The effect of income-based policies on mortality inequalities in Scotland: a modelling study

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Summary

Background The unequal distribution of income is a fundamental determinant of health inequalities. Decision making around economic policies could be enhanced by showing their potential health effects. We used scenario modelling to assess the effects of 12 income-based policies on years of life lost (YLL) and inequalities in YLL in Scotland for the 2017–21 period.

Methods In this modelling study, we used EUROMOD version H1.0+, a tax-benefit microsimulation model, to estimate the effects of hypothetical fiscal policies on household income for Scottish households in the 2014/15 Family Resources Survey (n=2871). The effects were modelled excluding housing costs. Income change from baseline was estimated for each quintile of the 2016 Scottish Index of Multiple Deprivation (SIMD) after weighting to account for differential non-response to the Family Resources Survey, and incomes were equivalised according to the Organisation for Economic Co-operation and Development's modified equivalence scale. A regression analysis of cross-sectional data was used to estimate the relationship between income change and all-cause mortality, followed up by a sensitivity analysis to account for uncertainties around the assumptions on effect size. Informing Interventions to reduce health Inequalities (Triple I), a health inequalities scenario modelling tool, was used to estimate policy effects on YLL and government spending after five years of theoretical implementation. The Triple I model used population estimates for 2016 stratified by sex, 5-year age group, and SIMD quintile, which were obtained from the National Records of Scotland. Preliminary estimates of relative policy costs were calculated from the EUROMOD-derived combined effects of each policy on tax bills, National Insurance contributions, and benefits receipts for Scottish households.

Findings Taxation-based policies did not substantially affect household incomes, whereas benefits-based policies had large effects across the quintiles. The best policy for improving health and narrowing health inequalities was a 50% increase to means-tested benefits (approximately 105 177 [4·7%] YLL fewer than the baseline of 2·2 million, and a 7·9% reduction in relative index of inequality). Effects on YLL and health inequalities were inversely correlated in response to changes in taxation policy. Citizen's Basic Income (CBI) schemes also substantially narrowed inequalities (3·7% relative index of inequality for basic scheme, 5·9% for CBI with additional payments for individuals with disability), and modestly reduced YLL (0·7% for the basic scheme and 1·4% with additional payments). The estimated government spending associated with a policy was proportional to its effect on YLL, but less closely related to its effect on inequalities in YLL.

Interpretation Policies that affect incomes could potentially have marked effects on health and health inequalities in Scotland. Our projections suggest that the most effective policies for reducing health inequalities appeared to be those that disproportionately increased incomes in the most deprived areas. Although modelling was subject to various assumptions, the approach can be useful to inform decisions around addressing the upstream determinants of health inequalities.

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Introduction

Health inequalities are the unjust and avoidable differences in people's health across the population and between specific population groups.[1] Although there have been substantial improvements in health over the past 30 years across Europe, these gains have been unequally distributed in society, widening relative health inequalities in many European countries.[2] In the UK, Scotland experiences both higher rates of mortality and higher levels of absolute and relative health inequality than other UK countries.[3]

The pathways that contribute to health inequalities are complex. The fundamental factors, however, are the unequal distribution of power, income, and wealth across society.[4] Income is strongly associated with health outcomes at national, neighbourhood, and household levels.[5] A range of material, social, and psychological mechanisms have been proposed to explain how absolute and relative income levels affect health. Income provides the means to access goods and services that support healthy living, such as diet, good housing, and leisure activities.[6] Income is

Research in context

Evidence before this study

Income is a fundamental determinant of health, with greater income associated with better health within a population. To inform our study, we did a systematic search for literature in the databases MEDLINE, Web of Science, and PROQUEST Public Health Database. We searched for articles from inception to July 2019, using the following search terms: (["benefit*", "credit*", "financ*", "loan*", "tax*", "income", "money", "wage*", "cash", "salar*", "debt*", "national insurance", "living wage", "minimum wage", "local tax", "council tax", or "income tax"] with ["increas*", "decreas*", or "change*"]) and ("model*" near ["stud*", "design*", "method*", or "analy*"]) and ("mortality" or "death"). After screening, we identified five relevant studies from the USA, and one from New Zealand. All US studies quantified the mortality effects of minimum wage changes, and the New Zealand study assessed effects of eliminating poverty, without specifying a policy driver. In four studies, the effects on mortality were predicted using a relationship derived from cross-sectional income and mortality data. By contrast, two US studies used quasi-experimental fixed-effects models to quantify the average effect of more than 200 state-level minimum wage increases (since 1980) on state-level mortality rates. In combination, the studies suggest that modest changes to income can have substantial health benefits and show the importance for policy makers of estimating policy effects on health. However, these studies only assessed the effects of minimum wage changes or an unspecified means of eliminating poverty and did not address how the policies would affect inequalities in mortality.

