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Patricia Cubi-Molla

David Mott

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Mendel Grobler

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FEBRUARY 2021

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Patricia Cubi-Molla
Office of Health Economics, London

David Mott
Office of Health Economics, London

Nadine Henderson
Office of Health Economics, London

Bernarda Zamora
Office of Health Economics, London

Mendel Grobler
Amgen

Martina Garau
Office of Health Economics, London

Corresponding Author:
Patricia Cubi-Molla
pcubi-molla@ohe.org

For further information please contact:

Professor Graham Cookson
Chief Executive, OHE
Honorary Visiting Professor in Economics at City, University of London

Tel +44 (0)207 747 1408
Email gcookson@ohe.org

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Funding and Acknowledgements

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INTRODUCTION

Governmental departments make decisions about how they use their budget. As their budget is usually fixed in the short-term, their funding decisions need to provide good value for money to ensure resources are used efficiently and societal welfare is maximised. To assess the value of different programmes, governmental departments conduct assessments, whereby the costs of a new programme are compared with the benefits that it is expected to provide. Different departments take different approaches when conducting such assessments. Health departments assess impact on life and health and often employ cost-effectiveness analysis whereas other departments that assess impact on human life often employ cost-benefit analysis and may or may not adjust for health status. Irrespective of the type of department, or the type of analysis being conducted, it is inevitable that a monetary value is applied to life and health because new programmes often impact population health, be it directly (e.g., new health interventions), or indirectly (e.g., new transport infrastructure).

In many countries, guidance documents set out the manner in which analyses should be conducted, often specifying precise values that should be used for different impacts. This often includes the value of life deemed most appropriate for allocating government expenditure. A well-known example from the United Kingdom (UK) is HM Treasury's 'The Green Book'. However, differing values of life and health are still used in analyses by departments despite commonality in outcome, giving rise to potential inconsistencies in decision-making and in considering the trade-offs against a broader public sector spending budget. A consistent multi-sector approach is necessary should improving societal welfare be a consideration.

This report presents a theoretical model on the issue, and applies the approach developed to review the literature and determine whether life and health is valued differently across governmental departments in a range of countries and identify any potential patterns between these countries.

METHODS

The countries of interest selected for this study were Australia, Canada, Japan, New Zealand, South Korea, The Netherlands, and the UK. For each country, a literature review was conducted to identify evidence from technical reports, guidelines, and tools published directly by government departments indicating methods for conducting impact assessments or appraisals. Where necessary, other published literature was also explored. The departments of interest were those known to use some form of valuation of human life: health, social care, transport, and the environment. Sources were identified via a targeted review of governmental websites, and supplemented with an EconLit database search for relevant academic papers.

Estimates of value of life identified in the literature review were collated in extraction tables. Metrics considered as valuations of life included the value of a statistical life (VSL), the value of a life year (VOLY), and the value of a quality-adjusted life-year (VOQ). The latter however is a measure both of health and of life, being a measure that adjusts the quantum of life gained by the health status of that life gained. These identified estimates were converted to one common metric (VOQs) to enable comparison, with the reverse conversion also performed. Conversions used in the academic literature, as well as pragmatic conversions based on the results of past studies, were employed in the analysis. Finally, the value of life in transport/environment departments was presented as a proportion of the value of life and health in health departments in each country using the most realistic/commonly applied estimates. These proportions were then compared between countries to

assess overall trends. To test the robustness of any findings, sensitivity analyses were also conducted that used alternate assumptions in the conversions.

RESULTS

We identified a value of life and of health through appropriate conversion for all departments apart from social care, and for all countries apart from South Korea. In the health portfolio, health technology assessment agencies primarily assess new drugs and generally used cost per QALY thresholds, though these were not always explicitly stated in guidance documents. In transport/environment, VSLs were more commonly used, though not all countries provided these values in guidance documents.

Generally, values for allocation of resources used in transport and the environment exceeded those used in health, often by a significant enough proportion to be a multiple thereof. For example, in the UK, the value considered in the health sector was between 27% and 41% of that used in transport, where the health value was based on the commonly employed £20-30K NICE threshold and the latter was based on a VSL from The Green Book. There were only two instances where the value in health exceeded values used in transport or environment. All other health estimates were far smaller (often <50%) than those used in transport or environment. Whilst the analyses may have been affected by the assumptions made when converting between metrics, the sensitivity analysis found that the overall trend held even with the most extreme assumptions – e.g., assuming that a life year would be equivalent in value to a quality-adjusted life year.

DISCUSSION

In most of the countries explored in this report, there is evidence that the criteria for resource allocation used by government or its agencies in the health sector values life and health significantly lower than the other non-health departments. Some of these differences may be methodological, with the use of cost-benefit analysis in transport and environment, whereas cost-effectiveness analysis is more common in health. Due to the different rationale underlying each approach, we observe that VSL and VOLY estimates are dynamic, as they are adjusted by inflation as time passes, whereas VOQ figures stay constant through the years.

We note that our analyses had limitations. In the health sector, data are dominated by assessment of medicines as is the available literature. Despite the commonality, it was not always possible to identify reliable estimates in all departments. In some cases, guidelines did not exist, and in others available guidelines did not include explicit values of life and health. This may reflect reluctance to be explicit although clearly threshold values are being applied as evidenced in the literature. It was therefore necessary to look at other sources and employ judgements to extract estimates. Furthermore, conversion between the identified metrics required several assumptions. We aimed to mitigate the impact of these assumptions by conducting sensitivity analyses.

From our theoretical model, the existence of different values of health across departments is not inconsistent with the idea of optimal resource allocation (in a static model) but only if perfectly counterbalanced by non-health attributes. However, we discuss that this situation is not stable in a dynamic approach, where some form of reconciliation is needed to correct the potential imbalance in the value of the same attribute (health and life) across public sectors. Reconciliation could range from reallocation of budgets, transfers of benefit, to adjustments of benchmarking thresholds. If neither are used, then as noted, optimal resource allocation can only be achieved by pure chance.

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CONCLUSION

Our study showed that resource allocation criteria used by government health portfolios systematically valued health and life less than did resource allocation criteria used by government environment and transport portfolios in all seven countries considered in our analyses. Such a finding is counter-intuitive and may be from a combination of methodological differences and from differences in portfolio performance measurement and goals. It cannot be said that this disparity is Pareto efficient unless counterbalanced by gains in non-health attributes and therefore a welfare loss is likely.

Comparing the value of department outcomes, such as life and health across different public sector departments, is essential. Governments should exercise due caution when measuring sector performance and setting goals within and across portfolios with high impact on societal welfare.

1. Introduction

1.1. Background

The public service is generally under considerable pressure in a changing world with growing demand for high-quality public services (Montibeller and Franco, 2011). Pressures on public sector budgets lead to concerns about the efficient allocation of public sector spending, along with the search for mechanisms to assess and ensure 'value for money' of options considered (Barroy and Gupta, 2020). Decisions on budget allocation between or across departments are generally made at a central government (Cabinet) level, but the factors, weights, and quantification of these decisions at the Cabinet level are not readily publicly available. Possibly as a consequence of that, over recent decades, much academic research effort has gone into mechanisms to achieve more efficient allocation of funds within specific departments or areas of spending (Weinstein and Zeckhauser, 1973; Boardman, 1997; Dolan, Layard and Metcalfe, 2011; Borge, Falch and Tovmo, 2008; New Zealand Treasury, 2018).

In countries with a universal healthcare system, there has been substantial discussion and academic debate about efficiency of funding *within health*, spawning a vast literature (Luyten and Denier, 2019; Devlin and Parkin, 2004; Ghijben et al., 2018). The opportunity cost of spending within health is a significant consideration and much of the literature is dedicated to the consideration of 'thresholds' above or below which the opportunity cost of spending is either acceptable or not. The methods used are, however, based on a core assumption that budgets are fixed (Weinstein and Zeckhauser, 1973; Birch, 2015; Hernandez-Villafuerte, Zamora and Towse, 2018). Consequently in healthcare, new projects, at least in theory, 'compete' for funding so that only those which are the most cost-effective will be funded, within the restriction of the budget (Martin, Rice and Smith, 2008; Meltzer and Smith, 2011).

In more pragmatic terms, countries around the world apply a form of health technology assessment (HTA) based on a formal assessment of the cost-effectiveness of health interventions and consideration of an explicit or implicit cost-effectiveness threshold to recommend if new treatments should be publicly funded for patients. It is debatable whether HTA bodies' approval threshold is intended to represent the opportunity cost of spending, or to what extent it plays a role in the recommendation of a new technology (Culyer et al., 2007; McCabe, Claxton and Culyer, 2008). But for all intents and purposes, decisions are made by benchmarking the outcomes of new projects against an explicit or implicit cost-effectiveness threshold (Cubi-Molla et al., 2020). The most common benchmarking metric used by HTA agencies is 'cost per QALY', where QALY stands for quality-adjusted life-year. One QALY is basically a year of life, adjusted for *quality of life* linked to the health status during that year (Kind, 2008). For example, in England the National Institute for Health and Care Excellence (NICE) sets *the value of a QALY* gained by a 'normal' treatment to a figure between £20-30K (NICE, 2013). In other words, NICE sets the general threshold of £20-30K as the maximum cost to be incurred by the NHS to obtain an additional 'unit of healthy life', measured in terms of QALYs for standard assessments.

Health is also a common metric in the outcome space across other public sectors such as transport or environment, albeit usually captured as full health in the form of life. In those sectors, cost-benefit analysis is the most commonly used method to compare alternatives 'competing' for funding (HM Treasury, 2018), and health outcomes are captured by measures related to *the value of a life*. Economic valuation of life has played a crucial role in the selection of public projects, since the early 1970s but less so in health. In health there has been some use of the human capital approach following on from the work of Becker (1962) and Grossman (1972) and some use of other

approaches relying on preferences, revealed or stated (Johannesson and Jönsson, 1991). The life value is often expressed using the value of a reduction in the risk of premature death, and therefore, it has been related to mortality analysis (e.g., the value of fatalities avoided).

The introduction of quality of life as a factor in the economic valuation of a life has also generated a debate in the literature. While QALYs have been available since the 1980s, they have largely been used in decision making within the health sector (e.g., via NICE). Historically, the measurement of quality of life has also been a research focus in a number of non-health sectors, as transport or environment (MacKillop and Sheard, 2018). However, that research neither evolved into the development of a sector-specific quality-of-life related measure, nor facilitated the introduction of (already developed) QALYs as a generic outcome measure in those sectors. McKillop and Sheard (2018) observe that not only the existence of an appropriate measure but also a complex combination of factors are needed to introduce novel policy ideas, as they illustrated how the idea of QALYs emerged and was adopted within the UK health policy.

Consequently, it is likely that benefits may be measured and valued slightly differently across public sector areas that measure the benefit either as life compared to 'health-adjusted life' or health. We could think for instance of a policy that generates an amount of life gained which is considered as good value for money by one sector but is rejected by another sector that uses a different benchmarking threshold that is a discounted form of life. Inconsistencies as the one described before may act as a buffer for individual departments or decision-making units, where decisions can be made independently of those in other sectors, in the sense that they do not 'compete' for the same resources (i.e., separate, fixed budgets).

It would be expected that in areas where the length and quality of the lives of citizens and voters can be valued and affected by such valuation, that government administrators would exercise high care and responsibility in managing expenditure within and across portfolios. At a minimum there would be a goal of Pareto efficiency and a vision that societal welfare be maximised where decisions are made that use as a criterion, the valuation of human life. In fact, the current gap in evidence with which to assess value for money within and across public sector activities can be seen as unacceptable.

Aside from Pareto efficiency, inconsistencies are a fundamental issue when considering trade-offs against a broader public sector spending budget. More recently, a number of authors have highlighted the importance of shifting the allocation framework and research towards an 'all-encompassing' multi-sector approach (Cylus and Smith, 2020; Barroy and Gupta, 2020), possibly to begin to ameliorate these shortcomings. A number of arguments support this shift, most notably: (1) the increasing interconnectivity of different departmental areas, where policies in one sector can also have benefits that go beyond that sector; and (2) the increasing need for a search for mechanisms to assess and ensure 'value for money' – for example, the economic pressures of the COVID-19 pandemic are significant leading to potentially substantial, rather than incremental, adjustments to spending allocations between departments.

While there is a vast literature on the value of health gains in specific sectors (Luyten and Denier, 2019; Giles, 2003; Roy and Braathen, 2017), few researchers have sought to compare how health gains are valued *across public sectors* (Weinstein and Zeckhauser, 1973; Abelson, 2003; Glover and Henderson, 2010). Similarly, we can identify in the literature a large number of papers on the monetary valuation of health (Vallejo-Torres, García-Lorenzo and Serrano-Aguilar, 2018), but those papers stay at the theoretical level, and do not offer a pragmatic view of how much money is linked to an additional unit of comparable benefit (e.g. a QALY, a life year, a life) in different public sectors. This study aims to provide evidence on this. In particular, the objective of our paper is to identify and compare estimates of the value of life and health informing resource allocation within the following government departments: health, transport, and environment. The term' value of life and health'

encompasses instruments aimed to capture the value of reducing the risk of death (mortality risks), increasing life expectancy, or improving health-related quality of life (Abelson, 2003; Chilton et al., 2020). We look at several key countries that introduced formal economic evaluation processes early on and have an impact on other countries' policy development. The following countries were selected: Australia, Canada, Japan, New Zealand, South Korea, the Netherlands, and the United Kingdom (UK). We focus on identifying explicit and implicit' value of life and health' measures or thresholds, included in official guidelines or alternative government documents at the departmental level, and compare them intra- and inter-country.

As stated before, attempts to assess and compare value for money across disparate sectors is a challenge, since different methodologies for measuring and valuing health are used, and the rationale behind implicit or explicit benchmarking thresholds is, in the best scenario, debatable (Mason, Jones-Lee and Donaldson, 2009). However, the different methods for valuing health and life have a conceptual and historical common aim: measuring net benefits (welfare) in order to establish critical cost-benefit ratios to inform two equivalent problems: the optimal selection of public projects, and the efficient inter-area allocation of a budget (Weinstein and Zeckhauser, 1973). We emphasise that our research is not intended to alter the political process, but rather to provide some evidence to better inform it, and to raise a number of important issues on assessing the value of public expenditure across different sectors.

This paper is structured as follows. The next section explores whether it is theoretically meaningful to compare government expenditure across different public sector departments, in terms of the value of each departmental outcome. Section 3 introduces the measures for valuing health that are addressed in this paper, and provides the methods used to map across measures. The literature search methodology and validation exercise are also detailed in this section. Section 4 provides the results of the literature review on value estimates by country, followed by the intra- and inter-country comparisons. Section 5 and 6 provide a discussion of results and limitations, and conclusion, respectively.

