Medical Teacher

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/imte20

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To cite this article: Jonathan Foo , David A. Cook , Martin Tolsgaard , George Rivers , Jennifer Cleland , Kieran Walsh , Mohamed Elhassan Abdalla , You You , Dragan Ilic , Robert Golub , Henry Levin & Stephen Maloney (2020): How to conduct cost and value analyses in health professions education: AMEE Guide No. 139, Medical Teacher, DOI: 10.1080/0142159X.2020.1838466

To link to this article: https://doi.org/10.1080/0142159X.2020.1838466

MEDICAL TEACHER
https://doi.org/10.1080/0142159X.2020.1838466

AMEE GUIDE

How to conduct cost and value analyses in health professions education: AMEE Guide No. 139

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ABSTRACT
Growing demand for accountability, transparency, and efficiency in health professions education is expected to drive increased demand for, and use of, cost and value analyses. In this AMEE Guide, we introduce key concepts, methods, and literature that will enable novices in economics to conduct simple cost and value analyses, hold informed discussions with economic specialists, and undertake further learning on more advanced economic topics. The practical structure for conducting analyses provided in this guide will enable researchers to produce robust results that are meaningful and useful for improving educational practice. Key steps include defining the economic research question, identifying an appropriate economic study design, carefully identifying cost ingredients, quantifying, and pricing the ingredients consumed, and conducting sensitivity analyses to explore uncertainties in the results.

KEYWORDS
costs and cost analysis; cost-effectiveness; economics; medical education; health professions education

Introduction

The purpose of this guide is to provide educational researchers with a systematic introduction to the use and application of cost and value analyses in health professions education (HPE). The primary audience of this guide is researchers wanting to conduct cost and value analyses. It assumes an intermediate level understanding of educational research but no prior knowledge of economic concepts.

In this guide, we provide a structure for conducting cost and value analyses. We introduce key concepts, methods, and literature, as well as lessons learnt from our own experience.

The content of this guide should enable readers to:

- Conduct simple cost and value analyses
- Hold informed discussions with economic specialists
- Undertake further learning on more advanced economic topics

The purpose of conducting cost and value analyses in health professions education

Cost and value analyses are predominantly used to inform decision-making. They provide an evidence base for considering

Practice points

- Economic cost is the value of all resources consumed, it includes not only resources that are paid for by a program, but also those that are donated or already owned.
- Cost and value analyses must be driven by a focused economic research question that considers the study design, study perspectives, alternatives being compared, and contextual factors.
- Prominent study designs related to cost and value include: cost analysis (evaluates only cost), cost effectiveness analysis (evaluates cost and educational outcomes), and cost benefit analysis (evaluates cost and monetary outcomes).
- Calculating the cost of an educational program involves identifying the types of resources consumed, measuring the volume of consumption for each resource, and assigning monetary prices to each resource.
- Sensitivity analyses should be used to estimate the uncertainty in the results of a cost and value analysis.

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Supplemental data for this article can be accessed here.

the resource implications of educational choices. Cost and value analyses support education that achieves maximum educational outcomes for a given spend, or a given educational outcome for a minimum spend (Maloney et al. 2017).

It is becoming increasingly important to consider cost and value in HPE given the growing demand for health workforce supply (Global Health Workforce Alliance 2013; World Health Organization 2016, 2017), rising training costs and student debt (Desrochers and Wellman 2011; Greysen et al. 2011), and calls for financial transparency and accountability in both education and healthcare (Sinaiko and Rosenthal 2011; Hillman et al. 2018). Cost and value analyses provide the opportunity to examine what works and at what cost, promoting the best use of limited educational resources to improve educational quality.

Background to this guide

The formal study of cost and value in HPE is relatively nascent. The methodological and reporting quality of studies in this area has been poor, and does not appear to have improved over time (Brown et al. 2002; Zendejas et al. 2013; Foo et al. 2019). The content of this guide draws on the more developed fields of health economics and education economics.

This guide is the companion guide to 'AMEE Guide 123. An Educational Decision-Makers Guide to Reading Studies of Educational Costs' (Maloney et al. 2019a; Maloney et al. 2019b). As the name suggests, AMEE Guide 123 is designed for readers of cost and value analyses, whereas this guide is for those wishing to produce such analyses.

Organisation of the guide

This guide leads with a brief overview of cost and value analyses in HPE. We then provide a structure for conducting cost and value analyses. Section 1 covers how to develop an economic research question. A worksheet is provided in Online Supplementary Appendix 1 that can be used by researchers to develop their own question. Section 2 teaches the basics of evaluating costs and outcomes. Section 3 looks at characterising uncertainty with sensitivity testing, Section 4 provides guidance on reporting, and Section 5 places the content of this guide within contemporary practice. Online Supplementary Appendix 2 provides a full running case-study, demonstrating the application of the content in the guide, and how each section fits together. Readers are directed to the Online Appendix at key milestones within this guide.

