Sensitivity analysis in summary measure of population health in France

Annabelle Lapostolle¹, Agnès Lefranc²,³, Isabelle Gremy², Alfred Spira¹

Background: The aim of this study is to provide estimates of the French burden of disease, using the WHO Global Burden of Disease methodology and to perform sensitivity analysis on different set of mortality data. Methods: The burden of disease is measured by disability-adjusted life years (DALYs) that take into account both mortality and morbidity data. Results were obtained using French mortality data for the years 2000 and 2001 and morbidity data estimated by WHO for France. Sensitivity analyses were conducted using different mortality data sets and various life tables as mortality norms. Calculations were also performed with and without discounting and age-weighting. Results: In France, the annual burden of disease was about 12.4 million DALYs. Depending on the mortality data set and the choice of social values used for calculation, results could be quite different. The use of WHO estimates for mortality resulted in an underestimation of 2.6% of total DALYs with respect to French data. Changes of the mortality norm imply changes in the number of years of life lost (YLLs), whereas the use of discounting and age-weighting mainly modifies the ranking of diseases. Conclusion: DALYs constitute a summary measure of population health, which is a powerful tool for the grading of health problems, allowing to compare fatal and non-fatal diseases. Nevertheless, the validity of results obtained depends primarily on the validity of the input data. Collecting morbidity data (mainly incidence) at the national level is hence an important step in order to assess more accurately the specific burden of diseases in France.

Keywords: burden of disease, disabled person, France, mortality

Summary measures of population health combine information about mortality and morbidity, as a means of describing the health of the population in a simple, easily comprehensible way. This type of indicator was developed following the major decrease in mortality in developed countries, as the traditional indicators of mortality previously used to describe the population (life expectancy and infant mortality) were no longer appropriate to describe the health of a population. In the same time, with the development of curative and preventive medicine, public health authorities formulated an increasing need for tools allowing to assess the overall performance of health actions, both in terms of mortality and morbidity.¹⁻⁶

Disability-adjusted life years (DALYs) were developed in the 1990s by the World Health Organization (WHO) and the World Bank as part of the Global Burden of Disease (GBD) Project.¹⁻³ DALYs were developed to respond to diverse health policy goals: the consideration of non-fatal diseases, the creation of an objective, independent measure for health systems evaluation and the quantification of disease burden with an indicator that can also be used for economic evaluation as age-weighting and/or discounting is included in the calculation.

Such indicators have been the subject of many critical and contradictory analyses.¹⁰⁻¹⁸ The main question concerns choosing the most appropriate indicator for the desired usage.¹ For this reason, these indicators can be used to assist public decision-makers in their choices as the allocation of resources for prevention, health care and research in the domain of health.¹,¹³,¹⁹,²⁰ For this type of use, it must be possible, with the tools chosen, to rank diseases in order of contribution to the burden of disease and injury.

The use of DALY permits such a ranking.⁷ For this reason, this indicator was used to select health problems that were addressed by specific objectives attached to the public health policy law adopted in 2004 in France. With this goal in mind, DALY must be estimated at regional and national levels, and the validity of these estimates must be evaluated. We present here an assessment of the burden of disease in France, based on the GBD method of WHO. These first results provide a ranking of diseases and injuries, which can be used to identify a list of eligible diseases (about 10) for a more detailed burden of disease analysis in future studies.

Methods

We calculated DALY for France using the GBD method described by WHO.⁸,⁹,¹² This indicator combines information about mortality and morbidity to describe the health of the population. DALYs are therefore calculated by summing up two components for all diseases: years of life lost (YLLs) that takes into account the burden of mortality, and years lived with disability (YLDs) that takes into account the burden of morbidity.

\[
\text{DALY} = \text{YLL} + \text{YLD}
\]

YLL were calculated from French mortality statistics for the years 2000 and 2001, the two most recent years for which cause-coded data were available. In France, the registration of deaths is exhaustive and mortality data have been registered by Epidemiological Centre for Medical Causes of Death (Centre d’Epidémiologie sur les Causes Médicales de Décès).²² For the 2 years on which the analysis was based, data concerning the number of deaths distributed by sex, age and cause (coded according to the detailed ICD-10 list) were available.
The results presented here are based on the mean annual number of deaths according to age, sex and category of causes (according to the GBD classification).

