## *Chapter-8*

# Local age preference, age weight and discounting parameters for computation of DALYs.

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Murray (1996 pages 54-61) has described ethical arguments in support and against unequal weighing of years lived at different ages. Overall he finds, from literature and his own experience with participants in international workshops, that there is wide spread support for unequal weighing of years lived at different ages. NBD study teams will have make their own ethical decision between equal age weights or unequal age weights. The age weight function for GBD study was chosen to be consistent with reports in the literature about preference for young adults over children or elderly. For example Lewis and Charny (1989) list out five commonly observed ethical rules to map out the boundaries of an age weighing function. However, ethical debate about desirability of unequal age weights still remain. A fuller understanding of the age weight function and its impact on relative values attached to death or disease at different ages, I hope will facilitate the debate. The purpose of this chapter is to examine the effect of age weight function and discounting from different angles and demonstrate implications of changing its parameter. So I first review an important difference between years of life lost (YLL), which is a time based measure and conventional counting of deaths at different ages. The next section examine the age weight function and propose a way of connecting the choice of age weight parameters with local age preferences, if any. I then proceed to discounting and examine effect of discounting on the relative weight of YLL values for deaths at different ages. Finally I examine the combined effect of discounting and age weighting on the relative weightages resulting from the YLL values of death at different ages. The discussions and illustrations are to read as a supplement to Murray's (1996) original exposition of the age weighting and life year discounting concepts.

## Reviewing difference between time based measure versus conventional measures of disease burden:

We have seen in chapter-1 that, a key factor leading to appearance of time based measure was the difficulty of incorporating importance of age at death and unrealised life opportunity into death rates. A death in old age counts similarly as a death in young age. This prompted Dempsey (1947) to argue for a time based measure. Conventionally, death of an infant due to acute respiratory infection (ARI), death of an young adult on account of tuberculosis and a death due to ischaemic heart disease (IHD) among elderly are all counted as one. We would then count so many deaths due to ARI, some deaths attributed to tuberculosis and yet some other number of deaths due to stroke. Things work pretty all right as long as the number of deaths attributed to ARI and tuberculosis are overwhelmingly more than deaths due to IHD. What happens when deaths attributed to tuberculosis reduces some what and falls slightly below the number of deaths due to IHD. We now have dilemma. Do we conclude that burden on account of tuberculosis is less than IHD? Saying so would might mean diversion of public health policy attention away from tuberculosis.

Table-8.1: Relative count of a death at different ages using a time based measure like the YLL, without any discounting or age weighting.

| Age | Deaths | YLL(0,0) | $YLL_x / YLL_{85}$ |
|---|---|---|---|
| 0 | 1 | 80.00 | 15.27 |
| 1 | 1 | 79.36 | 15.15 |
| 5 | 1 | 75.38 | 14.39 |
| 10 | 1 | 70.40 | 13.44 |
| 15 | 1 | 65.41 | 12.48 |
| 20 | 1 | 60.44 | 11.53 |
| 25 | 1 | 55.47 | 10.59 |
| 30 | 1 | 50.51 | 9.64 |
| 35 | 1 | 45.57 | 8.70 |
| 40 | 1 | 40.64 | 7.76 |
| 45 | 1 | 35.77 | 6.83 |
| 50 | 1 | 30.99 | 5.91 |
| 55 | 1 | 26.32 | 5.02 |
| 60 | 1 | 21.81 | 4.16 |
| 65 | 1 | 17.50 | 3.34 |
| 70 | 1 | 13.58 | 2.59 |
| 75 | 1 | 10.17 | 1.94 |
| 80 | 1 | 7.45 | 1.42 |
| 85 | 1 | 5.24 | 1.00 |

By switching to a time based measure like the YLL, YLD and DALY, we are counting more number of years of life lost on account of a child's death, compared to a death in old age. Table-8.1 shows the YLL(0,0) value of a male death at different ages. The YLL values are computed without any age weighting and discounting. Suppose we view the YLL value of a death at 85 years as one, what would be the relative size of YLL values for deaths at younger ages? The last column in Table-8.1 shows the ratio of YLL value of one death at a given age and the YLL value of one death at 85 years. Thus death of an infant immediately after birth is counted 15 times as the death of an elder at 85 years. Deaths at intermediate ages receive values between 1 and 15. This property transfers to the DALY measure. It is true that our search for a time based measure of disease burden sought to attach more importance to deaths at younger ages. The ethical question, now is, have we overshot in attaching too high a relative value to a death at younger ages, compared to deaths at older ages? The discounting parameters of the DALY formula should be examined from this perspective. Another question would be, whether we wanted to give highest weight to deaths at very early ages and monotonically reduce the YLL value as age increases, or we would attach higher weight to deaths of young adults compared to infants and children. This issue is addressed by the age weight parameter in the DALY formula. These two parameters would enable the NBD team to vary the relative importance attached to death or morbidity at different ages, in the light of local preferences and value systems. Although discounting refers to future years of life, it has a direct connection to age. From any given age in the life of an individual, relationship between age and calendar time is direct. The Lexis diagram (Lexis, 1875), traditionally used in demography, depicts the life path of a single individual by a line that makes a 45 degree angle with the age abscissa as well the calendar time ordinate. Thus for any person dying at a particular age and calendar time the years of life lost are in future as well as the unrealized age experience. Thus death at younger ages involve loss of a longer stream of standard life expectancy. Hence discounting the future life will in effect take away some years from this count in relation to a death at older ages.