Overview of cost and value analyses in health professions education

The terminology used to describe cost and value concepts is varied and inconsistent (Walsh 2014; Foo et al. 2019). Different terms may be used to describe the same concept, and the same terms may be used to describe different concepts. For clarity within this guide, we define key terms as they arise and have also provided a Glossary.

We use the phrase 'cost and value analyses' to include all forms of analysis that calculate economic cost, with or without a corresponding analysis of consequences/outcomes. Economic cost, synonymous with opportunity cost, is the total resources used up to achieve an outcome. It includes both explicit costs (actual monetary transfers, such as those that might be reported in accounting documents) and implicit costs (costs incurred that are not reported in accounting documents, such as after-hours instructor time, volunteer time, or donated equipment). The inclusion of implicit costs is critical to understanding the full resource implications of an education activity.

A structure for conducting cost and value analyses

Section 1: Develop an economic research question

A cost and value analysis usually starts with the desire to inform a decision on how to invest limited resources. The decision-making problem guides the design of the cost and value analysis and underpins the development a focused economic research question. Section 1 guides the specification of:

Section 1.1: Study design
Section 1.2: Study perspective
Section 1.3: Alternatives being compared
Section 1.4: Contextual factors
Section 1.5: Focused economic research question

Section 1.1: Study design

There are three main types of study designs related to cost and value useful for HPE researchers: cost analyses, cost effectiveness analyses (CEA), and cost benefit analyses (CBA). All three study designs evaluate cost, and can be differentiated by their measurement of outcomes. In the context of this guide, outcomes are the consequences (outputs) of the education activity. Thus, although one could view costs as an 'outcome', in the sense that it is a quantity measured as part of a program evaluation, we prefer to think of costs as inputs – the economic value of resources required to conduct an activity – rather than as outcomes (outputs). Importantly, not all monetary measures are costs; some monetary measures are outcomes (i.e. monetary benefits arising from an activity). The characteristics of study designs, along with the types of questions they answer, are outlined in Table 1, and are expanded upon in the subsequent sections.

Section 1.1.1: Cost analysis. A cost analysis evaluates the total resources used up (cost), without consideration of outcome. This type of study design answers the question: *"how much does it cost to conduct this activity?"* Such information is useful in identifying cost drivers (i.e. factors that change the cost of an intervention), informing resource allocation and priority setting, and providing a basis for choosing among options that are considered equally effective. One example of cost analysis is an investigation into the cost of a 15-station medical Objective Structured Clinical Examination (OSCE) by Brown et al. (2015) that calculated a cost per student of 355 GBP (460 USD). Another example is a study by Foo, Rivers, et al. (2017) that found the cost of student failure in a five-week physiotherapy clinical education experience to be 9,371 USD per student.

Table 1. Types of study designs and associated research questions.

Study design	Research question	Data analysed
Cost analysis	How much does it cost?	Cost (no outcomes)
Cost Effectiveness Analysis (CEA)	Which of these alternatives is the better option for achieving this specific objective, when considering both cost and outcomes?	Cost and outcomes in natural units (e.g. exam scores, patient bed days)
Cost Utility Analysis (CUA, a subset of CEA)		Cost and outcomes in utilities (e.g. quality-adjusted life year [QALY]).
Cost Benefit Analysis (CBA)	Is this activity worthwhile from an economic perspective?	Cost and outcomes in monetary units (e.g. cost of prescribed drugs, course registration fees).

The procedures for calculating cost in cost analyses are the same as those used in CEAs and CBAs, with the difference being that CEAs and CBAs also measure outcomes.

Section 1.1.2: Cost effectiveness analysis. A cost effectiveness analysis (CEA) evaluates both costs and outcomes, with outcomes measured in natural units. Natural units reflect 'raw' measurements relevant to education (e.g. exam scores, pass rates) or healthcare (e.g. length of stay, complication rate). A CEA answers the question: *"which of a given set of alternatives is the better option for achieving a specific objective, when considering both cost and outcomes?"* CEAs facilitate choice among a given set of alternatives, and are of most useful in situations where a decision-maker, operating with a given budget, is considering a limited range of options within a given field (Drummond et al. 2015). CEAs provide information on whether an intervention is 'good value' relative to the alternative intervention(s) used for comparison.

In the same way direct comparison between clinical or educational interventions requires outcomes be measured in the same units (e.g. in a meta-analysis), the same natural units must be used across interventions in a CEA for the alternatives to be compared. CEAs cannot be used to compare interventions measured in different natural units. An example of using a common metric is the study by Maloney et al. (2015) that reported a CEA using data from an RCT comparing face-to-face delivery versus blended delivery for achieving competency in evidence-based medicine, where competency was measured in both groups using Berlin Questionnaire score. A key limitation of CEAs is that they can only be used to evaluate one outcome at a time. This poses a difficulty to educational researchers who are often interested in multiple outcomes, particularly as an intervention may be superior on one measure, but inferior in another.

