Cancers: Costs in Relation to Disability-Adjusted Life Years

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Cancer represents a major health issue, concerning both the clinical burden (in terms of morbidity and mortality) and the consequent economic implications. With regard to the latter, Disability-Adjusted Life Years (DALYs) are often used to measure the burden of disease since they are a compound unit encompassing both disability and mortality, but substantial heterogeneity occurs when they are translated to monetary value. Each DALY due to cancer has shown to cost, on average, around 9000 USD in high- and upper-middle income countries, although this computation can be strongly influenced by fluctuations depending on cancer type and other parameters (e.g., country, prices). Moreover, the cost per cancer-related DALY has been found to be, on average, 32% (95% CI: 24–42%) of the corresponding countries' gross domestic product (GDP) per capita, which implies that the use of a priori established parameters, such as GDP or the value of a statistical life (VSL), might lead to presenting rough estimates highly different (even threefold) from what emerges a posteriori, after directly retrieving figures and/or building models out of available data.

health policy | cancer | costs | Disability-Adjusted Life Years | cost-per-DALY ratio | economic evaluation

1. Introduction

Cancer is widely recognized as a global problem for incidence, mortality, years of life lost and years lived with disability. Worldwide, an estimated 19.3 million new cancer cases (18.1 million excluding non-melanoma skin cancer) and almost 10.0 million cancer deaths (9.9 million excluding non-melanoma skin cancer) occurred in 2020 [1]. Furthermore, in 2017 cancer caused a global burden of 226.5 million years of life lost and 7 million years lived with disability [2]. Cancer causes health, financial and socioeconomic problems (including expenditure for medical and non-medical services, loss of productivity, and disability), thereby having an impact at an individual, family and social level [3].

Measuring the burden of disease related to cancer is a crucial topic for a public health system; as such, an evaluation is fundamental to assess the health status of a country and to make comparisons between countries possible [4]. The importance of establishing the disease burden related to cancer as precisely as possible is also dictated by the need to properly allocate the resources available to the national health system for the treatment and prevention of this diverse group of diseases [5].

Previous studies have used disability-adjusted life years as a measure of the epidemiologic burden of different cancers [6]. The disability-adjusted life-year (DALY) is a health metric combining the morbidity and mortality of a disease; it represents the sum of years lived with disability (YLD) and years of life lost (YLL) [7]. Expressing disease burdens in DALYs allows for the comparison of different diseases and therefore represents a useful tool for evidence-based healthcare policy-making [8].

The most recent estimate provided by the World Health Organization stated that the total annual economic impact of cancer worldwide is USD 1.16 trillion: this figure represents around 1.5% of the world's gross domestic product (GDP), amounting to approximately USD 85 trillion [9]. National costs for cancer care in the United States (U.S.) were estimated to be USD 190.2 billion in 2015 and USD 208.9 billion in 2020, with a 10% increase that was found to be primarily justified by the aging and growth of the U.S. population [10]. Other analyses estimated a direct health expenditure of around EUR 58 billion in five European countries only (France, Germany, Italy, Spain and United Kingdom) [11].

Accurately estimating the economic value of cancer-related DALYs should be an important goal for healthcare systems, especially considering that currently 30–50% of cancers can be prevented by avoiding risk factors and by implementing the existing evidence-based prevention strategies [12]. The cancer burden can also be reduced through early cancer detection, and appropriate treatment and care of patients who develop cancer [12].

2. Costs in Cancer-Related Disability-Adjusted Life Years

The pooled cost-per-DALY ratio equals around 9000 USD per DALY accountable to cancer. The total cost per DALY equals approximately one third of the national GDP per capita (32% [95% CI: 24–42%]) (**Figure 1**).

