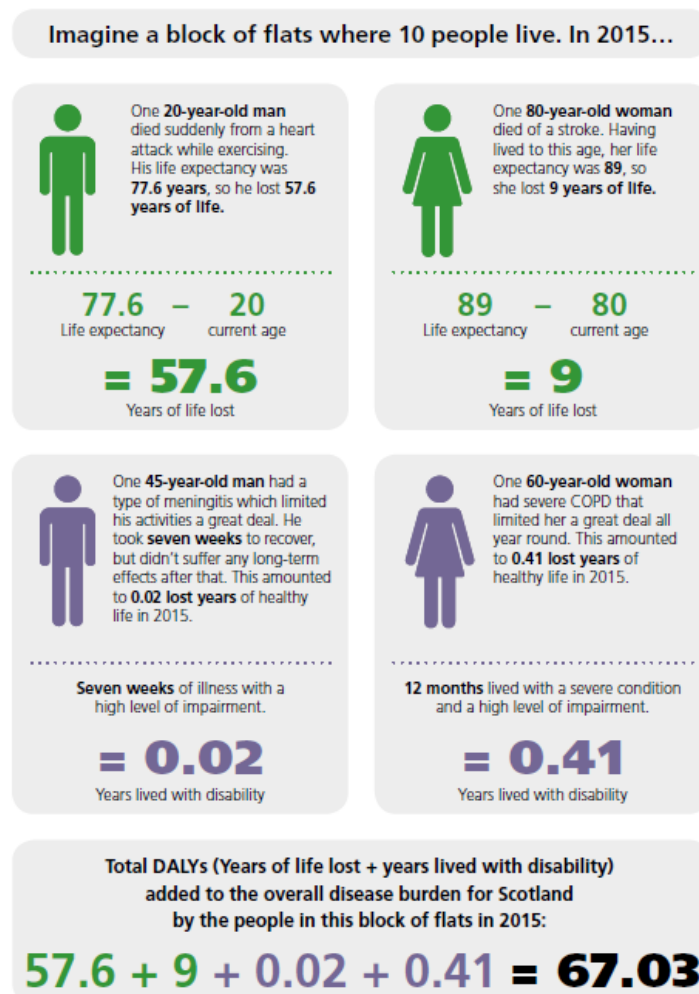


Supplementary Appendix for local area estimates

Burden of disease methodology

The Scottish Burden of Disease (SBOD) study [1] standardises estimates of morbidity and mortality in a composite measure called Disability-Adjusted Life Years (DALYs). It does this by framing morbidity and mortality in terms of health loss as a function of time. Estimates of the frequency of morbidity, such as prevalence, are transformed into Years Lived with Disability (YLD) using disability weights from the Global Burden of Disease (GBD) study [2]. Mortality estimates are converted into Years of Life Lost to premature mortality (YLL) by estimating the excess life expectancy lost due to death at a given age using national life tables.

An applied example of how DALYs, YLL and YLD are calculated is given in the infographic below.



Guide to using SBOD local estimates

- **DALYs measure total health loss** from the debilitating effects of morbidity and life lost due to early mortality.
- **YLD** depends on the **frequency of morbidity** and the **level of disability that is experienced**. This means that highly prevalent conditions do not necessarily result in high levels of YLD if the disability weight is low. Long-term causes which are, on average, successfully treated or managed have relatively low disability weights.
- **YLL** depends on the **frequency of mortality** and the **age at which the death occurs**. YLL accrues faster for deaths at younger ages compared to older ages. It may be possible for an area to have a higher death rate than another area, but have a lower YLL rate if the deaths were at older ages.
- YLD estimates for local areas are based on expected results only and have been modelled using the national age, sex and deprivation morbidity rates generated as part of the SBOD 2016 study. These national rates are three-year average of estimates from 2014-2016.
- YLL and mortality estimates are based on the three-year annual average of death registrations for each local area geography during 2014-2016. Around 1 in 10 death registrations were distributed to multiple cause of disease and injury
- The **lower the granularity**, the **more uncertain results** can become, especially for causes where the prevalence or mortality count is low. Where possible, it is essential to cross-check any comparisons with the underlying prevalence and/or mortality estimates.
- Direct **age-standardisation of rates is essential for cross-area comparisons**. Care must be taken when interpreting comparisons that are based on small numbers as it may lead to inappropriate conclusions, especially where differences seen largely exaggerated.

Geographical areas

The SBOD study has produced estimates at national level and at the following sub-national levels: regions (3), NHS boards (14) and local authorities (32). Populations for each of these areas were sourced from National Records of Scotland (NRS), based on 2016 mid-year population estimates [3].

