 International Journal of Epidemiology 2000;**29**:871–877

Estimating the burden of disease in one Swiss canton: what do disability adjusted life years (DALY) tell us?

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Background Examining life expectancy and general mortality rates, the health of the population of Geneva can be described as one of the best in the world. However, in some areas Geneva fares worse than the rest of Switzerland or Europe. To re-appraise the current health priorities of the Genevan population, we analysed the relative importance of specific diseases and injuries calculating DALYs.

Methods We followed the procedures developed for the Global Burden of Disease (GBD) study to ensure comparability. Some adaptations were made for mortality coding. Disability was estimated based on data for countries classified as Established Market Economies (EME) in the GBD study.

Results Non-communicable diseases accounted for 79% of the disability adjusted life years (DALY), injuries represented 12%, and communicable diseases and other disorders 9%. Ischaemic heart disease was the largest single contributor to DALY, followed by unipolar major depression. Neuropsychiatric disorders and mental health accounted for more than 23% of DALY.

Conclusions Some of the most important problems identified—depression, osteoarthritis and alcohol abuse—would have been overlooked in an analysis based solely on mortality data. The most striking finding is the importance of mental health problems. The main limitation is the lack of morbidity data for Geneva.

Keywords DALY, YLD, YLL, health priorities, burden of disease, Switzerland

Accepted 17 February 2000

Examining classical health indicators such as life expectancy and general infant and adult mortality rates, the health status of the population of Geneva, one of the 23 Swiss cantons,* can be described as one of the best in the world. Adult mortality rates have steadily declined for men and women in the past 15 years, leading to a life expectancy of 74.5 years for men and 81.6 years for women in 1992.[1] This is slightly higher than overall life expectancy in Switzerland (74.2 years for men and 81.1 years for women in 1992), which ranks at the top worldwide after Japan, together with Iceland, Sweden, France and Canada.[2] Maternal mortality has virtually disappeared in Geneva (two deaths 1981–1994) and infant mortality is among the lowest in Europe (4.7/1000 live births in 1996).[1,2] However, a more detailed analysis of available epidemiological data shows a slightly less favourable picture.[3] Excessive alcohol intake and related diseases are higher than in the rest of Switzerland and most western European countries. Tobacco consumption is still high among men and women, and is increasing among young people. As a consequence, lung cancer rates are persistently high in men and increasing among women with cardiovascular diseases the third cause of premature mortality (after cancer and violent deaths). Breast cancer and AIDS are both more frequent in Geneva than in the rest of Switzerland or Europe, and suicide rates among women and adolescents are alarmingly high. The health department of the canton of Geneva decided in 1996 to re-appraise the current health priorities of the Genevan population and, consequently, to develop a new health strategy for the canton.

Traditionally mortality-based indicators such as life expectancy and infant mortality have been used to measure changes in the health status of a population. In addition, specific mortality rates have been used to identify health problems that needed special attention. To take account of the fact that it may be 'natural' to die at a certain age, and that a death at age 80 should not be valued in the same way when setting health

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* The canton of Geneva has about 400 000 inhabitants. The Swiss political system being extremely decentralized, each of the 23 cantons is responsible for developing its own health system and health policy. Only few issues are regulated centrally, as for example private health insurance.

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priorities as a death at age 20, the concept of 'premature death'** was developed.[4–8] However, in industrialized countries where mortality rates are low, these are no longer sensitive indicators of change. As life expectancy is already very high, major changes in health status would need to occur to induce a measurable change in life expectancy. In Geneva, for example, we estimated that even if all deaths before age 50 were eliminated, life expectancy would only increase by 3.8 years for men and 2.1 years for women. If all deaths before age 70 were eliminated, life expectancy would increase by 8.3 years for men and 4.7 years for women. In countries with high life expectancies the issue is thus not so much to add quantity to life, but quality. Low and non-fatal consequences of acute and chronic disease and injury become as or more important than premature mortality.