A subset of the CEA is the cost utility analysis (CUA). Here, the unit is a standardised economic measure of outcome (a utility). In healthcare, the most common utility metric is the Quality-Adjusted Life Year (QALY), which reports disease burden using years of life adjusted by quality of life as defined by a standardised scale. The QALY facilitates comparison between diverse interventions (i.e. interventions targeting different conditions) and aggregation of outcomes (i.e. interventions that impact multiple health-domains). There is currently no straightforward and commonly accepted educational equivalent; however, it is possible that in the coming years a corresponding metric of educational utility will emerge.

Section 1.1.3: Cost benefit analysis. A cost benefit analysis (CBA) evaluates both costs and outcomes, where outcomes are measured in or converted to monetary units (e.g. $100 of education costs resulting in benefits of $200). This type of study design answers the question: "is this activity worthwhile from an economic perspective?" or "how should I allocate my resources across programs targeting varied outcomes?" CBAs provide information on whether an intervention represents absolute 'good value'. For example, Schreurs et al. (2018) conducted a CBA on a merit-based medical school selection program compared to a lottery system. That study calculated the additional cost of merit-based selection to be 139,000 EUR (164,000 USD), with additional benefits of 207,000 EUR (244,000 USD) arising from reduced attrition and remediation (compared to the lottery system). One possible conclusion from this CBA is that the cost incurred by merit-based selection is economically worthwhile because it is offset by the benefits.

Unlike CEAs, CBAs can make comparisons across interventions measuring different outcomes, and include multiple outcomes, since all outcomes are represented in a common (monetary) unit. Another advantage is that CBAs represent value in absolute rather than relative terms, and thus are not limited to comparisons among pre-specified alternatives. A potential disadvantage of CBAs is that they often involve the conversion of educationally meaningful (natural) units (e.g. student learning) to monetary units, which requires the use of assumptions and value judgements. The issue of monetising educationally meaningful units is complex and contentious; it is addressed further in Section 2.3.

Section 1.2: Study perspective

The study perspective is the viewpoint from which the costs and outcomes are evaluated (Husereau et al. 2013). Levels of perspectives include the individual (e.g. learner, patient, educator), institution (e.g. education institution, healthcare institution), system (e.g. education system, healthcare system), and society (i.e. wider impact across society). The choice of one or more perspectives should be driven by the intended audience (i.e. who is going to use the evaluation?), the purpose of the evaluation (i.e. what decision am I trying to inform?), and contextual values (i.e. who is affected?).

Haines et al. (2014) demonstrated that a given intervention can present different value propositions when viewed from different perspectives. Their cost analysis on interprofessional student clinics identified a saving for the national government of 66 AUD (47 USD) per student when compared to traditional hospital-based education. However, when evaluated from a university perspective, the interprofessional clinic was found to be 289 AUD (207 USD) more costly per student due to costs shifting from the government to the university.

Section 1.3: Alternatives being compared

It is essential to clearly articulate the alternatives being compared in the cost and value analysis. The comparators considered should reflect practical alternatives relevant to the decision-making problem. These could be alternative educational interventions, assessment approaches, administrative procedures, enrolment/selection pathways etc. Much of the research in HPE has focused on comparing one high cost approach to another high cost comparator, however we also encourage researchers to consider low cost options (Cook 2014). In traditional research, the superior approach is one that produces higher learning outcomes. However, the evaluation of cost along with learning outcomes opens the door to considering interventions that may actually be *less* effective, yet overall advantageous because they cost substantially less.

An example of a less effective, but less costly, intervention is the evaluation of self-guided learner pairs versus instructor-led training for resuscitation skills by Hasselager et al. (2019). In their study, 30% of the learner pairs group reached competency versus 60% of the instructor-led training group. However, because the learner pairs model was also less costly compared to the instructor-led model, it was able to train a greater number of individuals (233 versus 109 respectively) and resulted in a greater number of learners achieving competency (71 versus 65 respectively) for each 10,000 USD spent.

Section 1.4: Contextual factors

Awareness and reporting of contextual factors facilitate generalisability and transferability of study findings. In addition to considering how context impacts on the educational intervention, researchers should consider how context impacts on cost and value. Relevant factors to consider include those relating to geographic location (e.g. metropolitan versus rural), education setting (e.g. teaching hospital versus university), and system factors (e.g. public versus private funding systems) (Husereau et al. 2013).

Methodologically, the identification of contextual factors facilitates choice of assumptions used in calculations and will also support analyses of uncertainty. For reporting, being explicit about the contextual factors will assist readers in interpreting findings (Maloney et al. 2019b).

Section 1.5: Focused economic research question

As with all research, clearly articulating the research question is of paramount importance when conducting a cost and value analysis. The steps outlined in Sections 1.1 to 1.4 should help to refine a general decision-making statement into a focused economic research question, as shown in Example 1. Refer to Online Supplementary Appendix 2 Section 1 to view the development of the research questions for the running case-study.

Example 1. Developing a focused economic research question

Based on study by Maloney et al. (2015).