Cause list

Causes of disease and injury are divided into three hierarchical levels. The first level comprises of: non-communicable diseases; communicable, maternal, neonatal and nutritional diseases; and injuries. Within these three categories, the causes are further grouped into major disease groups *e.g.* cancers, cardiovascular diseases and musculoskeletal disorders. The individual causes of disease or injury *e.g.* ischaemic heart disease, stroke, and atrial fibrillation, are grouped within each major disease group. The SBOD study uses a cause list of 132 individual causes of disease and injury, which is based on an abridged version used in the GBD 2016 study [4]. For the local SBOD estimates a further abridged cause list of 68 causes of disease and injury was utilised.

Estimates of mortality

Data

Death registrations in Scotland were sourced from the NRS register of deaths [5] for the period 01 January 2014 to 31 December 2016. Estimates were reported as three-year annual averages across this time period to help smooth out fluctuations in annual estimates. Death records were allocated to each geographical area on the basis of an individual's postcode of residence. Therefore local estimates of fatal burden reflect the most recently recorded local area residency of an individual when they died.

A measure of life expectancy is required in order to calculate the YLL at any given age of death. In the SBOD study, we have defined life expectancy using the 2014-16 sex-specific National Life Tables for Scotland [6]. This life table provides the life expectancy for each single year of age stratified by sex, up to the age of 100 years,

which allows for the excess YLL to be calculated at any given age of death. In any instance whereby an individual was over the age of 100 when they died, their age was recorded to 100 in order to facilitate the calculation of YLL.

Our approach differs to that of the GBD study, which used an aspirational life table and assigns the same life expectancy to both men and women. The life table used in the GBD study has a much higher life expectancy than we have used, meaning that a direct comparison of YLL figures from the GBD study is not possible.

Allocating deaths to causes

Death registrations were allocated to causes of death based on the International Statistical Classification of Diseases and Related Health Problems 10th revision (ICD-10) codes [7] that were coded on the death registration. In Burden of Disease studies, these ICD-10 codes are grouped into cause-specific and ill-defined codes. Cause-specific codes refer to codes that are directly attributed to a given cause of disease or injury. Ill-defined death (IDD) codes, also known as garbage codes, are codes that are deemed not to be valid causes of death for the purpose of burden of disease studies, e.g. senility, atherosclerosis and hypertension.

The first step in allocating deaths to causes is to allocate cause-specific deaths based on the ICD-10 code recorded as the underlying cause of death. For deaths registrations in 2014-16, 88.9% were deemed to be cause-specific. The next step in the process was to allocate the IDDs. Firstly, allocations were made on the basis of drug-related deaths and injuries in the second contributory cause of death position, which accounted for a further 1.0% of deaths. A further 6.6% of deaths were assigned to causes of disease and injury by using the information pertaining to all contributory causes of death. Further information on this method and the allocation of the remaining 3.5% of deaths can be found in the [Invited Chapter of the 2017 Registrar General's Annual Review](#) [8].

Estimates of morbidity

Data

For the majority of causes of disease or injury in the SBOD study, estimates have been made using data sources which contain a patient Community Health Index

(CHI) number which was harnessed to enable the linkage of routine administrative data. The advantage of using datasets which contained CHI numbers was that the CHI enabled us to derive information relating to the patient demographics such as age, gender or socioeconomic status. The presence of a CHI number also allowed us to censor patients from estimates of morbidity when they died, and furthermore, allowed us to search across several datasets to ensure that our estimates of morbidity were as extensive as possible. An example of this was where we linked records from unscheduled care services with hospitalisation episodes data for a more comprehensive assessment of the burden of injuries.

Where non-routine sources of data were used to define estimates of morbidity e.g. Quality and Outcomes Framework (QOF) register data, national population surveys or surveillance of communicable disease data, it often did not include the full information which was necessary to produce the level of estimates which were required, in terms of demographic breakdown. This meant that the SBOD study team needed to make inferences on how to distribute the total number of cases by demographic (age, gender and socioeconomic status). The process for doing this was to base the underlying distribution of total cases on the most relevant source of data for which a distribution could be obtained. For example when using the aggregate Scotland total QOF register to define the total number of prevalent cases of asthma, the cases were distributed into specific age-gender-socioeconomic groups on the basis of the distribution that was observed for asthma GP consultations from the Practice Team Information dataset.

Further information on how estimates were obtained for specific conditions can be found in the form of individual Technical Reports on the [SBOD area of the ScotPHO website](#) [9].

