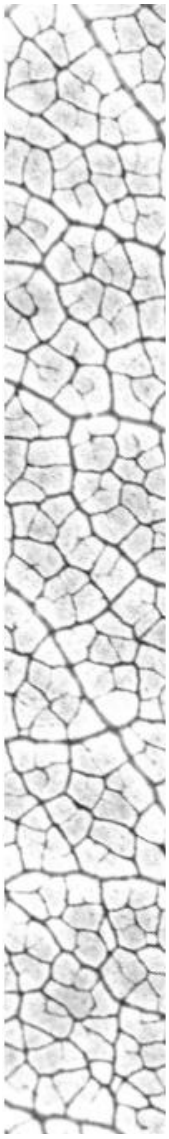

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How to prioritize health policies by understanding a spectrum of complete health to death

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Abstract
The effect of various health and illness status on society, has always been a matter of interest to public health researchers and policy makers. Specific mortality rate is a simple image of overall burden of a disease, but it only considers the fatality of a disease. Regarding this lack of representativeness, other indices are developed to investigate the burden of various diseases. Two of the most commonly used include Quality Adjusted Life Years (QALY) and Disability Adjusted Life Years (DALY). In both indices, in addition to mortality, other effects of a disease are introduced. Death is considered as zero quality or maximal disability but Weighting is used to quantify the non fatal effects of disease. QALY was developed earlier than DALY. This index is mostly used in cost utility studies to determine the necessity of a desired intervention. DALY index was introduced later to clarify calculations. DALY is calculated at the national and global level by the support of World Health Organization (WHO) regularly. However there are some different ways to calculate DALY, WHO promotes its standard method which has gone through some changes in years. QALY is an index of expected health (higher is better) but DALY is an index showing distance to an ideal health (lower is better). In this study we aim to investigate and compare the use of these two indices in public health studies.

Keywords: quality adjusted life years, disability adjusted life years, burden of disease

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INTRODUCTION

Although health systems are expected to combat the full range of healthcare problems in society, limitation of resources and available health interventions require policymakers to prioritize these problems. The impact of any health problem or illness on the overall societal health is a very important criterion in such prioritization. To compare these impacts, a number of indicators are needed to allow them to be quantified (Camps-Herrero et al. 2014). The mortality rate is the simplest of indicators that merely takes into account the outcome of death from a disease. This unilateral perspective to a single outcome cannot adequately reflect the role of a disease in society. Although disease-related death constitutes the most severe outcome of a disease, it is certainly not the only outcome (Mirzadeh et al. 2015). Consideration of mortality rate as the sole indicator disregards numerous nonfatal diseases such as psychiatric illnesses, despite their long-term, debilitating effects on the overall societal health (Vigo 2016). Therefore, it is preferable to employ indicators that make provision for other outcomes than mortality. Disability-Adjusted Life Year (DALY) and Quality-Adjusted Life Year (QALY) are two of the most important indicators used for prioritization and resource allocation (Whitehead and Ali 2010, Gold et al. 2002, Taft et al. 2018). In addition to the outcomes of death, disease-related disability and loss of quality of life (QoL) in patients pay role in these indicators to determine the overall impact of the disease. The DALY and QALY weight factors are used in these indicators to rate nonfatal outcomes and, ultimately, express all effects quantitatively in the form of a number. These calculations are made based on the premise that the best approach for measuring the burden of disease is to use the unit of time (Bravo Vergel and Sculpher 2008, Rahavi et al. 2018). Since the use of different methods in measuring these indicators does not allow a global comparison, attempts should be made to use standard methods for calculation to the extent possible (Wagner et al. 2015). The present study introduced and examined the calculation method of these indicators and investigated their various applications in health systems.