Deaths from unknown reasons were distributed between categories according to the GBD method recommendations: deaths by disease of unknown etiology were redistributed proportionally among other diseases according to sex and age; deaths by injuries of unknown cause were redistributed in a similar manner among other injuries.23

We also redistributed a subset of ill-defined cardiovascular deaths (ICD-10 codes I47.2, I49.0, I46, I50, 151.4–51.6, 151.9 and I70.9) to ischemic heart diseases (I20–I25) using the method recommended by WHO in order to solve miscoding problems for these diseases.24

YLLs were calculated by multiplying, for each cause, age group and sex, the number of deaths by standard life expectancy for the corresponding age and sex. The mortality norm initially chosen for comparison was the one used in the GBD analysis which is based on the West Level 26 reference table of Coale and Demeny.7 This norm is characterized by a life expectancy of 82.5 years for women and 80 years for men. For each cause, sex and age:

\[ \text{YLL} = N \times L, \]

where \( N \) is the number of deaths due to a given cause and \( L \) is standard life expectancy for the corresponding sex and age.

YLLs were also calculated from WHO estimates of mortality data for France, obtained by the GBD method: WHO estimated deaths by causes using French vital registration data from 1980 to 1999. Death rates by age and sex for specific causes were calculated and used in order to project rates for the year 2002.25 These rates were then applied to the UN Population Division estimates of population for France, obtained by the GBD method: WHO then applied an incidence/mortality ratio to French mortality to estimate specific incidences at national level. Consistency was checked using DISMOD II.26

Age-weighting and discounting were not applied to the calculation of YLL and YLD in the first instance. However, we also calculate DALYs using a discounting rate of 3% and the same age-weighting as in the GBD in order to allow comparisons with other burden of disease studies.

Finally, sensitivity was assessed by changing life table used as norm: the life table for France in 2001 and the projected life table for France in 2020.27 The DALY indicator was calculated as described above, varying only the mortality norm to measure the impact of this norm on the final indicator.28

### Results

The 10 leading causes of DALYs by sex are presented in table 1. In men, 6 of the 10 leading causes of DALYs correspond mostly to YLLs: trachea, bronchus and lung cancer, ischemic heart diseases, road traffic accidents, self-inflicted injuries, cerebrovascular disease and cirrhosis of the liver. In women, disability makes a greater contribution to the burden of disease than mortality: only 3 of the 10 leading causes of DALYs make a greater contribution to YLLs than to YLDs—cerebrovascular diseases, ischemic heart disease and breast cancer. In women, Alzheimer’s disease and other forms of dementia head the ranking, accounting for 7.5% of all DALYs. Unipolar depressive disorders were second, accounting for 7.1% of DALYs, whereas these diseases accounted for only 3.4% of deaths (eighth position).

In France, in the 2000–2001 period, there were a mean of 528,503 deaths per year, 20% of which (109,830 deaths) occurred before the age of 65.

Considering all causes of death together, we counted 6.8 million years of life lost, 60% of which were lost by men (4.1 million). The 10 most important causes of DALYs are presented in table 2.

The leading causes of YLLs differed according to sex. For men, the leading causes of YLLs were ischemic heart disease (9.2% of YLLs), followed by trachea, bronchus and lung cancers (9.0%), self-inflicted injuries (6.0%) and road traffic accidents (5.6%). For women, the leading causes of YLLs were breast cancer (7.8%), followed by ischemic heart disease (6.9%) and cerebrovascular diseases (6.0%). Alzheimer’s disease and other types of dementia, which were not included

### Table 1 Distribution of the 10 leading causes of DALYs by sex, France 2000–01

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause</th>
<th>Percentage of total DALYs (%)</th>
<th>Percentage of YLLs in DALYs (%)</th>
<th>Rank</th>
<th>Cause</th>
<th>Percentage of total DALYs (%)</th>
<th>Percentage of YLLs in DALYs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ischaemic heart disease</td>
<td>6.0</td>
<td>94</td>
<td>1</td>
<td>Alzheimer’s disease and other dementias</td>
<td>7.5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Trachea, bronchus, lung cancers</td>
<td>5.7</td>
<td>98</td>
<td>2</td>
<td>Unipolar depressive disorders</td>
<td>7.1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Alcohol use disorders</td>
<td>4.5</td>
<td>23</td>
<td>3</td>
<td>Hearing loss, adult onset</td>
<td>4.4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Road traffic accidents</td>
<td>4.1</td>
<td>84</td>
<td>4</td>
<td>Cerebrovascular disease</td>
<td>4.3</td>
<td>71</td>
</tr>
<tr>
<td>5</td>
<td>Cerebrovascular disease</td>
<td>3.9</td>
<td>66</td>
<td>5</td>
<td>Breast cancer</td>
<td>4.2</td>
<td>86</td>
</tr>
<tr>
<td>6</td>
<td>Self-inflicted injuries</td>
<td>3.8</td>
<td>96</td>
<td>6</td>
<td>Osteoarthritis</td>
<td>3.4</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Hearing loss, adult onset</td>
<td>3.4</td>
<td>0</td>
<td>7</td>
<td>Ischaemic heart disease</td>
<td>3.4</td>
<td>95</td>
</tr>
<tr>
<td>8</td>
<td>Unipolar depressive disorders</td>
<td>3.4</td>
<td>2</td>
<td>8</td>
<td>Chronic obstructive pulmonary disease</td>
<td>2.8</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Alzheimer’s disease and other dementias</td>
<td>3.1</td>
<td>24</td>
<td>9</td>
<td>Migraine</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Cirrhosis of the liver</td>
<td>2.4</td>
<td>87</td>
<td>10</td>
<td>Endocrine disorders</td>
<td>2.3</td>
<td>37</td>
</tr>
</tbody>
</table>
among the first 10 leading causes of YLLs for men, were ranked sixth for women, accounting for 3.2% of all YLLs.

