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Health metrics for helminth infections

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ABSTRACT

Health metrics based on health-adjusted life years have become standard units for comparing the disease burden and treatment benefits of individual health conditions. The Disability-Adjusted Life Year (DALY) and the Quality-Adjusted Life Year (QALY) are the most frequently used in cost-effect analyses in national and global health policy discussions for allocation of health care resources. While sometimes useful, both the DALY and QALY metrics have limitations in their ability to capture the full health impact of helminth infections and other 'neglected tropical diseases' (NTDs). Gaps in current knowledge of disease burden are identified, and interim approaches to disease burden assessment are discussed.

1. Introduction

1.1. Definition of health metrics

In a broad sense, *health metrics* are numbers assigned to quantify the impact of different diseases on personal health status. They are numerical judgments of the value of certain health states or treatment outcomes and, in the literature of the different disciplines that evaluate health outcomes, they can be referred to as 'preferences', 'values', or 'utilities' (Gold et al., 1996). In economics, the 'utility' of a transaction can be inferred from an informed, 'rational' consumer's willingness to pay for goods or services. By contrast, in health care, many personal factors can influence a person's valuation of a given health state. This makes it quite challenging to define health metrics that accurately reflect the value of individual health states to society-at-large.

The notion underpinning the use of such health 'utilities' is that they could allow us to compare the efficacy and effectiveness of different health interventions on a 'like-is-like' basis (Gold et al., 1996; Murray, 1996). If it is believed that if such metrics are applied to different diseases in a 'fair' manner, then the relative value of each intervention can be assessed in terms of the health utility gained, as captured by the health metric. The result is that decisions in favor of more 'effective' interventions can be made on a utilitarian basis across a broad range of health-related harms (Murray, 1996). The use of health metrics presupposes that the decision maker agrees with this unitization of health states, and that maximization of health utility is the right approach to allocation of limited health care resources.

1.2. Why try to quantify disease burden?

The move to quantify disease impact of different health states comes from the greater implementation of health economics in evaluation of disease control initiatives. It springs from the efforts of policymakers to improve the efficiency of health care investments and health care delivery in all settings, including less-developed countries.

In standard *cost-effectiveness analysis* (CEA), the final outcome that is typically assessed is 'cost per health-unit gained', while in *cost-benefit analysis* (CBA) the outcome is in the form of 'cost spent per costs saved or averted' through the intervention program. To conduct either CEA or CBA, there must be an identifiable, measurable, scalable, unitized consequence that results from the proposed treatment (or preventive care) given by the health program under study. In sum, the gain can either be measured as non-monetary health effects, as is done in CEA, or as associated monetary benefits, as is done in CBA. Those who pay for health care (payors) may be most interested in CBA, whereas patients, social programs, and

Abbreviations: QALY, Quality-Adjusted Life-Year; DALY, Disability-Adjusted Life-Year; GBD 2010, the Global Burden of Disease 2010 Project; Dw, disability weight; YLD, years lost to disability; YLL, years of life lost; NTD, neglected tropical diseases; VBD, vector-borne diseases; CEA, cost-effectiveness analysis; CBA, cost-benefit analysis.

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healthcare providers may be more interested in the outcomes that are included in CEA.

Early evaluations of helminth control programs used 'cases prevented' or 'cases cured' as the outcomes that were measured in their CEA (Guyatt, 1998). The drawback to this disease-centric approach was the outcomes could not then be compared among the different parasite infections, because each infection had its own pathogen-specific morbidities. Similarly, without a generalizable health metric, there was no meaningful comparison between deworming interventions and the many competing disease control programs implemented elsewhere in the health sector.

The cost effectiveness approach is fundamentally utilitarian in philosophy, encapsulating the belief that program impact can be potentially maximized at a minimum of cost (Gold et al., 2002). The assumption is that the expected outcomes of the program are *scalable* (i.e., retaining the same value at all locations and at all levels of aggregation), *additive* (i.e., two units gained are twice as valuable as one unit gained), and are *fungible* (i.e., interchangeable among different individuals in the same or different locations) (Murray, 1996). As discussed later in this paper, human health perception and health-seeking behavior diverge significantly from this assumed unitization of health. However, the creation of such health 'units' is essential to performing the sort of comparisons favored by health economists in their 'league table' rankings of health investments (Jamison, 1996, 2006). It has long been recognized in economics that the value of a transaction is determined by the consumer's (not the seller's) perception of value. Because of this, the units of health or health burden employed in CEA must in some way incorporate patient preferences about the possible alternative health outcomes that are being compared (Gold et al., 1996).