2. A conceptual model of resource allocation

In this section, we present a model where the government allocates resources across different public services. Our model is framed into the welfare economics literature, which provides the foundation for most approaches to allocative efficiency (Brouwer et al., 2008). We take a Pareto optimality perspective and a utilitarian standpoint, which measures welfare as the sum of individuals' utility. Since our research will focus on 'health' as the main factor that inputs into individuals' utility, we present the optimisation model frequently found in the health economics literature (Weinstein and Zeckhauser, 1973; Claxton et al., 2010; Griffin, Claxton and Sculpher, 2008a; Gravelle et al., 2006). In particular, our model builds on the resource-allocation model suggested by Meltzer and Smith (Meltzer and Smith, 2011), and Martin, Rice and Smith (Martin, Rice and Smith, 2008).

In our conceptual model, we assume that the government receives a total budget M to spend across public activities. For illustration purposes, we assume the total budget is fixed for the period under analysis, and the government makes the decision about how to allocate the budget across the different departments j={1,…,J} in that period. The objective of the government is to maximise total societal welfare, W(.), which is a function of the benefits (outcomes) derived from the different government departments. We classify the benefits around a set of attributes or domains that are deemed relevant to society (Cubi-Molla et al., 2021). There is a large literature on the identification of public sector outcome attributes. For example, the Australian National Development Index[1], or the Canadian Index of Wellbeing[2] are examples of initiatives which are part of the wider movement to go beyond economic indicators such as GDP when assessing societal welfare (Whitby, Seaford and Berry, 2014) and provide highly relevant inputs to the development of a measure of public sector desirable outcomes. Table 1 provides an illustrative comparison of different sets of attributes. Note that 'life and health' (H) are sometimes considered separately (Martin, Rice and Smith, 2008). In the present framework we also consider one single non-health attribute (A), such that H and A represent instruments of societal welfare. A can be easily extended to a vector of attributes (A_1, A_2, … A_K).

TABLE 1. COMPARISON OF THREE OUTCOME FRAMEWORKS

Canadian Index of Wellbeing	Australian National Development Index	Tentative attributes for UK
Education	Education, knowledge and creativity	Cultural advancement and enrichment
Leisure and culture	Culture, recreation and leisure	
Environment	Environment and sustainability	Improved environmental quality
Healthy populations	Health	Reduced mortality
		Reduced morbidity
Democratic engagement	Governance and democracy	Improved choices and autonomy of people
	Justice, fairness and human rights	Improved equity, reductions in inequality
		Enhancing law and procedural fairness
		Reassurance, security, improved safety
Community vitality	Community and regional life	
Living standards	Economic life and prosperity	Improved standards of living
Time use	Work and work-life balance	
	Children and young people's wellbeing	
	Indigenous wellbeing	
	Subjective wellbeing and life satisfaction	
		Consumer satisfaction with improvements in the quality of services per se

Source: (Cubi-Molla et al., 2021)

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[1] *http://www.andi.org.au/*
[2] *https://www.communityhealthandwellbeing.org/canadian-index-wellbeing*

The government seeks to allocate its budget, M comprising $\{m_1, m_2, \ldots, m_j\}$, across the departments $j=\{1,\ldots,J\}$, in such a way as to maximise the total welfare of society $W(H, A)$. Every government department invests m_j to generate h_j health outcomes and a_j outcomes in non-health attributes. For consistency, we assume that all the outcomes h_j and a_j can be expressed in terms of monetary benefits. The production function of health outcomes attributes in sector j, h_j, will be denoted by $f_j(m_j, z_j)$, with z_j capturing other factors. For instance, in the dimension corresponding to health, z_j could represent need for health care or environmental factors (Martin, Rice and Smith, 2008; Claxton et al., 2015; Griffin, Claxton and Sculpher, 2008b). We also assume that outcomes of the remaining (of societal welfare) non-health attributes, a_j, are generated through a production function $g_j(m_j, z_j')$. For simplicity we assume that $z_j = z_j'$. We also assume the factors in z_j are exogenous to the model. The model is illustrated in Figure 1.
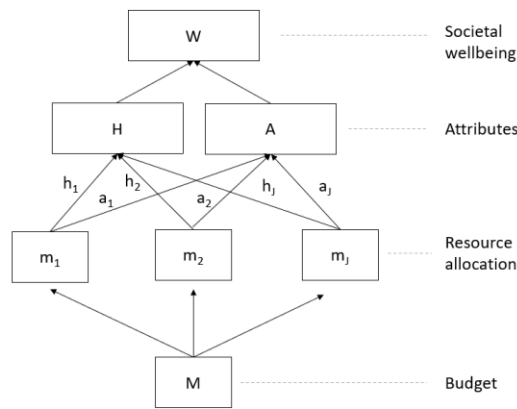

FIGURE 1. ELEMENTS OF OUR THEORY MODEL OF RESOURCE ALLOCATION.

The government allocates the total budget seeking to maximise the total welfare of society (we take a Pareto optimality perspective and a utilitarian standpoint which measures welfare as the sum of individuals' utility), subject to a budget constraint and the department-specific production functions:

$$
\begin{cases}
Max & W(H,A) \\
s.t. & H = \sum_j h_j \\
& A = \sum_j a_j \\
& h_j = f_j(m_j, z_j) \\
& a_j = g_j(m_j, z_j) \\
& \sum_j m_j \leq M
\end{cases}
$$

Note that in our model of welfare-maximising decision-making, for simplicity we assume the government is acting as a perfect agent for society and has access to perfect information on the costs and benefits of extant and potential new public sector activities.

Also note that we are assuming a functional form for H, implying that $\partial W/\partial h_j$ is the same for all j; this translates into assuming that the output production process is irrelevant to its impact on the welfare function. For example, scenarios as societal preferences putting a higher value on producing

health through education rather than through healthcare settings are not reflected in our model. However, this is not a necessary consideration in our work, given that it is the assessment of consistency in output valuation that is the goal.

The optimal level of expenditure in sector *j* derived from the model would be a function of the budget and the additional factors, as:

$$m_j^* = P_j(M, z_j), j = 1..J$$

In this simple model, the optimal allocation of budgets $\{m_j^*\}$ is achieved in a scenario where a marginal increase (e.g., one dollar or one pound) in the budget of any department (∂m_j) will have the same total effect ('marginal value' or *MV*) in the social welfare function, through health and non-health attributes:

$$MV_i = \frac{\partial W}{\partial H}\frac{\partial h_i}{\partial m_i} + \frac{\partial W}{\partial A}\frac{\partial a_i}{\partial m_i} = \frac{\partial W}{\partial H}\frac{\partial h_j}{\partial m_j} + \frac{\partial W}{\partial A}\frac{\partial a_j}{\partial m_j} = MV_j, \text{ for each } i, j \text{ in } \{1, 2, ..., J\}$$

Following the same notation as in Claxton et al. (2010), we define $\upsilon = \frac{\partial W}{\partial H}/\frac{\partial W}{\partial A}$ as the social value of health consumption relative to the non-health attribute *A*. The equilibrium formula leads us to:

$$\upsilon\left(\frac{\partial h_i}{\partial m_i} - \frac{\partial h_j}{\partial m_j}\right) = \frac{\partial a_j}{\partial m_j} - \frac{\partial a_i}{\partial m_i}, \text{ for each } i, j \text{ in } \{1, 2, ..., J\}$$

In situations where the *MV* of activities in one department exceeds that of another, available budgets shall be directed to the department with the higher *MV*. In principle, budget reallocation will occur until the *MV* is equal across all government departments – at that point, there is efficiency in public spending, social welfare is maximised, and any further reallocation of budgets would reduce social welfare.[3]

For illustrative purposes, consider two government departments: health and social care (HSC) and transport (T); and two attributes: *improved health* (H) and *improved standards of living* (A). Resources allocated to the transport sector can have a positive impact on health (for instance, reduced mortality from improved highway design); which would either have to be included in the metric or threshold used or would have to be disaggregated and reported separately to the central decision maker.[4]

Identifying the marginal value of each and every department is a cumbersome task where no or few common metrics exist. As mentioned before, for pragmatic reasons, social benefits in different areas of public spending are usually described and measured in a variety of different units, so it is typically very challenging to compare the value and opportunity cost of new investments. As recently indicated by Cylus and Smith (Cylus and Smith, 2020), the lack of a common welfare function makes the comparison of societal contributions of different sectors difficult. The authors acknowledge that setting up the trade-offs between government departments may be said to be unrealistic and even undesirable (Luyten and Denier, 2019). However, the global trend for public policy is for governments to increasingly think of spending decisions in terms of different forms of welfare (such as the use of subjective well-being to measure the impact of public policy (Dolan, Layard and Metcalfe, 2011; New Zealand Treasury, 2018; Whitby, Seaford and Berry, 2014)); and notably, we could identify countries where comparisons across departments actually rely on establishing 'exchange rates' between indicators corresponding to different attributes or domains (see for instance Norway (Borge, Falch

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[3] Note that we have not considered the possibility of taxation changes, i.e., we are simply limiting consideration to the relative allocation of resources and where sub-optimal outcomes are generated within that.
[4] Note that negative effects (for instance, reduction in health caused by increased pollution from a new highway) can also be captured in the model.

and Tovmo, 2008) or New Zealand (New Zealand Treasury, 2018)). Finally, note that our objective is not to set up a new pragmatic method aimed to replace the political process, but rather to provide some evidence to better inform it. The purpose of our model is therefore to illustrate the importance of consistency in the output valuation across departments for an efficient allocation of resources, as we explain in more detail below.

Despite these drawbacks, empirical work has attempted to identify the marginal productivity of specific sectors. In each case, the total budget for that sector is taken as a given, and the decision-maker must allocate the budget across different regional or programme-specific services. For instance, for the healthcare sector, a number of papers aim to estimate the marginal productivity of national health services as the cost of an additional unit of health benefit (Lomas, Martin and Claxton, 2019; Vallejo-Torres, García-Lorenzo and Serrano-Aguilar, 2018). However, note that these studies do not explicitly consider cross-department optimisation.

For our research, we interpret these marginal productivity estimates as the health benefit generated by a marginal change in the health sector budget, $\frac{\partial h_{HSC}}{\partial m_{HSC}}$. These estimates reflect the (inverse of the) value of health, interpreted as 'price' in monetary units of purchasing one additional unit of health. For the health sector, in particular in the context of health technology appraisal, the 'value of health' is typically measured in QALYs. For example, in England and Wales, an additional pound spent on an average healthcare resource is expected to generate at least 1/30,000 of a QALY. With similar reasoning applied to non-health sectors, the value of health can be retrieved from standard estimates used in economic evaluations. For instance, also in England, the Department for Transport (DfT) uses the 'value of a statistical life' (VSL) for assessing health-related outcomes, which were estimated at slightly above £2m in 2020 (DfT, 2019a). Therefore, one additional pound invested on transport would be expected to generate approximately 1/2,000,000 of a statistical life. Mapping QALYs to VSL could help to identify $\left(\frac{\partial h_i}{\partial m_i} - \frac{\partial h_j}{\partial m_j}\right)$, and therefore inform a decision maker about the optimal resource allocation. For instance, from our own computations (see Table 2), 1/2,000,000 of a statistical life would be roughly equivalent to 1/73,000 of a QALY. Following the example set out above, one additional pound spent on HSC would have a higher return than one additional pound spent in transport, all in reference to the attribute 'health'. Therefore, the extent to which resource allocation in T can increase the standards of living (compared to that in HSC), will be key to optimal decision making. Some form of reconciliation in the long term is needed to correct this potential unbalance, such as reallocation of budgets, transfers of benefit, or update of benchmarking thresholds. If neither are used, then optimality can only be achieved by pure chance.

3 Methods

3.1 Measuring the value of health and life

There are several different approaches for representing the value of life and health. The *value of a statistical life* (VSL; also known as the value of a prevented fatality [VPF]), is one of the most commonly applied methods. Different methods can be used to estimate a VSL, such as the human capital approach, revealed preferences, e.g., the wage-risk approach (also referred to as the wage differential or labour market method), and stated preferences, such as the willingness-to-pay (WTP, also referred to as contingent valuation) approach. The latter approach has been used to derive many key VSL estimates, such as the one employed in decision making in the UK (HM Treasury, 2018). The WTP approach involves asking a sample of participants to each state their WTP for a small risk reduction, which is then translated into an overall VSL estimate. Thus, as noted by Mason et al. (2009), a WTP-based VSL can be "defined as the aggregate WTP across a large group of individuals for small risk reductions which, taken over the whole group, can be expected to prevent one premature death during a forthcoming period" (p.935) (Mason, Jones-Lee and Donaldson, 2009). Importantly, therefore, a WTP-based VSL does not represent the amount that an individual is willing to pay to save a life, which is typically viewed as being priceless.

Another measure is the *value of a life year* (**VOLY**; or statistical life year [SLY]), which is useful for analyses of programmes or interventions that result in a small number of years of life being saved. VOLYs can be derived directly (e.g., using a WTP approach), or indirectly from an existing VSL estimate. The latter essentially involves dividing a population-level VSL by average life expectancy.

In some cases, particularly in the health setting, it is important to consider both morbidity and mortality. That is, quality of life gains should be considered alongside survival gains. The *quality-adjusted life-year* (QALY) achieves this by combining health state utilities (where 0 is equivalent to dead, and 1 is equivalent to full health) with survival gains, such that a year in full health corresponds to one QALY. The value of a QALY can be derived using either a supply-sided (opportunity cost) or a demand-sided (WTP) approach (Ryen and Svensson, 2015). Estimates using the former approach are based on the assumption of a fixed health care budget where each new technology will displace existing services, unless it is cost-saving. Supply-side estimates therefore more closely align with a "cost-effectiveness threshold". Estimates using the demand-side approach more closely align with other estimates of the value of a life as described above, as these are estimates of the societal WTP for a QALY. As such, these estimates are sometimes referred to as WTP-QALY estimates.

A clear unifying framework that demonstrates the conceptual link between VSLs, VOLYs, and WTP-QALYs has been provided in a recent study that was conducted on behalf of the Health and Safety Executive in the United Kingdom (Chilton et al., 2020). Future research may be able to utilise this framework to obtain value of life estimates that are better aligned and consistent. In lieu of such aligned estimates, comparisons between measures are inevitably imperfect.

In this paper, we will use the expression '**VOQ**' to refer to every threshold benchmarking used when life and health are measured in terms of QALYs (VOQ = 'value of QALY'). Both demand-side thresholds (referred as 'WTP-QALY') and supply-side thresholds will be captured under that label. This is because our aim is not to distinguish between different types of threshold; but to identify those explicitly or implicitly addressed in government-related publications, which are representing the government's willingness to pay for an additional QALY. Similarly, for simplification we will use the expression 'value of life' or '**VoL**' to encompass all types of estimates of the value of health and life (i.e., VSLs, VOLYs, and VOQs). This equivalence in the nomenclature is detailed in Box 1.