We thus wanted to use a synthetic indicator which combines fatal and non-fatal outcomes. Based on earlier attempts to develop a summary measure that combines mortality, morbidity and disability,[9–12] such an indicator was elaborated for the 1993 World Development Report 'Investing in health':[13] the disability adjusted life year (DALY).[14] The DALY extends the concept of premature death (potential years of life lost [PYLL]) to include equivalent years of 'healthy' life lost because of illness and disability (years lived with disability [YLD]).[15] The methods developed for this worldwide analysis are being used in studies in The Netherlands, Spain, Sweden, Australia and the USA,[16] although results have not been published yet.

We used the DALY method to identify the relative importance of specific diseases and injuries in the overall disease burden in the canton of Geneva. We describe the methodological adaptations needed for the specific situation in Geneva, present the results of the analysis by age group and sex, discuss the relative importance of specific health problems and identify the 15 most important problems. Major differences between the burden of disease in Geneva and other industrialized countries will be indicated. Finally, we discuss the relevance of these findings for the future health strategy in the canton of Geneva.

Materials and Methods

We followed the procedures used in the Global Burden of Disease study (GBD)[17] to ensure comparability with other studies using the same methodology.[18–21] Thus we describe only the adaptations made to the standard method (Appendix).

Mortality data

Mortality estimates came from the national 1990–1994 mortality data base for the canton of Geneva, the most recent data available at the time of the study. Data were averaged over the 5-year period to avoid unstable mortality rates due to the small population (400 000). In Switzerland information on cause of death is coded according to the 8th Revision of the International Classification of Diseases (ICD-8), while DALY were developed using mainly the ICD-9 classification. Therefore coding was revised to ensure comparability. Differences were found in the coding of viral hepatitis B and C, which were aggregated into a single category as infectious hepatitis.

Following the GBD systematic, health problems were ordered in a tree structure with three basic causes of death: communicable diseases and maternal, perinatal and nutritional disorders (Group I); non-communicable and chronic illnesses (Group II); and all injuries, intentional and non-intentional (Group III). Each group is divided into major subcategories that are mutually exhaustive and exclusive and which can be disaggregated into a third and fourth level to identify more specific causes of death.[22]

Irrelevant diseases such as most tropical diseases were excluded. Others that are very rare were not disaggregated at the third level (drowning). Three new subcategories were added due to the relative importance of the disease entities in Geneva: cancer of the larynx, sudden infant death and influenza with or without pneumonia. Finally, due to aggregated coding of prematurity and low birthweight in Geneva, both are included in the same subgroup, instead of using exclusively low birthweight as noted in the GBD classification.

To deal with 'ill-defined codes', we assumed that deaths due to injuries were not likely to be coded as an ill-defined cause; that in adults, ill-defined deaths are more likely to be due to deaths from chronic diseases than from transmissible diseases; and that in children, these deaths are probably due to diseases from Groups I or II. Based on these assumptions all deaths with ill-defined codes in adults were redistributed to Group II and in children to Groups I and II, proportionally to the existing deaths in each age and sex group.

With regard to cardiovascular diseases, coding for cerebrovascular disease is mostly correct or slightly overestimated while ischaemic heart disease (IHD) is more likely to be undercoded due to excessive coding of 'heart failure', 'ventricular dysrhythmias', 'general arteriosclerosis', and 'ill-defined descriptions and conditions of heart disease'. These codes are termed cardiovascular garbage codes. Based on the algorithm used in the GBD[23] we partially recoded ill-defined cardiovascular deaths to IHD.

