

BCEPS Working Paper #1 (2021)
Revised April 2021

Prioritarian Analysis in Health*

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* This paper is a draft of Chapter 6 of Matthew D. Adler and Ole F. Norheim, eds.,
Prioritarianism in Practice (Cambridge University Press, forthcoming)

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Background to the series

The Bergen Centre for Ethics and Priority Setting (BCEPS) is an inter-disciplinary global health research hub that aims to support ethically acceptable, fair, and efficient priority setting in national health systems on the path to Universal Health Coverage (UHC). BCEPS is based at the University of Bergen Department of Global Health and Primary Care in Norway (<https://www.uib.no/en/bceps/127910/about-bceps>).

The BCEPS working paper series was founded in 2021 as a way of making our research more rapidly and widely available.

Acknowledgements

We have followed the convention in the economics discipline of listing authors in alphabetical order. The author contributions were as follows. The main text was lead authored by Ole F. Norheim, who also lead the design and construction of the illustrative decision model. Ieva Skarda lead authored the section on lifetime wellbeing metrics within the context of the equivalence approach and the technical appendix, co-designed and validated the illustrative decision model, and used the model outputs to create the figures and tables. Richard Cookson advised on study design and drafted the background section. All authors made substantial contributions to re-drafting the manuscript.

For helpful comments, we would like to thank Matt Adler, Jim Hammitt, Lisa Robinson, Marc Fleurbaey, Grégory Ponthière and participants at various PiP and BCEPS workshops. Ieva Skarda was supported by the Wellcome Trust (Grant No. 205427/Z/16/Z). Richard Cookson and Ole F. Norheim were supported by the Bergen Centre for Ethics and Priority Setting (BCEPS), University of Bergen, via grants from the Trond Mohn Foundation (Grant No. BFS2019TMT02) and the Norwegian Agency for Development Cooperation (Grant No RAF 18/009, “Decision Support for Universal Health Coverage”). Norheim’s work was also supported by the Research Council of Norway through the project Inclusive Evaluation of Public Health Interventions (Grant no: 260588). The errors and opinions expressed in this chapter are the responsibility of the authors alone.

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Abstract

This chapter aims to present a practical prioritarian approach to economic evaluation of health programmes, taking into account impacts on income as well as health, with an illustrative application. We propose applying the prioritarian transform to lifetime well-being, defined as the sum of current period well-being over the lifetime.

We first describe two simple ways of combining individual-level information on income and health to generate an index of well-being, based on the equivalent life and equivalent income approaches respectively. We then illustrate how these two metrics can be used to conduct lifetime prioritarian evaluation using a simple hypothetical comparison of two funding options for cancer treatment in a low-income country – out-of-pocket payment (OOP) and universal public funding (UPF) via taxes or compulsory insurance premiums proportional to income. We compare the findings of lifetime prioritarian evaluation with those of utilitarian evaluation and benefit-cost analysis. We find that standard cost-effectiveness analysis and benefit-cost analysis are not sensitive to income redistribution, while lifetime prioritarian evaluation is sensitive not only to total effects on health and income but also to progressive redistribution of lifetime income, health and well-being favouring the worse-off.

Keywords: Health, income, priority setting, health financing, economic evaluation, prioritarian social welfare functions, cost-benefit analysis, cost-effectiveness analysis

6.1 Introduction

This chapter aims to present a practical prioritarian approach to economic evaluation of health programmes with impacts on both health and income, with an illustrative application that compares the results of prioritarianism (both ex and ex post variants), utilitarianism, and cost-benefit analysis. More specifically, it presents a lifetime prioritarian approach that gives priority to the worse-off in terms of lifetime well-being defined as the sum of current period well-being over the lifetime.

This chapter is a contribution to the “Prioritarianism in Practice” programme, which aims to advance our understanding of generalized utilitarian approaches to assessing governmental policy and social progress, including both prioritarian and utilitarian approaches, and including comparisons with standard approaches such as benefit-cost analysis (BCA) and cost-effectiveness analysis (CEA). We define “prioritarian” approaches as those that rank social outcomes according to the sum of a strictly increasing and strictly concave transformation of individual levels of well-being (Adler, 2012, 2019; Adler & Holtug, 2019)(see also Adler, chapter 2, this volume), and reserve the term “utilitarian” for those that rank social outcomes according to the sum of untransformed individual levels of well-being. We use the term “generalized utilitarian” approaches to cover both prioritarian and utilitarian approaches, though not egalitarian approaches involving non-separable functions of individual welfare, such as rank-dependent social welfare functions which respect to the strong Pareto principle and strictly egalitarian ones which do not (O'Donnell & Van Ourti, 2020; O'Donnell & Van Ourti, 2020).

In principle, the lifetime prioritarian approach described in this chapter can be applied to decisions about:

- a) specific health care technologies (e.g. reimbursement decisions for new, expensive drugs);
- b) designing health care benefit packages (e.g. whether to cover type 2 diabetes in a public health insurance plan and, if so, which treatments and with what co-payments),
- c) public health policies and regulations (e.g. bans on smoking in public places, “sin” taxes, health promotion campaigns, subsidies for sport and physical activity), and
- d) cross-sectoral social policies with important impacts on health as well as non-health outcomes (e.g. policies on education, transport and social protection).

Our illustrative example relates to a decision of the first kind – the funding of an expensive cancer drug in a low-income country – but the methods we describe are in principle applicable to all these kinds of decisions.

Hitherto, most empirical applications of prioritarianism in the health sector have focused on health as the measure of individual value.¹ This is fine for informing health care and public health decisions that are primarily intended to improve health and that are not also expected to have non-health consequences of direct concern to decision makers and stakeholders. However, it is less satisfactory for informing decisions which are expected to have important non-health consequences – for example, impacts on financial protection from the out-of-pocket costs of health care and the wider costs of illness.

In this chapter, therefore, we will focus on the broad and challenging question of how to apply prioritarianism to multi-dimensional measures of well-being that combine information about health and non-health dimensions of well-being. Applications of prioritarianism to health outcomes only, which have already been extensively documented elsewhere (R. Cookson et al., 2020), can then be seen as special cases of this more general problem. We examine two different well-being concepts: equivalent life and equivalent income. To keep things simple and tractable, however, we focus on operationalising these concepts using information about health and just one other dimension of individual well-being: the consumption of privately funded goods and services. We call this “income” and measure it using household income after taxes and cash benefits, adjusted for household size and composition. Both equivalent life and equivalent income can be extended to cover other non-health outcomes – for example, the consumption of publicly funded goods and services, the quality of personal relationships, and adverse experiences such as maltreatment, unemployment and incarceration – but we do not examine such extensions here.

In the health sector, methods for measuring health outcomes are well developed and health programmes are often assessed through economic evaluations before they are introduced through public finance. The dominant method for economic evaluation is cost-effectiveness analysis using a general summary measure of health outcome that allows comparison between different diseases and conditions, for example in terms of cost per QALY gained or a cost per DALY averted (Drummond et al., 2015; Neumann et al., 2017; Sanders et al., 2016). This is a quasi-utilitarian approach: it ranks distributions of health according to the sum of untransformed individual levels of health. In other words, cost-effectiveness analysis aims to maximize sum total net health benefit in terms of health gains minus health opportunity costs.

In the health sector, special concern for the worse off in terms of health has been identified as important in addition to the standard objective of health maximization (Paul Dolan et al., 2005; Fleurbaey & Schokkaert, 2009; Johri & Norheim, 2012; Paul Dolan, 2005; Sassi et al., 2001). Early contributions to this idea were typically made in the context of equity-efficiency trade-

¹ One reason for restricting information to health only has been pragmatic and institutional. The policy questions relevant for priority setting, e.g. the relative rank of new expensive drugs, are typically formulated in terms of health-, not well-being-impact. The health sector (with its limited budget) is responsible for improving health, not well-being. The standard methods used to inform these decisions are cost per Health-Adjusted Life Years analysis, where HALY is a measure of health, not well-being. Health policy makers see their job as primarily to improve health rather than income, and it has been argued that direct redistribution of income by fiscal instruments is more appropriate and efficient than indirect redistribution through the health service (for some limitations of this argument, see Robinson, Hammitt, Zeckhauser, 2016).

offs (Anand, 2002; Anand et al., 2001; Anand & Nanthikesan, 2001; E. Nord, 1993; Erik Nord, 1999; Wagstaff, 1991). The worse off are sometimes defined using a lifetime perspective – for example, expected healthy years from birth to death – and sometimes using a current period perspective – e.g. expected remaining future healthy years from the time of decision to death (Johansson et al. 2020). In a health context, the use of lifetime versus current period concepts of well-being can make an extremely important difference to who is considered badly-off. For example, a 100 year-old with skin cancer may be extremely well-off in terms of lifetime health but extremely badly-off in terms of current and remaining healthy years of life. In the health policy literature, current period health is typically what people have in mind when they talk about “severity of illness”, whereas lifetime health is typically what they have in mind when talking about “health inequality” – though policy rhetoric is often ambiguous about this and the concepts of “severity of illness” and “health inequality” can both be measured from both lifetime and current period perspectives. There are strong theoretical arguments favouring a lifetime health perspective, and considerable evidence of public concern for the worse off in lifetime health in many different countries (Bleichrodt et al., 2004; Bleichrodt et al., 2005; P. Dolan & Tsuchiya, 2012; Ottersen, 2013).

There may also be special concern for the worse off more broadly in terms of well-being, including non-health dimensions of well-being such as income.² The same issue of temporal perspective arises in this broader context, as to whether prioritarian concern focuses on current well-being or lifetime well-being. In this chapter we adopt a lifetime well-being perspective to prioritarian concern – that is, we explore the implications of giving priority to individuals with lower lifetime well-being.³ As we shall see later, however, when measuring current period well-being as a function of consumption we also assume that current period consumption is subject to diminishing marginal value. This could be seen as a kind of prioritarian concern in the space of current period income – i.e. concern to give priority to those who are worse off in terms of current period income. Under this interpretation, our approach could be thought of as a kind of “double prioritarianism” – priority to the worse off in terms of current period income, and then also priority to the worse off in terms of lifetime well-being. However, we prefer to interpret the assumption of diminishing marginal value of current period consumption as being motivated by concern to measure current period well-being accurately – a concern shared by utilitarians and prioritarians alike. So we interpret our approach as prioritarianism in the space of lifetime well-being, properly measured, without any additional concern for those who are worse off in terms of current period well-being.

In the health literature, applications of prioritarianism have departed from the more general approach described in earlier chapters of this book in three ways (see e.g. (Anand et al., 2001; Asaria et al., 2016; Asaria et al., 2015; R. Cookson et al., 2020; R. Cookson et al., 2021a; R. Cookson et al., 2017; Hernæs et al., 2017; Johansson & Norheim, 2011; O. F. Norheim, 2013;

² In this chapter we will use income interchangeably with consumption. From a theoretical perspective consumption is a better indicator of well-being than income, but conventions in the ‘equivalent income’ literature makes it easier to use the term ‘income’ which is also more user-friendly for non-economists.

³ Adler (2012), chapter 6, provides a philosophical defense of prioritarianism applied to lifetime well-being rather than shorter time-slices.

O.F. Norheim et al., 2020; O.F. Norheim et al., 2019; Ottersen, 2013; Ottersen et al., 2014). First, as already discussed, they have focused on health as the measure of individual advantage to define who is worse-off, rather than well-being more broadly including health and non-health dimensions. Second, they have focused on group-level distributions (e.g. based on social groups defined by socioeconomic status, ethnicity, geographical location or disease groups defined by disease classification) rather than individual-level distributions. Third, they have focused exclusively on *ex ante* prioritarianism based on expected health outcomes rather also on *ex post* prioritarianism based on realised health outcomes.

Prioritarianism in this narrower health-oriented sense has informed the development of various methods of “distributional” cost-effectiveness analysis (DCEA) in the health sector which provides information about the distribution of costs and effects as well as value-for-money in terms of total costs and effects (R. Cookson et al., 2020). In this literature, normative concerns about differences in health and well-being between people are often labelled as “equity” considerations and normative concerns about sum total health and well-being are often labelled as “efficiency” considerations. Empirical studies rarely distinguish explicitly between prioritarian and egalitarian frameworks, though they are typically based implicitly on a prioritarian approach.

The chapter is organized as follows. The next section provides background on standard approaches to economic evaluation in the health sector: cost-effectiveness analysis (CEA), benefit-cost analysis (BCA). Section 6.3 then examines two ways of constructing an index of lifetime well-being, suitable for prioritarian evaluation, based on information on length of life, health-related quality of life and income. Section 6.4 then illustrates the application of generalized utilitarian social welfare functions to these two measures of lifetime well-being compared with standard CEA and BCA, including both *ex post* as well as *ex ante* prioritarian approaches, using a common example involving a hypothetical cancer treatment programme in a low-income country. The final section concludes.

6.2 Background on standard economic evaluation in the health sector

This section provides some background on how standard methods of cost-effectiveness analysis (CEA) (Drummond et al., 2015) and benefit-cost analysis (BCA) (McIntosh et al., 2010; LA. Robinson et al., 2019a) are usually applied in practice in the health sector. Background on the theory and practice of BCA more generally are provided elsewhere (Adler, 2019; Boardman et al., 2018; McIntosh et al., 2010).

In practice, CEA and BCA studies used to inform health sector decision making usually measure health effects in terms of a summary measure of health such as the quality-adjusted life-year (QALY) or disability-adjusted life year (DALY). That is because summary measures

of health allow comparisons between mortality and morbidity effects of different kinds across different health conditions.

We therefore start this section by introducing summary measures of health before describing how they are used in practice in CEA and BCA studies. We also briefly discuss the use of distributional weights in CEA and BCA. As well as presenting aggregate headline findings, both CEA and BCA studies can also present a range of disaggregated information about costs and effects in a “dashboard” or “impact inventory”, along with qualitative information about potentially important costs and effects that were not quantified in the analysis.

6.2.1 Summary measures of health: health adjusted life years (HALYs)

Conceptually, the only important difference between a QALY and a DALY is the sign – a QALY is a healthy year gained and a DALY is a healthy year lost (Gold et al., 2002; Robberstad, 2005). So we will use the term “Health-Adjusted Life-Year” (HALY) to mean either a QALY gained or an averted DALY or other similar summary measure of health in terms of healthy years. There are differences in the technical details of construction, just as there are differences in the technical details of construction of different kinds of QALY and different kinds of DALY. Not all QALYs and DALYs are comparable, but they share the same basic conceptual motivation and underpinnings which we describe below.