Decision-making problem: A professor teaches evidence-based medicine and wants to improve the performance of his students. He is considering shifting from the existing face-to-face delivery to a blended model (where students engage with online activities prior to the face-to-face teaching, which is reduced). His Head of Department is wary of the costs associated with shifting away from a conventional face-to-face model, as they have heard that developing online content can be expensive.

Section 1.1: Study design: The professor is interested in both cost and outcomes. He will be choosing between teaching alternatives and will measure evidence-based medicine competency using the Berlin Questionnaire. Therefore, a cost-effectiveness analysis is the most appropriate study design.

Section 1.2: Study perspective: The professor needs to convince his Head of Department to allow his proposed changes. As such, he has decided to conduct the evaluation from the University perspective.

Section 1.3: Alternatives being compared: The first alternative is the current face-to-face approach. Through his reading of literature and discussions with colleagues, the professor has developed a blended model that he wants to implement.

Section 1.4: Contextual factors: The professor teaches medical students across several year levels at Monash University Australia. For the purposes of this evaluation, he decides to focus on his teaching of 3rd year students.

Section 1.5: Focused economic research question: Which of face-to-face or blended learning is more cost-effective for teaching 3rd year medical students at Monash University Australia, where cost is measured from the perspective of the university, and effectiveness is measured by Berlin Questionnaire score?

Section 2: Evaluate costs and outcomes

Section 2.1: Evaluating costs using the ingredients method

Arguably the most important part of a cost and value analysis is to obtain a robust and complete measure of the cost of each intervention. However, this is not as simple as consulting the program budget or a report from the accounting office. Indeed, accounting reports are nearly always inadequate as the sole source of costing information: they do not typically contain implicit costs (such as after-hours instructor time, volunteer time, or donated equipment) and they often distort true resource consumption (potentially due to institution regulations or office politics, for example a department may ensure they spend all money allocated to them each period to avoid their budget allocation being reduced in the next financial period). Moreover, many educational interventions are part of larger units of operation such that the intervention-specific costs are obscured (Levin et al. 2017). Therefore, a robust cost and value analysis requires a different, systematic approach to evaluating costs.

One common – and conceptually straightforward – approach is Levin's "Ingredients Method", popularised in education economics generally and recently gaining traction in HPE (Walsh et al. 2013; Zendejas et al. 2013; Foo, Ilic, et al. 2018; Levin et al. 2017). This approach involves four steps:

1. comprehensively itemize the resources used (e.g. time, materials, equipment, travel costs);

Table 2. Framework of cost ingredients with examples arranged according to cost categories.

Category	Ingredients	Examples
Personnel: these are all the people directly or indirectly involved in the educational development, delivery, and assessment. Careful measurement of personnel time is necessary, as there are often discrepancies between contracted and actual time utilisation (i.e. unpaid overtime, nights and weekends). Personnel costs include the stated wage, as well as associated costs such as allowances, retirement fund contributions, and taxation.	Teaching personnel Non-teaching personnel Clinical personnel Volunteer/In-kind personnel	Lecturer, tutor, simulated patients Administration, technical support Supervising clinician Real patient, peer tutor
Facilities: these are all the physical spaces directly or indirectly involved in the educational delivery. Factors to consider include seating capacity, fixtures/fittings (e.g. oxygen wall ports, ceiling tracking hoist, tables), and technology (e.g. projector, computers). Facilities may be built-for-purpose, pre-owned, or rented.	Dedicated teaching facilities Non-teaching facilities Clinical facilities Facility overheads	Lecture theatre, simulation centre Offices, storage Hospital ward, surgical theatre Maintenance, cleaning, utilities
Equipment and materials: these are all the furnishings, instructional equipment, and materials involved in the educational delivery. Equipment may be specifically for the educational program, shared across multiple programs, or rented. Costs may require apportionment across multiple periods/iterations.	Training equipment Equipment maintenance Medical equipment Medical consumables Information technology hardware Information technology software Office supplies Catering	Simulators, models Regular servicing Surgical tools, stethoscope Gloves, wound dressings, needles Tablets, virtual reality headsets Website hosting, software licencing Printing, stationary Food, drink
Other inputs: other inputs not covered under existing categories.	Advertising Communication Incentives Travel related costs	Website advertisement Postage, phone calls Monetary payments Accommodation, fuel, flights, parking
Learner inputs: these are all ingredients supplied by the learner. Take care to separate costs that occurred because of the education (e.g. time spent studying) which should be included, from costs that would have occurred regardless (e.g. normal food consumption) which should be excluded.	Learner time Learner equipment and materials Learner travel related costs	Time studying alone, time in class Personal computer, textbooks Accommodation, fuel

2. determine the quantities (units) of each resource actually used;
3. assign the unit price of each resource, and
4. multiply the units by price to determine total cost per resource.

We review each step in detail below.