## Understanding the age weight function:

The age weight function incorporated into the DALY formula is essentially an age weighting parameter (β), and a age weight scaling constant. Before proceeding to examine implications of changing this parameter value, I first examine the age weight scaling constant C.

### The age weight scaling constant C:

The DALY formula includes the following age weight function

$[A(x)]$. $A(x) = Cxe^{-\beta x}$

Where $C$ is the age weight scaling constant, $x$ is the age variable and β is the age weight parameter. Function of the age weight scaling constant $C$ in the age weight function needs elaboration. Murray (1994) explains that the constant $C$ is chosen so that the final burden estimates remain same as would be obtained if equal age weights were used instead. Thus the starting (reference) position is equal age weights which is commonly referred to as no age weights. The later nomenclature refers to the fact that no variable need be included in the formula of a time measure of disability or premature mortality to reflect equal age. Equal age weighting means that one year of life foregone at age *a* is valued the same as one year of life foregone at age *b* for *a* and *b* not equal. The implicit weight in this equal or no age weight scheme is one. A year of life lost (YLL) computed without age weighting is firmly tied to our experience of a year of time. Age weighting, by stretching or shrinking a year of life at different ages distorts this linkage between a time based measure of disease burden and the common experience of a year long of time. The age weight scaling constant seeks to rectify this distortion, while keeping the relative age preference property of the age weighting function. Thus the total DALYs computed with age weighting is scaled back to equal the total DALYs obtainable without any age weighting. The following procedure can be adopted to estimate the age weight scaling constant.

1. Compute disease burden with unequal age weights, using the chosen age weight parameter, and the age weight constant C set to equal one. Call this result $DALY^{u}$.
2. Compute disease burden without any age weight at all. Call this DALY(r,0).
3. Now the age weight scaling constant $C$ defined as; $C = \frac{DALY^{(r,0)}}{DALY^{u}}$
4. Use the C obtained above to compute the local burden of disease.

Murray (1994, 1996) used the unscaled and equal age weighted global disease burden estimates arrived at before its first publication in the WDR 1993 (World Bank, 1993) to calculate the value of *C* (0.1658). Murray, and Lopez (1996) then put this constant back to scale the DALY formula. Since then this value of *C* has been used for all burden of disease studies. Note that the age weight scaling constant depends on the age weight parameter chosen as well as the age specific distribution of DALYs. The age weight parameter β is a computational choice to be made by a national burden of disease team to reflect their understanding of social preference for age. On the other hand the scaling constant can be calculated only after the total disease burden is estimated. That might prompt some to conclude that discussion and debates about choice of age weight parameter has to wait till quite late in the burden of disease estimation process. However, since the value of age weight scaling constant is a function of the distribution of DALYs by age only and not by cause, it will be feasible to calculate the scaling constant once age specific estimates of disease burden is available. Age specific estimates of disease burden can be generated once the general demographic estimates are made.

Calculation of the scaling constant for AP corresponding to different values of age weight parameter is illustrated here. The general demographic estimates give age specific deaths and other data for computation of YLLs by age. Computation of the YLD component needs descriptive epidemiological estimates, which would usually take much longer than the general demographic estimates. For purposes of calculating the age weight scaling constant a provisional estimate of YLDs by age was indirectly arrived at using the age specific YLD-YLL ratio from latest GBD estimates for India. Provisional estimate of DALYs for AP was arrived at by combining the YLLs from general demographic estimates and the provisional YLDs by age group. Thus

$$DALY_x^{Provisional} = YLL_x + YLL_x \frac{YLD_x^{India}}{YLD_x^{India}}$$

Table-8.2 Age weight scaling constants for AP corresponding to different age weight parameters.

| Age weight parameter i. e. Beta | Age weight scaling constant C for AP |
|---|---|
| 0.030 | 0.1071 |
| 0.035 | 0.1364 |
| 0.040 | 0.1716 |
| 0.045 | 0.2133 |
| 0.050 | 0.2619 |

The provisional DALY estimate by age is then used to calculate the age weight scaling constant. Table-8.2 shows the estimated scaling constants for AP corresponding to different values of the age weight parameter. The scaling constant corresponding to $\beta$ = is 0.1715 slightly higher than the constant used in the GBD study. Note that the age weight scaling constant will change quite substantially, if we change the age weight parameter. For purposes of International comparisons, Murray (personal communication) advocates use of the GBD age weight function i.e. $\beta = 0.04$ and age weight scaling constant $C = 0.1658$.

