

Steady state assumptions in DALYs: effect on estimates of HIV impact

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Abstract

Objective—The disability adjusted life year (DALY) and the healthy life year (HeaLY) are both composite indicators of disease burden in a population, which combine healthy life lost from mortality and morbidity. The two formulations deal with the onset and course of a disease differently. The purpose of this paper is to compare the DALY and HeaLY formulations as to differences in apparent impact when a disease is not in an epidemiological steady state and to explore the implications of the differing results.

Design—HIV is used as a case study of a major disease that is entering its explosive growth phase in large areas of Asia. Data from the global burden of disease study of the World Bank and World Health Organisation for 1990 has been used to compare burden of disease measures in the two formulations.

Setting—The data pertain to global and regional estimates of HIV impact.

Results—The DALY attributes life lost from premature mortality to the year of death, while the HeaLY to the year of disease onset. This results in very large differences in estimates of healthy life lost based upon the DALY construct as compared with the HeaLY, for diseases such as HIV or those with a strong secular trend.

Conclusion—The demonstration of the dramatic difference between the two indicators of disease burden reflects a limitation of the DALY. This information may directly influence decision making based on such methods and is critical to understand.

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Approaches to measuring health status that incorporate morbidity and mortality into a single, composite number to represent a population's burden of disease have been developed to meet a variety of needs.¹⁻⁶ The purpose of this paper is to compare two such measures, the healthy life year (HeaLY) and the disability adjusted life year (DALY) as to differences in apparent impact when a disease is not in an epidemiological steady state, and to explore the implications of the differing results. HIV is used as a case study of a major disease that is entering its explosive growth phase in large areas of Asia. For successful control, HIV should be contained before its rapid growth phase and accurate tracking of its spread and assessment of its impact may strongly influence decisions to be taken for its control. The intent

is to demonstrate differences in the loss of healthy life from HIV when the two indicators are used.

These measures were formulated for different purposes and are calculated on different bases.^{5,6} The DALY comprises two components: (1) the loss from premature mortality or years of life lost (YLL), is based on deaths occurring in the current year; (2) the loss from morbidity or years of life lived with disability (YLD), is based on disability that will occur throughout a lifetime in those with onset of disease in the current year.⁵ The DALY has been especially useful for making large numbers of burden of disease comparisons as was done in the global burden of disease study.^{2,5}

The concept of the amount of healthy life lost or gained, originally developed by the Ghana Health Assessment Team in 1981 for assisting national resource allocation decisions, has recently been refined and reformulated as the healthy life year.^{1,6} It is based on the natural history of disease concept and measures the loss of healthy life from both premature mortality and morbidity caused by a disease.⁷ Unlike the DALY, both portions of HeaLY are based on counting life lost following the onset of disease (according to the natural history of disease perspective) and are attributed to the year of onset.

Methods

The technical basis for the DALY and the HeaLY constructs have been described in detail elsewhere.⁴⁻⁶ This study will restrict loss of healthy life to premature mortality only and henceforth both HeaLY and DALY refer to this component only (YLL for DALYs). The variables required in the estimation of DALY include numbers of deaths, age at death, and expectation of life. DALYs for HIV for selected regions in 1990 have been taken from the global burden of disease study*, and attribute loss from premature death to the year death occurs.

Data from the global health statistics work have also been used to generate HeaLYs to assess the loss of healthy life from premature mortality from HIV in selected regions.⁸ A complete technical review of HeaLYs is available and the same formulation has been used here.⁶ † HeaLYs attribute loss from premature death to the year of onset of the

* For formulas see Murray CJL, Lopez AD, eds. *The global burden of disease*. Geneva: World Health Organization, 1996:64-6; for DALY(YLL) results Annex table 7a-i: 469-504.

† Based on HeaLYs (premature mortality) = incidence × case fatality ratio × [E(Ao) - (Af - Ao)], where A is the average age at disease onset (Ao) and fatality (Af), and E(Ao) is expectation of life at Ao.⁶

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disease and in the case of HIV onset is considered as the time of documenting initial infection.

