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# Estimating the burden of disease attributable to physical inactivity in Scotland

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## Acknowledgements

This report was co-written by Dr Nick Townsend, Associate Professor in Public Health Epidemiology, Department for Health, University of Bath; Dr Tessa Strain, MRC Epidemiology Unit, University of Cambridge; and Dr Charlie Foster, Professor of Physical Activity and Public Health, School of Policy Studies, University of Bristol, on behalf of Public Health Scotland.

# 1. Executive summary

This project has reinforced the importance of physical inactivity as a risk factor for non-communicable disease and estimated its relative contribution to the burden of disease in Scotland at national, regional and local levels.

To estimate the burden of physical inactivity, we have evaluated the availability and quality of the data available. We have followed existing estimates using a mix of the Global Burden of Disease method or those using national data to create local estimates in other behavioural risk factors (such as alcohol). We have recognised the need to examine approaches to creating estimates of a Scottish population attributable fraction (PAF). All our work has been placed within an intersectional and multilevel approach to inequalities and physical activity participation.

We conclude with suggestions on how to better this output by updating estimates of the costs of physical inactivity across the Scottish healthcare system and to support the essential need to keep the development of physical activity as a priority for Scotland.

## 2. Introduction

Public Health Scotland (PHS) recently published findings from the Scottish Burden of Disease (SBoD) study exploring the impact of projected population changes on the annual disease burden over the next 20 years. Despite an overall decline in the projected population, the annual disease burden is forecast to increase by 21% over the next 20 years.<sup>1</sup> These estimates highlight the need to do things differently and the importance of physical activity in the prevention of noncommunicable disease. A prime example of this is physical inactivity, which presents a significant risk to the Scottish population.

Physical inactivity is recognised as one of four leading risk factors for non-communicable disease.<sup>2</sup> Conversely, we know that physical activity can play a vital role in the prevention, early intervention and management of many non-communicable diseases and long-term conditions.<sup>3,4</sup>

The COVID-19 pandemic and related protection measures, including lockdowns and restrictions to social mixing, has impacted on physical activity in the UK's population, across every domain including activity at work, home, active travel and recreation. Impacts of physical inactivity cut across health, social and economic sectors and are magnified by structural and personal inequalities.

The need to assess the magnitude of the burden of physical inactivity is now more important than ever. It will enable policy makers to identify appropriate systems-based actions to tackle health and social inequalities.

This report focuses on four stages:

1. What is the evidence for the relationship between physical inactivity and health outcomes?
2. How is this evidence impacted by personal and structural inequalities?
3. Estimating the burden of ischaemic heart disease (IHD) (as a proof-of-concept) to physical inactivity.
4. Recommendations and next steps.

### 3. What is the evidence of the relationship between physical inactivity and health outcomes?

We reviewed the most recent global and national reports, evidencing the degree of relationship between physical inactivity and health outcomes.

Diseases were included if:

1. There was evidence for a causal association with physical inactivity, preferably from a meta-analysis or prospective studies, considered to be at a convincing or probable level (Tables 1 and 2).
2. The evidence suggests that there is a correlation between physical inactivity and specific health outcomes, but the weight of evidence is considered to be less convincing or probable (Table 3).

We then supplemented this with newly published, or in press, systematic reviews and meta-analysis. These include reviews from the USA,<sup>5</sup> World Health Organization (WHO)<sup>6,7</sup> and the UK's Chief Medical Officers' Physical Activity Guidelines 2019. This investigation identified the most recent estimates for the relationship between physically active and inactive adults for specific causes of mortality and morbidity.

The findings of the review are summarised in two tables.

Table 1 presents a description of the health outcomes and the benefits of physical activity, as well as the relative risk and uncertainty range presented in the USA Physical Activity Guidelines report, Global Burden of Disease 2019 study and other reviews.

**Table 1: Physical activity relative risks and health benefits**

<b>Outcome</b>	<b>Benefit of physical activity</b>	<b>Relative risks (RR) and 95% uncertainty interval used in GBD 2019</b>	<b>Relative risks and 95% confidence intervals or uncertainty levels from other reviews</b>
All-cause mortality	Lowers risk.	Not used.	Not used.
Cardiometabolic conditions	Lowers cardiovascular incidence and mortality (including heart disease and stroke).	Ischaemic heart disease – 25% (0.754, 0.704–0.809) Ischaemic stroke – 26% (0.736, 0.659–0.811)	<ul style="list-style-type: none"> <li>• 2016<sup>8</sup> (0.77, 0.71–0.84).</li> <li>• 2016 (0.74, 0.72–0.77).</li> </ul>
Cardiometabolic conditions	Lowers incidence of type 2 diabetes.	Diabetes mellitus – 28% (0.722, 0.678–0.768).	2012 <sup>9</sup> (0.81, 0.76–0.85).
Cardiometabolic conditions	Lowers incidence of hypertension.	Not used.	Not used.
Cancer	Lowers incidence of colon cancer.	Colon and rectal cancer – 21% (RR 0.789, 0.735–0.850).	<ul style="list-style-type: none"> <li>• Colon cancer<sup>10</sup> – 18% (RR 0.82, 0.79–0.85).</li> <li>• Rectal cancer 1 – 12% (RR 0.88, 0.80–0.98).</li> </ul>
Cancer	Lowers incidence of breast cancer.	Breast cancer – 14% (RR 0.863, 0.829–0.900).	2017 <sup>11</sup> 0.87 (95% CI 0.81–0.93).

More recently, meta-analyses have examined the relationship between physical activity and incidence of a range of cancer types. Table 2 presents levels of physical activity and prevention of cancers from a range of in press and published meta-analysis.

**Table 2: Physical activity and cancer-related health benefits**

<b>% Reduction in RR and 95% confidence intervals from other reviews (high versus low physical activity)</b>	<b>Date of source studies</b>
Colorectal <sup>10</sup> – 23% (RR 0.77, 0.69–0.85).	2018
Bladder <sup>12</sup> – 15% (RR 0.85, 0.74–0.98).	2013 (non-significant)*
Endometrium <sup>13</sup> – 20% (0.80, 0.75–0.85).	2014 (RR 0.87, 0.80–0.95)*
Oesophagus <sup>10</sup> – 21% (RR 0.79, 0.72–0.87).	2018 (non-significant)*
Kidney – supported by USA PAG, but meta-analysis are inconsistent.	(non-significant)*
Stomach <sup>10</sup> – 17% (RR 0.83, 0.76–0.91).	2018 (RR 0.73, 0.60–0.88)*
Lung <sup>14</sup> – 21% (RR 0.79, 0.72–0.87).	2015 (RR 0.83, 0.76–0.91)*
Gallbladder <sup>10</sup> – 21% (RR 0.79, 0.64–0.98).	2018
Liver <sup>10</sup> – 27% (RR 0.73, 0.60–0.89).	2018 (RR 0.78, 0.66–0.93)*
Pancreatic <sup>10</sup> – 15% (RR 0.85, 0.78–0.93).	2018

\*Note: these estimates compared 17.5 mMET-h/week with 0 mMET-hr/week (the upper bound of the recommended level for health benefits according to the WHO).<sup>15</sup>

From the most recent meta-analysis, Table 3 summarises additional health benefits of physical activity across other health outcomes, including brain health, obesity or metabolic disease, falls and physical function.

**Table 3: Health benefits of physical activity to brain health, weight status, falls and physical function**

<b>Outcome</b>	<b>% Reduction in hazard ratio and 95% confidence intervals from other reviews (high versus low physical activity)</b>
Brain health	Reduces risk of dementia <sup>16</sup> 38% (HR 0.62, 0.54–0.70).
Brain health	Improves cognitive function. <sup>17</sup>
Brain health	Improves cognitive function following bouts of aerobic activity.

Outcome	% Reduction in hazard ratio and 95% confidence intervals from other reviews (high versus low physical activity)
Brain health	Improves quality of life. <sup>18</sup>
Brain health	Improves sleep. <sup>19</sup>
Brain health	Reduces feelings of anxiety and depression in healthy people and in people with existing clinical syndromes.
Brain health	Reduces incidence of depression. <sup>20</sup>
Weight status	Reduces risk of excessive weight gain.
Weight status	Weight loss and the prevention of weight regain following initial weight loss when a sufficient dose of moderate to vigorous physical activity is attained.
Weight status	An additive effect on weight loss when combined with moderate dietary restriction.
Falls	Reduces incidence of falls.
Falls	Reduces incidence of fall-related injuries.
Physical function	Improves physical function in older adults with and without frailty.

## 4. How is this evidence impacted by individual characteristics and structural inequalities?

In 2015, the Active Scotland Outcomes Framework gave an analysis of equality data in relation to physical activity levels.<sup>21</sup> Despite the evidence base for monitoring being described as 'variable', the data available presented a consistent message that inequalities in physical activity levels remain stubbornly present. Disparities in physical activity levels remain consistent by age, gender and socioeconomic status. Despite limited data differences in physical activity, levels are also evident by disability, ethnicity, sexual orientation, pregnancy/maternity and religion.

Recent international and English data suggest that the direct and indirect impacts of the COVID-19 lockdowns are very likely to have magnified these inequalities for both children and adults, with decreases in physical activity and increases in sedentary behaviours.<sup>22-30</sup> A rapid review of evidence into the impact of COVID-19 on physical activity inequalities indicates that inequalities that existed prior to March 2020 were further exacerbated.<sup>31</sup>

Any attempts to estimate the burden of physical activity upon mortality and morbidity outcomes would ideally be able to reflect both the double burden of inequalities for both the exposure (physical activity) and outcomes (mortality or morbidity). Estimates that do not account for differences by inequalities will inevitably be underestimates of the true burden of disease within these inequality groups.

## 5. Methods

### Estimating the burden of disease attributable to physical inactivity

To determine the population-level burden of disease attributable to physical inactivity we used the population attributable fraction (PAF) methodology. PAFs are an epidemiological measure widely used to assess the population health impact of exposures to risk factors. The PAF is defined as the proportion of all cases of a health outcome in a population that is attributable to a specific exposure,<sup>32</sup> in this case physical inactivity.

PAF requires a measure of exposure level (prevalence) and the disease-specific relative risks (RRs) of this exposure. It is calculated using the following equation:

$$PAF = \frac{P_e(RR - 1)}{P_e(RR - 1) + 1}$$

Where:

- $P_e$  = the estimated proportion of the population that is exposed to the risk factor of interest (that is prevalence expressed as a proportion).
- RR = the relative risk estimate for the risk factor of interest, representing the magnitude of the association between the risk factor and the disease.

### Calculating the burden of disease attributable to physical inactivity in Scotland

To calculate physical inactivity related PAFs for Scotland we required:

- prevalence measures for physical inactivity in the Scottish population
- measures of disease burden in the Scottish population

- disease-specific RRs for physical inactivity

## Prevalence measures for physical inactivity in the Scottish population

The most relevant measures of levels of physical activity in the Scottish population come from the Scottish Health Survey (SHeS). The SHeS provides a detailed picture of the health of the Scottish population through surveying private households and is designed to make a major contribution to the monitoring of health risks and outcomes in Scotland.

Data for physical activity prevalence in the Scottish population are available through the SHeS dashboard<sup>33</sup> at three geographical levels:

1. national
2. NHS health board
3. local authority

Levels of physical activity are presented for four categories, defined by minutes per week of moderate or vigorous activity, in Table 4. The highest level is defined as ‘meets recommendations’ linking to the UK Chief Medical Officers’ Physical Activity Guidelines.<sup>4</sup>

**Table 4: Physical activity categories defined as reported by SHeS**

Activity categories	Definition
Very low activity	Reported less than 30 mins/week of moderate physical activity, less than 15 mins/week vigorous physical activity or an equivalent combination of these.
Low activity	Reported 30–59 mins/week of moderate physical activity, 15–29 mins/week vigorous physical activity or an equivalent combination of these.

Activity categories	Definition
Some activity	Reported 60–149 mins/week of moderate physical activity, 30–74 mins/week vigorous physical activity or an equivalent combination of these.
Meets recommendations	Reported 150 mins/week of moderate physical activity, 75 mins vigorous physical activity or an equivalent combination of these.