Added value of this study

Our study quantified and compared how 12 policies would affect household incomes across different levels of socioeconomic deprivation. We subsequently estimated how these income changes would affect years of life lost (YLL) and inequalities in YLL. We found that the design and targeting of income-based policies has implications for their effects on health and health inequalities. We estimated that the most effective policies for reducing health inequalities were those that disproportionately increased incomes in the most deprived areas.

Implications of all the available evidence

Policies that increase incomes have the potential to reduce mortality rates. Increasing incomes for low-income groups can reduce inequalities in mortality. Modelling studies such as ours allow policy makers to evaluate and compare relative societal costs and benefits of alternate policies without needing to implement them first.

also a general expression of socioeconomic position. Inequality in income is well recognised as a determinant of health inequality at the population level, and the associated stress, incurred through relative social position and reduced social cohesion, is a proposed causal mechanism of these inequalities.[7]

The importance of social and economic factors as drivers of health inequality has been increasingly incorporated in UK policies.[8] The actions pursued to improve health and tackle inequality have, however, frequently focused on interventions that seek to alter individual behaviour.[8,9]

The recent transfer of various taxation and welfare powers, which affected 11 benefits and the power to change Income Tax rates, from the UK to Scotland under the Scotland Act 2016,[10] provides new opportunities for the Scottish Government to influence upstream determinants of health.

Modelling offers the opportunity to investigate the effects of potential policy interventions without implementation. This approach, therefore, offers one mechanism to address the evidence gap when considering upstream policies to address health inequalities. Furthermore, research has found that policy makers find such modelling evidence particularly powerful in opening discussions and guiding decision making.[11] One example is the Informing Interventions to reduce health Inequalities (Triple I) scenario modelling approach, which can be used to estimate the effects of interventions on health and health inequalities.[12] Currently there is little evidence of the effect of income change on mortality,[13] and it is important to assess how income policies would affect inequalities in mortality.

In this Article, we compare the effects of different policy approaches to altering household income in Scotland on years of life lost (YLL) and inequalities in YLL. YLL is a measure of premature mortality that gives greater weight to deaths at younger ages. Our aim is to provide decision makers with comparative information about the effectiveness of different policies.

Methods

Study design and data sources

We considered a range of fiscal policies that would affect household income and categorised them as either taxation-based, benefits-based, or novel (table 1). These policies were selected to represent a range of existing and potential future options, with varying levels of current practical and political feasibility, considering their similarity to recently implemented policy changes. The 50% increase in means-tested benefits policy, for example, was designed to bring the incomes of recipient households up to a minimum level for healthy living.[14] Some of the policies could be introduced in Scotland within existing devolved powers, whereas others would require UK-wide implementation.

We modelled the effect of each policy on the incomes (before housing costs) of all Scottish households (n=2871)

in the 2014–15 Family Resources Survey.[15] The Family Resources Survey is a cross-sectional household survey based on a two-stage stratified clustered probability sample of private households. We used EUROMOD version H1.0+,[16] a detailed tax-benefit microsimulation model developed by the Institute for Social and Economic Research (University of Essex, Colchester, UK) that enables researchers and policy analysts to estimate the effects of taxes and benefits on household income and work incentives. We ran the models for 2016, with monetary values uprated accordingly, and benefit uptake rates from the UK Government's Department for Work and Pensions and Her Majesty's Revenue and Customs. How EUROMOD models the UK economy is described fully by de Agostini.[17] We equivalised the household incomes using the Organisation for Economic Co-operation and Development's modified equivalence scale,[18] so that they could be compared between households of different sizes and compositions.

National-level results for Scotland were produced using weights that accounted for differential non-response to the Family Resources Survey.[17] Lower than average response rates had been observed in the Survey for single occupants, lone parents, couples with non-dependent children, households in purpose-built flats or maisonettes, individuals who owned their house outright, and households with self-employed or unemployed heads. For each policy, we estimated average household income change from baseline (no policy) for each quintile of the 2016 Scottish Index of Multiple Deprivation (SIMD),[19] using Family Resources Survey data that were linked to SIMD quintiles for us by the Department for Work and Pensions. All data processing was done using Stata/SE, version 13.1.

