BMJ Public Health

Prepandemic inequalities in the burden of disease in Scotland due to multiple deprivation: a retrospective study

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To cite: Grant I, Chalmers N, Fletcher E, *et al*. Prepandemic inequalities in the burden of disease in Scotland due to multiple deprivation: a retrospective study. *BMJ Public Health* 2023;**1**:e000191. doi:10.1136/bmjph-2023-000191

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjph-2023-000191).

Received 1 May 2023
Accepted 2 November 2023

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ABSTRACT

Background Health inequalities in Scotland are well documented, including the contribution of different causes to inequalities in mortality. Our aim was to estimate inequalities within a burden of disease framework, accounting for both premature mortality and the effects of morbidity, to understand the contribution of specific diseases to health inequalities prior to the COVID-19 pandemic.

Methods Disability-adjusted life-years (DALYs) for 70 individual causes of disease and injury were sourced from the Scottish Burden of Disease Study. Area-level deprivation was measured using the Scottish Index of Multiple Deprivation. Inequalities were measured by the range, Relative Index of Inequality, Slope Index of Inequality and attributable DALYs were estimated by using the least deprived decile as a reference.

Results The overall disease burden was double that in the most deprived areas (50 305 vs 20 955 DALYS per 100 000), largely driven by inequalities in premature mortality. The rate in the most deprived areas was around 48% higher than the mean population rate (Relative Index of Inequality=0.96), with 35% of DALYs attributed to differences in area-based deprivation. Many leading causes of disease burden in 2019—heart disease, drug use disorders, lung cancer and chronic obstructive pulmonary disease—were also the leading drivers of absolute and relative inequalities in the disease burden.

Conclusion Our study evidences the extent of the stark levels of absolute and relative inequality prior to the COVID-19 pandemic. Given prepandemic stalling of mortality trend improvements and widening health inequalities, and the exacerbation of these caused by COVID-19, urgent policy attention is required to address this.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Scotland has marked health inequalities across populations ranked by socioeconomic position and the absolute gap in premature mortality between the most and least deprived areas has increased since 2012.

WHAT THIS STUDY ADDS

⇒ This study has highlighted the extent of stark levels of absolute and relative inequality for specific causes of disease and injury in Scotland, prior to the COVID-19 pandemic, using range and distributional measures.

⇒ Many of the leading causes of disease burden in 2019—heart disease, drug use disorders, lung cancer and chronic obstructive pulmonary disease—were also the leading drivers of absolute and relative inequalities in the disease burden.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study underscores the importance of tackling systemic inequalities with effective interventions to mitigate further unjust health loss in the Scottish population.

INTRODUCTION

It is well evidenced that there is a clear link between levels of deprivation and life expectancy in Scotland, with those from the most deprived areas and backgrounds having significantly poorer life expectancy and general health outcomes.[1–3] Recent published data from the National Records of Scotland show that not only have overall differences in life expectancy between the most and least deprived populations have been worsening, but the gap in the number of years of healthy life expectancy is also widening. In terms of overall life expectancy, males in the most deprived areas have 13.5 year's lower life expectancy compared with their least deprived counterparts, and for females, the difference between the most and least deprived is 10.2 years.[4] Furthermore, healthy life expectancy in the most deprived areas of Scotland was more than 24 years lower than in the least deprived areas for both males and females.[5] COVID-19 has further highlighted and amplified these inequalities: inequalities in COVID-19 mortality rates follow a similar social gradient to that seen for all causes of death, that is, increasing with increasing

levels of deprivation, and the causes of inequalities in COVID-19 are similar to the causes of inequalities in health more generally.[6–8]