Mortality analyses are based on standard model life table West 26,[24] with a life expectancy at birth of 82.5 years for women. Life table West 25[25] for females is used for men (life expectancy at birth of 80 years). Thus deaths at all ages will be considered as a loss and included in the analysis, with a slight difference in the standard for males and females. For reasons of comparability we used the same age-weighting and discounting of future years (3%) as Murray *et al.*[26]

Disability data

The information required to estimate Years Lived with Disability (YLD)—disease incidence by age and sex, age of disease onset, disease duration in years, and degree of disability—is not available for Geneva in most cases. We thus indirectly estimated the YLD using data published by Murray *et al*. for the 35 countries classified as Established Market Economies (EME).[17,22] We used YLD/YLL (years life lost) ratios calculated for health conditions in EME to estimate YLD in Geneva when this ratio is <10 (i.e. AIDS, self-inflicted injuries/suicide). In conditions with a higher disability burden (YLD/YLL ratios >10; i.e. depression, osteoarthritis) we used primary data on incidence, age of onset, duration and degree of disability for EME countries as published in the GBD to calculate YLD in Geneva.

** First proposed by Demsey in 1947, a wide array of different measures have since been elaborated. The simplest and most widely used measure is 'potential years of life lost'. A potential limit to life is chosen arbitrarily (in general close to life expectancy of the population considered) and the duration of life lost due to death is the potential limit minus the age at death.

Throughout the study, EME estimates were validated for diseases for which information on disease incidence or prevalence was available for Geneva. Regarding unipolar major depression, one population-based survey had found higher incidence rates than the EME estimates.[27] As these data have not yet been confirmed by an epidemiological study, we used the more conservative EME estimates. Following consistent findings that dementia prevalence is higher in Geneva than in EME,[28] we increased the dementia incidence estimate for EME by 10% to calculate YLD. No other disease estimates were adjusted.

Results

Overall burden of disease

Between 1990 and 1994 the canton of Geneva lost 235 000 DALY every year to disability (53%) and premature death (47%). Men have an excess mortality at all ages. They contributed more (54% of total DALY) to the disease burden than women and accumulated 60% of all YLL. By age groups, contribution to DALY were similar in both sexes, highest in the 15–44 age groups, and lowest in children 5–14 years (Figure 1). Disability is proportionally more important than premature death in the 5–14 and 15–44 age groups (62.5% and 69% of the overall burden of disease attributable to disability, respectively), whereas mortality contributes more to the disease burden at age 60 and beyond (65.8% of the disease burden due to mortality).

Burden of disease by major disease groups

Overall, non-communicable diseases (Group II) accounted for 79% of the DALY, injuries represented 12%, and Group I (communicable diseases, maternal, perinatal and nutritional disorders) just 9%. Disability contributed more to DALY than premature death in Group II (59% DALY), while mortality was more important in Groups I and III (66% and 71%, respectively). Men and women contributed equally to DALY for non-communicable diseases (Figure 2), while men suffered more from injuries and communicable diseases (67.3% and 58.1%, respectively). Non-communicable diseases are the most important cause of DALY at all ages (Figure 3). The DALY from injuries and communicable diseases are highest for the 15–44 age group decreasing thereafter.

Relative disease burden within each disease group

In Group I, HIV/AIDS contributes 40% to YLD and 60% to YLL. Men 15–44 alone accumulated 38% of all DALY in this group. In Group II, neuropsychiatric disorders are the first cause of DALY (30.9%) (Figure 4), mainly due to the great disability associated with these disorders (38% of all YLD in this group). Neoplasms followed by cardiovascular diseases are the two main causes of death in this disease group, accounting for 81% of YLL. In Group III, unintentional injuries contributed more DALY, YLL and YLD than intentional ones. Men bore a much higher disease burden than women because of road traffic

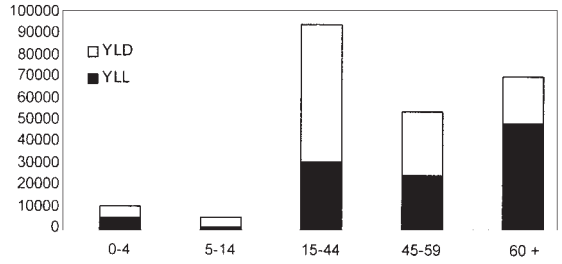

Figure 1 Disability adjusted life years (DALY) by years of life lost (YLL) and years lived with disability (YLD) and by age, Geneva 1990–1994