When making priority-setting decisions, health sector decision makers implicitly or explicitly have to compare the value of different kinds of health effect for different people with different diseases and conditions – for example, a five-point gain in a mental health symptom score for one group of patients versus a ten percent reduction in the risk of dying from cardiovascular disease for another group. HALYs provide a systematic method for comparing condition-specific health effects in terms of gains in healthy years of life, based on evidence and explicit value judgements. They also allow value for money to be assessed in a standardised way, by establishing a common cost-effectiveness benchmark (e.g. in terms of a cost per HALY gained) that can be used for deciding which services are best included in health care coverage (Culyer, 2016). There are many different ways of constructing HALYs and different HALY metrics are not fully comparable with one another.

An index of health-related quality of life in the current time period combines information on multiple dimensions of health-related quality of life to produce a single number on a ratio scale anchored at 0 (as bad as death) and bounded above at 1 (full health in the current period). The corresponding index of health-related disability is the same thing but with the scale inverted – i.e. a number anchored at 1 (as bad as death) and 0 (full health in the current period). This is then multiplied by the duration of the time period (in years) and summed across all relevant time periods to yield a HALY score that combines information on both length of life and health-related quality of life. The HALY is measured on a ratio scale and then normalized so that 1 represents a year of health gained or lost. Any set of numbers will serve for a ratio scale, so long as they are related by a constant multiplicative term – for example, one can measure distance in miles or kilometers, and one mile is always the same distance as 0.62 kilometers.

However, normalizing the HALY to mean a healthy year means choosing one specific version of the HALY ratio scale. This is analogous to normalizing the measure of distance – for example, measuring distance in terms of light-years. Other normalizations could be chosen, but this specific unit is convenient for certain purposes.

In principle you can even go below 0 for states of health considered to be worse than death; though thankfully such states are rarely encountered in practice.

The resemblance that a HALY has to some usages of “utility” in welfare economics has led some authors to describe HALYs as utilities, which can be misleading on a number of grounds (Bleichrodt & Gafni, 1996; Garber & Phelps, 1997; J. K. Hammitt, 2002, 2013, 2017). The term “utility” in welfare economics generally refers to an index of individual preference (“decision utility”) or well-being (“experienced utility”). The typical use of a HALY, however, is not necessarily as an indication of what any individual wants, or thinks, or feels, or chooses, or how well their life is going overall, but rather as a general measure of health (of which, doubtless, more will indeed usually be preferred). The HALY is not a value-free scientific measure of health, however, as the process of selecting, scoring and weighing the different dimensions of health requires a series of value judgements.

The HALY might be seen as a component of well-being, or as a partial indicator of health-related well-being, but it is by no means a complete measure of well-being. For most practical applications in the health sector, the objective is cast entirely in terms of health, with other outcomes considered only for their impact on health or the effectiveness of health interventions. To avoid confusion with the standard usage of the word “utility” in economics to mean preference or well-being, we avoid the use of terms like “cost-utility analysis” and do not refer to HALYs, QALYs or DALYs as “utilities”.

6.2.2 Cost-effectiveness analysis (CEA)

We now review the nuts and bolts of CEA using HALYs, including the cost-effectiveness plane and the basic concepts of the cost-effectiveness threshold value, health opportunity cost and net health benefit.

Cost-effectiveness analysis of a single decision option compared with an alternative entails estimating the incremental costs and health effects of that option compared to the current or reference situation. An option that reduces costs and increases health is a “dominant” or “win-win” option (i.e. clearly cost-effective). An option that increases costs and reduces health is a “dominated” or “lose-lose” option (i.e. clearly not cost-effective). If the consequences are estimated to be either increased costs accompanied by increased health, or reduced costs accompanied by reduced health, then an additional piece of information is required to determine whether the decision is cost-effective, i.e. the “threshold value” at which investments are considered cost-effective. This threshold value may be implicit and it may be an imprecise range rather than a precise point estimate, but it is needed if wants to claim that an option is cost-effective rather than not cost-effective.

This can be shown diagrammatically using a cost-effectiveness plane (see figure 6.1). The origin represents a baseline comparator of no change from the reference situation. Other points in the plane represent the total expected incremental costs and effects of alternative decisions compared with this baseline decision. The cost-effectiveness plane thus has four quadrants representing four logically possible cases: (1) North-East for cost-increasing and health-improving; (2) North-West for cost-increasing and health-harming (i.e. “dominated” in the cost-effectiveness sense); (3) South-East for cost-saving and health-improving (i.e. “dominant” in the cost-effectiveness sense), and (4) South-West for cost-saving and health-harming (“win-lose”).

[Figure 6.1 here]

The threshold value at which an option is considered cost-effective compared with an alternative can be given various interpretations (Faria & Lomas, 2020). For example, it can be given a “demand-side” interpretation in terms of the average willingness to pay for a HALY among the relevant population of individuals. Or a “supply-side” interpretation as the marginal production cost of a HALY from forgone activity that can no longer be undertaken. Or a “social norm” interpretation based on precedent from past decisions or benchmarks set by decision making bodies or other authoritative organisations. On the “supply-side” interpretation, cost-effectiveness can be interpreted as a test of whether the decision increases net health benefit i.e. sum total health gains minus sum total health opportunity costs. If so, cost-effectiveness analysis can be seen as a quasi-utilitarian approach to evaluation that seeks to maximise health (Richard Cookson, 2015).

Whatever interpretation is used, the basic idea is that a cost-increasing policy option can be considered “cost-effective” if its health gain per unit of cost compares favourably with (i.e. is higher than) the most attractive alternative way of using resources. The recognition of opportunity costs – i.e. that resources used in the provision of a programme would have generated value if used in their most highly valued use elsewhere – is fundamental to cost-effectiveness analysis. Every benefit attributed to a programme must be assessed relative to the benefits displaced when resources are diverted from alternative activities.

In a public health system with an exogenously fixed budget, the displaced activities will usually be alternative health programmes that would otherwise have been producing health benefits. This is as true when the budget is due to expand or contract over time as it is when it is due to remain constant. If the budget is set to grow, then the question is: “where to spend the next dollar?” The displaced activity is then the alternative health programme the next dollar could otherwise have been spent on. In this context, “exogenously fixed” does not necessarily mean “constant over time”. Rather, it means “beyond the control of the health sector decision maker who is making the priority setting decision”.

Things are different if the health budget is endogenous, however, in the sense that the decision maker can choose to increase the health budget rather than displace other health programmes.

In such settings, the displaced activities may include alternative health services, but they may also include other activities having both health and non-health benefits – such as other forms of public expenditure (e.g. education, transport, poverty reduction) or reduced taxes or insurance premiums allowing people to enjoy improved material living conditions. Whatever activity is displaced, there may be both health and non-health opportunity costs.

The estimation of health opportunity costs is more problematic if opportunity costs do in fact primarily fall on household consumption (via increased taxes or insurance premiums) or on reductions in public expenditure on programmes not primarily designed to improve health. In that case, it may be more helpful to conduct benefit-cost analysis rather than cost-effectiveness analysis, or to use a multi-dimensional index of well-being as we propose later in this chapter.

When assessing cost-effectiveness in this way, the process of adding up HALY gains and opportunity costs across individuals and groups embodies the value judgement that all healthy years count the same, no matter who gains or loses them – i.e. “a HALY is a HALY is a HALY”. The one caveat to this statement relates to the discounting of future costs and effects – a HALY in ten years’ time may be considered less valuable than a HALY this year. There are various reasons for discounting future costs and effects on efficiency grounds related to producing a more accurate estimate of sum total health and well-being – for example, “pure” time preference, allowing for the risk of a future “apocalyptic event” causing mass extinction, and allowing for economic growth and technological innovation (Claxton et al., 2011). There are also further equity considerations related to intergenerational equity in the distribution of costs and effects between age groups and birth cohort groups, which we do not address in this chapter.

6.2.3 Benefit-cost analysis (BCA)

Benefit-cost analysis is less commonly encountered in the health sector but may be applied to evaluations of cross-sectoral policies with important health and non-health impacts (Chang et al., 2018; McIntosh 2010; LA. Robinson et al., 2019a; L. A. Robinson & Hammitt, 2016; U.S. Department of Health and Human Services, 2016). The basic idea is to measure the most important health and non-health effects, value them in monetary terms, and then compare them with the costs. In practice⁴, BCA in the health sector is often applied using the following simple additively separable equation, where health effects are measured in HALYs and all costs and benefits are discounted to their net present values:

Total cost: Δc
 Total benefit: $\Delta y + \Delta s + \Delta h * v^h + \Delta x * v^x$

where
 Δc is sum total cost in terms of both public expenditure and private consumption
 Δs is the sum total benefit in terms of long-term savings in public expenditure
 Δy is the sum total benefit in terms of increase in private consumption

⁴ BCA can also be applied in more complicated ways, allowing for differences in WTP for health for different kinds of individuals, and for non-separable functional forms.

Δh is the sum total benefit in terms of increase in HALYs

v^h is the consumption value of a HALY (usually estimated based on willingness to pay data)

Δx is the sum total benefit in terms of any other relevant non-health outcome

v^x is the consumption value of any other non-health outcome (= average willingness to pay for one unit of that outcome)

The benefit-cost ratio is the ratio of total benefit to total cost; and the net monetary benefit is the total benefit minus the total cost. Notice that this simple applied approach uses the same monetary consumption value of health for all individuals, and does not use differential values based on differential willingness to pay by income and age group. This goes against the standard welfare economic theory of the Hicks-Kaldor compensation test but can be justified not only on grounds of simplicity but also on grounds of procedural egalitarian concern to value the same gains in lifespan and health-related quality of life equally for all individuals, irrespective of income, age, gender, disability or other characteristics.

The key advantage of BCA is that in principle it can account for a full range of benefits of any kind, rather than being restricted to health benefits only.⁵ It can therefore be used to evaluate health programmes with effects on financial protection as well as health, and cross-sectoral programmes involving expenditure across different policy sectors (e.g. education, transport, environment and social protection as well as health). If applied in this simple additively separable form, it also retains the other great advantage of CEA, which is that it only needs information on total or average effects: we do not need to know how effects are distributed between different kinds of individual.

6.2.3.1 Distributional weights

A common criticism of BCA is that it fails to allow for differences in the marginal value of income to different people (Adler, 2016; L.A. Robinson et al., 2016). To take an extreme example, a billionaire might be willing to pay a billion pounds for 3 months of poor quality life extension (0.2 of a HALY) whereas a million poor families might be unable and therefore unwilling to pay £1,000 dollars each for their sick child to access life-saving treatment bringing 50 years of good quality life extension each (50m HALYs). So in theory BCA could recommend treating the billionaire rather than the million sick children, despite the latter programme yielding 250 million times more healthy years (50m / 0.2). As already described, this problem is partly addressed in practice by using a common consumption value of health across all population groups.

However, this problem persists in relation to private consumption benefits – for example, increased employment, reduced commuting times and reduced work-days lost to illness will all generate larger private consumption benefits in prosperous geographical areas where individual incomes are higher. And the problem re-emerges in relation to health if one starts applying

⁵ In principle, CEA can count non-health effects as “costs” (so non-health benefits are reduced costs), but standard CEAs rarely do so.

BCA in more sophisticated ways than the simple additive equations above, which start to reflect large differences between individuals in their ability to pay for health gains.

To address distributional issues of this kind, “distributional weights” can be applied in BCA whereby monetary benefits to poorer individuals are valued more highly than monetary benefits to well off individuals (Adler, 2016; Boadway, 2016). This is sometimes done in the UK, though in the US most textbooks and guidance takes a negative view of distributional weights (Boardman et al., 2018; L.A. Robinson et al., 2018; L.A. Robinson et al., 2016).

Distributional weights are a numerical way of valuing benefits and opportunity costs more highly for some specific subgroups of the population than others. The choice of numéraire also has distributional implications – for example, whether everything is valued in terms of consumption or health. In theory, any choice of numeraire and any social welfare function can be replicated through a suitable choice of distributional weights for benefit-cost analysis based on money as the numeraire as discussed by Hammitt (J. Hammitt, 2020). In practice, distributional weights are rarely applied in BCA, but there are simple approaches that are sometimes used outside the health sector. For example, one simple approach to distributional weighting by income quintile groups is recommended by the UK Treasury in its “Green Book” of guidance for economic evaluation (HM Treasury, 2018). This approach is based on a simple individual well-being function whereby well-being is the log of median consumption or household income within each income quintile group. Under this approach, the distributional weight for income quintile group g is given by:

$$6.1 \quad \frac{y_j^{-1}}{\bar{y}^{-1}}$$

where y_g is the median income of group j and \bar{y} is the median income in the general population. A similar approach is recommend by the UK Department for Work and Pensions (DWP), based on an individual well-being function whereby well-being is an isoelastic function of income with an elasticity of the marginal value of income of 1.3 – reflecting an estimate by Layard and colleagues based on subjective well-being data from various countries (Fujiwara, 2010; Layard et al., 2008). According to this approach, the distributional weight for income group j is:

$$6.2 \quad \frac{y_j^{-1.3}}{\bar{y}^{-1.3}}$$

At levels of income in the UK in the late 2010s, this yields a weight to the poorest income quintile group compared with the middle group of between 2 (Treasury approach) and 2.5 (DWP approach).

Arguably, these distributional weights for monetary benefits are not “prioritarian” but “utilitarian” in nature, insofar as they adjust income benefits to allow for diminishing marginal individual value of income. They can thus be seen as utilitarian adjustments to income that measure well-being more accurately rather than prioritarian transformations of well-being that give priority to the worse off.

In CEA, by contrast, distributional weights are sometimes used that are prioritarian in nature – they aim to give priority to the worse off in terms of health (Bobinac et al., 2012; Lal et al., 2018; E. Nord et al., 1999; Wailoo et al., 2009). The standard approach is to use direct distributional weights that are applied in whatever *ad hoc* pattern is preferred by the decision maker – for example, health benefits to severely ill individuals might be assigned a weight that is two or three times higher than health benefits to the average individual. Typically, direct distributional weights are applied in relation to some measure of disadvantage – for example, greater weight to benefits and burdens for persons with low income, poor health, an orphan condition, or some other equity-relevant characteristic. To that extent, direct distributional weighting in CEA is an informal prioritarian approach giving priority to the worse off. However, as we shall see later (section 6.4), it is also possible to adopt more formal prioritarian approaches by using indirect distributional weights which are derived from a formal prioritarian social welfare function.

6.3 Lifetime well-being metrics for prioritarian evaluation

In what follows, we explore two ways of constructing a lifetime well-being metric suitable for generalized utilitarian evaluation of health policies, based on individual-level data on period specific mortality risk, health-related quality of life and consumption. We discuss two candidate measures, both of which are based on the “equivalence approach”: equivalent life and equivalent income.