Reliable, comparable information about the main causes of disease and injury in populations, and how these are changing and their effect on life expectancy and healthy life expectancy, is therefore a critical input for decision-making, planning and targeting interventions where they are most required. Traditional sources of information about the descriptive epidemiology of diseases, injuries and risk factors are generally incomplete, fragmented and of uncertain reliability and comparability.[9] A lack of a standardised measurement framework to permit comparisons across diseases and injuries and failure to systematically evaluate data quality can impede comparative analyses of the true public health importance of various conditions and risk factors.[10] A burden of disease framework can be used to summarise the debilitating effects of morbidity and premature mortality in a population in a consistent and comparable manner. This is achieved by framing the effects of years lived with disability (YLD) and years of life lost to premature mortality (YLL) on population health loss as a function of time, in a composite measure called disability-adjusted life-years (DALYs).[11] By framing health loss in this way, DALYs combine the effects of morbidity and mortality in an equitable way and allow planners and policymakers to have a better understanding of the contribution that different diseases and injuries make to the total burden of disease.[12]

Health inequalities in Scotland have been well documented, including the contribution of different causes to inequalities in mortality.[1 2 13–15] There is, however, little information on how specific diseases contribute to these health inequalities within a standardised measurement framework, accounting for both premature mortality and the effects of morbidity. Using data from the Scottish Burden of Disease (SBoD) study, we assessed the contribution of individual disease and injuries, across a broad range of causes of morbidity and mortality, to absolute and relative health inequalities in Scotland in 2019.

METHODS

Data

Area-level deprivation was measured using the Scottish Index of Multiple Deprivation (SIMD version 2016).[16] The SIMD quantifies deprivation based on data zones, a geographical unit comparable to a postcode. Using pooled and weighted data from seven domains (employment, income, crime, housing, health, education and geographical access), each data zone is given a composite rank out of 6976 data zones. The composite rank was then converted to a decile, with 1 assigned to the 10% most deprived data zones and 10 to the 10% least deprived data zones.

Estimates of the number of YLL, YLD and DALYs for 13 broad disease groupings and 70 individual causes of disease and injury were sourced from the SBoD 2019 study.[17] YLL estimates were derived by multiplying age group-based mortality counts by the aspirational age-conditional life expectance from the Global Burden of Disease Study's 2019 reference life table.[18] The deprivation decile was derived using the individual's postcode of registered residence. YLD estimates were based on applying 5-year age-specific rates, separately for each combination of deprivation decile for males and females, to mid-year population estimates for 2019, sourced from the National Records of Scotland.[19] As the underlying YLD rates were based on 2016 estimates, this approach assumed that any changes in the levels of YLD are entirely due to changes to the underlying demographic structure of the Scottish population.

Analyses

All analyses were carried out at the level of age group and SIMD decile to facilitate the calculation of age-standardised rates (ASR). ASR using mid-year population estimates were calculated directly to the 2013 European Standard Population.[19 20] ASR removes the contribution of differences in underlying population structure between SIMD deciles to facilitate like-for-like comparisons. All ASR findings are presented per 100 000 population.

We estimated inequalities using several measures. The absolute and relative range differences in ASR were estimated as the difference and ratio, respectively, between the most and least deprived deciles. Additionally, inequalities were measured using the Slope Index of Inequality (SII) and Relative Index of Inequality (RII).[21 22] The SII captures the difference in the average health status between a person in the highest socioeconomic group and a person in the lowest socioeconomic group. The SII is defined as the slope of the 'best fit' regression line showing the relationship between the health status of a particular group and that group's relative rank on the deprivation scale. ASRs were used to calculate SII and RII. An equal rate across the deprivation categories would give a horizontal line with a slope of zero (SII=0), indicating no inequalities. The SII can be interpreted as the absolute effect on health of moving from the lowest socioeconomic group through to the highest. The larger the absolute value of SII, the greater the inequalities observed. The RII describes the gradient of health observed across the deprivation scale, relative to the mean health of the whole population. Unless explicitly explained, the RII indicates the extent to which health outcomes are better in the least deprived areas, or worse in the most deprived areas, compared with the mean The RII was estimated by dividing the SII rate by the overall Scottish rate. A value of 0 for the RII indicates no inequality and a greater magnitude away from this value indicates greater inequality. Disease DALYs attributable to area deprivation were estimated by using the least deprived decile as the reference group and summing all DALYs in excess of this reference across the other nine

