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Population mortality impacts of the rising cost of living in Scotland: scenario modelling study

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ABSTRACT

Introduction To inform policymaking, it is important to understand the population health impacts of recent increased inflation, and of measures implemented to mitigate these.

Methods We used scenario modelling to estimate (a) how recent increased inflation would affect household incomes in Scotland, (b) how mitigation measures would modify these effects and (c) how mortality outcomes and inequalities in these would change as a result. Against a long-term average inflation scenario (baseline), we compared unmitigated recent inflation and inflation mitigated by UK Government support policies. We estimated differential price inflation by income quintile, based on the proportion of household spending on different goods and services. Using differential inflation rates, we estimated change in spending power (real income) for 2704 Scottish households in the 2015/16 Family Resources Survey, both with and without mitigating UK Government policies, and scaled these to the Scottish population. We estimated mortality effects using a cross-sectional relationship between household income and mortality, by deprivation quintile.

Results Unmitigated price inflation was 14.9% for the highest income quintile and 22.9% for the lowest. UK Government policies partially mitigated impacts of the rising cost of living on real incomes, although households in the most deprived areas of Scotland would still be £1400 per year worse off than at baseline. As a result, even with mitigating measures in place, premature mortality was estimated to increase by up to 6.4%, and life expectancy to decrease by up to 0.9%. Effects would be greater in more deprived areas, and health inequalities would increase as a result.

Conclusions Large and inequitable impacts on mortality in Scotland are predicted if real-terms income reductions are sustained. Progressive Cost of Living Support payments are not sufficient to offset the mortality impacts of the greater real income reductions in deprived areas.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Lower incomes are associated with increased mortality risk, hence the economy matters for public health.
⇒ The impacts of the rising cost of living and mitigating policies on mortality and inequalities require estimation to inform policymaking.

WHAT THIS STUDY ADDS

⇒ The mortality impacts of inflation and real-terms income reduction are likely to be large and negative, with marked inequalities in how these are experienced.
⇒ Implemented public policy responses are not sufficient to protect health and prevent widening inequalities.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Bolder and more progressive policy responses to the cost of living crisis are required if health is to improve and health inequalities are to narrow.

INTRODUCTION

In the UK and other countries, prices rose steeply during 2021 and 2022, following several years of low inflation.[1] Reasons for this increase include restrictions and disrupted supply of important goods including oil, gas and foods such as wheat and cooking oil because of the conflict in Ukraine.[2] This has a significant impact not least because modern economies depend on fossil fuels for food production and distribution.[3 4] Also, demand for goods and services has increased rapidly following the lifting of COVID-19 restrictions, putting pressure on suppliers to meet these increases.[2] In the UK, Brexit has also reduced the availability of labour to meet rising demand.[5] Despite labour shortages, wage growth has remained lower than the rises in prices.[1 2]

Inflation has not reached these levels in the UK since the 1970s. Changes in the economy since then, and recent trends in mortality, mean that the effects are likely to be different.[6] In Scotland, mortality inequalities have risen since the 1980s.[7] On aggregate, mortality rates were falling until 2012,

> **Box 1 UK Government Cost of Living Support package**
>
> In February and May 2022, the UK Government announced the following payments to help mitigate the cost of living crisis[14 15]:
> ⇒ £400 grant for all domestic energy customers.
> ⇒ £150 Council Tax rebate for households in bands A to D (the lowest four of eight house valuation bands), or those in receipt of Council Tax Reduction benefit.
> ⇒ £650 Cost of Living Payment to households in receipt of means-tested benefits.
> ⇒ £300 Pensioner Cost of Living Payment to pensioner households in receipt of Winter Fuel Allowance/Payment (payable to everyone of pensionable age).
> ⇒ £150 Disability Cost of Living Payment to recipients of disability-related benefits.
> Note: Household Support Fund monies were also provided to the Scottish Government to enable them to provide directed support as required. This amounted to £41 million for the period March–September 2022.[15]

but since then improvements have stalled.[8] This trend has been attributed largely to the austerity policies implemented over that time.[9] Mortality then increased during the COVID-19 pandemic, which also caused pressures on healthcare and other services, resulting in a substantial backlog of unmet needs.[9 10] These trends suggest the population may be less resilient to further shocks.