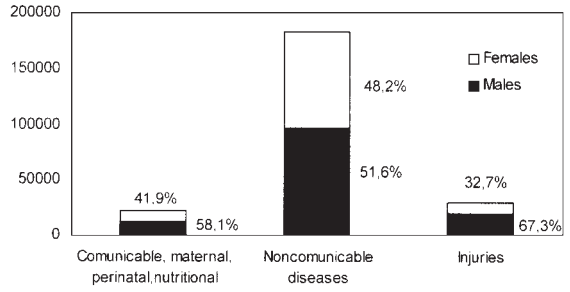

Figure 2 Disability adjusted life years (DALY) by groups of diseases and sex, Geneva 1990–1994

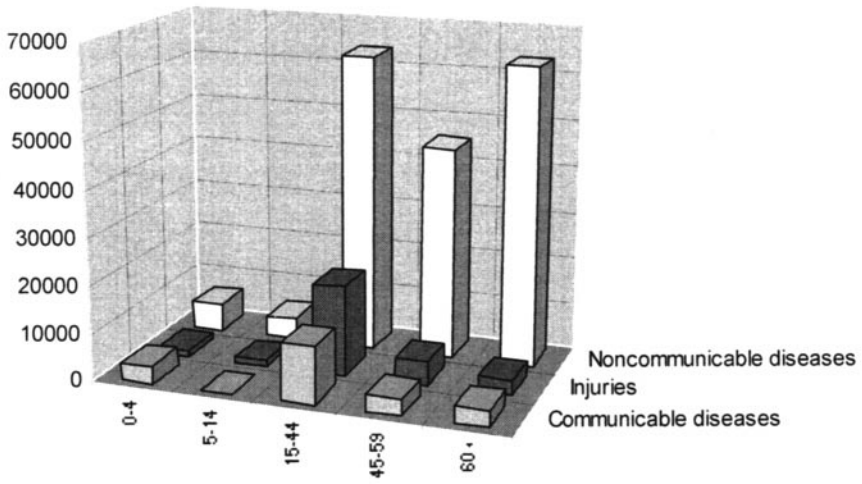

Figure 3 Disability adjusted life years (DALY) by groups of diseases and by age, Geneva 1990–1994

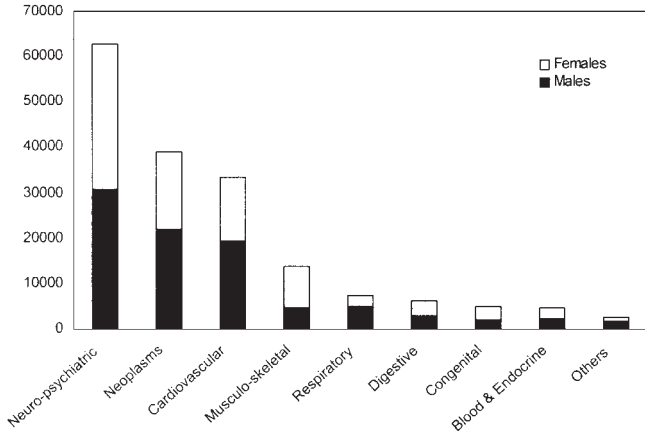

Figure 4 Disability adjusted life years (DALY) attributable to non-communicable diseases by sex, Geneva 1990–1994

accidents, poisoning (unintentional injuries), and suicide (intentional injuries).