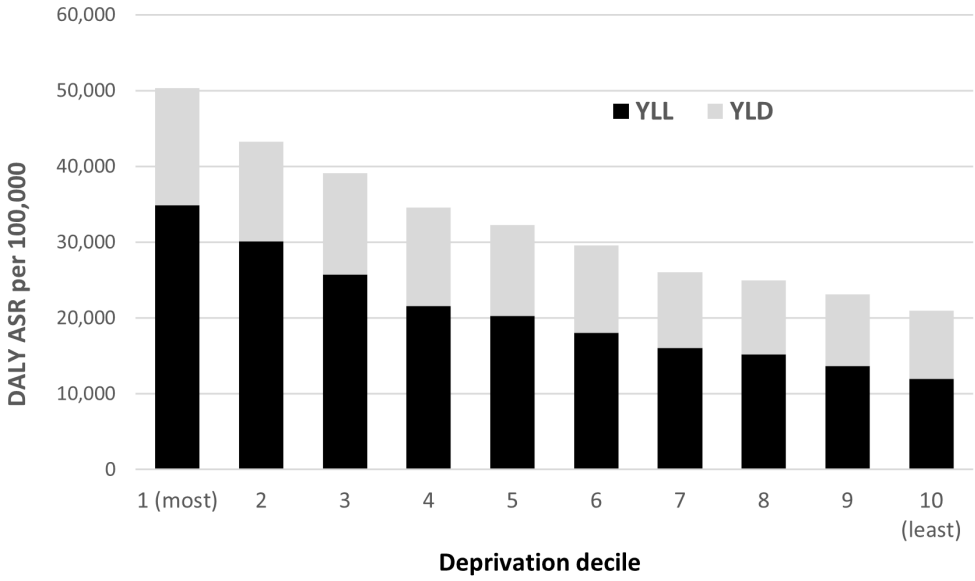

Figure 1 All-cause DALYs (per 100 000) by SIMD decile, Scotland, 2019. DALY, disability-adjusted life-year; SIMD, Scottish Index of Multiple Deprivation; YLD, years lived with disability; YLL, years of life lost.

deprivation deciles. All DALYs in excess of this reference group, were summed and expressed as a percentage of the overall disease burden.[23]

Results for all inequality measurements are presented for 13 disease groups and the 20 leading individual causes of disease and injury in Scotland, based on an abridged version of the disease classification from the Global Burden of Disease 2019 study.[18] All analyses were performed using R and RStudio.[24 25]

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

RESULTS

Inequalities in the disease burden

There were approximately 1 732 800 DALYs lost in Scotland in 2019 (ASR 32 093 per 100 000 population), with YLL accounting for 63.5% of total DALYs. We found evidence of marked inequalities in DALYs across areas experiencing different levels of deprivation (figure 1). DALYs in the most deprived areas were double that of the least deprived areas (ASR: 50 305 vs 20 955). Additionally, there were inequalities in the composition of DALYs across areas experiencing different levels of deprivation with YLL accounting for 67.8% of total DALYs in the most deprived areas, compared with 57.1% in the least deprived areas (figure 2). The impact of this meant that the contribution of YLD to total DALYs increased with decreasing levels of deprivation, from 32.1% in the most deprived decile, rising to 42.9% in the least deprived decile. Furthermore, YLL in the most deprived decile was over 1.5 times higher (34 922 per 100 000 population) than total DALYs (20 955 per 100 000 population) in the least deprived decile (online supplemental table 1).

Absolute and relative inequalities in all cause DALYs

The absolute difference in all-cause DALYs between the most and least deprived areas in Scotland was approximately 29 350 per 100 000 population (table 1). The relative difference in DALYs between the most and least deprived areas was 2.4, indicating that DALYs were 2.4 times higher in our most, compared with least, deprived areas. The RII was 0.95, which when multiplied by 0.5 and expressed as a percentage means that the rate in the most deprived areas was 47.5% higher than the mean rate of DALYs in the Scottish population. The difference between the most and least deprived areas, measured by SII was 30 502 DALYs per 100 000 population. DALYs attributable to differences in area deprivation accounted for 35% of total DALYs.