Variables used (table 1) include incidence, which refers to the number of new cases diagnosed as HIV positive by a confirmatory testing system in a year. The HIV/AIDS case fatality ratio (the proportion of cases who ever die, of those who develop the disease with onset in a year) is essentially one, that is all becoming infected will eventually die from the disease. This means that all new cases arising in a year are expected to die from HIV at some point in the future.

The DALY formulation incorporates social choices concerning the value of life lived at different ages and social time preference such that future life is discounted at 3% per annum. The same discount rate and the same life tables for expected life have been used in the HeaLY calculations, but age weighting has not been used. In a steady state the principal difference in the estimated loss of healthy life in the DALY and HeaLY formulations is because of differences in age weighting (plus possible relatively minor differences likely to result from the way disability losses are estimated that are not being considered in this paper) as DALYs are based on valuing life lived at any age differently; a year of life lived at age 25 has more value than a year of life lived at younger or older ages according to an exponential distribution. It has been shown that DALYs put a greater value on life lost at younger ages than do HeaLYs, but the differences are generally small.⁶⁻⁹ Data analysis was done using several interlinked spreadsheets in Microsoft Excel 7.0 with the variables described above.

Results

Table 1 shows the input variables and the years of life lost for HIV. The three regions display a 40-fold difference in incidence with Sub-Saharan Africa being 10 times that for India, which is four times that for the Middle Eastern Crescent. The three regions seem to be at different points in their epidemic potential. The epidemic is fully established in much of Africa and in some areas the incidence has apparently stabilised. Parts of India are now in a rapid growth state, whereas for most of the Middle Eastern Crescent HIV spread has only recently become evident. The reported age and sex distribution is more characteristic of heterosexual

KEY POINTS

- Disability adjusted life years (DALYs) and healthy life years (HeaLYs) combine the duration of healthy life lost from disability and premature death from diseases in a population into a single composite indicator of disease burden for that population.
- The way healthy life lost from diseases is determined in these methods has implications for both the measurement of disease burden and policy decisions regarding health interventions.
- DALYs attribute years of life lost from premature mortality to the year of death, while HeaLYs attribute them to the year of disease onset according to the natural history of disease concept.
- The DALY and HeaLY methods provide comparable results for diseases that approximate a steady state situation, but the HeaLY yields a more realistic estimate for conditions such as HIV that demonstrate a strong secular trend.
- These methodological issues pertaining to indicators of disease burden are important for health planning purposes as they have the potential of affecting health resource allocation decisions.

transmission; and Sub Saharan Africa has a somewhat younger average age of onset.

According to the global burden of disease study, nearly 7 million DALYs were lost from premature mortality caused by HIV attributable to 1990 for Sub-Saharan Africa. The losses for the Middle Eastern Crescent and India are minuscule compared with this and convert to 0.02–0.03 DALY per 1000 people in 1990 and is based on the number of deaths from HIV for 1990.

When the same data are used for the HeaLY construct with losses attributed to the year of onset, the loss seems to be four times greater for Africa with the HeaLY as compared with the DALY. For the Middle Eastern Crescent and India the difference is even more striking with the losses being 40 and 268 times more using HeaLYs rather than DALYs.

Discussion

The time perspective for attributing loss of healthy life as used in indicators of disease

Table 1 Apparent impact of HIV on mortality: DALYs as compared with HeaLYs, 1990

Indicator of impact*	Middle Eastern Crescent†	India	Sub Saharan Africa
DALYs‡ in thousands (rate per 1000 population)	16 (0.03)	17 (0.02)	7020 (13.8)
HeaLYs in thousands (rate per 1000 population)	642 (1.3)	4554 (5.4)	28 493 (55.8)
Annual incidence (per 1000 per year)	0.05	0.21	2.1
Case fatality ratio	1	1	1
Average age of onset (y)	31.6	31	27.5
Average duration of disease (y)	7	7	6.5
Average age of fatality (y)	38.6	38	34
Deaths from HIV‡ (thousands)	1	1	239

Expectation of life and discounting included in the calculations; age weighting included in DALY(YLL)s; for a detailed explanation of technical issues see references 2 and 4–6.