Rising inflation affects affordability of goods and services, particularly for low-income groups. For example, lower-income households spend a higher proportion of their expenditure on energy,[11] and so are disproportionately affected by rises in energy prices.[12] The UK Government has responded by introducing a range of policies to mitigate the rising cost of living: a universal Energy Price Guarantee (EPG)[13] and a series of more targeted Cost of Living Support payments (box 1).[14 15]

Income and income changes are key determinants of health.[16] Studies consistently show that low income is associated with poorer health,[17] and longitudinal studies have shown that falls in income have an adverse effect on health.[18–20] These impacts have differential effects on different populations. Rising inflation reduces a household's spending power, or real income, and so is likely to have significant effects on health and health inequalities.[21–23]

To inform policymaking, it is important to understand the population health impacts of unmitigated and mitigated inflation – that is, inflation without and with the mitigating policies described in box 1. We used scenario modelling to estimate the likely future impacts of recent levels of inflation on mortality in Scotland, both with and without the implemented mitigation measures.

METHODS
Study design
We modelled how wage inflation would affect nominal household income in Scotland in 2022/23 (with and without Cost of Living Support payments), and how

price inflation (with and without the EPG) would affect the spending power of that income. The analytical steps involved in estimating real income change under each of our four scenarios are illustrated in online supplemental figure 1. For each of these scenarios we estimated how the change in real income would affect premature mortality and life expectancy, by area deprivation quintile, compared with a 'business as usual' baseline scenario.

Change in nominal household incomes
First, we estimated how the income coming into Scottish households would change in 2022/23 under various assumptions. We used a tax-benefit microsimulation model (UKMOD)[24]: such models are used to answer 'what if' questions about how policy changes would affect the incomes of a representative sample of households. We used UKMOD to estimate nominal household income before housing costs for Scottish households in the 2015/16 Family Resources Survey (FRS; anonymised data; sample size 2704; response rate 56%).[25] Three alternative versions of 2022/23 (left-hand side of online supplemental figure 1) were modelled using UKMOD:
1. Average wage inflation for the preceding 10 years (2.6%).[26] This formed the basis of our subsequent 'baseline' scenario (ie, income unaffected by recent inflationary shocks).
2. Most recent wage inflation forecast for 2022/23 (5.1%).[27] This formed the basis of our subsequent 'unmitigated inflation' scenario.
3. Most recent wage inflation forecast for 2022/23 plus the UK Government's Cost of Living Support package (box 1, with the exception of the Household Support Fund, which could not be included because its direct impact on household incomes was not quantifiable). This formed the basis of our two subsequent 'mitigated' scenarios.

To enable comparison, household incomes were equivalised using the Organisation for Economic Co-operation and Development (OECD) modified equivalence scale. In this scale the reference is a couple with no children.

Differential change in price inflation
The spending power of nominal income – its value in real terms – is determined by price inflation, but price inflation is experienced differently across the population. During 2021 and 2022, prices for electricity and gas increased at a higher rate than those for other goods and services.[28] As poorer households spend a higher proportion of their total expenditure on electricity and gas (online supplemental table 1 and online supplemental figure 2)[11] this means they will have experienced a higher price inflation rate.

Our second step was therefore to calculate differential price inflation rates for quintiles (fifths) of the household income distribution. We estimated differential price inflation on the basis of the proportion of household expenditure spent on energy and other goods and services, by income quintile (2020/21, online supplemental table 1).

Expenditures in all groups except for electricity and gas were inflated by the latest available detailed Consumer Prices Index (CPI) figures (August 2022).[28] For example, food expenditures were inflated by the CPI inflation figure for food items.