Equivalent life values the components of well-being in terms of lifespan. This approach is a generalisation of the “quality adjusted life year” (QALY) concept in health economics – the idea being to measure wellbeing in terms of years of life adjusted for other dimensions of wellbeing, such as income, health-related quality of life and so on – and so is sometimes known as the “wellbeing QALY” approach. By contrast, equivalent income values the components of wellbeing in terms of income – i.e. the idea is to measure wellbeing in terms of income adjusted for various dimensions of wellbeing such as lifespan, health-related quality and other dimensions. More specifically, the equivalent life metric can be thought of as years of “good” life with a “good” reference level of income, health-related quality of life and other dimensions of wellbeing. The equivalent income metric can be thought of as dollars of “good” consumption with a “good” reference level of lifespan, health-related quality of life and other dimensions of wellbeing.

For simplicity we will focus just on income and health, but both approaches can readily be extended to include further dimensions of well-being as appropriate. Both approaches have

more demanding information requirements than standard CEA and BCA which only require separate modelling of health and income outcomes. Equivalent life and equivalent income approaches require joint modelling of both outcomes to provide information on health, income and potentially other dimensions of well-being at each time period for each individual or subgroup.

In theory, if all individuals have the same preferences and the same baseline levels of income and health, then equivalent life and equivalent income metrics should yield the same rankings of policy consequences for individual and social wellbeing. Differences can emerge, however, if individual preferences differ (Onder et al., 2019). Take two people with equal income and health, both below the reference levels for “good” income and health. If their preferences are the same, then their wellbeing is the same using either metric. However, imagine that person A cares more about health than person B. They would therefore be willing to pay a larger amount of their income to achieve “good” health, and would be willing to accept a smaller deterioration in their health to achieve a “good” income. Who is worse off? According to the equivalent income approach, person A is worse off than person B – because their equivalent income is their current income minus their (larger) willingness to pay for “good” health. By contrast, according to the equivalent life approach person A is better off than person B – because their equivalent life is their current health minus their (smaller) willingness to sacrifice health to achieve a “good” income. Differences can also emerge if baseline levels of income and health differ between individuals, in which case the choice of numeraire has distributional implications (J. Hammitt, 2020).

In practice, however, it is hard to measure differences in preferences between individuals and to identify individual-level effects on income and health. Hence economic evaluation studies usually rely on estimates of population average outcomes, sometimes broken down into subgroups using one or two readily measurable variables such as age and income. Different marginal rates of substitution are then estimated conditional upon population sub-group, with differences potentially reflecting either different baseline levels of income and age-related mortality risk and ill-health, or different utility functions, or both. However, differences between the two metrics can still emerge in practice due to differences in the ways that they are estimated. We illustrate by constructing the two metrics in different ways. We construct equivalent life using a simple parametric approach, based on an explicit current period wellbeing function, and we construct equivalent income using a simple non-parametric approach, based on evidence about average current period willingness to pay for health-related quality of life broken down by five different income groups. Neither of these simple practical approaches allows for individual-level preference heterogeneity in the strict sense of different utility functions, but they do allow for different baseline levels of income and health for different population sub-groups and they can give different rankings of programmes. It is possible to adopt the same simple non-parametric approach to equivalent life (i.e. using data on willingness to sacrifice health-related quality of life to achieve “good” income by the five socioeconomic groups) and the same simple parametric approach to equivalent income (as we show in Appendix A1). It is also possible to adopt different parametric and non-parametric approaches to estimating both metrics. We merely use these specific approaches as illustrations

of our general point that the specific empirical approach to estimating these metrics matters and needs to be given careful consideration, as well as the theory lying behind the metrics.

Below we spell out in more detail how our measures of equivalent life and income relate to the general “equivalence approach” in the welfare economics literature (Deaton & Muellbauer, 1980; Fleurbaey & Blanchet, 2013; Fleurbaey & Maniquet, 2011, also discussed in Adler and Decancq, chapter 3, this volume), and the specific measure of life-metric utility derived by Canning (Canning, 2013). Then we show how we operationalise equivalent life in a simple parametric way by making specific assumptions about the period specific well-being function. Finally, we show how we operationalise equivalent income in a simple non-parametric way using estimates of willingness to pay for full health by income group.

6.3.1 Using the ‘equivalence approach’ to derive ‘equivalent life’ and ‘equivalent income’

Both equivalent life and equivalent income follow the “equivalence approach” to constructing well-being measures (Deaton & Muellbauer, 1980; Fleurbaey & Blanchet, 2013; Fleurbaey & Maniquet, 2011). This is based on the idea that bundles of income, health and other attributes that individuals derive utility (well-being) from can be considered equally good as long as they are on the same indifference curve.

Similar to Canning (2013) we focus on three types of goods – period-specific consumption of traded goods, period-specific health quality and lifespan. Our aim is exclusively normative: we aim to value bundles of consumption, health quality and lifespan by constructing an index of well-being, but not to predict individual behaviour using the same well-being index.⁶ In particular, we do not need to assume that individuals always make “optimal” long-term plans as if they were fully informed rational self-interested maximisers of total well-being over the lifetime with rational expectations and infallible computational abilities. We are therefore not constrained by the potential behavioural paradoxes that might emerge if one were to make that behavioural assumption.

An individual’s lifetime profile of different traded goods consumed in different time periods is represented by the vector, \mathbf{x} (with a corresponding vector of prices \mathbf{p}), their profile of different

⁶ We leave open the question of whether wellbeing is supposed to represent “true” individual preferences – i.e. behavioural preferences that have been suitably “laundered” to ensure they meet appropriate theoretical conditions such as being well-informed and consistent – or some other philosophical construct.

health quality attributes over time is represented by the vector \mathbf{h} , (with an upper bound representing full health $\mathbf{h} \leq \mathbf{1}$)⁷, and their lifespan in years is represented by the scalar, l .⁸

Individuals are also endowed with an exogenous flow of period-specific income over their lifetime, represented by the vector, \mathbf{y} . Hence, an individual can be described by their allocation of the bundle $(\mathbf{x}, \mathbf{h}, l)$ and their endowment of income \mathbf{y} . The expression $\mathbf{x}\mathbf{p} \leq \mathbf{y}$ defines the set of individual budget constraints in each period i.e. it says that the individual cannot afford to consume more traded goods in a given period than their income in that period allows. We assume that the period-specific flows of income and health quality are exogenously given, and our only concern is to value different lifetime bundles of these goods from a normative perspective rather than to predict long-term savings, consumption and health behaviours.

Our general lifetime well-being function depends on income and health over the lifetime, as well as lifespan, and thus can be represented by $w(\mathbf{y}, \mathbf{h}, l)$. The function is consistent with more income being better for the individual, more current period health quality being better, and more lifespan being better as long as one's life is 'worth living', but in our general theoretical framework we make no further normative or behavioural assumptions.

Canning (2013), on the other hand, does make a set of standard assumptions about individual preferences. He assumes preferences are represented on the bounded set of all the possible bundles F by a continuous utility function $u(\cdot)$ increasing in each argument, and strictly increasing in life span l ; this latter assumption, however, rules out the possibility of some health states being valued worse than being dead; and also similarly rules out states with consumption so low which would make 'life not worth living'.

When operationalising the framework later in this chapter, we do assume a specific functional form for the well-being function $w(\mathbf{y}, \mathbf{h}, l)$, which also respects most of the assumptions for the utility function by Canning (2013). One key difference, however, is that like the standard HALY approach we allow the existence of states worse than being dead. States worse than being dead raise possible behavioural puzzles for rational choice theorists – for example, the question of why people in states worse than dead do not always kill themselves. However, as our aim is to value well-being rather than to predict behaviour, this issue does not constrain us.

In Canning's framework, when the individual consumes a bundle of traded goods \mathbf{x} , her indirect utility from income, health and life-span can be represented by $v(\mathbf{y}, \mathbf{h}, l) = \max_{\mathbf{x}} \{u(\mathbf{x}, \mathbf{h}, l) | (\mathbf{x}, \mathbf{h}, l) \in F, \mathbf{x}\mathbf{p} \leq \mathbf{y}\}$, where F is the set of all possible bundles of traded goods,

⁷ In Canning's original framework health quality is a multidimensional concept with multiple health attributes. We simplify this to unidimensional concept of health quality, i.e. we summarise the multidimensional health attributes \mathbf{m}_t in time period t in the standard way by $h_t(\mathbf{m}_t)$, where h_t is scalar measured on the standard ratio scale of health-related quality of life used in health economics, anchored at 0 (to mean a health state not worth living through) and bounded above at 1 (to mean full health). We use year-specific scalar values, h_t to represent the individual's health-related quality of life in year t .

⁸ We denote individual lifetime vectors in bold.

health attributes and lifespan. This means that, given prices, the individual indirect utility $v(.)$ can be defined as a function of income, health attributes and lifespan.⁹

Consistent with the equivalence approach, Canning (2013) defines equivalent life (or what he calls “life-metric utility”) using a hypothetical trade-off between the individual’s actual life with their actual lifespan, income and health profile and a hypothetical life with assumed reference levels of “good” income and full health.

We follow a similar approach. More specifically, we define ‘equivalent life’, l^* , as the hypothetical number of life years that together with full health quality \mathbf{h}_{\max} and a reference “good” level of income \mathbf{y}_{ref} would generate the same well-being for the individual as her actual situation:

$$6.3 \quad w(\mathbf{y}_{\text{ref}}, \mathbf{h}_{\max}, l^*) = w(\mathbf{y}, \mathbf{h}, l)$$

This condition states that the utility derived from consuming the reference bundle of income and health over a life span of l^* is the same as the utility derived from consuming the actual bundle of income and health over the actual life span l .

Canning (2013) proves the uniqueness and existence of the equivalent life for the general case that satisfies his assumptions. In our specific case with the specific utility function that we will define, it is straightforward to also derive a unique l^* from the equivalence condition in equation 6.3.

We will use a similar approach to derive equivalent income (y^*) – defined as ‘the hypothetical income that together with perfect health (and lifespan) would put the individual in a situation that is for her as good as her actual situation’ (Samson et al., 2018). To do this, we need to specify both a lifetime vector of reference “perfect” level of health quality, \mathbf{h}_{\max} , and a reference “perfect” length of life, which we shall denote by l_{\max} .¹⁰

We can then modify the ‘equivalence condition’ in equation 6.3 to implicitly define a lifetime vector of equivalent income \mathbf{y}^* (instead of equivalent life):

$$6.4 \quad w(\mathbf{y}^*, \mathbf{h}_{\max}, l_{\max}) = w(\mathbf{y}, \mathbf{h}, l)$$

Empirically, one way to find the lifetime vector of the hypothetical equivalent income \mathbf{y}^* is to use information on individual i ’s willingness to pay (WTP) for perfect health (Samson et al., 2018). For example, if we set the benchmark for perfect health at 1 in each time period, i.e.

⁹ For brevity, we have omitted the price vector \mathbf{p} from the list of arguments of $v()$.

¹⁰ Notice that to derive the equivalent income, we now need to set not only a reference value for health quality \mathbf{h}_{\max} , but also a reference value for lifespan l_{\max} .

$\mathbf{h}_{\max} = \mathbf{1}$, then the aggregate lifetime equivalent income could be calculated using information on the WTP for a year in full health:

$$6.5 \quad \sum_{t=0}^l y_t^* = \sum_{t=0}^l (y_t - WTP(h_t \rightarrow 1))$$

where $WTP(h_t \rightarrow 1)$ is the individual WTP for a year in full health of 1 (one HALY), given their actual health.¹¹

6.3.2 A parametric approach to operationalising equivalent life

One parametric way of operationalising the equivalent life approach is to follow Cookson et.al. (R. Cookson et al., 2021b), and assume a simple additive period-specific well-being function, which requires three normative parameters to be set based on various sources of evidence and value judgement. Individual well-being at time t can be expressed as:¹²

$$6.6 \quad w_t = h_t + u(y_t) - 1, \quad \text{where } u(y_{i,t}) = A - B \times (y_t)^{1-\eta}$$

In equation 6.6, h_t is individual health quality at time t measured in HALYs, y_t is individual consumption at time t measured in dollars, and the instantaneous utility from consumption $u(.)$ is specifically defined as $u(y_{i,t}) = A - B \times (y_t)^{1-\eta}$, where $\eta > 1$ (“eta”) is a parameter representing the elasticity of the marginal value of consumption, and “-1”, A and B are normalisation constants ensuring that the well-being measure scale is appropriately anchored, so that the value 1 is a ‘good year of life’ and the value 0 is ‘state in which life is barely worth living’ (R. Cookson et al., 2021b).

More specifically, the constants A and B are defined as

$$A = y_{min}^{(1-\eta)} / (y_{min}^{(1-\eta)} - y_{std}^{(1-\eta)}) \quad \text{and} \quad B = 1 / (y_{min}^{(1-\eta)} - y_{std}^{(1-\eta)}), \text{ where:}$$

- y_{std} is standard consumption for a good standard of living, set at a level that the relevant social decision makers consider to represent a good living standard; one way of operationalising this is to assume that the reference level of income is equal to median income in the relevant population.

¹¹ Alternatively, this could be expressed in terms of the aggregate individual WTP for a full lifespan in full health: $\sum_{t=0}^{l_{max}} y_t^* = \sum_{t=0}^l y_t - WTP(\sum_{t=0}^l h_t \rightarrow l_{max})$, where $WTP(\sum_{t=0}^l h_t \rightarrow l_{max})$ is the WTP for a life with full lifespan (to be defined) and in full health.

¹² For simplicity, we ignore the individual-level subscript i , but the well-being is derived for each individual i .

- y_{min} is minimal consumption for a life worth living, set at a level that the relevant social decision makers consider to represent a living standard so extremely bad that life is barely worth living.^{13,14}

The higher the eta parameter, the more rapidly diminishing returns set in as consumption increases. The theoretical literature on “eta” supports the possibility that $\eta \leq 1$, in which case the well-being function is not bounded from above. However, the empirical literature supports values of “eta” of at least 1 (Layard et al., 2008).

We now assume the period-specific well-being function defined in equation 6.6, to operationalise the equivalent life measure using the trade-off represented by the equivalence condition in equation 6.3.

First, consistent with the approach for quantifying equivalent life described in the previous section, we set a reference “good” level of current period income, $\mathbf{y}_{ref} = \mathbf{y}_{std}$, and a reference “good” level of current period health quality, $\mathbf{h}_{max} = \mathbf{1}$, as common benchmarks which apply to all individuals. This is consistent with the equivalence condition (6.3) in the following form $w(\mathbf{y}_{std}, \mathbf{1}, l^*) = w(\mathbf{y}, \mathbf{h}, l)$. After substituting equation 6.6 in this, to represent well-being, $w(\mathbf{y}, \mathbf{h}, l) = \sum_{t=0}^l \{h_t + A - B \times (y_t)^{1-\eta} - 1\}$, the equivalence condition becomes:

$$6.7 \quad \sum_{t=0}^{l^*} \{1 + A - B \times y_{std}^{1-\eta} - 1\} = \sum_{t=0}^l \{h_t + A - B \times y^{1-\eta} - 1\}$$

From 6.7 we express the equivalent life, adjusted for health and income, l^* :

$$6.8 \quad l^* = \sum_{t=0}^l \{h_t + A - B \times y^{1-\eta} - 1\}$$

Consistent with the framework outlined above, the difference $l - l^*$ represent the number of life years that an individual would be willing to give up to exchange a life with their actual lifetime income and health (\mathbf{y}, \mathbf{h}) for a life with a “good” level of lifetime income and in full lifetime health $(\mathbf{y}_{std}, \mathbf{1})$.