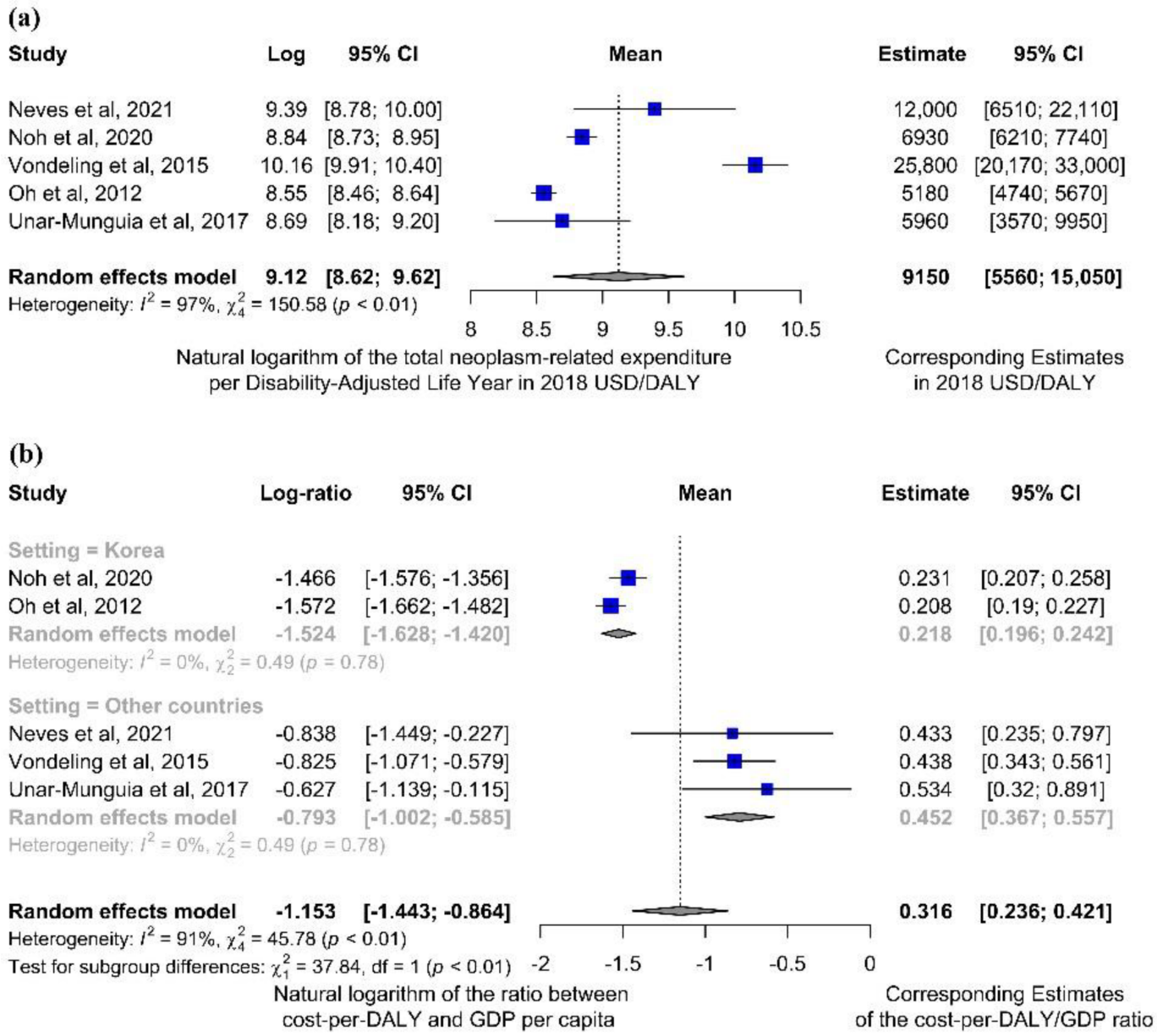

Figure 1. Forest plots for outcomes related to the cost-per-DALY ratio, according to meta-analytic computations described in the Methods. A meta-analytic estimate of the average cost per DALY ascribable to cancer (and its 95% CI), performed considering all studies eligible for the quantitative synthesis [13][14][15][16][17] (**a**). Expenditures per DALY were also considered in relation to the corresponding GDP per capita; (**b**) given that two studies were set in the same context (Korea) [14][16], a *post-hoc* subgroup analysis was also performed by separating them from other settings.

Considering only indirect costs, the pooled ratio was around 4000 USD. Relating the indirect costs-per-DALY ratio to the national GDP results in indirect expenditure per DALY equaling one seventh of the annual country's economic output per person (**Figure 2**).

