Water Research Australia

Fact Sheet

Disability-adjusted life years (DALYs): What are they and how are they used?

WHAT IS A DISABILITY-ADJUSTED LIFE YEAR (DALY)?

The disability-adjusted life year (DALY) is a way of measuring the population impact of a health problem, or the *burden of disease*, associated with a specific condition. It is a measure of the amount of time (in years) that is 'lost' due to imperfect health from a particular cause, taking into account both premature death and time lived in a state of ill-health (termed disability). It also incorporates a weighting for the severity of the disability.

> The DALY is a way to measure the amount of time 'lost' due to imperfect health ...

One DALY can be thought of as one lost year of 'healthy' life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

HOW IS THE DALY USED?

The DALY was developed for use in the first Global Burden of Disease (GBD) study in 1990 as a means of comparing the impacts of diverse health problems such as malaria, injuries, cardiovascular disease and mental illness. The population health burdens calculated in this manner can be used to set priorities for health intervention programs and to measure changes in population health status over time. The DALY is now an internationally recognised metric for quantifying and ranking disease burdens.

HOW IS THE DALY CALCULATED?

DALYs for a disease or health condition are calculated as the sum of the years of life lost (YLL) due to premature death in the population and the years lost due to disability (YLD) for incident (newly arising) cases of the health condition:

Disability Adjusted Life Year (DALY) = Years of Life Lost (YLL) + Years Lived with Disability (YLD)

Calculation of YLL requires information on the total number of people that have died from the disease and the age at which each person died. The population's standard life expectancy is then used to calculate the years of healthy life lost by subtracting the age of death from the expected life span. YLL can therefore be expressed as:

YLL = Sum of number of deaths × standard life expectancy at age of death

Calculation of YLD requires information on the number of incident cases of the health condition, the duration of symptoms, the severity of symptoms (measured using a severity weight, ranging from 0 for perfect health to 1 for death), and the likelihood of different health outcomes occurring. Determination of the YLD therefore requires establishing a disease model which divides the course of the disease into different possible outcomes according to severity, duration and the potential for long term effects after the initial illness. The calculation of YLD can be expressed as follows:

YLD = Sum of incidence × duration × severity weight

APPLICATION OF DALYS TO WATER GUIDELINES

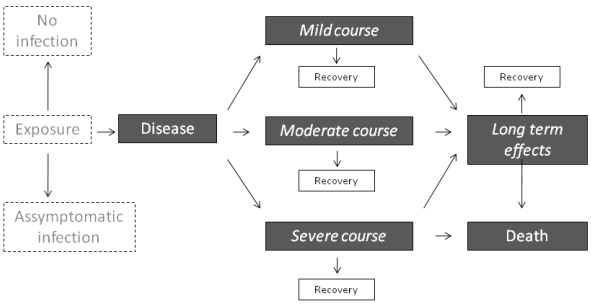
The microbial targets described in the Australian Drinking Water Guidelines are currently imprecise, with no quantifiable safety target for defining treatment adequacy. The DALY approach is one possible health-based target that could be introduced to provide quantification of the amount

of water treatment required depending on the degree of pathogen contamination in the source water. This involves use of quantitative microbial risk assessment (QMRA) to determine the amount of pathogen reduction needed to treat source waters to a 'safe' level.

CALCULATING DALYS FOR GASTROENTERITIS

When using the DALY as a metric for a health target for water treatment, the most relevant disease to consider is gastroenteritis. If a case of gastroenteritis occurs, there are generally three possible courses—mild, moderate or severe disease. Recovery is possible from each severity level while death occurs only from severe disease.

Each pathogen that causes gastroenteritis will have a different impact on health, and therefore a different DALY model. Fitting the model involves estimating the proportion of cases which fall to each severity level (transition frequency), the average time spent in each level (duration), the extent of the disability associated with each level (severity weight) and the proportion of cases that will recover. A generic model for gastroenteritis is shown in this diagram:



WHY HAS THE HEALTH TARGET BEEN SET AT 1 MICRODALY PER PERSON PER YEAR?

The "tolerable" level of 1 microDALY per person per year was introduced in the World Health Organization Guidelines for Drinking-Water Quality (2004) by analogy to the established "tolerable lifetime risk" for carcinogenic chemicals of 1 case of cancer per 100,000 exposed people over a 70-year lifetime. The population DALY burden for renal cancer caused by exposure to bromate in drinking water was estimated as 1.6 microDALYs per person per year, which was then used to set the slightly more conservative microbial health risk target of 1 microDALY per person per year for appropriate reference pathogens.

Use of the 1 microDALY per person per year as the health target for water guidelines means that each pathogen should be reduced to a concentration in treated water such that the pathogen causes a health impact below 1 microDALY per person per year. To determine what this means in terms of treatment requirements, the usual (or average) severity of a case of gastroenteritis due to each pathogen (DALY/case) needs to be calculated to ensure that, based on the likely incidence of cases, this health target is not exceeded.

The calculation of an average DALY/case is a complex procedure requiring clinical and population-based information for each reference pathogen. Reference organisms traditionally include a bacterium (*Campylobacter spp.*), a protozoan (*Cryptosporidium spp.*) and a virus (usually rotavirus). Water treatment needs to be sufficient to reduce each class of pathogen to an acceptable level.

IS THE DALY AN APPROPRIATE METRIC, AND WHAT ARE THE ALTERNATIVES FOR WATER TREATMENT?

The main alternative option for a health target is an infection risk target, as used by the US Environmental Protection Agency (US EPA), with the "tolerable" level set at 1 infection per 10,000 exposed people per year. This target sets a limit on the number of waterborne infections, regardless of whether symptoms occur. This approach uses the same QMRA calculations as the DALY method but does not take into account the differences in health impact (severity and duration of illness, or risk of death) between different pathogens.

While the DALY approach requires more information than the infection risk method, it offers the advantage of "adjusting" for the variable disease outcomes caused by different pathogens. The differential impact of each pathogen on health can be significant, with large differences in the risk of death or adverse long-term effects for different gastroenteritis pathogens. Use of the DALY target also enables a comparison of disease burdens across chemical, radiological and microbial hazards.

Some of the text for this document is reproduced from the World Health Organization website.

WaterRA Fact Sheet Series

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