Annual unmitigated inflation for electricity and gas in October 2022 was calculated between the Office of Gas and Electricity Markets (Ofgem) price caps for October 2021 (costing £1277 per year for a typical household)[29] and October 2022 (£3549 per year for a typical household)[30] and was 178%. The UK Government implemented the EPG of £2500 per year for a typical household from October 2022,[13] reducing the annual electricity and gas inflation rate to 96% (ie, mitigated price inflation for electricity and gas).We increased each income quintile's average expenditure on electricity and gas (online supplemental table 1) by 178% and 96% for the unmitigated and mitigated situations, respectively. We then divided the resulting overall expenditure by the original expenditure to give an annual inflation figure for each quintile.

Real income change

Third, we estimated the combined effect of wage inflation, the Cost of Living Support payments, and price inflation on the spending power (real income) of the households in each income quintile in 2022/23 (right-hand side of online supplemental figure 1). Four scenarios were modelled:

1. 'Baseline': 2022/23 if households had experienced the average wage and price inflation rates of the preceding 10 years (2.6%[26] and 1.8%,[31] respectively).

2. 'Unmitigated inflation': 2022/23 with 5.1% wage inflation[27] and differential unmitigated price inflation (incorporating the £3549 energy price cap).[30]
3. 'Mitigated by EPG': 2022/23 with 5.1% wage inflation and differential mitigated price inflation (incorporating the £2500 EPG).[13]
4. 'Mitigated by EPG and Cost of Living Support': 2022/23 with 5.1% wage inflation, differential price inflation mitigated by the £2500 EPG and Cost of Living Support payments (box 1).[13–15]

We used FRS survey weights to scale up the household data to produce a distribution that was representative of the Scottish population, and then assigned households to income quintiles on the basis of their income at baseline. We then estimated real income for each household under each scenario, by applying the relevant price inflation rate to the relevant nominal income (see figure 1 and online supplemental table 1):

$$real\ income = \frac{nominal\ income}{1 + \frac{inflation\ rate}{100}}$$

Households were then assigned to Scottish Index of Multiple Deprivation (SIMD) 2016 quintiles, so that their aggregated income data could be linked to routine mortality data. We used a mapping of the 2015/16 FRS households to SIMD 2016 quintiles (online supplemental table 2). Average real household income under each scenario was then calculated for SIMD quintiles using FRS survey weights. We calculated the Gini coefficient to estimate inequality in the population distribution of real income under each scenario.[32]
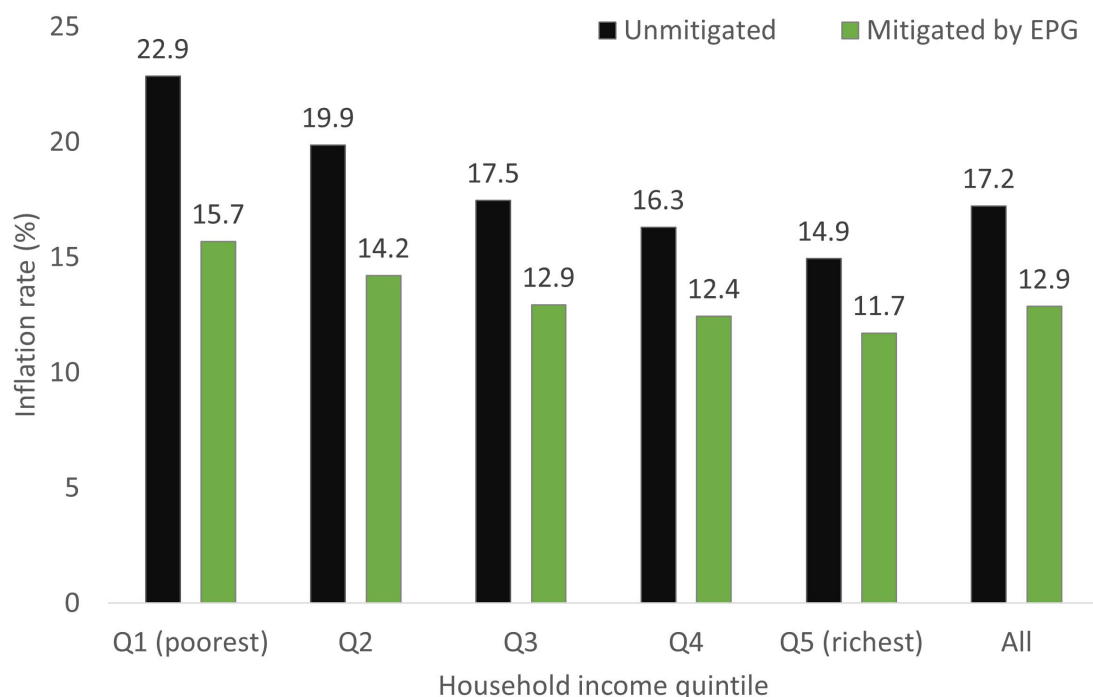
Figure 1 Estimated inflation by UK household income quintile, October 2022. EPG, Energy Price Guarantee; Q, quintile

