics, 2023c). However, the Golden Cohort were aged 87 to 97 in 2022, and weekly causes of death "involving" COVID-19 for age groups over 80 in 2022 totalled 21,693 (Office for National Statistics, 2023d), so these figures suggesting that the pandemic was not still a major contributor must be interpreted with caution[2]. As we write, in 2023, COVID-19 remains a significant threat for this group. This group came to include the large majority of people suffering Alzheimer's or dementia who were dying with the new disease, but whose cause of deaths might not

[1] The Census took place on 23 March 2021. The ONS highlight that estimates over 90 years are less reliable than other ages.

[2] It would be in the top 5 if any death *involving* Covid-19 were included as a covid death.

mention COVID-19 if they were not given a test in 2023, or if there was a preference to list suffering from Alzheimer's or dementia as the key underlying cause of death. In the first half of 2023 (up until 30th June), some 7,777 people aged 80+ in England and Wales had died with COVID-19 mentioned on their death certificate (Office for National Statistics, 2023f). This was 4.5% off all deaths of this age group in those 6 months. For people aged 90+, some 3,077 of them died with mention on their death certificates, again 4.5%. This suggests a change from earlier in the year possibly due to testing becoming more and more rare.

In 2023, the remaining members of the Golden Cohort were aged between 89 and 98 years old. The provisional weekly death data from ONS for England and Wales up to and including week 15 of 2023[3] reported a total of 8,643 deaths across all ages "involving" COVID-19—more than one quarter (2,326 or 27%) of these were in people over 90 years (Office for National Statistics, 2023d). There were 43,107 deaths in total in those aged over 90 years—5.4% of them recorded as involving COVID-19, with a clear difference between the sexes (males 6.3%, females 4.9%). A far higher proportion than that recorded will have died with the disease but were no longer being tested, or they died earlier than they would have done because they had been exposed to it.

1.4 Cost of living crisis, 2021 onwards

The "cost of living crisis" refers to a decline in disposable income for people living in the UK (and worldwide) that began in late 2021 (Hourston, 2022). The cost of food and energy—especially gas—rose. By March 2023, inflation stood at 8.9%. In the 12 months to March 2023, the price of food and non-alcoholic drinks had increased at the fastest rate in over 45 years, the price of electricity had increased by 66.7% and the price of gas (used mostly to heat homes) rose by 129.4% (Office for National Statistics, 2023b, 2023a). In the most recent ONS survey of public opinions[4], when asked what the most important issues facing the UK were 92% said the cost of living (followed by 85% mentioning the NHS), and half said they were worried about the cost of energy and food in the past two weeks (Office for National Statistics, 2023e). The substantial increases in the cost of living have given rise to the dire phrase "heating or eating", with people forced to choose between two basic needs in modern day Britain, including many of the remaining members of the Golden Cohort (Bullard, 2022). By July 2023, food inflation was still very high, being reported to then be 14.9%, as compared to the year before (BBC News, 2023).

[3] Released on 25 April 2023 including data up to week ending 14 April 2023.

[4] Public Opinions and Social Trends, Great Britain, 5 to 16 April 2023. Accessed 25 April 2023.

1.5 Health care collapse

When the Golden Cohort entered retirement, health and social care had seen significant increases in funding. However, before the pandemic struck, the NHS was under-funded and struggling to keep pace with demand (Marmot, 2023). This has been exacerbated by the pandemic, and by 2022, previously high rates of satisfaction with the NHS have fallen to a record low of 29%[5], and dissatisfaction with social care was measured at 57% of the population being unhappy, with those over 65 years were among the most dissatisfied (Morris et al., 2023). There is much reason to be dissatisfied. Waiting lists for routine treatments have dramatically increased, securing a GP appointment with the doctor can now be a great challenge, waiting times in A&E are now routinely beyond safe and acceptable levels, and reports of people dying at home while waiting for an ambulance which arrives too late became commonplace (Stevens, 2023). Some private health care firms that had been subcontracted to provide NHS services were also facing difficulties in 2023. One which handled 100,000 patients through its NHS GP practice (it's "remaining NHS service"), was on the brink of filing bankruptcy as we write (Sollof, 2023). It had been hailed as the new future just a few years earlier: "*Babylon Health is a UK AI firm that was promoted as the future of the NHS by the then health secretary Matt Hancock*".

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20 PAPER 4: SLOWING DOWN OR RETURNING TO NORMAL?

Synthetic Germany

Jon Minton

2022-07-23

Why a 20% East Germany/80% West Germany weighting was used to produce 'Synthetic Germany'

In the main paper we mention that a Synthetic Germany was produced as a comparator series by using a weighted average of East German and West German life expectancies. The weighting used was 20% East Germany and 80% West Germany.

This appendix describes why and how that particular weighting was arrived at.

Core problem and approach taken

The core problem is that we do not have a single Germany data series going back to the 1980s, as Germany was not unified at this time. However, we do have series for East Germany and West Germany. In the HMD separate East and West Germany series were still produced even after reunfication, alongside a complete Germany series.

By having separate East, West and complete Germany series for a common range of years, we can produce a synthetic Germany series as follows:

$$e_x^{syn}(t) = pe_x^e(t) + (1-p)e_x^w(t)$$

Where the superscripts syn, e and w indicate synthetic, east and west respectively.

The parameter p is the share of East Germany in the series.

The optimisation challenge is to select a value of p such that the discrepancy between $e_x^{syn}(t)$ and the observed life expectancies for Germany $e_x^{obs}(t)$ is minimised for all values of t.

This discrepancy is calculated using Root-mean-squared-error (RMSE)

Our comparator period is 1990-2010 inclusive. This is a period in which all three series exist and so can be compared, and before any possible slowdown effects are likely to exist.

Packages

```
library(tidyverse)
```

Data

We start with lifetable data for German populations. We only need e0 and e65, though the code can be adapted for other ages.

```r
# If getting from HMD directly we can use a script
# get_data_from_hmd.R
# as follows
# pacman::p_load(HMDHFDplus)
# source(here("R", "get_data_from_hmd.R"))

# We need life expectancy at age 0 and 65, which we can get from the lifetables

# We will load these lifetables directly (rather than using the script)

# To allow this script to be self-contained we will refer to the github file location directly

hmd_lt <- read_rds("https://github.com/JonMinton/change-in-ex/blob/main/data/lifetables.rds?raw=true")


# We will now just look for German data, and for ages 0 and 65 only

e0_e65 <-
  hmd_lt  %>%
    filter(Age %in% c(0, 65)) %>%
    filter(str_detect(code, "DEU")) %>%
    select(code, sex, year = Year, x = Age, ex) %>%
    arrange(year)
```

Functions

Commented functions written to produce Synthetic Germany are shown and run below

```r
# Functions for creating a synthetic Germany and selecting the optimal share of East and West Germany t

# Background: The Human Mortality Database (HMD) includes life expectancy data for Germany (DEUT), East
# (DEUTE) and West Germany (DEUTW). Of course there are no population data for Germany prior to reunifi
# but there are separate population data maintained for East and West German populations post-reunifica

# This means DEUTE, DEUTW, and DEUT are reported for a number of common years.

# The aim of this code is to produce a 'Synthetic Germany' for years prior to reunification. This 'Synt
# is based on a weighted average of East and West German population data. The weighting between these t
# is a parameter to determine based on an objective or loss function.
# A objective/loss function is a function that, given one or more numeric inputs (which can be varied),
# a single numeric output. The aim is to select the input that minimises the value returned by the func

# In this case, the input is the share of a value from the east german series (and so by implication th
# of West Germany as well), and the output to try to minimise is the root-mean-square-error (RMSE) betw
# observed life expectancy value from Germany as a whole, and the implied/simulated life expectancy val
# a synthetic Germany with the proposed East/West Germany share.


# The following function makes a synthetic germany series with a particular east germany share (p_east)
# The inputs east_germany and west_germany need to be vectors of the the same length.
# Additionally the proposed value p_east needs to be between 0 and 1.

make_synthetic_population <- function(east_series, west_series, p_east){
```

```
  stopifnot("Series are of different lengths" = length(east_series) == length(west_series))
  stopifnot("Proportion out of possible bounds" = between(p_east, 0, 1))

  east_series * p_east + west_series * (1 - p_east)
}

# The following function compares a proposed synthetic germany series against the referenced/observed v
# The series need to be of the same length to allow them to be pairwise compared.

# The arguments to what can be one of "RMSE", 'abs', and 'rel'
#  - The match.arg function checks that the input to this argument is one of the three valid inputs.
#  - the default argument for what is RMSE

compare_synthetic_to_reference <- function(synthetic, reference, what = c("RMSE", "abs", "rel")){
  stopifnot("Synthetic and reference are different lengths" = length(synthetic) == length(reference))

  what <- match.arg(what)

  if (what == "RMSE"){
    out <- (synthetic - reference)^2 %>%
      mean() %>%
      .^(1/2)
    return(out)
  } else if (what == "abs"){
    return(synthetic - reference)
  } else if (what == "rel"){
    out <- (synthetic - reference)/reference
    return(out)
  } else {
    stop("Wrong what argument (which should have been caught earlier")
  }
  NULL
}


# The following function wraps up the two previous functions, including a default proposed p_east share

# It includes a number of checks that the inputs are of the expected format, and a function within whic
# the columns and rows of interest to populate each series.

compare_series_get_rmse <- function(data, p_east = 0.20,
                                    east_label = "DEUTE", west_label = "DEUTW", ref_label = "DEUTNP",
                                    comp_period = c(1990, 2010))
{

  stopifnot("data is not a dataframe"      = "data.frame" %in% class(e0_e65)         )
  stopifnot("proportion not valid"         = between(p_east, 0, 1)                   )
  stopifnot("comp_period not a range"      = length(comp_period) == 2                )
  stopifnot("comp_period values not valid" = comp_period %>% is.numeric() %>% all()  )

  # Get the series
  extract_series <- function(data = data, code_label, comp_period){
    data %>%
```

```
      filter(code == code_label) %>%
      filter(between(year, comp_period[1], comp_period[2])) %>%
      arrange(year) %>%
      pull(ex)
  }


  message("getting East series")
  east_series <- extract_series(data, east_label, comp_period)
  message("getting West series")
  west_series <- extract_series(data, west_label, comp_period)
  message("getting reference series")
  ref_series  <- extract_series(data, ref_label,  comp_period)

  stopifnot("East/West series lengths differ" = length(east_series) == length(west_series))
  stopifnot("Ref series length differs from EastWest" = length(ref_series) == length(east_series))

  message("creating synthetic population and calculating RMSE")

  rmse <- make_synthetic_population(east_series, west_series, p_east = p_east) %>%
    compare_synthetic_to_reference(reference = ref_series)

  stopifnot("rmse failed: not length 1" = length(rmse) == 1)
  stopifnot("rmse failed: not right class" = class(rmse) == "numeric")

  rmse
}

# The following function (with a function inside it!) runs the optim function and packs the inputs
# in the way that optim expects.


run_optim <- function(data){
  pack_for_optim <- function(par, data){
    p_east <- par["p_east"]
    data %>% compare_series_get_rmse(p_east = p_east)
  }
  optim(
    par = c(p_east = 0.5),
    fn = pack_for_optim, data = data,
    lower = 0, upper = 1,
    method = "L-BFGS-B"
  )
}
```

Extracting series

The following manually extracts the series for females for x = 0 (for e0)

```
# Comparator period 1990-2010

# this pulls out the series of values for East Germany
east_series <-
```

```
  e0_e65 %>%
    filter(x == 0) %>%
    filter(code == "DEUTE") %>%
    filter(between(year, 1990, 2010)) %>%
    filter(sex == "female") %>%
    arrange(year) %>%
    pull(ex)

# This pulls out out for West Germany
west_series <-
  e0_e65 %>%
  filter(x == 0) %>%
  filter(code == "DEUTW") %>%
  filter(between(year, 1990, 2010)) %>%
  filter(sex == "female") %>%
  arrange(year) %>%
  pull(ex)

# And this pulls it out for Germany as a whole
ref_series <-
  e0_e65 %>%
  filter(x == 0) %>%
  filter(code == "DEUTNP") %>%
  filter(between(year, 1990, 2010)) %>%
  filter(sex == "female") %>%
  arrange(year) %>%
  pull(ex)
```

Gridsearch approach

The parameter whose loss function (RMSE) we want to minimise is called `p_share`. This is the proportion of the East Germany series (and so by implication `1 - p_share` is the proportin of the West Germany Series.

We start with a gridsearch approach, looking at each full percentage of `p_share` between 0 and 1

```
# And this function looks at each percentage value for share of East Germany
# between 0% and 100%, and pulls out the RMSE given this.

grid_pshare <-
  tibble(
    p_share = seq(0, 1, by = 0.01)
  ) %>%
    mutate(
      rmse = map_dbl(
        p_share,
        ~ make_synthetic_population(east_series, west_series, p_east = .x) %>%
          compare_synthetic_to_reference(., reference = ref_series))
    )
# The contents of the mutate function are complicated. Probably too complicated. ;)
# firstly they evoke map_dbl. This is a particular type of map function that forces the output
# to be a numeric (double) value. This is what we want as RMSE should be a number, and won't be
# a whole number (integer)

# The first argument map_dbl takes is p_share, this is the contents of the p_share column
```

```
# created alongside the tibble in the previous step.

# The next step is a function, make up of two steps joined together with the pipe operator %>%
# The use of the ~ at the start is tidyverse shorthand for 'function'.
# The argument which will be varying is p_share. Unfortunately this isn't the first argument to the
# first function - make_synthetic_population - which it's passed to.
# By default, the map function, like the pipe operator, will pass to the first argument slot in the
# function being passed to. To override this, the .x operator is used.
# This explicitly tells the map function where to put the argument of interest (p_share) in this case.
# (.x is used because there are map2 functions, taking two inputs. The first of these is referred to as
# .x, and the second as .y. This convention is also followed here for a single argument.)
# The result of the first step (before the pipe) of this operation in map_dbl is then passed to
# another function, compare_synthetic_to_reference, and fits in its first slot (marked with a . in this

# This isn't the most clear way of creating the operation. Instead, declaring a single function
# beforehand would likely be easier to understand. However it's a fairly concise shorthand that works!
```

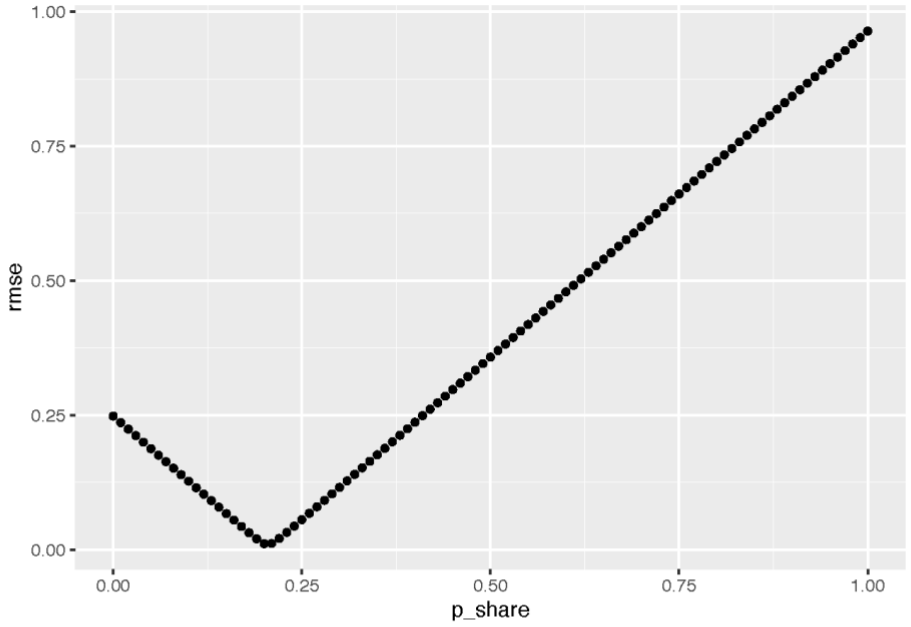
We can see the RMSE for each proposed p_east as follows:

```
grid_pshare
```

```
## # A tibble: 101 x 2
##    p_share  rmse
##      <dbl> <dbl>
##  1    0    0.248
##  2    0.01 0.236
##  3    0.02 0.224
##  4    0.03 0.212
##  5    0.04 0.200
##  6    0.05 0.188
##  7    0.06 0.176
##  8    0.07 0.164
##  9    0.08 0.152
## 10    0.09 0.139
## # ... with 91 more rows
```

And we can visualise how the RMSE varies with different `p_share` values as follows:

```
grid_pshare %>%
  ggplot(aes(p_share, rmse)) +
  geom_point()
```



So, there's a clear minimal RMSE when around 20% (p = 0.20) is proposed.

