LUND UNIVERSITY
Faculty of Medicine

Master's Programme in Public Health

Geographical inequalities in burden of disease at local authority level in Scotland: A subnational analysis for the Scottish Burden of Disease Study 2016

Georgia Dyer

Supervisor: Yan Borné

Associate Professor at Cardiovascular Research, Lund University, Sweden

Co-supervisor: Grant Wyper

Public Health Intelligence Adviser, Public Health Scotland, Scotland

Abstract

Background Scotland possesses the worst mortality outcomes and slowest improvement in life expectancy of Western Europe. Within Scotland, stark inequalities exist in both morbidity and mortality. There remains paucity in assessment of subnational variation in disease burden.

Aim This thesis explored geographical inequalities in burden of disease (BoD) across 32 Scottish authorities. Secondary analysis assessed association between geographical deprivation and disease burden.

Methods Local data was extracted from the Scottish Burden of Disease 2016 study and encompassed disability-adjusted life years (DALY), years of life lost (YLL), and years lived with disability (YLD) for 68 causes of disease across 32 Scottish local authorities. Geographical trends were assessed for age-standardised all cause rates and for national 10 leading causes, in addition to age- and sex-specific rates. The association between all cause DALY and deprivation was analysed using the Scottish Index of Multiple Deprivation (SIMD).

Findings Glasgow City possessed highest burden for all cause age-standardised rates. Western authorities had largest burden in 8 leading causes whilst Eilean Siar led in 2. Across authorities, working ages showed similar burden in lower back and neck pain, depression, and anxiety disorders. There was a significant association between all cause DALY and SIMD, increased disease burden was associated with increased deprivation. Generally, Western authorities showed greatest levels of deprivation and BoD; Western regions East Dunbartonshire and East Renfrewshire were exceptions, possessing lowest BoD and deprivation of 32 local authorities.

Conclusion Findings show subnational variation in BoD, with nationwide trends of psychosocial morbidity. These estimates at local level will inform policy makers and key stakeholders of effective resource allocation and priority setting across Scottish authorities. Policies that redistribute income to most deprived of the population hold greatest promise in addressing key determinants of health and accordingly geographical inequalities in BoD.

Table of Contents

Abbreviations

BoD	= Burden of Disease
CBT	= Cognitive behavioural therapy
DALY	= Disability-Adjusted Life Years
COPD	= Chronic obstructive pulmonary disease
GBD	= Global Burden of Disease
IHD	= Ischaemic heart disease
LBNP	= Lower back and neck pain
SBoD	= Scottish Burden of Disease
SEP	= Socioeconomic position
SDH	= Social determinants of health
SIMD	= Scottish Index of Multiple Deprivation
WCS	= West Central Scotland
YLL	= Years of Life Lost
YLD	= Years Lived with a Disability

1. Introduction

1.1 Background

Scotland has the highest mortality rates of Western Europe[1, 2]. Its excess mortality has historically been greater than the United Kingdom average, exacerbated by perpetually higher mortality rates occurring in younger working age groups[3]. This now manifests in Scotland possessing the widest mortality inequalities, congruous with the slowest improvement in life expectancy, of West and Central Europe[2, 4]. Studies aimed at explicating Scotland's trends in mortality, compared to its neighbouring countries of England and Wales, have accounted for differences in poverty and deprivation level[5-7]. However, the insufficiency of these hypotheses in providing an answer for Scotland's excessive premature mortality have resulted in the phenomenon of Scotland's inequitable health being coined the term "Scottish effect"[6].

In order to accurately depict a country's disease burden, it has become increasingly evident that inclusion of morbidity estimates in conjunction with mortality rates is imperative. Since the establishment of the Global Burden of Disease (GBD) study in 1990, the largest observational epidemiological study of its kind, an increasing number of countries are performing their own independent Burden of Disease (BoD) studies[8]. The Scottish Burden of Disease (SBoD) study is a national study that quantifies the health of the Scottish population based upon both morbidity and mortality estimates, calculated from fatal and non-fatal causes[9]. Estimates are given in disability-adjusted life years (DALY), a composite measure of total health loss from years lived with a disability (YLD) and years of life lost (YLL) due to premature mortality[9, 10]. SBoD utilises Scotland's comprehensive health management system; relying on country-specific data merits increased confidence and reliability of BoD estimates, in comparison to GBD's modelling approach[9].

The principal advantage BoD studies offer is the universal framework they provide for between country comparison of population health; however, gaining increasing recognition is the need for subnational regional estimates[11-13]. Health policy is devolved within the UK, and further within Scotland itself; governance, resource allocation, and service provision are devolved to the health boards and local authorities, who together integrate health services[14]. A recent study investigated BoD in local authority regions of England and made absolute comparison, at country level, to BoD in Scotland[13]. This recapitulated the established "Scottish effect" of Scotland possessing worse mortality outcomes compared to the UK however failed to provide practical insight into trends of health disparities within Scotland. Principally, studies that have

assessed subnational trends in mortality within Scotland have focused on the West of Scotland, and more specifically the Greater Glasgow area, owing to its established high excess premature mortality concurrent with high levels of deprivation[15-17]. The aforementioned "Scottish effect" extends to Glasgow City; adjustment for socioeconomic factors does not account for the city's excess mortality and thus the "Glasgow effect" is similarly alluded to in literature[16, 18-20]. The inconclusiveness of deprivation in explaining Scotland's mortality inequalities may in part be owed to the oversimplified and outdated measure of deprivation predominantly utilised, the Carstairs & Morris index[21]. The indicators of car ownership, male unemployment, overcrowding, and low social class do not effectively encapsulate the social and economic deprivation inflicted on present day society. Moreover, studies aimed at explaining the "Scottish effect" share the inherent specificity of focusing upon Glasgow or the West of Scotland, thus precluding extrapolation of findings to alternate local authorities[6, 7, 16]. Investigating geographical inequalities comparatively between the 32 Scottish unitary authorities will reveal subnational variation in health outcomes, and subsequently inform regional health boards of their priorities and the appropriate allocation of resources.

Accordingly, Scotland's devolved health policy and deprivation disparities necessitates local authority BoD analysis. The provision of morbidity estimates is a distinct value of BoD studies and will provide further insight into how regional differences of health outcomes manifest. A recent report by the SBoD study concluded almost one third of disease burden in Scotland to be attributed to inequalities in deprivation[22]. This report utilised the Scottish Index of Multiple Deprivation (SIMD) in a country-wide analysis. SIMD is currently the most comprehensive measure of resources and opportunities accessible at community level in Scotland, encompassing domains of area deprivation beyond traditional indicators. Therefore, utilising SIMD in local analysis will serve understanding of how social determinants of health (SDH) conduce toward inequalities between authorities[6, 18, 23].

This thesis will be the first detailed account of findings from the SBoD 2016 study for local authority regions of Scotland. In accord with the SBoD 2016 report detailing leading causes of BoD at national level, these will be applied in present analysis to assess how national trends manifest at subnational level. It is important to note, within Scotland and the UK health inequalities are used to describe the "unjust and avoidable differences in people's health" (the definition typically ascribed to health *inequities)* and hence this thesis will adopt terminology in alignment with Public Health Scotland[24]. This analysis has the fundamental implications of effectively identifying local authority health needs, resource allocation, and policy setting.

1.2 Research Questions

Do geographical inequalities in BoD exist between local authority regions of Scotland? To what extent does deprivation account for observed variation between authorities?

1.3 Aim of Study

The principal aim of this study is to describe geographical inequalities in trends of all cause and national 10 leading causes of disease burden, across 32 local authority regions of Scotland. The supplementary aim is to explore how deprivation level, measured by SIMD, contributes to observed variation in disease burden between authority regions.

2. Methods

2.1 Study Design and Setting

The aim of this study was to assess trends in BoD of the Scottish population, and therefore this was an ecological observational study design. Scotland is divided at an aggregate level into three regions (North, East, West), subdivided into fourteen NHS health boards, and further into 32 unitary authorities (otherwise termed local authorities). The local authority regions are shown in Figure 1. The subdivision from NHS health board to local authority is illustrated in Figure 1 of the supplementary material.

2.2 Data Collection

Data was obtained from the SBoD 2016 study[9]. BoD estimates were calculated from fatal (YLL) and non-fatal (YLD) causes provided by the National Records of Scotland[9, 25]. Data comprises BoD estimates for 68 causes of morbidity and mortality; stratified by geography, sex, and age-group. Age is given in five age-groups of: 0-14 years, 15-24, 25-44, 45-64 and 65 years and over. Estimates are given in DALY, YLL, YLD rates, prevalent cases and deaths. The 68 cause list is an abridged version of 132 causes. Causes of death at all ages are provided in a four-tiered hierarchy, level 1 constitutes the most aggregate level. Causes of morbidity and mortality were analysed at level 3 to ensure accurate depiction of population health status[13].

Estimates delineated by geography are given at region, health board, and local authority level. Local authorities were the focus of this study, which represent aggregates of the 32 council regions and not individual level data. Estimates are given in absolute numbers and age-standardised rates (per 100,000 of population). The 2013 European Standard Population was applied to all cause DALY rates with the unit of analyses both sexes and all ages, to account

for differences in age structure between population sub-groups. Population estimates for the local authority regions were based on the 2016 midyear populations of each respective area[25, 26].

2.3 Years of Life Lost and mortality estimates

YLL were computed by calculating the frequency of mortality and the national life expectancy at age of death. The Scottish national life table was applied, which ascribes males with a life expectancy of 77 years and females 88 years at birth[27]. YLL and mortality rates reflect a 3 year average across 2014-16. One tenth of death registrations were distributed to multiple causes of disease and injury[9].

2.4 Years Lived with a Disability

YLD were calculated by multiplying the frequency of morbidity (number of years lived with disability) and the level of disability experienced. Standard disability weights were applied for each cause, and comorbidity corrected for. YLD estimates for local authority regions were modelled and reflect a 3 year average across 2014-2016; variables included in the model were age, sex, and SIMD deprivation decile. A total of 400 stratifications of morbidity rates were produced for the 132 cause list. These were used in conjunction with the 2016 midyear population estimates to produce prevalence and YLD estimates for each geographical area.

2.5 Disability-Adjusted Life Years

DALY were computed by summing the YLD and YLL by cause, age group, sex, and local authority region. A RAG status measure was provided for all estimates indicating accuracy and robustness; a green status is indicative of highly accurate and robust estimates, amber of reasonably robust with up to a moderate degree of adjustments made to input data, and red of less comprehensive data sources with a high degree of adjustments performed and thus should be treated with a large degree of uncertainty[9]. Of the national 10 leading conditions included in analysis, 8 possessed green RAG status: ischaemic heart disease (IHD), depression, tracheal, bronchus and lung cancer (lung cancer), cerebrovascular disease, Alzheimer's disease and other dementias, drug use disorders, chronic obstructive pulmonary disease (COPD) and anxiety disorders. Lower back and neck pain (LBNP) and migraine possessed amber RAG status, whilst no conditions were rated red. The age category of 0-14 years was out of the scope of this thesis and therefore omitted from analysis.

2.6 Scottish Index of Multiple Deprivation

SIMD is a relative measure of deprivation computed by the Scottish Government[23]. SIMD represents 6,976 data zones which constitute between 29 and 746 data zones for each local authority. SIMD is composed of seven domains: income, employment, education, health, access to services, crime, and housing. SIMD ranks data zones from most deprived (ranking of 1) to least deprived (ranking of 6,976). SIMD ranking for each local authority was calculated by using population estimates for each data zone and multiplying by the corresponding SIMD ranking. Rankings were then aggregated and divided by the total population of the local authority, to produce a weighted-average SIMD score.

2.7 Statistical analysis

Descriptive statistics were produced for all cause and cause specific age-standardised rates, in addition to age-specific and sex-specific rates. Linear regression was performed to assess the effect of SIMD local authority ranking on all cause DALY rates. Both exposure (SIMD ranking) and outcome (all cause DALY) were weighted averages that adjusted for age and sex between regions. Statistical test was two-sided, p-value <0.05 was considered significant. Descriptive statistics and statistical analysis were conducted using R Studio version 1.2.5033 and R version 3.5.3; Figure 1 in the supplementary material was produced using the online data visualisation tool Flourish[28].

2.8 Ethical considerations

The SBoD 2016 dataset is publicly available, and approved for research purposes, therefore ethical approval from a committee was not required. Similarly, informed consent was not required from individuals as data was derived from a national registry. The principal of no harm holds relevance if citizens from identified authorities of large disease burden attribute their area of residence to increased personal risk of poor health. However, findings are based on population data rather than individual and thus should be interpreted as BoD and deprivation trends.

3. Results

3.1 All cause age-standardised rates

The all cause age-standardised DALY rates for local authority regions of Scotland are shown in Figure 2A and Figure 3. Glasgow City possessed highest all cause DALY rates (30,359 per

100,000 population); followed by West Dunbartonshire, Dundee City, North Lanarkshire, and Inverclyde, respectively, for highest overall disease burden. In comparison, East Renfrewshire possessed the lowest DALY rate (20,331 per 100,000 population); followed by East Dunbartonshire, Orkney Islands, Aberdeenshire, and Perth and Kinross, respectively.

Similar trends were observed for all cause age-standardised YLL and YLD rates (Figure 2B/C and 3). The all cause YLL rate was highest in Glasgow City (17,427 per 100,000 population) and lowest in East Renfrewshire (10,107 per 100,000 population); West Dunbartonshire, Dundee City, North Lanarkshire, and Inverclyde followed Glasgow City in highest fatal disease burden (YLL) (Figure 2B and 3). Whereas East Dunbartonshire, Orkney Islands, Perth and Kinross, and Aberdeenshire succeeded East Renfrewshire in all cause YLL rates. Similarly, all cause YLD rate was highest in Glasgow City (12,931 per 100,000 population) and lowest in East Renfrewshire (10,223 per 100,000 population); with West Dunbartonshire, North Ayrshire, Inverclyde, and North Lanarkshire succeeding in highest non-fatal disease burden (YLD) (Figure 2C and 3). Across the 32 local authorities, all cause YLL varied in range by 7,319 per 100,000 population compared to all cause YLD which showed a range of 2,708 per 100,000 population.

3.2 National ten leading causes of disease burden

The leading ten conditions contributing to overall disease burden, by age-standardised DALY rate, are shown in Table 1 of the supplementary material. The largest burden was from IHD, followed by LBNP, depression, cerebrovascular disease, and lung cancer (Figure 4; Table 1 and Figure 2 of supplementary material). Similar treads to all cause burden were observed, Glasgow City showed the highest DALY rate for five of the ten leading causes: IHD, depression, lung cancer, COPD, and anxiety disorders (Figure 4A/C/D/I/J). Eilean Siar showed the largest disease burden for LBNP and migraine (Figure 4B and 4G); whilst West Dunbartonshire, Renfrewshire, and Inverclyde exhibited largest BoD for cerebrovascular disease, Alzheimer's disease and other dementias, and drug use disorders (Figure 4E/F/H).

3.3 Age-specific rates of national leading causes

3.3.1 Age differences in causes

Similar trends were observed for age-specific DALY rates of the national 10 leading causes, across local authorities (Figure 4). For 65 years and over, causes predominantly affecting this age group were IHD, lung cancer, cerebrovascular disease, Alzheimer's disease and other

dementias, and COPD (Figure 4A/D/E/F/I). Whereas the cause most affecting 25-44 year olds was drug use disorders (Figure 4H). In the working age groups of 25-44 and 45-63 years, LBNP, depression, and anxiety disorders showed similar weighting of burden (Figure 4B/C/J). Similarly, the age group 15-24 years showed homogenous burden from migraine, with similar weighting to the former age categories (Figure 4G).