Absolute and relative inequalities in disease groupings

In terms of absolute rate differences of DALYs, between the most and deprived areas, substance use disorders had the largest difference (6837 DALYs per 100 000 population), followed by cancers (4783 DALYs per 100 000 population) and cardiovascular diseases (4583 DALYs per 100 000 population) (table 1). For all others disease groups, except sensory conditions, there were positive absolute rate differences, indicating that the rate of DALYs were higher in the most, compared with least deprived areas.

Relative rate differences between the most and least deprived areas were also evident. In over half (9 out of 17) of the disease groups, the relative rate difference was >2.0. Substance use disorders had the highest relative rate difference (20.5), followed by chronic respiratory

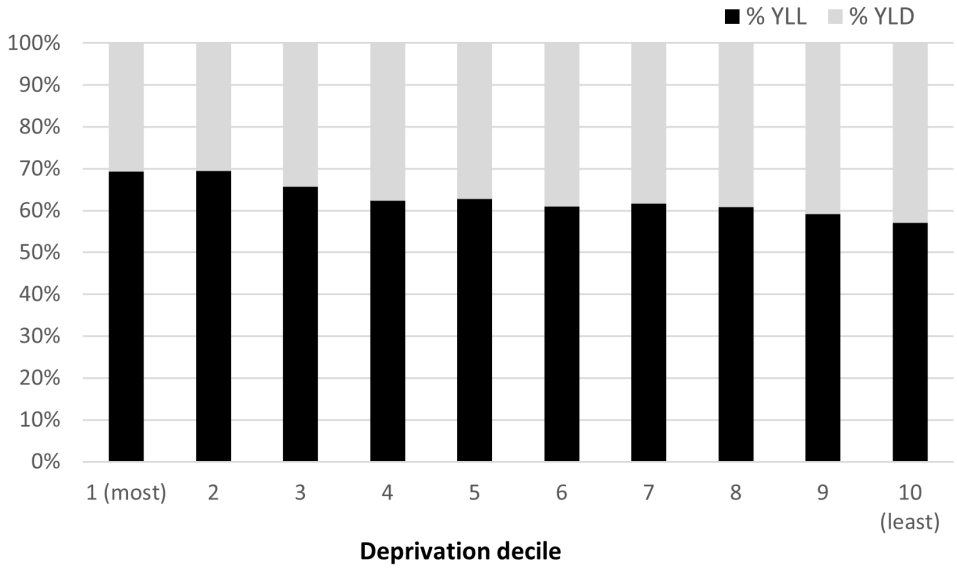

Figure 2 Proportion of YLL and YLD by SIMD decile, Scotland 2019. SIMD, Scottish Index of Multiple Deprivation; YLD, years lived with disability; YLL, years of life lost.

diseases (4.0) and digestive diseases (3.5). These three disease groups also had the highest RII values indicating that the rate in most deprived communities was higher than the mean rate of population: substance use disorders (RII=2.82), chronic respiratory diseases (RII=1.49), digestive diseases (RII=1.41).

The disease groups with the largest estimates of DALYs attributable to inequalities in area deprivation were: substance use disorders (84.5%); chronic respiratory diseases (54.0%) and digestive diseases (49.7%). Conversely, we found a negative association for DALYs inequality attributable DALYs for sensory conditions

Table 1 Inequalities in the broad causes of DALYs, per 100 000 population, Scotland, 2019

Disease group	ASR of DALYs per 100 000	Absolute rate difference between most and least deciles	Relative rate difference between most and least deciles	Slope Index of Inequality	Relative Index of Inequality	Attributable DALYs (%)
Cancers	6460	4780	2.0	4831	0.75	27.6
Cardiovascular diseases	5416	4583	2.3	5206	0.96	36.3
Neurological disorders	3534	1009	1.4	1069	0.30	22.3
Mental health disorders	2494	2464	2.6	2622	1.05	38.3
Musculoskeletal disorders	2263	399	1.2	530	0.23	13.7
Substance use disorders	2250	6837	20.5	6334	2.82	84.5
Chronic respiratory diseases	1871	2627	4.0	2788	1.49	54.0
Injuries	1646	1980	3.1	2061	1.25	43.5
Other non-communicable diseases	1506	826	1.7	922	0.61	24.2
Digestive diseases	1503	1953	3.5	2118	1.41	49.7
Diabetes and chronic kidney diseases	1133	1028	2.5	1108	0.98	38.3
Communicable, maternal, neonatal and nutritional diseases	1119	1069	2.5	1092	0.98	38.3
Sensory conditions	815	–204	–0.8	–169	–0.21	–13.8
All causes	32 093	29 350	2.4	30 512	0.95	35.3

ASR, age-standardised rate; DALYs, disability-adjusted life-years.