Is it exactly 20%? Let's check

```
grid_pshare %>%
  filter(rmse == min(rmse))
```

```
## # A tibble: 1 x 2
##   p_share   rmse
##     <dbl>  <dbl>
## 1     0.2 0.0114
```

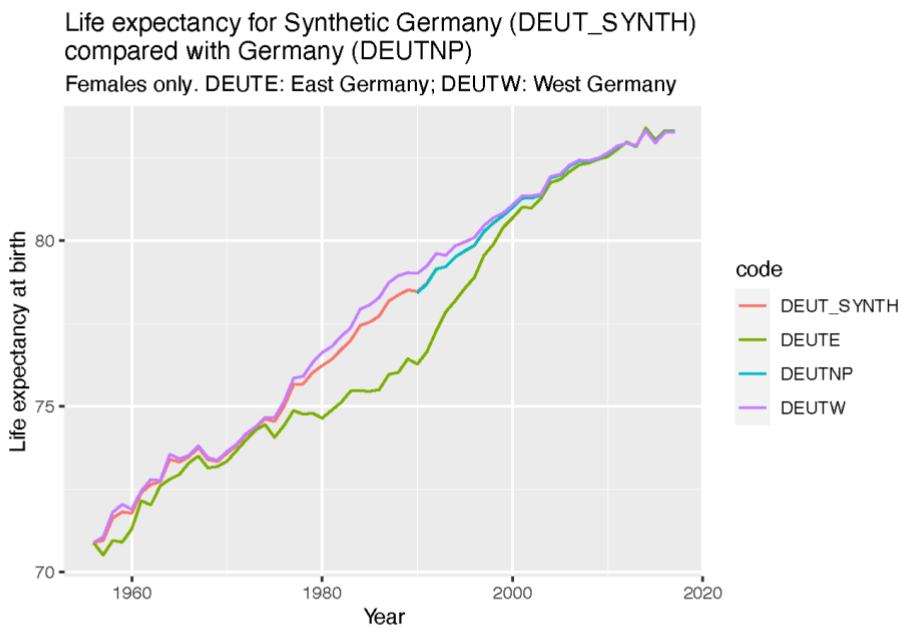
Yes, it's at 20% exactly (to the nearest %)

And what does the Synthetic Germany look like when this proposed mix is used?

```
e0_e65 %>%
  filter(code %in% c("DEUTE", "DEUTW", "DEUTNP")) %>%
  filter(sex == "female") %>%
  filter(x == 0) %>%
  pivot_wider(names_from = code, values_from = ex, values_fill = NA)  %>%
  arrange(year) %>%
  mutate(DEUT_SYNTH = 0.2 * DEUTE + (1 - 0.2) * DEUTW) %>%
  pivot_longer(cols = c("DEUTNP", "DEUTE", "DEUTW", "DEUT_SYNTH"), names_to = "code", values_to = "e0") 
  ggplot(aes(x = year, y = e0, group = code, colour = code)) +
  geom_line() +
  labs(
    x = "Year",
    y = "Life expectancy at birth",
```

```
    title = "Life expectancy for Synthetic Germany (DEUT_SYNTH)\ncompared with Germany (DEUTNP)",
    subtitle = "Females only. DEUTE: East Germany; DEUTW: West Germany"
  )
```

```
## Warning: Removed 34 row(s) containing missing values (geom_path).
```



We can see here that over the reference period `DEUT_SYNTH` (red line) matches `DEUTNP` (blue line) quite closely, as we would expect and hope for.

However the above only completes the calculation for one of the four populations of interest: We also need to do this for e65, and for males.

The following code starts to automate the process for these other three populations:

```
# This is a slightly laborious process, however, involving quite a bit of manual copying and
# pasting of bits of code. For example the above is only for females, and we might want to know
# the equivalent value for males. We might also want to calculate life expectancy for different ages.

# To start to automate further we can look at where the code above is repetitive, work out the
# common patterns in the repeated sections of code, and build functions around them.
# We can also look for where we've hard-coded values, and replace them with objects/references.

# Within the functions developed, a function called get_series() within the compare_series_get_rmse
# standardises the extraction of series. It looks as follows:

# extract_series <- function(data = data, code_label, comp_period){
#   data %>%
#     filter(code == code_label) %>%
```

```
#     filter(between(year, comp_period[1], comp_period[2])) %>%
#     arrange(year) %>%
#     pull(ex)
# }

# We can use this extract_series function within the broader function to get the RMSE for a given p_eas
# in fewer steps (for us)

e0_e65 %>%
  filter(x == 0) %>%
  filter(sex == "female") %>%
  compare_series_get_rmse(data =., p_east = 0.2)
```

```
## [1] 0.01138085
```

```
# This makes it easier to look for another manual combination of starting age (x) and sex

e0_e65 %>%
  filter(x == 65) %>%
  filter(sex == "male") %>%
  compare_series_get_rmse(data =., p_east = 0.2)
```

```
## [1] 0.01245946
```

```
# We can also use map_dbl and nesting to pass different datasets to this function

e0_e65 %>%
  group_by(sex, x) %>%
  nest() %>%
  mutate(rmse = map_dbl(data, compare_series_get_rmse, p_east = 0.2))
```

```
## # A tibble: 4 x 4
## # Groups:   sex, x [4]
##   sex        x data                 rmse
##   <chr>  <int> <list>              <dbl>
## 1 female     0 <tibble [152 x 3]> 0.0114
## 2 female    65 <tibble [152 x 3]> 0.00656
## 3 male       0 <tibble [152 x 3]> 0.0121
## 4 male      65 <tibble [152 x 3]> 0.0125
```

```
# We can repeat the grid search approach by adding a third column, p_share, containing
# a sequence of possible values of the p_east share. We can get all permutations of
# data and p_share using expand_grid (or expand.grid) as follows:

expand_grid(
  e0_e65 %>%
    group_by(sex, x) %>%
    nest(),
  p_share = seq(0, 1, by = 0.01)
) %>%
  select(sex, x, p_share, data)
```

```
## # A tibble: 404 x 4
##    sex        x p_share data
##    <chr>  <int>   <dbl> <list>
##  1 female     0    0    <tibble [152 x 3]>
```

```
##  2 female     0    0.01 <tibble [152 x 3]>
##  3 female     0    0.02 <tibble [152 x 3]>
##  4 female     0    0.03 <tibble [152 x 3]>
##  5 female     0    0.04 <tibble [152 x 3]>
##  6 female     0    0.05 <tibble [152 x 3]>
##  7 female     0    0.06 <tibble [152 x 3]>
##  8 female     0    0.07 <tibble [152 x 3]>
##  9 female     0    0.08 <tibble [152 x 3]>
## 10 female     0    0.09 <tibble [152 x 3]>
## # ... with 394 more rows
```

```
# Then we can pass to the function we used above to get the RMSE, as well as save to a new object

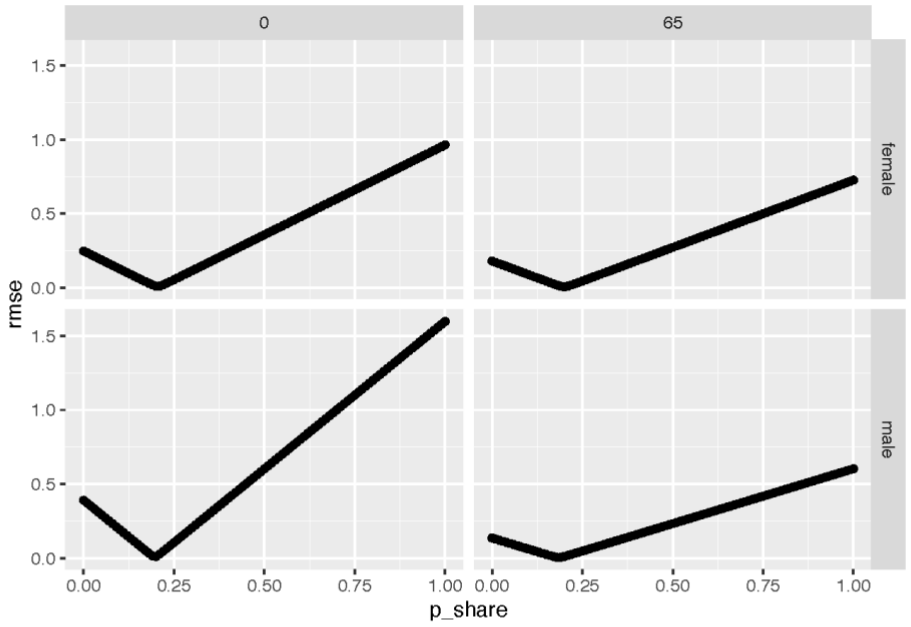
grid_search_pshares <-
  expand_grid(
    e0_e65 %>%
      group_by(sex, x) %>%
      nest(),
    p_share = seq(0, 1, by = 0.01)
  ) %>%
  select(sex, x, p_share, data) %>%
  mutate(rmse = map2_dbl(data, p_share, ~compare_series_get_rmse(data = .x, p_east = .y)))

grid_search_pshares
```

```
## # A tibble: 404 x 5
##    sex        x p_share data               rmse
##    <chr>  <int>   <dbl> <list>            <dbl>
##  1 female     0    0    <tibble [152 x 3]> 0.248
##  2 female     0    0.01 <tibble [152 x 3]> 0.236
##  3 female     0    0.02 <tibble [152 x 3]> 0.224
##  4 female     0    0.03 <tibble [152 x 3]> 0.212
##  5 female     0    0.04 <tibble [152 x 3]> 0.200
##  6 female     0    0.05 <tibble [152 x 3]> 0.188
##  7 female     0    0.06 <tibble [152 x 3]> 0.176
##  8 female     0    0.07 <tibble [152 x 3]> 0.164
##  9 female     0    0.08 <tibble [152 x 3]> 0.152
## 10 female     0    0.09 <tibble [152 x 3]> 0.139
## # ... with 394 more rows
```

This has now produced a lot of operations! What does it show?

```
grid_search_pshares %>%
  ggplot(aes(x=p_share, y = rmse)) +
  geom_line() + geom_point() +
  facet_grid(sex ~ factor(x))
```



So, it looks like approximately the same answer for each of the four groups. Let's check

```
grid_search_pshares %>%
  group_by(x, sex) %>%
  filter(rmse == min(rmse))
```

```
## # A tibble: 4 x 5
## # Groups:   x, sex [4]
##   sex        x p_share data                rmse
##   <chr>  <int>   <dbl> <list>              <dbl>
## 1 female     0    0.2  <tibble [152 x 3]> 0.0114
## 2 female    65    0.2  <tibble [152 x 3]> 0.00656
## 3 male       0    0.2  <tibble [152 x 3]> 0.0121
## 4 male      65    0.18 <tibble [152 x 3]> 0.00575
```

So, to the nearest whole %, the proposed share is 20% except for males at age 65, where it's 18%.

The following code chunk (not run) discusses how the answer could be made more precise by reducing the mesh size on the grid search.

```
# Using the grid search approach above, we could get more precise answers to the best share by
# making the grid search 'mesh' smaller. For example, we could include the resolution 10% by changing
# the by= argument in seq from 0.01 to 0.001.
# i.e.
# grid_search_pshares <-
#   expand_grid(
#     e0_e65 %>%
#       group_by(sex, x) %>%
```

```
#       nest(),
#     p_share = seq(0, 1, by = 0.001) # change from by=0.01 here
#   ) %>%
#   select(sex, x, p_share, data) %>%
#   mutate(rmse = map2_dbl(data, p_share, ~compare_series_get_rmse(data = .x, p_east = .y)))

# But this would take ten times as long to run, as there are ten times as many values to consider.

# We could also narrow the search space, to say between 0.15 and 0.25, and then narrow the mesh size to

# grid_search_pshares <-
#   expand_grid(
#     e0_e65 %>%
#       group_by(sex, x) %>%
#       nest(),
#     p_share = seq(0.15, 0.25, by = 0.001) # change from by=0.01, and start and end to 0.15 and 0.25 r
#   ) %>%
#   select(sex, x, p_share, data) %>%
#   mutate(rmse = map2_dbl(data, p_share, ~compare_series_get_rmse(data = .x, p_east = .y)))

# But again, we only know to do this because we first did the coarser search over the full range of val

# And now imagine if we wanted to do this for each individual age, or for many other countries
# with similar East/West (or North/South) population breakdowns. Or for many different reference period
```

The following code shows how the above answers can be arrived at using numeric optimisation using the `optim` function.

```
# The grid search approach can quickly become too computationally intensive. That's where numerical
# optimisation algorithms can be used instead.

# Within R, the standard function to use for numerical optimisation is optim.
# Optim passes a value or values to a function, and tries to get the smallest or largest value
# out of this function, rejigging the value/values passed to the function multiple times until it can't
# get a substantially improved (as in minimised/maximised) value from the function.
#

# To make the optim function work well with the functional programming approach used by the map functio
# I made a small wrapper function for optim:


# run_optim <- function(data){
#   pack_for_optim <- function(par, data){
#     p_east <- par["p_east"]
#     data %>% compare_series_get_rmse(p_east = p_east)
#   }
#   optim(
#     par = c(p_east = 0.5),
#     fn = pack_for_optim, data = data,
#     lower = 0, upper = 1,
#     method = "L-BFGS-B"
#   )
# }
```

```
# This function also specifies that a particular method, 'L-BFGS-B', which
# gives performs bounded optimisation be used, along with the lower and upper bounds

# I've also given the algorithm a starting value of p = 0.5, which we might assume if we had
# not looked at the data and performed the analysis previously.

# Having done this packing, we now can use optim for each combination of age and sex to get the
# best estimate for p_east in far fewer computational steps, and with much higher resolution

synth_germany_best_shares_via_optim <-
  e0_e65 %>%
  group_by(sex, x) %>%
  nest() %>%
  mutate(
    optim_outputs = map(data, run_optim)
  ) %>%
  mutate(
    optim_share = map_dbl(optim_outputs, pluck, "par")
  )

synth_germany_best_shares_via_optim
```

```
## # A tibble: 4 x 5
## # Groups:   sex, x [4]
##   sex        x data              optim_outputs    optim_share
##   <chr>  <int> <list>            <list>                 <dbl>
## 1 female     0 <tibble [152 x 3]> <named list [5]>       0.205
## 2 female    65 <tibble [152 x 3]> <named list [5]>       0.199
## 3 male       0 <tibble [152 x 3]> <named list [5]>       0.197
## 4 male      65 <tibble [152 x 3]> <named list [5]>       0.184
```

The optim function contains a lot of additional information. For example, we could get the best RMSE by interrogating the 'value' element as follows:

```
synth_germany_best_shares_via_optim %>%
  mutate(
    rmse_at_optim_pshare = map_dbl(optim_outputs, pluck, "value")
  )
```

```
## # A tibble: 4 x 6
## # Groups:   sex, x [4]
##   sex        x data              optim_outputs    optim_share rmse_at_optim_ps~
##   <chr>  <int> <list>            <list>                 <dbl>             <dbl>
## 1 female     0 <tibble [152 x 3]> <named list [5]>       0.205           0.00983
## 2 female    65 <tibble [152 x 3]> <named list [5]>       0.199           0.00654
## 3 male       0 <tibble [152 x 3]> <named list [5]>       0.197           0.0103
## 4 male      65 <tibble [152 x 3]> <named list [5]>       0.184           0.00472
```

```
# So, the best value for RMSE was higher (worse) for males at birth, and lowest (better) for
# males at age 65.
```

Conclusion

For all populations, a proposed share of around 20% East Germany/80% West Germany appears reasonable, even though slightly different shares are slightly more optimal for some populations.