3.3.2 Local authority differences in age-specific rates

Compared to nationwide trends of age differences in causes, local authority differences were observed. For COPD, Shetland Islands showed the largest disease burden in 25-44 years with a DALY of 521 (per 100,000 population) (Figure 4I). For drug use disorders, the highest proportion of 15-24 years affected was in West Dunbartonshire (DALY of 1,787 per 100,000 population) (Figure 4H).

3.4 Sex-specific rates of national leading causes

3.4.1 Sex differences in causes

Similar trends were observed across local authorities for sex-specific DALY rates of the national 10 leading causes (Figure S2). Causes with the greatest proportion of males affected were IHD and drug use disorders (Figure S2A/H). Whereas causes predominantly affecting females were migraine and anxiety disorders (Figure S2G/J). These trends were observed across all local authorities. Depression and COPD showed almost equal contributions to disease profiles from each sex, across authority regions (Figure S2C/I).

3.4.2 Local authority differences in sex-specific rates

Compared to nationwide trends of sex differences in causes, deviation was observed in West Dunbartonshire for lung cancer. This showed females to be predominantly affected compared to males (Figure S2D).

3.5 Linear regression of all cause DALY by SIMD ranking

The SIMD rank by local authority region is shown in Figure 3 of the supplementary material. Simple linear regression was performed to investigate the association between all cause DALY (age-standardised rate per 100,000 population) and SIMD ranking (Figure 5). A scatterplot was made which clearly depicted a strong negative linear relationship, data was confirmed to be normally distributed with a Shapiro-Wilk test. This allowed for a linear regression analysis which showed a significant relationship between SIMD ranking and DALY ($p < 0.0001$). The

slope coefficient for SIMD was -3.218 predicting for every 1 increase of SIMD rank the DALY rate would decrease by 3.2. The R^2 value of 0.86 indicates 86% of the variation in DALY can be explained by this model containing only SIMD rank. Glasgow City and Dundee City were observed outliers exhibiting particularly high deprivation and DALY rates. Generally, authorities from the West of Scotland showed greater levels of deprivation and BoD comparative to other regions; with the exception of Western authorities East Dunbartonshire and East Renfrewshire which were outliers to this trend. Significant associations were also found for all cause YLL and SIMD ranking and all cause YLD and SIMD ranking, results are shown in Figure 4 of the supplementary material.

4. Discussion

4.1 Main findings

This study aimed to describe subnational variation in trends of all cause and national leading causes of disease burden, across local authority regions of Scotland. For all cause age-standardised DALY, YLD, and YLL rates, Glasgow City possessed the highest disease burden whilst East Renfrewshire possessed the lowest. Authorities succeeding Glasgow City in highest all cause DALY were: West Dunbartonshire, Dundee City, North Lanarkshire, and Inverclyde (respectively from highest). Across Scotland, the fatal burden component had greater variance than non-fatal burden of all cause DALY; YLL ranged by 7,319 (per 100,000 population) whereas YLD ranged 2,708 (per 100,000 population).

Analysing BoD in national leading causes found Western authorities to possess largest burden for eight of ten conditions. Glasgow City had greatest burden for five causes (IHD, lung cancer, COPD, depression, and anxiety disorders). Glasgow has historically prevailed as the region with the highest excess mortality in Scotland and therefore leading in burden of three highly fatal conditions is consistent with this phenomenon[16, 29]. Offering further insight is the high BoD from two non-fatal causes (depression and anxiety disorders). This highlights the deficit within literature in capturing the full extent of Glasgow's health needs and societal challenges when mortality estimates are the chief focus. Interestingly, across all local authorities working ages showed a similar proportion of disease burden in LBNP, depression, and anxiety disorders. The SBoD 2016 study found depression was accountable for greater years lived in less than ideal health than were comparatively lost to premature mortality due to lung cancer[9]. The same held true for LBNP compared to lung cancer. This epitomises the severity of non-fatal disease burden ubiquitous across authorities.

The secondary aim of study was to explore how deprivation level, measured by SIMD, contributed to observed variation in BoD between authority regions. The significant negative association depicts deprivation to be a fundamental contributor to BoD across Scottish authorities. This was clearly illustrated by Glasgow City possessing largest deprivation concurrent with East Renfrewshire possessing the lowest. Glasgow City and Dundee City were outliers exhibiting notably low SIMD ranking (depicting high deprivation) and high DALY rates. In general, authorities from the West of Scotland showed greater levels of deprivation and disease burden comparative to other regions; with the exception of Western authorities East Renfrewshire and East Dunbartonshire which showed most positive health outcomes and the highest rank of SIMD (representing lowest deprivation) of 32 authorities.

4.2 Possible determinants of geographical inequalities in BoD

Overall, patterns in BoD portray Glasgow City and the West Central Scotland (WCS) conurbation to be principal drivers of Scotland's poor health outcomes. Important exceptions to this trend are the Western authorities of East Dunbartonshire and East Renfrewshire. Adopting a salutogenic approach asserts the importance of understanding the positive health profile of these authorities for the effective interpretation of geographical inequalities in disease burden. The insufficiency of deprivation in explaining the well-articulated "Scottish effect" (and moreover "Glasgow effect") highlight the necessity to consider SDH. Of particular significance, Scotland was not always "the sick man of Europe"[4]. It's worse mortality outcomes, compared to the rest of the United Kingdom and Western Europe, only manifested as a phenomenon from the 1970s onward[4]. This suggests the relevance of upstream determinant factors affiliated with this time period. Possible determinants of geographical inequalities in BoD will be discussed; focus will principally be accorded with domains of the SIMD index in addition to the wider health determinants of deindustrialisation, social welfare policies, and climate.

4.2.1 Individual health behaviours

The most tangible explanation for geographical inequalities in disease burden is the divergence of risk factor prevalence between authorities. Widely articulated negative health behaviours in Scotland constitute smoking, substance abuse, poor diet, and physical inactivity[30-32]. Tobacco smoking is the single most important modifiable risk factor for adverse health outcomes, and is closely associated with IHD[33], COPD[34], and lung cancer[35]. Interestingly, Glasgow City leading in disease burden of these causes does not correspond with Glasgow having the highest

smoking prevalence of local authorities. Dundee City has the highest prevalence of 24.5%, whilst East Dunbartonshire the lowest at 7.2%[36]. Dundee City was amongst top 5 authorities for all cause BoD, despite not having largest cause-specific DALY rates. This highlights the significance of smoking as a risk factor for increasing all cause BoD. The trend of females exhibiting larger proportion of burden from lung cancer compared to males in West Dunbartonshire deviates from the otherwise analogous sex-specific patterns observed across authorities. This may be indication of West Dunbartonshire undergoing the latter transition of the tobacco epidemic; where males and more affluent societal groups initially smoke and subsequently concede, with then females and deprived societal groups bearing greatest affliction to the habit[37]. For drug use disorders, the main trends of Inverclyde leading in age-standardised DALY rates and males disproportionately affected are in line with national 'problem drug using' prevalence rates[38]. However, there is discrepancy in the ranking of authorities in current disease burden compared to prevalence rates. This is likely owed to a considerable amount of problem drug using being hidden in society. Most notably, West Dunbartonshire having highest burden in 15-24 year old age group has not been previously reported[38].

4.2.2 Education

The proximate determinants of individual health behaviours are strongly associated with educational attainment[39]. An understanding of regional differences in educational attainment is important for informing health inequalities, as education not only influences individual choices (such as poor diet and sedentary lifestyle) but is intricately linked with social stratification later in life[40, 41]. Tod et al. (2019) assessed causes for stroke burden in Scotland and found low education to be the strongest explanatory factor, followed by area deprivation and tobacco smoking[42]. This highlights the significance of education when assessing inequalities in BoD, and reason for departure away from individual health behaviours. Education is intricately linked with self-esteem and psychosocial factors[41]. Sweeting et al. (2016) surveyed a West of Scotland cohort five times between ages of 15 and 36 for self-reported physical and mental health[40]. Findings concluded socioeconomic position (SEP) in adolescence (categorised by educational attainment and parental occupation) to be critical in portending future health inequalities[40]. Of note, parental SEP was not a significant factor which highlighted school based educational attainment as key driver of results.

In line with local BoD trends, there are marked regional differences in educational attainment across Scotland. East Dunbartonshire and East Renfrewshire scored higher than the Scottish average across all education indicators[43]. Interestingly, authorities showed similar proportions of school leavers with one or more qualification at SCQF level 4 (standard grade generally corresponding with age 15 years). Whereas there were marked inequalities at SCQF level 6. East Dunbartonshire (83.64%) and East Renfrewshire (83.75%) showed the greatest proportion whereas Dundee City (48.92%) and Clackmannanshire (49.68%) had the lowest[44]. This may partly explain eastern authorities of Dundee and Clackmannanshire being outliers in trends of all cause BoD and deprivation ranking, from the otherwise broad grouping of authorities by cardinal direction. The finding of Sweeting et al. (2016) is further supported by this, where school based educational attainment, from the ages of 15 years, was shown to be a critical determinant in future health and social mobility.

Certainly, differences in schools exist between regions, however at population level educational attainment is significantly socially patterned; differences are more reflective of the social gradient rather than the school environment itself[41]. Those of high deprivation have heightened vulnerability to the effects of low education and therefore equalising educational attainment and skill development at school is fundamental for reducing existing inequalities[41]. Assessing educational attainment amongst the Scottish adult population showed the City of Edinburgh to have the lowest proportion with no qualifications, whereas Western authority East Ayrshire had the highest (over a third of its population)[45]. There is some evidence for intergenerational inequality in Scotland, meaning those with no or low qualifications in present day face greater challenges than previous generations which were unqualified[46]. The stark regional differences in educational attainment align with current trends of BoD and likely perpetuate existing inequalities between authorities. This affirms the importance of increasing the connectivity of schools, families, and communities to ensure the capabilities of youth are developed across the social gradient in Scotland.

4.2.3 Deindustrialisation

Prior to discussion of the potential implications housing and employment have on observed trends, it is necessary to consider the historical upstream factors that influenced present day housing and employment conditions within Scotland. Deindustrialisation is a prominent hypothesis for the concentrated deprivation and disease burden in WCS. The West of Scotland underwent the largest scale of deindustrialisation within the UK[47]. Potent economic and

societal impacts are ascribed to deindustrialisation, through unemployment, poverty, and forced skill redefinition, all of which influence population health[48]. Seeking to test the hypothesis of deindustrialisation portending the heightened mortality inequalities in WCS, Walsh et al. (2010) comparatively analysed eleven Western Scottish authorities with twenty analogous post-industrial regions of Europe[47]. Results found WCS to exhibit the highest mortality rates and slowest improvement in life expectancy of respective regions. This association can partly be ascribed to present findings, authorities showing largest all cause DALY rates and highest deprivation all endured post-industrial decline, including the Eastern authorities of Dundee City and Clackmannanshire[49]. However, there are discrepancies in this hypothesis. The WCS appeared more affluent than many comparative regions, outperforming in several socioeconomic indicators reflective of post-industrial decline (employment, unemployment, tertiary education, and perceived neighbourhood safety); despite respective European areas being superior in health outcome trends[48]. The inclusion of East Dunbartonshire and East Renfrewshire in analysis may have partly contributed to these anomalies. Acknowledgement of the socio-political system within the UK and Scotland at the time offers further explanation for the inconsistencies in Walsh et al. (2010) findings[47].

4.2.4 Restrictive social welfare policies

The temporal aspect of deindustrialisation aligns with the emergence of the "Scottish effect", concomitant with the restrictive social welfare policies imposed by post-1979 UK Conservative government. Succinctly, these policies encompassed privatising nationalised industries, cuts in public expenditure, heavily subsidised selling of council houses, and dissolution of trade unions; collectively amounting to the highly precarious livelihood of working class communities[50]. The prominence of deindustrialisation at the time is likely to have exacerbated the effects of Margaret Thatcher's policies. The aforementioned European post-industrial regions were not subject to equivalent policies coincident with deindustrialisation, suggesting reason for reported discrepancies[47]. Whereas the West of Scotland experienced the highest proportion of industrial employment loss of the United Kingdom over the succeeding three decades[47]. Moreover, the WCS conurbation saw the greatest selling of council houses from the 'Right to Buy' policy, as a result of the highest proportion being in this region[50]. The majority of housing across Scotland were council owned and thus this became a prominent outcome of the Thatcherite agenda, occurring throughout authorities. The significant portion sold resulted in extensive waiting times for those in need as well as compromising the quality of those available[50]. Although benefiting a proportion of the population by enabling them to

become homeowners, the deficit created in state provided housing intensified deprivation and widened inequalities across Scotland[51].

4.2.5 Housing

The Right to Buy policy has since been abolished in Scotland, however the effects on health are still evident from Scotland's housing crisis[52]. The most direct effects of this are exemplified in the high rates of homelessness; in 2018, 29,894 households were assessed as homeless or threatened with homelessness across Scotland, with this figure overrepresenting younger age groups[46, 53]. However the housing crisis extends beyond the magnitude of homelessness, the crucial deficits in housing availability and affordability are experienced across the social strata[52].

Inadequate housing is a long established determinant of poor health outcomes and is strongly associated with mental health and the erosion of social capital[51, 55]. A study seeking to explain this association assessed the effect of housing conditions and neighbourhood characteristics in a randomly selected sample from the West of Scotland[56]. After adjusting for sociodemographic factors and housing tenure, results found a reduction of 93% in anxiety disorders. Social rented houses (owned by the council or housing associations) were more likely to expose tenants to harmful factors, such as damp and crime, whilst health promoting features such as garden access were less common than in privately rented housing or owned homes[56]. Findings support the notion that different housing tenures correlate with the deprivation gradient; social rented housing is often associated with high deprivation and adverse health[56]. This is exemplified through West Dunbartonshire (37%) and Glasgow City (34%) possessing the highest total social rented housing stock, congruent with high levels of deprivation and disease burden, whilst East Renfrewshire and East Dunbartonshire have the lowest proportion at 12% of local authorities[57]. Moreover, the vast majority of socially rented households in Western authorities are within the most deprived quintile of Scotland, proportions as high as 82% in Glasgow City and 81% in Inverclyde[57]. It is important to note, the issue is not over-reliance on social welfare services but rather the precarious livelihoods associated with them.

A key factor contributing to the paucity of affordable housing is gentrification[55]. Leith Walk in the City of Edinburgh is a prime example of this; the area was significantly affected by deindustrialisation and ensuant severe poverty, however in recent years gentrification has seen the average cost of living in the area to rise substantially[55]. Longstanding residents have noted

the commercialisation of social spaces have led to erosion of social capital, whilst private renters across the social strata are likely to have experienced sharp rises in rent[46]. This can have detrimental effects of forcing residents out of areas and dismantling communities, threatening social trust and social capital; which are aspects closely affiliated with mental health[41]. The impact of the housing crisis across the social gradient within Scotland can be inferred from present findings, young and older working age groups were shown to have similar disease burden from depression and anxiety across local authorities. It appears precarious housing will have differential effects on the population dependent on tenure, housing conditions, and neighbourhood characteristics. Therefore, different composition of housing dwellings between local authorities will likely contribute toward divergence in disease burden. Although deprived households remain particularly vulnerable to adversities[58].