	Policy description
Taxation-based policies	
Income Tax +1 p*	Income Tax rates increased by 1 p (to 21 p basic rate, 41 p high rate, and 46 p additional rate)
Income Tax –1 p*	Income Tax rates decreased by 1 p (to 19 p basic rate, 39 p high rate, and 44 p additional rate)
Personal Allowance +£1000	Income Tax tax-free Personal Allowance increased from £11 000 to £12 000
Personal Allowance –£1000	Personal Allowance decreased from £11 000 to £10 000
Council Tax increase*	Council Tax increased for mid-value to high-value properties: band E +7·5%, band F +12·5%, band G +17·5%, and band H +22·5%
Benefits-based policies	
Means-tested benefits +50%	50% increase in benefits paid to people who pass an income test (benefits and increased rates in appendix p 1)
Devolved benefits +50%*	50% increase in six benefits devolved to the Scottish Government (benefits and increased rates in appendix p 2)
Novel policies	
Citizen's Basic Income	Introduction of Citizen's Basic Income: an income from the state received by every citizen, not dependent on need; most benefits would be removed, as well as the Personal Allowance; Income Tax rates and National Insurance contributions modified to recoup most of the cost (appendix p 3)
Citizen's Basic Income Plus	Introduction of Citizen's Basic Income with additional payments for adults and children with disability (appendix p 3)
Local Income Tax*	Council Tax removed and all Income Tax rates increased by 3 p
Real Living Wage	Mandatory payment of the real living wage to all employees (calculated as £8·25 per h for 2016–17 by the Living Wage Foundation on the basis of living costs)
Benefit uptake +1%*	A 1% increase in the number of claimants of means-tested benefits, which might arise from wider availability of income-maximisation advice services, for example (appendix p 4)

Income Tax is a tax levied directly on personal income. The 2016 Income Tax structure was used in the analysis. Council Tax is a tax levied on households by local authorities on the basis of the estimated value of a property and the number of people living in it. The 2016 Council Tax rates were used in the analysis. Band E=market value in 1991 >£58 000–80 000. Band F=market value in 1991 >£80 000–106 000. Band G=market value in 1991 >£106 000–212 000. Band H=market value in 1991 >£212 000. *These policies could be introduced in Scotland with existing devolved powers.

Table 1: **Description of the 12 income-based policies**

Effect of household income change on mortality

A strong cross-sectional relationship between income and mortality has been established[5] and has been used in studies to estimate the effects of policies that would change household incomes.[20] We therefore used a regression analysis of cross-sectional data to estimate this relationship for Scotland. We used logarithmic transformations to linearise the relationship, on the assumption that a proportional change in income is likely to have a proportional effect on mortality. Log_2 transformation was chosen to represent income for ease of interpretation, such that the exponentiated coefficient would equal the change in mortality per doubling of income. We regressed $\log_e$-transformed all-cause mortality rates (European age-standardised rates), calculated using 2016 data from the National Records of Scotland[21] and the European Standard Population 2013,[22] on $\log_2$-transformed mean equivalised household income (before housing costs, values uprated to 2016 from Family Resources Survey 2014–15),[15] for SIMD 2016 quintiles (appendix p 5). A plot of the transformed values approximated a linear trend. For every doubling of household income, the regression predicted a mortality rate ratio of 0·454. We applied this estimated effect to the income changes estimated for each SIMD quintile in EUROMOD to predict each policy's effect on mortality rates for that quintile. The greatest uncertainties in our models related to the assumptions in the effect sizes, rather than to any sampling issues. We therefore tested the sensitivity of the results to the strength of this relationship by reducing the effect size by 25% (mortality rate ratio 0·590) and 50% (0·727).

