

1. What are the basic data inputs used to calculate a DALY for health interventions?

In their 1996 work, The Global Burden of Disease, Christopher Murray and Alan Lopez introduced the concept of disability adjusted life years (DALY), as a way to standardize the burden associated with over 100 diseases. The work contains data tables of deaths, years lived with a disability, and disability weights for each cause (disease or injury) disaggregated by region and country, age, and sex (for deaths and years lived with disability). This work was updated in 2004, and data can be found on the WHO's website: http://www.who.int/healthinfo/global_burden_disease/en/index.html.¹

Defining DALYs

DALYs measure the burden of disease by summing years of life lost due to a particular disease (YLL), and years of healthy life lost due to disability from a particular disease (YLD).²

In general, DALYs = YLL + YLD

More specifically,

$$DALY_{lost} = \sum_j T_j M_j \left(\frac{1 - e^{-rL_j}}{r} \right) + \sum_i \sum_j T_j I_{ij} D_{ij} \left(\frac{1 - e^{-rd_{ij}}}{r} \right)$$

Where:

- T_j is the total number of people in target group j
- M_j is the mortality rate associated with the disease
- I_{ij} is the incidence rate of functional outcome i in target group j (If there is only one outcome associated with a specific disease, then the incidence rate would be simply the incidence rate)

¹ Christopher Murray is now the director of the Institute of Health Metrics and Evaluation (IHME) at the University of Washington. IHME receives a large portion of their funding from the Gates Foundation.

² Taken from Stein, Alexander et al. (2008) "Potential impacts of iron biofortification in India." *Social Science and Medicine* vol 66, p 1797-1808. This is a modification of Murray's DALY equation. It excludes an age-weighting parameter.

of the disease in target group j). For example, for iron deficiency, functional outcomes include impaired physical activity, impaired cognitive development, and maternal mortality.

- D_{ij} is the corresponding disability weight
- d_{ij} equals the average remaining life expectancy
- L_i equals life expectancy for individual i
- r is the discount rate for future DALYs

Baseline values for population, mortality and incidence of disease (I, M, and I) are likely available through health systems data via WHO statistics, or Ministry of Health statistics, but could also be gathered using site-specific surveying. Murray and Lopez created standardized disability weights ranging from 0 to 1, with 0 representing perfect health, and 1 representing death.³ The discount rate for future DALYs, r , is most often 3 percent. This particular value is often used in the international health economics literature. Life expectancy, L , is standard life expectancy, and can be taken from country specific life expectancy tables, the global average, or the “best possible” value, which is the life expectancy in the country with the highest life expectancy (currently Japan). Researchers tend to use country-specific life expectancies, although in The Global Burden of Disease, Murray and Lopez use the “best possible” scenario.

The baseline DALY for a population can then be compared with an alternative value that estimates the value of a particular intervention (e.g., vaccine program) to assess the contribution to mortality and health in the common metric of healthy years.

DALYs for malnutrition

Malnutrition is considered a risk factor, not a specific disease. As such, the burden associated with malnutrition is calculated differently.

$$AB = \sum AF_j B_j \quad \text{where } AF_j = \frac{P(RR_j - 1)}{P(RR_j - 1) + 1}$$

Where:

- AB is the attributable burden for a given risk factor and population
- AF_j is the fraction of the burden from cause j
- B_j is the estimated population-level burden from cause j

³ Disability weights are defined with respect to the application of specific deliberative form of the person trade-off (PTO) method for measuring health state preferences. Data were collected from a group convened at the WHO with representatives of each region of the world. Murray (1997) “Understanding DALYs” *Journal of Health Economics* Vol 16 p 712. A complete list of disability weights for all sequelae are available in Murray’s Global Burden of Disease, Annex Table 3, or online at: http://www.who.int/healthinfo/global_burden_disease/daly_disability_weight/en/index.html.