Rather than use the exact `p_shares` calculated by `optim` as optimal for each of the populations, we decided to use 20% for all populations for ease of explanation within the main text. The precise optim values given above could be used instead, if the 20% assumption were felt to be too coarse.

Life Expectancies for selected populations

Jon Minton

2022-07-23

Aim

This appendix will show the life expectancies for the populations compared in the paper.

Data

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.6     v purrr   0.3.4
## v tibble  3.1.7     v dplyr   1.0.9
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
# load data
hmd_lt <- read_rds("https://github.com/JonMinton/change-in-ex/blob/main/data/lifetables.rds?raw=true")


# Labels for codes
country_code_lookup <-
  tribble(
    ~code, ~country,
    "DEUTNP", "Germany",
    "DEUTE", "East Germany",
    "DEUTW", "West Germany",
    "ESP", "Spain",
    "FRATNP", "France",
    "ITA", "Italy",
    "GBRTENW", "England & Wales",
    "GBR_SCO", "Scotland",
    "DEUTSYNTH", "Synthetic Germany",
    "NLD", "Netherlands"
  )

countries_of_interest <- c(
  "GBRTENW",
  "GBR_SCO",
  "GBR_UK",
```

```
  "FRATNP",
  "ESP",
  "ITA",
  "DEUTNP",
  "DEUTE",
  "DEUTW",
  "NLD"
)

source("https://raw.githubusercontent.com/JonMinton/change-in-ex/main/R/make_synthetic_germany_function

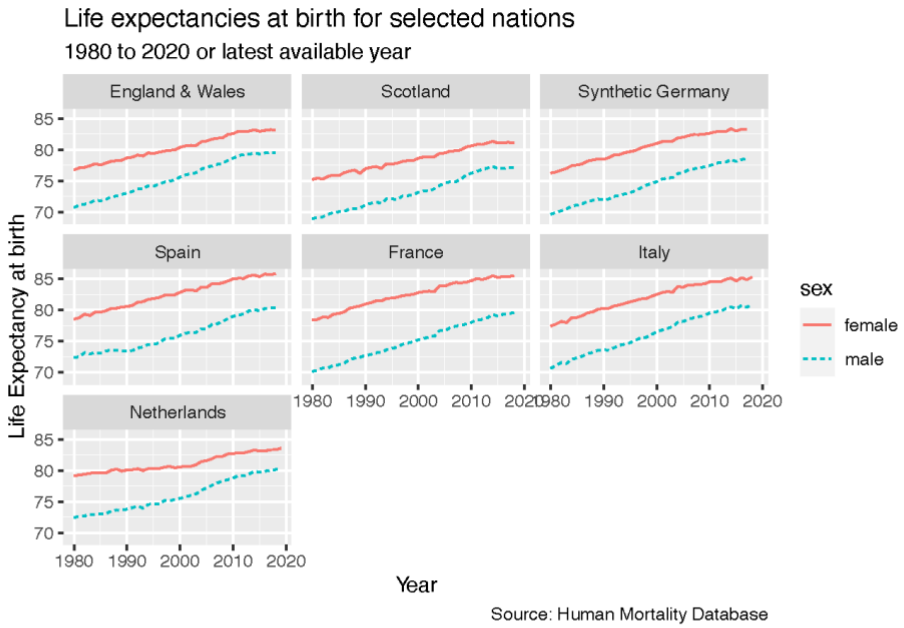
source("https://raw.githubusercontent.com/JonMinton/change-in-ex/main/R/make_pop_selection.R")
```

Graphs

Life Expectancy at birth

```
hmd_ex_selected_countries_with_synth %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  filter(x == 0) %>%
  ggplot(aes(x = year, y = ex, group = sex, colour = sex, linetype = sex)) +
  geom_line() +
  facet_wrap(~country) +
  labs(
    x = "Year",
    y = "Life Expectancy at birth",
    title = "Life expectancies at birth for selected nations",
    subtitle = "1980 to 2020 or latest available year",
    caption = "Source: Human Mortality Database"
  )
```

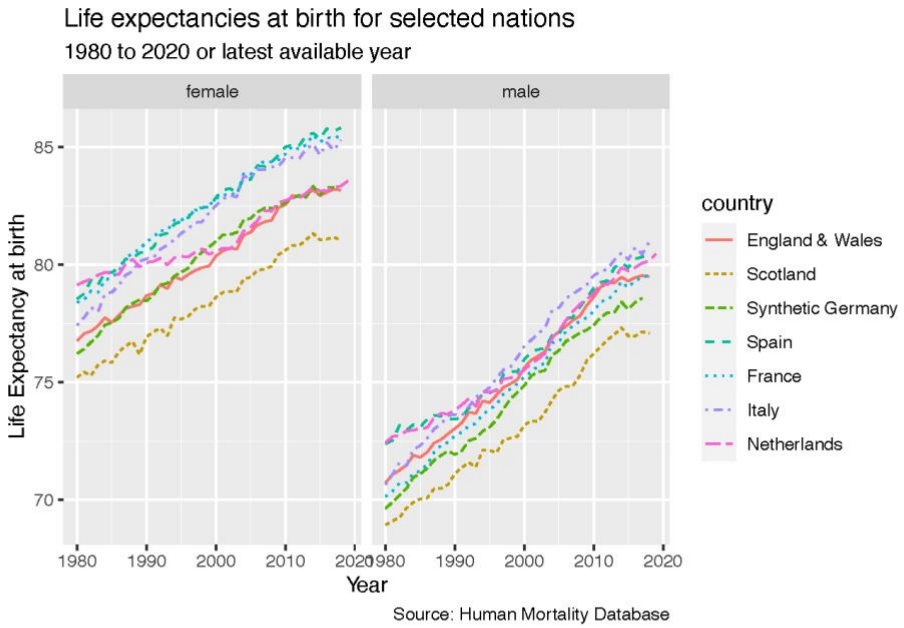
```
## Joining, by = "code"
```



Equivalently

```
hmd_ex_selected_countries_with_synth %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  filter(x == 0) %>%
  ggplot(aes(x = year, y = ex, group = country, colour = country, linetype = country)) +
  geom_line() +
  facet_wrap(~sex) +
  labs(
    x = "Year",
    y = "Life Expectancy at birth",
    title = "Life expectancies at birth for selected nations",
    subtitle = "1980 to 2020 or latest available year",
    caption = "Source: Human Mortality Database"
  )
```

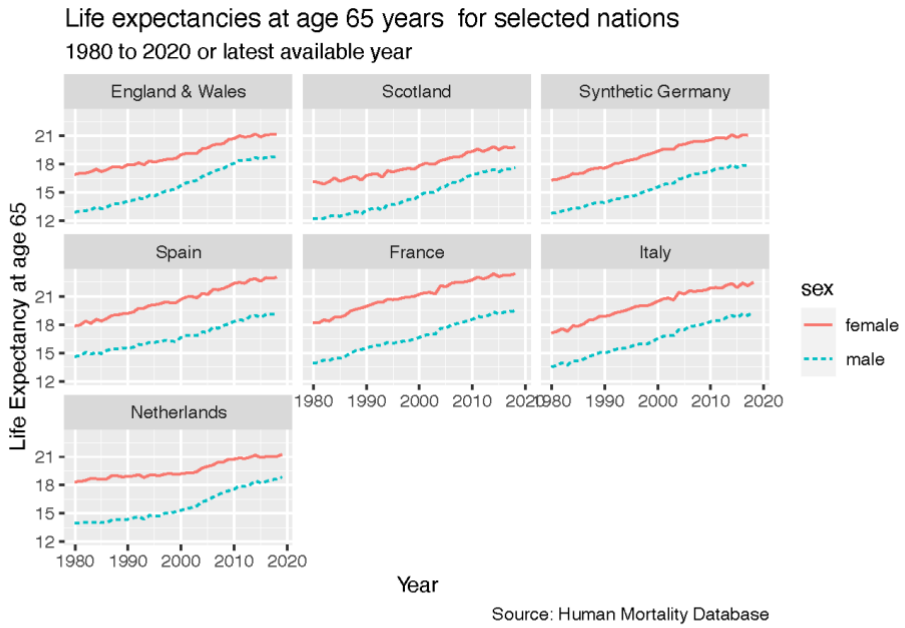
```
## Joining, by = "code"
```



Life expectancy at age 65

```
hmd_ex_selected_countries_with_synth %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  filter(x == 65) %>%
  ggplot(aes(x = year, y = ex, group = sex, colour = sex, linetype = sex)) +
  geom_line() +
  facet_wrap(~country) +
  labs(
    x = "Year",
    y = "Life Expectancy at age 65",
    title = "Life expectancies at age 65 years  for selected nations",
    subtitle = "1980 to 2020 or latest available year",
    caption = "Source: Human Mortality Database"
  )
```

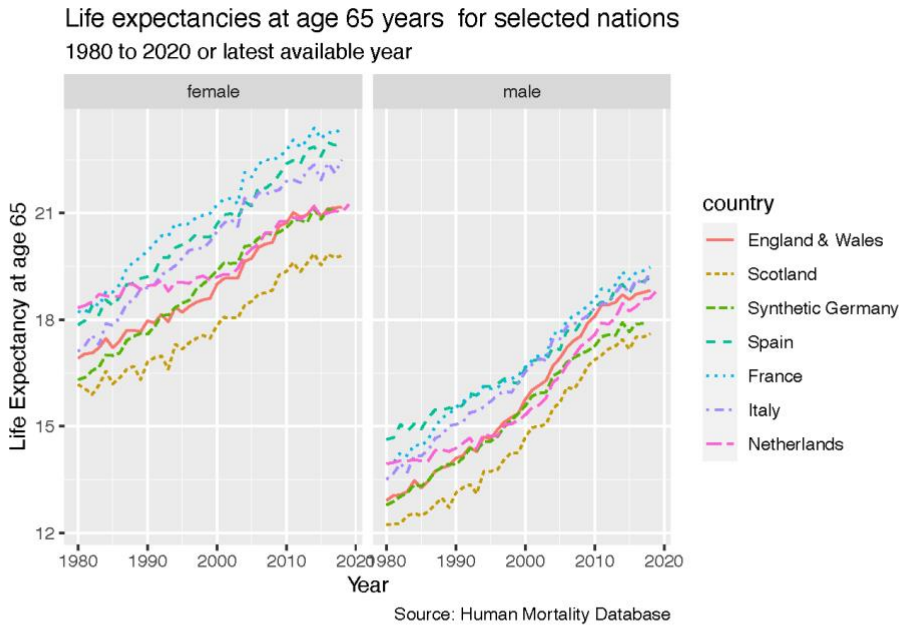
```
## Joining, by = "code"
```



Equivalently:

```
hmd_ex_selected_countries_with_synth %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  filter(x == 65) %>%
  ggplot(aes(x = year, y = ex, group = country, colour = country, linetype = country)) +
  geom_line() +
  facet_wrap(~sex) +
  labs(
    x = "Year",
    y = "Life Expectancy at age 65",
    title = "Life expectancies at age 65 years  for selected nations",
    subtitle = "1980 to 2020 or latest available year",
    caption = "Source: Human Mortality Database"
  )
```

```
## Joining, by = "code"
```



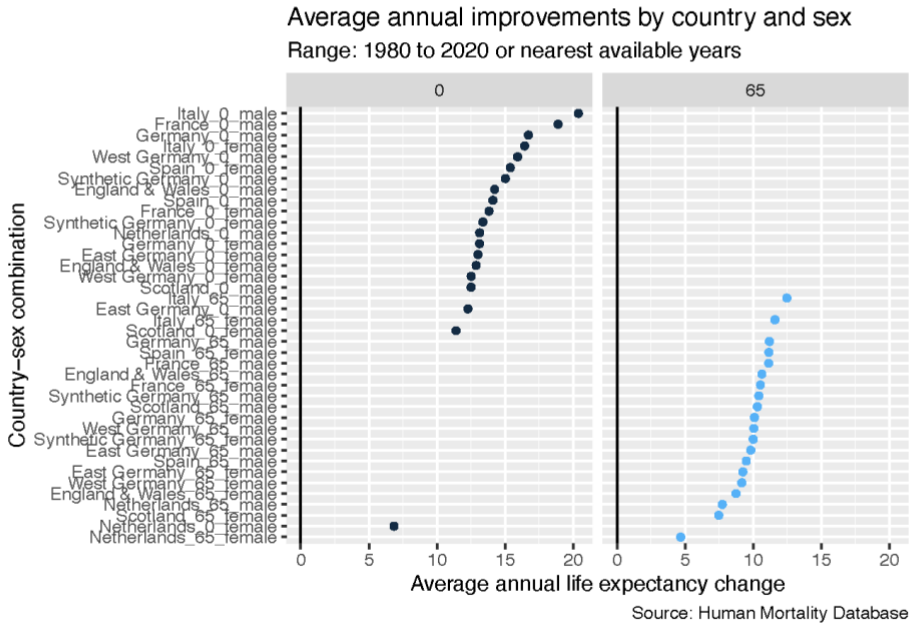
Average life expectancy change

The following shows the average change in life expectancy for each population over the full period, and including East Germany and West Germany as separate populations

```
hmd_ex_selected_countries_with_synth %>%
    filter(year >= 1979) %>%
    group_by(code, x, sex) %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    nest() %>%
    mutate(
      rwd_model = map(data, ~lm(delta_ex ~ 1, data = . )),
      ar_model  = map(data, ~lm(delta_ex ~ lag(delta_ex), data = .))
    ) %>%
    mutate(
      aic_rwd = map_dbl(rwd_model, AIC),
      aic_ar  = map_dbl(ar_model, AIC)
    ) %>%
    mutate(
      diff_aic = aic_ar - aic_rwd
    )  %>%
  # filter(diff_aic > 0)
  mutate(
    tidied_ar_model = map(ar_model, broom::tidy)
  ) %>%
  unnest(tidied_ar_model) %>%
  filter(term == "(Intercept)") %>%
```

```
  arrange(desc(estimate)) %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "East Germany", "West Germ
  select(code, country, x, sex, estimate, std.error) %>%
  mutate(display_label = glue::glue("{country}_{x}_{sex}")) %>%
  mutate(estimate_weeks = estimate * 52.25) %>%
  ggplot(aes(estimate_weeks, fct_reorder(display_label, estimate_weeks))) +
  geom_point(aes(colour = x), show.legend = FALSE) +
  expand_limits( x = 0) +
  geom_vline(xintercept = 0) +
  labs(
    x = "Average annual life expectancy change",
    y = "Country-sex combination",
    title = "Average annual improvements by country and sex",
    subtitle = "Range: 1980 to 2020 or nearest available years",
    caption = "Source: Human Mortality Database"
  ) +
  facet_wrap(~x)
```

```
## Joining, by = "code"
```

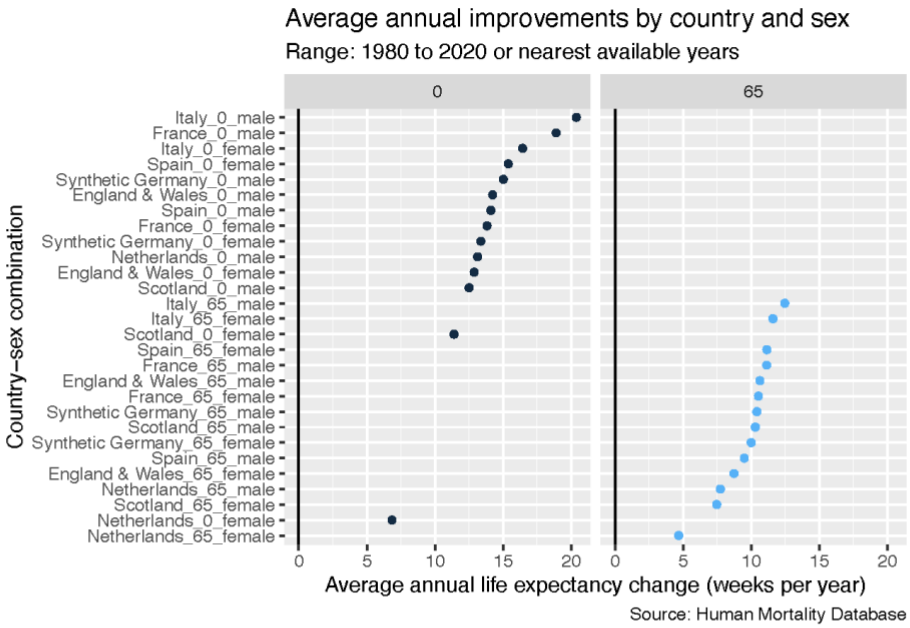


The figure below shows the same for those populations considered in the main paper.