Mortality effect

The final step was to estimate how the real income change experienced within each SIMD quintile was likely to affect mortality rates, premature mortality and life expectancy. We used the Informing Interventions to reduce health Inequalities ('Triple I') approach to estimate mortality impacts under each scenario. This is an existing policy scenario modelling approach that has been applied previously in Scotland.[33–35] There is evidence that income change is related to mortality risk, but no generalisable effect size is available.[18] Triple I uses the relationship between income difference and mortality, from cross-sectional data (see Supplemental Material Part 3, online supplemental table 3 and figure 3). As the mortality effect size calculation is a strong assumption, we conducted a sensitivity analysis by reducing the effect by 50%.

For each scenario we calculated life expectancy (Chiang method)[36] and standardised rate of premature mortality (deaths under 75 years), by deprivation quintile (SIMD). We also calculated inequalities in these health outcomes, using the Slope Index of Inequality (SII, linear) and Relative Index of Inequality (RII, linear).[37]

RESULTS

We estimated that unmitigated inflation in October 2022 would have ranged from 14.9% in the highest income quintile to 22.9% in the lowest income quintile. The EPG reduced this to between 11.7% and 15.7%, respectively (figure 1).

Under all scenarios, real-terms absolute income reductions would be higher for households in less deprived areas than more deprived areas (table 1, online supplemental table 4). However, households in the most deprived areas would be hit hardest in relative terms under the 'Unmitigated inflation' and 'Mitigated by EPG' scenarios. The addition of the partially targeted Cost of Living Support would reverse this, resulting in a smaller relative real-terms fall in income for those in more deprived than less deprived areas.

At baseline, the Gini coefficient for the distribution of real income across the population would be 30.5% (0% indicates perfect equality and 100% maximum inequality). Income inequality would increase by 4% under 'Unmitigated inflation' (Gini 31.8%) and 3% under 'Mitigated by EPG' (Gini 31.3%). Adding Cost of Living Support would reduce income inequality by 2% compared with baseline (Gini 29.9%).

The model estimated large mortality increases resulting from the real-terms reduction in incomes for each scenario. 'Unmitigated inflation' would increase mortality by 5% in the least deprived areas and 23% in the most deprived areas (online supplemental table 5). 'Mitigated by EPG' reduced the impact, resulting in estimated mortality increases between 3% and 16%, and 'Mitigated by EPG and Cost of Living Support' resulted in mortality increases of between 2% and 8%.

The average increase in premature mortality for the 'Unmitigated inflation' scenario was 16% compared with baseline (figure 2, online supplemental table 6). There were significant differences by deprivation, with 192 more premature deaths per 100 000 population per year in the most deprived areas and 11 more per 100 000 population per year in the least deprived areas. This increase in premature mortality was partially reduced under the 'Mitigated by EPG' scenario, and reduced further by the addition of Cost of Living Support, but the most deprived areas were still predicted to experience a relative increase around four times higher than that in the least deprived areas (8% and 2%, respectively). This scenario was estimated to result in 68 more premature deaths per 100 000 population per year in the most deprived areas and 6 more per 100 000 population per year in the least deprived areas.