Section 2.1.1: Identify and specify resource items. The first step is to identify all resources (ingredients) used to achieve the observed effect. Many of these resources may not be obvious in a cursory review, but can be discovered through diligent study. Generating a comprehensive list of relevant resources may be the most difficult, yet important, step in conducting a cost and value analysis. Therefore, it is necessary that investigators become familiar with the intervention being studied. Information may be obtained from a range of sources, including documents (e.g. the course blueprint, procedure documents, and unit handbook), interviews with stakeholders (e.g. those involved with planning, delivering, paying for, and participating in the program), and direct observation. It can be helpful to consider costs in each of the categories listed in the Ingredients Method: personnel, facilities, equipment and materials, other inputs, and learner inputs (McEwan 2012). The framework shown in Table 2 may be used as a starting point for identifying costs, although it will need to be tailored to a given program.

The comprehensive list of resources will likely need to be adjusted (usually shortened) before proceeding with the next step, because measuring each ingredient would require tremendous effort. There is a need to balance the effort taken to collect the information against the impact the information will have on the overall cost and ultimately the associated decision (Foo, Ilic, et al. 2018). Resources estimated as contributing a relatively trivial amount (e.g. less than 5%) can, if needed for practical purposes, be ignored. Of course, there is risk of underestimating the cost of a given resource (and thus incorrectly excluding it prematurely), and researchers need to balance expediency against rigour. Educational interventions nearly always incur high personnel costs, and thus substantial effort should be dedicated to investigating these costs (Walsh 2010). Other resources will vary depending on the situation. Refer to Online Supplementary Appendix 2 Section 2.1.1 to see the identification and specification of the resource items from the running case-study.

Section 2.1.2: Measure volume of resources in natural units. The second step is to measure how much of each resource was used or consumed. There are three main sources of volume data: documents (e.g. invoices, expense reports), reporting from stakeholders (e.g. surveys of students or interviews with students and staff), and direct observation (Levin et al. 2017). As with any area of research, the data collection approach should consider factors related to validity, reliability, and feasibility.

Choosing among these data sources involves a trade-off between accuracy of data and feasibility of collection (Mogyorosy and Smith 2005). In general, prospective data

Table 3. Template for calculating and reporting cost.

Category (2.1.1.)	Resource (2.1.1.)	Description (2.1.1.)	Volume (and source) (2.1.2.)	Price (and source) (2.1.3.)	Cost (2.1.4.)
e.g. Personnel	Teaching assistant	Graduate student	97 hours (Timesheets)	$53/hour (National agreement with teachers' union)	$5,141

collection is more accurate compared to retrospective data collection. This is particularly true when individuals are asked to remember and report information (e.g. time or money spent) because human memory is limited by many factors including recall bias (low accuracy when recollecting past events) and recency bias (attributing greater weight to an event that happened more recently). Where there is increased demand for accuracy, multiple data sources can be used to triangulate findings. Refer to Online Supplementary Appendix 2 Section 2.1.2 to see the measurement approaches used in the running case-study.

Section 2.1.3: Assign monetary prices to resource items. The third step is to assign a price to one unit of each resource. The most common approach for assigning prices to resources is to use their market price (Levin et al. 2017). The market price is the price at which the resource is bought or sold at in the marketplace (e.g. the advertised price for a simulator, or the hourly wage for a nurse). However, some items are not typically bought or sold (e.g. patient time), and therefore do not have a market price. In such situations, we typically use an estimated price known as the shadow price. The shadow price will often be based on the closest market alternative and should reflect what people would be willing to pay or give up to obtain the good or service. For example, volunteer patients do not have a market price (since we do not pay them), however, a close alternative is actors as standardised patients, which do have a market price. In the absence of close market alternatives, non-market valuation approaches may be useful (see Section 2.3). It is important to clearly describe the source of the price (e.g. expense report, wage structure established by government, or published literature).

The economic research question should be considered when selecting prices. The price selected should consider the study perspective (e.g. is the price from the perspective of the individual learner or the education institution?), contextual factors (e.g. private versus public prices), and the purpose of the research. For example, a study that seeks to guide local site-specific decisions might use specific local prices, whereas a study seeking to guide broader policy decisions for a wide (national or international) audience might seek to use more generalizable national prices (Sculpher et al. 2004). Refer to Online Supplementary Appendix 2 Section 2.1.3 to see the pricing method used for the running case-study.

Section 2.1.4: Calculate and report costs. The final step is to calculate the cost of each resource by multiplying the number of units (volume) and price. The volume, unit price, and total cost of resources should be reported, along with the source of this information (Neumann et al. 2016). Investigators should also be clear on the units in which the cost is reported, such as total cost, cost per year, cost per iteration, or cost per student. Table 3 provides a useful template for calculating and reporting cost. Refer to Online Supplementary Appendix 2 Section 2.1.4 to see the cost reporting for the running case-study.

Section 2.2: Cost adjustments

It is often necessary to adjust monetary amounts after they have been calculated. These principles apply not only to estimates of cost, but also to estimates of benefit (as will be described later). Here, we will cover the three most common types of adjustments: currency conversion, inflation, and discounting.