Equation 6.8 shows that the equivalent life measure can be derived using the equivalence approach for constructing well-being measures, or the hypothetical trade-off between individual’s actual levels of lifetime income and health and assumed reference levels of “good” of income and full health. Therefore, the lifetime well-being QALY can also be interpreted as a measure of equivalent life.

¹³ This does not necessarily mean it would be better for the person to die, since death is irreversible (lasting for all future periods) whereas we are here defining well-being for a single period only. Rather than thinking of zero well-being as being as bad as death, therefore, it may be more helpful to think of it as a period of life that is no better than unconsciousness. This is a normative judgement which does not have to coincide with the subsistence level of consumption needed to sustain life.

¹⁴ If we know the proportional estimate of minimal consumption as a share of standard consumption ($k = \frac{y_{min}}{y_{std}}$), it is possible to simplify the parameters by setting $A = \frac{k^{1-\eta}}{k^{1-\eta}-1}$ and $B = \frac{A}{y_{min}}$.

It is also possible to operationalise equivalent income using a parametric approach analogous to the one used to operationalise equivalent life (see appendix 6.A.1). However, in this chapter we use a different non-parametric approach to operationalising equivalent income.

6.3.3 A simple non-parametric approach to operationalising equivalent income

In this section we describe a non-parametric approach used to operationalise equivalent income based on estimates of willingness to pay (WTP) for full health quality by income group. We estimate WTP for a life year (VSLY), and by assumption WTP for a year in full health (a HALY), in a given country and for income subgroups, in three steps (Verguet & Norheim, 2020 (submitted)). First, following Robinson et al, for a given country a , the value of a statistical life (VSL $_a$) can be estimated from country b , adjusting for income differences (L. Robinson et al., 2019b).

$$VSL_a = VSL_b \left(\frac{GNI_a}{GNI_b} \right)^{\epsilon},$$

where GNI is per capita gross national income for countries a and b , and ϵ is income elasticity.

We convert VSL to the value of VSLY by starting from the fact that WTP studies typically have asked about preferences over risk reductions for persons with an average age of 35 years. We assume:

$$VSLY_a = \frac{VSL_a}{e_{35}},$$

where e_{35} is life expectancy at age 35 for country a .

Third, for different income groups within a country, we treat groups similarly and estimate $VSLY_i$ by income group, adjusting for variation in income with the income elasticity parameter:

$$VSLY_g = VSLY_a \left(\frac{I_j}{I_a} \right)^{\epsilon},$$

where I_j is income for a given income group and I_a is mean income in that country. In our example below, we use $\epsilon = 1.2$ and assume that all individual in the same income group have the same WTP (Table 6.3, shown later).

6.4 Illustrative example - cancer in Ethiopia

We now illustrate the application of generalized utilitarian social welfare functions to these two measures of lifetime well-being compared with standard CEA and BCA in a simple, stylized example: cancer treatment for patients in a low-income country such as Ethiopia.

6.4.1 Baseline distributions

Consider a cohort of 100,000 people in a low-income country, all aged 50 years and observed for the next 30 years.¹⁵ For simplicity, we assume the cohort has enjoyed 50 healthy years since birth and that the maximum lifespan is 80. Mean income is about US\$ 790 per year per person, and we assume that all income is consumed each year.¹⁶ We create an individual-level distribution of income within the cohort with a Gini index of 0.30 using a gamma distribution. This distribution is then split into five income quintile groups (with annual income ranging from US\$ 311 to 1371), and for simplicity we assume that individuals belong to their income group from birth and have no mobility over time across income groups. At age 50, fifty percent of individuals are diagnosed with a cancer that gives them substantially shorter health adjusted life expectancy (HALE) – an unrealistically high incidence rate that we use for illustrative purposes. We assume that low-income groups have a higher cancer mortality risk than high-income groups, but for simplicity we assume there are no differences between income groups in cancer incidence. The remainder of the cohort is healthy with background mortality typical for their income group. At baseline, the group with cancer pays US\$10 out-of-pocket per year they are alive for palliative care with low effectiveness. No other treatment is available.

Thus, we construct a highly stylized example where we can estimate lifetime health and lifetime income over the lifespan of the cohort. Lifetime income and expected healthy lifespan (measured in HALYs) by quintile for both groups at baseline are given in Figure 6.2.

[Figure 6.2. here]

Next, a new cancer treatment is proven effective in a randomized controlled trial and if introduced will improve survival and quality of life. The cost of the treatment is US\$ 250 per year and treatment reduces the annual risk of death from 0.4 (on average across quintiles) to 0.1 and quality of life improves from 0.8 to 0.9 per year alive.

With these inputs, we created a Markov model (Figure 6.3) following a cohort of 100,000 people, divided into subgroups, over 30 years and compared costs, survival and quality of life across subgroups.

[Figure 6.3 here]

As seen from the figure, the population is divided into ten subgroups, by quintile 1– 5 and by health status. Each group is followed over 30 cycles, facing a given annual mortality risk that differ by income and health status. The healthy groups face annual background mortality as given in standard life tables for this population. Groups with cancer face higher mortality due to their disease. In the intervention arm, annual mortality risk and quality of life differ from the status quo. Key input parameters for the Markov model are provided in Table 6.1. We assumed

¹⁵ All inputs are available data for Ethiopia, a country with a population of about 100 million people, a low-income country according to World Bank classification of country income groups. Incidence of cancer is stylized so as to illustrate distributions better.

¹⁶ GNI per capita in US\$, 2018 (World Bank database, Atlas method).

a social gradient in annual mortality risk with cancer, and applied the same gradient to estimate background mortality for the healthy groups, by quintile.

Parameter Variables	Q1	Q2	Q3	Q4	Q5
Probability of survival without treatment	0.36	0.48	0.6	0.72	0.84
Probability of survival with treatment	0.9	0.9	0.9	0.9	0.9
Cost of ineffective treatment per year (\$)	10	10	10	10	10
Cost of treatment per year alive (\$)	250	250	250	250	250
Quality of life with local cancer	0.8	0.8	0.8	0.8	0.8
Quality of life with treated cancer	0.9	0.9	0.9	0.9	0.9

Table 6.1 Input variables for Markov model (we only show parameters related to cancer patients, all others for healthy groups are held constant). Q1-Q5 = quintile 1-5.

When the model is run for 30 years, the model gives us the proportion in each subgroup surviving by year, their quality of life by year, associated annual treatment costs, and their income by year. Expected survival and HALYs by subgroup over 30 years are also provided.

The first result of this modelling exercise is a simplified cost-effectiveness analysis where only direct treatment costs are included; other indirect costs are not taken into account. Treatment costs are considered regardless of whether they are covered through public finance or out of pocket. For simplicity, neither costs or health outcomes are discounted.

Strategy	Cost (\$)	Incremental cost (\$)	Health (HALYs)	Incremental health (HALYs)	ICER
Baseline	16		12.9		
UPF	1,197	1,181	15.9	3.0	392

Table 6.2. Results from cost-effectiveness analysis. ICER = incremental cost-effectiveness ratio (\$/HALYs).

Note: All costs and health gains are per capita.

We see from Table 6.2 that incremental cost per HALY gained per person is about US\$ 390. This ICER is about 50% of GDP per capita (\$790) and would probably be considered cost-effective by criteria suggested for low-income countries (Woods et al., 2016). Observe that all costs and all health gains are summarised across all subgroups and over the complete time horizon and dived by population size. Results are thus, by convention, expressed as averages per capita.

The Markov model provides additional information about subgroups that we use for further analysis. For example, the model produces survival curves for each subgroup that we now extend and use to evaluate lifetime health and lifetime income, and their distribution.

[Figure 6.4 here]

With Markov modelling¹⁷, we can project new health (Figures 6.4 and 6.5) and income (Figure 6.6) distributions for two policy options: introduce the new cancer treatment with universal public finance (UPF) based on taxes or compulsory insurance premiums proportional to income, or let the cost be borne by the patients, out-of-pocket, at the point of consumption (OOP).

[Figure 6.5 here]

With the latter policy option (OOP), we assume that the poorest quintile cannot afford treatment, so they pay no treatment cost and gain no health benefit (see Figure 6.5), while all other patients do pay for treatment.¹⁸ Under UPF all cancer patients receive treatment, including those in the poorest quintile group, so total cost and health gains will be somewhat higher.

[Figure 6.5 here]

Under the out-of-pocket finance policy (OOP), individuals with cancer, except quintile 1 with no ability to pay out of pocket, receive an effective treatment which costs US\$ 250 per year out of pocket. This yields a benefit for the treated individuals in the form of added life years and quality of life in each year. Better survival increases the lifespan and hence also lifetime income despite their out-of-pocket payment. Individuals without cancer pay nothing, so they have now loss of income under OOP.

Under the universal public finance policy (UPF), the cancer treatment is covered by a public tax, defined as a proportion of income. In this case, individuals without cancer pay taxes and get somewhat lower income. All cancer patients, including quintile 1, receive treatment. Survival is therefore improved for cancer patients in quintile 1. For all other groups survival is the same as under the OOP policy.

We see from Figure 6.6 that the distribution of lifetime income is unequal at baseline, and the pattern changes when treatment is introduced. Cancer patients live longer and therefore have more net income (except the poorest quintile 1 that cannot pay out of pocket for treatment). The healthy groups pay taxes under UPF, and net income for them is lower than under OOP, and more so for the better off. Among the cancer patients, net income is higher under UPF compared to OOP, and more so for the worse-off quintiles.

We assume zero administrative and deadweight loss costs of UPF taxation. The task is to evaluate these distributions in a framework that includes both health and income.

6.4.2 Calculation of lifetime well-being

¹⁷ Note that we simply add the first 50 years where everyone is healthy and belongs to their income group to get a lifetime perspective. This is obviously a simplifying assumption.

¹⁸ In appendix 6.A.5 (Table 6.A.5.1), we show results under the assumption that the poorest quintile pays out of pocket for treatment. This less realistic scenario has the advantage of equal costs under OOP and UPF so is simpler to compare.

Recall that in this example we follow a cohort of individuals from age 50 for a further 30 years, and assume a maximum lifespan of 80. Assume that the cohort P consists of N individuals, each denoted by i . We assume all individuals live their previous 50 years with full health quality, 1, at their existing level of income, y_i . Then each individual's remaining lifetime *income* (starting at $t=50$) y_i can be calculated as $y_i = \sum_{t=50}^{l_i} y_{it}$ and remaining lifetime *health* as $h_i = \sum_{t=50}^{l_i} h_{it}$, where l_i is the individual's lifespan. All of these variables can also be aggregated over the entire lifetime, i.e. starting from $t=0$.

We want to compare two alternative policies that both improve well-being compared to the baseline. We have already shown in Figure 6.2 the estimated distribution of health and lifetime income at baseline in each group. For the subset of individuals with cancer, with no policies implemented, they pay out-of-pocket US\$ 10 per year they are alive for ineffective palliative care; the rest of the individuals pay nothing.

The next step involves transforming lifetime health and income in each quintile under each policy to a well-being number.

6.4.2.1 Equivalent life in the different scenarios

Recall that equivalent life as a measure of well-being, $w(y_i, h_i)$, uses health and income as inputs and are calculated using the well-being functions discussed above for equation 6.6. In this example, we set the elasticity of the marginal value of income $\eta = 1.26$, minimal income y_{min} to US\$ 50 and standard income $y_{std} = \text{US\$ } 713$ (mean income), and obtain the values of equivalent life in each year.¹⁹ The yearly values can then be aggregated over the lifetime to obtain the individual and quintile group level lifetime well-being. The net difference in equivalent life in the two scenarios (OOP vs UPF) is illustrated in Figure 6.7.

[Figure 6.7. here]

We see from Figure 6.7 that among the healthy, the proportional tax with UPF imposes a slightly larger well-being loss on the poor compared to the rich (lower left quadrant). Among the cancer patients, the well-being gains are largest in quintile 1 (the poorest) under UPF compared to OOP (lower right quadrant). Observe, however, that OOP will also improve net well-being compared to baseline.

6.4.2.2 Equivalent income

We make various simplifying assumptions empirically to estimate equivalent income, and we do not use the same well-being equation approach as for equivalent life, as discussed in section 6.3.3, but rather use willingness to pay estimates from previous studies.

¹⁹ For a discussion of these assumptions, see (Cookson, Skarda et al, 2021).

We denote by $WTP_i(h_i \rightarrow h^*)$ the individual's willingness to pay for a year in normal health compared to their health (quality of life) in the baseline scenario, and the individual's marginal willingness to pay for one HALY by wtp_i . We then make the further simplifying assumption that when this marginal value is constant with respect to income, health and time period, the marginal value for a health improvement for individual i can be calculated as WTP for full health multiplied with full minus actual health $WTP_i(h_i \rightarrow h^*) = (wtp_i \times (h^* - h_i))$. Full health as a reference point is set to one HALY.

We further assume that individual WTP is constant at the margin but varies according to individual income quintile group, denoted by g . An individual's marginal WTP for a HALY thus does not vary as their own level of lifetime income and lifetime health change, but it does depend on their fixed income group – thus capturing the concept of increasing marginal value of health at group level but not at individual level (people with higher income have higher WTP for health improvements). Then we can express individual WTP as WTP at the margin for each quintile (wtp_g) times the actual health increase from a move from actual health to full health i.e. $WTP_g(h \rightarrow h^*) = wtp_g \times (h_{max} - h)$.

In our example, the marginal willingness to pay for a HALY in our low-income country is estimated from US WTP data by quintile groups of income, as explained in section 6.3.3. If available, it would be better to use more fine-grained empirical estimates. In our example, we assume that all individual in the same income group have the same WTP (Table 6.3).

Income Quintile Group	Mean Annual Income (US\$)	WTP for a HALY
1	311	285
2	520	528
3	713	772
4	948	1,087
5	1,371	1,691

Table 6.3. Estimated willingness to pay for a HALY, by income quintile group

We see from Table 6.3 that people in lower income groups have lower WTP for a HALY, in line with an increasing marginal rate of substitution of income for health at group level.

6.4.3 Equivalent income in the different scenarios

Net lifetime income and lifetime health can then be estimated as equivalent income as explained for equation 6.5 above. Figure 6.7 illustrates the distribution of equivalent income under baseline, OOP and UPF.