```
hmd_ex_selected_countries_with_synth %>%
    filter(year >= 1979) %>%
    filter(!(code %in% c("DEUTE", "DEUTW", "DEUTNP"))) %>%  # Using only synthetic germany for longer t
    group_by(code, x, sex) %>%
```

```
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    nest() %>%
    mutate(
      rwd_model = map(data, ~lm(delta_ex ~ 1, data = . )),
      ar_model  = map(data, ~lm(delta_ex ~ lag(delta_ex), data = .))
    ) %>%
    mutate(
      aic_rwd = map_dbl(rwd_model, AIC),
      aic_ar  = map_dbl(ar_model, AIC)
    ) %>%
    mutate(
      diff_aic = aic_ar - aic_rwd
    )  %>%
  # filter(diff_aic > 0)
  mutate(
    tidied_ar_model = map(ar_model, broom::tidy)
  ) %>%
  unnest(tidied_ar_model) %>%
  filter(term == "(Intercept)") %>%
  arrange(desc(estimate)) %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  select(code, country, x, sex, estimate, std.error) %>%
  mutate(display_label = glue::glue("{country}_{x}_{sex}")) %>%
  mutate(estimate_weeks = estimate * 52.25) %>%
  ggplot(aes(estimate_weeks, fct_reorder(display_label, estimate_weeks))) +
  geom_point(aes(colour = x), show.legend = FALSE) +
  expand_limits( x = 0) +
  geom_vline(xintercept = 0) +
  labs(
    x = "Average annual life expectancy change (weeks per year)",
    y = "Country-sex combination",
    title = "Average annual improvements by country and sex",
    subtitle = "Range: 1980 to 2020 or nearest available years",
    caption = "Source: Human Mortality Database"
  ) +
  facet_wrap(~x)
```

```
## Joining, by = "code"
```


Average annual improvements by country and sex
Range: 1980 to 2020 or nearest available years
0
65
Country–sex combination
Italy_0_male
France_0_male
Italy_0_female
Spain_0_female
Synthetic Germany_0_male
England & Wales_0_male
Spain_0_male
France_0_female
Synthetic Germany_0_female
Netherlands_0_male
England & Wales_0_female
Scotland_0_male
Italy_65_male
Italy_65_female
Scotland_0_female
Spain_65_female
France_65_male
England & Wales_65_male
France_65_female
Synthetic Germany_65_male
Scotland_65_male
Synthetic Germany_65_female
Spain_65_male
England & Wales_65_female
Netherlands_65_male
Scotland_65_female
Netherlands_0_female
Netherlands_65_female
0
5
10
15
20
Average annual life expectancy change (weeks per year)
Source: Human Mortality Database

Time Series Models

Jon Minton

2022-07-21

Are annual ex time series random walks with drift (RWD) or do they have autocorrelation?

Section X of the main manuscript noted, from figure 1a and 1b, that there is substantial annual variation in annual changes in life expectancy. After taking the first difference in these series (i.e. subtracting for each value in the series its previous value), the series of remaining difference may be purely random. Alternatively, even after such differencing the series may have some degree of autocorrelation (i.e. the differenced value for one year may be informative as to the differenced value for the next one or more observations in the series), or there may be a moving average component to the series.

Different patterns of variation in the time series can be modelled using different specifications of the ARIMA modelling approach. ARIMA stands for Autoregressive (AR), Integrated (I), Moving Average (MA), and different ARIMA specifications are represented by the shorthand ARIMA(p, d, q). The p term indicates the number of autoregressive terms, the d term the number of times the series have been differenced, and the q term the number of moving average terms.

In this appendix we are primarily interested in comparing the ARIMA(0, 1, 0) specification with the ARIMA(1, 1, 0) specification. The ARIMA(0, 1, 0) is known as Random-Walk-with-Drift (RWD) and is the simpler of the two specifications. ARIMA(1, 1, 0) includes one autoregressive term p, meaning for each value in the series there is some correlation with the previous value in the series. For this autoregressive term p, a positive coefficient may be interpreted as indicating some degree of 'stickiness' in the series (a better-than-average value is more likely than by chance to be followed by a better-than-average value, and vice versa), whereas a negative coefficient interpreted as indicating some degree of 'oscillation' in the series (a better-than-average value is more likely than chance to be followed by a worse-than-average value, and so on).

This appendix section will first compare the two ARIMA model specifications ARIMA(0,1,0) (RWD) and ARIMA(1,1,0) (Autoregressive and integrated) for each of the time series. It will then use the auto.arima function from the fable package to consider a wider range of ARIMA model specifications and identify which model specifications are preferred for which datasets.

Preparation

First we load the requisite data, packages, and do the required data processing

```
# This loads the required packages (the pacman package must be installed first, using install.packages(
pacman::p_load(tidyverse, fable, here)

# The following code calculates e0 and e65 for the countries under consideration, using lifetables prev

hmd_lt <- read_rds(here("data", "lifetables.rds"))

# Labels for codes
country_code_lookup <-
  tribble(
```

```
    ~code, ~country,
    "DEUTNP", "Germany",
    "DEUTE", "East Germany",
    "DEUTW", "West Germany",
    "ESP", "Spain",
    "FRATNP", "France",
    "ITA", "Italy",
    "GBRTENW", "England & Wales",
    "GBR_SCO", "Scotland",
    "DEUTSYNTH", "Synthetic Germany",
    "NLD", "Netherlands"
  )

countries_of_interest <- c(
  "GBRTENW",
  "GBR_SCO",
  "GBR_UK",
  "FRATNP",
  "ESP",
  "ITA",
  "DEUTNP",
  "DEUTE",
  "DEUTW",
  "NLD"
)

source(here("R", "make_synthetic_germany_functions.R"))
source(here("R", "make_pop_selection.R"))

series_of_interest <-
  hmd_ex_selected_countries_with_synth %>%
    left_join(country_code_lookup) %>%
    mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Sp
    filter(!is.na(country)) %>%
    filter(between(year, 1979, 2020))
```

```
## Joining, by = "code"
```

```
series_of_interest
```

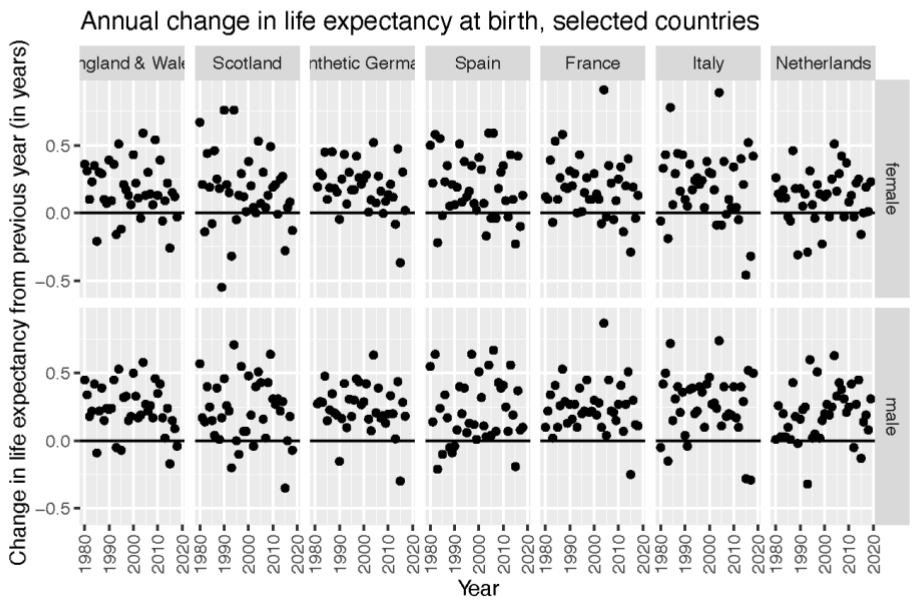
```
## # A tibble: 1,116 x 6
##    code   year     x sex       ex country
##    <chr> <int> <dbl> <chr>  <dbl> <fct>
##  1 ESP    1979     0 female  78.0 Spain
##  2 ESP    1979    65 female  17.6 Spain
##  3 ESP    1980     0 female  78.6 Spain
##  4 ESP    1980    65 female  17.9 Spain
##  5 ESP    1981     0 female  78.8 Spain
##  6 ESP    1981    65 female  18.0 Spain
##  7 ESP    1982     0 female  79.4 Spain
##  8 ESP    1982    65 female  18.4 Spain
##  9 ESP    1983     0 female  79.1 Spain
## 10 ESP    1983    65 female  18.1 Spain
## # ... with 1,106 more rows
```

Our series contains ex for x = 0 (life expectancy at birth) and x=65 (life expectancy at age 65 years), for each of the countries of interest, including 'Synthetic Germany'.

Visualisation

The data series look as follows for x = 0

```
series_of_interest %>%
  filter(x == 0) %>%
  group_by(country, sex) %>%
  arrange(year) %>%
  mutate(delta_ex = ex - lag(ex)) %>%
  filter(!is.na(delta_ex)) %>%
  ggplot(aes(x = year, y = delta_ex)) +
  geom_point() +
  facet_grid(sex ~ country) +
  geom_hline(yintercept = 0) +
  theme(
        axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)
  ) +
  labs(
    x = "Year",
    y = "Change in life expectancy from previous year (in years)",
    title = "Annual change in life expectancy at birth, selected countries",
    caption =  "Source: Human Mortality Database. Synthetic Germany based on 20% East/80% West German p
  )
```



ce: Human Mortality Database. Synthetic Germany based on 20% East/80% West German population weighting

(n.b. the data in this series are shown in years per year, rather than weeks per year as in the main figure)

The equivalent series for e65 is as follows:

```
series_of_interest %>%
  filter(x == 65) %>%
  group_by(country, sex) %>%
  arrange(year) %>%
  mutate(delta_ex = ex - lag(ex)) %>%
  filter(!is.na(delta_ex)) %>%
  ggplot(aes(x = year, y = delta_ex)) +
  geom_point() +
  facet_grid(sex ~ country) +
  geom_hline(yintercept = 0) +
  theme(
        axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)
  ) +
  labs(
    x = "Year",
    y = "Change in life expectancy from previous year (in years)",
    title = "Annual change in life expectancy at age 65, selected countries",
    caption =  "Source: Human Mortality Database. Synthetic Germany based on 20% East/80% West German p
  )
```



ce: Human Mortality Database. Synthetic Germany based on 20% East/80% West German population weighting

Calculating and comparing ARIMA(0,1,0) wih ARIMA(1,1,0)

A time series where each observation in the series is simply dependent on the previous value, plus some random variation (which may be negative), can be expressed as an ARIMA(0, 1, 0) model. By contrast, a model where each observation in the series oscillates slightly (i.e. 'worse-than-average' years are more likely than chance to be followed by 'better-than-average' years, and vice versa), is likely to be represented by an ARIMA(1, 1, 0) model, where the coefficient on this first term (called `p`) should be negative rather than positive.

These models can be fit using the `forecast` package, and model fit compared using the AICc metric.

```
fit_arima_model <- function(series, order){
  series %>%
    pull(ex) %>%
    as.ts(start = 1979) %>%
    forecast::Arima(order = order)
}

ts_model_comparisons <-
  series_of_interest %>%
    group_by(country, sex, x) %>%
    nest() %>%
    mutate(
      arima_010 = map(data, fit_arima_model, order = c(1, 1, 0)),
      arima_110 = map(data, fit_arima_model, order = c(1, 1, 0))
    ) %>%
  mutate(
    aicc_arima_010 = map_dbl(arima_010, ~summary(.) %>% pluck("aicc")),
    aicc_arima_110 = map_dbl(arima_110, ~summary(.) %>% pluck("aicc"))
  ) %>%
  mutate(
    which_preferred = if_else(aicc_arima_010 < aicc_arima_110, "Random Walk", "Autocorrelated")
  )
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

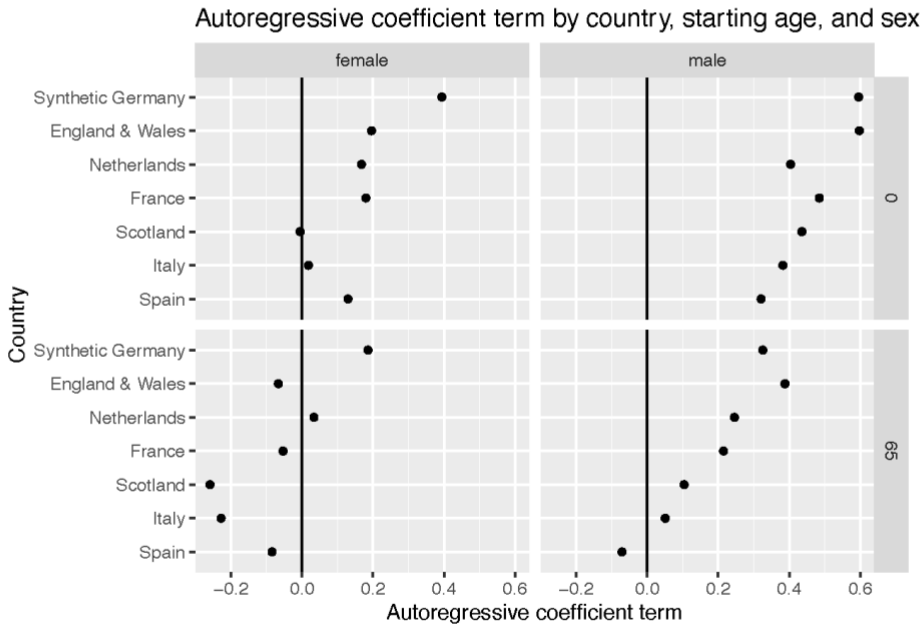
```
ts_model_comparisons %>%
  select(country, sex, x, which_preferred)
```

```
## # A tibble: 28 x 4
## # Groups:   country, sex, x [28]
##    country         sex        x which_preferred
##    <fct>           <chr>  <dbl> <chr>
##  1 Spain           female     0 Autocorrelated
##  2 Spain           female    65 Autocorrelated
##  3 France          female     0 Autocorrelated
##  4 France          female    65 Autocorrelated
##  5 Italy           female     0 Autocorrelated
##  6 Italy           female    65 Autocorrelated
##  7 Netherlands     female     0 Autocorrelated
##  8 Netherlands     female    65 Autocorrelated
##  9 England & Wales female     0 Autocorrelated
## 10 England & Wales female    65 Autocorrelated
## # ... with 18 more rows
```

The Autocorrelated specification (ARIMA(1,1,0)) is preferred to RWD (ARIMA(0,1,0)) for all populations. The following extracts the autocorrelation coefficients and visualises them.

```
get_ar_term_and_se <- function(mdl){
  tibble(
    ar = pluck(mdl, "coef"),
    ar_coef = pluck(mdl, "var.coef")[1,1] %>% sqrt()
  )
}

ts_model_comparisons %>%
  mutate(mdl_terms = map(arima_110, get_ar_term_and_se)) %>%
  select(x, sex, country, mdl_terms) %>%
  unnest_wider(mdl_terms) %>%
  arrange(ar) %>%
  ggplot(aes(ar, fct_reorder(country, ar))) +
  geom_point() +
  facet_grid(x ~ sex) +
  geom_vline(xintercept = 0) +
  labs(x = "Autoregressive coefficient term", y = "Country",
       title ="Autoregressive coefficient term by country, starting age, and sex")
```



The majority of these coefficients are positive, indicating 'stickiness' in the values in the series, rather than oscillation. The exception is for females for conditional life expectancy at age 65, where the coefficients are negative for England & Wales, France, Scotland, Italy, and Spain. This suggests that for older females the life expectancy series tends to 'oscillate' rather than 'stick'.