Section 2.2.1: Currency conversion. It is often necessary to convert monetary amounts from one currency to another, such as when conducting multinational studies or to conform to journal publication requirements. We propose two methods for conducting currency conversion. The simplest approach is to use the market exchange rate, as reported by banks and websites such as www.xe.com. A more complex, but recommended, approach is to convert using Gross Domestic Product (GDP) Purchasing Power Parity (PPP) using Organisation for Economic Co-operation and Development (OECD) data (Welte et al. 2004). This conversion approach is based on the amount required to purchase the same volume of goods and services in different countries. Conversation rates can be found at https://stats.oecd.org/Index.aspx?DataSetCode=PPPGDP.

Section 2.2.2: Inflation. Inflation refers to the increase in the price of goods and services over time, or conversely, can be thought of as reductions in the purchasing power of each unit of currency (Rutherford 2013). When using costs from past years or extending to future years, it is necessary to adjust costs using an inflation rate. There are several methods to calculate inflation. However, we will focus only on the simplest approach – the consumer price index (CPI) method (Figure 1). CPI monitors the price of a specific set of goods and services, thereby calculating changes in price over time (Levin et al. 2017). To use the CPI inflation method, the CPI rate for the specific years to be adjusted must be determined. There are many sources of CPI, specific to countries and also categories of goods and services, including the Bureau of Labor Statistics CPI for the United States, and Australian Bureau of Statistics CPI for Australia. The application of the CPI inflation method is shown in Example 2.

Section 2.2.3: Discounting. Money today is worth more than money in the future, even in the absence of inflation. Money on hand can be used for alternative purposes (e.g.

$$C_t = C_0 \times (1 + CPI)^t$$

Figure 1. Formula to calculate cost after inflation; where C_t = cost at time period t, t = years of inflation applied, C_0 = original cost, CPI = average annual inflation rate as a fraction.

Example 2. Consumer Price Index (CPI) inflation method
A student paid \$500 (C_0) for a course in 2010 (t = 0). A researcher wants to know how much this course would have cost in 2015 (t = 5), using an average annual inflation rate of 2.5% (CPI = 0.025).

$$\begin{aligned} C_5 &= 500 \times (1 + 0.025)^5 \\ &= 566 \end{aligned}$$

Therefore, \$500 in 2010 is equivalent to \$566 in 2015.

gaining interest as a bank deposit), and moreover there is a risk that future returns will not be received (e.g. a student may declare bankruptcy and therefore not pay back their student loan) (Gilead 2015).

Discounting is an economic calculation that converts future monetary amounts into their present value (Figure 2 and Example 3) using a discount rate. The discount rate can be expressed as a 'nominal' rate (percentage of change per year), or as a 'real' rate that represents the nominal rate plus a further adjustment for inflation. There are various approaches to estimating an appropriate discount rate; however, unfortunately there is no consensus on which one(s) should be used (Claxton et al. 2011). As a general guide, a real discount rate of 3% is appropriate for most high-income countries, as recommended in healthcare evaluations (Sanders et al. 2016). A higher real discount rate of 4–5% may be more appropriate for low- and middle-income countries (Haacker et al. 2019). Additionally, it is usually appropriate to explore how different discount rates might affect the final result by repeating the discounting calculation using several different rates (e.g. real discount rates between 0 and 10%) (Levin et al. 2017). Such analyses are one example of a sensitivity analysis, which will be covered in Section 3.

$$Present\ value = \frac{V_t}{(1 + r)^t}$$

Figure 2. Formula to calculate present value after discounting; where V_t = cost or benefit at time period t, t = number of years into the future at which the cost or benefit occurs, r = 'real' discount rate as a fraction.

Example 3. Calculating present value using a real discount rate.
An education institution expects to receive repayment of a \$20,000 (V_{10}) student loan as a lump sum 10 years (t = 10) from today. They want to know the present value of the loan, using a real discount rate of 3% (r = 0.03) that includes an adjustment for inflation.

$$\begin{aligned} Present\ value &= \frac{20,000}{(1 + 0.03)^{10}} \\ &= 14,882 \end{aligned}$$

Therefore, \$20,000 10 years from today has a present value of \$14,882.

Together with inflation, discounting allows us to combine past, present, and future monetary amounts in a single analysis. For studies evaluating short periods of time, the impact of inflation and discounting is minimal. However, education is typically a long-term investment, and if researchers try to study the phenomenon over several years then the choice of inflation rate and discount rate is critical. For example, in a study of physiotherapy education, the expected return after 30 years was \$13,000,000 using a low-risk discount rate (6%) versus \$500,000 using a high-risk discount rate (13%) (Rivers et al. 2015).

Section 2.3: Evaluating outcomes

Evaluating outcomes from educational interventions is well established in HPE research. By definition, CEAs and CBAs must include an evaluation of outcomes, in natural and monetary units respectively. A full explanation of evaluating outcomes is beyond the scope of this guide; in the following section we provide a brief overview along with suggestions for further reading.

