

Disability-Adjusted Life Years (DALYs)

A high-level overview

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DALYs

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What is a DALY?

Some may refer to DALYs as a “gap” measure

- What does this mean?

DALYs seek to quantify the “gap” between a population’s current health & a normative “ideal” of health/life expectancy (gap between current health & full health)

What is a DALY?

More DALYs = worse health

“0” = perfect health; “1” = death

Goal: Minimize DALYs (minimize health loss)

Note

Often used in LMICs since disability weights are freely & publicly available

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Comparison with “QALY”

Could be referred to as an “expectancy” measure; i.e., they measure healthy life years gained from interventions (combining quantity + quality of life in a single metric)

QALYs seek to quantify the expected quality-adjusted life years from an intervention (how many healthy life years will you gain)

Comparison with “QALY”

More QALYs = better health

“0” = death; “1” = perfect health

Goal: Maximize QALYs (maximize health gains)

Note

More likely to be used in high-income settings & even in these settings, utility's can be hard to get

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Comparison with “QALY”

- QALY: Uses preference-based “utility” weights about health states
- DALY: Uses condition/disease specific disability weights

Note

QALYs & DALYs are conceptually & numerically distinct

Why use summary measures of health?

- Allows for comparison across diseases/therapeutic areas
- Provides a common metric to inform resource allocation decision making
- Offers complementary information alongside condition-specific outcomes (e.g., HIV cases averted; hospitalizations avoided)

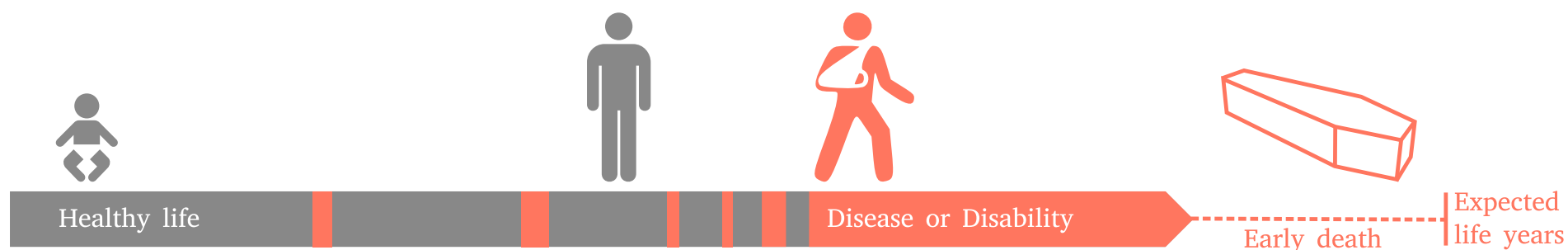
What is a DALY?

DALY

Disability Adjusted Life Year is a measure of overall disease burden, expressed as the cumulative number of years lost due to ill-health, disability or early death

$$= \text{YLD} + \text{YLL}$$

Years Lived with Disability + Years of Life Lost



$$\text{DALYs} = \text{YLL} + \text{YLD}$$

- YLL (Years of Life Lost): *The # of life years a person could have expected to live had they not died*
- YLD (Years Lived with Disability)

Years of Life Lost to Disease

For a given condition c ,

$$YLD(c) = D_c \cdot L_c$$

- D_c is the condition's disability weight
- L_c is the time lived with the disease.

Years of Life Lost to Premature Mortality

- YLL are defined by by a “loss function.”
- Drawn from a reference life table, indicating remaining life expectancy at age a .

$$YLL(a) = Ex(a)$$

Years of Life Lost to Premature Mortality

- Different approaches to identifying the time lost due to premature mortality:
 - Exogenous: Maximum length of life observed in modern world, i.e., “synthetic life table”; irrespective of country and socioeconomic characteristics/etc. (GBD 2021 used a LE of 86.6 years at birth; roughly similar to Japan + Monaco)
 - Endogenous: From a local/national life table - specific to a population’s mortality risks and health states (e.g., India/Zambia)
 - Simulation-based: Estimated within a disease-specific model using time-to-death (e.g., CVD; life expectancy might be different than whole population)

Years of Life Lost to Premature Mor

- Approach depends on the purpose of the study
 - **Synthetic life table:** Used to quantify disease burden across countries relative to a normative benchmark - helpful for global justice comparisons & resource allocations for LMICs
 - **Country-specific life table:** Useful when evaluating interventions within a specific setting (e.g., Uganda), where the goal is to quantify expected years of life lost within local mortality conditions.

Source: Anand & Reddy LSE 2019

DALYs

$$DALY(c, a) = YLD(c) + YLL(a)$$

- c is the condition's disability weight
- a is the remaining life expectancy at age a

$$\text{DALYs} = \text{YLL} + \text{YLD}$$

Simple DALYs Example

- Scenario: Person born with HIV
- Without treatment: Dies at age 30; lives entire life with untreated HIV
- With treatment: Survives to age 50; lives entire life with treated HIV

DALYs = YLL + YLD

- **Years of Life Lost (YLL):** Measures the gap between age at death and expected life expectancy, based on a synthetic reference life table
- YLLs are based on the **age at death**
- **YLL example:** Providing HIV treatment delays death from age 30 to age 50

Age	Life Expectancy	Age	Life Expectancy
0	88.9	50	39.6
1	88.0	55	34.9
5	84.0	60	30.3
10	79.0	65	25.7
15	74.1	70	21.3
20	69.1	75	17.1
25	64.1	80	13.2
30	59.2	85	10.0
35	54.3	90	7.6
40	49.3	95	5.9
45	44.4		

Source: <http://ghdx.healthdata.org/record/ihme-data/global-burden-disease-study-2019-gbd-2019-reference-life-table>

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DALYs = YLL + YLD

- Life years (LYs) gained: 20 years
- Without treatment (death at age 30); YLL = LE(30) = 59.2. years
- With treatment (death at age 50); YLL = LE(50) = 39.6 years
- Change in YLL (no treatment) - YLL (with treatment) = 59.2-39.6 = 19.6
total YLLs averted

! Important

YLL (measured as DALYs averted) $\neq$ LYs gained!