4.2.6 Employment

Concomitant with precarious housing widening health inequalities across Scotland is that of precarious employment. Deindustrialisation marked the establishment of globalisation. This transition brought major changes to Scotland's economy and labour market, most notably through the advancement of technological automation and sharp rise in the service sector economy[59]. Closely affiliated to globalisation and the growth of the service sector is precarious employment, constituting part time and unstable working arrangements such as zero-hour contracts[59]. Compounded by the economic recession of 2008, precarious labour markets now manifest across Scotland[46]. In 2013, the highest proportion of young people not in higher education, employment, or training was in Clackmannanshire, West Dunbartonshire, and East Ayrshire[43]; hence reflecting educational attainment as key factor in accessing the labour market. However the issue of employment in Scotland goes further than unemployment, to rising *under*employment and "churning", a conceptual term for when individuals fluctuate between low paid, short term work, and unemployment[59].

The cycle of unstable employment is disproportionately affecting younger ages in Scotland[46]. This has the clear proximate effects of underutilisation of skills, however there is evidence this predicates to fewer opportunities in life and worse health outcomes; educational attainment has been highlighted the most important risk factor[46, 60]. Although the effects of job insecurity are observed across the social gradient, individuals of higher SEP will have greater capacity to take on unpaid work to increase their skill set and hence will have a greater likelihood of securing permanent paid work in the future[46]. The precarious living and working conditions prevalent

across Scotland, and disproportionately affecting younger generations, may contribute toward the high disease burden of depression and anxiety disorders observed in working age groups[59]. Psychological distress in early adulthood limits social mobility in the future, which portends to exacerbation of inequalities over the life course if not effectively addressed. Subnational variance in precarious employment is not currently available and poses challenging to quantify given the dynamic nature of "churning". Qualitative research across local authorities is therefore required to explore the scale of precarious employment and foremost the effects this is having on health. Complementary attempts to quantify the regional distribution of the population within this employment category would provide valuable insight toward current trends of disease burden.

4.2.7 Access to health services

Within Scotland, the NHS provides universal healthcare free at the point of use. Therefore, deprivation limiting access to health services is not a widely acquiescent issue in Scotland. However, there is some evidence of the inverse care law; when provision of medical care inversely varies with population health needs[61]. Physician distribution in Scotland is generally skewed toward a greater number working in less deprived areas, in addition to more deprived areas having higher physician self-reported stress levels and patients spending less average time with a physician[62, 63]. Specifically, a steep social gradient of psychosocial morbidity has been shown in WCS[63]. There is some suggestion of multimorbidity of musculoskeletal and psychological disorders from present findings of the homogenous disease burden of LBNP observed in younger and older working age groups, across local authorities. This is line with nationwide BoD results showing high burden from LBNP and depression[9]. However, owing to BoD estimates being based on prevalence rates of disease burden multimorbidity cannot be reliably inferred from present analysis. Barnett et al. (2012) assessed approximately one third of primary care patients in Scotland, finding 11% of patients to have both a physical and mental health disorder and more than half young and middle-aged adults[64]. Although measured by the commonly criticised Carstairs & Morris index, this study additionally found a strong association with multimorbidity and area deprivation. Deprived areas exhibited similar prevalence of multimorbidity in patients 10-15 years younger compared to those in affluent areas[64]. This highlights that although individual SEP may not be key issue in accessing health services in Scotland, the provision of services may vary by area of residence.

Certainly, physical access to services holds relevance for Scotland's rural population. Rural Scotland accounts for 98% of the country's land mass, with only 17% of the population residing there[65]. Access to health services is an intrinsic challenge to rural populations of Scottish authorities[65]. This may offer explanation to the Shetland Islands showing sizeable disease burden for COPD in the 25-44 year age group. This is despite the Shetland Islands having amongst the lowest prevalence of smoking across authorities, behind East Dunbartonshire[43]. Rural Scottish authorities have lower rates of emergency and cancer admissions[65], however this may be reflective of the inaccessibility of hospitals rather than improved health outcomes. COPD has a high fatal burden component (YLL) and thus may allude to the higher BoD exhibited in findings. In addition to smoking being an important risk factor for COPD, a review by Postma et al. (2015) found COPD can also originate from as early as lung development in utero (when the mothers smoke) and in early childhood of low birthweight babies[34]. Reduced lung function is thought to begin diminishing from the age of 20 years, which may align with the trends exhibited in Shetland Islands. There is obvious logistical difficulty in investigating these associations and would require a case control study which has affiliated ethical implications; however it is an interesting conjecture.

4.2.8 Climate

Departing from the main SDH discussed, the physical determinant of climate may offer part explanation for trends in non-fatal burden. One third of the Scottish population is thought to have sub-optimal serum vitamin D levels owing to Scotland's high latitude position of 55° north[66]. The potential association between vitamin D and chronic diseases such as LBNP and depression is gaining increasing recognition, and may partly explain the homogenous patterns of multimorbidity across local authorities[67, 68]. Similarly, a growing body of research is investigating the association of migraine with vitamin D[69]. Although empirical evidence is heterogenous; the West of Scotland receives comparatively less sunlight compared to Scotland as a whole, and thus may contribute to Eilean Siar leading in disease burden for LBNP and migraine[69, 70]. Further, LBNP is often a premonitory migraine symptom and Eilean Siar leading in both causes may be indication of LBNP acting as mediator in the causal pathway[69]. Dumfries and Galloway succeeding Eilean Siar in both LBNP and migraine support the contingency of mediation.

Young ages are particularly susceptible to vitamin D deficiency and this has been shown in 16-34 year olds within Scotland having lower mean vitamin D levels than older ages[66]. This

would explain the chiefly homogenous DALY rates of migraine observed across age groups, with inclusion of 15-24 year group. However, the inconsistency of this hypothesis within literature necessitates data of average serum vitamin D levels by local authority, for reliable inference of climate as a determinant in current BoD patterns. Owing to the paucity of morbidity estimates at subnational level within Scotland, these are novel trends worthy of further investigation.

4.3 Policy recommendations

The emergent theme in present findings is the necessity to address the stark inequalities in SDH if the depicted health inequalities between local authorities are to be effectively mitigated. The fundamental determinants discussed convey that focus upon upstream factors is paramount if this is to be achieved. A national modelling tool, Triple I, has been developed, which models the impact of policy interventions on population health and government spending[71]. This tool has been used in tandem with a tax-benefit microsimulation model (EUROMOD) to estimate the effects of fiscal policies on household income across Scotland[72]. The structural level assessment of fiscal policies was employed alongside individual level assessment of prevention and mitigation interventions. Current UK policies have focused upon the latter approach, in modifying individual behaviours[73]. Local geographical variation in BoD of present study contributes key informative evidence toward the results from Triple I and associated policy recommendations.

Progressive income-based policies addressing the social and economic drivers of health inequalities showed most promise of the modelled strategies[71]. Twelve income-based policies were assessed following hypothetical implementation after five years, and constituted taxation-based, benefits-based, or entirely novel strategies[72]. Increasing existing benefits-based policies had greatest modelled impact for reducing YLL and narrowing inequalities. Specifically, increasing means-tested benefits by 50% projected universal minimum income for health living, encompassing carers, disabled, and the elderly through a coincident 50% increase in devolved benefits[72]. The effect on inequalities was disproportionate across the deprivation gradient, households in the most deprived quintile were predicted to gain largest benefit; based on the assumption incremental change in income will directly correlate to incremental change in YLL[72]. The implications are that greatest advances will occur in Glasgow City and WCS where most concentrated deprivation and largest BoD are observed.

Improvement in this authority conurbation is pertinent to the improvement of disease burden across Scotland as a whole.

Additionally, the introduction of two novel policies 'real' living wage and citizen's basic income (CBI) showed marked effects on reducing health inequalities. Currently 17% of Scotland's working age population earn less than living wage[74]. Inverclyde possesses the highest proportion earning under this threshold of 31% (7,000 inhabitants), whilst the City of Glasgow possesses the highest absolute number of 55,000[74]. The introduction of living wage would increase household's income across deprivation quintiles. Additionally, the CBI scheme constitutes all citizens receiving an income from the Scottish Government irrespective of need. Similar to increasing benefit-based policies, most deprived households would see a disproportionate increase in income whilst least deprived households would incur a negative change, owing to the proposed incorporation of increased income tax rates (by 6 pence) and national insurance rate set to 12% for all earnings. This raises question as to how such policies would be received by the population. Adjustment for tax and benefit fraud was not possible, this may have informed whether such policies would discourage work ethic rather than strengthen it as well as predicting the level of tax evasion that may arise. Pertinently, the concept of universal basic income encapsulated in the CBI scheme is one of widespread debate, and thus far no country enforces this as law[75]. However, CBI was shown to cost less than a quarter of increasing means-tested benefits by 50%[72], and thus congruent with its positive predicted outcomes alleviating inequalities at the source this social security policy developed by Scottish policy makers merits attention by the UK's political agenda.

Although income-based policies showed most promise for addressing upstream determinants of health, prevention and mitigation interventions retain inherent value for ensuring maximum population impact. Preventative interventions evaluated by Triple I addressed wider environmental influences on health, such as tobacco taxation and 20 mph speed limits[71]. However, present findings have implications for alternate prevention strategies. With regards to climate, current guidelines from the Scottish Government recommend daily vitamin D supplements of 10μg or 15 minutes of unprotected sun exposure[76]. Results imply promotion of these guidelines are required concurrent with prescription of vitamin D supplements. Specifically, the Western Isles and Dumfries and Galloway health boards may see reductions in DALY rates of LBNP and migraine if resource distribution is suitably focused. Similarly, the heightened burden of COPD in younger working ages exhibited in Shetland Islands

advocates for increased efforts by the local authority and the Shetland health board in understanding this anomaly whilst promoting awareness of risk factors.

Upon consideration of the importance of educational attainment in exacerbating existing inequalities, there is clear scope for increased efforts toward reducing the variance in education between regions. Within Scotland it is possible to leave school at the age of 16, a critical life stage for influencing future social mobility[41]. Although efforts to equalise academic attainment remain paramount, an increased emphasis on vocational training and skill development pose greater benefit to youth who face exclusion from both academia and the labour market. This has already been recognised by the Scottish Government[77]. The "Opportunities for All" commitment offers to find appropriate work or education placements for 16-19 year olds not in employment, education, or training[77]. Moreover, the Modern Apprenticeship program provides 30,000 opportunities annually with this extending to the recently implemented Foundation Apprenticeship program, which focuses upon providing S5 and S6 school pupils (ages 16-18 years) with industry-recognised qualifications[78]. Despite these being positive steps by the Scottish Government in addressing high rates of youth unemployment, acknowledging the social gradient prior to leaving school remains imperative. Foremost, vocationalism must not be viewed exclusively as increasing employability, its inherent value lies in promoting personal development and self-esteem amongst youth. These are key aspects to equity and ensuring universal capability of young people to take control of their futures[41]. Teaching staff should be provided with additional support for working across home and school boundaries concomitant with expansion of services outside of schools such as youth clubs. The latter has particular benefit for creating supportive networks that advise on key societal challenges, such as housing and debt. The well-established Citadel youth centre in the north of Edinburgh is a prime example of the benefit this can bring to communities[79] and local authority policy makers should seek to increase these initiatives.

Local BoD trends further inform mitigation strategies. Triple I concluded computerised cognitive behavioural therapy (CBT) and individual guided self-help for depression to be most effective in reducing excess premature mortality and percentage of hospitalisations, of the mitigation strategies assessed[71]. A key finding of this thesis is the necessity to acknowledge social patterning of health determinants when addressing BoD at local authority level. Pertinently, effectiveness was predicted to be greatest when households in most deprived quintile were targeted, compared to the entire population or proportionate to need[71]. This

contrasts advocation for proportionate universalism when addressing SDH, which constitutes acknowledging strategies must apply to all however the scale and intensity should be proportionate to the deprivation gradient[41]. Targeting CBT and individual guided self-help for depression to the most deprived quintile poses additional benefit for relieving disproportionate burden on physicians and health services in deprived regions. However, owing to widespread burden from depression and anxiety disorders across local authorities targeting the most deprived households would both reduce the eligible population and intervention impact. This asserts the complexity in implementing mitigation strategies that balance population health needs, cost, and effectiveness whilst retaining equity in their deliverance. Interestingly, positive effects of proportionate universalism have been shown in urban renewal investment in 14 differentially deprived neighbourhoods of Glasgow[58]. After five years the most deprived neighbourhoods that received the highest investment showed the greatest improvement in mental health, although reductions in inequalities remained modest[58].

The modelling of cost-benefit of policies and interventions through Triple I holds clear value, however trends in local BoD highlight discrepancy in Triple I projections. Foremost, given the complexity of the determinants discussed that manifest in stark geographical inequalities of burden, it gives rise to advocation for participatory action research. Conducting this in tandem with Triple I would offer deprived groups of Scottish society a voice, enabling a more comprehensive understanding of the disadvantages these communities face and ultimately how these align with results from Triple I. Kapilashrami & Marsden (2018) demonstrated the value of this approach for informing policy and planning processes in the City of Edinburgh[55]. Moreover, Triple I comprised the assessment of intervention effectiveness in respect to reducing YLL and did not include reducing YLD in predicted outcomes. The distinct geographical variation in BoD shown to arise from non-fatal causes implies modelled estimates of reduced inequalities are likely an underestimation of the impact proposed policies will have. Further, Triple I modelled the effect of single interventions through a static system approach. This is necessary for direct comparison between policies of their effectiveness. Although in concordance with present findings showing authorities in the WCS to possess highest disease burden in the majority of national leading causes, congruent with the strong association between all cause DALY and SIMD, implementation of multiple proposed interventions is likely to have greater effect than modelled estimates.

The Scottish Government's political will in targeting upstream determinants of health inequalities is evident. The proposed social security policies are aimed at redistributing income whilst assuring universal capacity to afford the cost of healthy living. However, Scotland currently possesses control over 15% of social security spending and 11 benefits[72]. The proposed CBI scheme and implementation of 'real' living wage are therefore not possible with existing devolved powers, and would necessitate administration by the Westminster Government[71]. The political deadlock that arose from Scotland's advocation for legal powers to pilot a supervised drug consumption room in Glasgow City centre (that was formally rejected by Westminster) signifies the challenge the Scottish Government may face in implementation of such policies, within the present structural governance of the UK[80].

4.4 Strengths and limitations

This is the first account of local authority SBoD data, and therefore a major strength of the study is that data represents the most accurate and robust morbidity and mortality estimates currently available for Scotland[9]. It holds greatest relevancy for local policy makers and key stakeholders within Scotland. Moreover, this study has important universally applicable implications. The significance of structural determinants on health outcomes is stark, together with the accumulative effect over time these can have on widening existing inequalities. The impact area of residence can have on health is fundamental, and has been demonstrated elsewhere in the subnational BoD studies conducted in England, Japan, and China[11-13].

A key limitation of this study are results are highly specific to Scotland and therefore are not generalisable. The use of SBoD estimates, rather than GBD modelled values, markedly limits cross-country comparisons. Principle drivers of this are the methodological choices made when generating BoD estimates. SBoD data used a national life table and the European Standard Population, both of these deviating from GBD's approach of adopting an aspirational high life table and World Standard Population[81]. Both methodological choices have been shown to impact how causes are ranked[82], and thus will have affected local authority estimates.