Section 2.3.1: Evaluating outcomes in natural units. For CEAs, outcomes are reported in natural units. The evaluation of such outcomes is well established in HPE research broadly and should be familiar to most educational researchers. A common approach to categorising outcomes follows Kirkpatrick's hierarchy: reaction (satisfaction), learning (knowledge, skills, and attitudes in a test setting), behaviour (in practice), and results (effects on patients and society) (Kirkpatrick 1996). Researchers will need to select their outcome(s), and then their measurement instrument. Outcomes should align with educational goals. Selection of an instrument should be made with consideration for the trustworthiness (validity and reliability) of the results it would produce (Cook 2010).

For CUAs, the units used are a utility metric. The most common utility metric is the Quality-Adjusted Life Year (QALY), which measures the effect of interventions on patient mortality and morbidity (length and health-related quality of life). QALYs may be relevant to HPE research when measuring the impact of an intervention on patient level outcomes. The most common approach to measuring health-related quality of life is the EQ-5D (Richardson and Manca 2004), a questionnaire designed to measure generic health status, and is the approach recommended by the UK National Institute for Health and Care Excellence (NICE) (National Institute for Health and Clinical Excellence 2008). Whitehead and Ali (2010) provide a primer on QALY calculation methods. As noted above, there is currently no educational equivalent of the QALY.

Section 2.3.2: Evaluating outcomes in monetary units. For CBAs, outcomes are reported in monetary terms. Some educational outcomes are already expressed in monetary terms (e.g. drug cost, laboratory test cost, or future earnings (Rivers et al. 2015)). However, in most cases, an outcome will require conversion from natural units to monetary units. Monetising natural outcomes involves answering questions such as 'what is the dollar value of a 6% improvement in exam score? Or spending three fewer

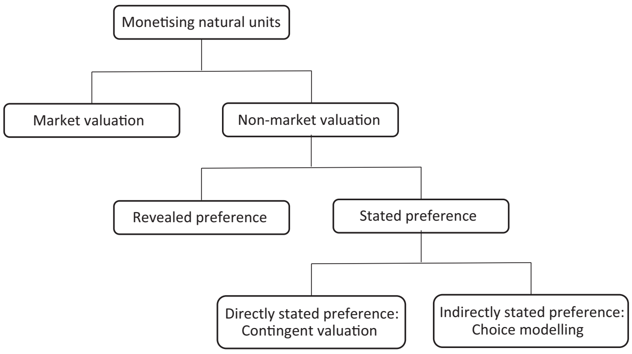

Figure 3. Summary of methods for monetising natural units.

hours studying? Or graduating six months earlier than expected?'

In the following paragraphs, we provide an overview of the main approaches to monetising natural units, these are indicated in text using *italics*. Figure 3 provides a visual representation of how these approaches are classified, and we recommend referring to this figure each time a new method is introduced. There are two overarching monetisation approaches – market and non-market valuation (Levin et al. 2017). *Market valuation*, similar to the concept of market price from Section 2.1.3, assigns a monetary value based on the amount for which one unit (of whatever is being measured) is bought and sold in the open market. For example, changes in prescribing behaviour can be monetised based on the market value of the drugs prescribed (Watson et al. 2001). Refer to Online Supplementary Appendix 2 Section 2.3 to see the approach to market valuation used in the running case-study.

In some cases, outcomes cannot be purchased because they are not typically bought or sold, as is commonly the case for educational research. An example of such an outcome is the monetary worth of having a graduate choose to work in a rural location, and in such cases *non-market valuation* must be used (Baker and Ruting 2014). Non-market valuation methods can be further divided into revealed and stated preference methods. *Revealed preference* methods use data on people's actual choices (e.g. choice of occupation, or professional development events attended), while *stated preference* methods utilise data from carefully worded questions asking people what choice they would make (e.g. intended choice of occupation, or intention to attend professional development events) (Boyle 2003). That is, revealed preference calculates value based on what people actually do, while stated preference calculates value based on what people say they would do. Therefore, revealed preference methods are generally considered more valid than stated preference methods, although obtaining the required data can be more difficult.

For example, a researcher may be interested in calculating the value graduates place on working in a metropolitan hospital compared to a rural hospital. A revealed preference approach to valuation could be to calculate the difference in wages for graduates working in metropolitan compared to rural hospitals, after adjusting for confounders (note this would only work if hospitals are free to set their own wages). At its simplest, a stated preference method could be to ask graduates "how much additional pay would you have to receive to work in a rural hospital compared to a metropolitan hospital?"