These mortality increases would cause a reduction in life expectancy. The model estimated that 'Unmitigated

Table 1 Estimated impact of cost of living scenarios on real incomes in 2022/23, by Scottish Index of Multiple Deprivation (SIMD) 2016 quintile.

Scenario	SIMD 2016 quintile				
	Q1 (most deprived)	Q2	Q3	Q4	Q5 (least deprived)
Baseline mean real household income (£/year)	25 945	29 155	31 288	34 510	42 018
Absolute change (£/year):					
Unmitigated	−3316	−3542	−3708	−3998	−4645
Mitigated by EPG	−2378	−2551	−2675	−2899	−3389
Mitigated by EPG and Cost of Living Support	−1366	−1607	−1865	−2152	−2750
Relative change (%):					
Unmitigated	−12.8	−12.1	−11.9	−11.6	−11.1
Mitigated by EPG	−9.2	−8.7	−8.5	−8.4	−8.1
Mitigated by EPG and Cost of Living Support	−5.3	−5.5	−6.0	−6.2	−6.5

EPG, Energy Price Guarantee ; Q, quintile; SIMD, Scottish Index of Multiple Deprivation.
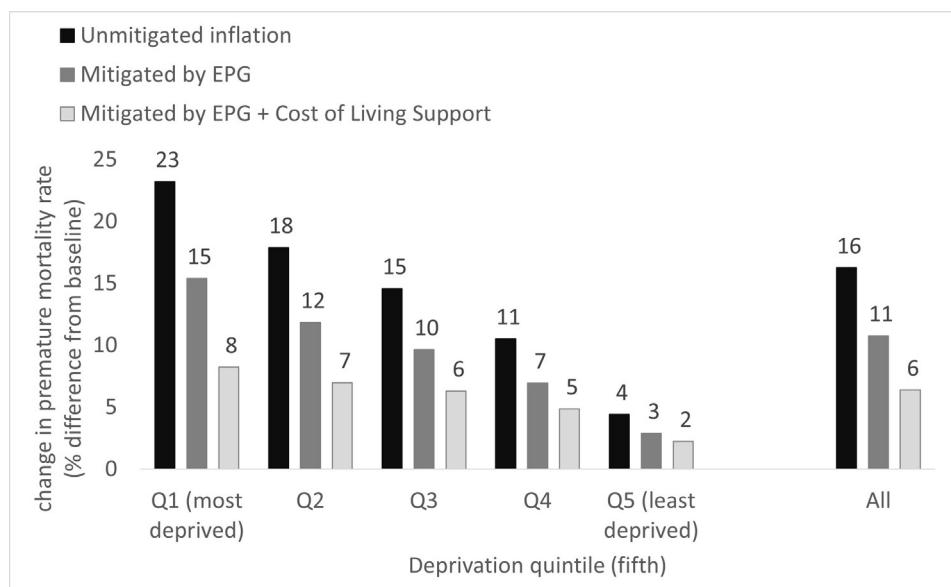
Figure 2 Relative impact of cost of living scenarios on premature mortality rates, compared with the baseline scenario, by Scottish Index of Multiple Deprivation (SIMD) 2016 quintile. EPG, Energy Price Guarantee; Q, quintile.

inflation' would decrease population-level life expectancy by 2.1% (1.6 years; online supplemental figure 4, table 7). The 'Mitigated by EPG' scenario would reduce life expectancy by 1.4% (1.1 years), and the scenario that included the Cost of Living Support would reduce life expectancy by 0.9% (0.7 years). In each case, more deprived areas were estimated to experience bigger reductions in life expectancy. These ranged from 2.7 years (3.7%) in the unmitigated scenario to 1.0 years (1.4%) in the scenario including both the EPG and Cost of Living Support payments.