[Figure 6.8 here]

We see from Figure 6.8 that among the healthy, the proportional tax with UPF imposes a loss of lifetime equivalent income. For cancer patients, the level of equivalent income is higher with UPF than with OOP. Among the cancer patients, with UPF, the gain in equivalent income is highest among the poorest (quintile 1). If we compare UPF and OOP, we see that UPF is redistributive, with the healthy getting somewhat lower equivalent income (and a larger well-being loss on the richer quintiles) while the cancer patients get higher equivalent income (they live longer and do not pay out of pocket).

Our task is, next, to compare and evaluate these distributions of well-being, measured as equivalent life or equivalent income, by the use of social welfare functions.

6.4.4 Prioritarian SWF for equivalent life and equivalent income: comparing the two scenarios

Social welfare can be quantified by transforming individual-level lifetime well-being numbers (measured as equivalent life or equivalent income) by a strictly increasing and strictly concave transformation function (as discussed in Adler, chapter 2, his volume) and then aggregating over individuals (for further details, see Appendix (6.A.3)). We use these SWFs to compare *distributions* of equivalent life (as illustrated in Figure 6.7) and equivalent income (as illustrated in Figure 6.8) under the two policies.

6.4.4.1 Ex ante and ex post evaluations

To evaluate distributions of health and income under OOP and UPF from the *ex ante* and *ex post* perspective²⁰, we use information on survival by income group and year available as output from the Markov model. For *ex ante* evaluations, we simply use as input expected life years at t_0 for each quintile, with and without cancer (see Figure 6.5, lower panel). Expected healthy lifespan is used to generate health distributions, and expected life years multiplied with net income (with OOP or UPF) gives us distributions of expected lifetime income. These are then converted into well-being numbers and the transformed sum of expected well-being for each policy is calculated as described above.

For *ex post* evaluations, we use information on survival by year, the survival curve method, as described by Adler and others ((Adler 2019, chapter 5), see also (Adler, 2020; Jamison et al., 2020)). We do not have information about identified individuals, but we have information on the expected proportion of each quintile in the cohort surviving each year, and we convert this information to a distribution profile of age at death by quintile (see Figure 6.9). For example, treatment for cancer patients, compared to the baseline, will shift a left-skewed distribution profile to the right (Figure 6.8, right panel).

[Figure 6.9 here]

²⁰ We follow the distinction made by Adler, chapter 2, this volume: (1) *ex ante* prioritarianism: the sum across individuals of transformed expected well-being; and (2) *ex post* prioritarianism: the sum across individuals of expected transformed well-being.

A higher proportion in each quintile survives for more years. Improvements in quality of life and lifetime income follows the same pattern. *Ex post* distributions in each quintile are aggregated by taking into account the expected proportion of people alive each year, their quality of life, and their net income, then transformed to equivalent life or equivalent income by year, and finally transformed and summarised by a prioritarian social welfare function (for more details, see Appendix: 6.A.3). This gives us the sum across individuals of expected transformed well-being.

6.4.4.2 Equally distributed equivalent well-being

For ease of comparison, we calculate equally distributed equivalent well-being (EDE_w) for each scenario and for *ex ante* and *ex post* evaluations. The EDE_w is the level of well-being that if equally distributed would generate the same level of social welfare as that generated by the actual distribution of well-being. EDE_w is ordinally equivalent to the index of social welfare – i.e. it ranks well-being distributions in the same order. EDE_w expresses the level of social welfare represented by a prioritarian SWF on the same scale as the measure of well-being. In Table 6.4, EDE is expressed as equivalent life (measured in good life years) or equivalent income (measured in dollars).²¹

6.4.5 Summary results

Table 6.4 compares social welfare per capita (expressed as EDE_w) calculated using equivalent income and equivalent life (with $\eta = 1.26$) across the two scenarios OOP and UPF, *ex ante* and *ex post*. We use the Atkinson SWF (as discussed in detail in Adler, chapter 2, this volume) and we use five values for γ , the gamma parameter, 0, 0.5; 1.0; 1.5; and 2. In the case when $\gamma = 0$, γ represents a utilitarian social welfare function, i.e. the welfare of people is not assumed to have diminishing social value.

Gamma	Baseline		OOP		UPF	
	Equivalent Income, \$	Equivalent Life, Well-Being QALYs	Equivalent Income, \$	Equivalent Life, Well-Being QALYs	Equivalent Income, \$	Equivalent Life, Well-Being QALYs
	<i>Utilitarian</i>					
0	49,023	61.8	50,032	63.8	50,046	64.3
	<i>Ex Ante Prioritarian, EDE_w</i>					
0.5	45,641	60.9	46,644	63.0	46,929	63.7
1	42,297	60.0	43,251	62.2	43,826	63.1
1.5	39,109	59.1	39,972	61.3	40,845	62.4
2	36,184	58.3	36,926	60.5	38,084	61.8
	<i>Ex Post, EDE_w</i>					
0.5	45,560	60.8	46,540	62.8	46,799	63.5
1	42,152	59.8	43,062	61.8	43,575	62.7
1.5	38,916	58.9	39,720	60.9	40,483	61.8
2	35,958	57.9	36,635	59.9	37,624	61.0

²¹ Note that EDE_w is not the same as expected EDE discussed in chapter 2, this volume. Rather, we are simply giving an ordinal rescaling of the *ex ante* and *ex post* valuation on the same scale as the measure of well-being.

Table 6.4. Summary per capita results for all evaluation approaches

Our example is set up so that universal public finance increases utilization of the cancer treatment among patients in the lowest-income group, increases consumption for other cancer patients (who no longer have to pay out-of-pocket treatment costs) and reduces consumption for the rest of the population (who have to pay additional taxes).

We see from Table 6.4 that EDE_w is higher for UPF and OOP than at baseline, and favours UPF over OOP. This holds, in this case, for all values of gamma tested, including $\gamma = 0$ (utilitarian SWF). In this case, the choice of well-being metric does not make a difference. Neither does the choice of *ex ante* versus *ex post* perspective.

The UPF scenario is favoured for two reasons: first, it generates additional health benefits in the worst-off groups (low-income cancer patients) and second, it delivers a progressive income redistribution favouring worse-off groups i.e. from rich to poor and healthy to sick.

Utilitarian evaluation based on equivalent life is also sensitive to the difference between OOP and UPF because equivalent life allows for diminishing marginal value of consumption in terms of health (or, equivalently, increasing willingness to pay for marginal health gains as consumption increases), although it is not sensitive to transfers of well-being.²²

Although SWF analysis is always at population level, we first presented social welfare in per capita terms in Table 6.4 because we believe it is easier to understand. Table 6.5 compares aggregate social welfare in a cohort of 100,000 individuals.

Gamma	OOP vs. Baseline		UPF vs. OOP	
	Equivalent Income, \$	Equivalent Life, Well-Being QALYs	Equivalent Income, \$	Equivalent Life, Well-Being QALYs
		<i>Utilitarian</i>		
0	100,898,997	193,523	1,428,816	53,701
		<i>Ex Ante Prioritarian, EDE_w</i>		
0.5	100,363,584	204,222	28,464,253	69,812
1	95,414,154	213,088	57,541,133	88,004
1.5	86,268,077	219,718	87,290,136	108,317
2	74,178,028	223,787	115,839,364	130,710
		<i>Ex Post, EDE_w</i>		
0.5	97,978,068	198,093	25,881,318	66,885
1	90,997,985	200,512	51,312,206	81,202
1.5	80,436,311	200,603	76,261,587	96,508
2	67,674,075	198,311	98,960,294	112,594

Table 6.5. Summary results for all evaluation approaches (incremental over 30 years in the cohort of 100,000 people)

Table 6.5 shows the results from a population-level rather than individual-level perspective and also in incremental terms making two pairwise comparisons: OOP versus baseline, and UPF

²² Utilitarian evaluation based on equivalent income would not be sensitive to this difference, if costs and survival were the same in the two scenarios, e.g. if also cancer patients in quintile 1 receive and pay for treatment out-of-pocket (as shown in Appendix, Table 6.A.4.1). This is so because the method to translate health and income allows for no diminishing marginal value of consumption.

versus OOP. From a decision-making perspective the relevant comparison is between the two relevant policy options: UPF versus OOP. Under utilitarian evaluation, this comparison shows that UPF provides a gain of \$1.4m dollars of equivalent income (\$14 per capita) or 53.7 thousand years of equivalent life or “wellbeing QALYs” (0.53 per capita). Under prioritarian evaluation these gains are valued more highly, because they are concentrated among worse off individuals – and the higher the gamma parameter value representing concern for the worse-off, the larger the gains.

Finally, we compare the two policy options using benefit-cost analysis, with results provided in Table 6.6. We show both benefits that include survivor consumption (benefits consist of income and health benefits) and benefits that exclude survivor consumption (benefits consist only of health benefits). Health benefits are converted to monetary terms using the population average willingness to pay for health. Costs are health care costs, whether paid for privately via OOP or publicly via UPF. We follow the standard convention in applied benefit-cost analysis of valuing health gains for rich and poor the same, rather than valuing them differentially at willingness to pay values that reflect differential ability to pay in rich and poor groups. This means that the health gains to poorer individuals under UPF compared with OOP are valued substantially more highly than their willingness to pay values. For this reason, the net benefit of UPF compared with OOP shown in Table 6.6 (\$38.4m with survivor consumption benefits and \$34.9m without) is much higher than the gain in equivalent income under utilitarian evaluation shown in Table 6.5 above (only \$1.4m).

	OOP vs. Baseline		UPF vs. OOP	
	Health Care Benefit, \$	Health Care Cost, \$	Incremental Health Care Benefit, \$	Incremental Health Care Cost, \$
<i>Including survivor consumption benefits</i>				
	285,930,999	85,163,168	59,971,344	21,489,949
<i>Benefit-Cost Ratio</i>	3.36		2.79	
<i>Net Benefit</i>	200,767,832		38,481,395	
<i>Excluding survivor consumption benefits</i>				
	176,429,032	85,163,168	56,407,196	21,489,949
<i>Benefit-Cost Ratio</i>	2.07		2.62	
<i>Net Benefit</i>	91,265,865		34,917,247	

Table 6.6. Benefit-cost analysis, total costs and benefits over 30 years in a cohort of 100,000 people.

If we slightly change our example so that cancer patients in the poorest quintile group receive and pay for treatment out-of-pocket, aggregate costs and survival are the same in the two scenarios – and so there is no health benefit of UPF, only an income redistribution effect. Benefit-cost analysis will then not distinguish between the OOP and UPF policy, while a prioritarian SWF will clearly do so (see Appendix, Table 6.A.4.1 and 6.A.4.2).

6.5 Conclusion

This chapter presents a practical prioritarian approach to economic evaluation of health programmes, taking into account impacts on income as well as health. Our approach proceeds in three steps.

First, we need information on the impact of health programs, both on changes in health and changes in income after all costs are taken into account, and on baseline levels of income and health. Second, we combine individual-level information on income and health to generate an index of well-being. We describe two ways of constructing a wellbeing index: the equivalent life and the equivalent income approach. We measure equivalent life using a well-being function with three parameters (reference income, minimum income, and the elasticity of the marginal value of income). We measure equivalent income using empirical data on willingness to pay for full health quality by income group. Third, we compare and rank health programmes by the sum of a strictly increasing and strictly concave transformation of individual levels of lifetime well-being.

We have illustrated how these two metrics can be used to conduct lifetime prioritarian evaluation using a simple hypothetical comparison of two funding options for cancer treatment in a low-income country – out-of-pocket payment (OOP) and universal public funding (UPF) funded by taxes or compulsory insurance premiums proportional to income. In our simple example, OOP had treatment and health effects for all cancer sufferers, except the poorest part of the population without ability to pay. UPF had treatment and health effects for all cancer sufferers, and income effects for all population sub-groups through taxation. Compared with OOP, UPF increases utilization of cancer treatment and reduces current period income in the lowest-income group of cancer sufferers: they now receive treatment, rather than remaining untreated, but have to pay insurance premiums. The overall effect is to increase lifetime income as well as lifetime health in this sub-group, since they live longer. UPF has no effect on utilisation, health or total income in other groups, but effects a progressive income redistribution from healthy (people without cancer) to sick (people with cancer) – people without cancer now pay additional insurance premiums while people with cancer only pay insurance but not higher out-of-pocket costs – with further progressivity since premiums are proportional to income.

We find that standard cost-effectiveness analysis and benefit-cost analysis are not sensitive to income redistribution, and so in our example their recommendations depend only on the total effects on health and income in the poorest group of cancer sufferers. Lifetime prioritarian evaluation is sensitive not only to total effects on health and income but also to progressive redistribution of lifetime income, health and well-being favouring the worse-off. It is more data intensive, however, since it requires effect estimates to be broken down by social group and it also requires baseline estimates of income and health for each social group from birth to death.

6.A. Appendix

6.A.1. A simple parameterisation of the equivalent income

In this appendix section we show how equivalent income could be operationalised in the same parametric way used to operationalise equivalent life, rather than in the non-parametric way used in the chapter based on estimates of willingness to pay for full health by income groups. We can impose the assumption of the well-being function in (6), and then use the equivalence condition in (4), to derive the expression for equivalent income under these assumptions.

More specifically, substitute equation 6.6 for the period-specific well-being function in the equivalence condition in 6.4, and get:

$$6.A.1.1 \quad \sum_{t=0}^{l_{max}} \{h_{max} + A - B \times (y_t^*)^{1-\eta} - 1\} = \sum_{t=0}^l \{h_t + A - B \times y_t^{1-\eta} - 1\}$$

This is the equivalence condition expressed as a trade-off over lifetime. To express lifetime equivalent income from it, it is useful to re-write the condition as multiple short-term trade-offs in each year up to the full lifespan l_{max} .^{23 24}

$$6.A.1.2 \quad \begin{cases} h_{max} + A - B \times (y_t^*)^{1-\eta} - 1 = h_t + A - B \times y_t^{1-\eta} - 1, & \text{for } 0 \leq t \leq l \\ h_{max} + A - B \times (y_t^*)^{1-\eta} - 1 = 0, & \text{for } l < t \leq l_{max} \end{cases}$$

When express y_t^* from the equation 6.A.1.2 and substitute in the equations for constants A , B as defined for equation 6.6, we obtain the following expression for equivalent income annually for each year t :

$$6.A.1.3 \quad y_t^* = \begin{cases} \left(y_t^{1-\eta} + (y_{min}^{1-\eta} - y_{std}^{1-\eta})(1 - h_t) \right)^{\frac{1}{1-\eta}}, & \text{for } 0 \leq t \leq l \\ y_{min}, & \text{for } l < t \leq l_{max} \end{cases}$$

We can aggregate the yearly equivalent income in 6.A.1.3 over the full life-span to get the expression for full lifetime equivalent income as:

$$6.A.1.4 \quad \sum_{t=0}^{l_{max}} y_t^* = \sum_{t=0}^l \left(y_t^{1-\eta} + (y_{min}^{1-\eta} - y_{std}^{1-\eta})(1 - h_t) \right)^{\frac{1}{1-\eta}} + (l_{max} - l)y_{min}$$

²³ When assuming the well-being function defined by (6) and the annual stream of income to be exogenously given, analysing the lifetime equivalence condition or trade-off in (6.A.1.1.) will yield the same expression for lifetime equivalent income as analysing the multiple short-term trade-offs in each year as in (6.A.1.2), and then aggregating the annual equivalent income.