Policy effects on YLL

Effects of the policies on YLL were estimated using our Triple I modelling tool. The Triple I model is described in detail elsewhere.[23] Briefly, it models policy effects on a closed cohort (Scottish adult population in 2016),[24] and policy effects are assumed to be immediate and constant over time. Population estimates for the closed cohort, stratified by sex, 5-year age group, and SIMD quintile, were obtained from National Records of Scotland. All-cause mortality rates for the subgroups were estimated using National Records of Scotland mortality data (2002–16) and a parametric survival

For the **Triple I tool** see http://www.healthscotland.scot/triplei

See **Online** for appendix

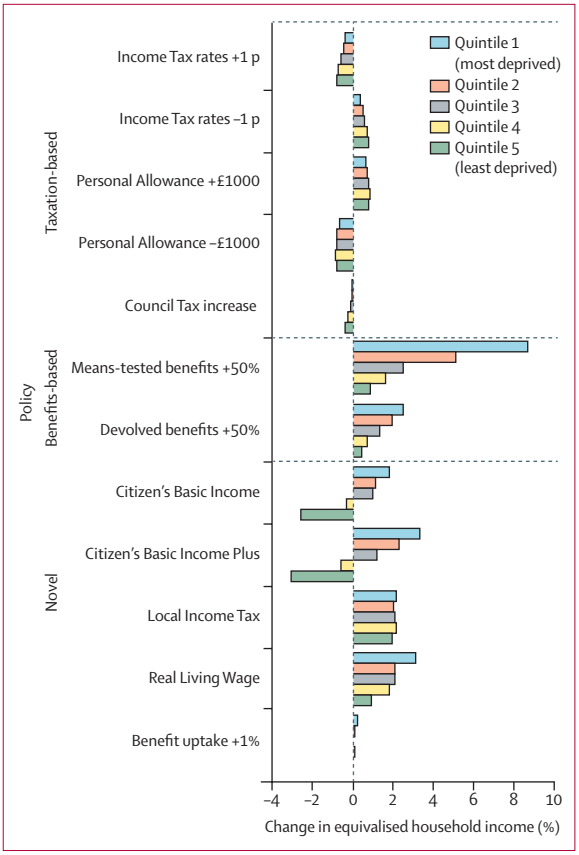

Figure 1: **Percent change in equivalised household income (before housing costs) for each policy by 2016 Scottish Index of Multiple Deprivation quintile**

model (exponential distribution), giving the following formula:

$$\text{Rate} = e^{(38\cdot37 + 0\cdot09\times\text{age} + 1\cdot05\times\text{male} - 0\cdot01\times\text{age}\times\text{male} - 0\cdot02\times\text{year} + 0\cdot57\times\text{Q1} + 0\cdot21\times\text{Q2} - 0\cdot23\times\text{Q4} - 0\cdot54\times\text{Q5})}$$

Q1–5 were SIMD quintiles, age was mean age of the age group in years, and SIMD Q3 and female were reference categories. For each year of follow-up, deaths in the absence of the policy (baseline scenario) were estimated using the rate predicted by the formula. For the policy scenario, the predicted effect of the policy on the mortality rate, by SIMD quintile, was used to adjust the baseline rate before estimating numbers of deaths. For each scenario, YLL were calculated for each age group as the difference between the individuals' age at death and their age-specific and sex-specific life expectancy, multiplied by the number of deaths for the group. We estimated the difference in YLL and inequalities in YLL between each policy and the baseline scenario after five years of implementation. Five years was selected because this interval corresponds approximately to local and national planning cycles. Inequalities were measured using the Relative Index of Inequality, a linear regression-based index that accounts for differences across the whole gradient of inequality, not just the gap in health outcomes between the most and least deprived.[25]

Policy costs

The combined effects of each policy on tax bills, National Insurance contributions, and benefits receipts predicted by EUROMOD for each household in the Family Resources Survey were grossed up to the national level