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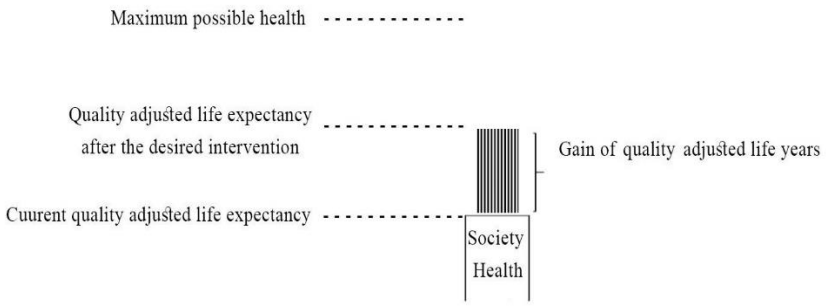

Fig. 1. Calculating QALY in cost-effectiveness interventions

DISCUSSION

Quality-Adjusted Life Year (QALY)

This term was first used by Zeckhauser in 1967 as an indicator that integrates both the length and quality of life (Zeckhauser and Shepard 1976), even though it was originally formed in the 1970s (Fanshel and Bush 1970). In a 1992 review article, 51 studies that adopted the QALY index in their methodology were examined with the conclusion that the use of QALY in cost-utility studies was associated with significant shortcomings (Gerard 1992, Griebsch et al. 2005). However, the number of studies using this index gradually expanded. Despite considerable debate surrounding the practical application of QALY, it is nowadays employed in numerous studies, particularly in cases where cost-utility plays an important role in decision-making (Bravo Vergel and Sculpher 2008, Umapathi and Natarajan 2019).

QALY is a composite indicator expressing the quality and quantity of life in a single measure that aims to offer a combination of personal, societal, and health-oriented perspectives to health as part of a comprehensive approach (Prieto and Sacristán 2003). It is defined as the number of years lived in perfect health. In other words, QALY is used to modify the life expectancy of individuals based on their health-related quality of life (HRQOL). The value of annual QALY is calculated by multiplying 1 to a factor less than or equal to 1 (≤1). This factor provides a weight proportionate to HRQOL and life expectancy. The most important application of QALY is in determining intervention success rates in improving the QoL, *i.e.* the value of added QALY as a result of a particular intervention, which is obtained by subtracting the post-intervention quality of life expectancy from the pre-intervention quality of life expectancy (**Fig. 1**).

Cost-effectiveness studies describe the cost-effect ratio and cost increases per unit of health, *e.g.* the number of lives saved. When QALY is used as the denominator of this fraction, these studies are sometimes called cost-utility studies. Such studies are particularly useful when QoL constitutes an important outcome of the intervention. These studies are very common and are applied in assessing health services, proposed new technologies, and extensive health interventions. If the overall budget is deemed constant, the value of post-intervention QALY is maximized when the level of service provision and the number of people who use services are increased. QALY has an inseparable relationship with applicability. In other words, health policies must be developed to be of the highest benefit to the greatest number of people. For instance, the National Institute for Health and Care Excellence's report specifies the use of QALY in cost-utility studies as the main method for estimating the cost-effectiveness of an intervention in public health. According to this report, interventions that do not surpass the £20,000 threshold per QALY are regarded as cost-effective (Judging whether public health interventions offer value for money, 2013). However, a European Commission survey of 1,361 participants from Belgium, France, Italy, and the UK arrived at the conclusion that this scale was not an adequate measure for offering advice on medical interventions and health technologies (Beresniak et al. 2015, Beigzadeh and Rastegar 2020).

QALY is traditionally measured through HRQOL factors, which are related to individual health experiences. The QALY ratio measures the QoL under a specific health condition, in which 1 and 0 indicate maximum health and death, respectively. The QoL factors are not related to any specific disease, condition, or disability; rather they are based on the value individuals place on their or others' health status (patient opinion vs. public opinion) (Bravo Vergel and Sculpher 2008). QALY is obtained by describing and examining different health conditions that are often associated with a disease. Time trade-off (TTO), standard gamble (SG), and the visual analogue scale (VAS) are among common methods for measuring this weight factor. In TTO, participants are asked to choose between being in a state of illness for a specified period or returning to full health for a shorter period. In SG, recovery to full health is predicated on the condition that a medical intervention is made. Participants are asked to choose between being in a state of illness or selecting a medical intervention that can result in either restoration to full health or death. In VAS, participants have to rate the condition of a disease on a scale of 0 to 100, with 0 and 100 indicating death and perfect health, respectively.