DALYs = YLL + YLD

- Now let's look at the disability weight component of the DALY
- YLD = DW x duration of disease (need to know age of onset; don't need age of onset for YLL)
 - The disability weight for HIV without treatment = 0.582 (source: GBD)
 - The disability weight for HIV with treatment = 0.078 (source: GBD)
 - Reflects the impact on health and daily life due to symptoms like weight loss, fatigue, frequent infections, etc.
 - Age of onset: Born with HIV (age of onset = 0)

$$\text{DALYs} = \text{YLL} + \text{YLD}$$

- In our HIV example,
- $\text{YLD} = \text{disability weight} * \text{duration with condition}$
 - Without treatment = 0.582×30 years (if age of onset was at 25 years, duration would be shorter; this would be 0.582×5 ; but in our example, person born with HIV, so duration = entire lifespan)
 - Without treatment, $\text{YLD} = 17.46$
 - With treatment = 0.078×50 years (if age of onset = 25 years & treatment began at dx, this would be 0.078×25)
 - With treatment, $\text{YLD} = 3.9$
 - Change in YLD = $17.46 - 3.9 = 13.56$ total YLDs averted

$\text{DALYs} = \text{YLL} + \text{YLD}$

- Without treatment:

- $\text{YLL} = 59.2$
- $\text{YLD} = 0.582 \times 30 \text{ years} = 17.46$
- **Total DALYs = 76.66**

- With treatment:

- $\text{YLL} = 39.6$
- $\text{YLD} = 0.078 \times 50 \text{ years} = 3.9$
- **Total DALYs = 43.5**

- **DALYs averted = $76.66 - 43.5 = 33.16$ DALYs averted**

Disability Weights

- Common values for small set of named health conditions (e.g. early/late HIV, HIV/ART)
- First iteration: expert opinion
- Second iteration: Pop-based HH surveys in several world regions (13,902 respondents)
 - Paired comparison of two health state descriptions which worse
 - Probit regression to calculate disability weights
 - 235 unique health states

Estimate	
Infectious disease	
Infectious disease	
Acute episode, mild	0.006 (0.002–0.012)
Acute episode, moderate	0.051 (0.032–0.074)
Acute episode, severe	0.133 (0.088–0.190)
Post-acute effects (fatigue, emotional lability, and insomnia)	0.219 (0.148–0.308)
Diarrhoea	
Mild	0.074 (0.049–0.104)
Moderate	0.188 (0.125–0.264)
Severe	0.247 (0.164–0.348)
Epididymo-orchitis	0.128 (0.086–0.180)
Herpes zoster	0.058 (0.035–0.090)
HIV: symptomatic, pre-AIDS	0.274 (0.184–0.377)
HIV/AIDS: receiving antiretroviral treatment	0.078 (0.052–0.111)
AIDS: not receiving antiretroviral treatment	0.582 (0.406–0.743)
Intestinal nematode infections: symptomatic	0.027 (0.015–0.043)
Lymphatic filariasis: symptomatic	0.109 (0.073–0.154)
Ear pain	0.013 (0.007–0.024)
Tuberculosis	
Without HIV infection	0.333 (0.224–0.454)
With HIV infection	0.408 (0.274–0.549)

Source: Salomon, Joshua A., et al. "Disability weights for the Global Burden of Disease 2013 study." The Lancet Global Health 3.11 (2015): e712–e723.

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Applying DALYs in your models

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Sage Journals

Tutorial



Modeling Disability-Adjusted Life-Years for Policy and Decision Analysis

Ashley A. Leech^{1,2}, Jinyi Zhu ^{3,4,5}, Hannah Peterson⁶, Marie H. Martin^{7,8}, Grace Ratcliff⁹, Shawn Garbett^{10,11}, and John A. Graves ^{12,13}

This study outlines methods for modeling disability-adjusted life-years (DALYs) in common decision-modeling frameworks. Recognizing the wide spectrum of experience and programming comfort level among practitioners, we outline 2 approaches for modeling DALYs in its constituent parts: years of life lost to disease (YLL) and years of life lived with disability (YLD). Our beginner approach draws on the Markov trace, while the intermediate approach facilitates more efficient estimation by incorporating non-Markovian tracking elements into the transition probability matrix. Drawing on an existing disease progression discrete time Markov cohort model, we demonstrate the equivalence of DALY estimates and cost-effectiveness analysis results across our methods and show that other commonly used “shortcuts” for estimating DALYs will not, in general, yield accurate estimates of DALY levels nor incremental cost-effectiveness ratios in a modeled population.

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Applying DALYs in your models

Points relevant to this workshop

- Commonly used DALY shortcut methods (like QALY-like proxies or death state accumulation) yield biased DALY and ICER estimates, especially when YLLs play a large role.
- In this method, payoffs are determined endogenously within the model. Payoff value is applied to the absorbing death state, so YLLs will continue to accumulate even after all cohort members have died (because unlike QALYs, dead is given a disability weight of 1)
 - Correct method: Counts YLL once at death using a life table (fixed penalty)
 - Incorrect method: Keeps counting YLL every year someone is in the “dead” state; inflated penalty that depends on model length

Applying DALYs in your models

After the break: We will walk you through how to correctly model DALYs in the Amua software

- First, from the decision tree model exercise that you completed earlier
- Second, in the Markov model that you finalized

Next up: Modeling DALYs in Amua

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