BOX 1. TERMINOLOGY FOR VALUE OF LIFE ESTIMATES

| | VoL | | |
	Value of Life		
Measures	**VSL**	**VOLY**	**VOQ**
	Value of a Statistical Life	*Value of a Life Year*	*Value of a QALY*
Also known as	VPF	SLY	Cost-per-QALY threshold
	Value of a Prevented Fatality	*Statistical Life Year*	WTP-QALY
Main estimation approaches	Human Capital Wage-risk trade-off WTP	WTP	Opportunity cost WTP

WTP: Willingness-to-pay; QALY: Quality-adjusted life year

3.2 Literature review

The aim of the literature review was to identify whether VoL thresholds exist within the health, social care, transport and environment departments of the seven selected countries, and to determine which thresholds are used to inform resource allocation decisions.

The review sought primarily to gather evidence from technical reports, guidelines, and tools published directly by government departments indicating methods for conducting impact assessments (e.g. The Green Book in the UK (HM Treasury, 2018)). Where necessary other published literature was explored, such as theoretical and methods papers as well as reports on empirical studies published in journals and government websites.

In the case of the department of health, we aimed to identify whether there was any variation in the VoL estimates used within the department, for example, thresholds used in HTA evaluation compared to public health. For the other departments, we sought to identify the standard VoL measure, i.e. not specific to a certain area within the department.

Sources were identified via two principal methods: a targeted review of government and departmental websites was conducted, seeking to identify official guidelines and tools published for use in impact assessments or cost-benefit analysis and so on. We sought to identify the most recent estimate available. EconLit database was also searched using variations of the terms "Value of life" and "Government/Department" and "UK/Australia/New Zealand etc.". The search terms used are reported in the appendix. Only documents in English were included. Papers were deemed relevant if they reported an explicit or implicit value of life or threshold in any department under consideration. In both cases, documents were prioritised if they stated an explicit VoL threshold. For countries where no explicit thresholds exist or could be identified, implicit thresholds (for example, thresholds elicited in academic papers and generally accepted or used in practice) were accepted as the best proxy available.

The results of the literature review were collated in extraction tables to ensure that the relevant information was documented for each estimate identified and to facilitate comparability in the analysis stage.

3.3 Validation process

Following the identification of a relevant estimate, a validation task was conducted to attempt to establish the extent to which the estimate is used to inform resource allocation within the department. For countries or departments where no estimate was identified by using the two aforementioned methods, we carried out a further search to attempt to fill in any gaps.

We conducted another literature search with wider search terms (See Appendix). However, no additional references were identified. We also approached key contacts in each of the countries where there were missing estimates, namely: the Netherlands, South Korea, Japan and New Zealand. The key contacts were local experts with active involvement in government-related health policy or health technology assessment. For Japan, an estimate for the department of environment was identified.

3.4 Comparisons

3.4.1 Intra-country comparisons

In order to compare estimates of the VoL between governmental departments, it was necessary to convert them. Given the primary focus on health, we set out to compare figures in terms of VOQs, while we note that the VoL in transport and environmental settings is often presented as the value of a statistical life (VSL) or the value of a life year (VOLY).

Equation 1 sets out the formula used to convert from VSL to VOLY, from Abelson (Abelson, 2003):

$$VOLY = \frac{\widehat{VSL}}{A} \qquad (1)$$

It therefore follows that the VSL can be calculated from a VOLY estimate:

$$VSL = \widehat{VOLY} \cdot A \qquad (2)$$

A is defined as in Equation 2:

$$A = \frac{[1 - (1 + r)^{-n}]}{r} \qquad (3)$$

Where n is the years of expected lifetime remaining and r is the rate at which future utility is discounted. The life expectancy and discount rate used in this calculation can have a significant impact on the overall estimates. For life expectancy, we followed convention by using life expectancy at age 40 (Abelson, 2003). Average life expectancy was identified for each country and 40 was subtracted from this figure to produce an estimate of n for each country. In practice, the most suitable age to calculate life expectancy from depends on the specific framing of the task used to estimate each VSL. Given the number of VSLs that we expected to identify and convert in this study, and the potential challenges associated with identifying the source of the numbers used in policy documents, we chose to use life expectancy at age 40 for all conversions. The implications of this assumption were explored in sensitivity analyses. For discount rates, government guidelines in each country were reviewed to identify suitable rates.

Converting VSL or VOLY to VOQ is challenging because the latter captures morbidity as well as mortality. Logically, it would be expected that QALY would be valued more highly than a life year, because it represents a year in full health as opposed to a year in average quality of life. The relationship between the two measures can be expressed as the following:

$$VOQ = w_t VOLY \qquad (4)$$

Where w_t represents the proportional change in WTP as a result of moving from average quality of life (as experienced in one VOLY) to full health (as is experienced in one QALY). Thus, one VOLY is only equivalent to one QALY if there is no change in societal value when moving from average quality of life to full health.

Mason et al. (2009) and Tehard et al. (2020) both set out approaches to estimate VOQ from a VSL/VOLY (Mason, Jones-Lee and Donaldson, 2009; Téhard et al., 2020). These approaches require comprehensive health state utility and life expectancy data. Their results indicate that WTP-QALYs are greater than VOLYs, in the region of 17-27% (a value of w_t of 1.17-1.27). This is considerably larger than the estimate of 8.7% cited in the CE Delft Environmental Prices Handbook (CE Delft, 2017). Given the substantive data requirements for replicating the approaches by Mason et al. (2009) and Tehard et al. (2020), we instead decided to adopt the most conservative conversion rate that we identified in the literature (a value of w_t of 1.087) in our baseline comparisons and to conduct sensitivity analyses around this number.

Given the high sensitivity of the estimates to the various assumptions described above, we also conducted sensitivity analyses to test the robustness of our conclusions. This included varying the expected remaining life expectancy in the VSL/VOLY conversions (i.e., using ages other than 40) and varying the conversion rate between VOLYs and VOQs (with an upper limit of 1:1 based on the rationale outlined above).

3.4.2 Inter-country comparisons

Comparisons between countries could be conducted in several ways. Our preferred approach was to estimate VoL in transport and environment departments as a proportion of the VoL in the health setting. These proportions could then be compared across countries to provide a clear indication of whether the same trends are found between countries and without having to consider variations in exchange rates or the need for purchase power parity.

To make this analysis clearer, a 'usual set' or standard case was selected from the full range of values identified in the literature review. For health, the most commonly applied VOQs were used where available (i.e., not those reserved for rare or oncology indications). For transport and environment, the values were assessed in detail and the most realistic were selected for use in the analysis.

4 Results

4.1 Literature review

4.1.1 Overview

A wide range of estimates were identified in different guidelines, reports and academic articles. Unsurprisingly, the VoL was generally expressed in QALYs in the health setting whereas it was almost always expressed as a VOLY or VSL in other settings. The VoL was also expressed using disability-adjusted life years (DALYs) in some countries, though this was rare and alternative estimates were always available (in QALYs, VOLYs or VSL).

In some countries, estimates of the value of a prevented fatality (VPF) are presented instead of VSLs. Whilst these differences in terminology can imply differences in their estimation, in our analyses we treat the two as equivalent. Additionally, in the UK, the term statistical life years (SLYs) was used rather than VOLYs; we also treat these as equivalent measures.

Generally, it was not possible to distinguish between guidance for health and for social care. Therefore, we focused solely on health.

4.1.2 Value of Life in the UK

General guidance

In the United Kingdom, HM Treasury publish, and regularly revise, a document called 'The Green Book', which provides guidance on how to appraise policies, programmes and projects (HM Treasury, 2018). Within Annex 2, which discusses non-market valuation techniques, several estimates are included for use in analyses. This includes £60,000 per Statistical Life Year (SLY) and per QALY. It also references the Department for Transport (DfT) guidance on the monetary value of a VPF, though it does not cite a specific value (see 'Transport' section for further information). Due to The Green Book, not all departments have their own specific guidance on the value of life, and those that do may simply refer to guidance from The Green Book.

Health

In the United Kingdom, the Department of Health and Social Care (DHSC) is responsible for government policy on health and adult social care and oversees the National Health Service (NHS). A 2010 DHSC report that outlined how the health impacts of government policies should be quantified provided two thresholds (Glover and Henderson, 2010), citing research conducted by/for the DfT. The first was an estimate of £60,000 per QALY, and the second an estimate of £1,722,000 per prevented fatality. These figures are intended to be used within governmental impact assessments to guide policymakers' decision-making, such as social cost-benefit analyses. Whilst the previously cited guidance is now a decade old, the £60,000 per QALY figure is cited in the latest version of The Green Book (HM Treasury, 2018) and has also been referenced in a recent report published by Public Health England (PHE). The PHE report was focused specifically on estimating the return on investment for older adult NHS and social care (PHE, 2020).

Whilst the previously mentioned figures may be used in governmental impact assessments or other internal analyses, different figures are used when determining which new medical technologies to fund within the NHS. In England and Wales, the National Institute for Health and Care Excellence (NICE) use cost-utility analysis and apply VOQ of £20,000-£30,000, where technologies are generally funded if the incremental cost-effectiveness ratio (ICER) is less than £30,000 (NICE, 2013). For

medicines that provide a survival benefit for patients that are near the end of their lives, a QALY weighting is applied such that the threshold effectively increases to £50,000 per QALY. Additionally, for very rare diseases, a QALY weighting can be applied such that the threshold effectively increases to £100-£300K per QALY, under the highly specialised technologies programme. In Northern Ireland, NICE decisions are generally implemented. However, in Scotland, the Scottish Medicine Consortium (SMC) is responsible for HTA, and functions in a similar manner to NICE, conducting its own assessments using cost-utility analysis etc. In contrast to NICE, the SMC does not state explicit thresholds (SMC, 2017).

Transport

In the United Kingdom, the DfT are responsible for the transport network. The DfT publish transport analysis guidance (TAG) and have a regularly updated 'data book' that contains various estimates for use in analyses (DfT, 2019a). The TAG data book allows users to enter the year of interest to obtain relevant estimates. The VPF estimate for 2020 is £2,064,189. The accompanying social impact appraisal guidance explains that the DfT use a value of £1,000,000 in 1997 prices, which was based on stated preference research, and incorporates human costs, the loss of output due to injury and medical costs (DfT, 2019c). The VPF figure can be used in impact appraisals, such as assessments of new transport infrastructure, which may have an impact on expected fatalities.

Additionally, DfT's environmental impact appraisal guidance explains that a value of £60,000 per DALY is used in the context of environmental noise, which may be applicable to transport-related projects (DfT, 2019b). The source provided for this estimate is a 2014 study by the Department for Environment, Food and Rural Affairs (Defra; see 'Environment' section for further information).

Environment

In the United Kingdom, Defra is responsible for the natural environment, the food and farming industry, and the rural economy. Defra's guidance for air quality appraisal provides estimates for use when monetising the impact of changes in emissions (Defra, 2019). For chronic mortality as a result of air pollution, a VOLY estimate of £42,780 is provided. For acute mortality, the VOLY estimate is £22,110. Both estimates are based on a contingent valuation study, though figures are updated to reflect current prices (Chilton et al., 2004). When considering morbidity in addition to mortality, the guidance refers to the £60,000 per QALY figure from The Green Book (HM Treasury, 2018).

Defra's guidance on environmental noise recommends that DALYs are used to reflect the value of impacts related to annoyance from environmental noise. In alignment with the DHSC's £60,000 per QALY figure, Defra state that a value of £60,000 per DALY should be applied (Defra, 2014).

4.1.3 Value of Life in the Netherlands

General guidance

In the Netherlands, an organisation called CE Delft publish a document called the 'Environmental Prices Handbook'. This is not a governmental document and it does not appear to be publicly referenced by governmental departments or agencies in their guidance. Nonetheless, it is very comprehensive, and a range of governmental agencies were represented on the advisory committee of the project, which provided regular feedback. The 2017 version of the handbook provides some estimates for the value of a life for use in analyses/assessments (CE Delft, 2017). Specifically, it cites the OECD VSL estimate of approximately €2.4 million (OECD, 2012), with the authors of the handbook suggesting that this implies a VOLY of €60,000 - €120,000. The handbook also refers to the NEEDS Project EU25 VOLY estimates of €40,000 for chronic mortality and €60,000 for acute mortality. All of these estimates relate to air pollution specifically.

Health

In the Netherlands, the Ministry of Health, Welfare and Sport (VWS) is responsible for health care and public health, amongst other responsibilities. The National Health Care Institute (Zorginstituut Nederland; ZIN) advise on the treatments that are provided as part of the standard Dutch health care package. Much like NICE, ZIN assesses new medicines based on cost-effectiveness and generally approve medicines if the ICER is below a certain threshold value (ZIN, 2016). However, one major difference is that ZIN takes a societal perspective in their analyses. The exact threshold value applied depends on the severity of the disease, which is estimated using a measure called proportional shortfall (PS) (ZIN, 2015). PS is calculated by taking the disease-related QALY loss and dividing this by the remaining QALY expectation (in the absence of the disease). It is therefore bound between zero (no disease-related QALY loss) and one (immediate death as a result of the disease), with higher values indicating a more severe disease. For a PS of 0.1 up to and including 0.4, the VOQ is €20,000. For a PS between 0.41 and 0.7, the threshold is up to €50,000 per QALY. For a PS of 0.71 and above, the VOQ is up to €80,000. Generally, if a treatment does not meet these conditions, it would be rejected by ZIN.

Transport and Environment

In the Netherlands, the Ministry of Infrastructure and Water Management is responsible for transport and land management, amongst other responsibilities. Several agencies work under its remit, including PBL Netherlands Environmental Assessment Agency and Rijkswaterstaat. Whilst these agencies conduct analyses to assess new infrastructure projects etc., there are no explicit, publicly accessible, up to date estimates for the VoL.

In 2000, The Ministry of Transport, Public Works and Water Management (now the Ministry of Infrastructure and Water Management) and the Ministry of Economic Affairs (now the Ministry of Economic Affairs and Climate Policy) published guidance based on a large-scale research programme entitled 'Economic Effects of Infrastructure'. The guidance, referred to as the OEEI-Guideline, is regularly referenced in governmental documents. In Appendix G, a value of €1,500,000 per fatal accident is provided. This value is a European average from OECD report that was published in 1998. It is stated clearly that the values provided are not "concrete standards for valuing external effects", which is presumably why no guidance is provided as to how to use this figure. More recently, in 2013, the PBL Netherlands Environmental Assessment Agency published 'General Guidance for Cost-Benefit Analysis'. However, this document does not contain any estimates for the VoL, which may indicate that no specific values are formally recommended. A 2008 journal article supports this suggestion. Goebbels et al. (2008) state that allocation decisions in the Netherlands were not based on an explicit VSL and attempted to estimate the implicit VSL. However, the authors found that estimates varied substantially, ranging from €1,000,000 to €11,000,000.

Other

In 2016, a report (in Dutch) was published titled 'Methodology for Cost-Benefit Analysis in the Social Domain'. The report was jointly commissioned by the Ministry of the Interior and Kingdom Relations, the Ministry of Health, Welfare and Sport, the Ministry of Education, Culture and Science, and the Ministry of Social Affairs and Employment. In the report, a QALY range of €50,000 to €100,000 is provided, and it is noted that these values "do not increase over time". CE Delft reference this range when providing a rationale for their €70,000 VOQs figure, which is claimed to be the central value of the range.