- P is the prevalence of the exposure (For malnutrition, exposure is meant to be percentage of the population at least 2 standard-deviations below the mean weight-for-age, based on national surveys)
- RR_j is the relative risk of disease or injury for cause j in the exposed group compared to the unexposed group.⁴

To estimate the attributable burden, one must know:

1. Relative risks for each cause of death and disability related to the exposure
2. Levels of exposure to the risk factor
3. Burden of disease due to each cause of death and disability in a given population

In their work Undernutrition, Mason et al. (1996) attempted to calculate the burden of disease from malnutrition using data from 55 studies. They estimated the relative risk of both morbidity and mortality as a function of the standard deviation of nutritional status. Data were unavailable for the adult population; thus the authors reported relative risk rates for children only. Murray and Lopez then derived attributable burden of malnutrition from Mason et al.'s findings, and reported results in The Global Burden of Disease (shown in Table 2 of the Appendix).⁵

Specific diseases associated with malnutrition

The following deficiencies associated with general malnutrition are listed in The Global Burden of Disease:

- protein-energy malnutrition
- iodine deficiency
- vitamin A deficiency
- iron-deficiency anemia

Because these specific diseases are included in The Global Burden of Disease, Murray and Lopez have already assigned disability weights and assessed DALYs for these diseases, and present these results in their work.

2. Have DALYs been used outside of basic health interventions? Have they been used for agriculture projects? Other?

In short, yes, DALYs have been used outside of basic health interventions, but the intervention must be tied to a specific health outcome in order to use the DALY method. For example, in

⁴ RR of death or disability for individuals at different levels of exposure compared to some reference are usually estimated from case-control or prospective studies.

⁵ Global Burden of Disease, Chapter 6 Quantifying the Burden of Disease and Injury Attributable to Ten Major Risk Factors, Table 6.13, Page 312.

evaluating the cost-effectiveness of biofortification projects, researchers have focused on a particular disease, for example, Vitamin A deficiency, and calculated DALYs before and after an intervention. In this way, researchers were able to quantify impacts in terms of DALYs. DALYs have also been used to assess the burden of disease linked to poor water, sanitation, and hygiene, but again, the interventions can only be evaluated with reference to the impact on specific diseases.

3. If this has been done, what was involved? Did they use the exact same inputs as were used for health interventions, or was the data (or the calculation) modified in any way?

Biofortification

According to HarvestPlus:

Biofortification is the process of breeding food crops that are rich in bioavailable micronutrients, such as Vitamin A, Zinc, or Iron. Through biofortification, scientists aim to provide farmers with crop varieties that provide increased levels of essential micronutrients and thereby reduce anemia, cognitive impairment, and other nutritionally related health problems in hundreds of millions of people.

DALYs have been used in ex ante analysis to determine the potential cost-effectiveness of biofortification programs. Key authors include:

- **Alexander J. Stein**, Scientific fellow at European Commission, JRC, Institute for Prospective Technological Studies (IPTS)
- **Roukayatou Zimmermann**, German Development Institute
- **Matin Qaim**, University of Goettingen, Germany

Stein et al. (2005) use a slightly modified version of Murray and Lopez’s DALY equation for use in biofortification cost-effective analysis.⁶ We have shown Stein’s equation on page 1. In contrast to Murray and Lopez’s version, Stein et al. chose to exclude an age-weighting term that assigns a higher weight to the disabilities of the young than the elderly. Their reasoning is that the age-weighting is implicit because outcomes that affect young children add up to more DALYs lost than those that affect adults.

Also, Stein et al. chose to use country-specific figures for life expectancy (rather than the “best possible” life expectancy values used by Murray and Lopez) because they reasoned that improvement in nutritional status alone is unlikely to change the national average life expectancy.

As an example of Stein et al.’s methodology for obtaining input values, we can look to his work “Plant breeding to control zinc deficiency in India: how cost-effective is biofortification?” Stein used the following sources to obtain values:

⁶ Stein, A.J. et al. (2005). Analysing health benefits of biofortified staple crops by means of the disability-adjusted life years approach—a handbook focusing on iron, zinc and vitamin A. *HarvestPlus Technical Monograph* No. 4. HarvestPlus, Washington, D.C. Available: <http://www.harvestplus.org/pdfs/tech04.pdf>.