*Incidence, age of onset, and duration data are from Murray and Lopez (1996) Global Health Statistics pp 250, table 46. †Includes the Middle East, North Africa, Central Asia, and Pakistan. ‡From Murray and Lopez (1996) Global Burden of Disease, Annex tables 6 (deaths) and 7, pp 433–504.

burden is important for both measurement and policy development. DALYs use a current year perspective for premature mortality and a time at onset perspective for disability, while HeaLYs use a time at onset perspective for both. If the incidence remained constant, there were no interventions to affect the natural history of the disease and there was no population growth, then an epidemiological steady state would exist. The differences in methods would become less important in such a steady state situation where the same numbers of new cases and deaths will be recorded each year. In the presence of a secular increase or an epidemic situation, however, these indicators will yield differences that may be large and in the case of HIV dramatically so. Using HeaLYs the loss of healthy life resulting from HIV for India and the Middle Eastern Crescent is seen to be truly important already and even in this early stage of the epidemic would demand urgent attention. The HeaLY would seem to better reflect what needs attention.

The time of onset perspective in HeaLYs is useful because it is based on the natural history of disease concept and emphasises the future implications of new cases of a disease.^{6,7} This perspective stresses the importance of prevention and focuses on the lifetime impact of disabling or fatal conditions. It also allows an assessment of new interventions especially when a disease is demonstrating a secular trend. These features would not be captured by a current year perspective that reflects deaths of cases with onset in the past. In the presence of a secular trend, a protracted duration of disease and high case fatality will further increase the HeaLY-DALY difference.

In general, the time of onset perspective is most useful in thinking about preventing disease whereas the current year perspective may be useful for treatment interventions for the current burden of disease. The latter use, however, would require a reformulation of the disability component of the DALY to obtain a current year disability perspective as well.

The differences between the regions in table 1 change depending on the measure used. DALYs tend to place India and the Middle Eastern Crescent on a similar DALY loss rate of 0.02–0.03 per 1000 population. However, there is a gradient seen in the HeaLY rate from 1 to 55 per 1000 population that seems consistent with impressions regarding the burden of HIV in these regions in the literature.¹⁰ Although in either case the burden is greatest in Africa and least in the Middle East, HIV is likely to gain in relative ranking compared with other conditions within each of these regions when the HeaLY method is used. This emphasises the expected loss of healthy life based on the current incidence and may affect the prioritisation of efforts to prevent HIV when compared with other diseases.

The differences seen in table 1 between DALYs and HeaLYs relate to premature mortality only and are a result of the attribution process as the same data have been used to generate both measures. The information if provided to health managers, planners, and policy makers would create widely divergent programmes for HIV control. When compared with other diseases the relative importance of a specific condition may substantially change within a region or country. Although a single disease is used for demonstration purposes, the optimal use of burden of disease measures is in making relative comparisons and assessing effectiveness of interventions.⁶

It is important to note that this study focuses on the differences between HeaLYs and DALYs and not on the validity of the original data used to generate DALYs. All limitations of the data set affect both indicators and it is expected the differences between HeaLYs and DALYs will remain as long as the same data are used to generate them.

In conclusion, the value of the DALY for making multiple comparisons in a standardised fashion has been well documented although its utility in assisting resource allocation decisions at national and local levels has been questioned.^{6,11} This study has used data for HIV to demonstrate the need to carefully assess the time perspective used in a burden of disease indicator. The very large difference in estimates of healthy life lost based upon the DALY construct as compared with that of the HeaLY for a disease such as HIV dramatically demonstrates this need. The HeaLY construct more appropriately reflects the consequences related to disease onset and interventions occurring in a year than the DALY. This information may directly influence decision making and is critical to understand.

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