Table 2 Inequalities in the 20 leading causes of DALYs, Scotland, 2019

Leading causes	ASR of DALYs per 100 000	Absolute rate difference between most and least deciles	Relative rate difference between most and least deciles	Slope Index of Inequality	Relative Index of Inequality	Attributable DALYs (%)
Ischaemic heart disease	2572	3027	3.2	3165	1.23	46.2
Alzheimer's disease and other dementias	1764	492	1.4	576	0.33	25.0
Drug use disorders	1673	5452	28.3	5003	2.99	88.0
Tracheal, bronchus and lung cancer	1596	2475	4.3	2518	1.58	54.9
Cerebrovascular disease	1450	790	1.8	1022	0.70	30.7
Chronic obstructive pulmonary disease	1293	2358	6.4	2442	1.89	67.6
Low back and neck pain	1269	355	1.3	430	0.34	17.5
Depression	1243	1212	2.6	1282	1.03	38.2
Other cancers	1183	955	2.1	865	0.73	24.8
Headache disorders	982	−19	1.0	20	0.02	15.0
Other cardiovascular and circulatory diseases	908	574	1.8	738	0.81	30.2
Anxiety disorders	852	809	2.5	861	1.01	37.9
Self-harm and suicide	789	1315	4.9	1279	1.62	56.8
Colon and rectum cancer	752	226	1.3	219	0.29	21.4
Diabetes mellitus	744	688	2.5	760	1.02	39.7
Lower respiratory infections	699	670	2.5	717	1.03	37.9
Cirrhosis and other chronic liver diseases	626	1107	5.4	1164	1.86	62.6
Alcohol use disorders	577	1385	10.2	1332	2.31	74.4
Breast cancer	555	84	1.2	77	0.14	8.0
Other digestive diseases	431	465	3.0	502	1.17	47.9
All cause DALY	32 093	29 350	2.4	30 512	0.96	35.3

ASR, age-standardised rates; DALYs, disability-adjusted life-years.

(−13.8%). The estimates of inequality attributable DALYs for all other disease groups ranged from 13.7% for musculoskeletal disorders to 43.5% for injuries.

Absolute and relative inequalities in individual causes

Of the 20 leading causes of diseases burden, drug use disorders had the largest absolute rate difference (5452 DALYs per 100 000 population) between the most and least deprived areas, followed by ischaemic heart disease (3027 DALYs per 100 000 population), lung cancer (2475 DALYs per 100 000 population) and chronic obstructive pulmonary disorder (2358 DALYs per 100 000 population) (table 2). For most of the remaining causes, there were positive absolute rate differences in DALYs, indicating DALYs were higher in the most compared with least deprived areas. The only exception to this was headache disorders, which had a negligible negative estimate of −15 DALYs per 100 000 population.

Relative rate differences between the most and least deprived areas were also evident across most of the leading individual causes of disease burden. Drug use disorders had the highest relative rate difference (28.3) then followed by alcohol use disorders (10.2), chronic obstructive pulmonary disorder (6.4), cirrhosis and other chronic liver diseases (5.4) and self-harm and suicide (4.9).

The diseases with the highest relative rate differences also had some of the highest RII values, indicating that the rate in most deprived communities was higher than the mean rate of population (Scotland-level RII=0.96) for these diseases: substance use disorders (RII=2.99), alcohol use disorders (RII=2.31), chronic obstructive pulmonary disorder (RII=1.89), cirrhosis and other chronic liver diseases (RII=1.86), self-harm and suicide (RII=1.6) and lung cancer (RII=1.6). Notably, several conditions out with the leading causes of disease burden in Scotland had high RII values in the most deprived decile compared with mean rate of population, including schizophrenia (RII=5.5) and epilepsy (RII=4.7) (online supplemental table 2).