- The target group was chosen to be children under 5 years of age
- Size of target group was taken from Census of India data
- Disability weights were assigned using The Global Burden of Disease as a point of reference, but being more specific for a developing country context
- Incidence rates were extrapolated from Indian National Family Health Surveys and UNICEF data
- India-specific life tables were used to calculate remaining life expectancy
- Actual zinc intake was computed from the Indian National Sample Survey
- Potential zinc intake was based on existing consumption and assumed changes in zinc content of the biofortified wheat and rice

Water, Sanitation, and Hygiene

Pruss et al. (2002) use the DALY method to calculate the disease burden associated with poor water, sanitation, and hygiene. As with malnutrition, sanitation and hygiene are considered to be risk factors, not a specific disease. To address this, authors combined DALYs from diseases deemed to be exclusively (or nearly exclusively) due to poor water, sanitation, or hygiene. These specific diseases included infectious diarrhea, schistosomiasis, trachoma, round worm, hookworm, and whipworm.

The authors then created 6 scenarios of living conditions, assigned relative risk ratios to each scenario based on existing literature, and calculated incidence rates and mortality associated with each of the above diseases based on the relative risk ratios. These incidence rate and mortality rate values were plugged into the DALY formula given by Murray and Lopez to obtain DALYs associated with poor water, sanitation, and hygiene.

4. If the Ag Policy and Statistics Group wanted to use DALYs, how might they calculate it? Does the data to do this calculation already exist, or would they have to be collecting different data?

To use the DALY method for agricultural interventions, the intervention must first be associated with a specific disease (or multiple diseases), such as Vitamin A deficiency, iron deficiency, or iodine deficiency.

Data would need to be obtained from existing sources or collected to provide values for the following variables as described above⁷:

- total number of people in target group
- mortality rate associated with the disease
- incidence rate of specific disease
- disability weight (which can come from The Global Burden of Disease)
- life expectancy

⁷ Murray and Lopez. 1996. The Global Burden of Disease.

- discount rate for future DALYS

DALYs are often associated with cost-effective analysis, and this type of analysis is often times done ex ante. As such, it appears that DALYs as traditionally used would be most useful for the Agricultural Policy team in providing guidance in programmatic planning, and not large scale evaluations of programs.

Appendix

Table 1: Disability Weights

Disability Class	Severity Weight	Indicator conditions
1	0.00-0.02	Vitiligo on face, weight-for-height less than 2 SDs
2	0.02-0.12	Watery diarrhea, sever sore throat, severe anemia
3	0.12-0.24	Radius fracture in a stiff cast, infertility, erectile dysfunction, rheumatoid arthritis, angina
4	0.24-0.36	Below-the-knee amputation, deafness
5	0.36-0.50	Rectovaginal fistula, mild mental retardation, Down-syndrome
6	0.50-0.70	Unipolar major depression, blindness, paraplegia
7	0.70-1.00	Active psychosis, dementia, severe migraine, quadriplegia

Source: Murray and Lopez. (1996) The Global Burden of Disease. Disease-specific disability weights are given in Annex Table 3 of the work.

Table 2: Burden of disease and injury attributable to malnutrition, 1990

Region	Deaths (1000s)	As % of total Deaths	YLLs (1000s)	As % of total YLLs	YLDs (1000s)	As % of total YLDs	DALYs (1000s)	As % of total DALYs
EME	0.0	0.0	0	0.0	0	0.0	0	0.0
FSE	0.0	0.0	0	0.0	0	0.0	0	0.0
IND	1,722.0	18.4	58,086	29.0	6,450	7.4	64,536	22.4
CHN	278.0	3.1	9,366	7.9	1,781	2.0	11,147	5.3
OAI	679.0	12.3	23,037	20.1	2,721	4.3	25,758	14.5
SSA	2,619.0	31.9	89,305	39.4	7,129	10.4	96,434	32.7
LAC	135.0	4.5	4,540	8.1	520	1.2	5059	5.1
MEC	447.0	9.8	15,152	14.4	1,489	3.3	16,641	11.0
World	5,881.0	11.7	199,486	22.0	20,089	4.2	219,575	15.9
Developed Regions	0.0	0.0	0	0.0	0	0.0	0	0.0
Developing Regions	5,881.0	14.9	199,486	24.3	20,089	5.1	219,575	18.0

Source: Murray and Lopez. (1996) The Global Burden of Disease, Chapter 6, Table 6.3, Page 312.

Sources

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