4.5 Methodological considerations

Principal methodological considerations concern the application of SIMD. Foremost, this index was aggregated from data zone level to represent an average for each local authority region. Within local authorities' a stark contrast in deprivation and health outcomes exists. Newton Mearns, a data zone within Glasgow, has an average life expectancy of 72 years for males and

81 years for females; whilst Dalmarnock, another Glasgow data zone 18km from Newton Mearns, has an average life expectancy of 67 years for male and 75 years for female[25]. This highlights the innate limitation in aggregating an area-based deprivation measure to local authority level. The association between deprivation and BoD has been analysed at greater granularity than present study in the SBoD deprivation report[22]. Certainly, variation of deprivation remains within data zones as the index does not identify deprived individuals.

A further common criticism is the inclusion of the health domain in SIMD. The application of SIMD in explaining observed geographical variation in BoD is arguably invalidated by health encompassed in the index, and therefore the exposure variable (SIMD) is in direct association with the outcome variable (all cause DALY). However, the health domain constitutes 14% of SIMD's composition and previous sensitivity analysis has shown similar results are obtained when the health domain is excluded from SIMD[22, 23]. Therefore this is not a limitation considered to affect the findings of present study.

The inclusion of attributable burden estimates for major risk factors would have increased reliability and robustness of results. Population attributable fractions can be applied to relevant risks for the health outcome of interest, thus allowing the proportion of DALY that would have been avoided in the absence of excess risk exposure to be estimated. This would have greatly informed geographical inequalities of BoD; however, given the scope of this thesis it was not possible to include attributable risk burden in analysis.

There are certain methodological considerations attributed to the study design of an ecological observational study. Foremost is that of ecological fallacy. The inferences made were at an aggregate local authority level and therefore cannot be inferred as representing BoD, and moreover the association with deprivation, at an individual level. This incorporates the inherent limitation of SIMD being an area-based measure of deprivation. An additional limitation owed to the study design is the crude nature of utilising secondary data. Demographic information beyond what was included (age and sex) was not known. Ethnic and migratory differences between authorities may have acted as effect modifiers, affecting the strength of association between SIMD and all cause DALY and moreover the external validity of local BoD analysis[7]. Finally, as this was an exploratory study assessing trends of disease burden, the interpretation of findings was limited to inference of potential determinants and it was not possible to distinguish causal directions.

Potential confounders were not accounted for in statistical analysis. Adverse health behaviours are immediate causative factors in BoD and therefore adjusting for these would have increased robustness of association between all cause DALY rate and SIMD. However, individual behaviours such as smoking, alcohol, and poor diet are strongly associated with the social gradient[21]; and therefore the significance of these factors in BoD are considered encapsulated in the SIMD measure and the corresponding divergence of deprivation between local authorities.

Further, there are fundamental aspects in the generation of non-fatal morbidity estimates that must be acknowledged. Foremost, YLD are modelled estimates which include variables age, sex, and SIMD deprivation decile in the model. Therefore analysis at local authority level creates a circular methodological issue, council area estimates of YLD apply deprivation rates to council area populations, which in turn affect DALY rates. YLL estimates avoid this circularity as death rates are based on actual area of residence. BoD rates for LBNP and migraine were less accurate than the other national leading causes analysed, demonstrated by the amber RAG status. Findings for LBNP and migraine should thus be interpreted with caution. The additional non-fatal leading causes of depression and anxiety disorders had green RAG status and therefore the suggested psychosocial morbidity remains a reasonable inference.

Finally, fixed severity distributions were applied to the 68 causes of disease and injury, with the exception of all cancers, cirrhosis, and epilepsy[81]. Severity distributions summarise the range of health loss from a disease by categorising disability into mild, moderate, and severe. Different disability weights are then assigned to the relevant level of severity for the generation of YLD estimates[83]. Fixed severity distributions were taken from the GBD study owing to resource constraints[9]. Assuming fixed severity across local authorities can misrepresent non-fatal estimates and underestimate the scale of socioeconomic inequality in burden[83]. This may have contributed to the similar BoD from non-fatal causes observed across local authorities, and moreover to all cause YLD showing much less variation across Scotland compared to all cause YLL. The wider implications are all results by deprivation ranking are likely conservative estimates.

5. Conclusion

This thesis provides the first account of geographical inequalities in BoD at local authority level in Scotland. Local estimates found Western authorities to lead in disease burden for eight of ten national leading causes, with North Western authority Eilean Siar possessing largest burden for LBNP and migraine. Interestingly, East Dunbartonshire and East Renfrewshire showed polarised BoD and deprivation compared to their neighbouring western counterparts. The potential determinants of BoD trends exhibited have been discussed, with focus upon upstream factors. The inherent complexity in differentiating causes of geographical inequalities is clear, although educational attainment appears a prominent determinant for intensifying existing inequalities. The stark disparities in deprivation seen across authorities highlight this as a key driver in disease burden. In light of local BoD trends, the implications for national preventative and mitigative interventions for subnational implementation have been discussed. Paramount are progressive policies that disproportionately redistribute income to the most deprived societal groups; these strategies are predicted to pose greatest impact. Henceforth, if Scotland is to effectively tackle its population health, fundamental is the need for equitable income-based policies that directly address upstream health determinants and thereupon subnational inequalities.

6. References

1. Barbieri M, Wilmoth JR, Shkolnikov VM, Glei D, Jasilionis D, Jdanov D, et al. Data Resource Profile: The Human Mortality Database (HMD). International Journal of Epidemiology. 2015;44(5):1549-56.

2. McCartney G, Walsh D, Whyte B, Collins C. Has Scotland always been the 'sick man' of Europe? An observational study from 1855 to 2006. European Journal of Public Health. 2012;22(6):756-60.

3. Norman P, Boyle P, Exeter D, Feng Z, Popham F. Rising premature mortality in the U.K.'s persistently deprived areas: only a Scottish phenomenon? Social Science and Medicine. 2011;73(11):1575-84.

4. Whyte B & Ajetunmobi T. Still "The Sick Man of Europe'? Scottish mortality in a European context 1950-2010: an analysis of comparative mortality trends.: Glasgow Centre for Population Health; 2012.

5. Schofield L, Walsh D, Munoz-Arroyo R, McCartney G, Buchanan D, Lawder R, et al. Dying younger in Scotland: Trends in mortality and deprivation relative to England and Wales, 1981-2011. Health Place. 2016;40:106-15.

6. Hanlon P, Lawder RS, Buchanan D, Redpath A, Walsh D, Wood R, et al. Why is mortality higher in Scotland than in England and Wales? Decreasing influence of socioeconomic deprivation between 1981 and 2001 supports the existence of a 'Scottish Effect'. Journal of Public Health | Oxford Academic. 2005;27(2):199-204.

7. Popham F & Boyle PJ. Is there a 'Scottish effect' for mortality? Prospective observational study of census linkage studies. Journal of Public Health | Oxford Academic. 2011;33(3):453-8.

8. Stein C & Newton J. Sharing the burden: a new European Burden of Disease Network is formed. European Journal of Public Health. 2017;27(2):191-2.

9. Scottish Burden of Disease Team. The Scottish Burden of Disease Study, 2016. Overview report. Scottish Public Health Observatory. 2017.

10. Institute of Health Metrics Evaluation (IHME). Global Burden of Disease (GBD) study: IHME; 2016 [cited 2020 14 April]. Available from: http://www.healthdata.org/gbd/data.

11. Nomura S, Sakamoto H, Glenn S, Tsugawa Y, Abe SK, Rahman MM, et al. Population health and regional variations of disease burden in Japan, 1990-2015: a systematic subnational analysis for the Global Burden of Disease Study 2015. Lancet. 2017;390(10101):1521-38.

12. Zhou M, Wang H, Zhu J, Chen W, Wang L, Liu S, et al. Cause-specific mortality for 240 causes in China during 1990-2013: a systematic subnational analysis for the Global Burden of Disease Study 2013. Lancet. 2016;387(10015):251-72.

13. Steel N, Ford JA, Newton JN, Davis ACJ, Vos T, Naghavi M, et al. Changes in health in the countries of the UK and 150 English Local Authority areas 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2018;392(10158):1647-61.

14. Scottish Government. SPICe Briefing: The National Health Service in Scotland. 2016.

15. Hanlon P, Walsh A, Whyte B. Let Glasgow Flourish. Glasgow Centre for Population Health; 2006.

16. Walsh D, McCartney G, Collins C, Taulbut M, Batty GD. History, politics and vulnerability: explaining excess mortality in Scotland and Glasgow. Public Health. 2017;151:1-12.

17. Livingston M, Lee D. "The Glasgow effect?"- the result of the geographical patterning of deprived areas? Health Place. 2014;29:1-9.

18. Carstairs V & Morris R. Deprivation: explaining differences in mortality between Scotland and England and Wales. BMJ. 1989;299(6704):886-9.

19. Exeter DJ, Boyle PJ, Norman P. Deprivation (im)mobility and cause-specific premature mortality in Scotland. Social Science and Medicine. 2011;72(3):389-97.

20. Leyland AH, Dundas R, McLoone P, Boddy FA. Cause-specific inequalities in mortality in Scotland: two decades of change. A population-based study. BMC Public Health. 2007;7:172.

21. McCartney G, Collins C, Walsh D, Batty GD. Why the Scots die younger: synthesizing the evidence. Public Health. 2012;126(6):459-70.

22. Scottish Burden of Disease Study. Deprivation Report. NHS Health Scotland; 2016.

23. Scottish Government. Scottish Index of Multiple Deprivation 2020 [cited 2020 23 March]. Available from: https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/.

24. Public Health Scotland. What are health inequalities? 2019 [updated 2019 14 February; cited 2020 11 May]. Available from: http://www.healthscotland.scot/health-inequalities/what-are-health-inequalities.

25. Scottish Government. National Records of Scotland (NRS) 2016 [cited 2020 01 May]. Available from: https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population.

26. Wyper GMA, Grant I, Fletcher E, McCartney G, Fischbacher C, Stockton DL. How do world and European standard populations impact burden of disease studies? A case study of disability-adjusted life years (DALYs) in Scotland. Archives of Public Health. 2020;78:1.

27. National Records of Scotland. Life Tables for Scotland 2014-2016.; 2017.

28. Flourish. [Available from: https://flourish.studio/.

29. McCartney G CC, Walsh D, Batty D. Accounting for Scotland's Excess Mortality: Towards A Synthesis. Glasgow Centre for Population Health; 2011.

30. Shelton NJ. Regional risk factors for health inequalities in Scotland and England and the "Scottish effect". Social Science and Medicine. 2009;69(5):761-7.

31. Gray L & Leyland AH. A multilevel analysis of diet and socio-economic status in Scotland: investigating the 'Glasgow effect'. Public Health Nutrition. 2009;12(9):1351-8.

32. Scottish Government. The Scottish Health Survey. 2019.

33. Kondo T, Nakano Y, Adachi S, Murohara T. Effects of Tobacco Smoking on Cardiovascular Disease. Circulation Journal. 2019;83(10):1980-5.

34. Postma DS, Bush A, van den Berge M. Risk factors and early origins of chronic obstructive pulmonary disease. Lancet. 2015;385(9971):899-909.

35. Warren GW, Cummings KM. Tobacco and lung cancer: risks, trends, and outcomes in patients with cancer. Am Soc Clin Oncol Educ Book. 2013:359-64.

36. The Scottish Public Health Observatory. Tobacco use: adult smoking in Scotland 2019 [Available from: https://www.scotpho.org.uk/behaviour/tobacco-use/data/adult-smoking-in-scotland/.

37. Lopez AD, Collishaw N E, Piha T. A Descriptive Model of the Cigarette Epidemic in Developed Countries. Tobacco Control. 1994;3:242-7.

38. Information Services Division. Prevalence of Problem Drug Use in Scotland: 2015/16 Estimates. NHS National Services Scotland; 2019.

39. Guma J, Sole-Auro A, Arpino B. Examining social determinants of health: the role of education, household arrangements and country groups by gender. BMC Public Health. 2019;19(1):699.

40. Sweeting H, Green M, Benzeval M, West P. The emergence of health inequalities in early adulthood: evidence on timing and mechanisms from a West of Scotland cohort. BMC Public Health. 2016;16:41.

41. Marmot M, Bell R. Fair society, healthy lives. Public Health. 2012;126 Suppl 1:S4-S10.

42. Tod E, McCartney G, Fischbacher C, Stockton D, Lewsey J, Grant I, et al. What causes the burden of stroke in Scotland? A comparative risk assessment approach linking the Scottish Health Survey to administrative health data. PloS One. 2019;14(7):e0216350.

43. Karanwal S MA, Barkat S, Walker D, Targosz J, Van Heelsum A, Stockton D, Fischbacher C, Neill K, Gasiorowski A,. Health and Wellbeing Profile: Scotland overview. Edinburgh: ScotPHO - ISD Scotland; 2015.

44. The Scottish Public Health Observatory. Online Profiles Tool 2018 [Available from: https://www.scotpho.org.uk/comparative-health/profiles/online-profiles-tool.

45. Scotland's Census. 1991-2011 Census results [Available from: https://www.scotlandscensus.gov.uk/census-results.

46. Scottish Government. The life chances of young people in Scotland: an evidence review for the First Minister's Independent Advisor on Poverty and Inequality. 2017.

47. Walsh D, Taulbut M, Hanlon P. The aftershock of deindustrialization--trends in mortality in Scotland and other parts of post-industrial Europe. European Journal of Public Health. 2010;20(1):58-64.

48. Taulbut M, Walsh D, Parcell S, Hartmann A, Poirier G, Strniskova D, et al. What can ecological data tell us about reasons for divergence in health status between West Central Scotland and other regions of post-industrial Europe? Public Health. 2013;127(2):153-63.
49. Beatty C & Fothergill S. Recovery or stagnation?: Britain's older industrial towns since the recession. Regional Studies. 2020.
50. Collins C & McCartney G. The impact of neoliberal "political attack" on health: the case of the "Scottish effect". International Journal of Health Services. 2011;41(3):501-23.
51. Stewart J. A review of UK housing policy: ideology and public health. Public Health. 2005;119(6):525-34.
52. Boyack S. Housing crisis 'not a short-term issue'. Scottish Federation of Housing Associations. 2018.
53. Scottish Government. Homelessness in Scotland: 2018 to 2019 2019 [Available from: https://www.gov.scot/publications/homelessness-scotland-2018-2019/.
55. Kapilashrami A & Marsden S. Examining intersectional inequalities in access to health (enabling) resources in disadvantaged communities in Scotland: advancing the participatory paradigm. Internationak Journal of Equity Health. 2018;17(1):83.
56. Macintyre S, Ellaway A, Hiscock R, Kearns A, Der G, McKay L. What features of the home and the area might help to explain observed relationships between housing tenure and health? Evidence from the west of Scotland. Health Place. 2003;9(3):207-18.
57. Scottish Government. Social Tenants in Scotland, 2017.
58. Egan M, Kearns A, Katikireddi SV, Curl A, Lawson K, Tannahill C. Proportionate universalism in practice? A quasi-experimental study (GoWell) of a UK neighbourhood renewal programme's impact on health inequalities. Social Science and Medicine. 2016;152:41-9.
59. Harkins C & Egan J. The rise of in-work poverty and the changing nature of poverty and work in Scotland: what are the implications for population health? Glasgow: Glasgow Centre for Population Health; 2013.
60. Scottish Government. Consequences, risk factors, and geography of young people not in education, employment or trainint (NEET) - Research Findings. Edinburgh; 2015.
61. Jameson JE. Inverse care law. Lancet. 1971;1(7700):648-9.
62. Blane DN, McLean G, Watt G. Distribution of GPs in Scotland by age, gender and deprivation. Scottish Medical Journal. 2015;60(4):214-9.
63. Mercer SW & Watt GC. The inverse care law: clinical primary care encounters in deprived and affluent areas of Scotland. Annals of Family Medicine. 2007;5(6):503-10.

64. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. Lancet. 2012;380(9836):37-43.

65. Scottish Government. Rural Scotland: key facts 2018. 2018.

66. Purdon G CF, Rutherford L & Marcinkiewicz A,. Vitamin D status of Scottish adults: Results from the 2010 & 2011 Scottish Health Surveys. Food Standards Agency in Scotland; 2013.

67. Parker GB, Brotchie H, Graham RK. Vitamin D and depression. Journal of Affective Disorders. 2017;208:56-61.

68. Zadro J, Shirley D, Ferreira M, Carvalho-Silva AP, Lamb SE, Cooper C, et al. Mapping the Association between Vitamin D and Low Back Pain: A Systematic Review and Meta-Analysis of Observational Studies. Pain Physician. 2017;20(7):611-40.

69. Nowaczewska M, Wicinski M, Osinski S, Kazmierczak H. The Role of Vitamin D in Primary Headache-from Potential Mechanism to Treatment. Nutrients. 2020;12(1).

70. Wu Z, Malihi Z, Stewart AW, Lawes CM, Scragg R. The association between vitamin D concentration and pain: a systematic review and meta-analysis. Public Health Nutrition. 2018;21(11):2022-37.

71. Pulford A, Richardson E, Agbato D, et al. Informing Interventions to reduce health Inequalities (Tripe I). Edinburgh: NHS Health Scotland; 2019.

72. Richardson E, Fenton L, Parkinson J, Pulford A, Taulbut M, McCartney G, et al. The effect of income-based policies on mortality inequalities in Scotland: a modelling study. Lancet Public Health. 2020;5(3):e150-e6.

73. Kriznik NM, Kinmonth AL, Ling T, Kelly MP. Moving beyond individual choice in policies to reduce health inequalities: the integration of dynamic with individual explanations. Journal of Public Health | Oxford Academic. 2018;40(4):764-75.

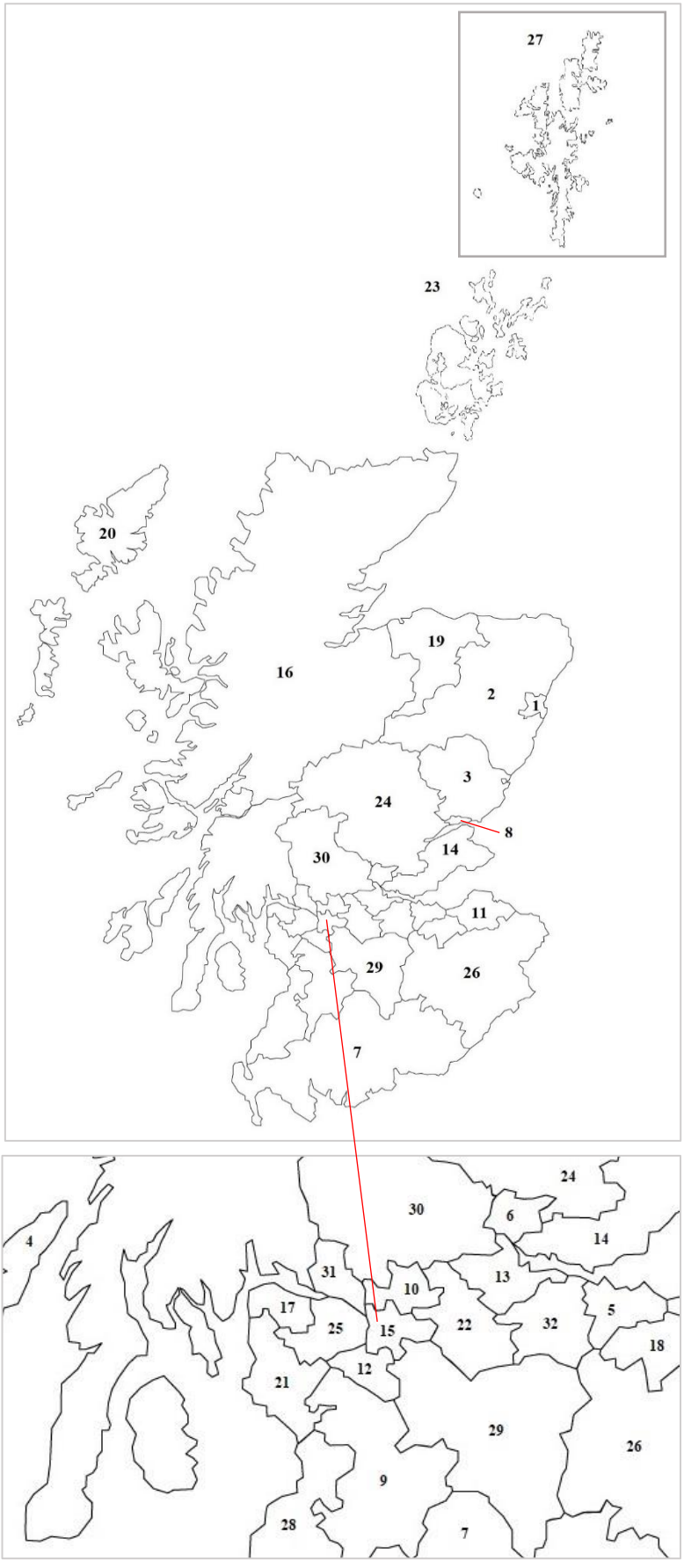
74. Scottish Government. Living Wage: a data cube spreadsheet 2020 [cited 2020 24 April]. Available from: https://statistics.gov.scot/resource?uri=http%3A%2F%2Fstatistics.gov.scot%2Fdata%2Fliving-wage.

75. Vlandas T. The Political Economy of Individual Level Support For the Basic Income in Europe. Journal of European Social Policy. Forthcoming, 2020.

76. ScotPHO. Vitamin D: policy context: Public Health Scotland; 2019 [updated 2019 05 August; cited 2020 27 April]. Available from: https://www.scotpho.org.uk/life-circumstances/vitamin-d/policy-context/.

77. Scottish Government. Developing the young workforce: Scotland's youth employment strategy 2014 [Available from: https://www.gov.scot/publications/developing-young-workforce-scotlands-youth-employment-strategy/pages/2/.
78. Scottish Government. Young people: training and employment 2020 [Available from: https://www.gov.scot/policies/young-people-training-employment/apprenticeships/.
79. The Citadel Youth Centre. Citadel: Annual Report 2019. 2019.
80. Scottish Government. Safer drug consumption room correspondence with UK Home Office: FOI release 2019 [Available from: https://www.gov.scot/publications/foi-19-01755/.
81. Wyper GMA, Grant I, Fletcher E, McCartney G, Stockton DL. The impact of worldwide, national and sub-national severity distributions in Burden of Disease studies: A case study of cancers in Scotland. PloS One. 2019;14(8):e0221026.
82. Wyper GMA, Dyer GMC, Fletcher E, Grant I, McCartney G, Stockton D L,. Does the choice of life table in Burden of Disease studies impact how causes are ranked? Burden of Disease in Europe: Taking stock and moving forward; Copenhagen Denmark, 2020.
83. Wyper GMA, Grant I, Fletcher E, Chalmers N, McCartney G, Stockton DL. Prioritising the development of severity distributions in burden of disease studies for countries in the European region. Archives of Public Health. 2020;78:3.

7. Figures



1. Aberdeen City
2. Aberdeenshire
3. Angus
4. Argyll and Bute
5. City of Edinburgh
6. Clackmannanshire
7. Dumfries and Galloway
8. Dundee City
9. Easy Ayrshire
10. East Dunbartonshire
11. East Lothian
12. East Renfrewshire
13. Falkirk
14. Fife
15. Glasgow City
16. Highland
17. Inverclyde
18. Midlothian
19. Moray
20. Eilean Siar
21. North Ayrshire
22. North Lanarkshire
23. Orkney Islands
24. Perth and Kinross
25. Renfrewshire
26. Scottish Borders
27. Shetland Islands
28. South Ayrshire
29. South Lanarkshire
30. Stirling
31. West Dunbartonshire
32. West Lothian

***Figure 1*: Thirty two Scottish Local Authority regions**

Top left panel: Map of Scotland.

Bottom left panel: Magnified view of Central Belt.

Right panel: List of local authorities corresponding to numbers on maps.

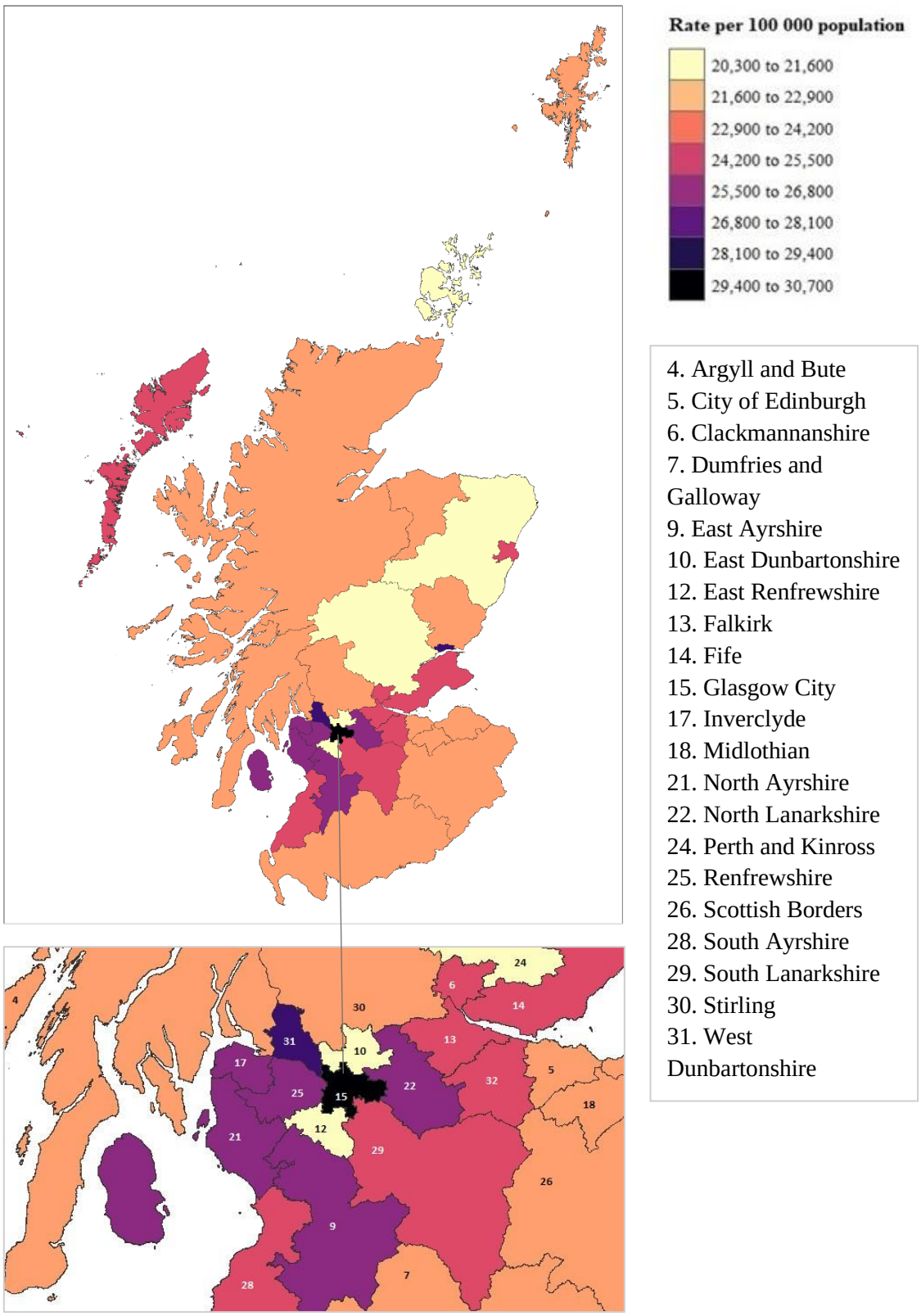


Figure 2A: **All cause age-standardised DALY rates per 100,000 population by Scottish Local Authorities, 2016.**
Bottom left panel: magnified view of Central Belt. *Right panel:* list of local authorities.
DALY= disability-adjusted life years. Numbers correspond to authorities.

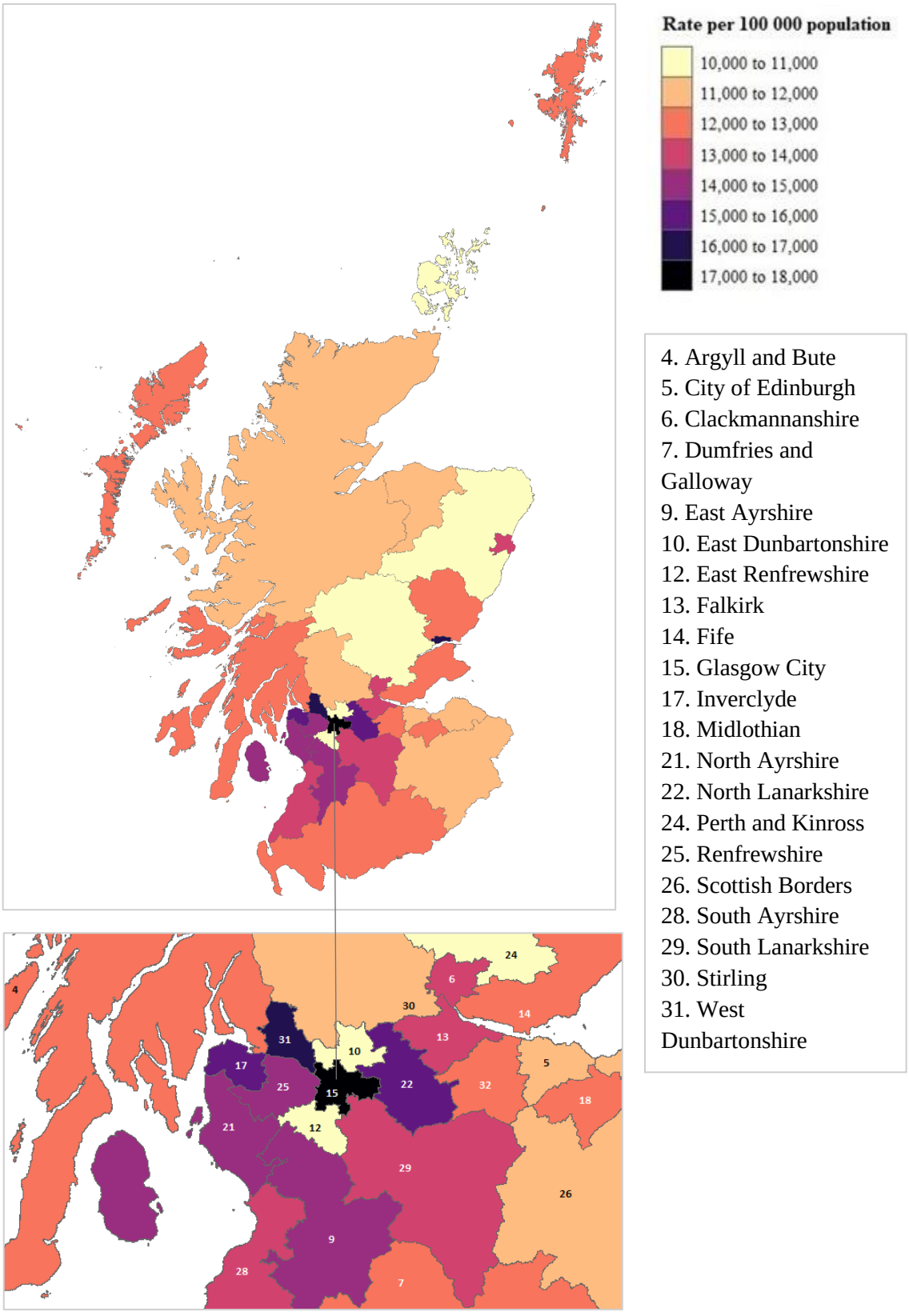


Figure 2B: **All cause age-standardised YLL rates per 100,000 population by Scottish Local Authorities, 2016.**
Bottom left panel: magnified view of Central Belt. *Right panel:* list of local authorities.
YLL= years of life lost. Numbers correspond to local authorities.