The fifteen most important health problems in Geneva

Table 1 shows diseases or injuries ranked by their specific contribution to the overall burden of disease. Ischaemic heart disease was the largest single contributor to DALY, followed by unipolar major depression. Neuropsychiatric disorders contribute six of the 15 priority problems, accounting for 20.9% of DALY. HIV/AIDS is the third contributor to DALY in Geneva. Suicide and other self-inflicted injuries account for more DALY than road traffic accidents and falls. The remaining priority health problems are respiratory (trachea, bronchus, lung) and breast cancer. Together neuropsychiatric disorders, malignant neoplasms, cardiovascular diseases and unintentional injuries are responsible for 68.5% of the DALY in Geneva. Comparing health problems by gender (Tables 2 and 3), it appears that poisoning (mainly acute reaction or drug overdose) and HIV/AIDS are more important in men than women, as well as alcohol use and road traffic accidents. Neuropsychiatric conditions, although important in men, are relatively more important in women. The male/female ratio (in per cent of DALY) for trachea, bronchus and lung cancer is >2 although respiratory cancer still remains the second most important cancer in women.

Table 1 Proportion of disability adjusted life year (DALY) attributed to the fifteen most important health problems

	Disease	% of total DALY	Contribution YLD[a]-YLL[b] % YLD	% YLL
1	Ischaemic heart disease	8.0	8.6	91.4
2	Unipolar major depression	6.9	100.0	0
3	AIDS	4.8	25.4	74.6
4	Alcohol use	4.7	96.6	3.4
5	Suicide/other self-inflicted	3.8	8.6	91.4
6	Osteoarthritis	3.1	99.1	0.9
7	Trachea, bronchus, lung cancer	2.9	7.3	92.7
8	Dementia + Degenerative CNS	2.8	97.9	2.1
9	Cerebrovascular	2.6	30.1	69.9
10	Road traffic accident	2.5	31.3	68.7
11	Schizophrenia	2.1	100	0
12	Falls	2.1	65.2	34.8
13	Breast cancer	1.9	13.6	86.4
14	Bipolar disorder	1.7	100	0
15	Obsessive-compulsive disorder	1.7	100	0

[a] Years lived with disability.

[b] Years of life lost.

Table 2 Proportion of disability adjusted life year (DALY) attributed to the fifteen most important health problems for men

	Disease	% of total DALY	Contribution YLD[a]-YLL[b] % YLD	% YLL
1	Ischaemic heart disease	9.2	9.6	90.4
2	Alcohol use	7.2	97.2	2.8
3	AIDS	6.7	24.6	75.4
4	Suicide/other self-inflicted	4.4	5.1	94.9
5	Unipolar major depression	4.3	100	0
6	Trachea, bronchus, lung cancer	3.9	6.7	93.3
7	Road traffic accident	3.5	29.8	70.2
8	Poisoning	2.3	2.3	97.7
9	Osteoarthritis	2.2	98.9	1.1
10	Cerebrovascular	2.1	30.4	69.6
11	Falls	2.1	62.5	37.5
12	Schizophrenia	2.0	100	0
13	Dementia + Degenerative CNS	1.9	97.1	2.9
14	Prostate cancer	1.6	33.0	67.0
15	COPD	1.6	50.5	49.5

[a] Years lived with disability.

[b] Years of life lost.

Table 3 Proportion of disability adjusted life year (DALY) attributed to the fifteen most important health problems for women

	Disease	% of total DALY	Contribution YLD[a]-YLL[b] % YLD	% YLL
1	Unipolar major depression	10.0	100	0
2	Ischaemic heart disease	6.7	7.0	93.0
3	Osteoarthritis	4.2	99.3	0.7
4	Breast cancer	4.1	13.6	86.4
5	Dementia + Degenerative CNS	3.9	98.4	1.6
6	Cerebrovascular	3.3	29.9	70.1
7	Suicide/other self-inflicted	3.0	14.6	85.4
8	AIDS	2.6	27.8	72.2
9	Schizophrenia	2.3	100	0
10	Falls	2.1	68.4	31.6
11	Bipolar disorder	2.0	100	0
12	Obsessive-compulsive disorder	1.9	100	0
13	Trachea, bronchus, lung cancer	1.8	8.6	91.4
14	Alcohol use	1.7	93.6	6.4
15	Colon/rectum cancer	1.6	20.3	79.7

[a] Years lived with disability.

[b] Years of life lost.