Severity and disability

In burden of disease studies, a measure of disability is required to apportion the level of health loss experienced by a given condition. The disability weights used in the SBOD study were those which were used in the GBD 2016 study [2]. These weights give a level of disability for each cause of disease and injury graded between 0 (no disability) to 1 (death), with higher levels of disability being an indicator of more debilitating causes of disease or injury. The GBD 2016 study defines disability

weights at the health state level, rather than that by individual cause. A health state is groupings of disease sequelae that reflect key differences in symptoms and functioning. For each cause, the estimated proportions of how morbidity should be allocated into severities (e.g. mild, moderate and severe disease) is more commonly referred to as a severity distribution. To facilitate calculations of disability weights for each cause, we used the severity distributions published in GBD 2016, with the exception of cirrhosis, epilepsy and all cancer types, where we derived our own using Scottish specific estimates.

Creating local estimates of morbidity

As part of the national SBOD study, we estimated morbidity of 132 causes of disease or injury using a range of data sources e.g. primary care, secondary care, national surveys and disease registers. Whilst we were able to extract, or impute, information relating to an individual's demographic characteristics (age, gender, socioeconomic status) we were not able to gain inferences into the observed distribution of morbidity into local geographies for each cause.

To facilitate estimates of morbidity by local area geography we created estimates of morbidity rates by 5-year age-group, gender and Scottish Index of Multiple Deprivation (SIMD) decile [10]. This resulted in 400 stratifications of morbidity rates for each of the 132 causes. These rates were used in conjunction with 2016 NRS mid-year population estimates [3] for each local area to estimate the expected prevalence and YLD for each local area.

Although local estimates have been published across 68 causes of disease and injury, they were calculated for each 132 causes of disease or injury and aggregated to form the abridged cause list to ensure that estimates were made using the lowest granularity of information available.

Uncertainty over estimates

SBOD estimates do not currently contain confidence intervals, because confidence intervals only capture the uncertainty around the point-estimate, rather than additional uncertainties such as uncertainties in severity distributions, disability weights or whether the data which estimates are based upon is representative of the

full population. These factors are important, and the provision of confidence intervals would underplay their value.

Estimates of morbidity are based on national prevalence and YLD rates and should be treated as expected values rather than observed. Estimates of mortality and YLL are based on observed local data, but as data have been averaged across three-years and as single deaths can be distributed across multiple causes, some death counts may be non-integer.

Death estimates (numbers and rates) have been suppressed for all local authorities for age-groups under 25 years. The effect of this has been carried through to NHS board and regional death estimates which have also been appropriately suppressed to avoid differencing.

To reflect the uncertainty associated with small numbers and rates, any estimate which is (deaths), or is based on (YLL and DALYs) a death count of less than 5 has its **cell highlighted in red**. Exceptions to this are causes of disease that were not deemed possible causes of death in burden of disease studies (migraine, tension-type headache, anxiety disorders, depression, osteoarthritis, low back and neck pain, sensory conditions and dental health conditions). Users of the SBOD local profiles should be aware of the data underlying any estimates, particularly for YLL as it accumulates as a much faster rate than YLD, so data based on small numbers of death can quickly rise to several hundred YLL. Please refer to the [Guide to using SBOD local estimates on page 2 of this technical report](#).

In order to provide a measure of the degree of accuracy and relevance of estimates to users, we have developed a measure to indicate the data quality of estimates. This measure assigns a RAG (Red; Amber; Green) status to each cause of disease or injury indicative of the accuracy and relevance of the estimates. Interpretation of the RAG status can be defined on the continuous scale outlined below:



Scores towards the **GREEN** end of the scale can be assumed to be highly accurate and relevant, as they have been developed using robust sources with up to a small degree of adjustments made to the input data. Moderately accurate and relevant

scores sit in the **AMBER** range. These are deemed to be reasonably relevant and robust data sources with up to moderate degree of adjustments performed on the input data. Those scores towards the **RED** end of the scale have been derived using less comprehensive or relevant data sources with a high degree of adjustments performed to the input data and should be treated as having a large degree of uncertainty.

The data quality was assessed using the criteria below, on a scale of 1 to 5, with the weighted scores being assessed on a continuous scale:

Morbidity (YLD and prevalence):

- Relevance and accuracy of the data source used to measure the population of interest;
- Degree of adjustments performed to the input data;
- Likelihood that the implemented disease model captured the burden of morbidity.

Mortality (YLL and deaths):

- Contribution of ill-defined deaths as a total of all deaths.

DALYs:

- Weighted-average of morbidity and mortality scores, where the weights were defined as the proportions of YLD and YLL of DALYs for the given cause of disease or injury for all ages and both sexes.

Additional information

Further information relating to any of the technical aspects of the processes in the SBOD study, please contact the SBOD study team (nhs.healthscotland-sbod-team@nhs.net).

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