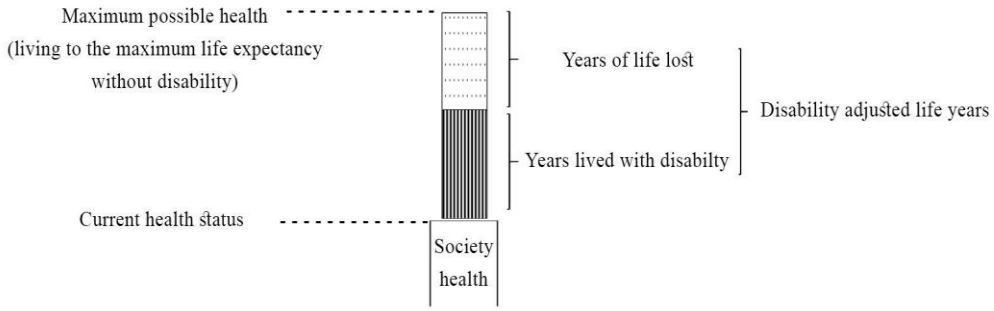

Fig. 2. DALY is an indicator of distance between current health status and maximum possible health of society

Another method is the utilization of the EQ-5D Instruments in which any health condition is measured based on five dimensions of mobility, self-care, usual activities (work, study, leisure*, etc*.), pain/discomfort, and anxiety/depression (Torrance 1986, Whitehead and Ali 2010).

The QALY framework prepares the ground for developing alternative indicators such as DALY.

Disability-Adjusted Life Year (DALY)

DALY was introduced in the late 1980s and early 1990s to measure the burden of disease on the basis of the years of life lost and years of life lived with a disability. Backed by the World Bank and the World Health Organization (WHO), the concept of DALY has gained widespread popularity and is applied in various national and international studies. The concept of Global Burden of Disease (GBD) was first introduced in 1996 in an essay under such chapters as "The GBD's Approach to Measuring Health Status," "How the World Dies Today," and "Disability: The Invisible Burden" that discussed the impacts of diseases in a comprehensive fashion (Murray et al. 1996). Since then, the WHO has been regularly issuing GBD estimates, with the latest revision published in 2016 (Vos et al. 2017). DALY is currently the most widely used indicator across cultures. Burden of Disease (BoD) studies use the DALY index in an attempt to rate the burden of each disease, taking into account the disease-induced premature mortality and disabilities. This indicator expresses the years of life lost due to death or disability in the form of a number. In other words, DALY is the sum of years lost due to premature death and years of life lived with a disability. The share of the years of life lost due to death and years of life lived with a disability will be greater in severely fatal diseases and chronic illnesses, respectively (Mirzaei et al. 2016, Ghanbari et al. 2020). The WHO supports BoD studies at the national level in order to allow the measurement of GBD. These studies are conducted based on a similar concept and methodology. In addition to representing an indicator for measuring the burden of a disease on societal health, DALY is commonly used in cost-effectiveness studies (cost per DALY reduction) (Mathers et al. 2006). However, the quality of data will expectedly vary across regions. In the latest GBD study, 25 and 44 countries had the highest and lowest quality of data, respectively (Naghavi et al. 2017).

Table 1. Top 5 causes of years of life lost (YLLs); years lived with disability (YLDs) and disability-adjusted life years (DALYs) in Iran (2017)

Common causes of death (Mortality)	Common causes of disability (YLD)	Common causes of life lost (YLL)	Common causes of life lost & disability (DALY)
Ischemic heart disease	Headache disorders	Ischemic heart disease	Ischemic heart disease
Stroke	Low back pain	Road injuries	Neonatal disorders
Alzheimer's disease	Depressive disorders	Neonatal disorders	Road injuries
Road injuries	Drug use disorders	Stroke	Headache disorders
Hypertensive heart disease	Anxiety disorders	Congenital defects	Low back pain

The DALY of a disease is the sum of years of life lost due to premature death and years of life lost due to a related disability. In general, DALY is the distance between the status quo and a hypothetical ideal state in which individuals live with perfect health until their respective life expectancy (**Fig. 2**).