## Measures of disease burden in the Scottish population

Measures of disease burden in the Scottish population are available from the Scottish Burden of Disease (SBoD) study. The SBoD estimates the burden of individual diseases and injuries, with estimates available at NHS board and local authority geographies. The non-fatal and fatal disease burden is estimated separately, and also in combination, as described below:

- YLL = years of life lost: a measure of premature mortality that takes into account both the frequency of deaths and the ages at which they occur.<sup>34</sup>
- YLD = years lived with disability: a measure reflecting the frequency of illness and the impact an illness has on quality of life before it resolves or leads to death.<sup>35</sup>
- DALYs = disability-adjusted life years: one DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of YLL and YLD.<sup>36</sup>

## Disease-specific relative risks for physical inactivity

Although it is common to present physical activity by levels such as those presented above, in reference to national and international recommendations, obtaining RRs that link to the specific SHeS levels is challenging. It requires work on risk factors against these specific cut-offs. To calculate the PAFs for physical activity for these categories would require a separate RR for each level against 'meets recommendations'. Such data were not available and would be limited in their use

beyond these categories. This is important as the SHeS changed their physical activity measurement tool in 2020 and 2021 to use the International Physical Activity Questionnaire (IPAQ). This means that physical activity data collected in these years will be based around ‘metabolic equivalent of task’ (METs). METs are the ratio of the work metabolic rate to the resting metabolic rate, with one MET defined as 1 kcal/kg, approximately equivalent to the energy cost of sitting quietly.<sup>37</sup>

An approach was developed to establish a RR estimate for a selected volume of physical activity where METs are provided and different categories of physical activity levels exist.

To do this, METs equivalents were calculated for each category of physical activity (very low, low, some activity and meets the recommendations) defined by the SHeS. This was achieved by identifying the middle number of minutes per physical activity category and multiplying the minutes by 4.5 METs as recommended in previous studies.<sup>8</sup> This resulted in identifying total MET minutes, or MET hours, for each category of physical activity (Table 5).

**Table 5: MET values for SHeS categories of physical activity**

Activity categories	Moderate minutes	Total MET minutes/week	Total MET hours/week	Total MET hours/day
Very low activity	15	67.5	1.125	0.161
Low activity	45	202.5	3.375	0.482
Some activity	105	472.5	7.875	1.125
Meets recommendations	150	675	11.25	1.607

To calculate RRs between categories, it was assumed that the relationship between RR and MET hours per week followed a 0.25 power transformation, resulting in the following equation<sup>38</sup>:

$$RR = 1 + b \text{ MET hours/day } 0.25$$

The 0.25 power transformation has been used in previous studies.<sup>32,39</sup> It was chosen as it closely models the observed findings that RRs for chronic disease fall quickly with a small addition of physical activity, but further increases produce diminishing returns. Relative risks for disease types were then taken from a systematic review and meta-analysis that derived single continuous physical activity metrics, to account for the dose-response relationship.

## 6. Results

### Calculating the burden of ischaemic heart disease attributable to physical inactivity

For this study we focused on ischaemic heart disease (IHD) as a proof-of-concept because data on this were available from the SBoD and RRs had been calculated through a systematic review and meta-analysis. IHD is also the most common single cause of death within Scotland and was the leading cause of disease burden in 2019. Data also indicate that excess cardiovascular deaths were also recorded during the COVID-19 pandemic.

The meta-analysis of IHD incidence using a change in METs approach suggests that the RR for a change from 0 MET hours/day to 1.61 MET hours/day, equivalent to moving from no physical activity to obtaining recommendations, is 0.80 when adjusted for body weight, or 0.77 when not adjusted for body weight. Risk reductions after adjusting for body weight allow for an assessment of the independent effect of physical activity on health outcomes, although at least part of any observed effect is likely to be mediated by maintenance of healthy weight status and could be considered.

These values can be put into the following equation:

$$RR = 1 + b \text{ MET hours/day}^{0.25}$$

Such that:

$$0.8 = 1 + b(1.61)^{0.25} \quad \rightarrow \quad b = -0.1775$$

This value can then be used to estimate the relative risk for a unit increase of MET h/day at any physical activity level.

For example, the relative risk of IHD incidence associated with a change from 'very low activity' (0.161MET h/day) to 'meets recommendations' (1.607MET h/day) is estimated as follows:

- RR very low activity =  $1 - 0.1775 \times 0.1610.25 = 0.888$
- RR meets recommendations =  $1 - 0.1775 \times 1.6070.25 = 0.800$
- RR very low activity → meets recommendations =  $\frac{\text{RR meets recommendations}}{\text{RR very low activity}}$

Where:

$$\frac{\text{RR meets recommendations}}{\text{RR very low activity}} = 0.800/0.888 = 0.901$$

Following this process for all levels of physical activity measurement from the SHeS, we can calculate the RR of moving between any of the levels (Table 6).

**Table 6: Relative risk of IHD incidence in moving from original physical activity category to final physical activity category**

Physical activity category	Final category: low activity	Final category: some activity	Final category: meets recommendations
Original category: very low activity	0.960	0.921	0.901
Original category: low activity	N/A	0.960	0.939
Original category: some activity	N/A	N/A	0.979

In Table 6 we have presented changes from lower categories of physical activity to higher ones, demonstrating the lower risk for people with higher levels of activity, or the decrease in risk of IHD if an individual becomes more active. It is obviously possible to calculate the reverse and take account of decreases in activity or to consider the greater risk for those at lower levels of activity. It is these we will use in calculating the proportion of IHD health burden due to individuals not meeting recommended activity levels in Scotland.

# Calculating the attributable burden of inactivity on IHD outcomes by NHS health board in Scotland

To estimate the IHD disease burden attributable to physical inactivity in the Scottish population, we will use the RRs for being in a lower category of activity compared to meeting recommendations. These can be calculated using the methods detailed above and correspond to the RRs between the same categories presented in Table 6. In Table 7, we present the increased risk of IHD for those in the three categories of physical inactivity, relative to those meeting recommendations.

**Table 7: Relative risks of physical inactivity compared to meeting the physical activity recommendations**

Physical activity category	Relative risk of IHD compared to meeting activity recommendations
Very low activity	1.11
Low activity	1.06
Some activity	1.02

## Worked example

We can use these RRs to calculate PAFs for any area level for which physical activity prevalence figures are available. As an example, we will work through the calculations for the Ayrshire and Arran Health Board (Table 8).

**Table 8: Prevalence of physical activity categories for Ayrshire and Arran Health Board against relative risk for IHD compared to meeting physical activity recommendations**

Physical activity category	Relative risk of IHD compared to meeting activity recommendations
Very low activity	1.11
Low activity	1.06
Some activity	1.02

To calculate the PAF for those with very low activity compared to those meeting recommendations we use the equation from earlier:

$$PAF = \frac{P_e(RR-1)}{P_e(RR-1)+1} = \frac{0.28(1.11-1)}{0.28(1.11-1)+1} = 0.0298$$

From this, we can conclude that 2.98% of the burden of IHD in Ayrshire and Arran comes from those who have very low activity. We can then calculate this attributable fraction for each level of activity, for each health board, using the SHeS prevalence data and the RRs. Once we have done this, we can apply these PAFs to the measures of burden from the SBoD study. If we estimate that 2.98% of the burden of IHD within Ayrshire and Arran comes from those with very low physical activity, we can apply this to measures of disease burden from the SBoD study. We do this in Table 9 for YLL to IHD in Ayrshire and Arran.

**Table 9: Calculating YLL due to IHD, by physical activity category, Ayrshire and Arran Health Board**

Physical activity category	Prevalence (%)	PAFs (%)	IHD YLL	Attributable IHD YLL
Very low activity	28	2.98	10,723.70	318.6
Low activity	3	0.19	10,723.70	20.9
Some activity	10	0.21	10,723.70	23.5
Meets recommendations	58	0	10,723.70	0

This means that for Ayrshire and Arran, 362 of the years of life lost due to premature death from IHD can be attributed to individuals not reaching recommended levels of activity. Of these 362 years of life lost, around 88% are accounted for by individuals in the very low activity category. This high burden is a result of the high proportion of individuals in this category and the higher RR for IHD for those with 'very low activity'.

## **All territorial NHS boards in Scotland**

Similar findings were observed in all health boards, as shown in Figure 1 (data for all figures in this report are available in the appendices).