²⁴ In the potential extra life years t of full life span which go beyond the individual's actual lifespan, i.e. for t values when $l < t \leq l_{max}$, we are comparing the well-being from full health and equivalent income, with the well-being from being dead, i.e. zero well-being.

From (6.A.1.4) we can also express WTP for each year of full health over one's life and up to the full lifespan, as the difference between one's actual income and the hypothetical equivalent income each year:

$$6.A.1.5 \quad \begin{aligned} WTP(h_t \rightarrow 1) &= y_t - y_t^* = \\ &= \begin{cases} y_t - \left(y_t^{1-\eta} + (y_{min}^{1-\eta} - y_{std}^{1-\eta})(1 - h_t) \right)^{\frac{1}{1-\eta}}, & \text{for } 0 \leq t \leq l \\ 0 - y_t^* = -y_{min}, & \text{for } l < t \leq l_{max} \end{cases} \end{aligned}$$

In the years up to one's actual lifespan, i.e. for t -values such that $0 \leq t \leq l$, the WTP for full health is a function of one's income and health $WTP(h_t \rightarrow 1) = f(y_t, h_t)$, moreover this function is increasing in one's actual income and decreasing in one's actual health quality, i.e. , i.e. $\frac{\partial f(y_t, h_t)}{\partial y_t} > 0$ and $\frac{\partial f(y_t, h_t)}{\partial h_t} < 0$. In the potential extra years that go beyond one's actual lifespan, i.e. for t -values such that $l < t \leq l_{max}$, the WTP is simply 'minus y_{min} '. It means that an individual would be willing to "trade off being dead with being alive" if they were given at least the income of y_{min} , which would "make the year of life barely worth living" (which is the anchor point of the well-being function characterised in (6), for a year in full health but with income of y_{min}).

6.A.2. When are equivalent life and equivalent health equivalent?

In this appendix section we show that equivalent life and equivalent health will yield the same recommendations if they are both operationalised using the well-being function represented by equation 6.6. This result only holds, however, if we use a function that is additively separable in health and income.

Let us re-write the equivalence condition in 6.3 so that it defines the lifetime vector of 'equivalent health quality' \mathbf{h}^* :

$$6.A.2.1 \quad w(\mathbf{y}_{std}, \mathbf{h}^*, l_{max}) = w(\mathbf{y}, \mathbf{h}, l)$$

\mathbf{h}^* here represents "equivalent health": it is the hypothetical lifetime vector of health quality that, together with full lifespan l_{max} and a reference "good" level of income \mathbf{y}_{std} , would generate the same well-being for the individual as her actual situation.

To express lifetime equivalent health, it is useful to re-write the condition as multiple short-term trade-offs in each year up to the full lifespan l_{max} :²⁵

$$6.A.2.2 \quad \begin{cases} h_t^* + A - B \times y_{std}^{1-\eta} - 1 = h_t + A - B \times y_t^{1-\eta} - 1, & \text{for } 0 \leq t \leq l \\ h_t^* + A - B \times y_{std}^{1-\eta} - 1 = 0, & \text{for } l < t \leq l_{max} \end{cases}$$

In 6.A.2.2 the trade-off in the years beyond one's death, i.e. for t such that $l < t \leq l_{max}$ involves making the comparison to "being dead" which would yield a well-being of zero.

When express the annual equivalent health h_t^* from 6.A.2.2, get:

²⁵ When we assume the well-being function in 6.6 and the annual stream of income to be exogenously given, analysing the lifetime trade-off in equation 6.A.2.1 will yield the same answer for equivalent health as analysing multiple short-term trade-offs in each year, up to the full life-span l_{max} , as in 6.A.2.2.

$$6.A.2.3 \quad h_t^* = \begin{cases} h_t + A - B \times y_t^{1-\eta} - 1, & \text{for } 0 \leq t \leq l \\ 0, & \text{for } l < t \leq l_{max} \end{cases}$$

When aggregate the annual expressions up to the full lifespan, then one gets the expression for lifetime equivalent health $h^* = \sum_{t=0}^l \{h_t + A - B \times y_t^{1-\eta} - 1\}$, which is the same as the expression for equivalent life in equation 6.8.

This result would not necessarily hold, however, if health and income were not additively separable in the well-being function, e.g. in the case when there are important interactions between health and income.

6.A.3. Prioritarian SWFs for equivalent life and equivalent income

In this appendix we write down the formal equations for the prioritarian SWFs used in the illustrative example. If we assume a population of N individuals, indexed by $i=1..N$, and denote by w_i the lifetime well-being of individual i , then we can quantify social welfare S as:

$$6.A.3.1 \quad S = \sum_{i=1}^N g(w_i), \quad \text{where} \\ g(w_i) = \begin{cases} \frac{1}{1-\gamma} \{w_i\}^{1-\gamma} & \text{for } \gamma \geq 0 \text{ and } \gamma \neq 1 \\ \ln w_i & \text{for } \gamma = 1 \end{cases}$$

When $\gamma = 0$, equation 6.A.3.1 represents a utilitarian evaluation, and when $\gamma > 0$, then it represents a prioritarian evaluation.

In section 4 (illustrative example – cancer in Ethiopia), we evaluate social welfare in three policy scenarios – the baseline scenario, out of pocket finance policy scenario and universal public finance policy scenario.

We use both well-being measures:

- equivalent life, i.e. $w_i(h_i, y_i) = l_i^*$ where l_i^* is defined by equation (8), and
- equivalent income, i.e. $w_i(h_i, y_i) = y_i^*$ where y_i^* defined by equation (5).

Below we show how to derive these well-being measures in the three scenarios.

Baseline scenario

Assume that a subset of individuals $i \in C$ are ill with cancer, and they pay an out-of-pocket fixed cost $e > 0$ per year they are alive for ineffective palliative care; the rest of the individuals pay nothing.

The lifetime equivalent income of individual i can be expressed as:

$$6.A.3.2 \quad y_i^* = \sum_{t=0}^{49} y_{it}^* + \sum_{t=50}^{l_i} y_{it}^* =$$

$$= \sum_{t=0}^{49} (y_{it} - WTP_i \times (1 - h_{it})) + \sum_{t=50}^{l_i} (y_{it} - e_{|i \in C} - WTP_i \times (1 - h_{it}))$$

where $e_{|i \in C}$ means that the cost e is faced only if an individual is in the group with cancer, $i \in C$, and is zero otherwise.

Similarly, we will use this notation for other variables, e.g. for any variable x :

$$x_{|i \in C} = \begin{cases} x, & \text{if } i \in C \\ 0, & \text{if otherwise} \end{cases}$$

The equivalent life of individual i can be quantified as:

$$\begin{aligned} 6.A.3.3 \quad l^*_i &= \sum_{t=0}^{49} l^*_{it} + \sum_{t=50}^{l_i} l^*_{it} = \\ &= \sum_{t=0}^{49} \{h_{it} + A - B \times (y_{it})^{1-\eta} - 1\} + \sum_{t=50}^{l_i} \{h_{it} + A - B \times (y_{it} - e_{|i \in C})^{1-\eta} - 1\} \end{aligned}$$

where A and B , are the constants as defined for the equation 6.6.

Out-of-pocket finance policy scenario

Assume that the subset of individuals with cancer $i \in C$ now can receive an effective treatment which costs z per year out of pocket to the cancer patient and yields a benefit for the treated individual i in the form of l'_i added life years and added health quality in each year equal to h'_i . Also, this treatment cannot be afforded by the poorest individuals in the lowest income quintile group (i.e. income quintile group 1), marked by $g=1$.

In this scenario, the lifetime equivalent income of individual i can be expressed as:

$$\begin{aligned} 6.A.3.4 \quad y^*_i &= \sum_{t=0}^{49} y^*_{it} + \sum_{t=50}^{l_i+l'_i|i \in C \& g \neq 1} y^*_{it} = \\ &= \sum_{t=0}^{49} (y_{it} - WTP_i \times (1 - h_{it})) + \\ &\quad + \sum_{t=50}^{l_i+l'_i|i \in C \& g \neq 1} (y_{it} - z_{|i \in C \& g \neq 1} - e_{|i \in C \& g=1} - WTP_i \times (1 - h_{it} - h'_i|i \in C \& g \neq 1)) \end{aligned}$$

Where for any variable $x_{|i \in C \& g \neq 1} = \begin{cases} x, & \text{if } i \in C \text{ and } g \neq 1 \\ 0, & \text{if otherwise} \end{cases}$, which means that any variable x applies only to the cancer patients not in the 1st income quintile group, and is zero otherwise;

and where $e_{|i \in C \& g=1} = \begin{cases} e, & \text{if } i \in C \text{ and } g = 1 \\ 0, & \text{if otherwise} \end{cases}$ means that the palliative care cost e is faced by the cancer patients in the bottom income quintile group only.

Similarly, the equivalent life of individual i can be quantified as:

$$\begin{aligned}
6.A.3.5 \quad l^*_i &= \sum_{t=0}^{49} l^*_{it} + \sum_{t=50}^{l_i+l'_i|_{i \in C \& g \neq 1}} l^*_{it} = \\
&= \sum_{t=0}^{49} \{h_{it} + A - B \times (y_{it})^{1-\eta} - 1\} + \\
&\quad + \sum_{t=50}^{l_i+l'_i|_{i \in C \& g \neq 1}} \{h_{it} + h'_{i|_{i \in C \& g \neq 1}} + A - B \times (y_{it} - z_{i \in C \& g \neq 1} - e_{i \in C \& g = 1})^{1-\eta} \\
&\quad - 1\}
\end{aligned}$$

Universal public finance policy

Assume the scenario above, but the cancer treatment is covered by a public tax, defined as a proportion τ of income. In this case, cancer patients in quintile 1, with low ability to pay out of pocket, will also receive treatment. Also, we assume $\sum_{i=1}^N (l_i + l'_{i \in C} - 49) \times z_{i \in C} = \tau \times \sum_{i=1}^N \sum_{t=50}^{l_i+l'_i|_{i \in C}} y_{it}$ (the tax rate is such that it exactly covers the cohort health care costs).

In this scenario, the lifetime equivalent income of individual i can be expressed as:

$$\begin{aligned}
6.A.3.6 \quad y^*_i &= \sum_{t=0}^{49} y^*_{it} + \sum_{t=50}^{l_i+l'_i|_{i \in C}} y^*_{it} = \\
&= \sum_{t=0}^{49} (y_{it} - WTP_i \times (1 - h_{it})) + \\
&\quad + \sum_{t=50}^{l_i+l'_i|_{i \in C}} \left((1 - \tau) \times y_{it} - WTP_i \times (1 - h_{it} - h'_{i|_{i \in C}}) \right)
\end{aligned}$$

Similarly, the equivalent life of individual i can be quantified as:

$$\begin{aligned}
6.A.3.7 \quad l^*_i &= \sum_{t=0}^{49} l^*_{it} + \sum_{t=50}^{l_i+l'_i|_{i \in C}} l^*_{it} = \\
&= \sum_{t=0}^{49} \{h_{it} + A - B \times (y_{it})^{1-\eta} - 1\} + \\
&\quad + \sum_{t=50}^{l_i+l'_i|_{i \in C}} \{h_{it} + h'_{i|_{i \in C}} + A - B \times ((1 - \tau) \times y_{it})^{1-\eta} - 1\}
\end{aligned}$$

Ex ante evaluation

To calculate the *ex ante* social welfare, we use $E(w_j)$ as input in the social welfare transform $g()$, where $E(w_j)$ denotes the expected lifetime well-being at $t=0$ for an individual in quintile group j , calculated for all quintile groups $j=1, \dots, 5$:

$$S^{EAP} = \frac{N}{5} \sum_{j=1}^5 g(E(w_j)) = \frac{N}{5} \sum_{j=1}^5 g\left(\sum_{t=0}^{l_{max}} w_{jt} p_{jt}\right)$$

The expected lifetime well-being for group j , is calculated as $E(w_j) = \sum_{t=0}^{l_{max}} w_{jt} p_{jt}$, where p_{jt} is the probability that an individual in group j survives up to age t . Finally, we multiply the term with $\frac{N}{5}$ which is the number of people in each quintile group.

For simplicity, we do not distinguish here between individuals with and without cancer, but we carry out this calculation separately for both groups – the group with cancer and the group without cancer.

Ex post evaluation

If individual-level data was available, we could calculate the ex-post social welfare as follows:

$$S^{EPP} = \sum_{i=1}^N g\left(\sum_{t=0}^{l_i} w_{it}\right)$$

However, as we do not have individual-level data on wellbeing, we estimate the *ex-post* wellbeing distribution using period-specific survival probabilities for each income quintile group (that we extract from our Makrov model), and then use that as input in the social welfare transform $g()$:

$$S^{EPP} = \frac{N}{5} \sum_{j=1}^5 \sum_{t=0}^{l_{max}} \left\{ (p_{jt} - p_{j,t+1}) g\left(\sum_{\tau=0}^t w_{j\tau}\right) \right\}$$

More specifically, as we do not have information on w_{it} but only on w_{jt} , we estimate the proportion of people in each quintile group j with life expectancy of t years (or, alternatively, people dying at age $t+1$) as $p_{jt} - p_{j,t+1}$ and multiply that with their lifetime wellbeing, which can be calculated as the cumulative sum of well-being up to age t , $\sum_{\tau=0}^t w_{j\tau}$.