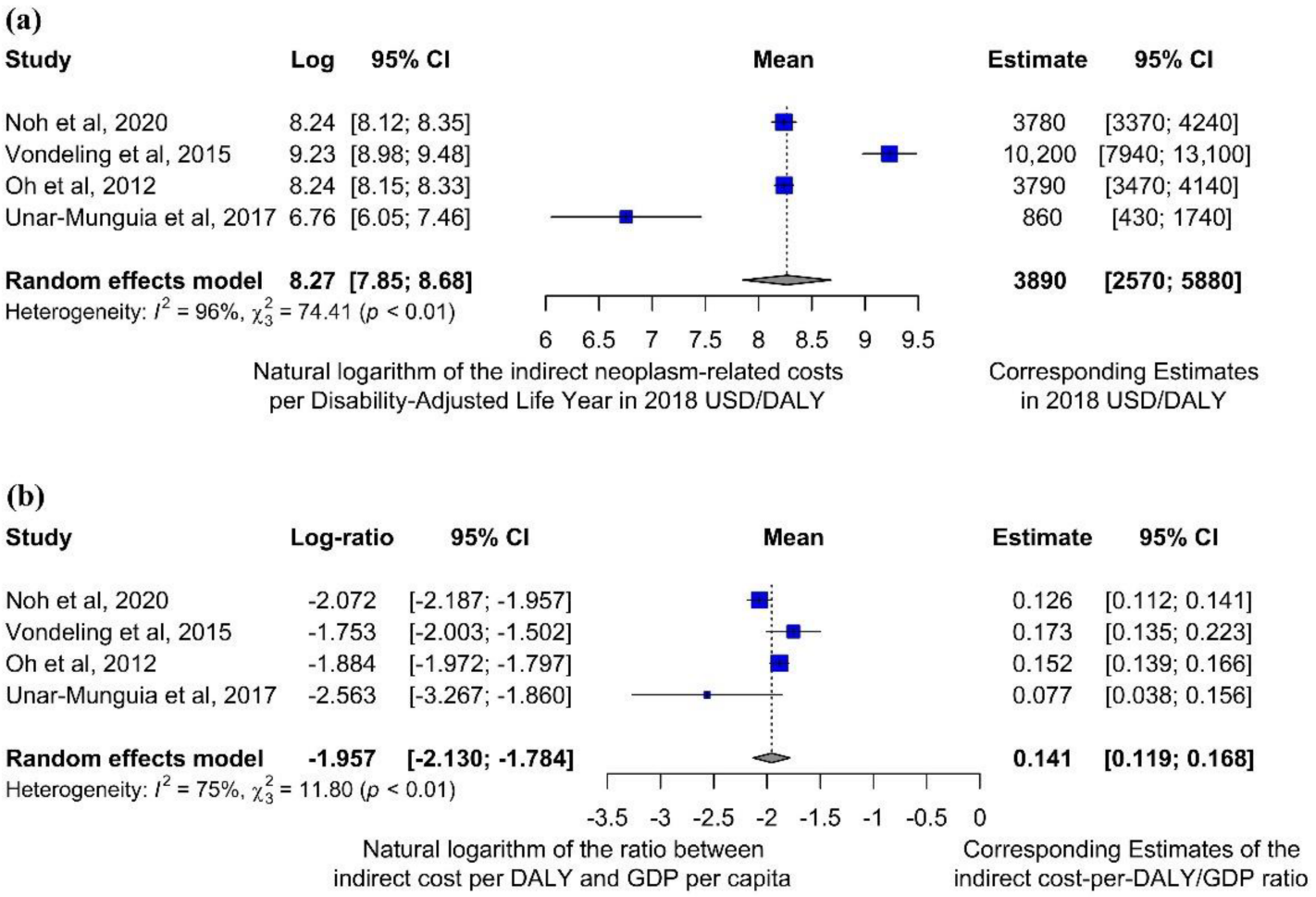

Figure 2. Forest plots for outcomes related to the ratio between indirect costs and DALYs, according to meta-analytic computations described in the Methods. A meta-analytic estimate of the average indirect cost per DALY ascribable to cancer (and its 95% CI), performed considering all studies reporting indirect cost data [14][15][16][17] (**a**). Indirect expenditures per DALY were also considered in relation to the corresponding GDP per capita (**b**). One study [13] was not included in this computation due to absence of indirect cost data.