	SIMD Q1 (most deprived)	SIMD Q2	SIMD Q3	SIMD Q4	SIMD Q5 (least deprived)	Whole population total	Relative index of inequality
Taxation-based policies							
Income Tax rates +1 p	2607 (0·4%)	2750 (0·5%)	2928 (0·7%)	2734 (0·8%)	2304 (0·9%)	13 322 (0·6%)	–0·006 (–0·5%)
Income Tax rates –1 p	–2587 (–0·4%)	–2725 (–0·5%)	–2892 (–0·7%)	–2694 (–0·8%)	–2264 (–0·9%)	–13 164 (–0·6%)	0·006 (0·5%)
Personal Allowance +£1000	–4602 (–0·7%)	–3911 (–0·8%)	–3662 (–0·8%)	–3170 (–0·9%)	–2226 (–0·9%)	–17 573 (–0·8%)	0·003 (0·2%)
Personal Allowance –£1000	4891 (0·7%)	4353 (0·8%)	3916 (0·9%)	3397 (1·0%)	2333 (0·9%)	18 889 (0·8%)	–0·003 (–0·2%)
Council Tax increase	121 (0·0%)	407 (0·1%)	701 (0·2%)	871 (0·2%)	1141 (0·5%)	3241 (0·1%)	–0·004 (–0·4%)
Benefits-based policies							
Means-tested benefits +50%	–57 614 (–8·6%)	–27 274 (–5·3%)	–11 779 (–2·7%)	–6123 (–1·7%)	–2385 (–0·9%)	–105 177 (–4·7%)	–0·099 (–7·9%)
Devolved benefits +50%	–17 770 (–2·7%)	–10 791 (–2·1%)	–6449 (–1·5%)	–2649 (–0·8%)	–1299 (–0·5%)	–38 959 (–1·7%)	–0·027 (–2·1%)
Novel policies							
Citizen's Basic Income	–12 668 (–1·9%)	–6223 (–1·2%)	–4774 (–1·1%)	1107 (0·3%)	7420 (2·9%)	–15 140 (–0·7%)	–0·046 (–3·7%)
Citizen's Basic Income Plus	–23 373 (–3·5%)	–12 546 (–2·4%)	–5603 (–1·3%)	2280 (0·6%)	8856 (3·5%)	–30 388 (–1·4%)	–0·074 (–5·9%)
Local Income Tax	–15 062 (–2·2%)	–11 100 (–2·1%)	–9836 (–2·2%)	–8123 (–2·3%)	–5460 (–2·2%)	–49 581 (–2·2%)	0·000 (0·0%)
Living Wage	–21 735 (–3·2%)	–11 727 (–2·3%)	–10 050 (–2·3%)	–7022 (–2·0%)	–2644 (–1·0%)	–53 179 (–2·4%)	–0·022 (-1·7%)
Benefit uptake +1%	–1712 (–0·3%)	–288 (–0·1%)	0 (0·0%)	–70 (0·0%)	0 (0·0%)	–2070 (–0·1%)	–0·003 (–0·2%)

Data are absolute difference (% difference) from the baseline scenario. A positive difference represents an increase in YLL from baseline. SIMD=Scottish Index of Multiple Deprivation. YLL=years of life lost.

Table 2: **Estimated effects of each policy on YLL and inequalities in YLL for the Scottish population and by SIMD 2016 quintile, after 5 years of theoretical implementation**

using the relevant weights. The summed effect was subtracted from that for the baseline (no policy) scenario, to give an estimate of the net relative cost of each policy for the Government. However, the calculation excluded health-related costs such as lost productivity and associated tax revenue, as well as health-care costs. In the absence of data required to do a more comprehensive health economics analysis, these estimates were intended to provide a comparative guide for policy makers about policy options.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

We estimated that the taxation-based policies considered could result in small changes to household incomes that differed little between the most and least deprived areas (figure 1, appendix p 6). Policies involving low taxation could benefit people in less deprived areas more than those in more deprived areas. The benefits-based policies could have disproportionate effects across the deprivation gradient, resulting in large income increases for households in the most deprived areas and modest increases for the least deprived. Of the novel policies, Local Income Tax could have the most even effect across the quintiles. The other novel policies disproportionately increased incomes for individuals in more deprived areas, and the two Citizen's Basic Income (CBI) policies reduced incomes in less deprived areas (figure 1, appendix p 6).

In the baseline scenario, with no changes to taxation or benefits, we estimated that there would be 2·2 million YLL over five years. The average annual YLL rate would be 66% lower in the least deprived areas (5905 YLL per 100 000 people per year) than in the most deprived areas (17 236 YLL per 100 000 people per year). The Relative Index of Inequality for the baseline scenario would be 1·25, meaning that the range between the most and least deprived areas would be approximately 1·25 times the population average YLL rate (10 673 YLL per 100 000 people per year), or 13 341 YLL per 100 000 people per year. The YLL rate would increase by 2668 YLL per 100 000 people per year for each of the 5 years with each increasing deprivation quintile.