4.1.4 Value of Life in Canada

General guidance

As of 1st September 2018, the Treasury Board of Canada Secretariat (TBS) has a policy on cost-benefit analysis, which sets out the mandatory requirements for federal departments and agencies "when undertaking such analysis as part of a Regulatory Impact Analysis" (TBS, 2018). The policy explicitly states that departments must use the VSL specified in TBS's cost-benefit analysis guide (TBS, 2007), which must be expressed in "constant dollars of their desired price year using Statistics Canada's Consumer Price Index".

The cost-benefit analysis guide itself (TBS, 2007) refers to a literature review of VSL studies within a report prepared for Environment Canada and Health Canada, which identified a mean VSL of CA$5.2 million in 1996 dollars (Chestnut, Mills and Rowe, 1999). The guide adds that this value is CA$6.11 million in 2004 dollars (after adjustment for inflation) and states that this value should be used by all departments (with the necessary inflation adjustment).

Health

In Canada, the Department of Health (Health Canada) and the Canadian Agency for Drugs and Technologies in Health (CADTH) do not currently use explicit cost-effectiveness thresholds.

Several studies have been conducted to determine an implicit threshold. A recent study attempted to estimate the VOQ for Canada as a whole, using province-level data (Ochalek et al., 2019). The authors recommended a country-wide threshold of CA$30,000, however it has been argued that this estimate is not well-supported by the evidence presented in the paper (Cubi-Molla et al., 2020). Nonetheless, the authors note that their estimate is fairly consistent with the implied VOQ range for Canada estimated in another analysis of CA$26,596- CA$33,560 in 2013 CA$ (Woods et al., 2016).

On the other hand, elsewhere it has been suggested that the VOQ is much higher in practice. One estimate suggests that it is closer to CA$80,000 per QALY (Paris and Belloni, 2014b). This is based on a review that found that most positive recommendations had an ICER below this threshold level, however it was acknowledged that this threshold did not constitute a clear cut-off. Another analysis of the implicit VOQ also focused on recommendations, but specifically those from the pan-Canadian Oncology Drug Review (pCODR) between 2011 and 2017 (Skedgel, Wranik and Hu, 2018). The pCODR focuses on four criteria, of which 'value for money' is only one, but nonetheless the authors find that there is evidence of a 'maximum acceptable cost-effectiveness threshold' of CA$140,000 per QALY for oncology drugs. This is, to an extent, validated by recent evidence from the Patented Medicine Prices Review Board (PMPRB), which suggests that a range between CA$50,000 - CA$100,000 is used in practice, with oncology drugs at the higher end of the range (PMPRB, 2019b).

It is important to note that changes will soon be made in Canada. At the time of writing the report, the PMPRB was in the formal consultation stage of establishing a new nationwide system of list and net pricing of medicines. One of the key changes implies that a threshold of CA$60,000 is expected to be applied to a set of new medicines with certain characteristics, and combined with other factors, in order to generate a 'maximum rebated price' (PMPRB, 2019a).

4.1.5 Value of Life in Japan

Health

In Japan, the Ministry of Health, Labour and Welfare (MHLW) consults with the Central Social Insurance Medical Council (Chuikyo) on matters relating to the pricing of pharmaceuticals and medical devices. Traditionally, Japan has not used cost-effectiveness as a criterion for informing pricing and reimbursement decisions. However, in 2012, a subcommittee of the Chuikyo (the 'Special

Committee on Cost-Effectiveness') was set up to discuss issues relating to economic evaluation, which led to a pilot program in 2016. It was decided that cost-effectiveness analysis would be used, with QALYs as the measure of benefit, but that the results would be used to adjust prices of pharmaceuticals and medical devices, rather than to determine whether they should be reimbursed (Fukuda and Shiroiwa, 2019). Thus the 'threshold' in this case relates to the threshold upon which price adjustments are made. In the pilot, the threshold was set at ¥5 million per QALY, i.e., an ICER below this value would not result in any price adjustment. For ICERs of ¥10 million or above, the price would be adjusted at the maximum rate (90% of the premium). ICERs between ¥5 million - ¥10 million would result in a price adjustment using a linear relationship, i.e., from no adjustment to the maximum rate.

Following the pilot program, the final proposal suggested a change to the re-pricing scheme as a result of the uncertainty in estimating ICERs (MHLW, 2019). Instead of a linear relationship in the ¥5 million - ¥10 million interval, there would be two adjustment rates prior to the maximum rate, one for ¥5 million - ¥7.5 million and another for ¥7.5 million - ¥10 million. In addition, it was noted that some products would require 'special considerations' and therefore face different price adjustments. The special considerations apply to products for rare diseases that have insufficient alternatives, products for paediatric conditions, and anti-cancer drugs. For these products, there is no price adjustment below ¥7.5 million, and the maximum rate is not used unless the ICER exceeds ¥15 million. As with the standard price adjustment, there are two rates within this interval, with the midpoint used as the cut-off (¥11.25 million). In both the standard case or the case for products requiring special considerations, if an ICER range straddles a reference value, the expert committee will be responsible for determining the appropriate adjustment rate. In February 2019, the full-scale implementation of cost-effectiveness evaluation was approved by the general assembly of the Chuikyo (MHLW, 2019). As no price adjustment occurs for treatments with ICERs that do not exceed ¥5 million, this figure can effectively be considered as the baseline threshold.

Transport

In Japan, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is responsible for matters relating to transportation, amongst other responsibilities. There is no clear evidence to suggest that MLIT recommend a specific value of a life for regulatory impact, or cost-benefit, analyses.

However, a 2007 report by the 'Study Group on Economic Analysis of Damage and Loss in Road Accidents' provided two estimates of the VSL in Japan, which were calculated based on willingness to pay for a risk in mortality reduction (Cabinet Office Japan, 2007). Two values were provided: ¥226 million (95% confidence interval: 206-248) based on a 50% reduction in risk; and ¥462 million (95% confidence interval: 424-505) based on a 17% reduction in risk. These values were considered to be within a reasonable range, though further research was recommended. More recently, a journal article that aimed to look into the relationship between WTP, VSLs and other factors (e.g. age) claimed that the Cabinet Office in Japan recommend the ¥226 million figure for the VSL, though no references are provided to substantiate this claim (Morisugi et al., 2017).

Environment

In Japan, the Ministry of the Environment is responsible for matters relating to the environment. There is no clear evidence to suggest that the Ministry of the Environment recommend a specific value of a life for regulatory impact, or cost-benefit, analyses.

Nonetheless, one study attempted to value health loss from environmental risks using contingent valuation methods, conducted in Shizuoka (Itaoka et al., 2007). The survey asked participants to value mortality risk reductions relating to air pollution. They estimated multiple VSLs based on different types of risk reduction, ranging from ¥103-344 million. The authors note that these

estimates are smaller to those in other countries, and that additional studies will be needed to validate the results.

4.1.6 Value of Life in Australia

General guidance

Estimates for the VSL and VOLY in Australia can be found in a note published by the Australian Department of the Prime Minister and Cabinet (PM&C) in 2019, entitled 'Best Practice Regulation Guidance Note: Value of Statistical Life' (PM&C, 2019). These values are based on a working paper prepared for the Office of Best Practice Regulation which endeavours to establish a monetary value for lives saved (Abelson, 2008). The research reviews the three main methods of eliciting VSL, namely: wage-risk studies, studies of consumer purchases and stated preference surveys. Following this review, along with considerations of international guidelines, the author argues that a VSL of AU$3.5 million and a VOLY of AU$151,000 should be adopted by public agencies in Australia. The guidance published by PM&C does indeed adopt these values, updating them to 2019 prices using consumer price index (CPI) data, resulting in a VSL of AU$4.2 million and a VOLY of AU$213,000. According to PM&C, the note "provides guidance on how officers preparing cost-benefit analysis in Regulation Impact Statements should treat the benefits of regulations designed to reduce the risk of physical harm". Thus, it would seem reasonable to assume that these estimates are intended for practical use in cost-benefit analyses and to therefore play a role in informing resource allocation decisions. However, it appears unlikely that these estimates are used consistently across government departments and within all public agencies in Australia. As is shown in the subsequent sections, some government departments may use their own VSL and VOLY estimates, which differ from those provided within the PM&C note.

Health

There is no explicit value of a life, or cost-effectiveness threshold, used within the Australian Department of Health, its HTA body for medicines, the Pharmaceutical Benefits Advisory Committee (PBAC), or its HTA body for medical services, the Medical Services Advisory Committee (MSAC).

There have been many attempts to find an implicit threshold using PBAC decisions, but the range of estimates is large (from AU$28,033 up to AU$69,000). One study looked at PBAC decisions between 1994 and 2003 and identified the highest VOQs at which a drug was recommended was AU$52,400 (Henry, Hill and Harris, 2005); this was taken to be the implied threshold. Above this threshold, 9 of 11 applications were rejected or withdrawn, and 2 were given conditional approval (subject to price reductions). However, the authors suggest that there is no evidence that this implicit threshold is actively used to guide PBAC's decisions.

In preparing a report for the OECD, a country profile describing the value of pharmaceutical pricing in Australia estimated a cost-effectiveness threshold based on outcomes of PBAC submissions between 2005 and 2009 (Paris and Belloni, 2014a). PBAC assessment reports do not include an exact value of the ICER of the intervention but an indication of the range in which the ICER of the product is included: AU$15,000-45,000; 45,000-75,000; 75,000-105,000; 105,000-200,000. In a sample of products considered by the authors, they find that medicines with an ICER above AU$75,000 were never recommended for inclusion in the Pharmaceutical Benefits Scheme (PBS). For medicines with an ICER higher than AU$45,000, they were only recommended in exceptional circumstances, such as in indications with high clinical need and no alternative.

Another study attempted to estimate the VOQs by using empirical top-down approaches, utilising government health expenditure data (Edney et al., 2018). Their combined approach resulted in an estimate of AU$28,033 for base-case reference ICERs in Australia, with a 95% confidence interval of AU$20,758 to AUA$37,667.

In a comparison between NICE and PBAC decisions for 58 matched submissions between 2005 and 2015, an implicit threshold of AU$50,000 was used for PBAC (Wang, Gum and Merlin, 2018). Whilst ICERs differed within the paired submissions to each agency, assuming an AU$50,000 threshold for PBAC led to relatively high agreement between NICE and PBAC decisions, with misalignment only occurring in 8 submission pairs. The authors conclude that industry may assume an implicit VOQ in the case of PBAC when constructing ICERs.

Another report, prepared for Public Health Association Australia, looked at the cost-effectiveness of preventative interventions in terms of cost per DALY prevented (Vos et al., 2010). In this report, the authors deemed an intervention to be cost-effective if the cost per DALY prevented was less than AU$50,000. This threshold was derived based on "rules of thumb related to available national income and empirical evidence on funding decisions", primarily the idea that GDP per capita can be used as a reference point. The authors argue that their threshold reflects the available empirical evidence on what constitutes acceptable value for money for Australia. They also add another threshold for interventions deemed to be "very" cost-effective of AU$10,000 per DALY prevented.

No explicit or implicit additional threshold was identified in the literature related to MSAC.

Transport

The Department of Infrastructure, Transport, Regional Development and Communications is charged with the responsibility for infrastructure and transport in Australia; in doing so the department is required to make decisions that may increase or decrease risks to human life. Within this department sits the Bureau of Infrastructure, Transport and Regional Economics (BITRE), which provides economic analysis, research and statistics on infrastructure, transport issues to inform Australian government policy development.

In 2009, BITRE published a research report estimating the total cost to society of road traffic accidents for the year 2006, which required the cost per fatality to be monetarised (BITRE, 2009). BITRE used a hybrid human capital approach that includes many additional social costs outside of the health/life domain, these are namely hospitalisation costs, funeral costs, prosecuting for driving offences and a monetary value of grief. The cost per road fatality derived using BITRE's unique approach is estimated to be AU$2.4 million (in 2006 Australian dollars). This figure is largely informed by the bureau's previous research which established the hybrid approach, citing that the human capital approach is appropriate where there are doubts about the reliability of values revealed by individuals in willingness-to-pay studies. However, even with the additional social costs, BITRE state that their estimate is "conservative" and that if a willingness-to-pay approach had been used, the estimated cost of a fatality would have been considerably higher, at around AU$6.2 million (Hensher et al., 2009).

Whilst BITRE publishes a yearly report which systematically updates the VSL estimate, these research reports estimate the social costs of traffic accidents retrospectively. There is little evidence to suggest that these estimates are used to prospectively inform resource allocation in the Department of Infrastructure, Transport, Regional Development and Communications.

Environment

The National Environment Protection Council (NEPC) is a government agency within the Australian Department of Agriculture, Water and the Environment. In 2013, a consulting report was prepared for the NEPC designed to inform the National Plan for Clean Air, which provided VOLY estimates based on a number of academic and government sources (Boulter and Kulkarni, 2013). The estimates, which can be found in the appendices of that report, were AU$288,991 (as of 2011) for the VOLY and an average AU$6 million (as of 2006) for the VSL.

Given that this is just one government document from a subsection of the Australian Department of Agriculture, Water and the Environment, it is difficult to conclude whether these figures are actually used to inform resource allocation decisions. In particular, it is important to note that the report itself was not published directly by the Department.

4.1.7 Value of Life in New Zealand

General guidance

Estimates of the VSL can be found in governmental guidelines entitled 'Guide to Social Cost Benefit Analysis' produced by the New Zealand Treasury (New Zealand Treasury, 2015). Specifically, it states the VSL in 2013 was NZ$3.85 million. This document recommends that cost-benefit analysis forms part of all significant government decisions. It is also acknowledged that value of life is frequently required to be estimated when conducting cost-benefit analysis, thus the report provides a standard value to ensure consistency since many projects increase or decrease the risk to life. It states that contingent valuation is used to derive the VSL estimate, referring to a survey of international studies into the value of life (Viscusi and Aldy, 2003) and a stated preference survey undertaken by the Ministry of Transport (Miller and Guria, 1991). Further details of the Ministry of Transport report are included later in this section.

More recently, the New Zealand Treasury introduced a cost-benefit analysis tool, CBAx, which contains a database of values to help government agencies monetise impacts and complete accurate cost-benefit analyses. According to the accompanying guidance, the tool is "designed to support rigorous transparent evidence-based CBA of budget and policy initiatives" (New Zealand Treasury, 2018). Based on the version for Budget 2020 (released September 2019), the VSL estimate, adjusted to 2020, is NZ$4,918,898. The tool also contains an estimate for the value of a QALY of NZ$33,306 (adjusted to 2020).

Given that the value of life estimates are included in guidance and supporting tools (CBAx), it is reasonable to suggest that these estimates are intended for practical use in cost-benefit analyses and thus to inform resource allocation decisions. However, it is more difficult to verify whether these estimates are used *consistently* across government departments and within all public agencies in New Zealand.