**Figure 1: Number of YLL due to IHD attributable to physical inactivity, by NHS health board**

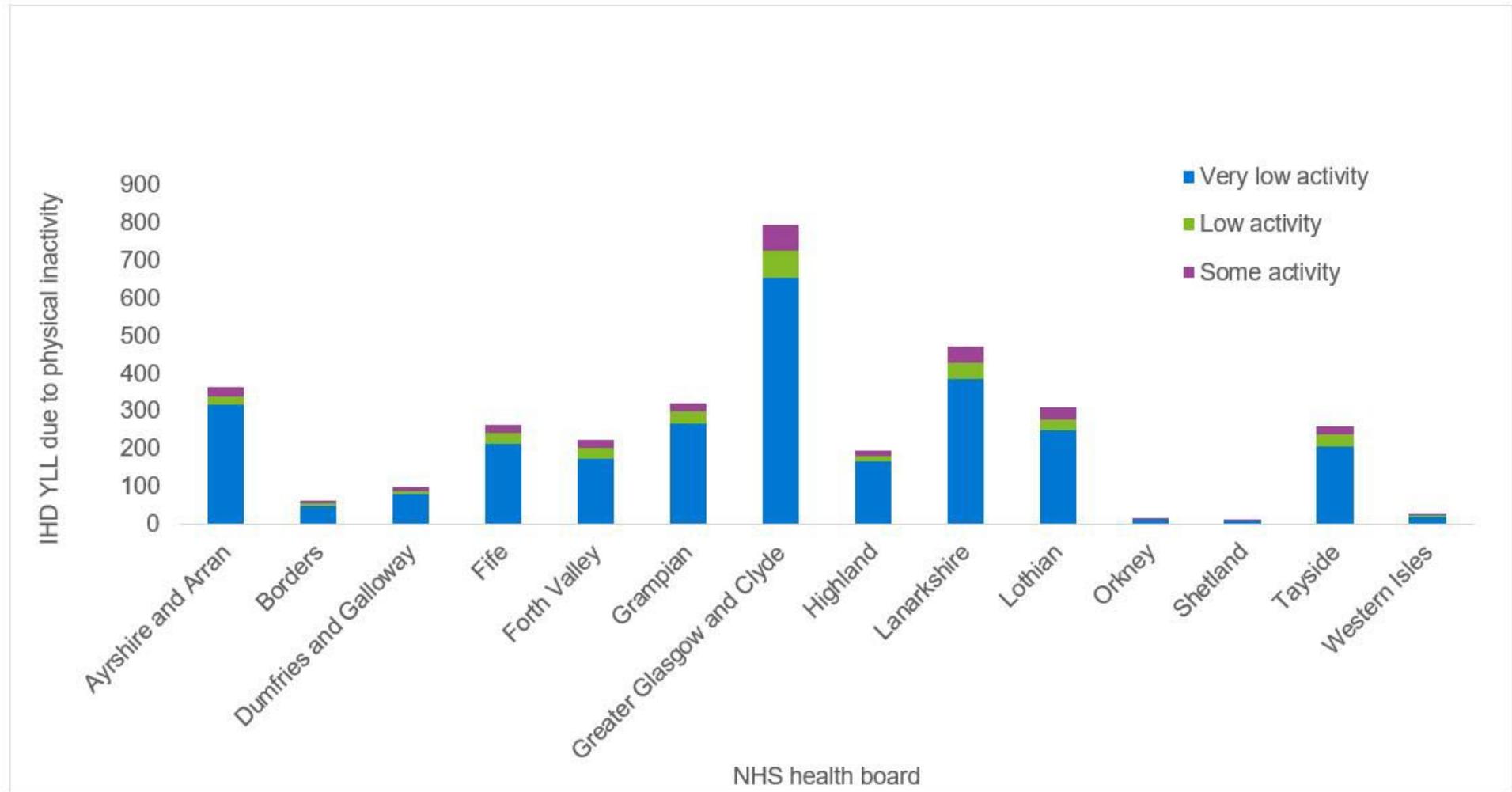


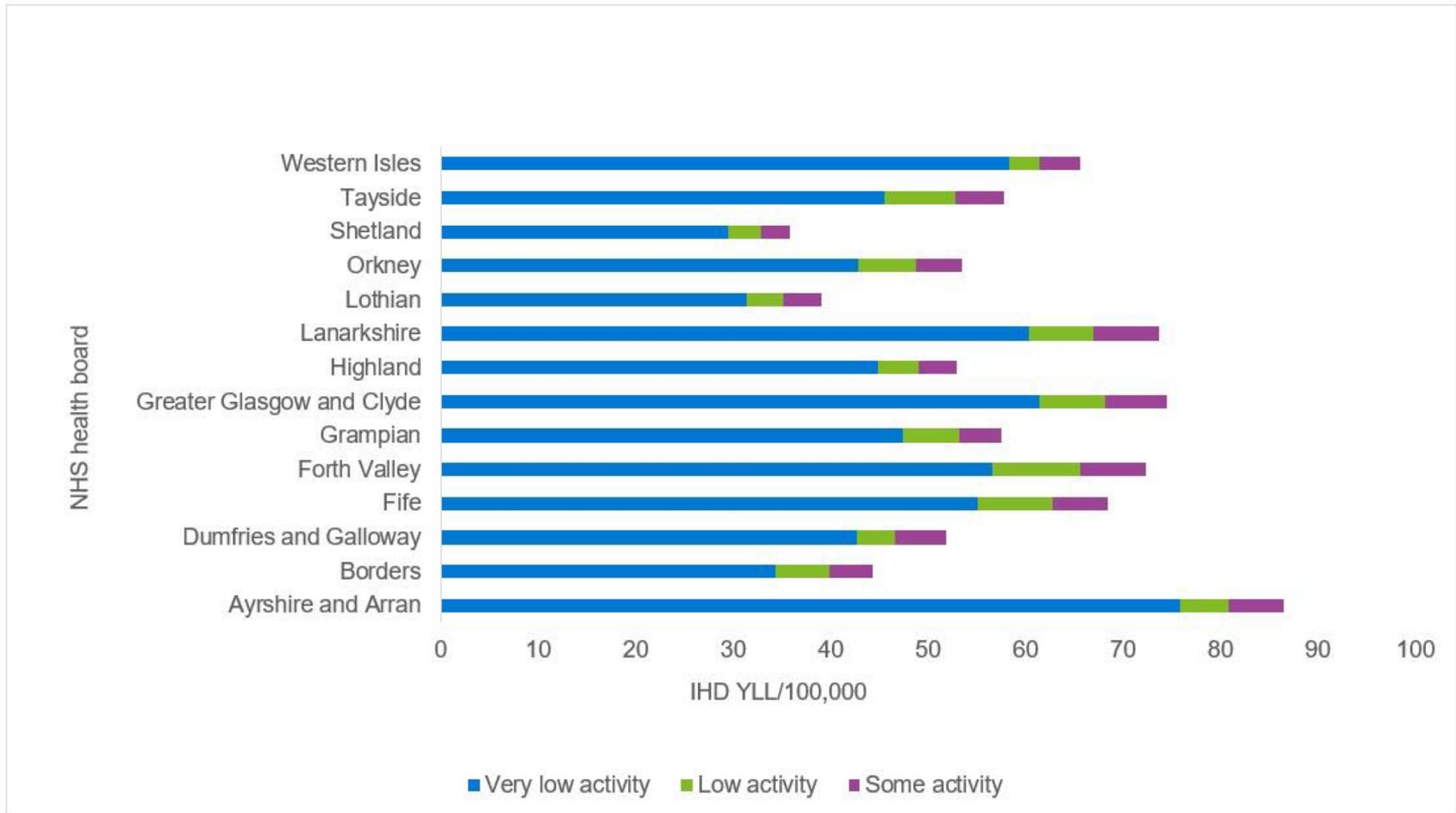
Figure 1 shows a total of 3,409 years of life lost throughout Scotland due to IHD that are attributable to physical inactivity. Eighty-two percent, equivalent to 2,800 YLL, is due to individuals in the 'very low activity' category.

Although the total number of YLL provides an absolute measure of the burden of IHD from premature mortality, the number of YLL will be heavily dependent on the population size of each health board. To control for this, we use age-standardised rates of YLL, as published by the SBoD (Figure 2).

The median rate of IHD YLL attributable to physical inactivity in health boards is 57.6 YLL/100,000, with the median lost to very low activity 46.5/100,000.

Significant variation in rates for YLL due to physical inactivity are found across the country, ranging from 35/100,000 in Shetland to 86/100,000 in Ayrshire and Arran (Figure 3).

Figure 2: Crude rate of YLL due to IHD attributable to physical inactivity, by NHS health board





## Measuring years of life lost attributable to changes in activity levels

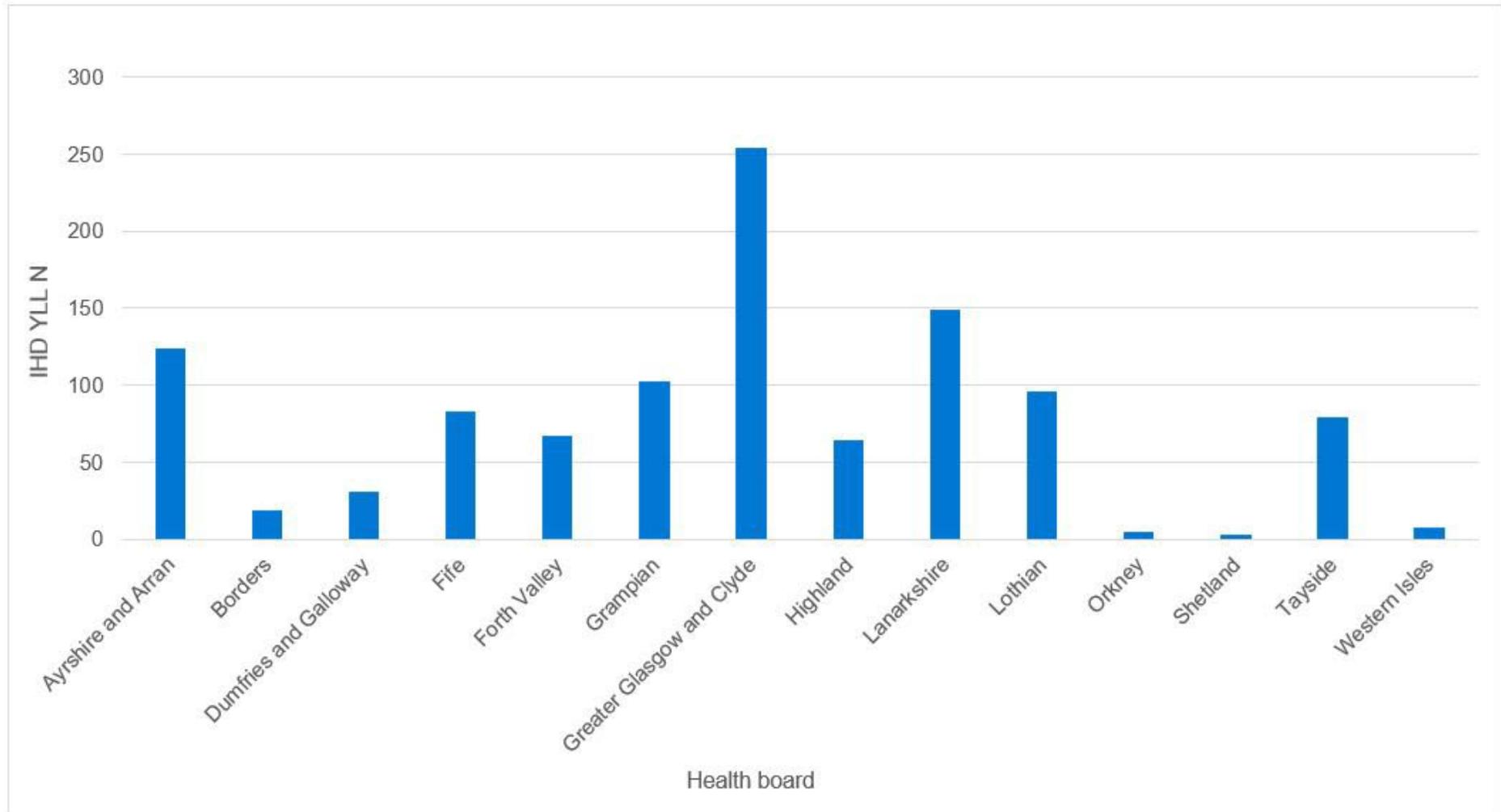
The above figures, in presenting PAFs, demonstrate the number of IHD YLL attributable to physical inactivity.

This is comparable to the number of YLL that could have been avoided had everyone met recommended levels.

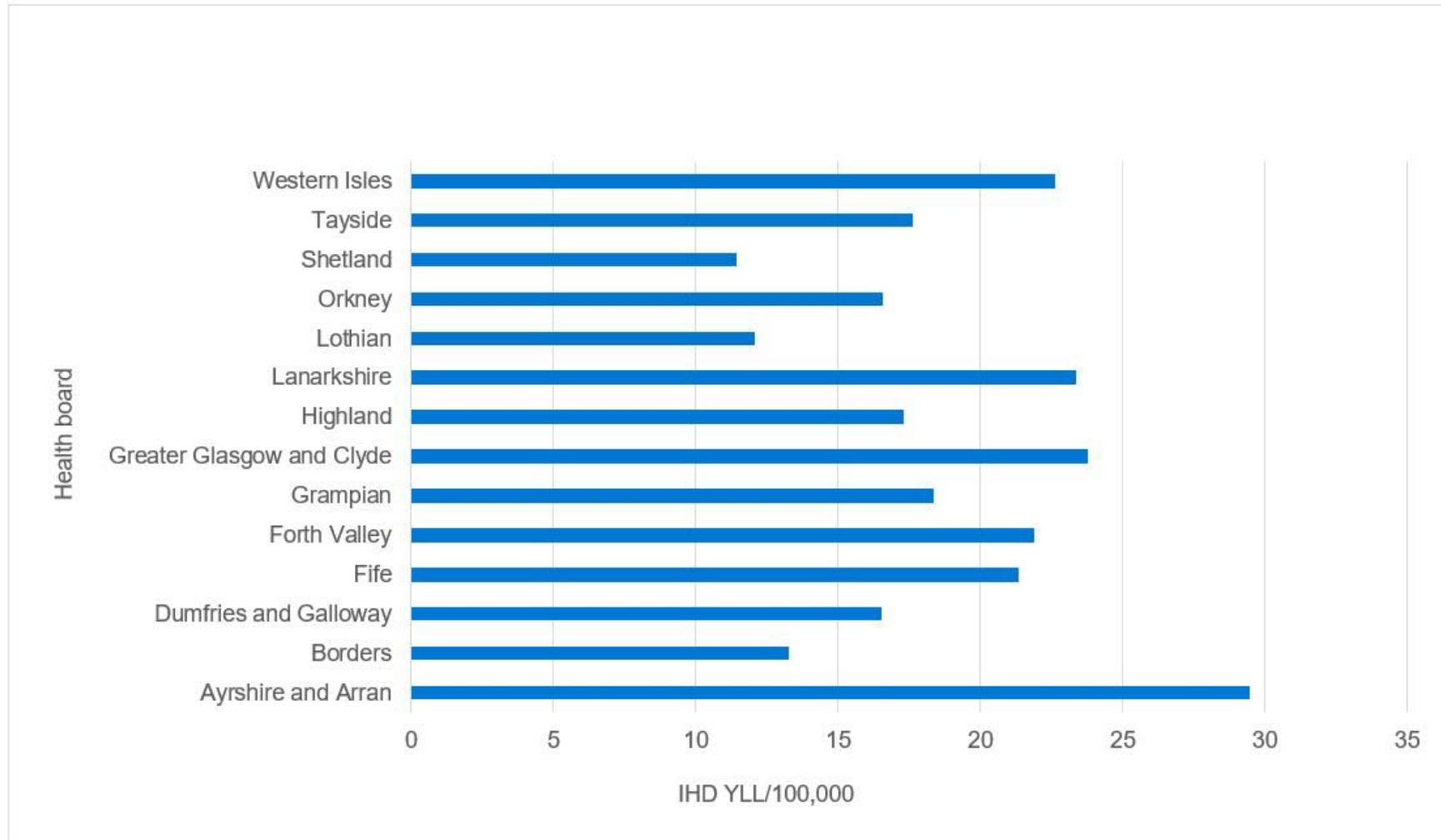
It is also possible to calculate the number that could have potentially been averted if the population distribution moved to a higher level, but still did not meet recommended levels. For example, if the cases in the very low activity category increased their activity levels in line with those in the low activity category, an equivalent of 1,083 YLL from premature IHD death in Scotland could have potentially been averted (Figure 4).

These can also be expressed as rates to allow comparison between health boards (Figure 5) and similar variations are found in rates throughout Scotland, as seen in Figure 6.