## Connecting age weight parameters to local age preference:

Calculating age weight scaling constant is a technical detail that is necessary to facilitate discussion about age preference. The substantive issue for decision by a NBD team is the specific values of age weight parameters to be used for a study. Murray (1994, 1996) has described various philosophical arguments that may lie behind observed age preferences in society. What ever be its philosophical underpinnings, any preference for age shared by members of a society would either manifest in express or implied actions of people and / or reflect in views held by social, political and intellectual leaders. To translate such shared notions and values into the specific parameter values of an age weighting function people must be able to relate if alternate parameter values is consistent with their values. People do not hold views about age preference in terms of a mathematical age weighting function. Rather they would hold a view about importance of specific age groups, for example, the life of an young adult is most important. So a description of different age weight functions in terms of socially culturally identifiable notion of age preference is required to facilitate choice by policy analysts of the most suitable age weight parameters.

Mathematical properties of the function chosen by Murray (1994) for purposes of age weighting has been well investigated. For example the first two derivatives of this function are;

$A'(x) = C(1-\beta x)e^{-\beta x}$ and

$A''(x) = C\beta(\beta x-2)e^{-\beta x}$

Thus the global maxima i.e. peak of the age weight function occurs when $(1-\beta x) = 0$, which implies that $x = \frac{1}{\beta}$. This is the age which gets the highest weightage in the unequal age weight scheme. One way of equating this to social preferences would be to think of it as society's notion of peak age in life. The magnitude of age weight at the peak age would give some idea about the extent of age based inequality society would be willing to tolerate. Similarly the age range with a weight of more than 1 implied by the chosen age weight function should coincide with societal notions of more important age groups. Let us call this the prime ages in life. Table-8.3 shows these three values for different parameter values of the age weight function.

Table-8.3 Implications of different age weight parameters.

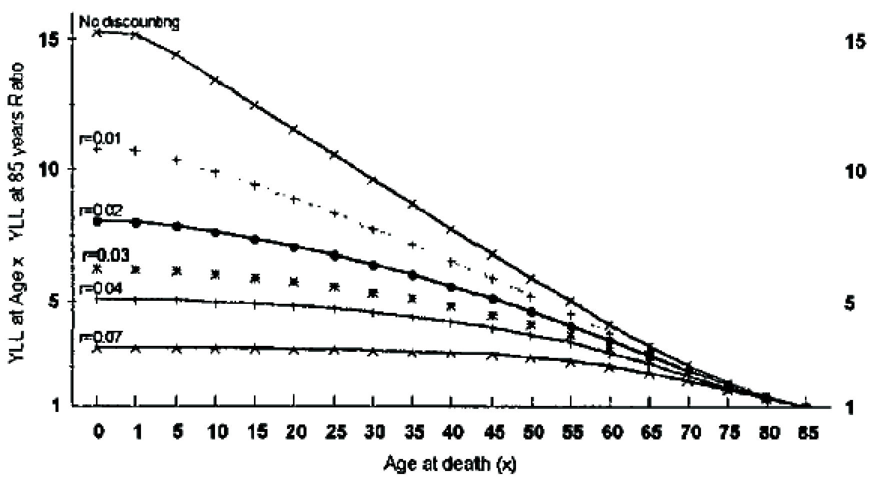
| Age weight parameter i.e. beta | Age weight scaling constant C for AP | Peak age (years) | Weight of Peak age | prime age range with weight >= 1 |
|---|---|---|---|---|
| 0.030 | 0.1070 | 33.33 | 1.31 | 14.39 - 64.27 |
| 0.035 | 0.1363 | 28.57 | 1.43 | 10.65 - 60.08 |
| 0.040 | 0.1715 | 25 | 1.58 | 8.04 - 56.99 |
| 0.045 | 0.2132 | 22.22 | 1.74 | 6.2 - 54.50 |
| 0.050 | 0.2618 | 20 | 1.93 | 4.87 - 52.34 |

The GBD age weight function ($\beta$= 0.04) implies that the peak age is 25 years. It gives larger than unit weight to life between ages 8 to 57 years. Setting $\beta$ = 0.035 would mean that we view 28 to 29 years as the peak age of life and life between 11 to 60 years as the prime ages. Reducing the $\beta$ = 0.030 further shifts the peak age upwards to 33 years, with life between 14 to 64 years considered as prime ages. If we increase the age weight parameter, say $\beta$ = 0.045, the peak age reduces to 22 years, and prime age range is between 6 to 54 years. Setting $\beta$ = 0.05 means a peak age of 20 years and prime age range of 5 to 52 years. These implications should help NBD study teams in choice of the age weight parameters, suitable for their local conditions.

