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Brief Report

Comparisons of cost-utility analyses for major diseases: A focus in the Australian context

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Abstract: This article delves into the nuances of cost-utility analyses applied to prevalent health conditions, examining the distinctive approaches for lung cancer, ischemic heart disease, and depressive disorders in Australia. The study explores the impact of utility-based units such as Disability-Adjusted Life Years, Quality-Adjusted Life Years, and Potential Years of Life Lost in economic evaluations. Notably, variations in disability weights and their implications on comparability are scrutinized, providing insights into the economic burden and cost-effectiveness of interventions. Findings reveal nuanced evaluation techniques' critical importance and contextual relevance in health economic assessments.

Keywords: cost-utility analysis; disability-adjusted life years; quality-adjusted life years; potential years of life lost; health economics; disease burden

1. Introduction to economic evaluation in healthcare

In healthcare, economic evaluation is used to gauge how efficiently health resources are used and assist in allocative decisions. Economic evaluation involves the comparative analysis of alternative courses of action regarding their cost efficacy and subsequent consequences. To conduct an economic evaluation, the economist often employs four techniques that can be used to measure the effectiveness of health intervention on the population and health system. These techniques include the Cost-Effectiveness Analysis, Cost-Utility Analysis, Cost-Benefit Analysis, and Cost-Consequence Analysis [1].

Cost-Effectiveness Analysis (CEA) compares the costs and health outcomes of different interventions, typically measured in natural units, such as lives saved or cases prevented. The goal is to determine which intervention provides the greatest health benefit for the lowest cost. Cost-Utility Analysis (CUA) extends CEA by incorporating quality of life into the analysis, using utility-based measures like Quality-Adjusted Life Years (QALYs) or Disability-Adjusted Life Years (DALYs), which capture both the quantity and quality of life. This allows for a more comprehensive evaluation of interventions that affect both survival rates and quality of life. Cost-Benefit Analysis (CBA), on the other hand, assigns monetary values to both the costs and benefits of interventions, allowing decision-makers to compare different health interventions across various sectors. This technique is particularly useful when interventions have non-health-related outcomes. Finally, Cost-Consequence Analysis (CCA) presents the costs and outcomes of interventions side by side without combining them into a single measure. While it provides a detailed picture of all the consequences of an intervention, it can be more difficult to interpret due to the lack of a single outcome measure [2].

Attributed to the differences between these techniques, the following will explain how the cost-utility analyses of the burden of disease differ, respectively, from the utility-based units selected. Furthermore, these differences will be exemplified by using the diseases that are well known to burden the Australian population, including lung cancer, ischemic heart disease, and mental illness disorders [3].

2. Overview of cost-utility analyses

Cost-utility analyses (CUAs) are becoming increasingly common in Australia and worldwide. Contributing to a greater Cost-Effectiveness Analysis, the Cost-Utility Analysis is arguably the best health economic evaluation technique that allows decision-makers to compare health interventions [4]. In the health context, a CUA compares the costs and outcomes of different treatments, which are then expressed as utility-based units. These units represent the qualitative and quantitative values of a person's level of health and well-being before or after the treatment and are displayed as a numerical value representing years. These are often illustrated as Disability-Adjusted Life Years (DALY), Quality-Adjusted Life Years (QALY), and Potential Years of Life Lost (PYLL) [4]. For DALY and QALY, the values portray how a disease or intervention produces a quantitative change in the person's life expectancy whilst weighing against the degree of disability or the quality of life that the person would experience for the years assessed. The key difference between them is that DALYs are the measure of years in perfect health that have been lost, whereas QALYs are the measure of years lived in perfect health that are gained. Likewise, CUAs can identify how a person's life expectancy is reduced through disease processes or the failure to provide service, which is represented as Potential Years of Life Lost [5].

3. Utility-based units explained

The Disability-Adjusted Life Year (DALY) is a key metric used to quantify the overall burden of disease, integrating both the impact of premature mortality and the effects of living with health conditions that impair quality of life. It represents the gap between a population's current health status and an ideal state of full health where everyone lives to old age without disease or disability. The DALY incorporates not only the years lost due to early death but also the time spent living with illness or disability. This model allows public health organizations, including the World Health Organization (WHO), to prioritize health interventions by comparing the burden of different diseases across populations and regions.