Alternative approach to establishing if series are autocorrelated

An alternative way to determing whether the series are autocorrelated is to compare two linear regression equations: one in which change in life expectancy is regressed against an intercept; another in which the change in life expectancy is additionally regressed against the change in the previous year

```
alt_approach_autocorrelated <-
  hmd_ex_selected_countries_with_synth %>%
      filter(year >= 1979) %>%
      filter(!(code %in% c("DEUTE", "DEUTW", "DEUTNP"))) %>%  # Using only synthetic germany for longer
      group_by(code, x, sex) %>%
      arrange(year) %>%
      mutate(delta_ex = ex - lag(ex)) %>%
      nest() %>%
      mutate(
        rwd_model = map(data, ~lm(delta_ex ~ 1, data = . )),
        ar_model  = map(data, ~lm(delta_ex ~ lag(delta_ex), data = .))
      ) %>%
      mutate(
        bic_rwd = map_dbl(rwd_model, BIC),
        bic_ar  = map_dbl(ar_model, BIC)
      ) %>%
      mutate(
        diff_bic = bic_ar - bic_rwd
      ) %>%
    mutate(
      which_preferred = ifelse(diff_bic < 0, "Autocorrelated", "RWD")
    ) %>%
      left_join(country_code_lookup) %>%
      mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "
    filter(!is.na(country))
```

```
## Joining, by = "code"
```

```
alt_approach_autocorrelated %>%
  select(country, x, sex, bic_rwd, bic_ar, which_preferred)
```

```
## Adding missing grouping variables: `code`
```

```
## # A tibble: 28 x 7
## # Groups:   code, x, sex [28]
##    code    country             x sex    bic_rwd bic_ar which_preferred
##    <chr>   <fct>           <dbl> <chr>    <dbl>  <dbl> <chr>
##  1 ESP     Spain               0 female    1.99  -7.45 Autocorrelated
##  2 ESP     Spain              65 female   -5.81 -15.4  Autocorrelated
##  3 FRATNP  France              0 female   -2.08  -4.67 Autocorrelated
##  4 FRATNP  France             65 female   -4.73 -10.4  Autocorrelated
##  5 ITA     Italy               0 female   13.4    2.80 Autocorrelated
##  6 ITA     Italy              65 female    6.71  -7.93 Autocorrelated
##  7 NLD     Netherlands         0 female  -15.4  -11.8  RWD
##  8 NLD     Netherlands        65 female  -33.1  -29.5  RWD
##  9 GBRTENW England & Wales     0 female   -8.97 -12.8  Autocorrelated
## 10 GBRTENW England & Wales    65 female  -13.9  -18.8  Autocorrelated
## # ... with 18 more rows
```

This approach also identifies most, but not all, of the populations to exhibit some degree of autocorrelation. (n.b. the more stringent BIC was used instead of AICc in this example, which may explain discrepancies

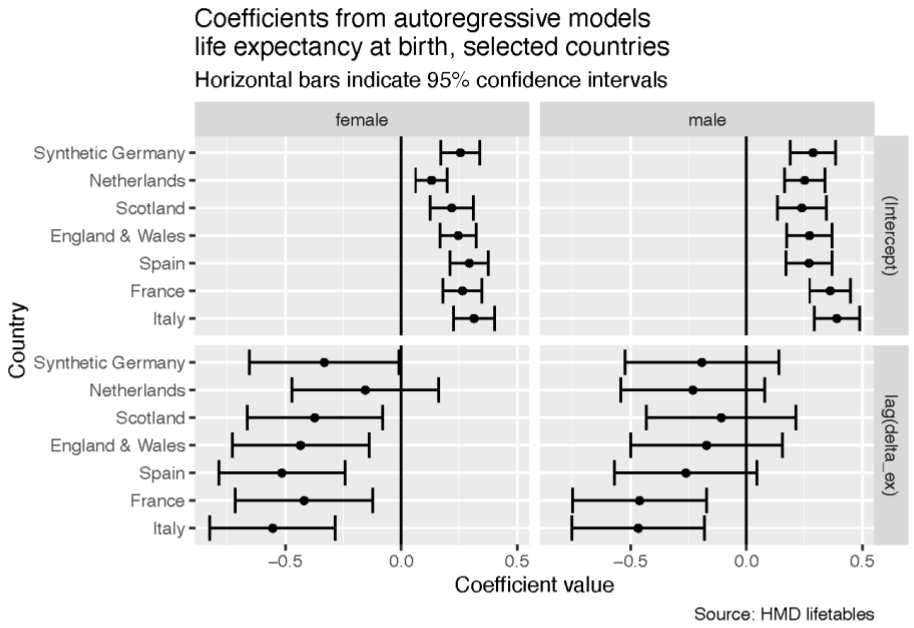
between approaches)

For each of the above, the intercept (average improvement per year) and autocorrelation term can be extracted as follows:

```
alt_approach_autocorrelated  %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  select(country, x, sex, ar_model) %>%
  mutate(tidied_model = map(ar_model, broom::tidy)) %>%
  select(-ar_model) %>%
  filter(x == 0) %>%
  unnest(tidied_model) %>%
  ggplot(aes(estimate, reorder(country, estimate))) +
  geom_point() +
  facet_grid(term~sex) +
  geom_vline(xintercept = 0) +
  geom_errorbarh(aes(xmin = estimate - 1.96  * std.error, xmax = estimate + 1.96 * std.error))  +
  labs(
    x = "Coefficient value",
    y = "Country",
    title = "Coefficients from autoregressive models\nlife expectancy at birth, selected countries",
    subtitle = "Horizontal bars indicate 95% confidence intervals",
    caption = "Source: HMD lifetables"

  )
```

```
## Joining, by = c("code", "country")
## Adding missing grouping variables: `code`
```



Here all autoregression coefficients are negative, most of which are statistically significant at $p < 0.05$.

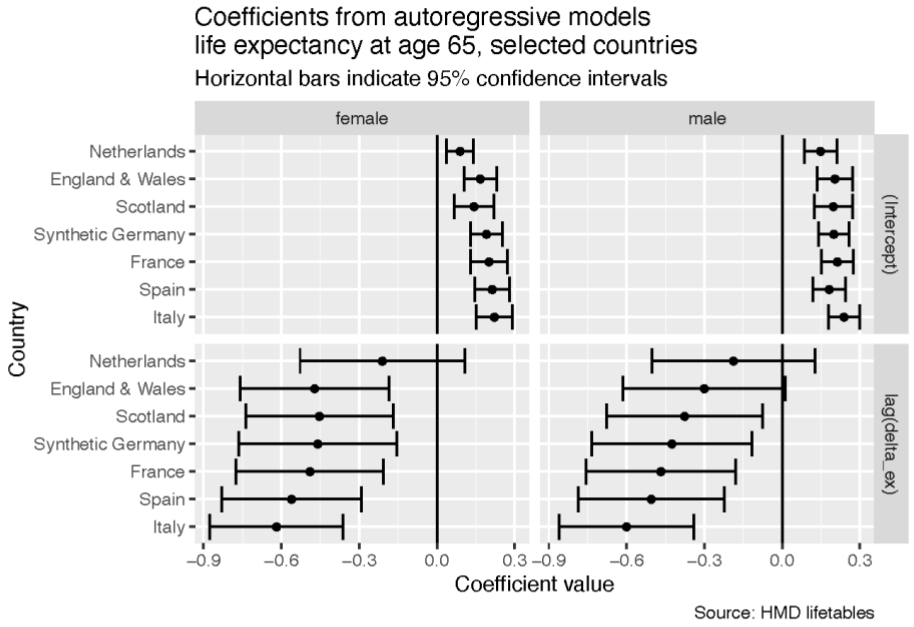
The following shows the equivalent trends for $x = 65$

```
alt_approach_autocorrelated  %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  select(country, x, sex, ar_model) %>%
  mutate(tidied_model = map(ar_model, broom::tidy)) %>%
  select(-ar_model) %>%
  filter(x == 65) %>%
  unnest(tidied_model) %>%
  ggplot(aes(estimate, reorder(country, estimate))) +
  geom_point() +
  facet_grid(term~sex) +
  geom_vline(xintercept = 0) +
  geom_errorbarh(aes(xmin = estimate - 1.96  * std.error, xmax = estimate + 1.96 * std.error))  +
  labs(
    x = "Coefficient value",
    y = "Country",
    title = "Coefficients from autoregressive models\nlife expectancy at age 65, selected countries",
    subtitle = "Horizontal bars indicate 95% confidence intervals",
    caption = "Source: HMD lifetables"

  )
```

```
## Joining, by = c("code", "country")
```

```
## Adding missing grouping variables: `code`
```



Here the negative correlations appear even stronger, and of larger magnitude in Italy than elsewhere. It also appears that the two coefficients are negatively associated, with Netherlands having the lowest average annual improvement, but also the smallest (and non-significant) magnitude of negative autocorrelation; Italy appears the converse.

Comparing a wider range of ARIMA models

The `auto.arima` function in the `fable` package allows a larger range of ARIMA-type models to be compared. The following code applies this function to each of the populations.

```
tmp <-
series_of_interest %>%
  as_tsibble(key = c(sex, x, country), index = year) %>%
  model(arima = ARIMA(ex ~ pdq(0:3, 1, 0:3))) %>%
  report() %>%
  select(sex, x, country, ar_roots, ma_roots ) %>%
  arrange(country, x, sex)
```

```
## Warning in report.mdl_df(.): Model reporting is only supported for individual
## models, so a glance will be shown. To see the report for a specific model, use
## `select()` and `filter()` to identify a single model.
```

```
tmp
```

```
## # A tibble: 28 x 5
##    sex        x country           ar_roots  ma_roots
##    <chr>  <dbl> <fct>             <list>    <list>
```

```
##  1 female     0 England & Wales   <cpl [1]> <cpl [0]>
##  2 male       0 England & Wales   <cpl [0]> <cpl [0]>
##  3 female    65 England & Wales   <cpl [1]> <cpl [0]>
##  4 male      65 England & Wales   <cpl [1]> <cpl [0]>
##  5 female     0 Scotland          <cpl [0]> <cpl [1]>
##  6 male       0 Scotland          <cpl [0]> <cpl [0]>
##  7 female    65 Scotland          <cpl [2]> <cpl [2]>
##  8 male      65 Scotland          <cpl [0]> <cpl [2]>
##  9 female     0 Synthetic Germany <cpl [1]> <cpl [0]>
## 10 male       0 Synthetic Germany <cpl [0]> <cpl [0]>
## # ... with 18 more rows
```

The length of the vectors ar_roots and ma_roots indicate, respectively, how many ar or ma terms were identified in the best fitting model for the population indicated by sex, x (starting age) and country. For example, for females in England & Wales, from age 0, an ARIMA(1,1,0) model is preferred, whereas for females in Scotland, from age 0, an ARIMA(0, 1, 1) model is preferred.

There are few populations for which the random-walk-with-drift (RWD) model is preferred to more complex models, but also not a single alternative model specification (such as ARIMA(1,1,0)) which is preferred for the majority of populations.

Changepoint Approach

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2022-07-22

Aim

The aim of this appendix is to present results for an alternative method of attempting to detect discontinuities in the series of life expectancy changes for different countries. The main approach used was segmented regression using the `segmented` package. The segmented regressions were fit to the data itself y t. This alternative approach instead involves fitting data to the first differences $y(t) - y(t-1)$ t.

The alternative approach identified some similar breakpoints/changepoints to the main, segmented approach. However it differed for many populations in identifying adjacent or near-adjacent changepoints in the data. Further inspection of these pairs of changepoints indicated that the approach developed inadvertently operated as a form of outlier detector algorithm, removing from the series extreme values. Though extreme values are a genuine phenomenon within mortality change data, they were not the primary purpose of the analysis, and so this approach was not used within the main manuscript.

Description of approach

- We first fit a 'null' (no change) model to the data. These are models that represent the assumption that no change occurred in trends in life expectancy over time.
- Then we fit a series on one-break models to the data. These are models that represent the assumption that a single significant change occurred to the series over time. From this series of one-break models, we attempt to find the best one-break model.
- We then fit a series of two-break models to the data. These are models that represent the assumption that were were two significant changes to the series over time. From this series of two-break models, we attempt to find the best two-break models.
- We now have three models to compare: the null model (M_0), the best one-break model (M_1), and the best two-break model (M_2). Although both M_1 can be compared directly[1] with M_0, and M_2 can be compared directly with M_0, M_2 cannot necessarily be compared directly with M_1. Instead, the triplet of models (M_0, M_1 and M_2) are compared indirectly using BIC[2]. BIC stands for Bayesian Information Criterion, like the similar AIC (An Information Criterion or Akaike's Information Criterion), is a penalised model fit score. By penalised this means that the fit of the model to the data (more specifically its log likelihood) is calculated, then a 'penalty' is applied to this score based on the complexity of the model. BIC and AIC differ only according to how the penalty is applied, with BIC tending to penalise more complex models more severely than AIC. This means BIC will tend to be more conservative in selecting models, providing some protection against overfitting. Both AIC and BIC can be used to compare both nested and non-nested models based on the same dataset, unlike the F-test, the Lagrange Multiplier Test, and so on. Measures of model fit should *not* be used to compare models fit to different datasets.[2], which like AIC provides a penalised model fit score. Lower BIC scores

[1] By 'compared directly', we mean that one model specification can be expressed as a restricted/constrained version of another model, the unrestricted model, with one or more terms in the unrestricted model set to fixed values, usually zero, in the restricted model. Such models can be compared directly using an F-test

[2] For example, it would be wrong to conclude that a model with an R^2 or adjusted R^2 fit to one dataset of 0.80 is 'better' than a model with an R^2 or adjusted R^2 of 0.50 fit to a different dataset, even though R^2 and its variants are often (mis)interpreted in this way

indicate better fit to the data, and so, for each dataset, the model (M_0, M_1 or M_2) with the lowest BIC will be selected.
- For the best of the three models for each dataset, the breakpoint or breakpoints (if any), and the model predictions, will be presented and visualised.