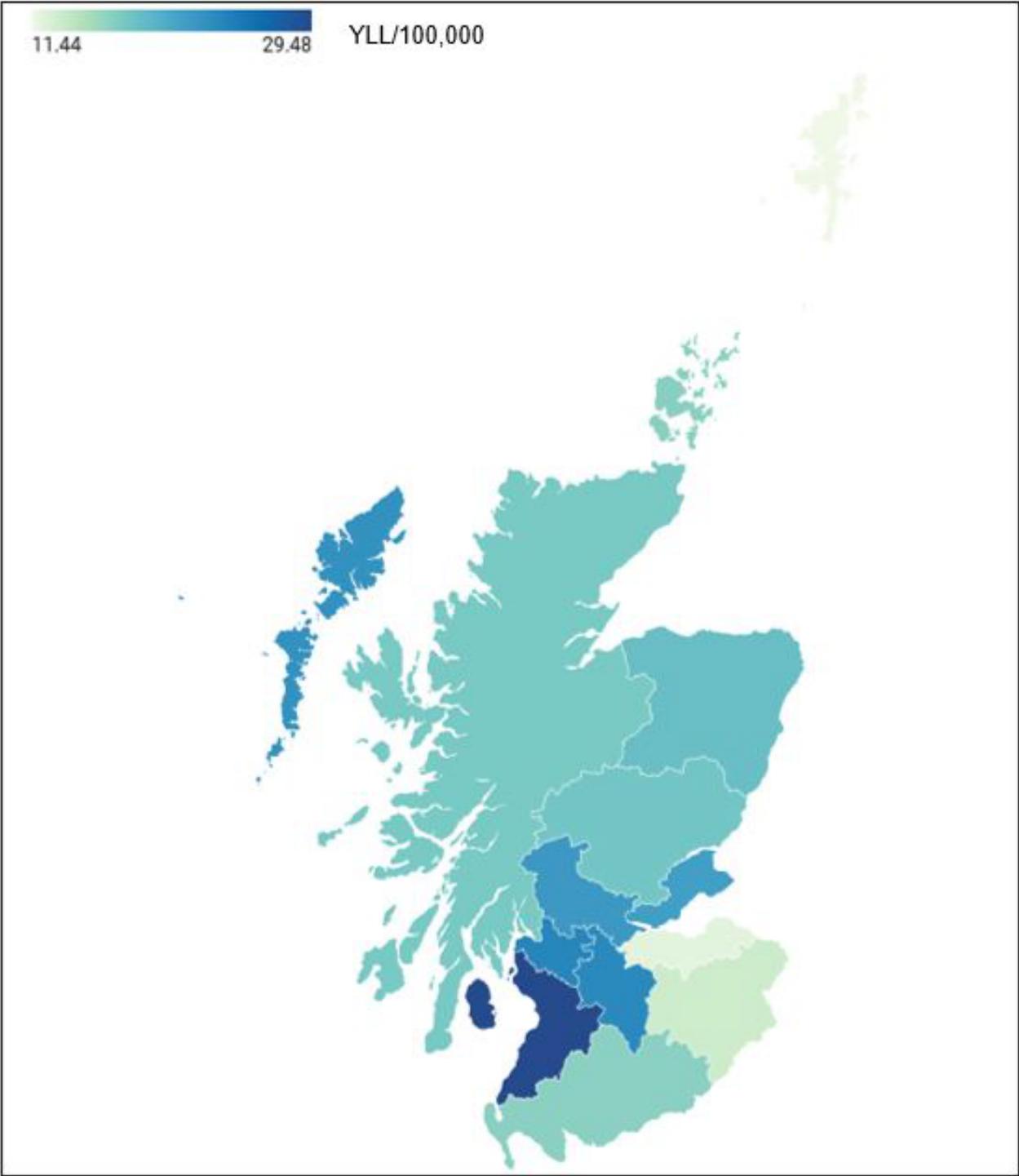
**Figure 4: Number of years of life lost due to IHD, that would be avoided if individuals in very low category increased to low activity, by NHS health board**



**Figure 5: IHD YLL/100,000 avoided if individuals in very low category increased to low activity, by NHS health board**



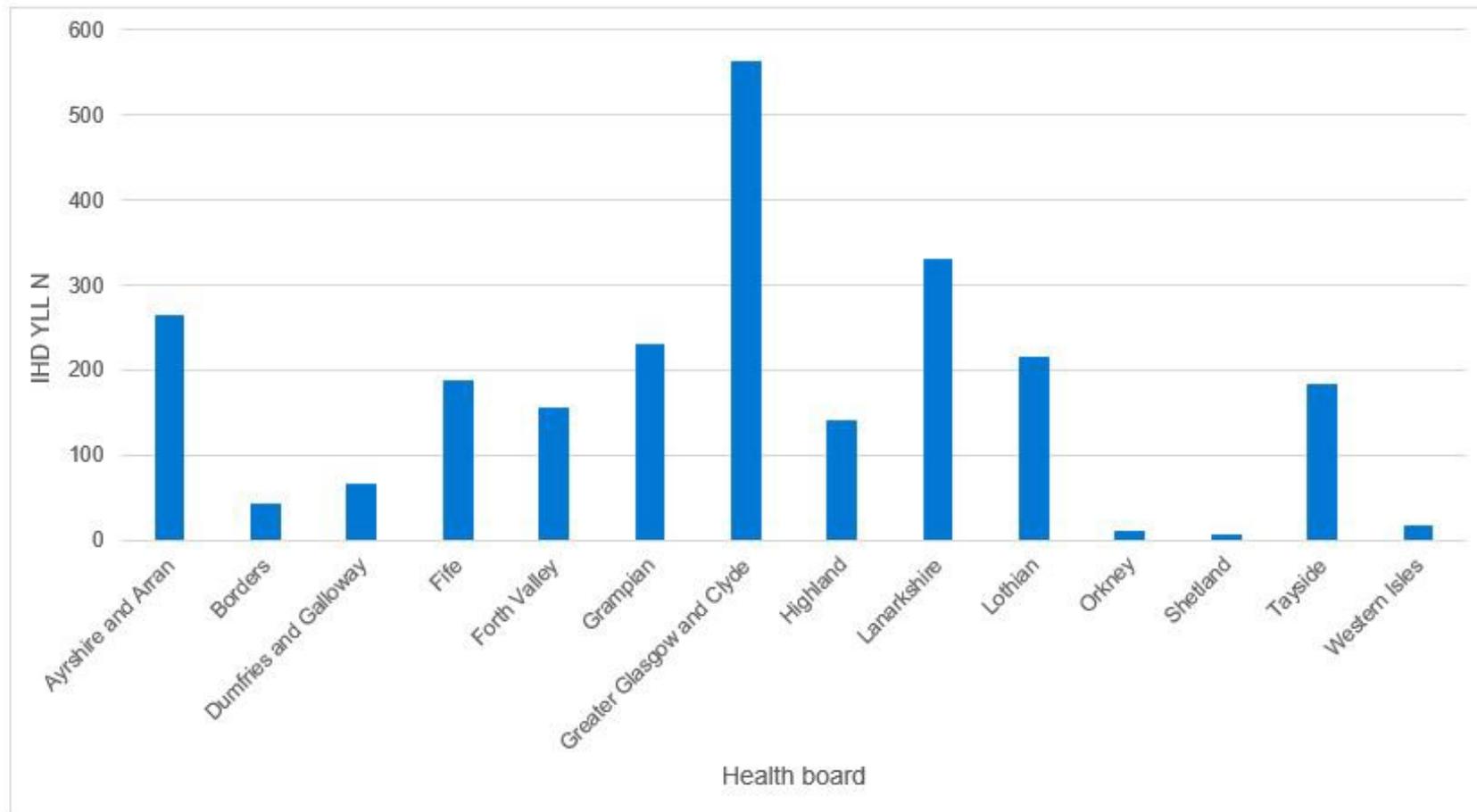
**Figure 6: Choropleth of IHD YLL/100,000 avoided if individuals in very low category increased to low activity, by NHS health board**



Map data: Crown copyright and database right 2020. Created with Datawrapper.

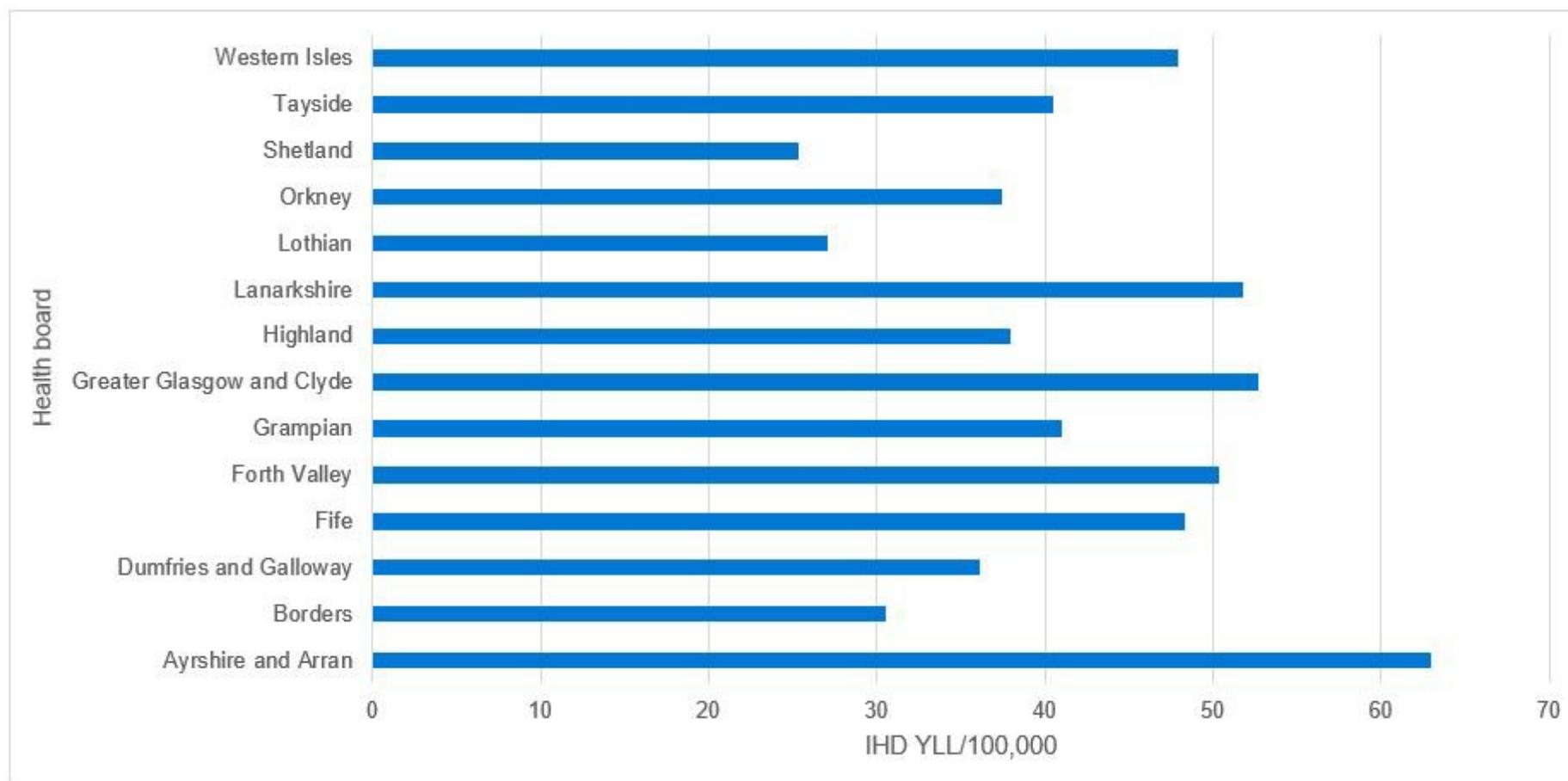
The same can be done to study the IHD YLL avoided if those in the very low and low categories of activity moved into the 'some activity' category, which is one below the recommendations in the SHeS classifications (Figure 7).