The estimate of all-cause inequality attributable DALYs was 35.3%; however, this varied considerably by individual cause (table 2). Of the 20 leading causes of disease burden, DALYs attributable to inequalities in area deprivation ranged from 88.0% for drug use disorders, 74.4% for alcohol use disorders DALYs and 67.6% for chronic obstructive pulmonary disorder, to 17.5% for low back and neck pain and 15% of headache disorder DALYs.

DISCUSSION

Our study evidences the extent of stark levels of absolute and relative inequality, using range and distributional measures, in Scotland in 2019, prior to the COVID-19 pandemic. The overall disease burden was double that in the most deprived areas in Scotland, largely driven by inequalities in mortality. We found that the gap in the burden of disease is so wide that the fatal burden of disease (YLL) in the most deprived areas was higher than the total burden of disease (DALYs) in the least deprived areas. We already know from life expectancy figures that people in the most deprived communities die at younger age. They also spend more than a third of their lives in poor health compared with the least deprived communities.[4 5] Our findings further strengthen our understanding of the cause-specific diseases driving the interaction between stalling mortality improvements, healthy life expectancy and health inequalities.[26 27]

Many of the leading causes of disease burden in 2019—heart disease, drug use disorders, lung cancer and chronic obstructive pulmonary disease (COPD)—were also the leading drivers of absolute and relative inequalities in the disease burden. Causes such as: alcohol, and drug use disorders; liver cirrhosis; COPD; lung cancer; and, self-harm and suicide, exhibited the largest relative inequalities in disease burden which is consistent with results published elsewhere in the literature.[2 13 15] The absolute and relative inequalities in the burden of disease in Scotland from these causes underline that the health of the population, and health inequalities within the population, are shaped by wider determinants of health such as economic, social, and environmental factors and not solely due to individual health behaviours.[28 29] On the other hand, there were health conditions where there were smaller, to no, inequalities, for example, sensory conditions, headaches and some musculoskeletal conditions indicating that burden does not vary across deprivation groups for these causes. Triangulating these results with estimates of inequality-attributable DALY estimates for COVID-19 indicates that although COVID-19 infection has likely increased all-cause inequalities, there are several other causes of disease which have a much larger impact in driving levels of all-cause inequality in the burden of disease.[8]

The COVID-19 pandemic has caused almost unprecedented change across health, education and the economy in Scotland and across the world. COVID-19 has been shown to have a substantial impact on the population health in Scotland; however, this impact was not shared equally across areas experiencing different levels of socioeconomic deprivation; in Scotland, the marked inequalities in COVID-19 YLL reported in 2020 were further exacerbated in 2021, to the extent that approximately half of COVID-19 YLL was attributable to inequalities in area deprivation. This widening of inequalities in 2021 was confirmed across all measures of absolute and relative inequality.[7 8] Furthermore, health problems that existed before the COVID pandemic, have not gone away, and in many cases have been exacerbated through the impact of the economic lockdown and the unintended consequences of the policy responses to the pandemic, and unless future harm is prevented, this trend will continue.[30 31] Integrating this impact, quantitively, is difficult, and trends may not be comparable due to the major disruptions, and changes in access to, and delivery of, services, and the competition between causes of mortality.[32] These inequalities have emerged through the syndemic nature of COVID-19—as it interacts with and exacerbates existing social inequalities in the disease burden and the social determinants of health[33]—prior to the pandemic, improvements in life expectancy and healthy life expectancy in Scotland had stalled since 2012, with a slowdown in the overall progress of reducing mortality and widening of socioeconomic inequalities in mortality.[5 34–37] The results presented in this paper are, therefore, likely to be representative of wider pre pandemic trends given that YLD does not change quickly over time and that YLL estimates ultimately drive changes in the overall DALYs. Our estimates help us to understand the state of prepandemic inequalities, providing important baseline positions that can be triangulated with robust, and locally relevant, emerging evidence, to assess the likely impact of the pandemic, and other public health crisis such as the current cost-of-living crisis, on non-COVID and COVID-19-related health inequalities.