Table 2 (premature mortality) and online supplemental file 8 (life expectancy) highlight the interaction between deprivation level and income reduction in the relationship between income change and health. These results illustrate how the functional form of the income–mortality relationship (see online supplemental figure 3) translates into mortality effects across the socioeconomic gradient. Table 2 shows how the same real-terms reduction in income would have a bigger effect on premature mortality rates for those in more deprived areas than those in less deprived areas. The same level of income reduction would result in five times higher relative increase in premature mortality in the most deprived quintile compared with the least deprived quintile, and a seven times bigger reduction in life expectancy. Reducing incomes by 2% in the most deprived areas causes the same premature mortality impact as an 8–10% reduction in the least deprived areas. Differences in the actual real income change experienced between the deprivation quintiles will modify the mortality effect differences further.

As well as simply comparing the most and least deprived groups, it is useful to examine inequality across the whole population. We estimated this using the Slope Index of Inequality (SII) and Relative Index of Inequality (RII): these measures estimate the absolute and relative difference, respectively, between the most and the least deprived ends of the socioeconomic gradient. At baseline, the SII indicated that absolute inequality was 713 additional premature deaths per 100 000 population per year, and 13 fewer years of life expectancy (online

Table 2 Estimated change (%, positive=increase) in premature mortality rates compared with baseline for a range of reductions in real household income, by Scottish Index of Multiple Deprivation (SIMD) 2016 quintile.

SIMD 2016 quintile	Reduction in real household income					
	2%	**4%**	**6%**	**8%**	**10%**	**12%**
Q1 (most deprived)	2.89	6.02	9.41	13.08	17.06	21.37
Q2	2.30	4.82	7.58	10.60	13.90	17.51
Q3	1.90	4.00	6.31	8.85	11.66	14.74
Q4	1.39	2.93	4.64	6.55	8.67	11.04
Q5 (least deprived)	0.58	1.25	2.01	2.87	3.85	4.97
All	2.10	4.39	6.90	9.64	12.64	15.93

Q, quintile; SIMD, Scottish Index of Multiple Deprivation.

supplemental table 9). The RII expresses this absolute gap in relative terms (relative to the population average of the health outcome), and shows that, at baseline, the premature mortality rate at the most deprived end of the socioeconomic gradient was 77% higher than the population average, and life expectancy was 8% lower.

The 'Unmitigated inflation' scenario would greatly increase these pre-existing inequalities: absolute inequalities rising by 30% for premature mortality and 21% for life expectancy, and relative inequalities rising by 12% and 23%, respectively. The EPG and Cost of Living Support would mitigate these increases, but under all the scenarios modelled, both absolute and relative inequalities would rise.

We conducted a sensitivity analysis by reducing the size of the income–mortality relationship by 50%. This reduced the effects on life expectancy, premature mortality, and inequalities by around 50% for each scenario.

DISCUSSION
Principal findings
The population is experiencing high price inflation rates; poorer households are experiencing the highest rates, as they spend a greater proportion of their income on energy. Households in the most deprived areas of Scotland would have seen the biggest relative reduction in income in real terms, but the partially targeted Cost of Living Support payments will give some protection. The payments partially mitigate the impacts of price increases but households in the most deprived areas will still be around £1400 (5.3%) worse off in real terms on average. Without the Cost of Living Support payments we estimate that income inequality would widen; the addition of Cost of Living Support reduces income inequality slightly.

Our modelling predicts large, inequitable mortality increases. Even with mitigation by the EPG and Cost of Living Support payments, real-terms income reductions could result in population-wide premature mortality increases of up to 6.4%, and life expectancy decreases of up to 0.9%. This compares with an increase in premature mortality in Scotland of 7.4% between 2019 and 2020 – an effect that has been largely attributed to COVID-19 deaths.[38] The effects would be greatest in the most deprived areas, so absolute and relative mortality inequalities would increase.

The targeted Cost of Living Support payments are progressive as they provide most benefit to households in the most deprived areas. However, they are insufficient to offset the greater falls in real incomes and potential increased mortality for these households. Health inequalities will widen as low-income groups bear higher health impacts for a given change in income.