**Figure 7: Number of YLL due to IHD that would be avoided if individuals in very low and low categories increased to some activity, by NHS health board**



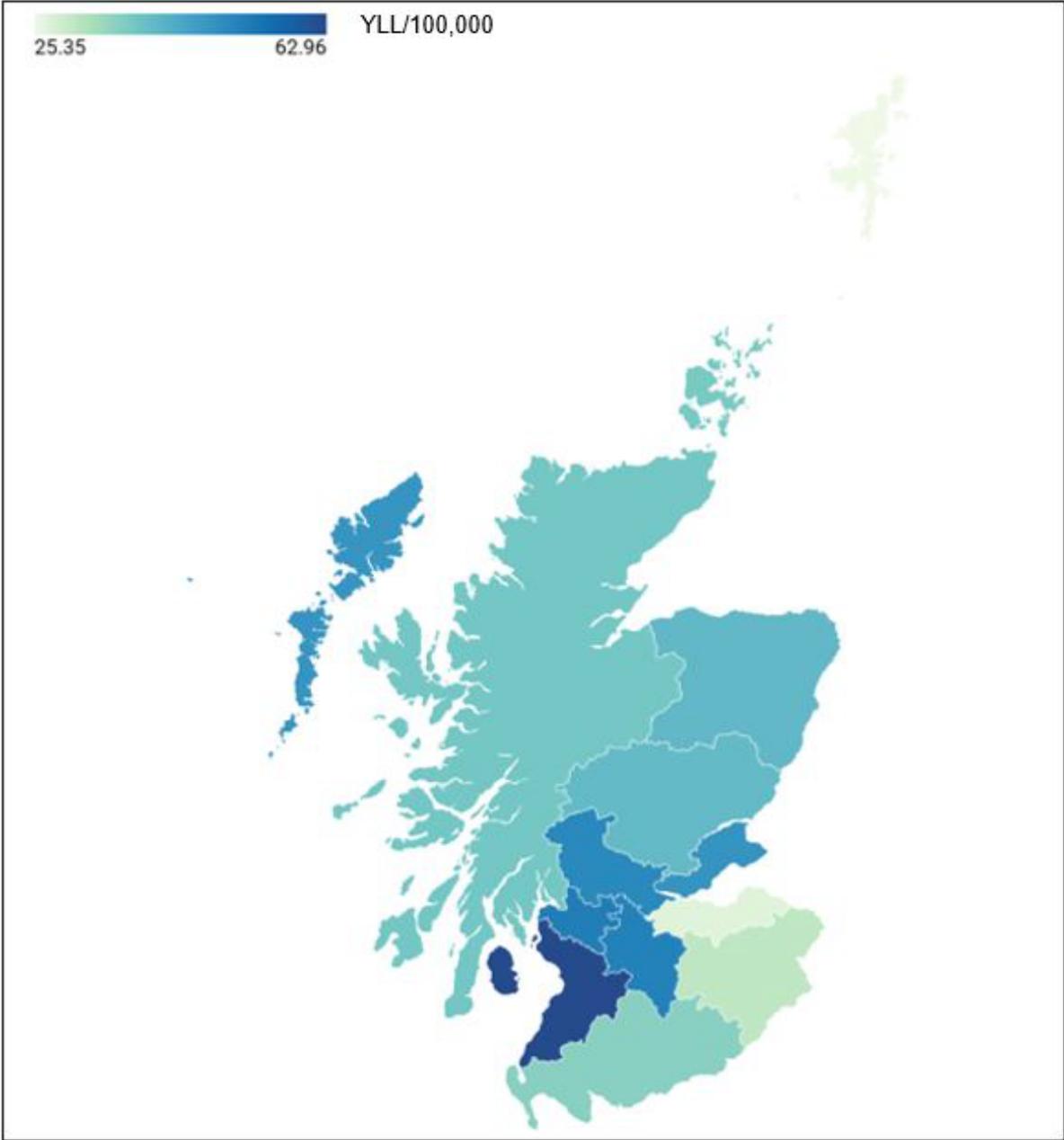
This is the equivalent of 2,409 YLL to early IHD death throughout Scotland. With a median rate of 40.7 YLL/100,000 in health boards and a range from 25/100,000 in Shetland to 62/100,000 in Ayrshire and Arran (Figure 8).

**Figure 8: IHD YLL/100,000 avoided if individuals in very low and low categories increased to some activity, by NHS health board**



The rate of IHD YLL saved aligns with an increase in physical activity. Figure 9 presents the YLL saved by those in very low and low categories who then increased to some physical activity.

**Figure 9: Choropleth of IHD YLL/100,000 avoided if individuals in very low and low categories increased to some activity, by NHS health board**



Map data: Crown copyright and database right 2020. Created with Datawrapper

## Burden of IHD DALYs due to physical inactivity by Scottish local authority

The SHeS and the SBoD both present data at the local authority level, so it is also possible to calculate the burden of physical inactivity for local authorities (not controlling for weight change).

A total of 4,523 IHD DALYs are attributed to low activity each year, around 82% due to those in the very low activity category (Figure 10).

As DALYs are a combination of years lived with disability (YLD) and YLL we can study the burden from premature death and that from disability (Figure 11).

The majority (91%) of the 4,523 IHD DALYs are due to YLL, equivalent to 4,113 YLL, reflecting the high case fatality of IHD. Years of life lost are higher here than in the previous example, as RRs that do not control for weight change have been used. This is to account for the benefit of physical activity in lowering weight and the health benefits associated with this.

Using DALY crude rates enables us to control for population size, allowing us to compare local authorities and highlighting the geographical inequalities present. A median rate of 78.7/100,000 IHD DALYs are attributed to physical inactivity within local authorities (Figure 12).

A range from 47/100,000 IHD DALYs in the City of Edinburgh to 160/100,000 in Clackmannanshire is shown in Figure 13.

Once again, when presented as rates, the majority of these IHD DALYs are made up of YLL due to premature mortality from IHD (Figure 14).

Moving individuals from the very low activity category to low activity would result in avoiding 1,423 DALYs, of which 1,294 would be YLL (91%), with the total DALYs avoided higher in local authorities with larger populations (Figure 15).

The rates demonstrate that relative savings would be greatest were the burden is highest (Figure 16).

Figure 10: Number of IHD DALYs attributed to physical inactivity by category, by local authority

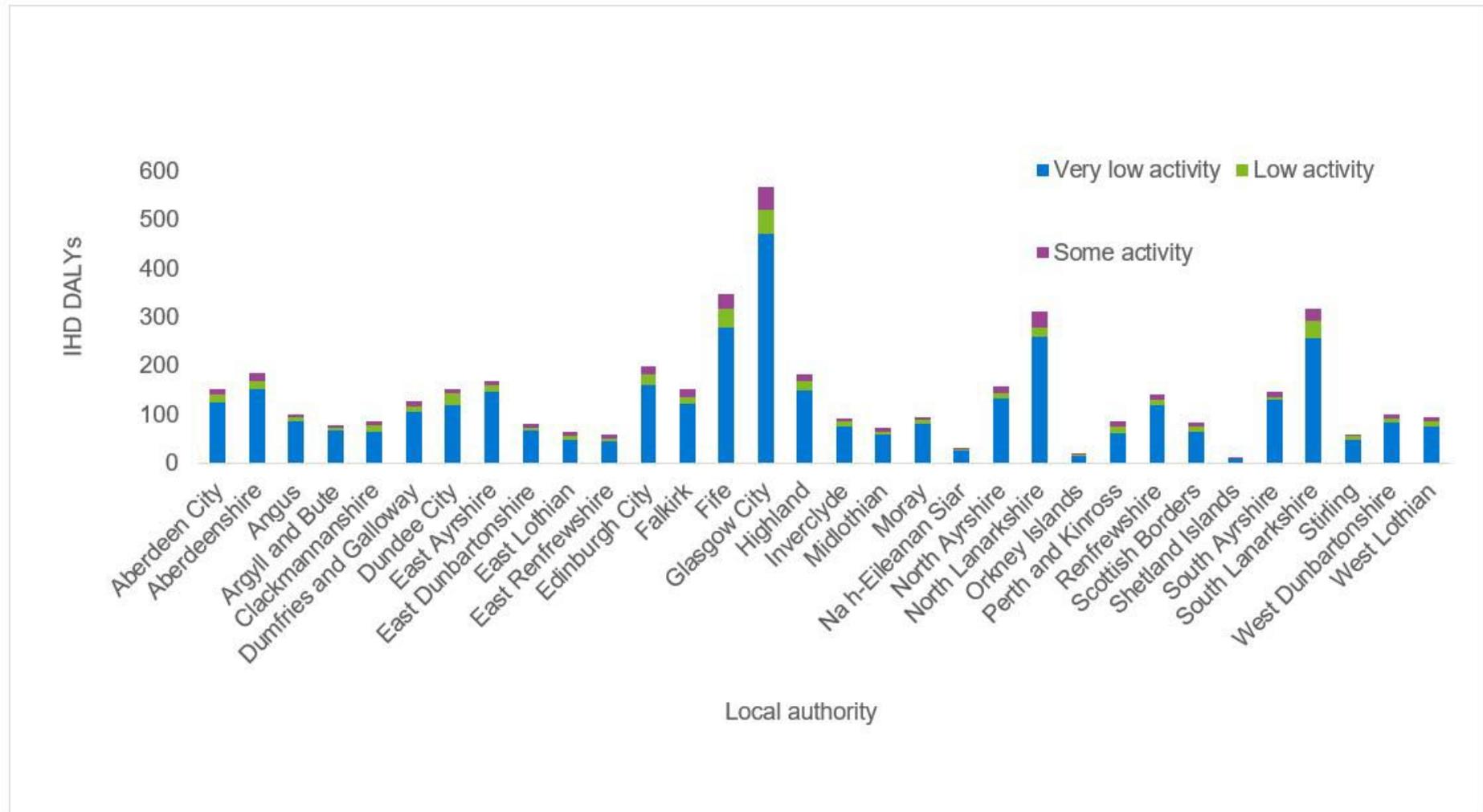


Figure 11: Number of IHD DALYs attributed to physical inactivity by YLD and YLL, by local authority