Strengths and limitations

This study has several important strengths. First, this study assesses the impact of inequalities using DALYs for over 70 individual diseases, conditions and injuries. DALYs provide a composite, internally consistent measure of population health loss which can be used to evaluate the proportionate burden of different diseases and injuries and compare population health by geographical region and over time. By combining information on fatal and non-fatal burden, BOD studies allow planners and policymakers to have a better understanding of the contribution that different diseases and injuries make to the total burden of disease and how this burden varies by levels of deprivation. This in turn supports decisions about where prevention and service activity should be focused to address health inequalities in Scotland.

YLD estimates are derived from surveys, and routine administrative data and as such may not be fully representative of the underlying burden by deprivation decile, for example, administrative data are reflective of demand

rather than need. This is also relevant for severity distributions, which are internationally derived with cancers being the main exception. In terms of impact of study results by deprivation decile, on the absolute scale this is most relevant for the causes with the largest YLD estimates, or those where YLD is the main contributor to disease-specific DALYs. For those causes which have a larger YLL component, it is plausible that any biases in YLD from unmet need or survey-specific bases will have a smaller impact on the DALY estimate if this unmet need causes disease-specific excess mortality.

Our measure of deprivation is area-based rather than individual measure and is, therefore, likely to misclassify many individuals into categories that do not reflect their individual experiences.[38] Although the SIMD includes health indicators in its range of domains (thereby raising the theoretical possibility of reverse causality whereby people are ordered by the health outcome rather than socioeconomic deprivation), the employment-income deprivation index (ie, excluding the health measures) is very highly correlated with the overall SIMD index and so this is unlikely to have changed the results.[39 40] Furthermore, the SII and RII have the advantage that they are based on data about the whole population, rather than just the extremes, and so take into account inequalities across the entire distribution of inequality. They do, however, require a reasonably linear relationship between outcomes and exposures.[41]

Some burden of disease studies attempt to propagate the uncertainty around DALY estimates by estimating uncertainty intervals, which combine sampling error and non-sampling errors arising from study design. This approach was developed to avoid misleading users over how precise confidence intervals were, given they only capture the extent of sampling error. However, other approaches have been developed to give a sense of how uncertain an estimate might be, such as developing a scoring system over how certain, or otherwise, an estimate may be.[42] In this context, the results which we have found for neck and low back pain and headaches have the highest levels of uncertainty when using the uncertainty measured estimated via the SBOD study.

CONCLUSION

This study demonstrates that even before the COVID-19 pandemic there was a steep stepwise gradient in the burden of disease experienced across the Scottish population. This was evident for YLL and YLD, and almost every specific cause of death. By exploring cause-specific inequalities within a standardised measurement framework, to permit equitable comparisons across diseases and injuries, we confirm the stark gap between the most and least deprived areas in Scotland in 2019 prior to the COVID-19 pandemic and show that many of the leading causes of disease burden in 2019 were also the leading drivers of absolute and relative health inequalities in the disease burden.

Given the prepandemic stalling of mortality trend improvements and widening health inequalities, and the exacerbation of these caused by COVID-19, urgent policy attention is required to reduce the burden of fatal and non-fatal conditions in Scotland.

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Contributors IG (guarantor): conceptualisation, methodology, writing–original draft. GMAW: conceptualisation, methodology, review and editing EF: methodology, formal analysis, review and editing. FL, GM and DS: review and editing. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the Scottish Burden of Disease Study was approved by the Public Benefit and Privacy Panel for Health and Social Care under application number 1920-0222 (PAC 51-14). As clinical records are provided without explicit patient consent, the panel requires the public benefit of the research to clearly outweigh any impact on individual patient privacy, and appropriate safeguards and security to be in place to protect patients. The panel granted access to deidentified patient data, accessible only through Public Health Scotland with data safeguarding qualifications. In addition, a data protection impact assessment was also completed (DP20210404) to identify, assess and mitigate any actual or potential risks to privacy created by a proposed or existing process or project that involves the use of personal data. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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