Health

There is no explicit value of a life or cost-effectiveness threshold within the New Zealand Department of Health or its HTA body, the Pharmaceutical Management Agency (PHARMAC).

According to Thokala et al. (2018), "Whilst researchers have tried to imply the threshold from previous decisions, PHARMAC states that they' fund medicines within a fixed budget, and as cost-effectiveness is only one of its nine decision criteria used to inform decisions, thresholds cannot be inferred or calculated'" (p.515). One such study looked at the average VOQs ratios implied by PHARMAC decisions between 1998 and 2001, finding that they are "broadly consistent with a ceiling of NZ$20,000" (Pritchard, 2002). However, it was not a systematic analysis of PHARMAC's decision reports; meaning that this estimate may not be an accurate representation, even over this short time frame.

Furthermore, the Treasury's CBAx tool provides VOQs estimates similar to those of more traditional cost-effectiveness thresholds. In 2016/17, PHARMAC funded proposals had a net present value (NPV) of 37 QALYs per million dollars spent; in 2015/16 the figure was 52 QALYs per million and in 2018/19 the figure was 118 QALYs per million. The CBAx tool takes the highest NZ$ per QALY over these years – a figure of NZ$33,306 per QALY gained – which is claimed by the Treasury to be "more aligned internationally".

Since there is no explicit cost effectiveness threshold or VoL within the Department of Health in New Zealand, there is no single monetary value used in decision-making regarding health resources. As mentioned above, cost-effectiveness is one of nine decision-making criteria used to inform decisions, but PHARMAC believe that an explicit threshold is incompatible with their approach to funding medicines in the context of a fixed budget which changes year on year. That said, the Treasury has recommended that a value of NZ$33,306 per QALY be used in cost-benefit analysis outside of the health sector.

Transport

There is an explicit VSL estimate provided by the New Zealand Ministry of Transport, which is based on a willingness to pay survey conducted in 1989/1990 (Miller and Guria, 1991) and has been updated yearly by indexing on average hourly earnings. The study established that the New Zealand population would be willing to pay NZ$2 million for a safety improvement that results in the expected avoidance of one premature death. The latest 'Social cost of road crashes and injuries' report published an update of the VSL in 2018 using crash and injury data from 2015 to 2017. The updated value was reported as NZ$4.34 million per fatality, at June 2018 prices (New Zealand Ministry of Transport, 2019). All of this is in alignment with the guidance provided by the New Zealand Treasury and the CBAx tool (New Zealand Treasury, 2015, 2018).

Given that a VSL estimate is frequently cited in the New Zealand Ministry of Transport resources and regularly updated, it would be reasonable to suggest that it is in fact used to inform resource allocation within this department.

Environment

No values were identified for specific use in the environmental setting. However, it seems reasonable to suggest that the values from the CBAx tool can be applied in environmental cost-benefit analyses.

4.1.8 Value of Life in South Korea

Health

In 2003, the Ministry of Health and Welfare commissioned the Health Insurance Review and Assessment Service (HIRA) to develop a new health technology assessment (nHTA) program, which began in mid-2007 (Lee and Salole, 2016). As part of this program, cost-effectiveness evidence is assessed to determine whether a treatment should be reimbursed. Although not the only factor considered, cost-effectiveness is an important criterion, and treatments are assessed using cost-effectiveness analyses with QALYs as the measure of benefit. However, it has been noted that South Korea does not have an explicit cost-effectiveness threshold (EIU, 2017). Regardless of this, the threshold is generally accepted to be around 25 million KRW, which is tied to South Korea's GDP per capita in 2016 (Bae et al., 2018; Yoo et al., 2019). The link to GDP per capita may have been due to the recommendation by WHO that a threshold value should be between 1 and 3 times a country's GDP per capita. However, a published report by National Evidence-based Healthcare Collaborating Agency (NECA) reviewed various contingent valuation (WTP) studies that may have also been influential, as results were often close to the 25 million KRW figure (NECA, 2011). Finally, it has also been suggested that a higher, flexible threshold value of up to 50 million KRW has recently been applied for a limited number of drugs for cancer and rare diseases (i.e., orphan drugs).

In practice, the ICER is compared to the threshold value to inform the final decision. However, as is the case in other countries, it has been shown that an ICER above (or below) the threshold does not guarantee rejection (or acceptance) in South Korea. A study found that, in 17 of 46 cases (37%) where the ICER exceeded 25 million KRW, the treatment was still reimbursed, though none were

more than double GDP per capita, i.e. 50 million KRW (Bae et al., 2018). Additionally, some cases where the ICER was below 25 million KRW were still rejected due to uncertainty.

It is worth highlighting that not all treatments are assessed for their cost-effectiveness in South Korea. To be assessed, treatments must have at least one alternative (comparator) and must be found to be superior to the alternative(s). Additionally, treatments with an 'essential drug' designation are exempt from cost-effectiveness evaluation. These designations are relatively hard to achieve, as the treatment must meet all of the following criteria: a) there are no alternatives; b) it is for a serious life-threatening condition; c) it is used to treat small patient groups; and d) it demonstrates significant clinical/survival improvement (Yoo et al., 2019). Finally, for cancer or orphan drugs that do not meet the 'essential drug' criteria, there can be a cost-effectiveness analysis waiver in some circumstances, though a risk-sharing agreement must subsequently be agreed.

Transport and Environment

There is no clear evidence to suggest that the Ministry of Land, Infrastructure and Transport (MOLIT) or the Ministry of Environment (MOE) recommend a specific value of life for use in analyses. However, some studies have been conducted to estimate the VSL in South Korea. A relatively recent contingent valuation study funded by the MOE was published, which estimated respondents' WTP to avoid risks associated with carcinogenic chemicals (Lee et al., 2015). Using a double-bounded dichotomous choice method, they estimated a VSL of 796 million KRW based on responses from a sample of 1,434 individuals from the South Korean population. When comparing their results with other South Korean VSL studies, the most recent of which was published in 2008, they find that their estimate is relatively high in comparison. Nonetheless, they conclude that their estimate is far smaller than VSL estimates from other countries. Indeed, their estimate equivalent to around US$650,000, whereas the OECD base value was US$3,000,000 in 2005 prices (Roy and Braathen, 2017).

Due to the lack of clear, reliable evidence in South Korea, this country was omitted from the analysis.

4.2 Intra-country comparisons

In this section, the values identified in the literature review are compared for each country in tables and figures. To maximise comparability, values have been adjusted to 2019 prices wherever advisable and possible. Additionally, VSLs have been converted to VOLYs, and DALY estimates removed, for easier comparisons with VOQs.

South Korea was not included in the analysis, due to the lack of robust estimates across departments.

4.2.1 United Kingdom

There are clear differences in the VoL in the UK in governmental guidelines (Table 2). For example, while NICE appraise treatments at a £20,000-30,000 QALY threshold, HM Treasury recommend a value of £60,000 per QALY for health-related appraisals. To convert the VPF (cited in the Green Book and in Department for Transport guidance) to a VOLY estimate, a discount rate of 1.5% was used and life expectancy at birth was identified as 81.1 years. After converting the VOLY and QALY values (£67,650 and £73,535, respectively) that exceed the 'normal' threshold range by NICE. Similarly, VOLY estimates from the Green Book and from environmental guidance (specifically related to the chronic effects of air pollution) also exceed this range considerably, with or without conversion to QALYs. Figure 2 illustrates these findings, focusing on the QALY estimates (the last column of Table 2).

TABLE 2. VALUE OF LIFE IN THE UK

No.	Area	Source	Relevance	Type of Estimate	Stated Value (£)	Year	2019/2020 Value* (£)	VOLY (£)	VSL (£)	QALY (£)
1	Health	NICE	Threshold used to assess 'normal' treatments	QALY	20,000-30,000	2013	20,000-30,000	18,399-27,599	663,351-995,027	**20,000-30,000**
2	Health	NICE	Threshold used to assess 'end-of-life' treatments	QALY	50,000	2013	50,000	45,998	1,658,378-3,316,756	**50,000**
3	Health	NICE	Threshold used to assess 'highly specialised technologies'	QALY	100,000-300,000	2017	100,000-300,000	91,996-275,988	3,316,756-9,950,268	**100,000-300,000**
4	Health	HM Treasury	Health-related appraisal (Green Book)	QALY	60,000	2018	60,000	55,198	1,990,054	**60,000**
5	Transport	HM Treasury/DfT	Social cost-benefit analysis (Green Book)	VPF	2,064,189	2020	2,064,189	67,650	**2,064,189**	73,535
6	Environment	Defra	Valuing life lost due to chronic effects of air pollution	VOLY	42,780	2017	*45,343*	**45,343**	1,383,543	49,288
7	Environment	Defra	Valuing life lost due to acute effects of air pollution	VOLY	22,110	2017	*23,435*	**23,435**	715,068	25,474
8	Other	HM Treasury	Social cost-benefit analysis (Green Book)	SLY	60,000	2018	60,000	**60,000**	1,830,770	65,220

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance suggests that this is required/appropriate. Only the values in *italics* were adjusted. Values in **bold** are the original values, after adjustments. A discount rate of 1.5% and life expectancy of 81.1 were used in calculations. All values are in local currency.
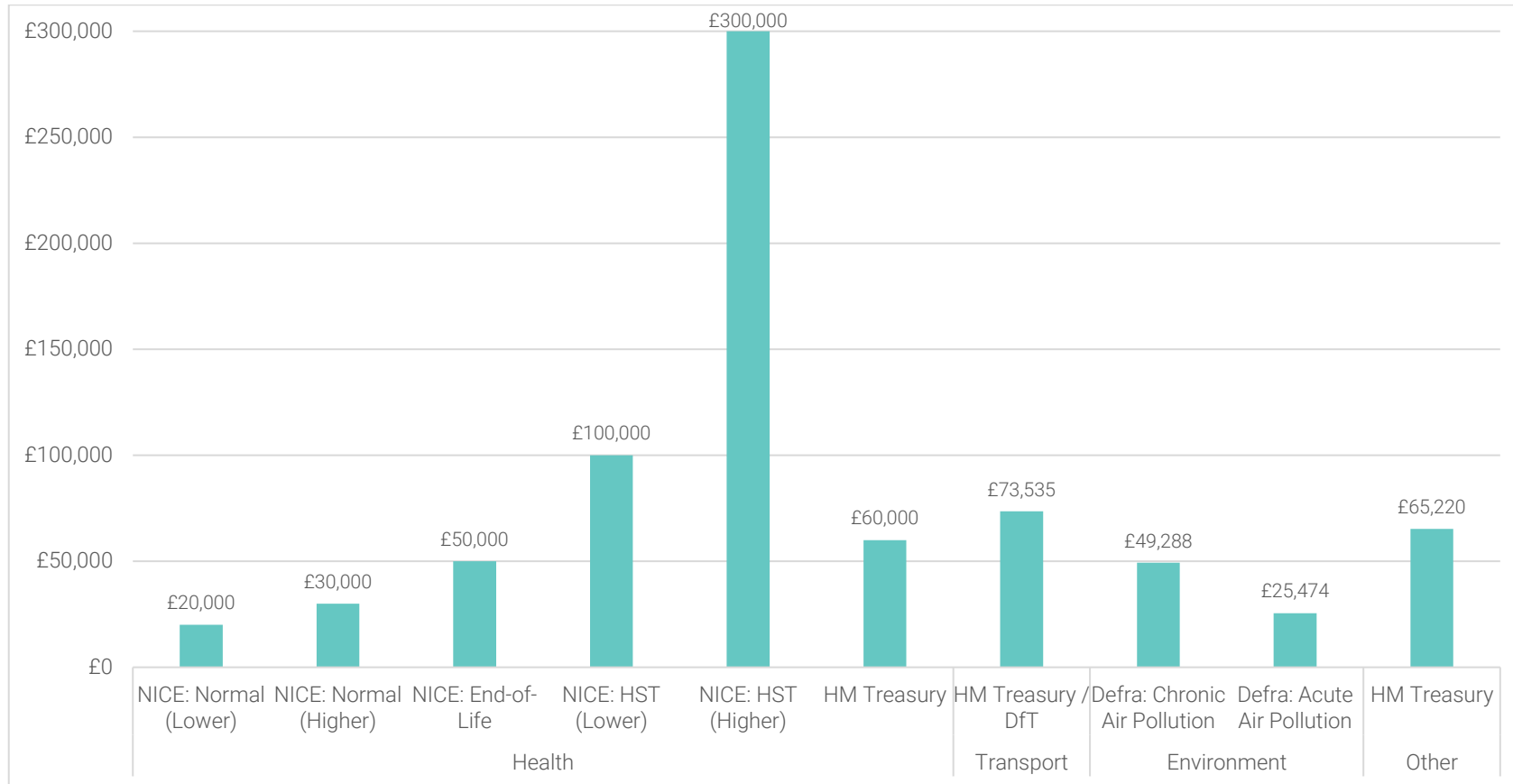
FIGURE 2. VALUE OF LIFE IN THE UK (£ PER QALY)

4.2.2 The Netherlands

In the Netherlands, there is some evidence to suggest that VoL differs between departments. ZIN employs three different QALY thresholds based on a measure of the severity of the disease (proportional QALY shortfall) ranging from €20,000-80,000. The transport VPF from the OEEI-Guideline, which was not updated to current prices, translates to €52,777 per QALY, which is in the middle of this range. The VSL and VOLY estimates from the Environmental Prices Handbook translate to €84,443 and €80,703 per QALY respectively, both exceeding ZIN's range. Given that a proportional QALY shortfall of >0.71 indicates a very severe disease and will apply in only a small subset of cases, it would seem reasonable to conclude that VoL is higher outside of the health setting. This is further supported by the higher range for QALYs in the social domain (€50,000-100,000). Figure 3 illustrates these findings, focusing on the QALY estimates (the last column of Table 3).

TABLE 3. VALUE OF LIFE IN THE NETHERLANDS

No.	Area	Source	Relevance	Type of Estimate	Stated Value (€)	Year	2019/2020 Value* (€)	VOLY (€)	VSL (€)	QALY (€)
1	Health	ZIN	Treatments with proportional QALY shortfall of 0.10-0.40	QALY	20,000	2015	20,000	18,399	671,639	**20,000**
2	Health	ZIN	Treatments with proportional QALY shortfall of 0.41-0.70	QALY	50,000	2015	50,000	45,998	1,679,098	**50,000**
3	Health	ZIN	Treatments with proportional QALY shortfall of 0.71-1.00	QALY	80,000	2015	80,000	73,597	2,686,557	**80,000**
4	Transport	OEEI Guideline	Values for transport infrastructure projects: European average from an OECD publication	VPF	1,500,000	1998	1,500,000	48,553	**1,500,000**	52,777
5	Environment	CE Delft	Valuing life lost due to air pollution (though VOLY is preferred)	VSL	2,400,000	2012	2,400,000	77,685	**2,400,000**	84,443
6	Environment	CE Delft	Valuing the health impact of environmental pollution	VOLY	70,000	2015	*74,244*	**74,244**	2,293,699	80,703
7	Other	SEO	Values for social cost-benefit analysis in the social domain	QALY	50,000-100,000	2015	50,000-100,000	45,998-91,996	1,679,098-3,358,196	**50,000-100,000**
8	Other	CE Delft	Central estimate of the range for social cost-benefit analysis in the social domain	QALY	70,000	2015	70,000	64,397	2,350,737	**70,000**

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance states to do so. Only the values in *italics* were adjusted.