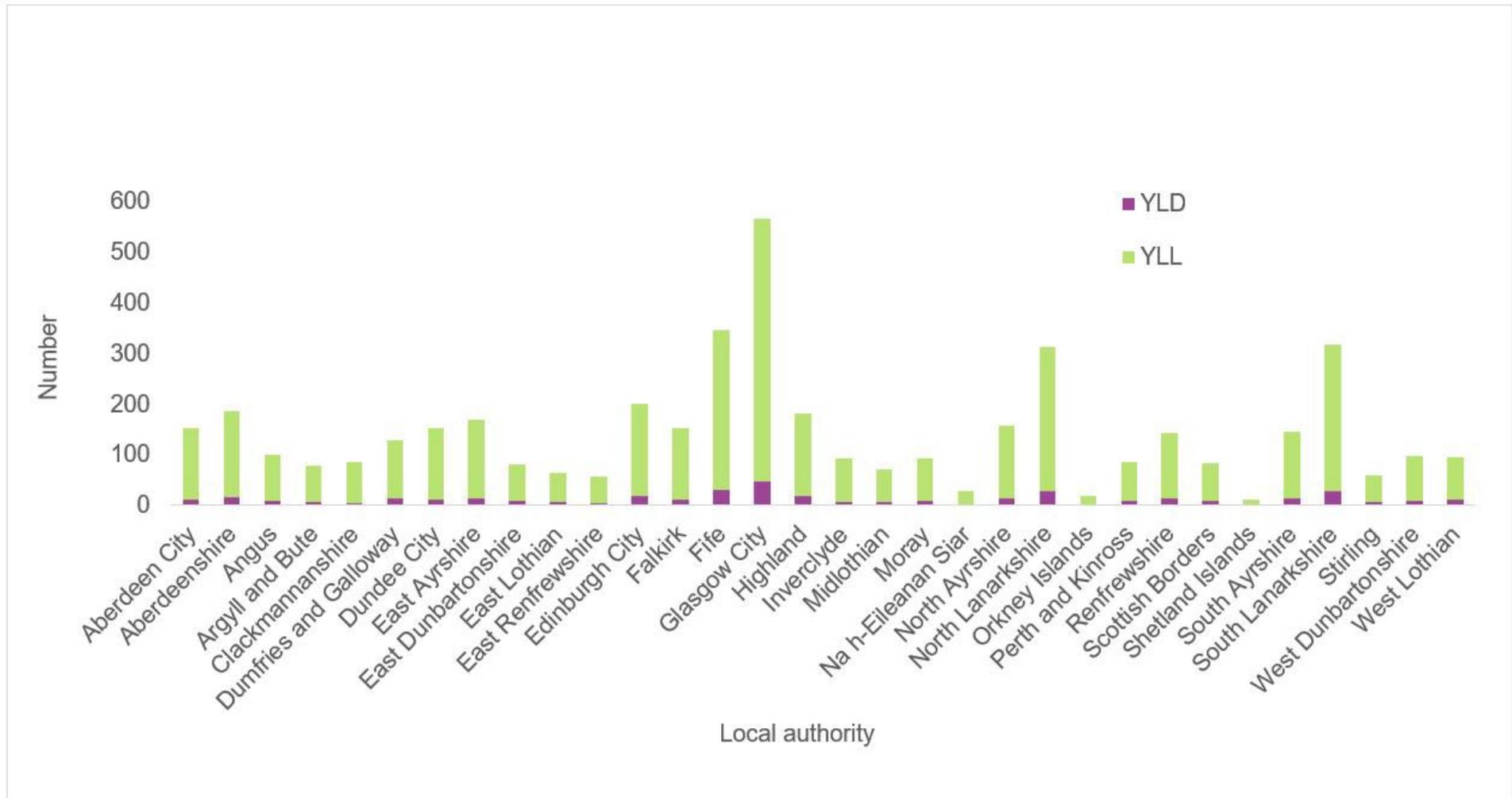
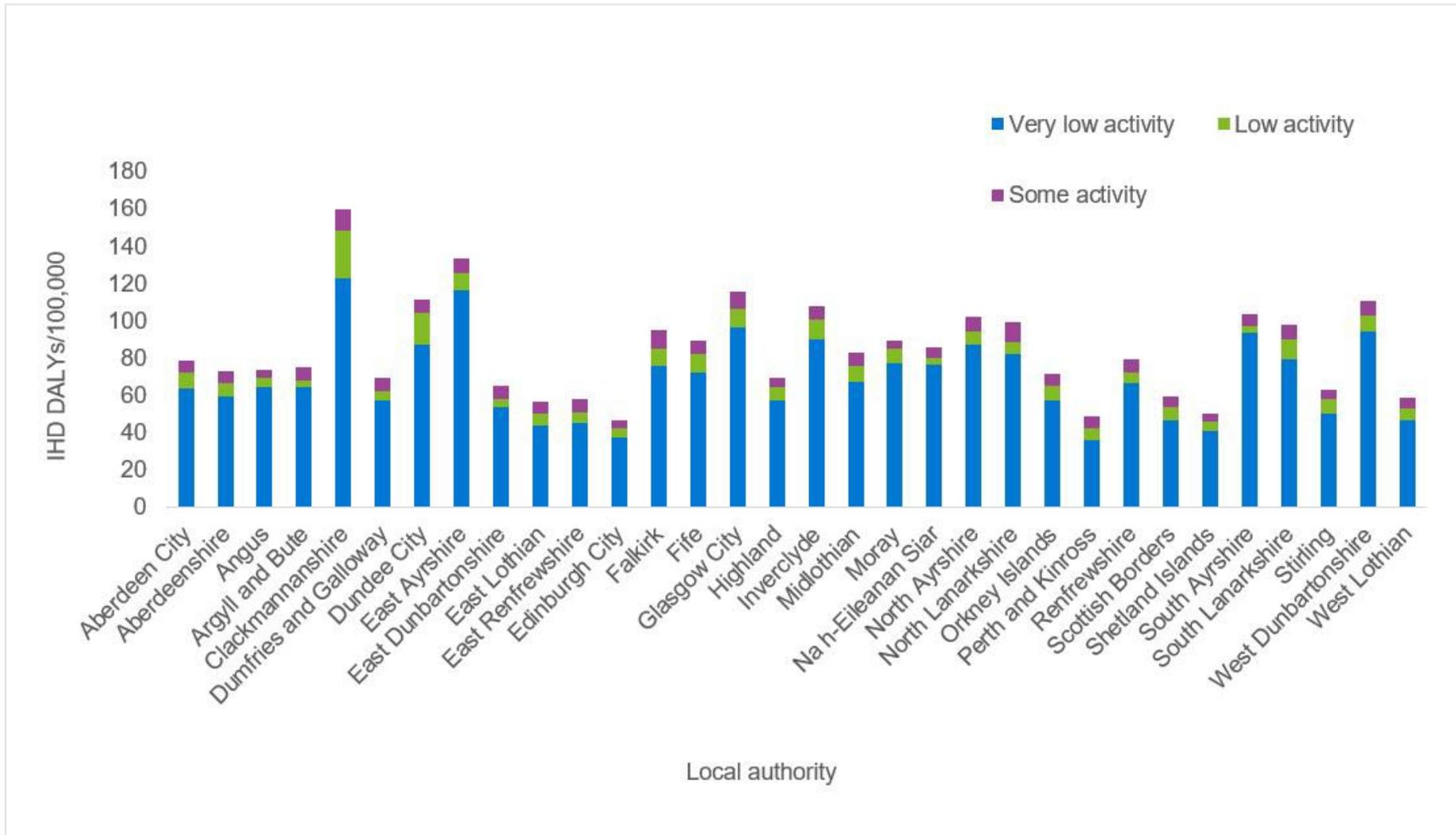
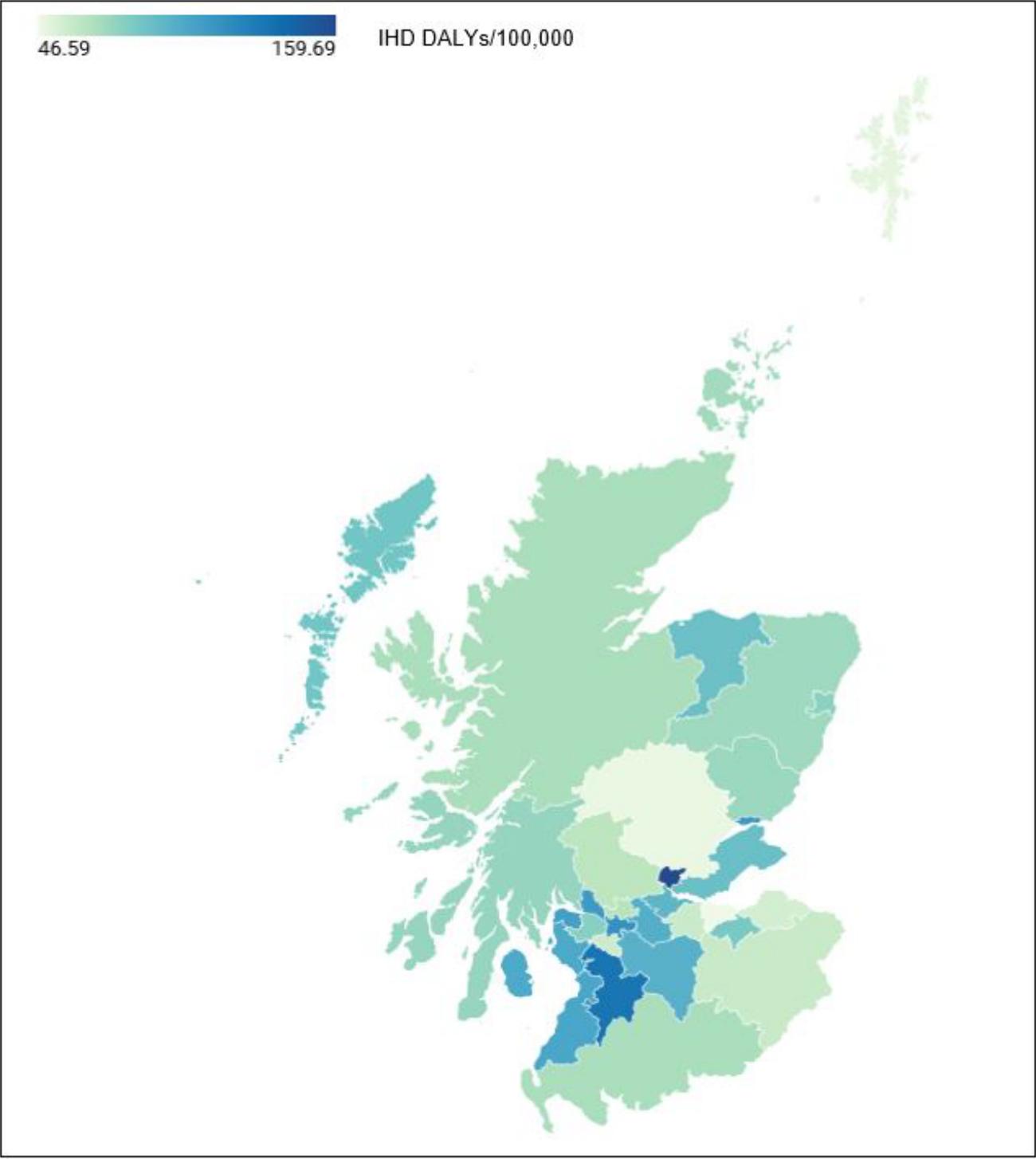


Figure 12: IHD DALYs crude rate attributed to physical inactivity by category, by local authority