Strengths and weaknesses
A strength of the modelling approach is that it shows not only the aggregate population impact of the rising cost of living but also its impact on health inequalities. Our model incorporated both differential inflation (because more deprived populations spend a higher proportion of their income on the goods with most inflated prices) and also the higher mortality impact of a reduction in spending power in the most deprived populations. We employed two well-documented and widely used policy modelling approaches: UKMOD and Triple I.[24 33] However, there are several limitations to the methods that should be recognised.

Our price inflation estimates did not include owner-occupiers' housing costs (the costs associated with owning, maintaining and living in one's own home) or other factors affecting a household's expenditures. For example, households in Scotland spend more on electricity and gas than the UK average,[39] so our UK-based rates may be underestimates. Owner-occupiers' housing costs increased less than food and energy did over the study period[28]: if we had been able to include these, our inflation estimates for all household spending would have been lower. Our rates exceed the official CPI rate because the CPI calculation effectively downweights electricity and gas expenditure to 3.4%,[28] whereas these expenditures averaged 5.3% for households in 2021.[14] Our rates exceed Institute for Fiscal Studies' estimates due to differing data and time periods.[12]

Our UKMOD modelling assumed uniform wage inflation, although wage growth will differ between public and private sectors. Underrepresentation of certain groups in the FRS data may affect the accuracy of our calculations. We included policies with a direct quantifiable impact on household incomes, but could not include policies such as the UK Government's Household Support Fund or the Scottish Government's rent freeze and eviction ban. We estimated real income change for households before housing costs, but housing is another expenditure that will differ by income level. Income effects for income quintiles were mapped to deprivation quintiles to enable linkage to routine mortality data; this will have reduced the effect range as there are low- and high-income households in each deprivation quintile (online supplemental table 2).

There are several assumptions within our modelling, and these are the greatest sources of uncertainty in the results. Therefore we did not attempt to include uncertainties due to random variation in model inputs in our modelling as these would have given a false sense of precision. Instead we used sensitivity analysis to illustrate the uncertainties arising from the key assumption here as a better means of illustrating the uncertainties: this showed that even if the relationship was half as strong, impacts on mortality would still be substantial.

Evidence from longitudinal studies on the relationship between income and mortality is lacking so our Triple I modelling used cross-sectional estimates of the relationship. This shows the effects of long-term exposure to different income levels rather than short-term effects. This means that our mortality impact estimates

are not predictions for 2022/23 in isolation, but indicate the likely magnitude of the effects of sustained income changes. It is worth noting, however, that in the decade between 2010/11 and 2021/22, the Triple I model predicted impacts of changes in income on mortality that were consistent with the pre-pandemic stalling of life expectancy in Great Britain.[35][40] This suggests that the modelled mortality changes are plausible if income effects persist.

The mortality effects presented do not account for individuals' responses to rising costs that could mitigate real-terms income reductions, for example, working longer hours or reducing energy consumption. Effects of recession, austerity or unemployment were also not considered and may compound the effects. Mortality effects are important to measure, but they are a narrow measure of health; our concurrent health impact assessment considers wider health effects.[41]

Implications

Our analysis contributes to evidence that the economy matters for population health.[42] Evidence suggests that since 2012, economic conditions in the UK have caused stalling of life expectancy and widened health inequalities, as austerity led to weaker social security and reduced income for the poorest households.[9]

Our modelling applies specifically to Scotland but similar effects are likely across the UK as we have modelled the impact of UK Government measures. The mortality impact of inflation in other jurisdictions will depend on the effectiveness of government and other responses in mitigating the effect on real incomes.

The potential impacts of inflation and reduced real incomes are likely to be large and negative, with marked inequalities in how these are experienced. Impacts will depend on the mitigating policies that are implemented, as well as the distribution of income in the population. More progressive policy responses are required to protect health and prevent widening inequalities as a result of the cost of living crisis.

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