Breaks in the data are estimated by fitting the following model specifications:

- M_0: $\frac{de_x}{dt} \sim \alpha$
- M_1: $\frac{de_x}{dt} \sim \alpha + \beta T$, where

$$T = \begin{cases} 1 & \text{if} \quad t \geq \tau \\ 0 & \text{otherwise} \end{cases}$$

- M_2: $\frac{de_x}{dt} \sim \alpha + \beta_1 T_1 + \beta_2 T_2$, where

$$T_1 = \begin{cases} 1 & \text{if } \tau_1 \leq t < \tau_2 \\ 0 & \text{otherwise} \end{cases}$$

and

$$T_2 = \begin{cases} 1 & \text{if } t \geq \tau_2 \\ 0 & \text{otherwise} \end{cases}$$

i.e. the selection of τ_1 and τ_2 partitions the model into three sections: $\frac{de_x}{dt} \sim \alpha$ where $t < \tau_1$, $\frac{de_x}{dt} \sim \alpha + \beta_1$ where $\tau_1 \leq t < \tau_2$, and $\frac{de_x}{dt} \sim \alpha + \beta_2$ where $t \geq \tau_2$. As $\tau_1 < \tau_2$, only values of τ_2 which are greater than τ_1 are considered. Otherwise all whole integer values of τ are seached through for both M_1 and M_2.

The above analyses are performed for each population group, comprising different combinations of country, sex, and starting age.

Extracting relevant data

```
# load packages

library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.6     v purrr   0.3.4
## v tibble  3.1.7     v dplyr   1.0.9
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
# load data
hmd_lt <- read_rds("https://github.com/JonMinton/change-in-ex/blob/main/data/lifetables.rds?raw=true")


# Labels for codes
country_code_lookup <-
  tribble(
    ~code, ~country,
```

```
    "DEUTNP", "Germany",
    "DEUTE", "East Germany",
    "DEUTW", "West Germany",
    "ESP", "Spain",
    "FRATNP", "France",
    "ITA", "Italy",
    "GBRTENW", "England & Wales",
    "GBR_SCO", "Scotland",
    "DEUTSYNTH", "Synthetic Germany",
    "NLD", "Netherlands"
  )

countries_of_interest <- c(
  "GBRTENW",
  "GBR_SCO",
  "GBR_UK",
  "FRATNP",
  "ESP",
  "ITA",
  "DEUTNP",
  "DEUTE",
  "DEUTW",
  "NLD"
)

source("https://raw.githubusercontent.com/JonMinton/change-in-ex/main/R/make_synthetic_germany_functions

source("https://raw.githubusercontent.com/JonMinton/change-in-ex/main/R/make_pop_selection.R")


change_in_ex_selected_countries <-
  hmd_ex_selected_countries_with_synth %>%
    group_by(code, x, sex) %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    ungroup()
```

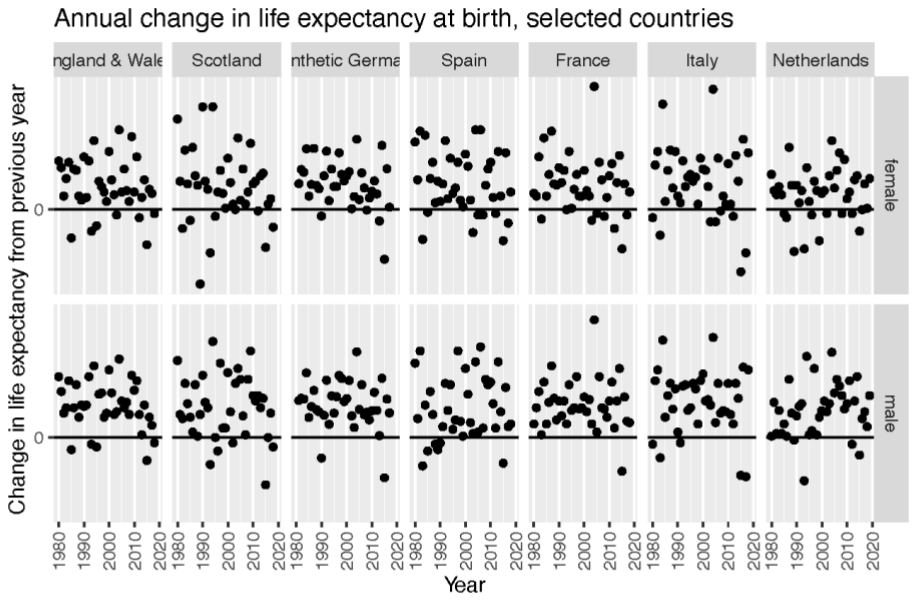
Visualise

```
change_in_ex_selected_countries %>%
  filter(x == 0) %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  ggplot(aes(x = year, y = delta_ex)) +
  geom_point() +
  facet_grid(sex~country) +
  geom_hline(yintercept = 0) +
  scale_y_continuous(breaks = seq(-30, 50, by = 10)) +
  theme(
        axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)
  ) +
  labs(
```

```
    x = "Year",
    y = "Change in life expectancy from previous year",
    title = "Annual change in life expectancy at birth, selected countries",
    caption =  "Source: Human Mortality Database. Synthetic Germany based on 20% East/80% West German p
  )
```

```
## Joining, by = "code"
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



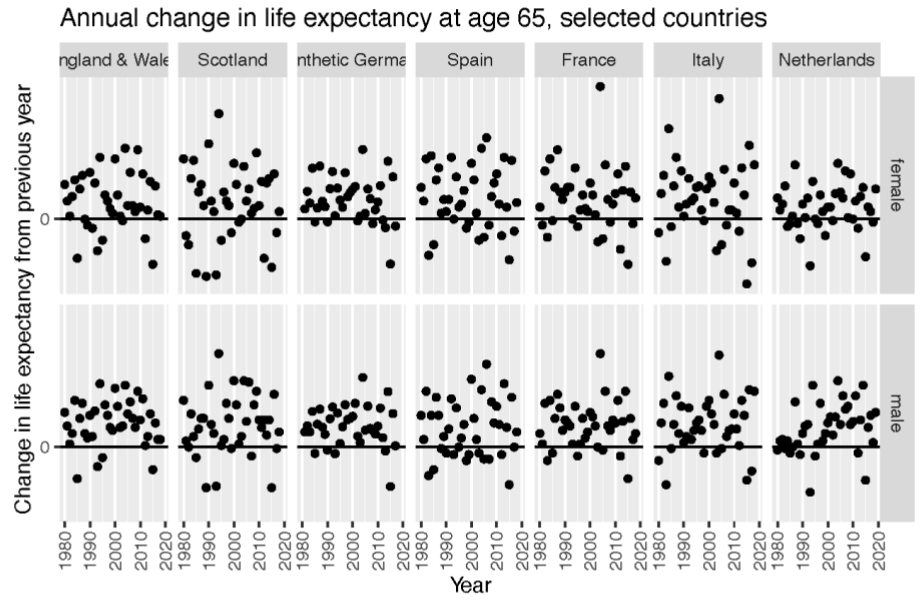
ce: Human Mortality Database. Synthetic Germany based on 20% East/80% West German population weighting

```
change_in_ex_selected_countries %>%
  filter(x == 65) %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  ggplot(aes(x = year, y = delta_ex)) +
  geom_point() +
  facet_grid(sex~country) +
  geom_hline(yintercept = 0) +
  scale_y_continuous(breaks = seq(-30, 50, by = 10)) +
  theme(
        axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1)
  ) +
  labs(
    x = "Year",
    y = "Change in life expectancy from previous year",
```

```
    title = "Annual change in life expectancy at age 65, selected countries",
    caption =  "Source: Human Mortality Database. Synthetic Germany based on 20% East/80% West German p
  )
```

```
## Joining, by = "code"
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



ce: Human Mortality Database. Synthetic Germany based on 20% East/80% West German population weighting

Functions

The following are functions used to try to identify the best possible breakpoint/changepoint years

```
# Breakpoint functions

run_alt_with_given_tau <- function(tau, df){
  df <-
    df %>%
    filter(!is.na(delta_ex)) %>%
    mutate(
      T_param = ifelse(year < tau, FALSE, TRUE)
    )

  lm(delta_ex ~ T_param, data  = df)
}
```

```r
# This function was not used in the end. The reason is because the fitness landscape is
# difficult to navigate. Instead a gridsearch approach was used

get_best_tau_from_optim <- function(df, buffer = 2, what = c("tau", "optim")){
  # We can put in some data validation checks too

  what <- match.arg(what)

  years <- df$year
  tau_lower <- min(years) + buffer # the lower bound
  tau_upper <- max(years) - buffer # the upper bound
  tau_start <- (tau_upper + tau_lower) / 2 # start just in the middle
  # (This shouldn't matter if the algorithm is robust)

  get_result_from_model <- function(par, df, what = c("AIC", "BIC", "model")){
    # Again, can carry out more validation checks
    what <- match.arg(what)

    tau <- par[["tau"]] # This is how parameters are packed up by optim
    model <-
      df %>%
      arrange(year) %>%
      mutate(delta_ex = ex - lag(ex)) %>%
      filter(!is.na(delta_ex)) %>%
      mutate(T_param = ifelse(year < tau, FALSE, TRUE)) %>%
      lm(delta_ex ~ T_param, data = .)
    if (what == "model") {return(model)      }
    if (what == "BIC")   {return(BIC(model)) }
    if (what == "AIC")   {return(AIC(model)) }

    # NULL should never be returned! If it has something's gone wrong!
    NULL
  }

  optim_obj <-
    optim(
      par = list(tau = tau_start),
      fn = get_result_from_model,
      method = "L-BFGS-B",
      lower = tau_lower,
      upper = tau_upper,
      df = df
    )
  # Need to make the result dependent on the what argument

  if (what == "tau") {return(optim_obj[["par"]])}
  else if (what == "optim"){ return(optim_obj) }

  # Again, the following should never be triggered
  NULL
}
```

```r
# This is the function actually used, for a single changepoint value

get_best_tau_from_gridsearch <- function(df, buffer = 2, what = c("best", "all")){
  # We can put in some data validation checks too

  what <- match.arg(what)

  years <- df$year
  tau_lower <- min(years) + buffer # the lower bound
  tau_upper <- max(years) - buffer # the upper bound
  tau_searchrange <- tau_lower:tau_upper
  get_result_from_model <- function(tau, df, what = c("BIC", "AIC", "model")){ #I've changed the order
    # Again, can carry out more validation checks
    what <- match.arg(what)

    model <-
      df %>%
      arrange(year) %>%
      mutate(delta_ex = ex - lag(ex)) %>%
      filter(!is.na(delta_ex)) %>%
      mutate(T_param = ifelse(year < tau, FALSE, TRUE)) %>%
      lm(delta_ex ~ T_param, data = .)
    if (what == "model") {return(model)      }
    if (what == "BIC")   {return(BIC(model)) }
    if (what == "AIC")   {return(AIC(model)) }

    # NULL should never be returned! If it has something's gone wrong!
    NULL
  }

  search_df <- tibble(
    tau = tau_searchrange
  ) %>%
    mutate(bic = map_dbl(tau, get_result_from_model, df = df))

  if (what == "all") {return(search_df)}

  if (what == "best") {
    out <-
      search_df %>%
      filter(bic == min(bic)) %>%
      select(tau, bic)
    return(out) # I've changed this to compare both tau and bic more easily with 2 cp models
  }
  # Again, the following should never be triggered
  NULL
}

# This is a modification of get_best_tau_from_gridsearch, for two taus
get_best_taus_from_gridsearch <- function(df, buffer = 2, what = c("best", "all")){
  # We can put in some data validation checks too

  what <- match.arg(what)
```

```r
years <- df$year
tau_lower <- min(years) + buffer # the lower bound
tau_upper <- max(years) - buffer # the upper bound

# Now need to list the permutations of taus to consider

tau_grid <- expand_grid(
  tau1 = tau_lower:tau_upper,
  tau2 = tau_lower:tau_upper
) %>%
  filter(tau2 > tau1) # tau2 should be greater than tau1

get_result_from_model <- function(tau1, tau2, df, what = c("BIC", "AIC", "model")){ #I've changed the
  # Again, can carry out more validation checks
  what <- match.arg(what)


  model <-
    df %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    filter(!is.na(delta_ex)) %>%
    mutate(T_param = ifelse(
      year < tau1,
      "bp0",
      ifelse(
        year < tau2, "bp1", "bp2"
        )
      )
    ) %>%
    lm(delta_ex ~ T_param, data = .)
  if (what == "model") {return(model)      }
  if (what == "BIC")   {return(BIC(model)) }
  if (what == "AIC")   {return(AIC(model)) }

  # NULL should never be returned! If it has something's gone wrong!
  NULL
}

search_df <- tau_grid %>%
  mutate(bic = map2_dbl(tau1, tau2, get_result_from_model, df = df))

if (what == "all") {return(search_df)}

if (what == "best") {
  out <-
    search_df %>%
    filter(bic == min(bic)) %>%
    select(bic, tau1, tau2)
  return(out)
}
# Again, the following should never be triggered
NULL
```

```
}
```

Running the functions

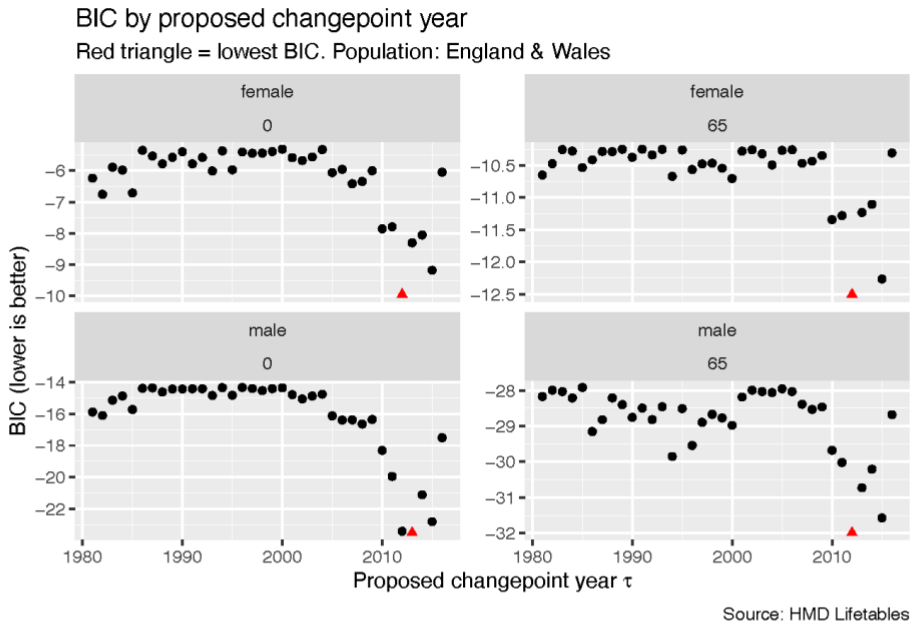
Single changepoint

The following calculates the best single breakpoint model for each population

```
changepoint_breakpoint_models <-
  hmd_ex_selected_countries_with_synth %>%
  filter(code != "DEUTNP") %>%
  filter(year >= 1979) %>%
  group_by(code, x, sex) %>%
  nest() %>%
  mutate(
    mdl_outputs = map(data, get_best_tau_from_gridsearch, what = "all")
  )
```

The relationship between proposed `tau` (i.e. changepoint year) and BIC is shown for England & Wales below

```
changepoint_breakpoint_models %>%
  filter(code == "GBRTENW") %>%
  unnest(mdl_outputs) %>%
  group_by(x, sex) %>%
  mutate(min_bic = bic == min(bic)) %>%
  ungroup() %>%
  ggplot(aes(tau, bic, colour = min_bic, shape = min_bic)) +
  geom_point() +
  facet_wrap(~ sex + x, scales = "free_y") +
  scale_colour_manual(values = c(`TRUE` = 'red', `FALSE` = "black")) +
  scale_shape_manual(values = c(`TRUE` = 'triangle', `FALSE` = 'circle')) +
  labs(
    title = "BIC by proposed changepoint year",
    subtitle = "Red triangle = lowest BIC. Population: England & Wales",
    x = expression(paste("Proposed changepoint year ", tau)),
    y = "BIC (lower is better)",
    caption = "Source: HMD Lifetables"
  ) +
  theme(legend.position = "none")
```



We can see here that 2012 is consistently identified as having the lowest BIC for each of the four subpopulations, except for males where x = 0, where 2013 is identified instead. We can also see that the 'fitness landscape' (i.e. how BIC changes as the proposed changepoing years change) is quite uneven, and so simple numerical optimisation algorithms like Newton-Ralphson are likely to get 'stuck' at local rather than the global optima, and so the results of such algorithms may be quite dependent on starting parameters.