Major differences exist between WHO estimated of mortality for France and actual French mortality data. WHO estimates of mortality in France were 499,040 deaths in 2002 (Global Burden of Disease 2002), corresponding to an underestimation of 5.6% with respect to French data. Table 3 shows a classification of diseases according to their contribution to the total number of deaths using both data sources. For example, for cerebrovascular diseases, the difference is 3676 deaths, implying a 9% underestimation for WHO evaluations of the number of deaths actually observed for this disease. Conversely, deaths linked to chronic obstructive pulmonary disease (COPD) were the seventh leading cause of death and accounted for 3.2% of all deaths according to WHO estimates. According to French mortality data, this disease accounted for 1.5% of deaths and was ranked 16th, corresponding to a more than 100% overestimation of deaths due to this disease by WHO. For some cause-of-death categories, the difference between observational and estimated data exceeded 25%; skin diseases, skeletal muscle diseases, endocrine disorders and respiratory infections.

Table 4 shows the results obtained if the life table used to define the mortality gap is changed. The use of the standard life table led to an estimation of 6.8 million YLLs and 12.4 million DALYs. Using the French life table for 2001 provided 2.6% more YLLs and 1.4% more DALYs than estimated from the standard table recommended by WHO. This difference depends on the sex: use of the French life table decrease the number of YLLs (−2.8%) and of DALYs (−1.7%) for males, whereas for females YLLs and DALYs are increased (+10.7%). The use of the projected life table for 2020 further increased this difference: values were 14.7% higher for YLLs and 8.1% higher for DALYs than estimated with WHO mortality norms. Number of YLLs is increased by using the projected life table for both males and females (+9.2 and +23.1%).

Figure 1 presents the impact of the use of discounting and age-weighting on the 10 leading causes of DALYs. We can see that for both males and females, diseases occurring at active ages of life reach higher rank by the use of such weights: unipolar depressive disorders and alcohol use disorders. For males alcohol use disorders and unipolar depressive disorders are at the first ranks with the use of discounting and age-weighting whereas such diseases were ranking 3rd and 8th without such weights. For females, unipolar depressive disorders represents 6.4% of total DALYs without any weights and 13.7% with discounting and age-weighting.
On the contrary, diseases occurring at older ages like Alzheimer’s disease, ischaemic heart disease, cerebrovascular disease and trachea, bronchus and lung cancers tend to decrease in rank, whatever the sex.

Discussion

The use of DALY makes it possible to express mortality and morbidity in the same units (years of life), highlighting diseases, usually not considered in studies of mortality alone. This study of DALY in France in 2000 and 2001 highlighted the importance of non-fatal diseases. For example, in mortality analysis, no death was attributed to diseases of the sense organs, whereas such diseases accounted for about 5% of DALYs. The choice of an indicator for the description of the health of the population is very important and depends heavily on its intended use. Several lines of evidence suggest that the DALY indicator provides a more appropriate measure of the health of the population than the simple use of mortality or premature death statistics.

The quality of DALY estimates also depends on the quality of data used for calculation. The use of WHO estimates to measure morbidity does not seem to be the most appropriate solution for a study of the burden of disease. Concerning mortality, we have shown that there were many differences between WHO estimates data and observed data for France. These differences could be explained by the fact that we used French mortality for 2000 and 2001 and that WHO estimates for 2002 were based on 1999 data that were processed differently. Indeed, French vital registration moved from ICD-9 to ICD-10 between 1999 and 2000 and from manual coding to automatic coding. According to a double coding study carried out by the CepiDC, these changes induced a division by approximately two of the number of deaths for which COPD is the primary cause.30 This has been discussed in a recently published paper.31 However, for most groups of causes used in the GBD and in the present study, changes in the revision of the classification used for death causes coding did not change the deaths statistics drastically.