Calculating Disability-Adjusted Life Years (DALY) requires details specific to the individual and their population. One DALY can be perceived as a one-year loss of healthy life. Similarly, the higher the DALY associated with a disease, the greater the burden of that disease. DALYs are calculated as the sum of the years of life lost (YLL) due to premature death in the assessed population and the years lost due to disability (YLD) for people living with a disease. As YLL corresponds to the number of deaths (n) multiplied by the standard life expectancy (SLE) at the age at which death occurs, and YLD is the number of prevalent cases (PC) multiplied by the disease's disability weight (DW) [6]. Therefore, the formula can be presented as:

$$\text{DALY} = (\text{YLL}= n \times \text{SLE}) + (\text{YLD}= \text{PC} \times \text{DW}).$$

Calculation of Quality-Adjusted Life Years, however, is simpler. Firstly, calculating the QALYs requires conceiving the quality of life from zero to one using a pre-scored health state utility system, where zero equates to death, and one equates to perfect health. This figure is then multiplied by the period that the disease is present, represented in years, thus giving the number of quality-adjusted life years. It assumes that a year of life lived in perfect health is worth 1 QALY and that a year lived in less-than-perfect health is worth less than 1 [1,7]. Therefore, the formula appears as:

$$\text{QALY} = \text{Health state utility} \times \text{Years of life with the disease.}$$

Potential Years of Life Lost (PYLL) is a measure of premature mortality that quantifies the impact of early deaths on a population. It is calculated by subtracting an individual's age at death (age) from the standard life expectancy (SLE) for each person who has died. The total PYLL for the population is the sum of these individual values, which is then divided by the number of living individuals in the population below the standard life expectancy (P) [8,9]. The formula is expressed as:

$$\text{PYLL} = \sum (\text{SLE} - \text{age})/P.$$

For disease-specific analysis, the Percentage Potential Years of Life Lost (PPYL) is calculated by adjusting the PYLL based on the percentage of deaths attributed to the disease (%disease). This provides a measure of how much a specific disease reduces the average life expectancy of the population. The formula is:

$$\text{PPYL} = (\text{PYLL} \times 100)/\%\text{disease.}$$

Incorporating uncertainty analysis into the calculation of disease burden metrics, such as PYLL, enhances the robustness of health impact assessments. One useful approach is to apply Monte Carlo simulations, which allow for the propagation of uncertainty by repeatedly sampling from probability distributions of input variables, such as age at death, life expectancy, or disease-specific mortality rates. By generating an array of potential outcomes, this technique produces a range of PYLL estimates rather than a single deterministic figure, providing insight into the distribution, variability, and confidence intervals around the results.

Furthermore, scenario-based analyses can offer valuable perspectives by stratifying PYLL calculations across age groups, sexes, or occupational categories. For example, examining PYLL by age group may reveal which life stages experience the greatest burden of premature mortality, guiding age-specific public health interventions. Similarly, comparing PYLL by sex or occupation can uncover disparities that inform targeted health and safety policies.

By integrating Monte Carlo simulations and subgroup analyses, public health policy can better capture the complexities of disease impact, enabling more precise prioritization of resources and policy-making that aligns with the needs of diverse populations. These enhancements also support more dynamic cost-utility and cost-effectiveness analyses, reinforcing evidence-based approaches to healthcare planning and intervention design.

4. Application of CUAs to common diseases in Australia

As mentioned, DALYs are calculated by using the predetermined disability weight of the disease. Historically, studies on disease burden draw heavily on the set of disability weights derived from 'The Global Burden of Disease' [10]. For this, a panel of health professionals developed disability weights in a deliberative group exercise by evaluating 22 indicator conditions using the 'person trade-off' [11]. Based on the resulting values, the conditions were then grouped into seven different classes of severity, and study participants were asked to allocate a set of typical cases for a particular disability. This resulted in the conditions having a definition for the average severity level in that class and thus provided a numerical scale to which to define the disability weight [11]. For the diseases of interest, lung cancer, ischemic heart disease, and mental health depressive disorders, the World Health Organization [6] awarded these the disability weights of 0.15, 0.439, and 0.416, respectively. More recently, a research consortium including the Institute for Health Metrics and Evaluation, Harvard University, Johns Hopkins University, the University of Queensland, and the World Health Organization has endeavored a revision of the global burden of disease. Collaborating with an international network of hundreds of experts, a comprehensive re-estimation of disability weights was established [11]. For the diseases of interest, lung cancer, ischemic heart disease, and mental health depressive disorders, the revised disability weight was further defined to reflect the different impacts respective to the stages of the disease. For lung cancer, the diagnosis and primary therapy phase (0.288), metastatic phase (0.451), and terminal phase (0.54) were depicted. For ischemic heart disease, the weight was incrementally scaled from having mild angina (0.033) to severe heart failure (0.179) due to ischemic heart disease. Lastly, depressive disorders have been revised as mild (0.145), moderate (0.396), and severe (0.658) [12]. These values represent a significant increase in disability weight since the initial 1996 data set and have highlighted a growing concern for the disabling impacts of mental health depressive disorders. In light of this, it is noteworthy for the health economist that the disability weight and measurement method are identifiable to ensure true comparability between assessments.