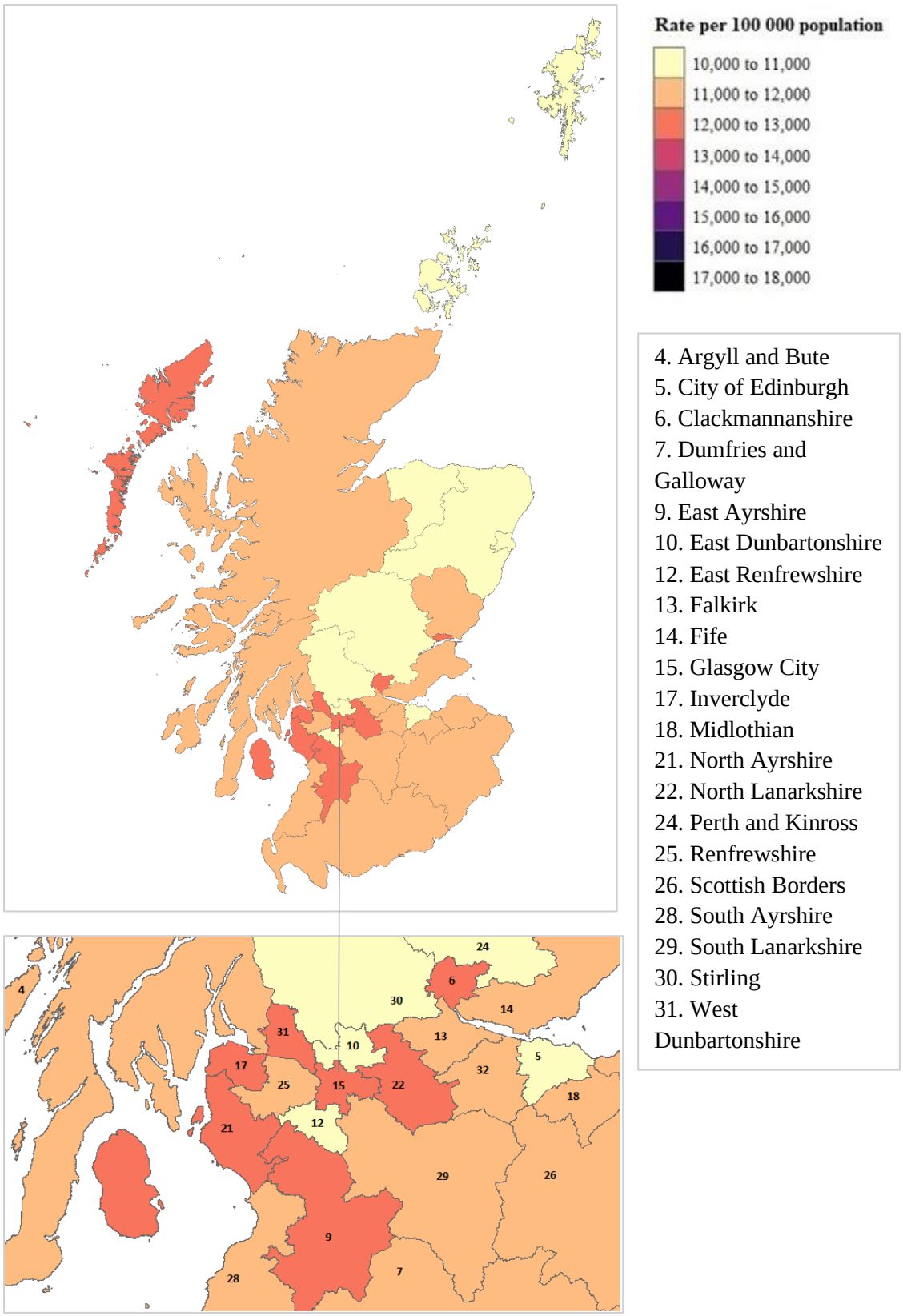


Figure 2C: **All cause age-standardised YLD rates per 100,000 population by Scottish Local Authorities, 2016.**
Bottom left panel: magnified view of Central Belt. *Right panel:* list of local authorities.
YLD= years lived with a disability. Numbers correspond to local authorities.

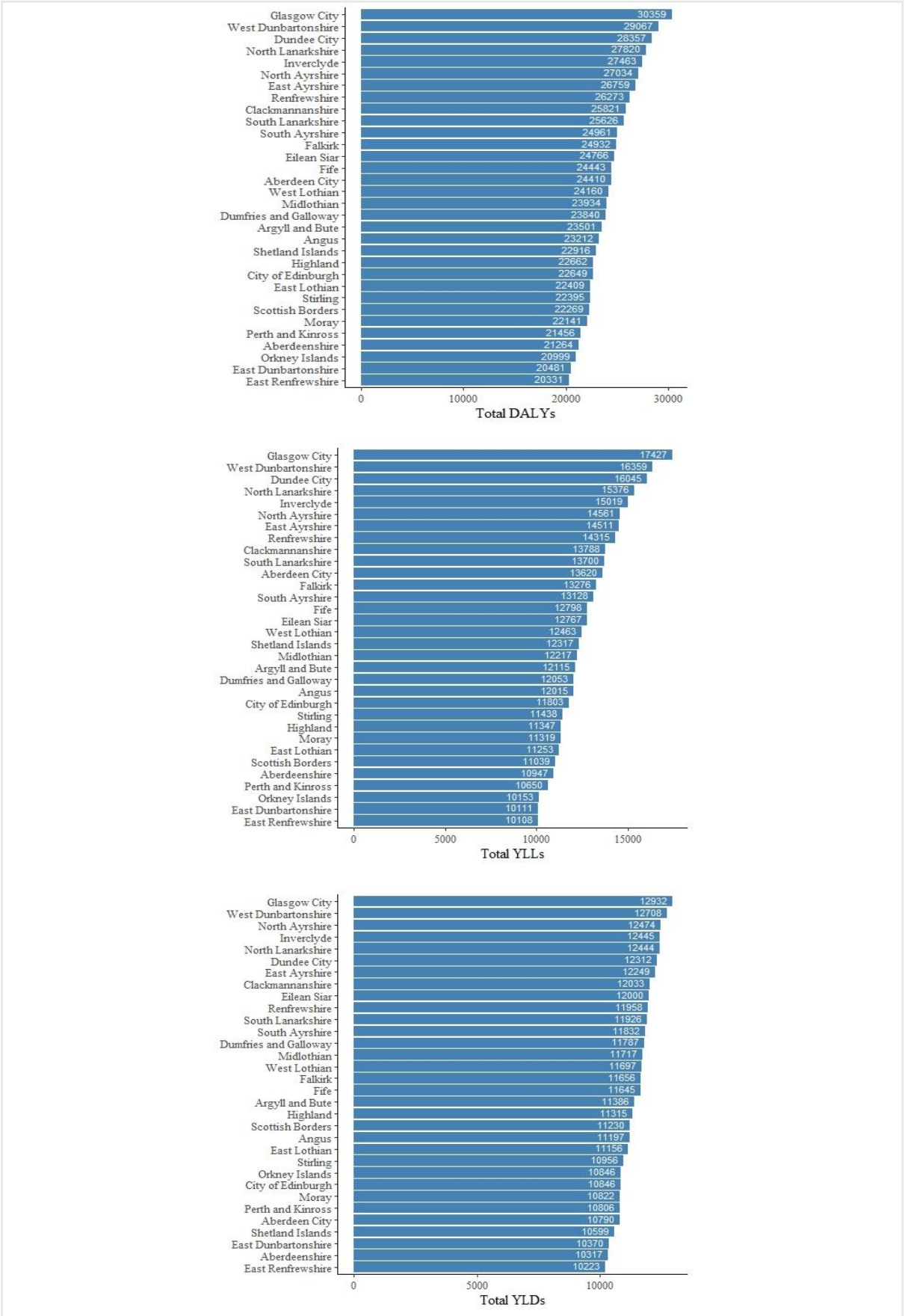
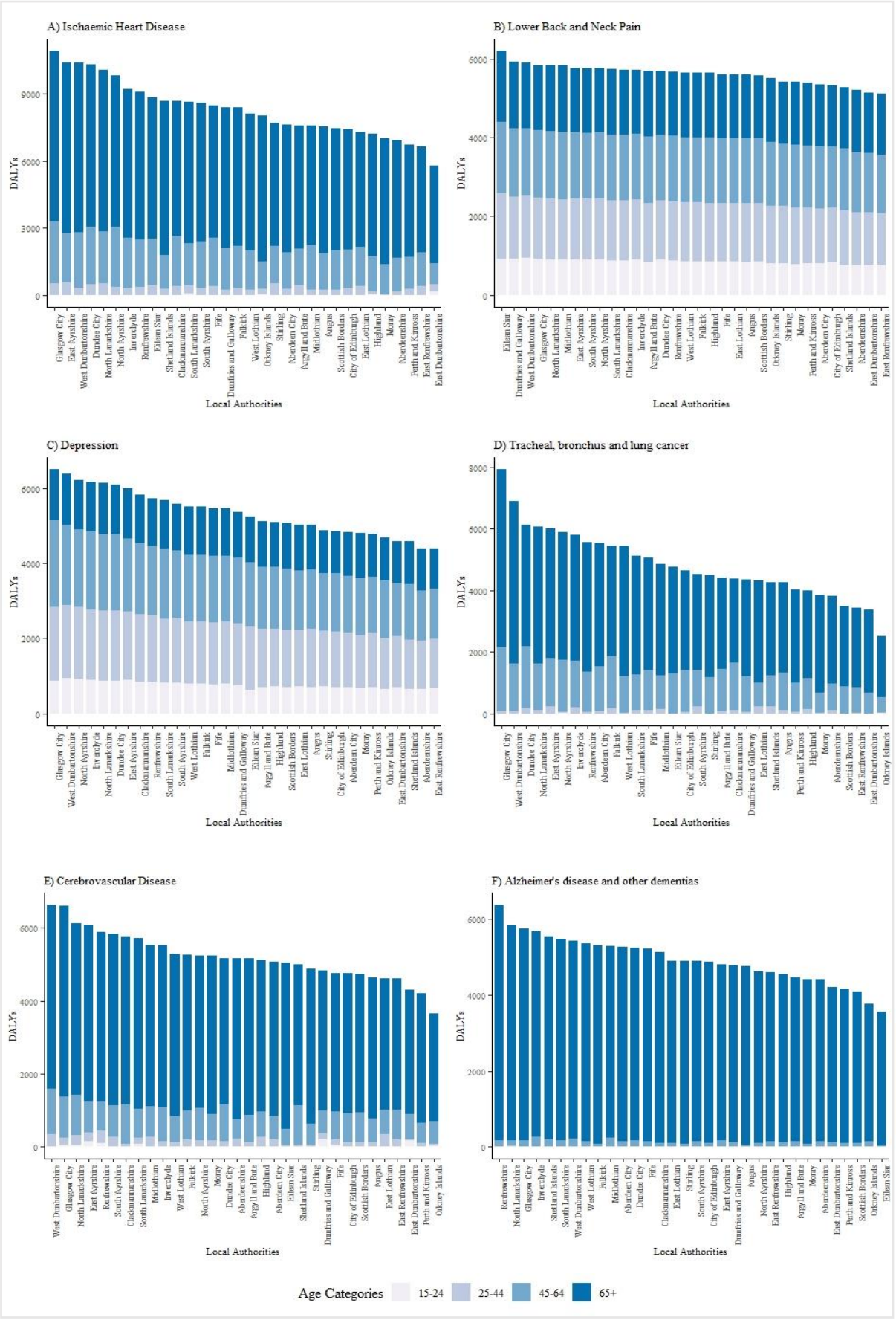


***Figure 3*: All cause age-standardised DALY, YLL, and YLD rates per 100,000 population by Scottish Local Authorities, 2016**

DALY= disability-adjusted life year. YLL= years of life lost. YLD= years lived with a disability.


A) Ischaemic Heart Disease
B) Lower Back and Neck Pain
C) Depression
D) Tracheal, bronchus and lung cancer
E) Cerebrovascular Disease
F) Alzheimer's disease and other dementias
DALYs
Local Authorities
Age Categories
15-24
25-44
45-64
65+

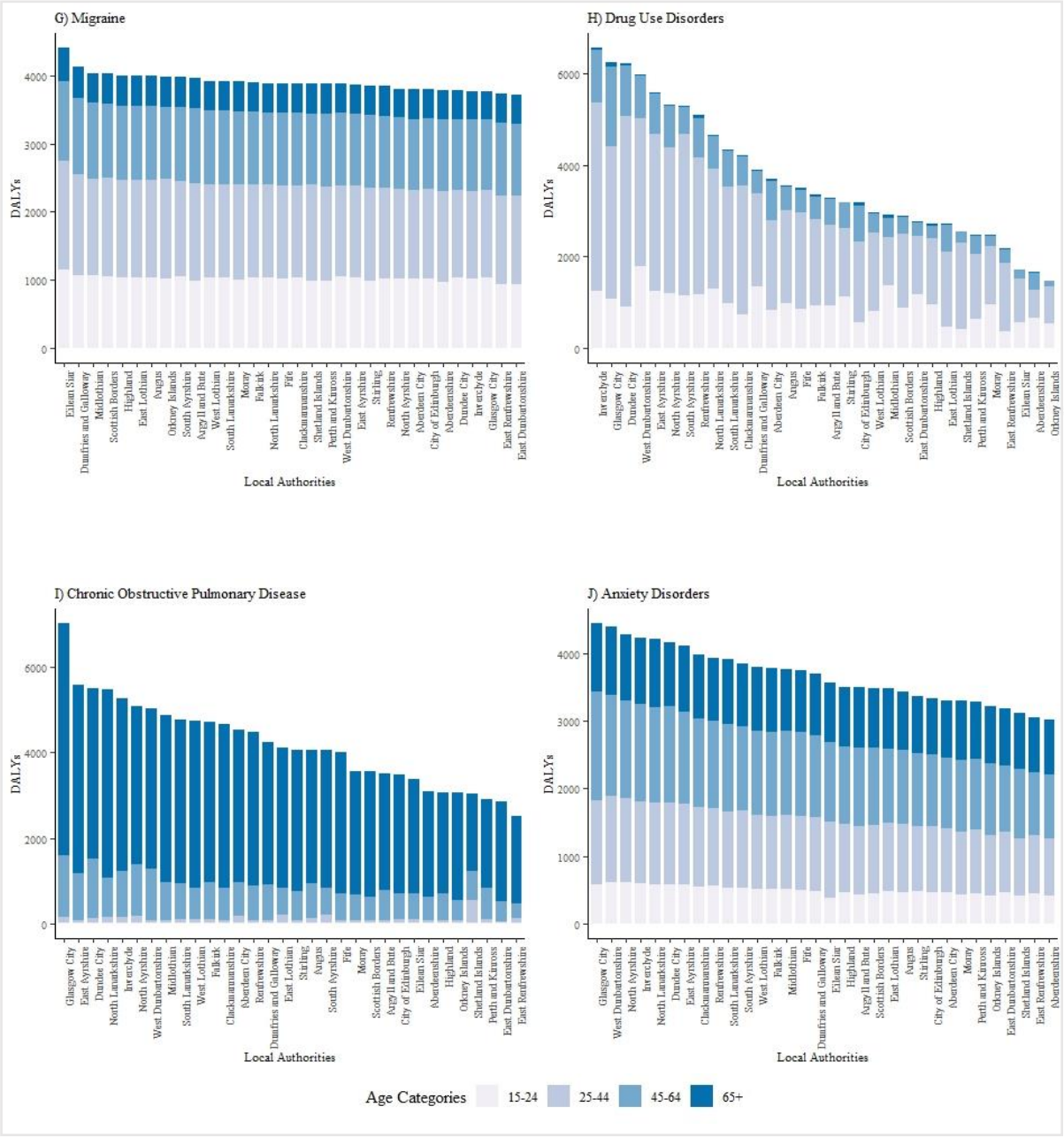


Figure 4: **Age-specific rates of burden (DALY) per 100,000 population, by age group, for the national 10 leading causes in Scotland, both sexes, 2016.**