## Discounting years of life:

The DALY formula includes the discounting factor = $e^{-r(x-a)}$, where $r$ is the discount rate, $a$ is the age at death or age of onset, in case of disabilities. *For* YLL, $x$ is the index of integration of life lost from the time of death till the expected age of death under the chosen standard life table. For YLD, $x$ is the index of integration from the age of onset till end of the average duration of disability starting at that age. Murray (1996, p 44-54) reviewed various arguments for and against discounting of future life and chose to use a low positive discount rate mainly to reduce the problem of excessive sacrifice by the current generation for future generations. To illustrate the nature of tradeoffs involved in choice of the discount rate, I have computed YLL for a death at different ages, assuming different discount rates ranging from no discounting and upto 7% discounting per year. The computations under "no discounting" scenario is exactly the same as shown in Table-1 earlier. Other computations are similar, assuming no age weighting and various discounting rates as shown in Figure-1. The $YLL_x$:$YLL_{85}$ ratio is plotted in Figure-1 for respective discount rates. Thus if no discounting is used, the YLL value of deaths at ages 0 to 35 years would be 2.35 times the YLL value of a death at age 85 years. The YLL value of a death at 65 years is twice that of a death at 85 years. If we discount future life at the rate of 3%, the YLL value of deaths in ages 0 to 60 years would be 1.4 times the YLL value of a death at 85 years. If we adopt a discount rate of 7% the YLL value of deaths in ages 0 to 70 would be about 1.1 times the YLL value of a death at 5 years.

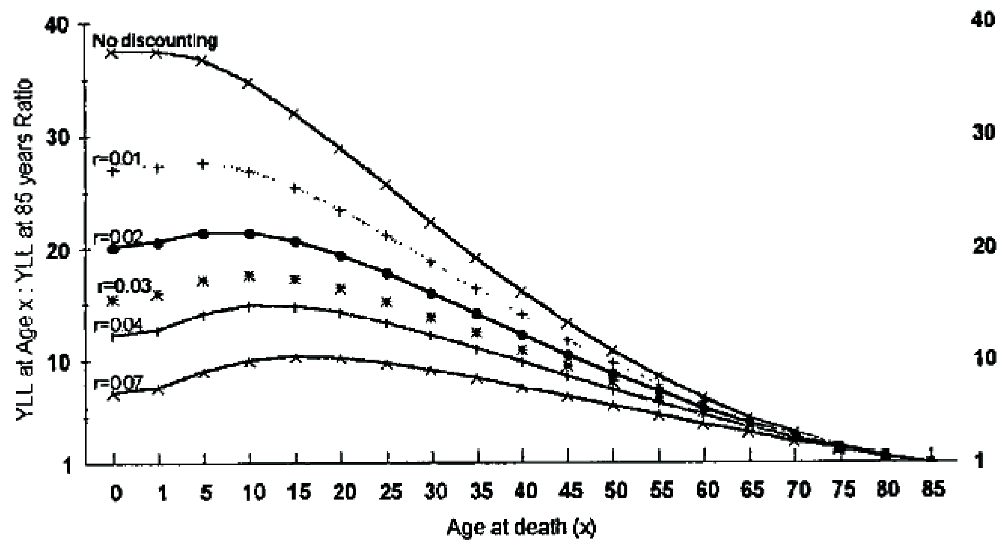
Figure-8.1: Effect of discounting without age weights on the relative YLL value of a death by at different ages.



## Combined effect of age weighting and discounting parameters:

Figure-8.2 shows the combined effect of discounting and age weighting on the relative YLL values of deaths at different ages. I have used the standard age weighting parameter value of b=0.04 and C=0.1658. First, note that age weighting without discounting increases the relative value of a death at younger ages quite high. Death of an infant immediately after birth is weighted about 38 times the death of an elder at 85 years.

Figure-8.2: Effect of discounting with age weights (β=0.04) on the relative YLL value of a death by at different ages.




Discounting future life years at the rate 3% per year in addition to the age weighting brings down the relative weight of a death in infancy to about 15 times that of a death at 85 years.This is almost same as no discounting and no age weighting. Another effect of adding the age weighting scheme is the slightly higher weight given to deaths at ages between 1 to 15 years compared to death of infants.The death at 20 years is weighted almost same as the death of a new born infant. The weight gradually reduces there after to reach the unit level at 85 years. Additional figures can be constructed for different age weighting parameters. These figures may be useful for NBD teams to deliberate on age weighting and discounting choices.

## References

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