Increasing means-tested benefits by 50% was estimated to have the biggest effect on reducing YLL of all scenarios tested (by approximately 105 177 YLL from baseline over 5 years, or approximately 4·7% YLL prevented) and inequalities in YLL (by approximately 0·099, equivalent to 7·9%; table 2, figure 2). Sizeable reductions in YLL were also estimated for the real Living Wage, Local Income Tax, and increasing devolved benefits by 50% (table 2, figure 2). The two CBI policies would also be effective in narrowing inequalities in YLL (table 2), reducing the Relative Index of Inequality by 0·05 (3·7%) for CBI and 0·07 (5·9%) for CBI Plus (ie, including additional payments for individuals with disabilities), and also reducing overall YLL (0·7% for CBI and 1·4% for CBI Plus).

Any changes to taxation policy (figure 2) either reduced YLL but widened inequalities (ie, if taxes were decreased, thus increasing incomes), or increased YLL while narrowing inequalities (if taxes were increased, thus reducing incomes).

We did sensitivity analyses by assessing the effect of attenuation of the relationship between income change and all-cause mortality by 25% or 50% and found that the effects on YLL would be reduced by 33% and 60%, respectively. Effects of the policies on premature mortality

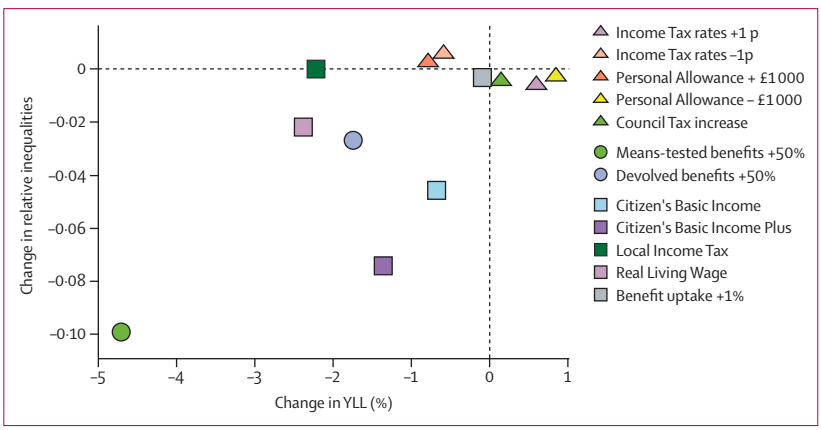

Figure 2: **Effects of income-based policies on YLL and inequalities in YLL after 5 years relative to baseline**
Symbols represent the policy type: triangles for taxation-based, circles for benefits-based, and squares for novel policies. YLL=years of life lost.

	Net cost per year (£ million)
Income Tax rates +1 p	−429
Income Tax rates −1 p	429
Personal Allowance +£1000	513
Personal Allowance −£1000	−541
Council Tax increase	−135
Means-tested benefits +50%	2173
Devolved benefits +50%	773
Citizen's Basic Income	442
Citizen's Basic Income Plus	535
Local Income Tax	1288
Real Living Wage	1264

Increasing benefit uptake by 1% has been excluded because we were unable to reliably estimate the implementation investment required to achieve the 1% increase. Negative costs indicate revenue to government. The cost for the Real Living Wage includes a £2148 million increased wage bill that is likely to be shared between the Government and employers, minus reduced benefit expenditure and the Government's net savings arising from increased tax and National Insurance contributions.

Table 3: **Direct fiscal cost for each income-based policy**

(defined as deaths in people younger than 75 years) were also calculated (appendix p 7), and mirrored the trends described for YLL.

The implications of the policies for annual government spending ranged from £541 million increased revenue (reducing the Personal Allowance by £1000) to £2173 million increased spend (increasing means-tested benefits by 50%; table 3). Estimated effects on YLL were related to cost: more expensive policies resulted in greater reductions in YLL, whereas cost-saving policies were estimated to increase YLL. By contrast, the cost of a policy was not closely related to its effect on health inequalities. In particular, the CBI policies appeared to have good potential for reducing inequalities at less than a quarter of the cost of increasing means-tested benefits by 50%.

Discussion

In this study, we have used scenario modelling to compare how 12 income-based policies might affect household incomes, YLL, and inequalities in YLL in Scotland. We found that the biggest apparent reductions in YLL resulted from policies that increased household incomes the most, and consequently cost the most. By contrast, the cost of a policy was not closely related to its effect on health inequalities, suggesting that the design of the policy was more important than its cost. Progressive policies that disproportionately increased incomes in the most deprived areas compared with the least deprived areas were best at reducing inequalities.