4.1. Lung cancer: A growing health concern

In Australia, lung cancer has become commonplace in the health domain, with 18,751 cases of people with the disease at the time of the 2015 census, demonstrating an age-standardized incidence rate of 43 cases per 100,000 persons [10]. Lung cancer is currently the fifth most common cancer, accounting for 9% of the total cancer prevalence within the population [13]. Of all the cancer types, lung cancer is the third most costly in Australia, with an economic burden estimated to be $297.3 million annually in direct and indirect costs for new patients diagnosed with the disease [14,15]. In 2015, Australians lost 157,486 DALY (DW = 0.15) resulting from lung cancer, with the vast majority of the DALYs, 94% for men and 93% for women, attributed to premature death [16,17]. This is evident as the mean age of people diagnosed with lung cancer was 70 years of age and had a relative five-year survival rate of 13% [17]. However, Morampudi, Arun Gowda and Patil [18] suggest this value is closer to 91,695 DALY, with a discount rate of 3%. Although discounting can be influential on the outcomes of economic evaluations, numerous studies use discounts to calculate DALYs, including the World Health Organization [6], which report using time-discounted and age-weighted DALYs within their health statistics and information systems. For the health economist, differentiating between discounted and non-discounted values is essential to adequately present the disease burden.

To address the burden of lung cancer, an inquiry into the effectiveness of lung cancer screening with low-dose computed tomography as an intervention method has been conducted. The results indicate that a biennial screening program for individuals aged 55 to 74 years with high-risk characteristics is the most cost-effective form of a screening program for the full Australian population, with an estimated incremental cost-effectiveness ratio of $83,545 per QALY gained. This is largely attributed to the 20% reduction in lung cancer mortality resulting from the early detection and treatment of lung cancer [19]. In recent years, the number of years of potential life lost to lung cancer in Australia has been estimated to be 58,450 [20]. However, as PYLL only includes the population under the standard life expectancy, currently 83 years of age in Australia [21]. PYLL does not indicate the true burden of disease as an economic value compared to DALY and QALY values. Likewise, the 2018 ischemic heart disease census used the age of 75 as the cut-off, proclaiming that there were 871,807 PYLLs in Australia [21]. This inclusion criteria alteration for the data pool ultimately skews the results and can give a false impression when compared to datasets taken in similar timeframes.

4.2. Ischemic heart disease: Economic impact and intervention strategies

Superior to lung cancer's heightened prevalence, ischemic heart disease is the leading cause of death in Australia for both males and females, accounting for almost 14% of the total burden of the disease [22]. During the 2017–2018 census, an estimated 580,000 Australians were reported as having ischemic heart disease [23]. Attributed to its title, ischemic heart disease implies a seemingly unsurpassable economic burden estimated at $10.4 billion from direct costs such as hospital admission and treatment and indirect costs from absenteeism, accounting for 8.9% of the total disease expenditure in the Australian health system [16]. In 2015, Australians lost 328,773 DALY (DW = 0.439) resulting from ischemic heart disease [16]. This equates to 0.56 DALY per ischaemic heart disease case, which is significantly less than lung cancer, which is 8.398 DALY per case. This may suggest that although ischemic heart disease has a higher prevalence, lung cancer has a more profound impact.