Comparison with established market economies countries

We compared our results with the overall DALY estimates for EME countries in the Global Burden of Disease study.[29] The crude rate of DALY per 1000 inhabitants per year is similar in Geneva (123.7) and in EME (123.8). The main differences appear in the relative weight attributed to certain diseases or injuries. A higher proportion of DALY come from HIV/AIDS in Geneva (4.8%) than in EME (1.3%). Cardiovascular diseases are proportionally less important in Geneva (14% versus 18.6%), while neuropsychiatric conditions (30.3% versus 25%) and malignant neoplasms (16.1% versus 15%) are proportionally more important in Geneva than in EME. The relative contribution of DALY due to unintentional injuries is similar in EME and Geneva (8%). However, the weight of specific conditions differs. For example, traffic accidents have a greater importance in EME (4.4%) than in Geneva (2.5%), while poisoning (acute reaction or drug overdose) represents 1.6% in Geneva and 0.3% in EME. Intentional injuries are also more important in Geneva because suicides represent 3.8% of total DALY in Geneva, but only 2.2% in EME.

Conclusion

The most striking finding of this burden of disease study is the importance of mental health problems. The proportion of total disease burden due to unipolar major depression (6.9%), alcohol abuse (4.7%), suicides (3.8%), bipolar disorders (1.7%), obsessive compulsive disorders (1.7%) and schizophrenia (2.1%) together is 20.9%. If one adds dementia (2.8%) to this group of conditions, they represent almost one quarter (23.7%) of the overall disease burden of the canton of Geneva. Unipolar major depression appears as first priority for women and fifth for men according to the DALY analysis. The data currently available for Geneva support this result, as 9.4% of women and 5.6% of men reported a medically diagnosed depression during a population-based survey in 1993.[30] This was considerably higher than the Swiss average (5.4% and 2.5%, respectively). In addition, 36% of women and 31% of men considered themselves to be in bad mental health. Regarding alcohol abuse, 3.6% of women and 12.2% of men reported at-risk consumption in the same survey, as compared to 1.9% and 8%, respectively, on Swiss average. Suicide rates are also higher than the Swiss average, particularly in women and adolescents, Switzerland being among the European countries with the highest suicide rates. These results are remarkable considering that the canton of Geneva has one of the best developed and widely accessible psychiatric care systems in the world. The public sector provides excellent in- and outpatient services. The total number of psychiatrists (public and private) has tripled between 1980 and 1996, reaching a density of one per 2000 inhabitants. In 1995, health insurance reimbursed about 70 Swiss francs per inhabitant for psychiatric and psychotherapeutic treatments, double the Swiss average. This study thus indicates that a new strategy to deal with mental health problems may have to be developed with a clear shift from the past focus on curative services towards a more holistic approach integrating health promotion, and primary and secondary prevention. This conclusion would be consistent with a recent opinion survey on mental health which pointed to the need for more preventive activities including better and earlier detection of mental problems, the creation of social support networks, information campaigns targeted at the general public and at children and adolescents, and adequate training of health professionals.[30]

This has been the first attempt to identify the most important health problems in the canton of Geneva using DALY as a single unit of measurement. Combining mortality, morbidity and disability allowed for comparisons between specific health conditions that would not be comparable otherwise. Some of the most important problems identified—depression, osteoarthritis, alcohol abuse and injuries from falls—would have been overlooked in an analysis based solely on mortality data, as more than two-thirds of the weight of each of these diseases is represented by disability. However, some of the assumptions underlying the method such as age weighting, discount rates and the valuation of disabilities have been challenged.[31–33] It is probable that age weighting, which reflects a higher valuation of life in early adulthood than in young children and old people, and discount rates reflecting social time preferences, do not influence the list of priority health problems in any major way. In fact the sensitive analysis carried out in the GBD study showed that modifying these specific values did not affect the ranking of importance of the main diseases. However, as pointed out recently,[34] the valuation of life lived with disability remains an unsolved problem. Valuing life lived with disability less than a healthy life could lead to discriminate strongly against patients who have less potential for health than others. We would suggest that the priorities identified through the DALY analysis be first compared to locally available evidence and then be used to highlight areas that need special attention. We believe the main limitation of this analysis is the lack of morbidity data for Geneva which forced us to rely on estimates for the EME. Consequently, the comparison with the results for EME as published in the GBD is mostly driven by differences in mortality patterns. The study thus points to the need for consistent long-term data collection, particularly for those conditions where mortality plays a minor part in the attributable disease burden. Meanwhile these first results can serve as baseline against which the future evolution of the health status of the Genevan population can be compared in a more complete way than using only mortality data. In addition, once results from DALY analyses carried out in other European regions become available, similarities and differences should be examined in more detail.