We used a detailed model, incorporating a representative sample of Scottish households, so our findings are applicable to Scotland as a whole. As such, this work can inform decision makers in Scotland about resource allocation and policy formulation. Our Triple I modelling tools are freely available for use. In addition to YLL, effects can be estimated for premature mortality and hospital admissions. It should be noted, however, that we have not considered all possible income-based policies, so our findings should not divert attention from other policies.

There are limitations to our study that should also be acknowledged. As with all modelling work, the findings should be interpreted in the context of the model specifications and assumptions. A key assumption was that an increase in income would result in reduced mortality and that this effect could be adequately predicted from a regression analysis of cross-sectional income and health data. There is good evidence that change in income is likely to be causally related to changing health, as income and health are strongly linked,[5] and reverse causality (change in health status leading to change in income) has been broadly rejected at the population level.[26] Nonetheless, the relationship could feasibly be weaker than we estimated, which would affect the absolute results (although not the relative effect of each policy in relation to the others). The sensitivity analysis showed that the strength of the relationship between income and health is an important factor in the estimated policy effect sizes, and our results are likely to represent the upper limit of the effects.

The modelling incorporates some simplifications that should also be considered. We modelled each policy in isolation, although in reality multiple policies could be implemented concurrently. Looking at policies in isolation permits estimation of the effects of changing only that policy, while keeping all other factors constant. Only a policy's direct costs, savings, and effects are included in the modelling. If a policy proposal is to be revenue-neutral, the effects of changes in taxation also need to be considered in the decision making process on this policy's introduction. Accounting for this effect could be achieved by combining policies at the EUROMOD modelling stage and repeating the assessment of estimated health effects using Triple I (akin to the CBI policy modelling described in appendix p 3). However, neither the Triple I nor EUROMOD models can account for how a change in income might affect behavioural responses within a household that could also change their income and health, such as deciding whether to work or not, or to work more or fewer hours. Tax and benefit fraud could not be accounted for in the modelling, potentially leading to slight overestimation of the proportional income change for each policy.

Our work shows how scenario modelling can be used to address the lack of evidence on the effectiveness of upstream interventions and the potential value of some income-based policies for the Scottish Government's desire to fix inequalities at source.[27] Modelling studies such as ours can inform policy makers about probable effects of policies on health and health inequalities before they are implemented. Previous studies focused on the effects of single income-based policies on mortality,[20,28] whereas we have compared multiple policies with differing approaches to income redistribution.

Health-impact modelling has been used to predict the health effects of the UK soft drinks industry levy[29] and of minimum unit pricing for alcohol in Scotland.[30] Because of their focus on specific downstream health behaviours, these studies adopted more advanced modelling techniques than we were able to and incorporated behavioural responses to some extent. Nonetheless, our more generalised modelling approach allows disparate policies with multiple potential pathways between the exposure and the health outcome to be included and compared.

Our finding that the policies that increased household incomes most might result in the biggest reductions in YLL suggests that the Government's aim of making Scotland a healthier place could be advanced by greater investment in policies that increase household income. Although we expected this result given the clear negative relationship between household income and mortality rate, it is supported by quasi-experimental analyses of income change on mortality in the USA.[31]

However, we also found that not all policies that improve health would reduce health inequalities. Policies that increase incomes relatively uniformly across the socioeconomic gradient, such as reducing Income Tax or increasing the tax-free Personal Allowance for Income Tax, could increase inequalities while improving health. The more disproportionately a policy can affect incomes across the gradient, even to the extent of increasing them in the most deprived areas and decreasing them in the least deprived, the greater an effect it will have on reducing health inequality. We found only one study that had assessed how income-based policies would affect health inequalities.[32] Di Novi and colleagues[32] found that health-care tax credits in Italy increased inequalities in health status, and that the policy could be redesigned to reduce this effect. Similarly, Griffin and colleagues[33] estimated that almost one-third of the health interventions recommended by the National Institute for Health and Care Excellence were likely to increase health inequalities. An increased focus on the effects of policies and interventions on health inequalities is clearly needed so that they do not have unintended consequences. Making fairer and healthier societies will require consideration about how progressive each policy's direct effects are.

Contributors

GM and MR conceived and led the study. ER conducted the analyses and wrote the paper. All authors contributed to drafting the paper, provided substantive comments on the paper and approved the final version.

Declaration of interests

All authors are NHS employees. We declare no competing interests.

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