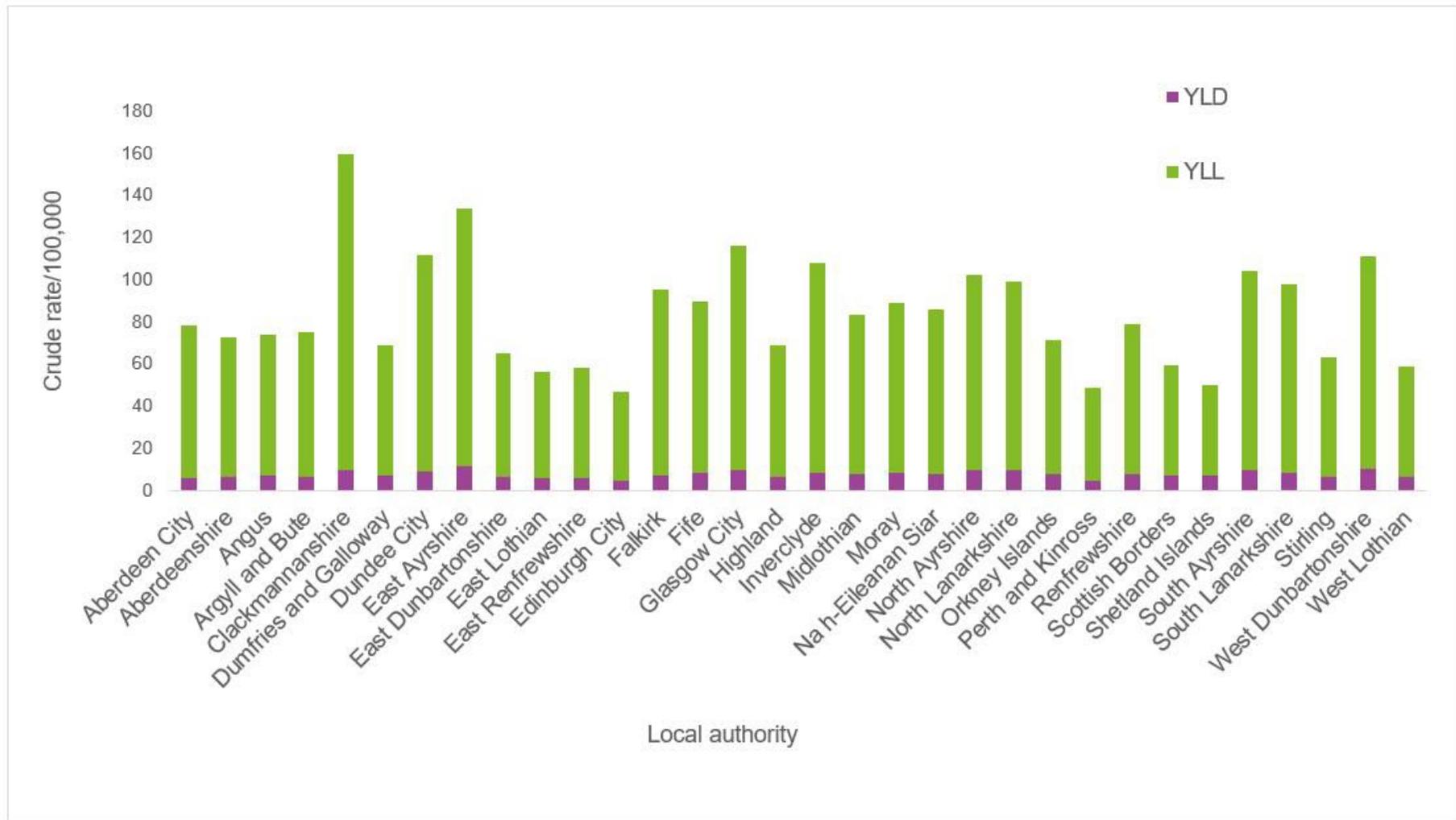


**Figure 13: Choropleth of IHD DALYs/100,000 attributed to physical inactivity, by local authority**

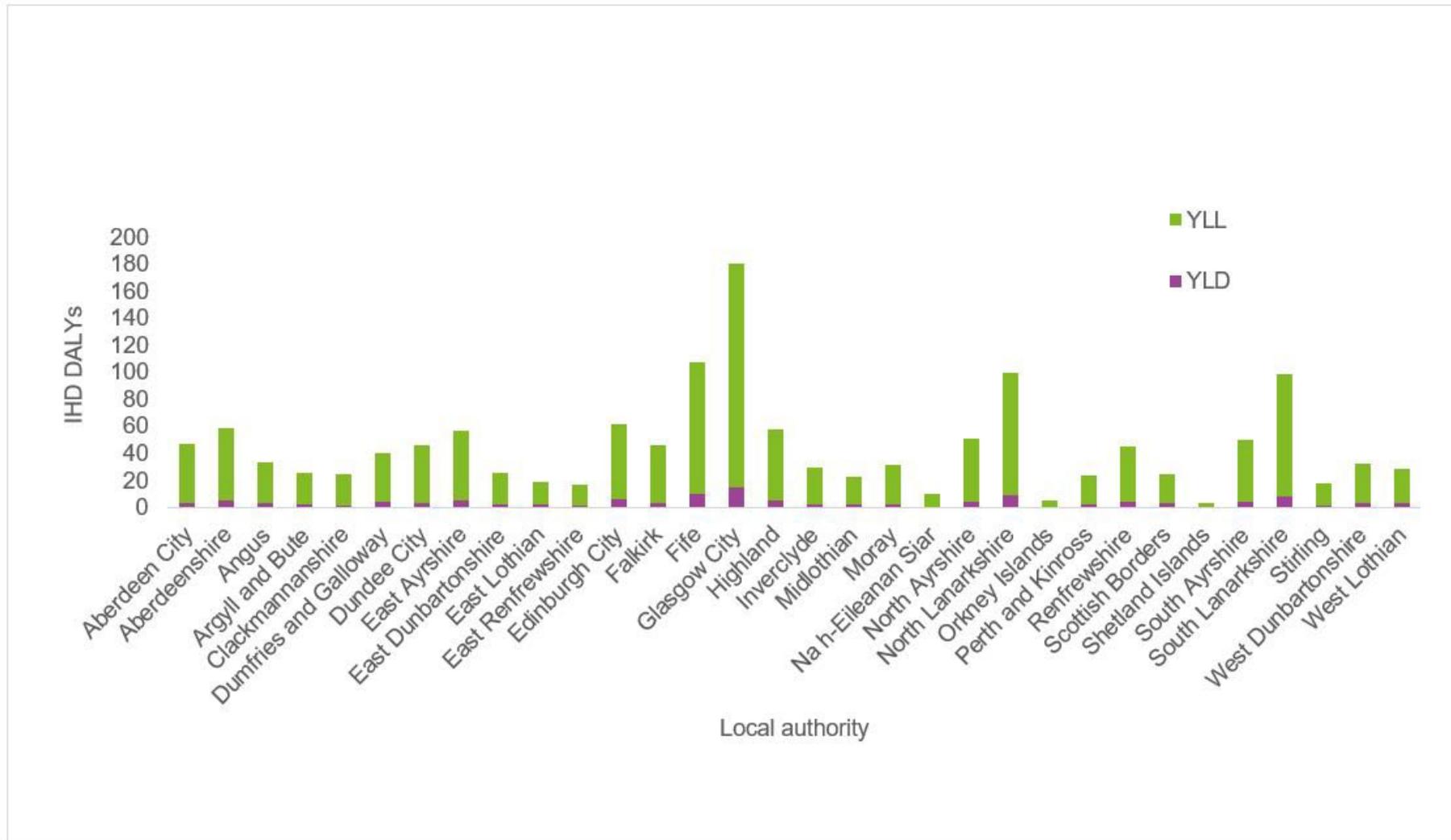


Map data: Crown copyright and database right 2019. Created with Datawrapper.

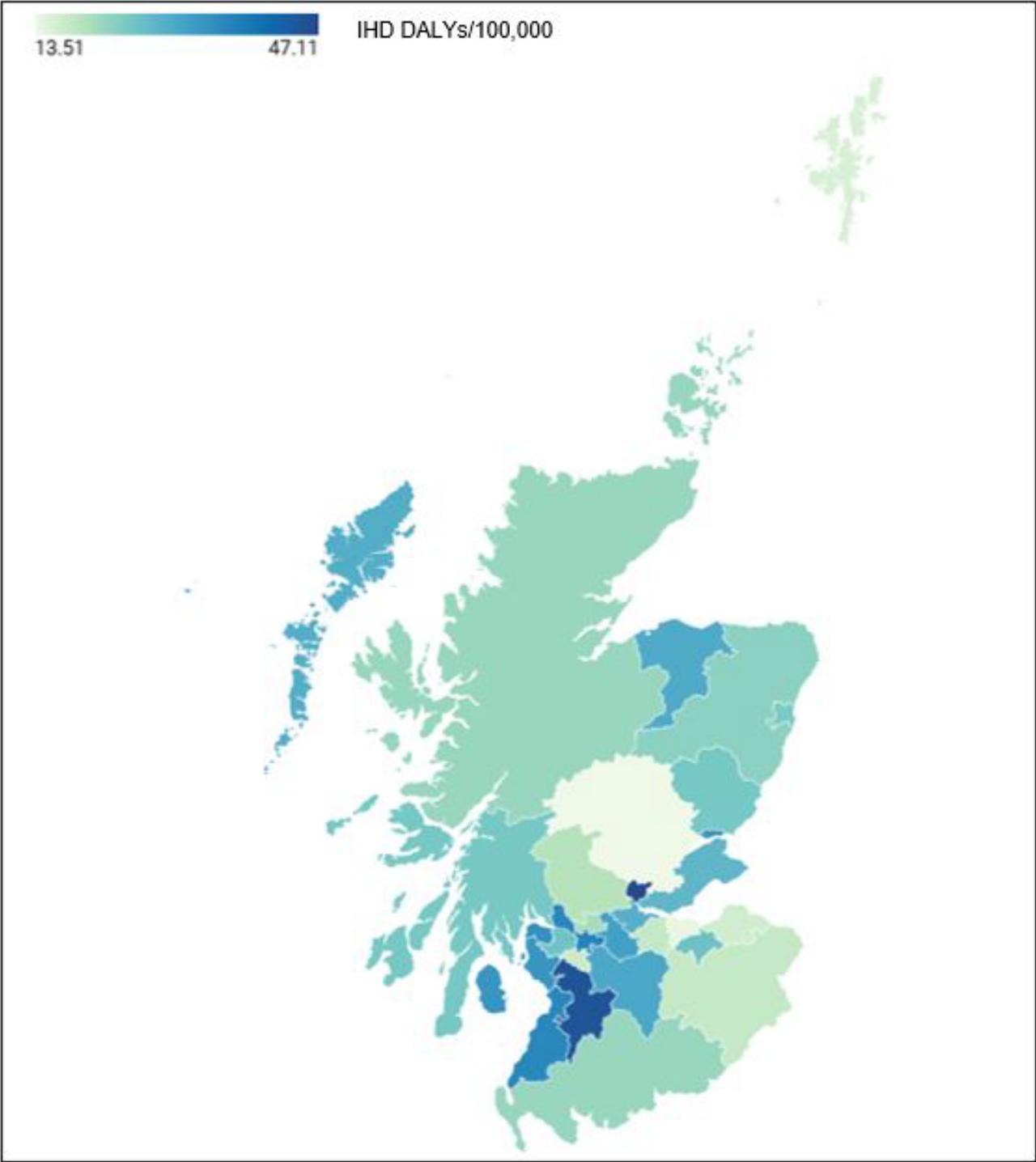
**Figure 14: Crude rate IHD DALYs/100,000 attributed to physical inactivity by YLD and YLL, by local authority**



**Figure 15: Number of IHD DALYs attributed to physical inactivity that would be avoided if individuals in very low activity category moved into some activity category, by local authority**



**Figure 16: Choropleth of IHD DALYs/100,000 avoided if individuals in very low category increased to low activity, by local authority**



Map data: Crown copyright and database right 2019. Created with Datawrapper.

## 7. Recommendations and next steps

This study has reinforced that low physical activity is a risk factor associated with adverse health outcomes. Furthermore, we have explored methods to estimate its relative contribution to the burden of disease in Scotland at national and sub-national levels.

We have reviewed the availability and quality of the evidence available and highlighted the potential to explore further estimates of the disease burden attributable to physical inactivity. Risk factor-based estimates of disease burden are increasingly important as they allow us to demonstrate what the impact of reducing exposure to adverse risks, such as very low and low physical activity, can have on disease burden.

This study reinforces the importance of physical activity and the potential role that it can play in preventing the forecasted disease burdens becoming a reality in Scotland.<sup>1</sup>

We have also studied inequalities, presenting outputs on local inequalities data to help target potential physical activity policy actions and interventions. This will help focus resources on those most at need and those most inactive across Scotland.

Further developments in this work could calculate the burden of physical inactivity for all disease types provided by the SBoD, including estimates of the attributable burden for all causes.

Work on estimating the relevant burden of physical inactivity would benefit from linking to a range of data sources within Scotland, alongside the SBoD. For example, relating estimates calculated here to NHSScotland cost data would allow an estimate of the financial burden of physical inactivity accrued in treating conditions and diseases associated with it.

A focus on linking sources of data would be beneficial for research, prevention and treatment efforts. It would allow a complete picture of the burden of physical inactivity to be built and for interventions to be targeted and monitored on an ongoing basis.

In this report, although we have sought to describe the geographical inequalities in physical inactivity related to ill health within Scotland, we have not sought to explain them. Future work should be carried out to understand why these inequalities are apparent, allowing further targeting of approaches. Such work would benefit from the data linkage described above and would ideally focus on individuals with very low activity levels in the first instance. Those in this lowest category of activity are estimated to determine more than 80% of the physical inactivity disease burden within Scotland.

## Appendix

### Data tables for figures presented above

Figure 1 data table: Number of YLL due to IHD attributable to physical inactivity, by NHS health board

Location	Very low activity	Low activity	Some activity
Ayrshire and Arran	318.60	20.85	23.49
Borders	47.84	7.61	6.17
Dumfries and Galloway	79.53	7.23	9.76
Fife	213.56	29.42	21.90
Forth Valley	174.53	27.75	20.66
Grampian	265.59	32.15	24.47
Greater Glasgow and Clyde	655.83	72.33	67.25
Highland	165.75	15.83	14.28
Lanarkshire	385.99	42.57	43.17
Lothian	248.77	29.97	30.40
Orkney	11.26	1.55	1.26
Shetland	6.92	0.76	0.71
Tayside	205.88	32.74	22.16
Western Isles	20.08	1.06	1.43
<b>Total</b>	<b>2,800.12</b>	<b>321.84</b>	<b>287.10</b>

**Figures 2 and 3 data table: Crude rate YLL due to IHD attributable to physical inactivity, by NHS health board**

Location	Very low activity	Low activity	Some activity	Total
Ayrshire and Arran	75.89	4.97	5.60	86.46
Borders	34.38	5.47	4.44	44.28
Dumfries and Galloway	42.77	3.89	5.25	51.91
Fife	55.13	7.60	5.65	68.38
Forth Valley	56.65	9.01	6.70	72.36
Grampian	47.45	5.74	4.37	57.56
Greater Glasgow and Clyde	61.41	6.77	6.30	74.48
Highland	44.82	4.28	3.86	52.96
Lanarkshire	60.34	6.65	6.75	73.74
Lothian	31.40	3.78	3.84	39.01
Orkney	42.82	5.90	4.79	53.50
Shetland	29.55	3.26	3.03	35.84
Tayside	45.60	7.25	4.91	57.75
Western Isles	58.39	3.09	4.17	65.65
<b>Median</b>	<b>46.52</b>	<b>5.61</b>	<b>4.85</b>	<b>57.66</b>

**Figure 4 data table: Number of YLL due to IHD that would be avoided if individuals in very low category increased to low activity, by NHS health board**

<b>Location</b>	<b>Physical activity attributed to YLL</b>
Ayrshire and Arran	123.77
Borders	18.48
Dumfries and Galloway	30.74
Fife	82.64
Forth Valley	67.41
Grampian	102.64
Greater Glasgow and Clyde	253.79
Highland	64.02
Lanarkshire	149.37
Lothian	95.82
Orkney	4.36
Shetland	2.68
Tayside	79.51
Western Isles	7.77
<b>Total</b>	<b>1,083.00</b>

**Figures 5 and 6 data table: IHD YLL/100,000 avoided if individuals in very low category increased to low activity, by NHS health board**

<b>Location</b>	<b>YLL</b>
Ayrshire and Arran	29.48
Borders	13.28
Dumfries and Galloway	16.53
Fife	21.34
Forth Valley	21.88
Grampian	18.34
Greater Glasgow and Clyde	23.77
Highland	17.31
Lanarkshire	23.35
Lothian	12.09
Orkney	16.57
Shetland	11.44
Tayside	17.61
Western Isles	22.61
<b>Median</b>	<b>17.97</b>

**Figure 7 data table: Number of YLL due to IHD that would be avoided if individuals in very low and low categories increased to some activity, by NHS health board**