Acknowledgements

The study was carried out in 1997 as part of a mandate given by the health department of the canton of Geneva to the Institute for Social and Preventive Medicine.

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Appendix

Disability adjusted life years (DALY) are obtained from the addition of two components: years of life lost (YLL) and years lived with disability (YLD). *DALY = YLL + YLD.* The value of time lived at different ages is captured in DALY defining a continuous age-weighting function and utilizes a discount rate to reflect time preference.

1. The general formula to calculate YLL is: $\sum_{x=0}^{x=l} d_x e_x$ where e_x is life expectancy at each age, d_x deaths at age x and l is the last age group. Therefore the required data to quantify YLL are:

- Deaths during the period studied, distributed by cause of death, age group, and sex.
- Life expectancy for each age from Model-Life Table West 26[24] for females and using, for males, the Model-Life Table West 25[25] for females.

2. The general formula to quantify YLD is $\sum_{x=0}^{x=l} n_x i_x L_x D$, where n is the population in the age group x, i is the incidence of disease in each age group (x), L is the average of duration for each age group, and D is the level of disability. So that, to calculate YLD is needed:

- Incidence by age group and sex for the different diseases and injuries.
- Average duration of each disease for the different age groups by sex.
- Average of age of onset of each disease for the different age groups by sex.
- Disability weight from 0 to 1.

3. Social value of years lived.

Years lost due to mortality and years lost due to disability are unequal values as a result of using a continuous mathematical function for the weights at each age: $y = Cxe^{-\beta x}$, where x is the age corresponding to each year of life lost; $C = 0.1658$; $\beta = 0.04$

This function can be adjusted introducing a constant (K) in order to modify weights, $y = KCxe^{-\beta x} + (1 - K)$. Value of K ranges from 0 to 1. When $K = 0$ years lost have equal value. When K has a value higher than 0, years lost acquire different values depending on age. To calculate DALY $K = 1$ is used. The age weight increases gradually from birth to the age of 25 and then decreases.

4. Time preference: Applying a discount rate for years lost, present health benefits are valued more than future health benefits. Murray has chosen in his study a low positive rate of 3% for the calculation of DALY, using the formula:

$$\boxed{years\_lost\_discounted = \frac{1}{r} - \frac{e^{-rL}}{r}}$$

where r = discount rate and L is years lost in YLL or duration in YLD.

5. A general formula for calculating the number of DALY lost by one individual can be developed:

$$\text{YLL or YLD} = \int_{x=a}^{x=a+L} D(kCxe^{-\beta x} + (1-K))e^{-r(x-a)}dx =$$

$$= D\left\{\frac{KCe^{ra}}{(r+\beta)^2}\begin{bmatrix} e^{-(r+\beta)(L+a)}\left[-(r+\beta)(L+a)-1\right] \\ -\,e^{(r+\beta)a}\left[-(r+\beta)a-1\right] \end{bmatrix} + \frac{1-K}{r}(1-e^{-rL})\right\}$$

For YLL: a = age at death, L = life expectancy at age a, D = 1 (death), C = 0.1658,

K = constant to modify age weights, β = 0.04, r = discount rate

For YLD: a = age of onset of disability, L = duration in years, D = disability weight,

C = 0.1658, K = constant to modify age weights, β = 0.04, r = discount rate.