6.A.4 Alternative tables (equal costs in OOP and UPF: cancer patients in quintile 1 receives treatment under OOP)

Gamma	Baseline		OOP		UPF	
	Equivalent Income, \$	Equivalent Life, well-being QALYs	Equivalent Income, \$	Equivalent Life, well-being QALYs	Equivalent Income, \$	Equivalent Life, well-being QALYs
<i>0</i>	49,022	61.8	<i>Utilitarian</i>		50,046	64.3
			<i>Ex Ante Prioritarian, EDE</i>			
<i>0.5</i>	45,641	60.9	46,669	62.9	46,929	63.7
<i>1</i>	42,297	60.0	43,290	62.1	43,826	63.0

1.5	39,109	59.1	40,029	61.3	40,845	62.4
2	36,184	58.3	37,005	60.4	38,084	61.8
<i>Ex Post, EDE</i>						
0.5	45,560	60.8	46,565	62.8	46,799	63.5
1	42,152	59.8	43,101	61.8	43,575	62.7
1.5	38,916	58.9	39,777	60.8	40,483	61.8
2	35,958	57.9	36,711	59.8	37,624	61.0

Table 6.A.4.1. Summary results for all evaluation approaches

	OOP vs. Baseline		UPF vs. OOP	
	Benefit, \$	Cost, \$	Benefit, \$	Cost, \$
<i>Including survivor consumption benefits</i>				
	3,459	1,067	0.00	0.00
Benefit-Cost Ratio	3.24		NA	
<i>Excluding survivor consumption benefits</i>				
	2,328	1,067	564.07	214.90
Benefit-Cost Ratio	2.18		2.68	

Table 6.A.4.2. Benefit-cost analysis

The benefits including survivor consumption benefits consist of income and health benefits. The benefits excluding survivor consumption benefits consist only of health benefits. Health benefits are converted to monetary terms using the population average willingness to pay for health.

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Figures

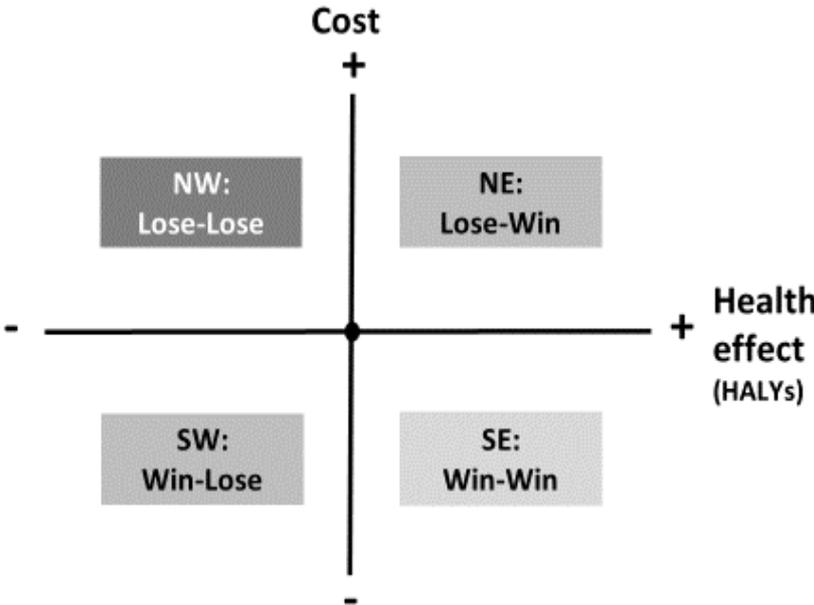


Figure 6.1. Cost-effectiveness plane

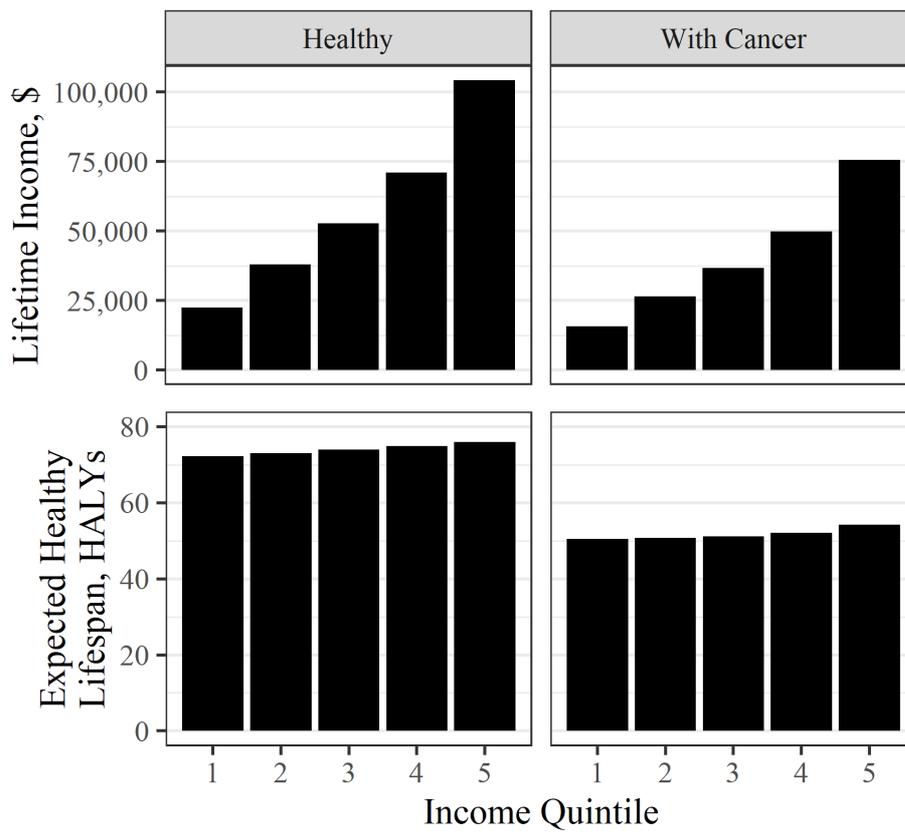


Figure 6.2. Baseline distributions of income and health

Note: Lifetime income is undiscounted sum for period income by quintile (annual income times expected lifespan, by quintile).

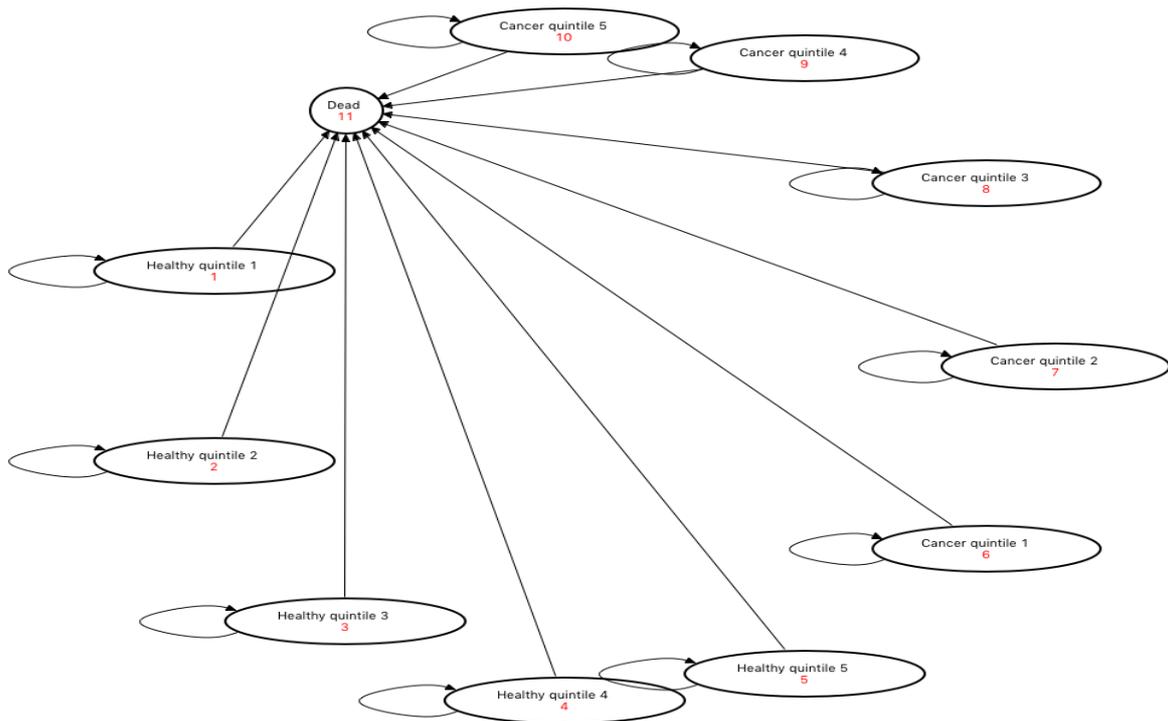


Figure 6.3. State transition diagram for the Markov model. The population is divided into ten subgroups, by quintile 1 (lowest income) – 5 (highest income), and by health status (healthy or with cancer).

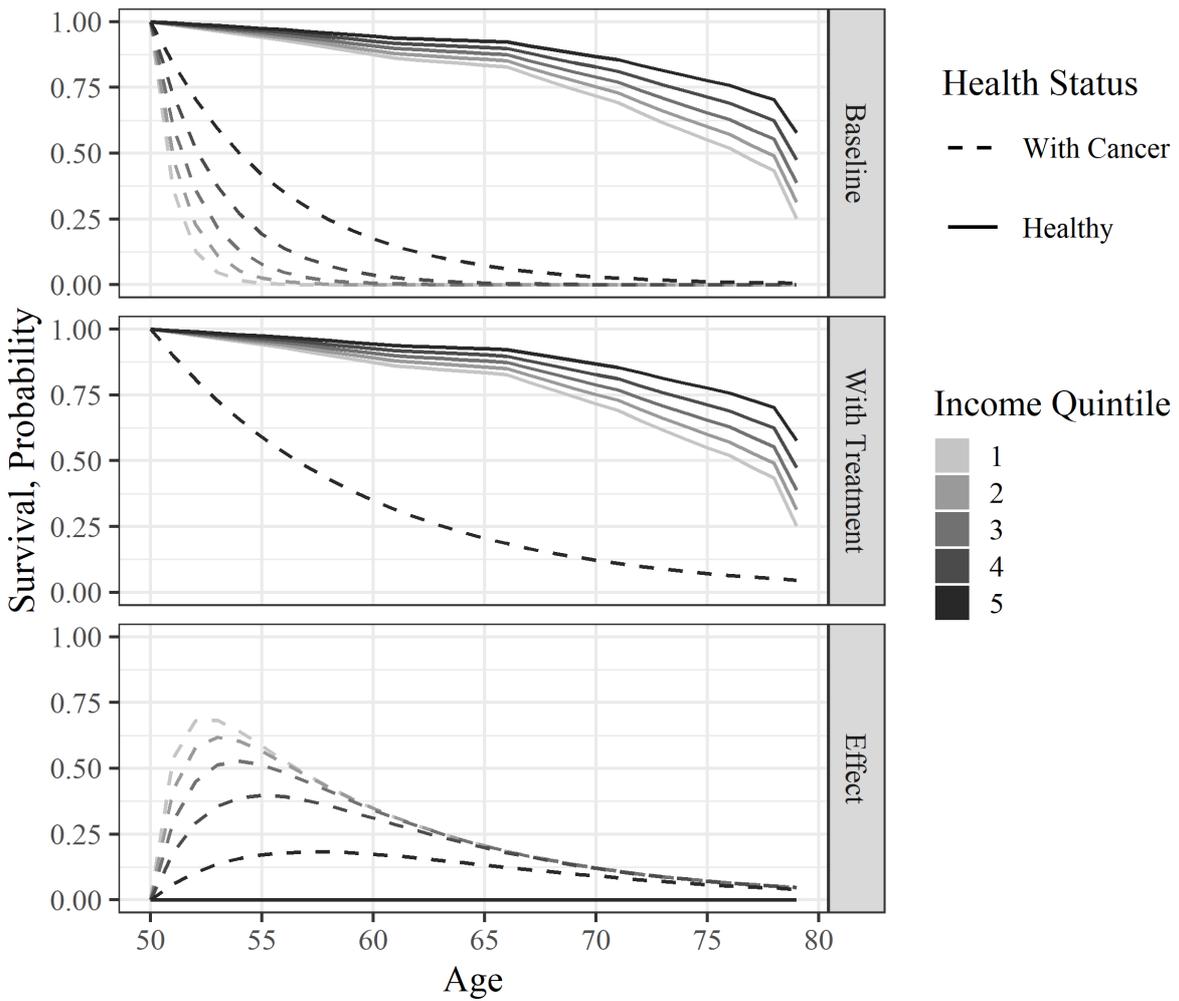


Figure 6.4. Survival by income quintile group with and without treatment, and the resulting effects, comparing the healthy (solid lines) and cancer (dotted lines) populations.

Note: Under OPP, the survival effect is zero for the poorest group 1 of cancer patients who do not receive treatment because they cannot afford it.

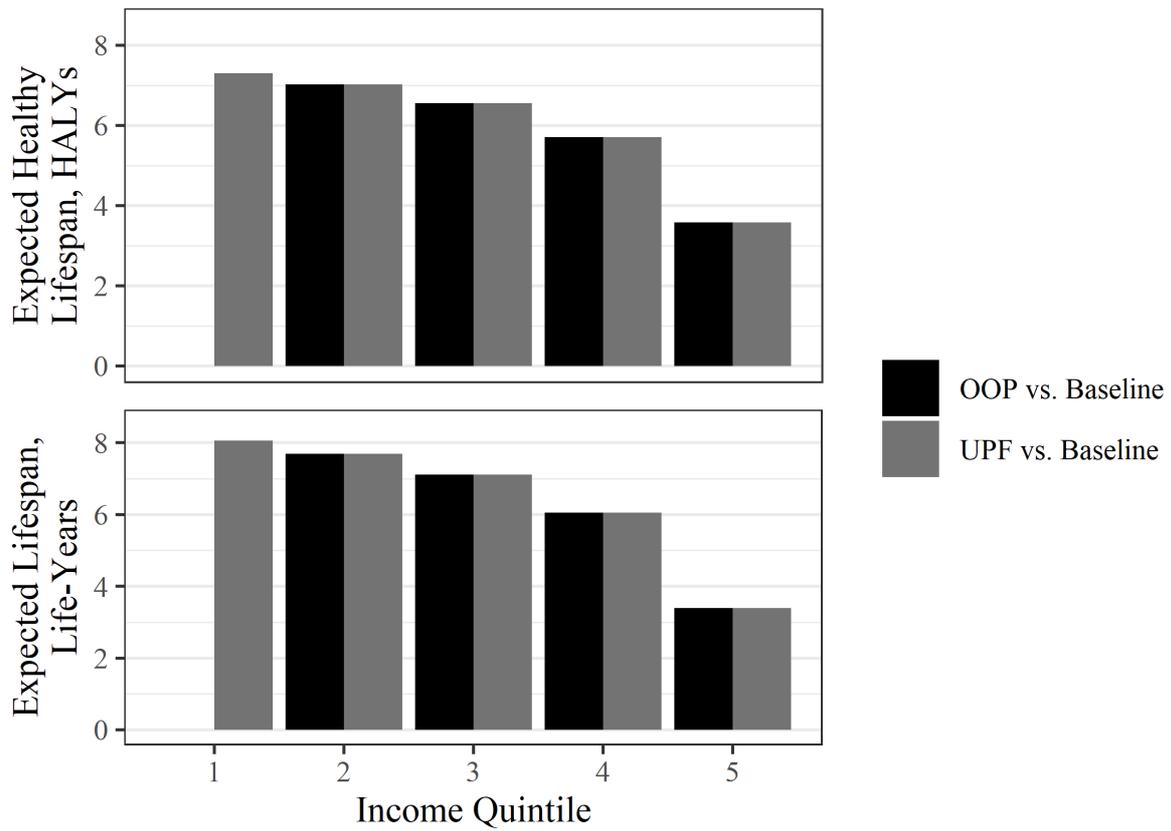


Figure 6.5. Treatment effect (net increase) on expected life span measured in years and health adjusted life years for the cancer patients with OOP and UPF, by income quintile