To address the heightened prevalence of ischemic heart disease, exercise-based rehabilitation programs have been introduced to improve the quality of life, reduce healthcare costs of associated treatment, modify coronary risk factors, and reduce mortality after an acute coronary event [24]. The rehabilitation program studied began within two weeks of hospital discharge and lasted for six weeks, consisting of three sessions per week. Each session lasted between 60 min and 90 min and included a combination of exercise, education, and psychosocial counseling. The sessions were conducted in groups, with additional one-on-one counseling available if needed. The intervention was found to result in an incremental cost saving of $42,535 per QALY gained when compared to the standard care option following rehabilitation [24].

4.3. Depressive disorders: Addressing the non-fatal burden

Mental health conditions such as depressive disorders have become increasingly highlighted in the health field. Unlike the fatal conditions mentioned, depressive disorders are considered the largest non-fatal illness that affects the Australian health system. In Australia, 1.16 million people, or 6.2% of the population, registered as experiencing a depressive disorder in 12 months [25]. This represents a prevalence larger than lung cancer and ischemic heart disease combined. Much to dismay, the social and economic costs of depression in Australia are approximately $12.6 billion per year [26]. In 2015, Australians lost 136,033 DALY (DW = 0.416) resulting from mental health depressive disorders, although, much like ischemic heart disease, DALYs were accrued over the life span of the population rather than premature mortality [16]. This is evident as mental health illnesses such as depressive disorders are more common in youth-aged groups. The association between lung cancer and ischemic heart disease with a subsequent depressive disorder diagnosis is often referred to as a comorbidity. Thus, depressive disorders may be affected by other disease prevalences that have reemerged in later age groups [27].

A treatment is considered cost-effective if the cost per QALY gained falls below a specified threshold, indicating that the benefits it provides justify the costs involved. The willingness to pay (WTP) threshold plays a critical role in determining whether an intervention is deemed cost-effective. In Australia, the WTP threshold is typically set at $50,000 per QALY gained, though this can vary depending on the context. If an intervention's cost-effectiveness ratio is below this threshold, it is generally considered cost-effective, meaning that the health outcomes it generates justify its costs [28,29]. Based on recently published economic evaluations, mental health disorders are, on average, the most cost-effective to treat regarding their cost per QALY gained. One report suggested an economic evaluation of a dietary intervention for treating major depression had a cost-effective ratio of $2775 per QALY saved [30]. Likewise, internet-based cognitive behavior therapy (ICBT) has been demonstrated to have a cost-effective ratio of $3,489 per QALY saved. Its effectiveness was further made evident by the fact that, on average, patients receiving ICBT spent 55% of their time in remission of their depressive disorder [31].

5. Conclusion

In conclusion, economic evaluation plays a pivotal role in assessing the efficiency of health resource utilization and informing allocative decisions in healthcare. However, its utility is ultimately shaped by the evaluation methods employed, particularly in how disease burden is quantified through various metrics. The differences between DALY, QALY, and PYLL techniques demonstrate that cost-utility analyses can yield differing results depending on the utility-based units selected. As illustrated in the examples of lung cancer, ischemic heart disease, and mental health disorders, these disparities are not just statistical but are deeply contextualized by the nature of the diseases themselves, whether they are fatal or non-fatal, their demographic prevalence, and the age of the affected population. For instance, diseases like lung cancer, which predominantly impact older populations and have high fatality rates, lead to higher DALY values due to the combination of premature mortality and significant disability. In contrast, mental health conditions, although highly prevalent, typically affect younger age groups and result in a significant non-fatal burden, which is reflected in the higher QALY gain potential from interventions such as cognitive behavioral therapy. Moreover, diseases like ischemic heart disease, though common and responsible for a substantial mortality burden, may have lower DALY values per case compared to lung cancer, indicating that despite their higher prevalence, their individual impact may be less severe in terms of years of life lost.

The aggregate DALYs and costs of these three diseases underscore the multifaceted nature of economic evaluation. When combined, these three diseases result in a total of 622,292 DALYs and an economic burden of $23.3 billion annually. Ultimately, while economic evaluation can provide valuable insights into disease burden, it is the integration of various contributory factors such as disease severity, demographic data, and the stage of disease that allows health economists to make valid, comparable, and effective assessments. The comprehensive understanding of the burden posed by different diseases enables better decision-making, policy development, and prioritization of healthcare resources, ensuring that interventions are both cost-effective and impactful across diverse populations.

Conflict of interest: The author declares no conflict of interest.

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