Hence, the overall cancer-related indirect expenditure and productivity losses per DALY ascribable to the disease were much lower than the numerical value of the GDP per-capita, and the same held for the total expenditure (i.e., also including direct costs). This implies that the actual estimates of global costs of the disease may be quite different from the “economic value” obtained multiplying DALYs by the GDP per capita. For example, the fact that cost estimates would be cut by around 70% implies that, if a posteriori computed parameters were used, the global cancer cost estimate forecast in a previous study [18] would be reduced from one billion to 300 million 2018 USD.

This might be explained by the fact that GDP measures the monetary value of all final goods and services produced in a country in a given period (generally a year). Consequently, GDP is composed of goods and services produced for sale in the market and includes some non-market production (e.g., defense or education services provided by the government) [19], which may entail an excess computation of costs in relation to the actual economic burden of the disease when the GDP is taken as a predetermined proxy of the cost per DALY. Thus, the

remarkable differences highlighted cast doubts on the reliability of estimates obtained by valuing the monetary burden from simple analyses based on DALYs and GDP per capita, a methodology widely used not only for cancer [20] but also in many other sectors such as infectious disease [21], injuries [22] and maltreatment-related illnesses [23].

Another study [24] used the VSL as a proxy of the cost per DALY: the VSL can be defined as the monetary value of a mortality risk reduction that would prevent one statistical death [25][26]. When the tradeoff values are based on choices in market contexts, the VSL can be adopted as an indicator of the marginal cost of enhancing safety and the population's willingness to pay for mortality risk reduction [27]. The use of the VSL as a proxy of the cost per DALY has already been applied to genetic [28], occupational [29] and infectious diseases [30].

However, it is interesting to notice that figures obtained by Ranganathan et al. [24] using the VSL methodology appeared to provide a cost-per-DALY estimate absolutely comparable to the value of the GDP per capita, with no appreciable difference in the magnitude of estimated costs: in fact, the ratio between VSL and GDP per capita ranged between a minimum of 0.823 (in Nepal, 786/955) and a maximum of 1.058 (in Pakistan, 1521/1437). Thus, it is likely that, as previously observed for the case of GDP per capita, even using the VSL may equally lead to overestimating total costs of DALYs.

In light of the above, some implications emerge for both researchers and policy-makers. First of all, the availability of reliable estimates on the cost of cancer is absolutely required in order to steer targeted choices at the several levels of the decision-making process and to accurately allocate resources. For this reason, further studies are needed to provide a reasonable cost-per-DALY parameter that can be used to estimate the costs of cancers starting from relevant DALYs, similarly to the approach already adopted for different sectors [31], where previously published cost-per-DALY estimates [32][33] were considered and applied instead of fixed parameters like GDP or VSL. This would imply more challenging research but would also lead to a clearer understanding of the actual economic burden ascribable to cancer.

Subsequently, more precise computations of this burden would allow policy-makers to quantify the number of resources deployed in relation to DALYs and therefore to conversely evaluate the economic benefits resulting from the reduction of these pathologies [34][35]. As a result, this would also help policy-makers to assess the need for improving healthcare policies in terms of primary prevention, screening programs and early diagnosis of cancer diseases [13].

3. Conclusions

Cancer represents a major health issue, concerning both the clinical burden (in terms of morbidity and mortality) and the consequent economic implications. With regard to the latter, DALYs are often used to measure the burden of disease since they are a compound unit encompassing both disability and mortality, but substantial heterogeneity occurs when they are translated to monetary value.

Each DALY due to cancer has shown to cost, on average, around 9000 USD in high- and upper-middle income countries, although this computation can be strongly influenced by fluctuations depending on cancer type and other parameters (e.g., country, prices). Moreover, the cost per cancer-related DALY has been found to be, on average, 32% (95% CI: 24–42%) of the corresponding countries' GDP per capita, which implies that the use of a priori established parameters, such as GDP or VSL, might lead to presenting rough estimates highly different (even threefold) from what a posteriori emerges after directly retrieving figures and/or building models out of available data. Therefore, further research is needed to understand the actual value of DALYs connected to cancer, and to provide reliable cost estimates that may provide reasonable ground to policy-makers for appropriate decision-making.

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