Indeed, given the observed differences for mortality, it seems likely that, for a certain number of diseases, estimates of morbidity are not very reliable. A certain number of local studies of disease burden have made use of YLD/YLL ratios to estimate the morbidity component, in cases in which local mortality data were available.5,32,33 This method presents the advantage of not requiring local incidence data. However, the use of these ratios can be questioned, because they also depend heavily on WHO estimates.

The ideal solution for obtaining a reliable indicator would therefore be to collect data for disease incidence, duration and disability for each of the health states defined in the global burden of disease. This task has proved to be a major undertaking, and very few teams have carried out complete analyses of the burden of disease at a national level.34,35 In France, the data required to calculate YLD are difficult to obtain for the entire range of diseases. For this reason, we intend to determine incidences, durations and disability weights for only a selection of about 10 diseases and injuries in a subsequent work. This work will provide information about the validity of WHO estimates for the calculation of DALY in a repetitive manner in France, with the aim of following the health of the population over time and of contributing to evaluate the public health law in addition to other indicators.

The DALY indicator is easy to understand and provides an overall picture of health problems. Studies of the burden of disease based on this indicator lead to a ranking of diseases and injuries in their totality, providing a complete description of the health status of a population at a given time. This indicator, which is not limited to mortality, incidence or prevalence data, provides a more complete picture of health as defined by WHO.

While the estimates are based on objective data (mortality, incidence of disability and duration of the disease), the results obtained also depend on the arbitrary choice of parameters.
used in the calculation of DALY: the mortality norm chosen, the use or not of age-weighting and discounting, and the choice of disability weight. The use of this indicator requires total clarity in the choice of these parameters, to make it clear what is being calculated. As part of the current work, we first choose not to use discounting nor age-weighting. We then calculated DALYs using the same values for these parameters as the ones used by WHO in the GBD study. Comparison of the two sets of results illustrates the fact that diseases occurring at active ages see that their relative importance increase when such parameters are introduced in the calculation. This reflects the consequences of social preferences, that one may consider as non-justified.12,13

The choice of the mortality norm has already been the subject of much debate in the literature.12,28 In this article, we chose to present results obtained using the standard life table of the GBD, which reduces considerably the difference between males’ and females’ life expectancy at birth. In France, this difference was about 7 years in 2001 instead of 2.5 years with the standard life table used in GBD. Use of the GBD standard life table leads to an overestimation of DALYs for men compared with the French mortality norm, increasing by the same way the gender gap of the burden of disease. Each choice has its own advantages: the use of standard life table allows comparisons between countries whereas the life table of the population provides an objective norm.

Comparison of DALY between countries requires the use of the same parameters in the calculation of this indicator. In studies of national burden of disease in developed countries with same methodological choices, a similar hierarchy of main causes of DALYs is obtained. However, if we compare French with same methodological choices, a similar hierarchy of main causes of DALYs is obtained. However, if we compare French with same methodological choices, a similar hierarchy of main studies of national burden of disease in developed countries the same parameters in the calculation of this indicator. In France, this of the GBD, which reduces considerably the difference between males’ and females’ life expectancy at birth. In France, this difference was about 7 years in 2001 instead of 2.5 years with the standard life table used in GBD. Use of the GBD standard life table leads to an overestimation of DALYs for men compared with the French mortality norm, increasing by the same way the gender gap of the burden of disease. Each choice has its own advantages: the use of standard life table allows comparisons between countries whereas the life table of the population provides an objective norm.

Comparison of DALY between countries requires the use of the same parameters in the calculation of this indicator. In studies of national burden of disease in developed countries with same methodological choices, a similar hierarchy of main causes of DALYs is obtained. However, if we compare French results with those for Australia, we find that France has a higher frequency of DALYs for Alzheimer’s disease, depression, hearing loss, problems associated with alcohol and injuries (road traffic accidents and suicides).24 Conversely, ischaemic heart diseases, cerebrovascular and respiratory diseases (asthma and COPD) were ranked lower in France than in Australia on the basis of DALY. A Dutch study ranked anxiety second and visual problems fourth.35 These two diseases were not found to be particularly important in France. A similar classification was obtained for Los Angeles, with the exception of diseases and injuries inherent to the urban environment: murders, drug use and problems associated with drug use and HIV/AIDS.32

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Conflicts of interest: None declared.

Key points

- Since the 1990s, DALYs are frequently used in order to describe population health and value choices in the calculation of this measure (discounting, age-weighting and mortality norm) had been much debated without reaching any consensus.
- This study presents the first national burden of disease study undertaken in France.
- It states value choices for the evaluation of French public health law, setting a clear framework for the calculation and the use of DALY at the country level.

References


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