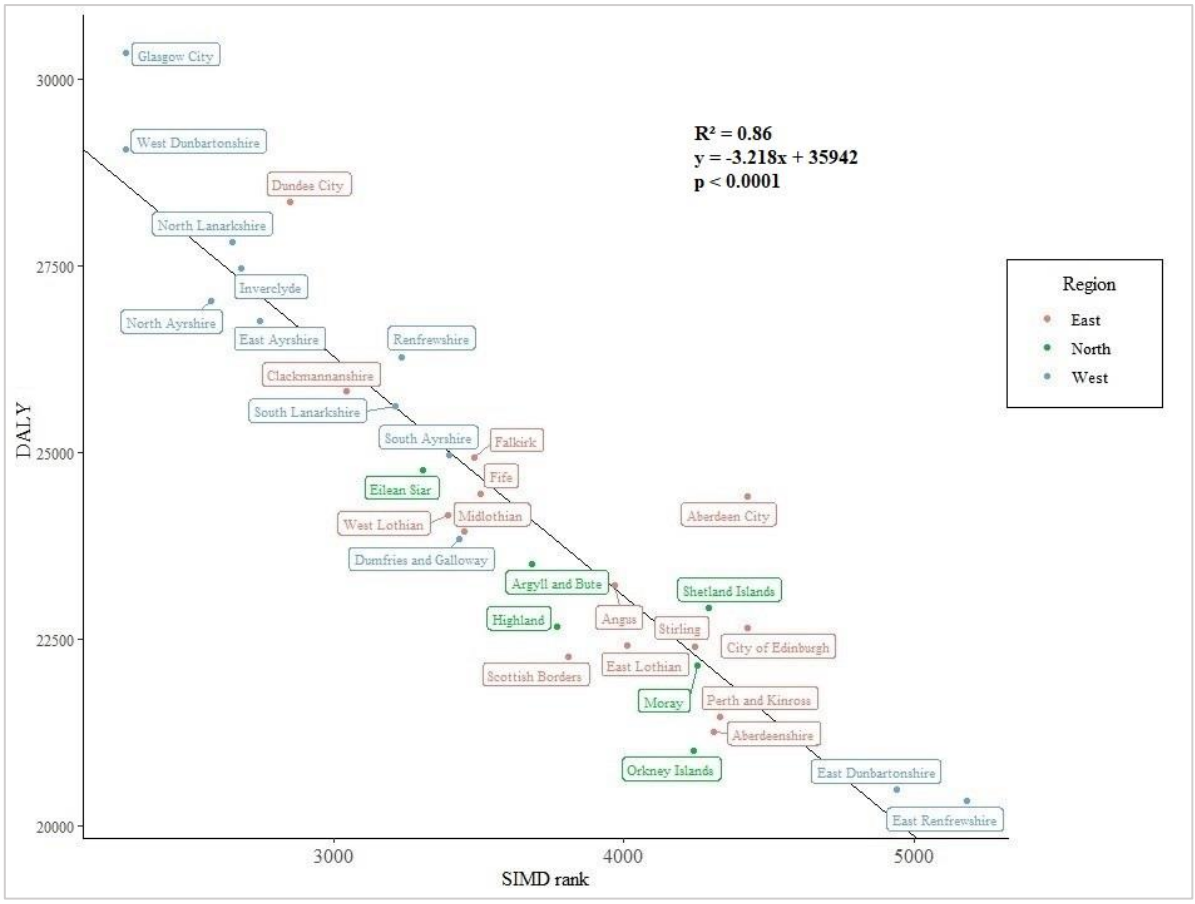


Figure 5: **Linear regression plot showing all cause age-standardised DALY rates per 100,000 population by SIMD rank for Scottish Local Authorities, 2016.**
DALY= disability-adjusted life years. SIMD= Scottish Index of Multiple Deprivation.
SIMD rank of 1= most deprived; rank of 6976= least deprived.
Line of best fit is shown.

8. Supplementary Material

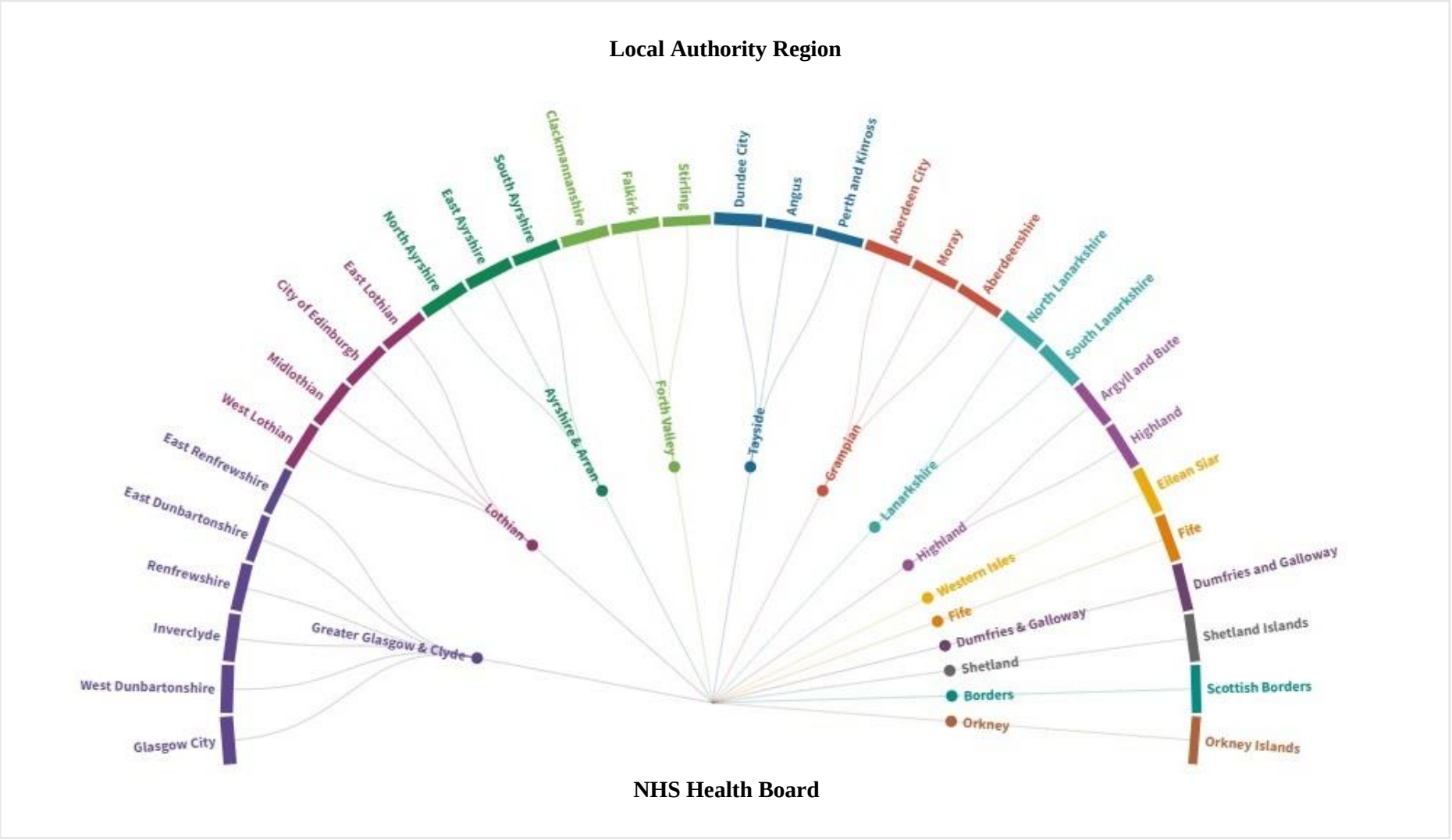
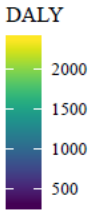
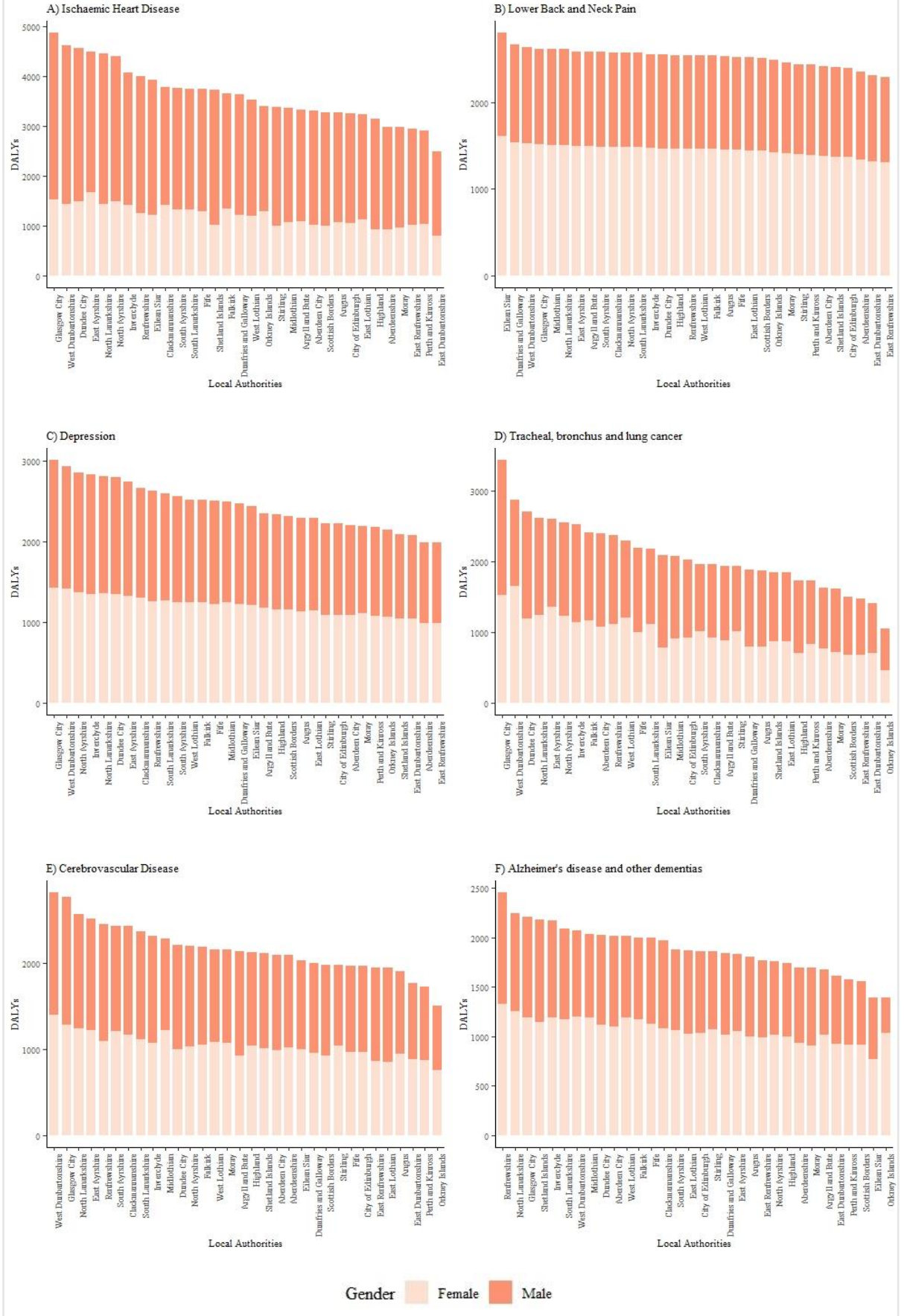


***Figure S1*: Radial dendrogram showing the subdivisions of Scotland by NHS health board and local authority region.**

Table S1 **: Age-standardised DALY rate per 100,000 population for the national 10 leading causes by Scottish local authorities, 2016**

	Ischaemic Heart Disease	Lower Back and Neck Pain	Depression	Cerebrovascular Disease	Tracheal, Bronchus and Lung Cancer	Alzheimer's disease and other dementiass	Migraine	Chronic Obstructive Pulmonary Disease	Drug Use Disorders	Anxiety Disorders
Aberdeen City	1621	1210	1095	1046	1186	1039	865	952	856	748
Aberdeenshire	1467	1180	993	1059	811	871	874	644	339	680
Angus	1599	1274	1141	959	923	932	918	858	792	784
Argyll and Bute	1620	1295	1169	1066	958	880	918	737	731	801
City of Edinburgh	1586	1204	1106	990	1007	959	864	729	754	757
Clackmannanshire	1875	1295	1327	1206	971	1005	887	966	1005	909
Dumfries and Galloway	1789	1343	1229	1000	933	942	947	889	833	846
Dundee City	2226	1286	1394	1089	1346	1034	859	1176	1512	954
East Ayrshire	2220	1305	1367	1252	1301	949	882	1167	1294	937
East Dunbartonshire	1207	1166	1036	888	706	829	854	590	555	718
East Lothian	1574	1274	1140	970	914	964	919	858	646	790
East Renfrewshire	1424	1159	988	970	731	909	858	521	519	686
Eilean Siar	1901	1407	1214	1018	1019	698	1011	704	371	830
Falkirk	1794	1278	1252	1095	1195	1041	892	985	747	860
Fife	1833	1272	1246	992	1089	1030	889	826	798	856
Glasgow City	2358	1318	1498	1382	1696	1134	854	1478	1488	1023
Highland	1527	1281	1162	1066	858	897	921	645	574	799
Inverclyde	1973	1292	1408	1153	1252	1127	861	1110	1551	965
Midlothian	1632	1319	1242	1156	1031	1047	925	1016	562	859
Moray	1464	1232	1091	1083	795	867	901	740	512	752
North Ayrshire	2132	1302	1421	1096	1270	927	867	1088	1231	976
North Lanarkshire	2164	1318	1401	1287	1296	1159	887	1143	1041	962
Orkney Islands	1671	1250	1067	758	523	745	919	635	308	731
Perth and Kinross	1430	1223	1087	866	857	817	893	622	560	745
Renfrewshire	1948	1283	1308	1222	1181	1255	878	933	1166	896
Scottish Borders	1591	1267	1157	991	741	806	923	734	633	797
Shetland Islands	1819	1203	1042	1055	917	1095	896	675	613	710
South Ayrshire	1848	1306	1273	1218	984	964	910	847	1231	877
South Lanarkshire	1834	1297	1294	1185	1087	1089	896	992	1002	890
Stirling	1651	1230	1109	996	960	959	884	846	675	764
West Dunbartonshire	2221	1332	1459	1405	1459	1074	882	1067	1316	1005
West Lothian	1719	1280	1256	1090	1148	1055	896	984	660	863