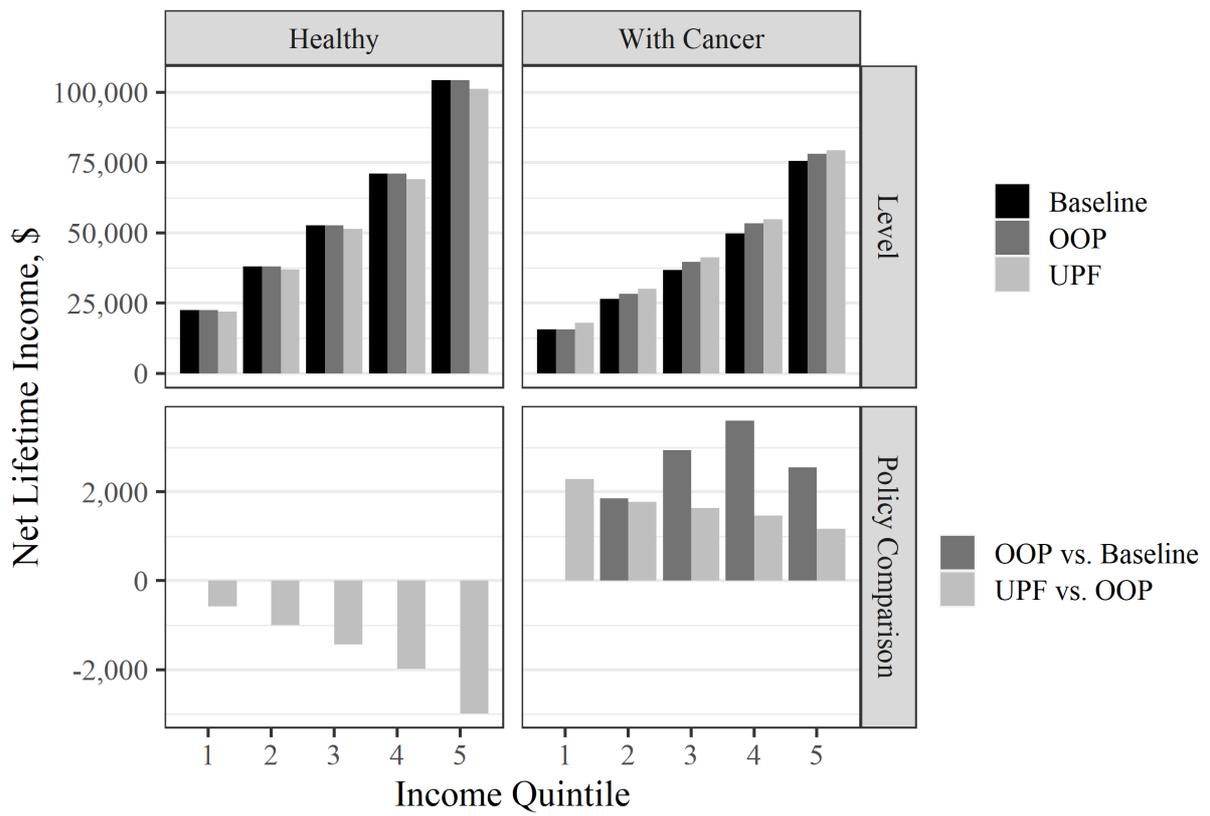


Figure 6.6. Net per capita lifetime income at baseline, with OOP and UPF for the healthy and cancer groups, by income quintile – levels and incremental comparisons
Note: All values are expected values for each group, aggregating over possible lifespans

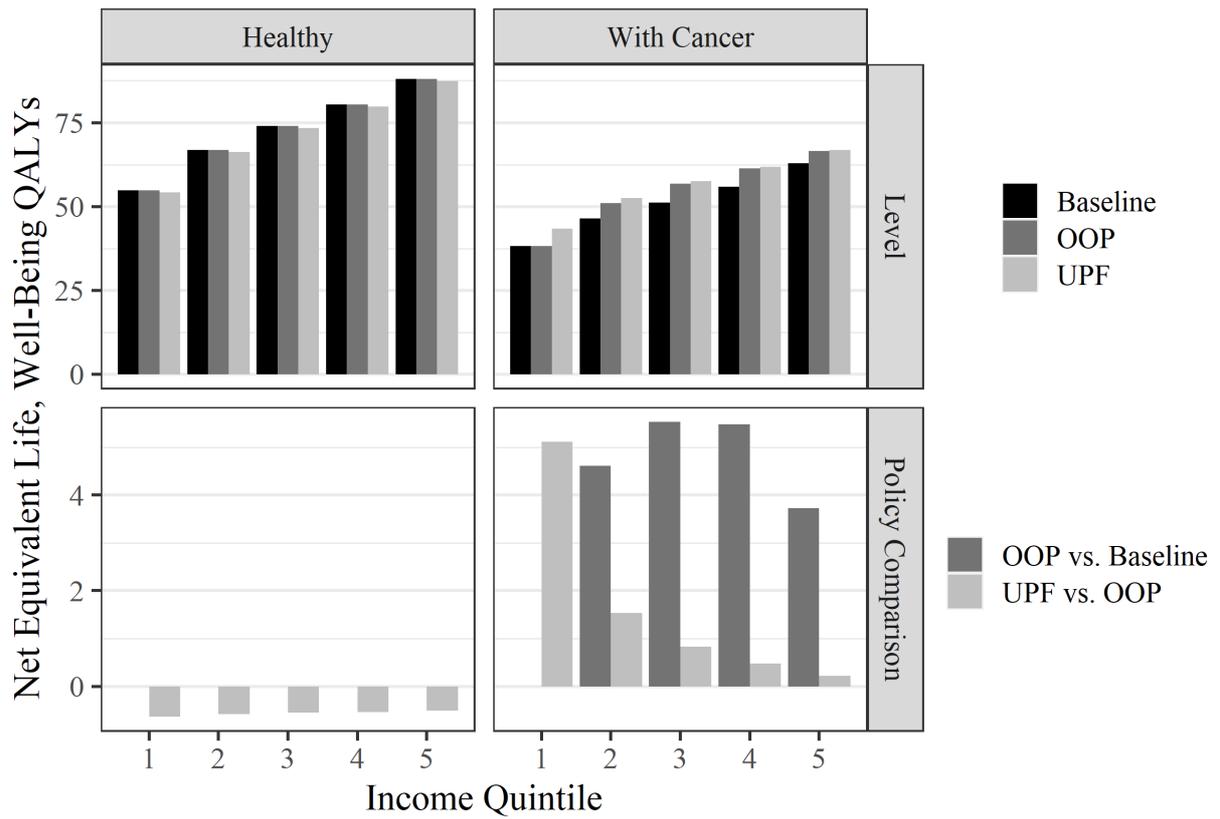


Figure 6.7. Net lifetime equivalent life at baseline, with OOP and UPF for the healthy and cancer groups, by income quintile – levels and incremental comparisons
Note: All values are expected values for each group, aggregating over possible lifespans

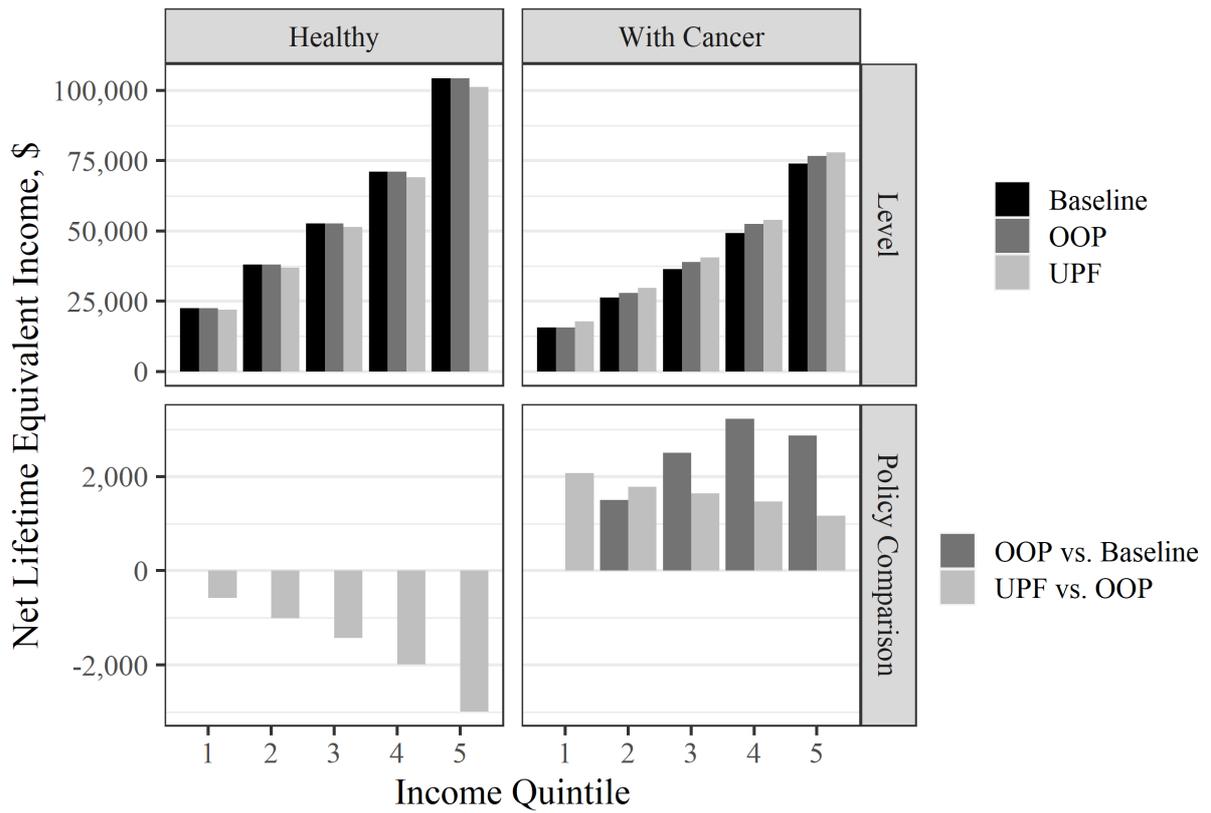


Figure 6.8. Net lifetime equivalent income at baseline, with OOP and UPF for the healthy and cancer groups, by income quintile— levels and incremental comparisons
Note: All values are expected values for each group, aggregating over possible lifespans

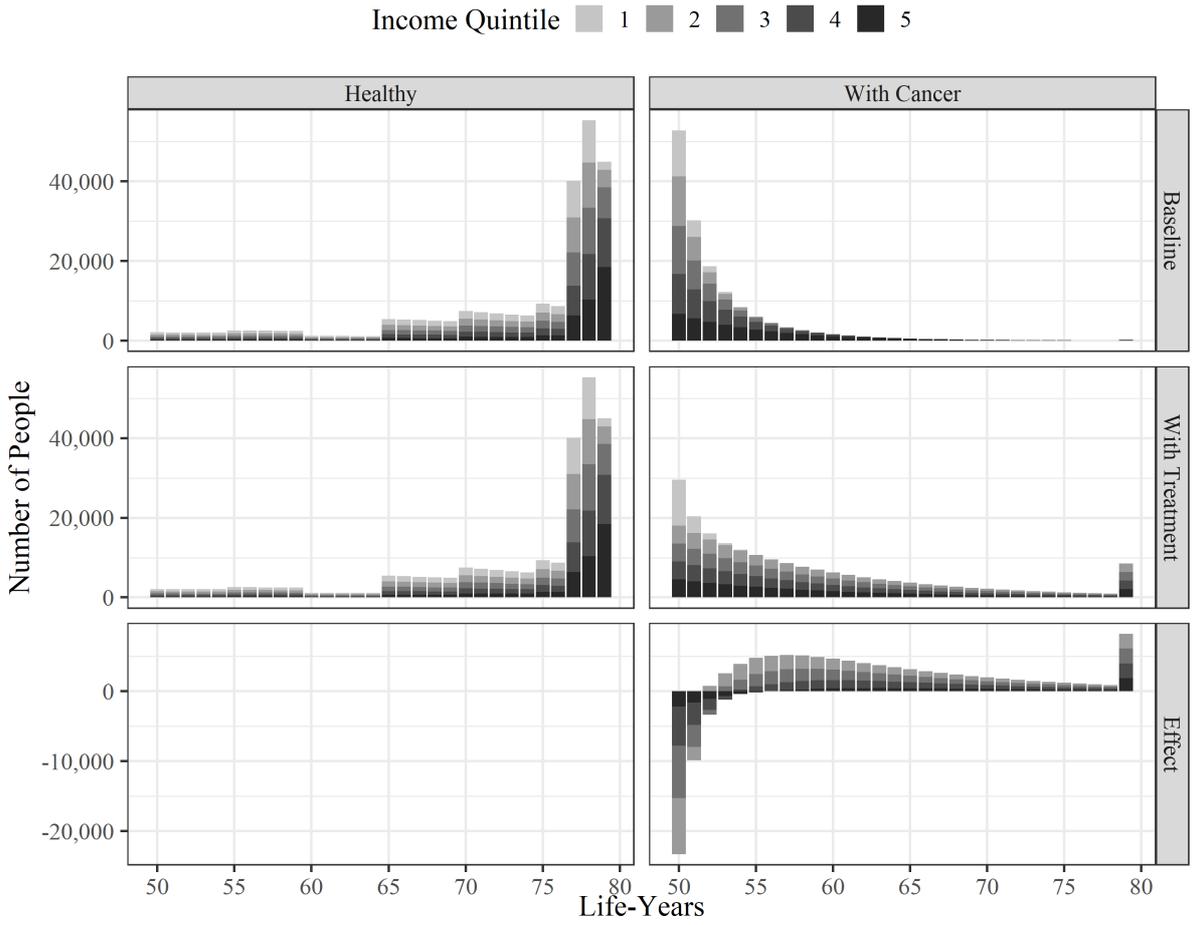


Figure 6.9. Ex post evaluation: Distribution of age at death (measured in life years after age 50) by quintile and health status in the cohort of 100,000