Values in **bold** are the original values, after adjustments. A discount rate of 1.5% and life expectancy of 81.8 were used in calculations. All values are in local currency.

FIGURE 3. VALUE OF LIFE IN THE NETHERLANDS (€ PER QALY)

4.2.3 Canada

There is evidence to suggest that VoL in Canada varies between settings. Whilst there are no explicit QALY thresholds used by CADTH, the highest estimate of an implied health threshold is CA$140,000 (for oncology drugs), which is far lower than the comparable estimates for transport and environment from the TBS (CA$283,612 when converted to QALYs). Figure 4 illustrates these findings, focusing on the QALY estimates (the last column of Table 4).

TABLE 4. VALUE OF LIFE IN CANADA

No.	Area	Source	Relevance	Type of Estimate	Stated Value (CA$)	Year	2019/2020 Value* (CA$)	VOLY (CA$)	VSL (CA$)	QALY (CA$)
1	Health	PMPRB	Estimate of the lower bound of the QALY threshold range	QALY	50,000	2019	50,000	45,998	1,683,060	**50,000**
2	Health	PMPRB	Estimate of the upper bound of the QALY threshold range (oncology drugs)	QALY	100,000	2019	100,000	91,996	3,366,119	**100,000**
3	Health	Skedgel et al.	Academic estimate of an implied threshold for pCODR (oncology drugs)	QALY	140,000	2018	140,000	128,794	4,712,567	**140,000**
4	Health	PMPRB	Proposed future threshold value	QALY	60,000	2020	60,000	55,198	2,019,672	**60,000**
5	Transport	TBS	Estimate for use in cost-benefit analysis	VSL	6,110,000	2004	*8,079,656*	260,912	**8,079,656**	283,612
6	Environment	TBS	Estimate for use in cost-benefit analysis	VSL	6,110,000	2004	*8,079,656*	260,912	**8,079,656**	283,612

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance states to do so. Only the values in *italics* were adjusted.

Values in **bold** are the original values, after adjustments. A discount rate of 1.5% and life expectancy of 81.9 were used in calculations. All values are in local currency.
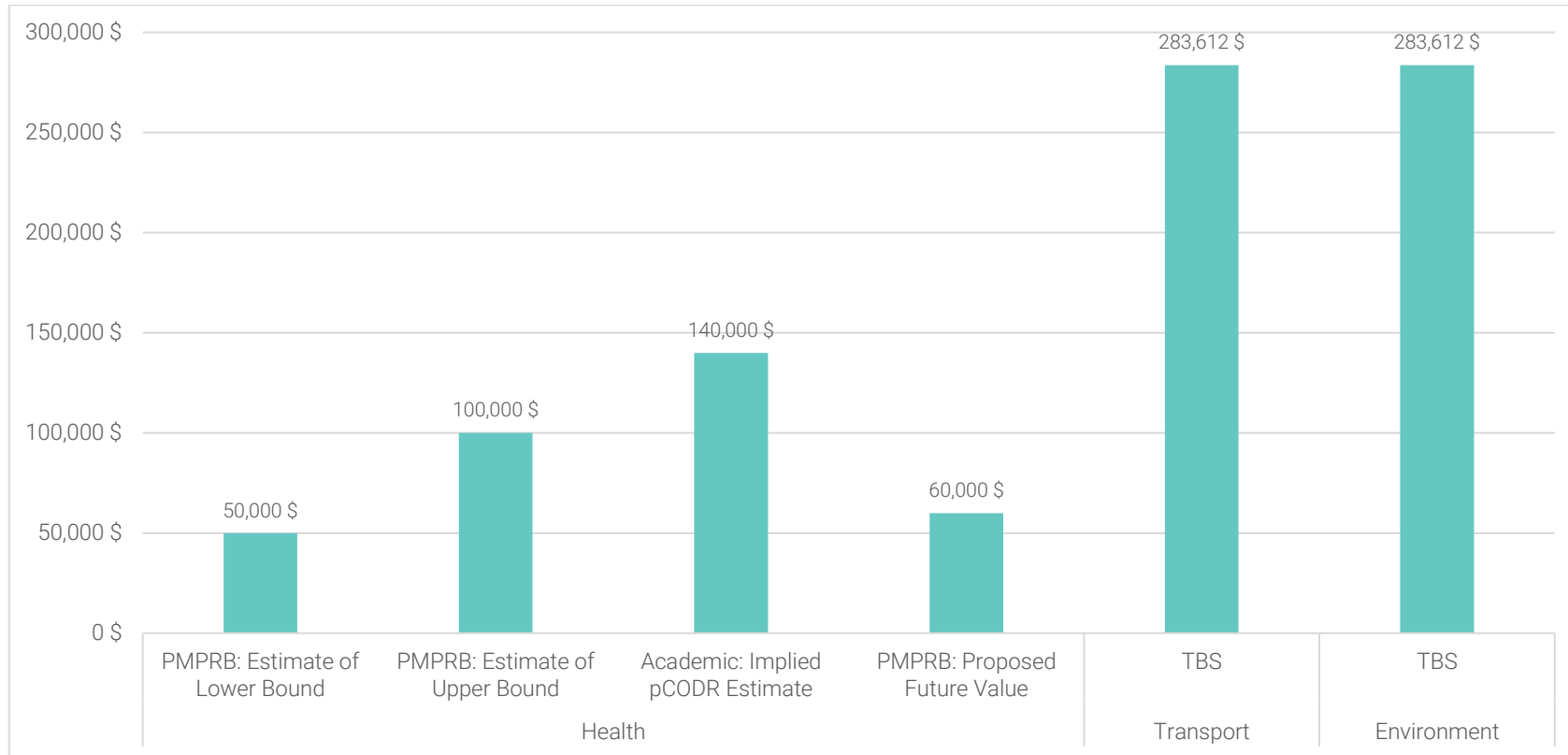
FIGURE 4. VALUE OF LIFE IN CANADA ($ PER QALY)

4.2.4 Japan

In Japan, there is little evidence to suggest differences in the VoL between governmental departments, which may be explained by a lack of formal evidence of values that are used in the transport and environment settings. The estimates that were identified in these settings fit reasonably well within the 'normal' price adjustment threshold range set by MHLW. Whilst the transport and environment values were not adjusted to current prices, inflation rates in Japan have been low in these time periods (and occasionally negative), therefore this would have little impact on the comparisons. Figure 5 illustrates these findings, focusing on the QALY estimates (the last column of Table 5).

TABLE 5. VALUE OF LIFE IN JAPAN

No.	Area	Source	Relevance	Type of Estimate	Stated Value (¥)	Year	2019/2020 Value* (¥)	VOLY (¥)	VSL (¥)	QALY (¥)
1	Health	MHLW	Price adjustment threshold for 'normal' treatments	QALY	5,000,000-10,000,000	2019	5,000,000-10,000,000	4,599,800-9,199,600	158,701,235-317,402,469	**5,000,000-10,000,000**
2	Health	MHLW	Price adjustment threshold for products with 'special considerations'	QALY	7,500,000-15,000,000	2019	7,500,000-15,000,000	6,899,700 13,799,400	238,051,852 476,103,704	**7,500,000-15,000,000**
3	Transport	Cabinet Office Morisugi et al.	Estimates in relation to road accidents	VSL	226,000,000-462,000,000	2007	226,000,000-462,000,000	7,739,790-15,822,049	**226,000,000-462,000,000**	8,413,152-17,198,567
4	Environment	Itaeka et al.	Estimates in relation to air pollution	VSL	103,000,000-344,000,000	1999	103,000,000-344,000,000	3,527,427-11,780,920	**103,000,000-344,000,000**	3,834,313-12,805,860

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance states to do so. Only the values in *italics* were adjusted.

Values in **bold** are the original values, after adjustments. A discount rate of 2% and life expectancy of 84.3 were used in calculations. All values are in local currency.
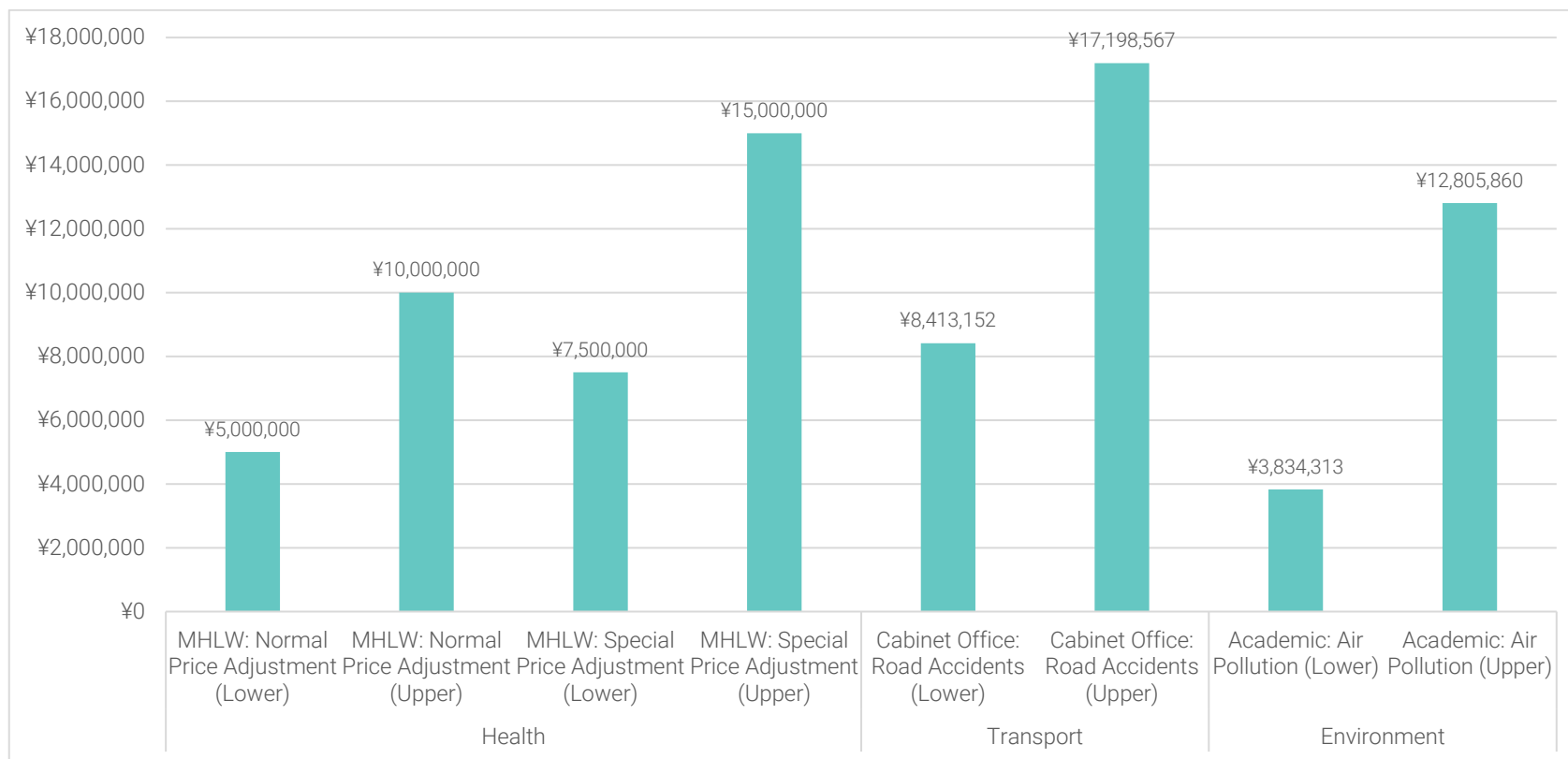
FIGURE 5. VALUE OF LIFE IN JAPAN (¥ PER QALY)

4.2.5 Australia

There is evidence to suggest that the VoL in Australia varies between settings. Whilst there are no explicit QALY thresholds used by PBAC, the highest estimate of an implied health threshold is AU$75,000, which is far lower than the estimates for transport and environment (the lowest of which is AU$199,832 when converted to QALYs). This also holds if the PM&C values are used in transport and environment contexts. Figure 6 illustrates these findings, focusing on the QALY estimates (the last column of Table 6).

TABLE 6. VALUE OF LIFE IN AUSTRALIA

No.	Area	Source	Relevance	Type of Estimate	Stated Value (AU$)	Year	2019/2020 Value* (AU$)	VOLY (AU$)	VSL (AU$)	QALY (AU$)
1	Health	Henry, Hill & Harris	Estimate based on PBAC decisions between 1994-2003	QALY	52,400	2003	52,400	48,206	996,295	**52,400**
2	Health	Paris & Belloni	Estimate of maximum cut-off based on PBAC decisions between 2005-2009	QALY	75,000	2009	75,000	68,997	1,425,994	**75,000**
3	Health	Wang, Gum & Merlin	Threshold used to compare PBAC and NICE decisions 2005-2015	QALY	50,000	2015	50,000	45,998	950,663	50,000
4	Transport	BITRE	Estimate of the cost per road fatality	VSL	2,400,000	2006	*3,215,595*	183,838	**3,215,595**	199,832
5	Environment	NEPC/Boulter & Kulkarni	Economic analysis to inform the National Plan for Clean Air	VOLY	288,991	2011	288,991	**288,991**	5,054,867	314,133
6	Environment	NEPC/Boulter & Kulkarni	Economic analysis to inform the National Plan for Clean Air	VSL	6,000,000	2006	6,000,000	343,025	**6,000,000**	372,868
7	Other	PM&C	For use in cost-benefit analyses for regulation impact statements	VOLY	213,000	2019	213,000	**213,000**	3,725,676	231,531
8	Other	PM&C	For use in cost-benefit analyses for regulation impact statements	VSL	4,900,000	2019	4,900,000	280,137	**4,900,000**	304,509

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance states to do so. Only the values in *italics* were adjusted.