A) Ischaemic Heart Disease
DALYs
Local Authorities
B) Lower Back and Neck Pain
DALYs
Local Authorities
C) Depression
DALYs
Local Authorities
D) Tracheal, bronchus and lung cancer
DALYs
Local Authorities
E) Cerebrovascular Disease
DALYs
Local Authorities
F) Alzheimer's disease and other dementias
DALYs
Local Authorities
Gender
Female
Male

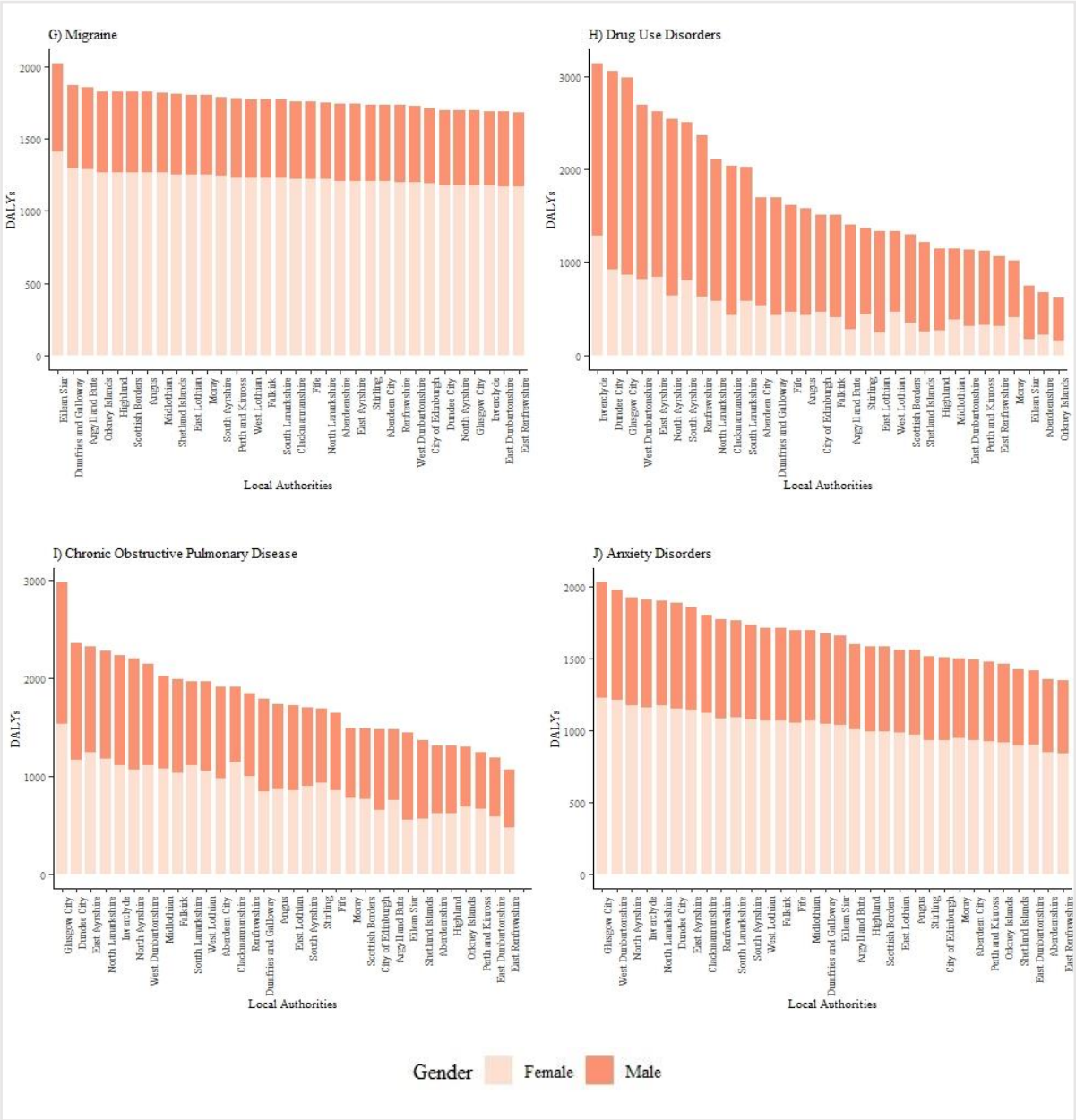


***Figure S2*: Age-standardised rates of burden (DALY) per 100,000 population, by sex, for the national 10 leading causes in Scotland, 2016.**

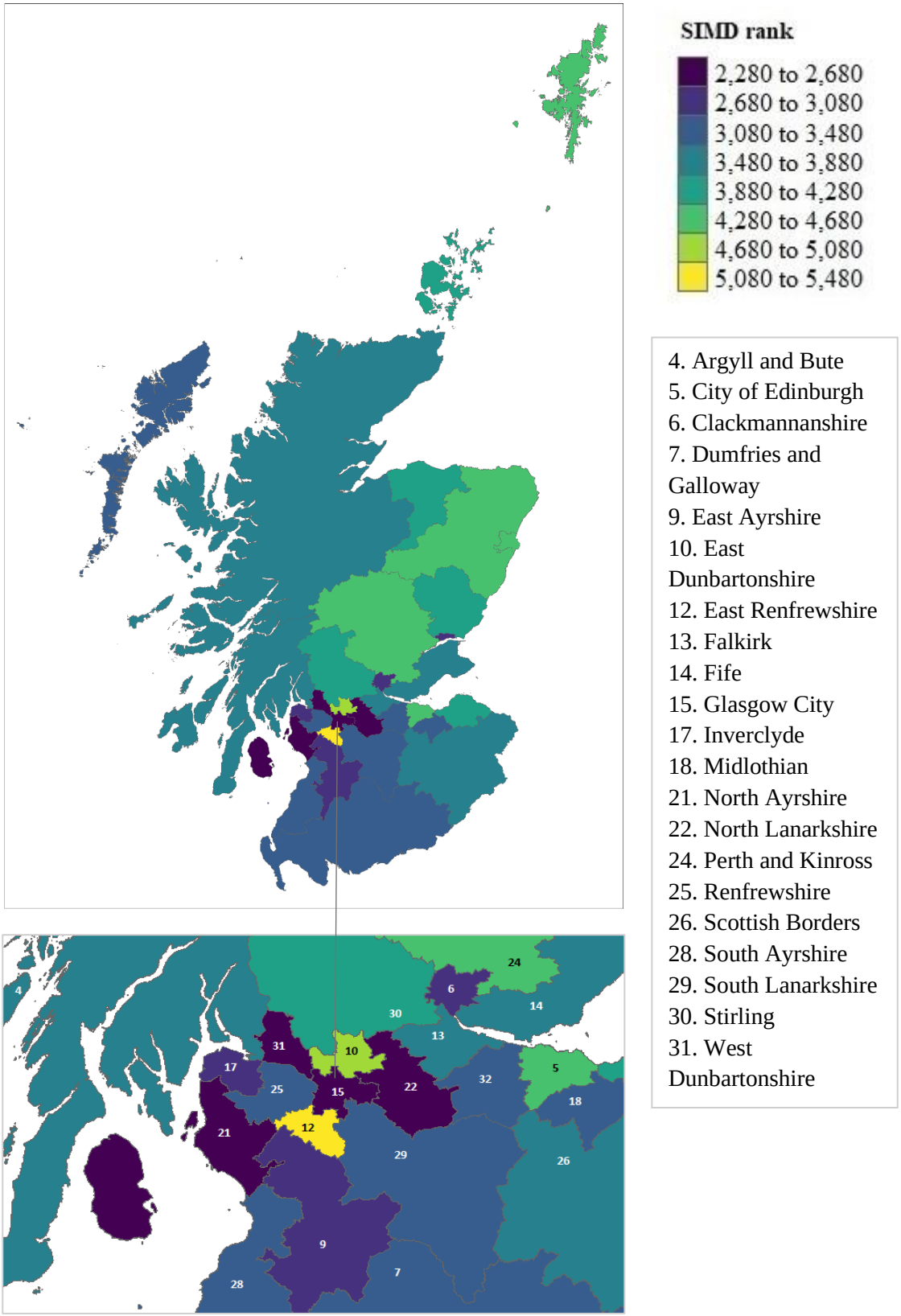


***Figure S3*: SIMD rank by Scottish Local Authorities, 2016.**
SIMD=Scottish Index of Multiple Deprivation.
SIMD rank of 1= most deprived; rank of 6976= least deprived.

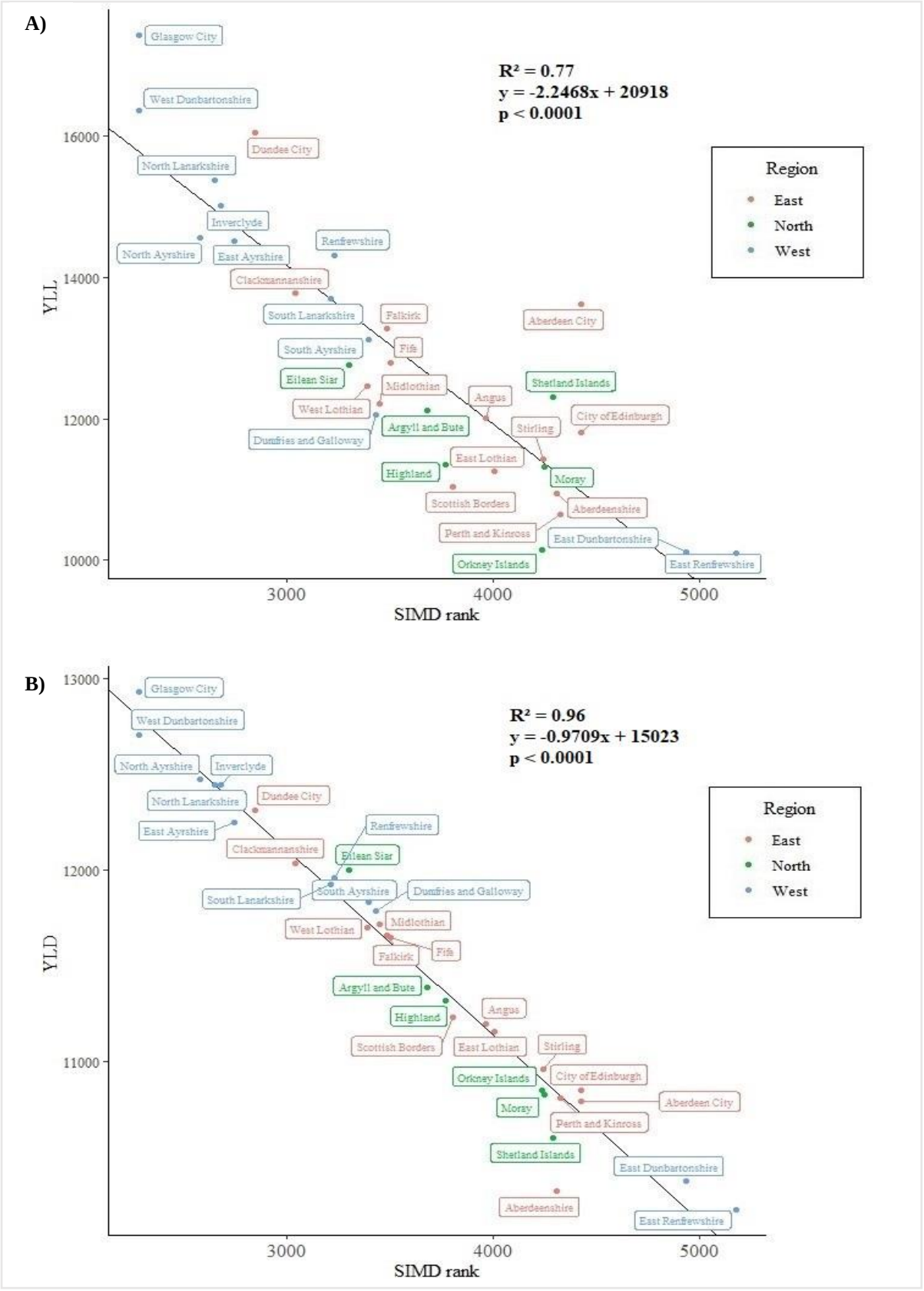


Figure S4: **Linear regression showing all cause age-standardised A) YLL rates and B) YLD rates per 100,000 population by SIMD rank for Scottish Local Authorities, 2016.**
YLL= years of life lost. YLD= years lived with a disability. SIMD= Scottish Index of Multiple Deprivation. SIMD rank of 1= most deprived; rank of 6976= least deprived.
Line of best fit is shown.

9. Popular Science Summary

Burden of disease studies aim to quantify how non-fatal and fatal conditions contribute to the number of years a person lives in less than ideal health and how much of an individual's maximum lifespan is shortened due to premature mortality. Through this approach, the Scottish Burden of Disease study has identified leading causes of disability and death affecting Scotland's population. The importance of understanding subnational geographical variation in disease and socioeconomic deprivation are gaining increasing recognition. This thesis is the first account of subnational estimates of disease burden at local authority level in Scotland. Variation in leading causes of disease between local authorities are described and shown to strongly correlate with area-based deprivation. Western Scottish authorities showed greatest disease burden and deprivation, with the exception of two Western authorities East Dunbartonshire and East Renfrewshire which had the most positive health and deprivation outcomes of all local authorities. Non-fatal conditions of depression, anxiety disorders, and lower back and neck pain were found to have widespread burden in working age groups across all local authorities. The suggested underlying causes of geographical variation in disease burden and deprivation are discussed. Relevant prevention and mitigation strategies together with income-based policies for reducing overall burden of fatal and non-fatal conditions are then presented based upon findings. Overall, targeting the uneven deprivation across Scotland necessitates prime focus, specifically progressive policies that offer redistribution of income and assurance of universal capacity to afford healthy living. Collectively, local disease burden estimates inform public health interventions and appropriate policy responses for the effective improvement of Scotland's population health.

10. Acknowledgements

I would like to thank my supervisor Yan Borné for her encouragement and invaluable feedback. Grant Wyper for not only his expert knowledge of SBoD but for providing me with the opportunity to analyse local Scottish data. Calum Young for his continual support throughout, and for teaching me the joys and trials of R Studio, without which this thesis would not be to the same standard. The views expressed in this thesis are those of the author and not necessarily those of the NHS or SBoD team.