For two changepoints

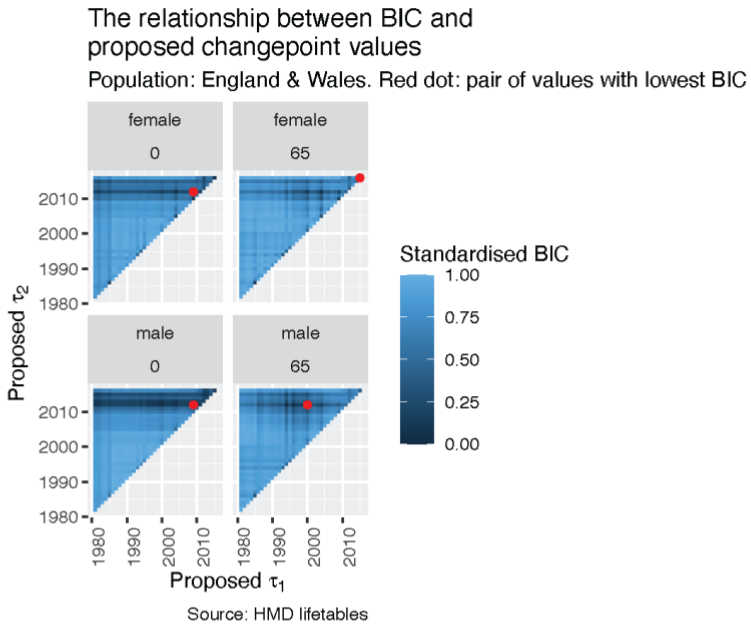
The following code identifies the best two changepoint model for each population

```
changepoint_breakpoints_models <-
  hmd_ex_selected_countries_with_synth %>%
  filter(code != "DEUTNP") %>%
  filter(year >= 1979) %>%
  group_by(code, x, sex) %>%
  nest() %>%
  mutate(
    mdl_outputs = map(data, get_best_taus_from_gridsearch, what = "all")
  )
```

Whereas for a single changepoint the relationship between BIC and proposed τ can be visualised as a scatterplot, for two values τ_1 and τ_2 they can be visualised as a heatmap instead. Our only known constraint is that $\tau_2 > \tau_1$, meaning within the heatmap only a triangle rather than rectangle of candidate values needs to be considered.

The following shows this heatmap for England & Wales. A red dot is added to indicate the pair of candidate values $\{\tau_1, \tau_2\}$ with the lowest BIC. As the range of BIC differs with each dataset, the values are normalised for each subpopulations such that the highest value is 1 and the lowest 0.

```
changepoint_breakpoints_models %>%
  filter(code == "GBRTENW") %>%
  unnest(mdl_outputs) %>%
  group_by(x, sex) %>%
  mutate(bic_std = (bic - min(bic)) / (max(bic) - min(bic))) %>%
  ggplot(aes(x = tau1, y = tau2, colour = bic_std, fill = bic_std)) +
  geom_raster() +
  facet_wrap(~ sex + x, ncol = 2) +
  scale_color_viridis_c() +
  geom_point(colour= 'red',
             data = changepoint_breakpoints_models %>%
              filter(code == "GBRTENW") %>%
              unnest(mdl_outputs) %>%
              group_by(x, sex) %>%
              mutate(bic_std = (bic - min(bic)) / (max(bic) - min(bic))) %>%
              filter(bic_std == min(bic_std))
  ) +
  coord_fixed() +
  theme(axis.text.x = element_text(angle = 90)) +
  labs(
    x = expression(paste("Proposed ", tau[1])),
    y = expression(paste("Proposed ", tau[2])),
    fill = "Standardised BIC",
    title = "The relationship between BIC and\nproposed changepoint values",
    subtitle = "Population: England & Wales. Red dot: pair of values with lowest BIC",
    caption = "Source: HMD lifetables"
  )
```

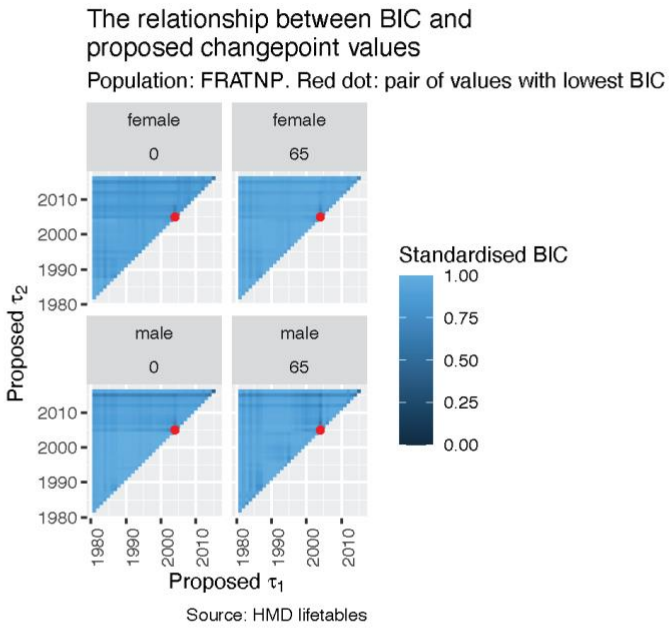


We can see in the above that, for males for x = 65, a $\{\tau_1, \tau_2\}$ pairing of {2000, 2012} has been identified. For males and females where x = 0, a near-contiguous pairing of {2009, 2012} has been identified. And for females where x = 65 a contigious pairing of {2015, 2016} had the lowest BIC.

Similar identification of contiguous and near-contiguous pairings were also identified for many other countries. For example, the following shows this for France.

```
changepoint_breakpoints_models %>%
  filter(code == "FRATNP") %>%
  unnest(mdl_outputs) %>%
  group_by(x, sex) %>%
  mutate(bic_std = (bic - min(bic)) / (max(bic) - min(bic))) %>%
  ggplot(aes(x = tau1, y = tau2, colour = bic_std, fill = bic_std)) +
  geom_raster() +
  facet_wrap(~ sex + x, ncol = 2) +
  scale_color_viridis_c() +
  geom_point(colour= 'red',
             data = changepoint_breakpoints_models %>%
              filter(code == "FRATNP") %>%
              unnest(mdl_outputs) %>%
              group_by(x, sex) %>%
              mutate(bic_std = (bic - min(bic)) / (max(bic) - min(bic))) %>%
              filter(bic_std == min(bic_std))
  ) +
  coord_fixed() +
  theme(axis.text.x = element_text(angle = 90)) +
  labs(
```

```
    x = expression(paste("Proposed ", tau[1])),
    y = expression(paste("Proposed ", tau[2])),
    fill = "Standardised BIC",
    title = "The relationship between BIC and\nproposed changepoint values",
    subtitle = "Population: FRATNP. Red dot: pair of values with lowest BIC",
    caption = "Source: HMD lifetables"
  )
```

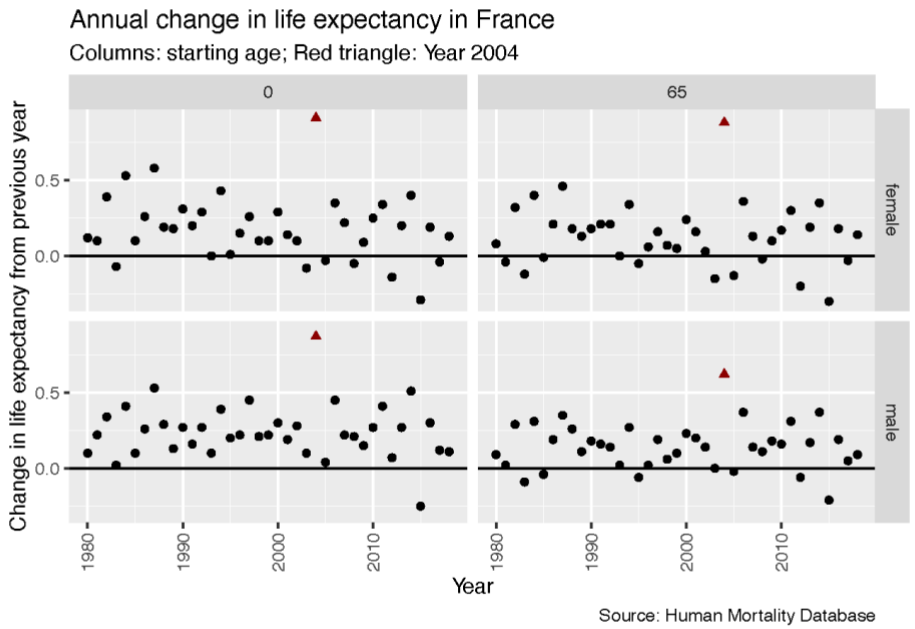


For France, for all four subpopulations, a pairing of {2004, 2005} was identified. If we look at the series for France, we can see why this pair of years may have been identified

```
change_in_ex_selected_countries %>%
  filter(code == "FRATNP") %>%
  filter(year >= 1979) %>%
  left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("France"))) %>%
  filter(!is.na(country)) %>%
  filter(between(year, 1980, 2020)) %>%
  mutate(is_2004 = year == 2004) %>%
  ggplot(aes(x = year, y = delta_ex)) +
  geom_point(aes(shape = is_2004, colour = is_2004)) +
  facet_grid(sex ~ x) +
  scale_shape_manual(values =c(`TRUE` = "triangle", `FALSE` = "circle")) +
  scale_colour_manual(values =c(`TRUE` = "darkred", `FALSE` = "black")) +
  geom_hline(yintercept = 0) +
  theme(
```

```
      axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1),
      legend.position = 'none'
  ) +
  labs(
    x = "Year",
    y = "Change in life expectancy from previous year",
    title = "Annual change in life expectancy in France",
    subtitle = "Columns: starting age; Red triangle: Year 2004",
    caption =  "Source: Human Mortality Database"
  )
```

```
## Joining, by = "code"
```



We can see that for each of this subpopulation, year = 2004 (i.e. the change in ex from 2003 to 2004) was much higher than all other years, and so these points are outliers. So, it appears the changepoint approach has inadertently 'detected' this outlier.

Best model for each population

The following code shows the best performing model, from the best zero, one and two changepoint models, for each of the populations.

```
estimate_null <- function(df){
  df %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
```

```
    filter(!is.na(delta_ex)) %>%
    lm(delta_ex ~ 1, data = .)
}

  hmd_ex_selected_countries_with_synth %>%
    filter(code != "DEUTNP") %>%
    filter(year >= 1979) %>%
    group_by(code, x, sex) %>%
    nest() %>%
    mutate(
      mdl_0 = map(data, estimate_null),
      bic_0    = map_dbl(mdl_0, BIC)
    ) %>%
    select(code, x, sex, mdl_0, bic_0) %>%
    left_join(
      changepoint_breakpoint_models %>%
        unnest(mdl_outputs) %>%
        group_by(code, x, sex) %>%
        filter(bic == min(bic)) %>%
        select(code, x, sex, tau1 = tau, bic_1 = bic)
    ) %>%
    left_join(
      changepoint_breakpoints_models %>%
        unnest(mdl_outputs) %>%
        group_by(code, x, sex) %>%
        filter(bic == min(bic)) %>%
        select(code, x, sex, tau1_2 = tau1, tau2_2 = tau2, bic_2 = bic)
    ) %>%
  select(-mdl_0) %>%
  ungroup() # %>%
```

```
## Joining, by = c("code", "x", "sex")
## Joining, by = c("code", "x", "sex")
```

```
## # A tibble: 36 x 9
##    code       x sex     bic_0  tau1  bic_1 tau1_2 tau2_2  bic_2
##    <chr>  <dbl> <chr>   <dbl> <int>  <dbl>  <int>  <int>  <dbl>
##  1 DEUTE      0 female   4.19  2005   3.67   1991   2002  -3.14
##  2 DEUTE     65 female -20.6   1987 -22.8    1987   2002 -26.9
##  3 DEUTW      0 female -16.0   1988 -17.1    1988   2015 -16.8
##  4 DEUTW     65 female -27.4   2015 -26.8    2004   2005 -27.5
##  5 ESP        0 female   1.99  1983   1.99   1983   1984   1.95
##  6 ESP       65 female  -5.81  2014  -3.32   1983   1984  -2.94
##  7 FRATNP     0 female  -2.08  2015  -1.97   2004   2005 -10.5
##  8 FRATNP    65 female  -4.73  2015  -3.05   2004   2005 -14.2
##  9 ITA        0 female  13.4   2005  14.3    2004   2005  10.7
## 10 ITA       65 female   6.71  2005   9.02   2004   2005   4.41
## # ... with 26 more rows
```

```
run_tau_1 <- function(tau, df){
  df %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    filter(!is.na(delta_ex)) %>%
    mutate(T_param = ifelse(year < tau, FALSE, TRUE)) %>%
```

```
    lm(delta_ex ~ T_param, data = .)
}

run_tau_2 <- function(tau1, tau2, df){
  df %>%
    arrange(year) %>%
    mutate(delta_ex = ex - lag(ex)) %>%
    filter(!is.na(delta_ex)) %>%
    mutate(T_param = ifelse(
      year < tau1,
      "bp0",
      ifelse(
        year < tau2, "bp1", "bp2"
        )
      )
    ) %>%
    lm(delta_ex ~ T_param, data = .)
}

make_path_coords <- function(df, taus = NULL, mdl){
  stopifnot(
    "wrong number of coefficients for the model type" =
    length(coefficients(mdl)) == length(taus) + 1
  )

  min_x = min(df$year)
  max_x = max(df$year)

  coeffs <- coefficients(mdl)

  y0 <- coeffs[1]

  out <- tribble(
    ~x, ~y,
    min_x, y0
  )

  if(length(coeffs) == 1){
    out <- out %>%
      bind_rows(
        tribble(
          ~x, ~y,
          max_x, y0
        )
      )
    return(out)

  } else if (length(coeffs) == 2){
    out <- out %>%
      bind_rows(
        tribble(
          ~x, ~y,
          taus[1], y0,
```

```
          taus[1], y0 + coeffs[2],
          max_x, y0 + coeffs[2]
        )
      )
    return(out)

  } else if (length(coeffs) == 3){
    out <- out %>%
      bind_rows(
        tribble(
          ~x, ~y,
          taus[1], y0,
          taus[1], y0 + coeffs[2],
          taus[2], y0 + coeffs[2],
          taus[2], y0 + coeffs[3],
          max_x, y0 + coeffs[3]

        )
      )

    return(out)
  }
  return(NULL) # should not be triggered
}

# Let's try this with 0cp

paths_0cp <-
  hmd_ex_selected_countries_with_synth %>%
    filter(code != "DEUTNP") %>%
    filter(year >= 1979) %>%
    group_by(code, x, sex) %>%
    nest() %>%
    mutate(
      mdl_0 = map(data, estimate_null)
    ) %>%
    mutate(bic = map_dbl(mdl_0, BIC)) %>%
    mutate(
      tau_paths = pmap(.l = list(df = data, mdl = mdl_0), make_path_coords)
    ) %>%
  select(code, x, sex, bic_0cp = bic, paths_0cp = tau_paths)

# Now 1cp
paths_1cp <-
  changepoint_breakpoint_models %>%
    unnest(mdl_outputs) %>%
    group_by(code, x, sex) %>%
    filter(bic == min(bic)) %>%
    ungroup() %>%
    mutate(
      mdl_with_best_1cp = map2(tau, data, run_tau_1)
    ) %>%
    mutate(
```

```
      tau_paths = pmap(
        .l = list(
          df = data,
          mdl = mdl_with_best_1cp,
          taus = c(tau)
        ),
        make_path_coords
      )
    ) %>%
    select(
      code, x, sex, bic_1cp = bic, paths_1cp = tau_paths
    )

# and now for 2cp
paths_2cp <-
  changepoint_breakpoints_models %>%
    unnest(mdl_outputs) %>%
    group_by(code, x, sex) %>%
    filter(bic == min(bic)) %>%
    ungroup() %>%
    mutate(mdl_with_best_2cp = pmap(.l = list(tau1=tau1, tau2=tau2, df=data), run_tau_2)) %>%
    mutate(taus = map2(tau1, tau2, c)) %>%
    mutate(
      tau_paths = pmap(
        .l = list(
          df = data,
          mdl = mdl_with_best_2cp,
          taus = taus
        ),
        make_path_coords
      )
    ) %>%
    select(code, x, sex, bic_2cp = bic, paths_2cp = tau_paths)

best_cp_paths <-
  reduce(list(paths_0cp, paths_1cp, paths_2cp), left_join) %>%
    rename(start_age = x) %>%
    pivot_longer(cols = starts_with(c("path", "bic")), names_to = c(".value", "path_type"), names_sep =
    group_by(code, start_age, sex) %>%
    mutate(
      bic_rank = as.character(rank(bic))
    ) %>%
    ungroup() %>%
    unnest(paths) %>%
    left_join(country_code_lookup) %>%
  mutate(country = factor(country, levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spai
  filter(!is.na(country)) %>%
  group_by(country, sex, start_age) %>%
  filter(bic_rank == 1)
```