Values in **bold** are the original values, after adjustments. A discount rate of 5% and life expectancy of 82.6 were used in calculations. All values are in local currency.
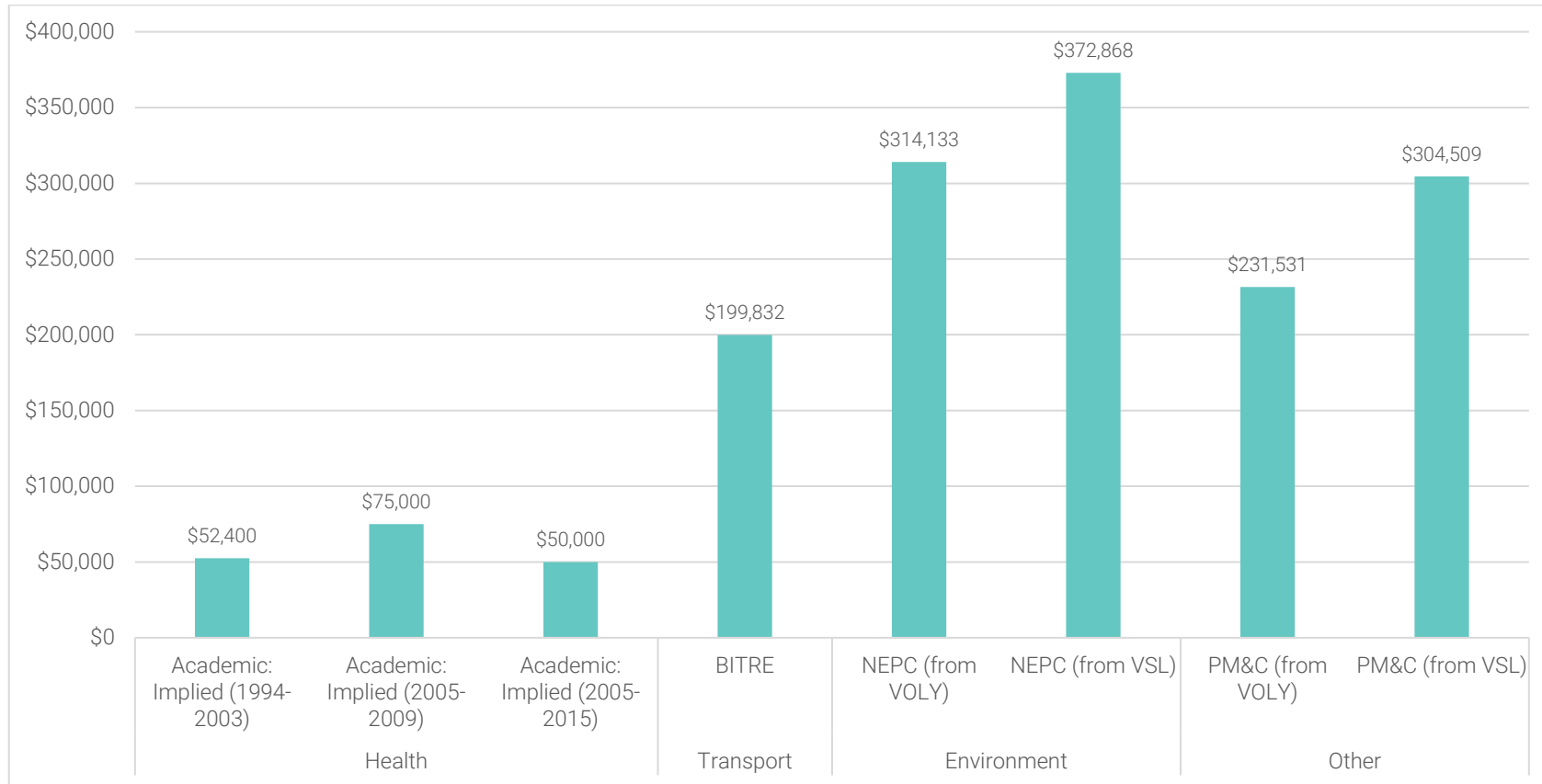
FIGURE 6. VALUE OF LIFE IN AUSTRALIA ($ PER QALY)

4.2.6 New Zealand

There is evidence to suggest that the VoL in New Zealand varies between settings. Whilst there are no explicit QALY thresholds used by PHARMAC, the highest estimate in the health setting (from the Treasury) is NZ$33,306 per QALY, which is far lower than the estimates for transport and environment (the lowest of which is NZ$225,347 when converted to QALYs). Figure 7 illustrates these findings, focusing on the QALY estimates (the last column of Table 7).

TABLE 7. VALUE OF LIFE IN NEW ZEALAND

No.	Area	Source	Relevance	Type of Estimate	Stated Value (NZ$)	Year	2019/2020 Value* (NZ$)	VOLY (NZ$)	VSL (NZ$)	QALY (NZ$)
1	Health	Pritchard et al.	Academic estimate based on PHARMAC decisions from 1998-2001	QALY	20,000	2001	*28,342*	26,073	667,896	**28,341**
2	Health	Treasury	Value from the CBAx tool for use in cost benefit analysis	QALY	33,306	2019	33,306	30,640	784,904	**33,306**
3	Transport	Ministry of Transport	Estimate in the context of road crashes and injuries	VSL	4,340,000	2018	*4,494,540*	207,311	**4,494,540**	225,347
4	Transport	Treasury	Value from the CBAx tool for use in cost benefit analysis	VSL	4,900,000	2019	4,900,000	226,013	**4,900,000**	245,676
5	Environment	Treasury	Value from the CBAx tool for use in cost benefit analysis	VSL	4,900,000	2019	4,900,000	226,013	**4,900,000**	245,676

*Values were only updated to 2019/2020 values if they were not already up to date, and if guidance states to do so. Only the values in *italics* were adjusted.

Values in **bold** are the original values, after adjustments. A discount rate of 3.5% and life expectancy of 81.3 were used in calculations. All values are in local currency.
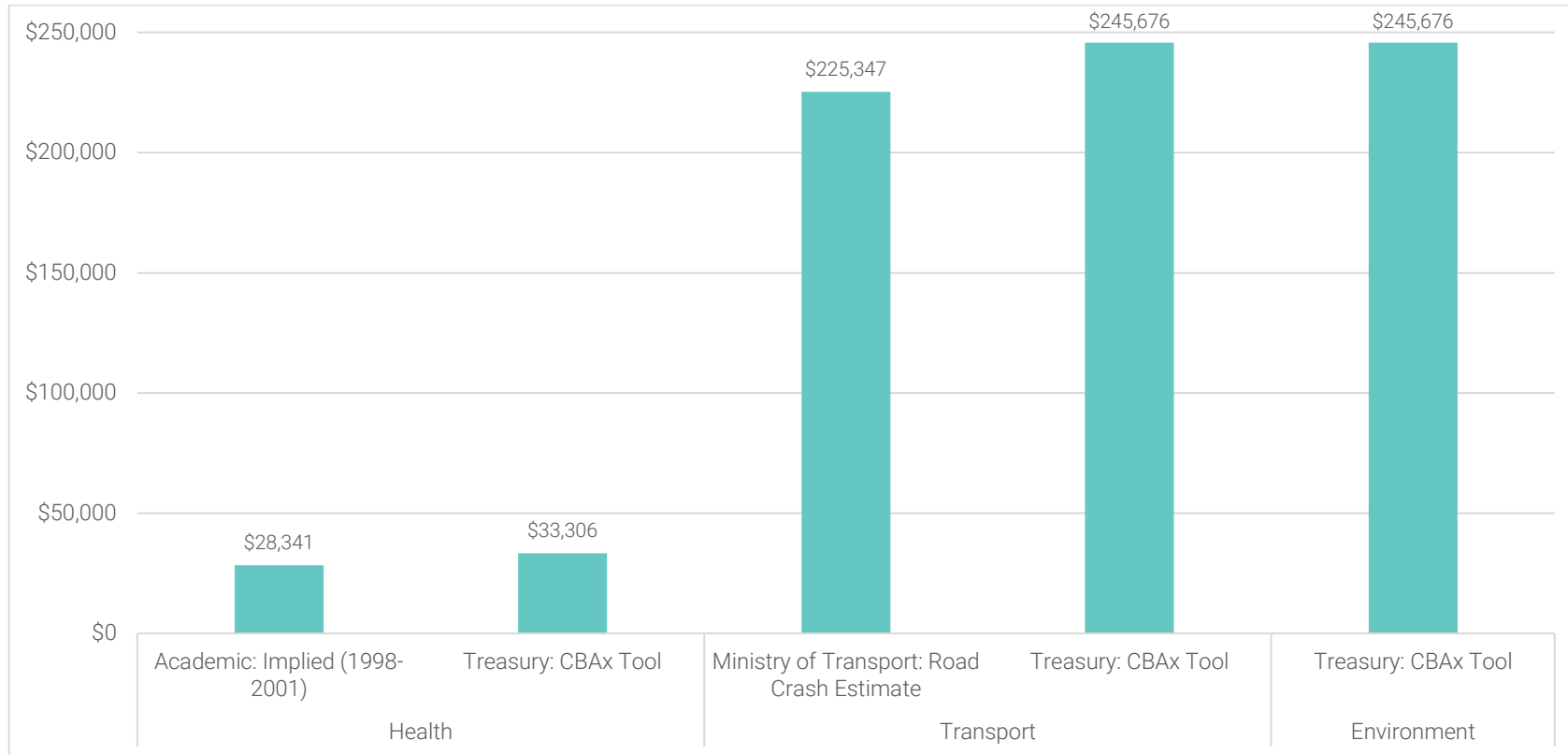
FIGURE 7. VALUE OF LIFE IN NEW ZEALAND ($ PER QALY)

4.3 Inter-country comparisons

In this section, the magnitude of the transport and environment value estimates are compared to the health values. As noted in the methods section, this was achieved by using a subset of values representing the 'general case' from the full range of values identified in the literature review. For health, the most commonly applied VOQ figures were used where available (i.e., not those reserved for rare or oncology indications). For transport and environment, the values were assessed in detail and the most realistic were selected for use in the analysis. The rest of this section sets out the rationale for selecting the chosen values in each country, followed by the comparison itself.

In the **United Kingdom**, the single technology appraisal QALY threshold from NICE of £20,000-£30,000 was chosen as the most regularly applied threshold range in health. The Green Book refers to Department for Transport guidance in relation to the VPF, implying that this value is most appropriate for transport. In the environment setting, Defra provides two VOLY estimates, which were therefore used in this analysis. However, it could be argued that the Green Book values (which are all larger) could be used in this setting too. In the **Netherlands**, the only identified values in the health setting were from ZIN (€20,000-€80,000), with the exact value used dependent on the severity of the condition. We have taken the lowest threshold value as the baseline. The VPF from the OEEI Guideline was the only transport estimate identified and thus was also selected. The Environmental Prices Handbook suggests that VOLYs are preferred over VSLs, thus the VOLY estimate was used. For **Canada**, the PMPRB estimates of the QALY threshold range were used for health, as the other estimates were either specific to oncology or not currently in use. Given the clear guidance to use the Treasury's VSL, this value was used for both transport and environment. For **Japan**, the baseline threshold (the cut-off for price adjustment for 'normal' treatments) was used alongside the two identified VSLs for transport and environment. For **Australia**, given the lack of a single explicit threshold, the two higher academic estimates were used. The BITRE estimate was used for transport as this was the only transport-specific value identified. For environment, the VOLY estimate was used to align with the Netherlands; this was the smaller of the two values. For **New Zealand**, the Treasury values were used across all departments. The Treasury values slightly exceeded the other values identified for health and transport.

Table 8 contains the comparisons. Each row is in the country's own currency. The raw VOQ values identified for health, and the converted values (from VSL/VOLY to QALY) for transport and environment. The 'health as %' column indicates the size of the health values as a proportion of the non-health values. As there are ranges for health in all but one country, a range is typically provided in this column. For example, in the UK, the lower end and the higher end of the NICE threshold range are 27% and 41% of the value identified for transport, respectively.

TABLE 8. INTER COUNTRY COMPARISONS

Country	Health		Transport			Environment		
	Source	Value(s)	Source	Value	Health as %	Source	Value	Health as %
UK	NICE	20,000 - 30,000	DfT/Green Book	73,535	27% - 41%	Defra	25,474	79% - 118%
							49,288	41% - 61%
NL	ZIN	20,000	OEEI Guideline	52,777	38%	CE Delft	80,703	25%
CA	PMPRB	50,000 - 100,000	Treasury	283,612	18% - 35%	Treasury	283,612	18% - 35%
JP	Implicit	5,000,000	Cabinet Office	8,413,152	59%	Academic	3,834,313	130%
				17,198,567	29%		12,805,860	39%
AUS	Academic (x2)	52,400 - 75,000	BITRE	199,832	26% - 38%	NEPC	314,133	17% - 24%
NZ	Treasury	33,306	Treasury	245,676	14%	Treasury	245,676	14%

All values are in local currency.

Table 8 illustrates that generally, the values in the health setting are far lower than those from the transport and environment settings, with the value of life used in health often <50% of the value used in transport and environment. There are only two examples where the value in transport or environment exceeds the value used in health. The first is the smaller of the two Defra estimates in the UK, which is intended for capturing the acute mortality impact of air pollution. Had a broader estimate been used, such as one from the Green Book, the value would be at least double the upper health value of £30,000 (see Table 2). The other example is the smaller of the two academic estimates in Japan, also in environment, which was the lowest value from that particular study. The authors of the study acknowledged that *all* of their VSL estimates were low in comparison to similar studies conducted in other countries. It is also worth noting that several of the transport and environment estimates had not been updated to current prices due to a lack of official guidance to do so. Had this adjustment been made, the differences would have been even larger, in the same direction.

4.4 Sensitivity analysis

As numerous assumptions are required to convert between VSLs, VOLYs and VOQs, it is important to test whether these assumptions could impact the findings. As noted earlier, two big assumptions relate to the age upon which life expectancy is calculated when converting between VOLYs and VSLs (40 was used in our analysis), and the conversion rate between QALYs and VOLYs (a rate of VOQ = 1.087 VOLY was used in our analysis). Both of these assumptions have clear limits. Using life expectancy at birth (age zero) will result in the smallest possible VOLYs when converting from VSLs, holding all else equal. Using a conversion rate of 1 to 1 between VOQs and VOLYs will result in the smallest possible VOQ estimates when converting from VOLY to VOQ. We therefore repeated the inter-country comparison analysis using both of these alternative assumptions at the same time; the results are in Table 9.

In comparison to Table 8, the environment and transport values in Table 9 are all lower as expected. The changes are far larger for estimates that were originally VSLs, as the life expectancy assumption has a bigger impact than the VOQ to VOLY conversion assumption, as the latter did not change drastically. Whilst the absolute values changed, and the percentages increased, none of the estimates for transport or environment increased from below 100%.

TABLE 9. INTER COUNTRY COMPARISONS SENSITIVITY ANALYSIS: AGE = ZERO & VOLY = QALY

Country	Health		Transport			Environment		
	Source	Value(s)	Source	Value	Health as %	Source	Value	Health as %
UK	NICE	20,000 - 30,000	DfT/Green Book	44,167	45% - 68%	Defra	23,435	85% - 128%
							45,343	44% - 66%
NL	ZIN	20,000	OEEI Guideline	31,951	63%	CE Delft	74,244	27%
CA	PMPRB	50,000 - 100,000	Treasury	171,956	29% - 58%	Treasury	171,956	29% - 58%
JP	Implicit	5,000,000	Cabinet Office	5,569,278	90%	Academic	2,538,211	197%
				12,375,477	40%		8,477,130	59%
AUS	Academic (x2)	52,400 - 75,000	BITRE	163,696	32% - 46%	NEPC	288,991	18% - 26%
NZ	Treasury	33,306	Treasury	182,625	18%	Treasury	182,625	18%

All values are in local currency.