In the early development of DALY, the following two questions were taken into account: 1) How long should people in good health live? and 2) How should years of life lost due to death be compared to years of life lived with a disability? (Murray et al. 1996). The first and second questions are answered by calculating the years of life lost and the disability weights, respectively. Based on these descriptions, DALY is equal to the years of life lost due to death plus years of life lived in disability (**Fig. 2**). Various methods have been proposed to measure the years of life lost. The lost years can be calculated by multiplying the number of deaths to the standard life expectancy. The standard life expectancy is considered identical across the world in order to allow comparisons to be made between all parts of the world (23); although local life expectancy indices have been used in a number of regional studies. The most common cause of death might be identical to the most common cause of DALY, although common causes of disability are usually different. Ischemic heart disease is the most common cause of death, years of life lost, and DALY in Iran (**Table 1**) (Mirzaei et al. 2017, Iran Health Data 2017).

The years of life lost were initially calculated using a 3% discount rate and the non-uniform distribution of the value of lost years. However, these weights have been omitted in recent studies in order to facilitate the understanding of the years of life lost (Murray et al. 2012). In order to calculate DALY, the concept of "years of potential life" needs to be expanded to allow for the possible years of living a healthy life lost due to a disease-induced disability. The years of life lost due to disability is calculated by multiplying the number of incident cases in the average duration of the case to the disability weight on a scale of 0 (perfect health) to 1 (death). The general formula is as follows:

Years Lost due to Disability = number of incident cases × disability weight × average duration of the case

The weights used for calculating disability in DALY are different from those used in QALY. QALY weights are related to different health conditions and DALY weights to diseases on the disability index. QALY measures years of a healthy life, whereas DALY measures the disability weight of years lost. It can be hypothesized that a negative DALY is almost equal to a QALY. To better understand this difference, health interventions are expected to reduce the DALY of a disease and increase its QALY (Sassi 2006, Grosse et al. 2009). Disability weights in these calculations indicate levels of social inclination for different health statuses. For instance, a weight of 0.4 for a state demonstrates that society prefers to live for two years in this state (2 x 0.4 = 0.8 years lost) rather than one year in perfect health (one year lost). Unlike QALY, DALY uses estimates that are associated with certain diseases, rather than health statuses, which can arguably be accounted for by practical considerations. The developers of DALY consider health self-assessment potentially misleading and underline the use of secondary data and expert opinion for describing diseases (Murray 1994, Zeckhauser et all 2019).

Given the difficulty of calculating a disease-induced disability, particularly in cases of severely fatal diseases, a number of studies have only sufficed to calculate the years of life lost (Vos et al. 2017). The years of life lost is occasionally used to calculate the natural history of a disease, although the problem lies in the changing treatments, prognoses, and societal capacity to handle such incidents over time (Mirzaei et al. 2016). The degree of uncertainty in the calculation of DALY differs by the region in question, ranging from ±1% in high-income countries to ±15-20% in Sub-Saharan Africa. This distinction can be attributed to the difference in the availability of data. On the other hand, the type of disease in question also contributes to uncertainty. For instance, uncertainty for ischemic heart disease varies from about 12% in high-income countries to 25-35% in Sub-Saharan Africa. Such uncertainty, even in high-income countries, is associated with uncertainty in determining the cause of death and the attribution of death to specific codes (Department of Information 2017, World Health Organization 2006).

CONCLUSION

QALY and DALY are the two most widely used indicators for the simultaneous presentation of a picture of mortality and other disease-related complications in the form of a number. Backed by WHO and the World Bank, DALY has gained widespread popularity and is continuously measured, employed, and published in GBD studies. By integrating the concept of quality in a quantity, *i.e.* years of life, QALY measures the actual enhancement of the QoL in a tangible way for individuals and can be used as an effective instrument to study the efficacy of various interventions and increase the public desire to pay for health-related costs. Iranian health policymakers are expected to use these indicators for allocating health resources among patients, prioritizing regions in terms of resource provision, and submitting health intervention performance reports.

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