The ultimate factor driving the move toward CEA is the knowledge that resources are limited for investment in health care and the efficient allocation of scarce resources would be an ethical 'good' for the world community. The salient policy discussion in setting disease control priorities has been, "How much health can we buy for 1 million dollars?" (Jamison, 1996) Unfortunately the basic cost-effect algorithm is an essentially linear approach that is often not well suited to the realities of health care, and not well suited to the non-linear economic features of low-income life (Banerjee and Duflo, 2011; King and Bertino, 2008).

1.3. The challenge of disease burden assessment for parasites

In defining the health burden of developing countries, there is a new appreciation of the role of chronic parasitic diseases in the perpetuation of disability, particularly in the setting of rural poverty (Engels and Savioli, 2006). In highly developed regions such as Europe and North America where parasites are now infrequent, we tend to conceptualize infectious diseases predominantly as 'acute' health problems that will respond rapidly to appropriate antimicrobial therapy and leave the treated patient with only minimal or no lasting disability. While there is an increasing realization that a number of major chronic diseases are caused by infection, including those caused by human papilloma virus (HPV), *Helicobacter pylori*, HIV, hepatitis B virus (HBV) and hepatitis C virus (HCV), in high-income countries, the impact of communicable diseases is often considered to be minimal compared to the impact of chronic non-communicable diseases (Gwatkin et al., 1999; Murray et al., 2012c).

By contrast, in the developing world, parasitic infections are common, recurrent, and long-lasting health problems that represent an ongoing inflammatory challenge and a significant health threat to the populations who are at continuing daily risk for reinfection (Jia et al., 2012; Satayathum et al., 2006; Wang et al., 2012). Also, in the context of health burden assessment, it is important to realize that parasite-related disease outlasts the period of parasitic infection (Giboda and Bergquist, 1999)—in the typical endemic setting, active infection represents only a major *risk factor* for parasite-associated disease. Although past Global Burden of Disease Program assessments (Mott, 2004; Murray and Lopez, 1996) have assumed that patients with helminth infections are 'mostly asymptomatic', this is not true—meta-analysis of available clinical evidence has shown that helminth infections are associated with many significant morbidities and chronic/permanent disabilities (Carabin et al., 2011; Chan, 1997; Furst et al., 2012a; King et al., 2005; Quattrocchi et al., 2012).

There is a severe lack of information on the long-term outcomes of patients exposed to chronic parasitic infections during their childhood or young adulthood. Risk of advanced pathology over time has often only been inferred via cross-sectional studies (e.g., King et al., 1988), in which patient age serves as a proxy for duration of exposure among long-term residents of an endemic area.

Formal decision analysis for health care resource allocation is often based on Markov-type models that project the expected outcomes of an intervention based on the probabilities of disease, its proper diagnosis, and its response to different treatments over time (King et al., 2011; Petitti, 2000). For helminth diseases, such a life-path analysis approach has suffered from a lack of well-measured longitudinal data inputs. Conditional probabilities for transition from mild to more severe health states are mostly unknown (Kirigia, 1997, 1998). It has been demonstrated that both patients and 'disease experts' have a poor ability to prognosticate on the risk of transition between health states associated with the various conditions associated with helminth infection (Kirigia, 1997, 1998). By the same token, most formal treatment studies have typically provided outcomes and follow-up of therapy for only 1–2 years' duration (Richter, 2003).

While it is true that there are many highly effective antihelminthics for treating these parasitic infections (e.g., praziquantel, albendazole, mebendazole; Anonymous, 2010), within a resource-challenged region, access to effective treatment is still not generally available. Furthermore, even after successful therapy, environmental factors can strongly favor the process of reinfection (Jia et al., 2012; Satayathum et al., 2006). As a result, for the majority of local residents, the worm infections will frequently recur, and disease will persist for most of their lives. In fact, worm infections are so common that chronic manifestations of infection-associated disease are often mistaken as normal for health status in endemic areas (Amazigo et al., 1997; Danso-Appiah et al., 2004; Mekheimar and Talaat, 2005; Ukwandu and Nmorsi, 2004). This makes it difficult for people in endemic areas to provide a valid comparison of their infected health state to a 'full-health' state, which is understood to be the expected norm in the cultures of high-income, highly developed economies, such as Europe, Japan, or North America. As discussed later in the article, this places limitations on the use of standard health metric valuation approaches for diseases of developing countries.

2. Commonly used health metrics: DALYs and QALYs

This section reviews the approaches most commonly used to quantify disease-related health burden in policy discussions. The metrics used most often are generically referred to as Health-Adjusted Life-Years (HALYs) (Carabin et al., 2005). Disability-Adjusted Life Years, or DALYs, and Quality-Adjusted Life Years, or QALYs, are the two formulations most frequently seen in the literature (Gold et al., 2002).