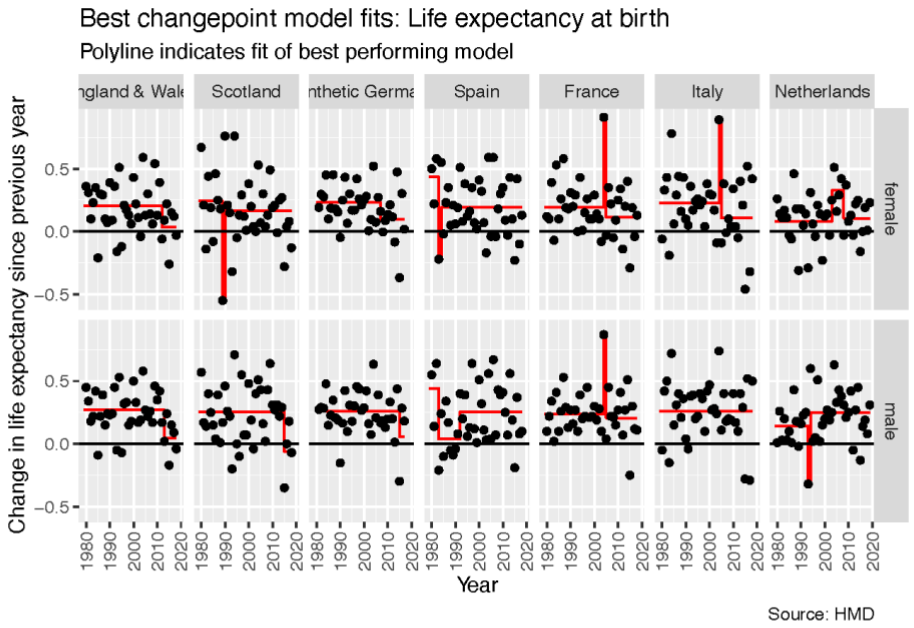
```
## Joining, by = c("code", "x", "sex")
## Joining, by = c("code", "x", "sex")
## Joining, by = "code"
```

The best changepoint model (if any), along with the points, are shown for life expectancy at birth below

```
best_cp_paths %>%
  filter(start_age == 0) %>%
  ggplot(aes(x, y)) +
  geom_path(colour = "red") +
  facet_grid(sex ~ country ) +
  expand_limits(y  = 0) +
  geom_hline(yintercept = 0) +
  theme(
      axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1),
      legend.position = 'none'
  ) +
  geom_point(
    aes(year, delta_ex),
    inherit.aes = FALSE,
    data = change_in_ex_selected_countries %>%
      filter(x == 0) %>%
      filter(year >= 1979) %>%
      left_join(country_code_lookup) %>%
      mutate(
        country = factor(
          country,
          levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spain", "France", "Italy", "N
          )
        ) %>%
        filter(!is.na(country))   %>%
        filter(between(year, 1980, 2020))
  ) +
  labs(
    x = "Year",
    y = "Change in life expectancy since previous year",
    title = "Best changepoint model fits: Life expectancy at birth",
    subtitle = "Polyline indicates fit of best performing model",
    caption = "Source: HMD"
  )
```

```
## Joining, by = "code"
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



We can see that the best-performing model is a two changepoing model with contiguous years for Scottish females, Spanish females, French females, Italian females, French males and Dutch males. For each of these models it is clear that the model in effect 'detected' an outlier of either exceptionally high annual change (France and Italy) or exceptionally low or negative annual change (Scottish males, Spanish females, Dutch males).

For England & Wales (both males and females) and for Scottish females, a single changepoint model was selected, with lower rates of annual life expectancy gain after around 2011 than before. For Scottish males this fell to negative values (declining rather than stalling mortality). A somewhat similar pattern is observed for Germany, but this appears to be less consistent in term and less severe than for England & Wales.

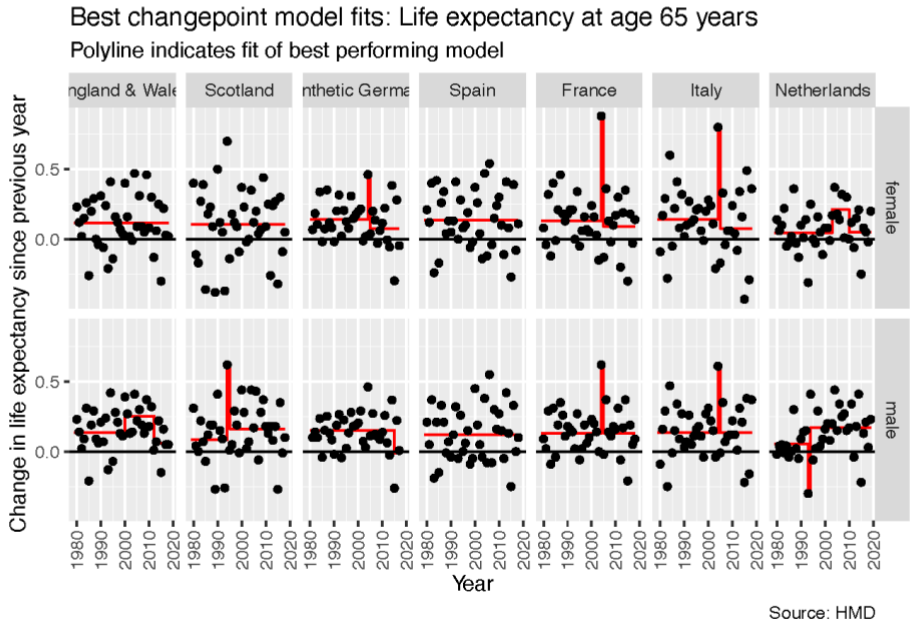
The equivalent graph for life expectancy from age 65 is shown below:

```
best_cp_paths %>%
  filter(start_age == 65) %>%
  ggplot(aes(x, y)) +
  geom_path(colour = "red") +
  facet_grid(sex ~ country ) +
  expand_limits(y  = 0) +
  geom_hline(yintercept = 0) +
  theme(
      axis.text.x = element_text(angle = 90, vjust = 0.5, hjust=1),
      legend.position = 'none'
  ) +
  geom_point(
    aes(year, delta_ex),
    inherit.aes = FALSE,
    data = change_in_ex_selected_countries %>%
```

```
    filter(x == 65) %>%
    filter(year >= 1979) %>%
    left_join(country_code_lookup) %>%
    mutate(
      country = factor(
        country,
        levels = c("England & Wales", "Scotland", "Synthetic Germany", "Spain", "France", "Italy", "N
        )
      ) %>%
      filter(!is.na(country))   %>%
      filter(between(year, 1980, 2020))
) +
labs(
  x = "Year",
  y = "Change in life expectancy since previous year",
  title = "Best changepoint model fits: Life expectancy at age 65 years",
  subtitle = "Polyline indicates fit of best performing model",
  caption = "Source: HMD"
)
```

```
## Joining, by = "code"
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```



For changes in conditional life expectancy from age 65 two changepoint models with contiguous years were identified for females in Germany, France and Italy; and for males in Scotland, France, Italy and the Netherlands.

Summary and conclusion

This appendix has show the implementation and results of applying an alternative method to identifying distinct changes in trends in life expectancy for the selected countries. In many cases, a two changepoint model was identified. However, often these two changepoint models involved contiguous years, and appear to in effect be operating as outlier detection algorithms, picking out exceptional years from the series.

Although the fact these individual years are outliers is important to note, as it illustrates how varied life expectancy change series can be when single years are used, these single years cannot, by definition, define or constitute a change in trend, which was the purpose of this exercise. It is for this reason that the segmented approach was used instead of this approach in the main paper.

The changepoint approach could be adapted to be less 'sensitive' to outlier years by narrowing the search space for τ_2 conditional on τ_1 so as to be two or more years later. (e.g. if τ_1 were 1990 then candidate values for τ_2 would start from 1992 instead of 1991.) However, the choice of how much to narrow down the search space in this way is somewhat arbitrary, so was not adapted further for this paper.

21 PAPER 5: WHEN EXPERTS DISAGREE

Appendix 1: Background material

Specific Aims and Objectives

- Explore contrasting views of public health experts on recent life expectancy trends in England and Wales.
- Identify causal factors for the changes in life expectancy seen
- Explore experts' understanding of the role of austerity
- Explore experts' views on the role of migration
- Investigate experts' opinion of the impact these factors may have had on the UK's COVID-19 response
- Identify areas for future research
- Provide recommendations for solutions, where a problem is identified

Data management

Data management follows the University of Oxford's remote working guidance in light of the COVID-19 pandemic.[1] Recordings of the interviews were downloaded to the University's IT network in a password-protected format. Recordings were transcribed into the same folder. Consent forms and recordings will be stored securely for 3 years on university servers before being destroyed.

Additional materials

Participant information sheet and written consent form are below (Figures 1 and 2).

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UNIVERSITY OF OXFORD

Health outcomes in the UK 2010-2020: Interviews with public health experts

PARTICIPANT INFORMATION SHEET

Central University Research Ethics Committee Approval Reference: [SOGE 1A2020-205]

1. Introductory paragraph

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

2. Why is this research being conducted?

According to the Office for National Statistics (ONS), trends in improvements in life expectancy at birth in England and Wales have stalled in recent years. However, the underlying drivers of this are widely disputed, as indeed is the evidence for the slowdown in improvements at all.

This research aims to hear from a wide range of experts in this field in order to collate views on the slowdown in life expectancy improvements, underlying causes, and possible solutions, if a problem is perceived. Interviews will be conducted with participants over Microsoft Teams, and analysed using thematic analysis with intention to publish the results.

Participants will be approached directly for interview who have expertise in this area and, in particular, who hold different or opposing views.

The purpose of this is to explore a wider range of explanations, provide a summary of contrasting and varying views, and to prompt further research in areas identified.

The results will be anonymised and quotations not attributable to any individual.

3. Why have I been invited to take part?

You have been invited to take part due to your expertise and work in the field of life expectancy in the United Kingdom.

4. Do I have to take part?

No. It is up to you to decide whether or not to take part. You can withdraw yourself from the study, without giving a reason, by advising me/ us of this decision. You can withdraw any information you have contributed to the research at any point after interview and any data collected from you by that point would then be deleted. However, any data used in published materials, or material submitted for publication, at that point would not be able to be altered.

Figure 1: Participant information sheet

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Dr Lucinda Hiam, DPhil student
Oxford University telephone number: +44 (0) 1865 285 070
Oxford University e-mail: Lucinda.hiam@kellogg.ox.ac.uk

UNIVERSITY OF OXFORD

Consent to take part in Health outcomes in the UK 2010-2020: Interviews with public health experts

Central University Research Ethics Committee (CUREC) approval reference: SOGE 1A2020-205

Purpose of Study: To explore experts' views on health outcomes in the UK, 2010-2020.

	Please initial each box if you agree with the statement
I confirm that I have read and understand the information sheet dated August 2021 for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
I understand that my participation is voluntary and that I am free to withdraw at any point, without giving any reason. I am aware that any published materials using my information cannot be altered.	☐
I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	☐
I understand the extent to which I could be that I will not be identifiable from any publications or other research outputs.	☐
I consent to being audio and video recorded.	☐
I understand how audio recordings will be used in research outputs.	☐
Use of quotations: Please indicate your preference (select *one* option): a) I do not wish to be quoted. **or** b) I agree to the use of quotations in research outputs if I am not identifiable.	☐
I give permission for you to contact me again to clarify information.	☐

Template written consent form, version 4.0, March 2021

Figure 2: Written consent form

Appendix 2: Participant details

Appendix Table 1: Type of institute and area of expertise of those interviewed

Expert	Institute	Area of expertise
E1	Academic and NHS	Public health
E2	NGO	Economist
E3	Academic	Economist
E4	Academic	Demography
E5	Academic and NHS	Public health
E6	Ex-civil service	Public health
E7	Academic	Public health
E8	Civil service	Statistician
E9	NGO	Economist
E10	Ex-civil service	Medical doctor
E11	Academic	Medical doctor
E12	NGO	Demography

Appendix Table 2: Type of institute and area of expertise of those approached for interview that did not respond

Institute	Area of expertise
Civil service and NHS	Health inequalities
Academic	Health inequalities
Academic	Demography
Academic	Medicine
Academic	Health inequalities
Academic	Health inequalities
Civil service	Public health
Demographer	Demography
NGO	Health inequalities

References

1. University of Oxford. Guidance for researchers working remotely with participant data 2020 [cited 2021 25 August]. Available from: https://researchsupport.admin.ox.ac.uk/covid-19/data#collapse2299901 accessed 25 August 2021.