<b>Location</b>	<b>YLL</b>
Ayrshire and Arran	264.31
Borders	42.51
Dumfries and Galloway	67.17
Fife	186.96
Forth Valley	155.10
Grampian	229.53
Greater Glasgow and Clyde	562.45
Highland	140.47
Lanarkshire	331.03
Lothian	214.67
Orkney	9.86
Shetland	5.94
Tayside	182.96
Western Isles	16.47
<b>Total</b>	<b>2,409.44</b>

**Figures 8 and 9 data table: IHD YLL/100,000 avoided if individuals in very low and low categories increased to some, by NHS health board**

<b>Location</b>	<b>YLL</b>
Ayrshire and Arran	62.96
Borders	30.55
Dumfries and Galloway	36.12
Fife	48.27
Forth Valley	50.34
Grampian	41.01
Greater Glasgow and Clyde	52.67
Highland	37.99
Lanarkshire	51.75
Lothian	27.09
Orkney	37.48
Shetland	25.35
Tayside	40.52
Western Isles	47.91
<b>Median</b>	<b>40.76</b>

**Figure 10 data table: Number of IHD DALYs attributed to physical inactivity by category, by local authority**

Location	Very low activity	Low activity	Some activity	Total
Aberdeen City	123.83	16.68	12.69	153.20
Aberdeenshire	152.24	17.64	16.40	186.28
Angus	86.56	7.19	5.68	99.43
Argyll and Bute	67.56	4.32	7.30	79.18
Clackmannanshire	65.40	13.83	5.86	85.10
Dumfries and Galloway	105.97	9.66	13.06	128.69
Dundee City	119.83	23.17	10.10	153.10
East Ayrshire	147.72	11.74	9.93	169.39
East Dunbartonshire	66.94	5.56	8.76	81.27
East Lothian	48.99	7.40	6.88	63.27
East Renfrewshire	44.72	6.02	7.12	57.86
Edinburgh City	160.83	20.79	18.75	200.37
Falkirk	120.83	15.43	15.65	151.91
Fife	279.80	38.70	28.81	347.31
Glasgow City	470.79	49.93	46.43	567.15
Highland	150.29	19.20	12.99	182.48
Inverclyde	76.42	9.29	6.28	91.99
Midlothian	58.60	7.12	6.62	72.34
Moray	81.34	7.66	4.54	93.54
Na h-Eileanan Siar	26.20	1.39	1.88	29.47
North Ayrshire	133.99	10.23	12.68	156.90
North Lanarkshire	258.93	20.61	32.47	312.02

Location	Very low activity	Low activity	Some activity	Total
Orkney Islands	14.99	2.07	1.68	18.74
Perth and Kinross	62.69	11.61	11.78	86.08
Renfrewshire	119.09	10.36	12.83	142.28
Scottish Borders	64.53	10.30	8.36	83.18
Shetland Islands	9.62	1.07	0.99	11.68
South Ayrshire	130.93	5.56	9.38	145.87
South Lanarkshire	256.58	35.49	26.42	318.49
Stirling	47.14	7.93	4.83	59.89
West Dunbartonshire	83.77	8.19	6.93	98.89
West Lothian	75.24	10.71	9.96	95.91
<b>Total</b>	<b>3,712.37</b>	<b>426.87</b>	<b>384.04</b>	<b>4,523.29</b>

**Figure 11 data table: Number of IHD DALYs attributed to physical inactivity by YLD and YLL, by local authority**

Location	YLD	YLL	DALYs
Aberdeen City	6.01	72.25	78.26
Aberdeenshire	6.51	66.22	72.73
Angus	7.07	66.41	73.48
Argyll and Bute	6.39	68.56	74.95
Clackmannanshire	9.41	150.28	159.69
Dumfries and Galloway	7.22	61.80	69.02
Dundee City	9.18	102.49	111.67
East Ayrshire	11.49	122.21	133.70
East Dunbartonshire	6.53	58.40	64.93
East Lothian	5.76	50.36	56.13
East Renfrewshire	5.52	52.31	57.84
Edinburgh City	4.51	42.08	46.59
Falkirk	7.18	87.82	94.99
Fife	8.15	81.40	89.54
Glasgow City	9.80	106.06	115.86
Highland	6.60	62.39	68.98
Inverclyde	8.16	99.76	107.92
Midlothian	7.34	75.74	83.09
Moray	8.03	80.92	88.95
Na h-Eileanan Siar	7.60	78.10	85.70
North Ayrshire	9.36	92.80	102.16
North Lanarkshire	9.24	89.95	99.19
Orkney Islands	7.44	63.68	71.12

Location	YLD	YLL	DALYs
Perth and Kinross	4.69	44.02	48.70
Renfrewshire	7.65	71.43	79.08
Scottish Borders	6.84	52.74	59.58
Shetland Islands	7.05	42.66	49.71
South Ayrshire	9.40	94.41	103.81
South Lanarkshire	8.38	89.59	97.97
Stirling	6.10	57.02	63.12
West Dunbartonshire	10.13	100.78	110.91
West Lothian	6.54	52.33	58.87
<b>Median</b>	<b>7.28</b>	<b>71.84</b>	<b>78.67</b>

**Figures 12 and 13 data table: IHD DALYs crude rate attributed to physical inactivity by category, by local authority**

Location	Very low activity	Low activity	Some activity	Meets requirements
Aberdeen City	63.25	8.52	6.48	78.26
Aberdeenshire	59.44	6.89	6.40	72.73
Angus	63.96	5.32	4.20	73.48
Argyll and Bute	63.95	4.09	6.91	74.95
City of Edinburgh	37.40	4.83	4.36	46.59
Clackmannanshire	122.73	25.95	11.01	159.69
Dumfries and Galloway	56.84	5.18	7.00	69.02
Dundee City	87.40	16.90	7.37	111.67
East Ayrshire	116.60	9.27	7.84	133.70
East Dunbartonshire	53.48	4.45	7.00	64.93
East Lothian	43.46	6.57	6.11	56.13
East Renfrewshire	44.70	6.02	7.12	57.84
Falkirk	75.56	9.65	9.79	94.99
Fife	72.14	9.98	7.43	89.54
Glasgow City	96.18	10.20	9.48	115.86
Highland	56.81	7.26	4.91	68.98
Inverclyde	89.66	10.89	7.37	107.92
Midlothian	67.30	8.18	7.60	83.09
Moray	77.35	7.28	4.31	88.95
Na h-Eileanan Siar	76.18	4.05	5.47	85.70
North Ayrshire	87.24	6.66	8.26	102.16
North Lanarkshire	82.31	6.55	10.32	99.19

Location	Very low activity	Low activity	Some activity	Meets requirements
Orkney Islands	56.87	7.87	6.39	71.12
Perth and Kinross	35.47	6.57	6.66	48.70
Renfrewshire	66.19	5.76	7.13	79.08
Scottish Borders	46.22	7.37	5.99	59.58
Shetland Islands	40.96	4.54	4.22	49.71
South Ayrshire	93.18	3.95	6.68	103.81
South Lanarkshire	78.93	10.92	8.13	97.97
Stirling	49.67	8.35	5.09	63.12
West Dunbartonshire	93.95	9.19	7.77	110.91
West Lothian	46.18	6.58	6.11	58.87
<b>Median</b>	<b>65.08</b>	<b>7.07</b>	<b>6.95</b>	<b>78.67</b>

**Figure 14 data table: Crude rate IHD DALYs/100,000 attributed to physical inactivity by YLD and YLL, by local authority**

Location	YLD	YLL	DALY
Aberdeen City	1.86	22.33	24.19
Aberdeenshire	2.04	20.74	22.78
Angus	2.36	22.17	24.53
Argyll and Bute	2.09	22.39	24.47
Clackmannanshire	2.78	44.33	47.11
Dumfries and Galloway	2.28	19.49	21.77
Dundee City	2.76	30.77	33.52
East Ayrshire	3.87	41.16	45.04
East Dunbartonshire	2.06	18.45	20.51
East Lothian	1.70	14.88	16.59
East Renfrewshire	1.63	15.46	17.09
Edinburgh City	1.38	12.87	14.25
Falkirk	2.18	26.73	28.91
Fife	2.52	25.15	27.67
Glasgow City	3.12	33.79	36.92
Highland	2.08	19.66	21.74
Inverclyde	2.60	31.74	34.33
Midlothian	2.28	23.50	25.77
Moray	2.69	27.07	29.76
Na h-Eileanan Siar	2.59	26.65	29.24
North Ayrshire	3.07	30.44	33.51
North Lanarkshire	2.94	28.65	31.60
Orkney Islands	2.28	19.53	21.81

Location	YLD	YLL	DALY
Perth and Kinross	1.30	12.21	13.51
Renfrewshire	2.45	22.92	25.37
Scottish Borders	2.03	15.66	17.69
Shetland Islands	2.23	13.48	15.71
South Ayrshire	3.25	32.68	35.94
South Lanarkshire	2.59	27.68	30.27
Stirling	1.84	17.16	18.99
West Dunbartonshire	3.30	32.82	36.12
West Lothian	1.96	15.68	17.64
<b>Median</b>	<b>2.28</b>	<b>22.65</b>	<b>24.95</b>

**Figure 15 data table: Number of IHD DALYs attributed to physical inactivity that would be avoided if individuals in very low activity category moved into some activity category, by local authority**

Location	YLD	YLL	DALY
Aberdeen City	3.57	43.78	47.35
Aberdeenshire	5.38	52.97	58.35
Angus	3.27	29.93	33.20
Argyll and Bute	2.29	23.56	25.85
Clackmannanshire	1.49	23.61	25.11
Dumfries and Galloway	4.34	36.24	40.58
Dundee City	3.76	42.20	45.96
East Ayrshire	4.97	52.08	57.06
East Dunbartonshire	2.61	23.07	25.67
East Lothian	1.93	16.77	18.70
East Renfrewshire	1.65	15.45	17.10
Edinburgh City	5.85	55.45	61.30
Falkirk	3.48	42.75	46.24
Fife	9.90	97.42	107.32
Glasgow City	14.99	165.72	180.72
Highland	5.59	51.92	57.51
Inverclyde	2.24	27.03	29.27
Midlothian	2.04	20.40	22.44
Moray	2.84	28.46	31.30
Na h-Eileanan Siar	0.89	9.16	10.06
North Ayrshire	4.73	46.74	51.47
North Lanarkshire	9.32	90.07	99.39

Location	YLD	YLL	DALY
Orkney Islands	0.61	5.14	5.75
Perth and Kinross	2.35	21.52	23.88
Renfrewshire	4.41	41.24	45.64
Scottish Borders	2.91	21.78	24.69
Shetland Islands	0.53	3.16	3.69
South Ayrshire	4.63	45.86	50.49
South Lanarkshire	8.53	89.88	98.41
Stirling	1.74	16.28	18.02
West Dunbartonshire	2.95	29.26	32.20
West Lothian	3.20	25.55	28.74
<b>Total</b>	<b>128.99</b>	<b>1,294.46</b>	<b>1,423.46</b>

**Figure 16 data table: IHD DALYs/100,000 avoided if individuals in very low category increased to low activity, by local authority**

Location	YLD	YLL	DALY
Aberdeen City	1.86	22.33	24.19
Aberdeenshire	2.04	20.74	22.78
Angus	2.36	22.17	24.53
Argyll and Bute	2.09	22.39	24.47
City of Edinburgh	1.38	12.87	14.25
Clackmannanshire	2.78	44.33	47.11
Dumfries and Galloway	2.28	19.49	21.77
Dundee City	2.76	30.77	33.52
East Ayrshire	3.87	41.16	45.04
East Dunbartonshire	2.06	18.45	20.51
East Lothian	1.70	14.88	16.59
East Renfrewshire	1.63	15.46	17.09
Falkirk	2.18	26.73	28.91
Fife	2.52	25.15	27.67
Glasgow City	3.12	33.79	36.92
Highland	2.08	19.66	21.74
Inverclyde	2.60	31.74	34.33
Midlothian	2.28	23.50	25.77
Moray	2.69	27.07	29.76
Na h-Eileanan Siar	2.59	26.65	29.24
North Ayrshire	3.07	30.44	33.51
North Lanarkshire	2.94	28.65	31.60
Orkney Islands	2.28	19.53	21.81

Location	YLD	YLL	DALY
Perth and Kinross	1.30	12.21	13.51
Renfrewshire	2.45	22.92	25.37
Scottish Borders	2.03	15.66	17.69
Shetland Islands	2.23	13.48	15.71
South Ayrshire	3.25	32.68	35.94
South Lanarkshire	2.59	27.68	30.27
Stirling	1.84	17.16	18.99
West Dunbartonshire	3.30	32.82	36.12
West Lothian	1.96	15.68	17.64
<b>Median</b>	<b>2.28</b>	<b>22.65</b>	<b>24.95</b>

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