In conclusion, the overall trend that health is valued less by those in the health setting relative to the environment and transport settings appears to be robust to the assumptions made when converting between measures.

5. Discussion and limitations

5.1. Discussion

The comparison of government expenditure across public sector departments is not only theoretically meaningful, but desirable (Cylus, Papanicolas and Smith, 2016). The systematic and substantial undervaluation of life and health by departments of health indicates that allocative efficiency is likely compromised and there has likely been a sizable welfare loss.

From a theoretical perspective, if we assume that the ultimate goal of governments when they distribute resources is to make optimal decisions for their citizens, then economic evaluations of any government investment must be consistent, and resources should be allocated efficiently across portfolios. It is important to recognise that a measure *for within health systems prioritisation* (which is what the QALY is) does not necessarily translate to overall resource allocation. The current cost per QALY threshold is used in a number of countries to determine if new technologies should be introduced into the NHS, given the current budget constraint. On that basis, the threshold needs to be set at a level which reflects the opportunity cost in terms of health gain within the existing health budget. This of course raises questions of whether the health budget is optimal, and how a government should determine the welfare opportunity cost at the margin of putting additional resources into the health system or environment or transport. For that, we would need to understand the contribution of health gain to societal welfare. Recommendations that economic evaluations should reform from within and should take into account all costs and benefits that are important to society (Johannesson et al., 2009; Jönsson, 2009) represent an important first step to facilitate the comparison of attributes across sectors; yet, societal preferences in defining the value of the attributes (in terms of trade-offs) are needed to correct the imbalances across sectors

Our analysis also supports the fact that identifying and describing the VoL from disparate public sector activities, in a manner that facilitates comparison, is theoretically meaningful. We presented in section 2 a theoretical model allowing for this comparison. First, benefits will be assessed around a set of attributes or domains that are relevant to society – 'health' being one of them. This assumption is supported by a large number of papers that seek to identify country-specific public sector outcome attributes. 'Health and life' outcomes generated by sector *j* were denoted as h_j. For pragmatic reasons, 'health and life' benefits from different areas of public spending are usually described and measured in a variety of different units (as QALYs, VOLYs, or VSL), so it is typically very challenging to compare the value and opportunity cost of new investments. However, under a set of assumptions it is plausible to estimate equivalences between these outcome measures, as long as a posterior sensitivity analysis proves that results are robust to changes in the assumptions supporting the mapping, as we showed in this report.

Fully variable budgets are probably the most argued condition for the social welfare model suggested by this report. In the alternative where investments are made within an exogenously determined, annually 'fixed' budget risks decisions which are suboptimal now and in the future. To move to an optimal distribution, criteria for approval should attract additional resources as long as the total increase in the welfare resulting from improvement in the 'best' attributes outperform the welfare lost resulting for a lower improvement in the 'worse' attributes, relative to the other departments. For instance, resources allocated to the transport sector (T) can have a positive impact on health, but may not be not as cost-effective as investments in Health and Social Care sector (HSC) $\left(\frac{\partial h_{HSC}}{\partial m_{HSC}} > \frac{\partial h_T}{\partial m_T}\right)$; however, the transport sector can possibly make a more efficient contribution to the improvement of non-health standards of living than HSC sector $\left(\frac{\partial a_T}{\partial m_T} > \frac{\partial a_{HSC}}{\partial m_{HSC}}\right)$. The optimal

allocation of resources between both sectors depends on the relative position of differences in both attributes, weighted by the social value that society puts on health in relation to standards of living:
$$\upsilon\left(\frac{\partial h_{HSC}}{\partial m_{HSC}} - \frac{\partial h_T}{\partial m_T}\right) = \frac{\partial a_T}{\partial m_T} - \frac{\partial a_{HSC}}{\partial m_{HSC}}.$$

More pragmatically, there is evidence in the countries studied that the VoL criteria used by those in the health sector are systematically lower than that in other comparable sectors. In some countries this is *significantly lower* than the VoL provided in other non-health departments. In the vast majority of cases, VoL in the health setting is far lower than VoL in the transport and environment settings. Given that the upper health values we captured are likely to only be applied in a smaller subset of cases (e.g., based on severity, rarity, or unmet need), the fact that commonly used values rarely exceed those from transport or environment is notable. Furthermore, three of four cases where the upper health value exceeds the transport/environment value could potentially be explained based on the estimates used.

Empirically, we might correlate some of these differences in VoL with the fact that transport and environment use cost-benefit analysis as a form of economic evaluation to inform decision making, whereas department of health performs a cost-effectiveness analysis targeting the same aim – that of efficient allocation of resources. Because of the different rationale underlying each approach, in reality we observe that VSL and VOLY estimates are dynamic, in the sense that they are adjusted by inflation as time passes, whereas VOQs figures stay constant through the years. The findings of this study are therefore inclined to worsen over time.

From our theoretical model, the existence of different values of health (inverse of $\partial h_j / \partial m_j$) across departments is not absolutely inconsistent with the idea of optimal resource allocation (in a static model), subject to an unlikely condition. The required condition is a higher value of health has to cancel a lower value in other attributes (such as standards of living or education). This situation, however, may not be stable in a dynamic approach, where some form of reconciliation is likely to be needed to correct this potential imbalance in the value of the same attribute (health and life) across public sectors. These forms of reconciliation could range from reallocation of budgets, transfers of benefit, to adjustments of benchmarking thresholds.

In addition, the use of a societal perspective to inform resource allocation decisions implies a methodological shift from interpreting and determining the threshold as the society's willingness to pay (WTP) for 'units of health' (e.g., QALYs). In this context, the government would set the value given to the QALY by society as a price, representing the maximum willingness to pay of the society for a unit of health gain, and then will fund all the new technologies which are 'buying' QALYs below that threshold. This approach has a strong implication: the budget for health would be not fixed but set automatically by the total expenditure. Ultimately, the valuation of QALYs in monetary terms would facilitate the 'trading off' of healthcare investments with investments in other sectors; as discussed above, the ability to inform resource allocation between sectors is one of the major benefits of the societal perspective. However, a necessary condition for this 'trading off' would be the development of comprehensive outcomes measures – and the establishment of society's WTP for these – across all other sectors. Also, note that if we could obtain a value for health representing the WTP of society for health, this value would apply across all public sectors, and therefore applying the same value to health in all the public sector departments is possible optimal allocation of the total budget, and potentially the only stable solution in the long run.

Note also that the social value of health consumption relative to the non-health attribute (v), is a very relevant element in the decision-making process. For example, the British Social Attitudes Survey shows an increasing importance of health relative to other attributes (57% of the respondents have 'health' as the highest priority for extra government spending in 2018 – education is ranked the second, with only 21%, compared to 42% supporting 'health' versus 30% prioritising 'education', in

2010).[5] If the relative value of health (compared to other attributes) continues to increase, incremental non-health benefits will have to prove to be significant enough to support additional funding.

5.2. Limitations

This study has numerous limitations. The first relates to our ability to identify reliable estimates via a literature review. We sought to identify the value of health estimates that are currently used in practice in analyses across multiple departments in multiple countries. The ideal sources for this information are governmental guidelines for the implementation of cost-benefit analyses, impact assessments or similar, such as the Green Book in the UK. However, in most of the cases guidelines refer to the value of health used for medicines assessment/HTA; when it comes to non-medicine intervention such as surgical procedures it is harder to find evidence of thresholds. In addition, not all countries have an equivalent document and, in some cases, such as in the Netherlands, guidelines existed but explicit values of health were not provided. This meant that we often had to rely on other documentation, that typically did not clearly state that a certain value is recommended or required to be used in analyses. Furthermore, many of these documents simply referred to academic studies, often several, further complicating our task of identifying a single, preferred value (or range of values). As a result, we have had to use our judgement when deciding upon which values to prioritise in our analysis (specifically the inter-country comparisons). However, wherever possible, we have aimed to take a conservative approach.

The second relates to our analysis. Whilst converting between VSLs and VOLYs is fairly well established, this is not the case for converting between VOLYs and QALYs. We identified a ratio in our literature review and used this for our main analyses. However, it is not clear whether this is entirely appropriate. We tried to mitigate any impact of this by conducting a sensitivity analysis whereby the two measures were equivalent, as this would provide the smallest possible QALY values on the basis that a VOLY would not be valued more highly than a QALY.

The third main limitation addresses four main caveats related to the theoretical model presented in this paper. First, at making the comparisons of sector-specific estimates of 'value of health and life', we are assuming that every sector is producing outcomes on their efficiency frontier (i.e., $h_j = f_j(m_j^*, z_j)$, and $a_j = g_j(m_j^*, z_j')$), and assuming an optimal fixed budget. Second, we compare the 'value of health' retrieved (implicitly or explicitly) from government documents. We do not capture those marginal productivity values estimated in the academic literature, but the explicit value of health figures that are used in government resource allocation; and we will therefore assume that those estimates are correct (regardless of whether they match those in the academic literature). Third, our model does not set a time horizon, whereas most resource allocation processes in government happen over prescribed time horizons and so to some extent truncate the time period over which returns to the spending are considered. Finally, the model does not distinguish between consumption spending and capital investment. While 'health' is a consumption and investment good (yet it is treated as consumption in most public budgeting), 'transport' is a clear form of capital investment. Therefore, it might be that differences in the valuation of health gains are masking different criteria for consumption and investment spending.

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[5] *http://nesstar.ukdataservice.ac.uk/webview/*

6 Conclusion

Comparing government expenditure across different public sector departments, in terms of the value of each department outcome, is not only possible but also desirable. In that respect, it is essential to identify the relevant social attributes and to quantify the value of the attributes for each public sector. We have shown that health is valued less by those responsible for allocating resources in health than those in the environment and transport portfolios. This overall trend that appears to be robust to the assumptions made when converting between measures.

The process of determining public spending budgets for different public services to ensure allocative efficiency is a major public policy challenge. We consider the current gap in evidence with which to assess value for money across public sector activities to be unconscionable. Yet, decisions about allocating public sector budgets are being made anyway, in the absence of evidence, and improving the evidence base for such decisions would assist by promoting debate and explicit consideration about what the goals of public spending are.

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Appendix

Initial search (general)

In EconLit (#189):

Search	Bucket	Terms	Field	Records	Notes
1	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life"	AB		
	B	government OR governmental OR government OR department OR departmental OR departments OR guideline OR guidelines OR decision-maker OR decision-makers OR policy OR policies OR "impact assessment" OR "regulation" OR "impact assessments" OR "regulations" OR "regulatory"	TX	189	Original search p
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea"	TX		

Further search (validation)

Search	Bucket	Terms	Field	Records	Notes
	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved"	AB		
1	B	government OR governmental OR government OR department OR departmental OR departments OR guideline OR guidelines OR decision-maker OR decision-makers OR policy OR policies OR "impact assessment" OR "regulation" OR "impact assessments" OR "regulations" OR "regulatory"	TX	140	Original search plus "value for lives saved" added
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea"	TX		
	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality"	AB		
2	B	government OR governmental OR government OR department OR departmental OR departments OR guideline OR guidelines OR decision-maker OR decision-makers OR policy OR policies OR "impact assessment" OR "regulation" OR "impact assessments" OR "regulations" OR "regulatory"	TX	140	Search 1 plus two VPF terms added to bucket A
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea"	TX		
	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality"	AB		
3	B	government OR governmental OR government OR department OR departmental OR departments OR guideline OR guidelines OR decision-maker OR decision-makers OR policy OR policies OR "impact assessment" OR "regulation" OR "impact assessments" OR "regulations" OR "regulatory"	TX	167	Search 2 plus three multicountry terms added to bucket C

Search	Bucket	Terms	Field	Records	Notes
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
4	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality"	AB	168	Search 3 with different terms in bucket B
	B	treasury OR government OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR guidance OR ministry OR department	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
5	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR "years gained"	AB	215	Search 4 will additional terms in bucket A
	B	treasury OR government OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR guidance OR ministry OR department	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
6	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR "years gained"	AB	219	Search 5 with CEA and CUA added to bucket B
	B	treasury OR government OR guidance OR ministry OR department OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR "cost-effectiveness analysis" OR "cost-utility analysis"	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
7	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR VSL OR VOLY OR VPF OR VLY	AB	200	Search 6 with added abbreviations and removal of 'years gained' in bucket A, and CEA/CUA removed and 'appraisal' added in bucket B

Search	Bucket	Terms	Field	Records	Notes
	B	treasury OR government OR guidance OR ministry OR department OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR appraisal	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
8	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR VSL OR VOLY OR VPF OR VLY OR "value of human life" OR "value of a human life"	AB	200	Search 7 with 'value of (a) human life' added in bucket A
	B	treasury OR government OR guidance OR ministry OR department OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR appraisal	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
9	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR VSL OR VOLY OR VPF OR VLY OR "value of human life" OR "value of a human life"	AB	205	Search 8 with 'assessment' and 'evaluation' added in bucket B
	B	treasury OR government OR guidance OR ministry OR department OR policy OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR appraisal OR assessment OR evaluation	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
10	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR VSL OR VOLY OR VPF OR VLY OR "value of human life" OR "value of a human life"	AB	208	Search 9 with additional terms in bucket B
	B	treasury OR government OR governmental OR governments OR guidance OR guideline OR guidelines OR ministry OR ministerial OR department OR departmental OR departments OR policy OR policies OR regulation OR regulatory OR regulations OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR appraisal OR assessment OR evaluation	TX		

Search	Bucket	Terms	Field	Records	Notes
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		
11	A	"Value of life" OR "Valuation of life" OR "Value of a life" OR "Valuation of a life" OR "value of a statistical life" OR "value of statistical life" OR "valuing a statistical life" OR "value for life saved" OR "value for lives saved" OR "value of a prevented fatality" OR "value of preventing a fatality" OR "life saved" OR "lives saved" OR "fatality prevented" OR "fatalities prevented" OR VSL OR VOLY OR VPF OR VLY OR "value of human life" OR "value of a human life"	AB	222	Search 10 with additional terms in bucket B
	B	treasury OR government OR governmental OR governments OR guidance OR guideline OR guidelines OR ministry OR ministerial OR department OR departmental OR departments OR policy OR policies OR regulation OR regulatory OR regulations OR "impact assessment" OR "environmental assessment" OR "cost-benefit analysis" OR "benefit-cost analysis" OR appraisal OR assessment OR evaluation OR transport OR transportation OR environment OR environmental	TX		
	C	UK OR "United Kingdom" OR "England" OR "Scotland" OR "Wales" OR "Australia" OR "New Zealand" OR "Canada" OR "Netherlands" OR "Japan" OR "Korea" OR "multi-country" OR "multicountry" OR "Europe"	TX		

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