With regards to the stated preference approach to valuation of outcomes, there are two main methods – contingent valuation (directly stated) and choice modelling (indirectly stated) (Baker and Ruting 2014). *Contingent valuation* uses questions to estimate the highest amount that people would be willing to pay for an outcome. At its simplest, this involves directly asking, "what would be the maximum you would have been willing to pay for this course?" (see Maloney et al. (2012) for an example). *Choice modelling* is a more sophisticated technique, in which participants are indirectly asked to value their preferences by selecting between bundles of alternatives with variations in attributes. For example, Cleland and colleagues asked UK final year medical students to choose between 18 pairs of hypothetical job positions, each position described according to the following attributes: familiarity with hospital, geographical location, opportunities for partner, potential earnings, clinical reputation, and working conditions. Each attribute had two or more possible levels (e.g. for potential earnings: average, 5% above average, 10% above average, or 20% above average), which were systematically varied across the hypothetical positions. Their study found that respondents would require earnings 44% above average to move from a post with excellent working conditions to one with poor working conditions (Cleland et al. 2017). Extrapolating this result, and assuming an average salary of 30,000 GBP (39,000 USD), the estimated value of excellent working conditions (compared to poor working conditions) would be 13,200 GBP (17,000 USD). Choice modelling can be a powerful tool, although the learning curve for this approach is steep and we recommend collaboration with an economist or health economist. Refer to Cleland et al. (2018) for a guide on using choice modelling in HPE.

Monetising natural outcomes is an accepted practice with both educational outcomes (Levin et al. 2017) and health outcomes (Claxton et al. 2015), although it is not without its critics (Harris 1987; Johnson 2009). We acknowledge there are both philosophical and methodological concerns with the monetisation process. However, an exploration of these debates is beyond the scope of this paper.

Section 2.4: Combining costs and outcomes

Section 2.4.1: Combining cost and effects in CEAs. Once we have estimated the cost and outcomes, the next step is to combine these in a way that facilitates decision-making. There are many ways to do this. For CEAs, the simplest approach is to divide the cost by the outcome to calculate the average cost per outcome, known as the cost-effectiveness ratio (CER).

When two or more alternatives are compared, an incremental cost-effectiveness ratio (ICER) will typically be calculated (see Figure 4). The ICER evaluates the difference in costs and outcomes between a reference intervention (known as the base case) and the alternative(s) (Drummond et al. 2015; Lin et al. 2018; Rivers et al. 2017). The calculation of a CER and ICER is provided in Example 4.

When comparing one alternative to another, the ICER of each alternative can be graphically represented on a 'cost-

$$ICER = \frac{Cost\ of\ intervention - Cost\ of\ base\ case}{Outcome\ of\ intervention - Outcome\ of\ base\ case}$$

Figure 4. Formula to calculate incremental cost-effectiveness ratio (ICER).

effectiveness plane' (Figure 5). One option is selected as the reference point (the base case). The difference in outcome is represented on the x-axis, and the difference in cost is represented along the y-axis. The gradient (slope) of the line between the base case (at the origin) and each alternative represents the ICER. The plane is divided into four quadrants that reflect the four options for the ICER, namely: 1. More effective and more costly, 2. More effective and less costly, 3. Less effective and less costly, and 4. Less effective and more costly. Figure 5 plots the results of Example 4, illustrating that the virtual reality approach is more cost-effective than the facemask approach, as it has a smaller gradient (i.e. a smaller increase in cost per increase in average grade). Refer to Online Supplementary Appendix 2 Section 2.4.1 for the calculation of ICER and plotting the cost-effectiveness plane for the running case-study.

Section 2.4.2: Combining cost and benefits in CBAs: Net value, benefit-cost ratio, and break-even analysis. For CBAs, there are many ways to combine the cost and the monetised outcomes or "benefits" (note that benefits can be both positive and negative monetary outcomes). One of the simplest analyses is to calculate the net value by subtracting the cost from the benefit (i.e. net value = benefit – cost). From a purely economic perspective, only actions with a positive net value should be taken, and decision-makers should seek alternatives with the highest positive net value (Levin et al. 2017). However, this does not always hold true in real life decision-making, as many actions taken in health and education are influenced by non-economic drivers (e.g. equal access, social mobility).

The net value is an absolute representation of cost-benefit. To compare alternatives with large differences in scale, a relative representation such as a ratio may be more useful. The benefit-cost ratio is calculated by dividing benefits by costs. A benefit-cost ratio greater than 1 is one where the benefits exceed the costs. Higher benefit-cost ratios are preferred, and they can be easily applied when deciding between alternatives. Put simply, a benefit-cost ratio of 1.2 can be interpreted as "for every dollar invested, there will be a return of \$1.20" (Levin et al. 2017).

In some interventions where there are net savings, decision-makers may be interested to know how long it will take for these savings to offset the initial investment made to develop the intervention. The answer can be derived from a break-even analysis. The general formula for break-even is initial investment divided by annual net value (to calculate number of years for break-even), as shown in Example 5 (Levin et al. 2017). Refer to Online Supplementary Appendix 2 Section 2.4.2 to see the net value, benefit-cost ratio, and break-even analysis for the running case-study.

Example 5. Calculation of net value, benefit-cost ratio, and break-even point

A simulation activity costs \$50,000 (cost) every year and results in \$60,000 of avoided surgical complications (benefit) every year. The development of the simulation activity cost \$30,000.

a) Net value = benefit − cost = 60,000 – 50,000 = 10,000

Therefore, every year, there is a net saving of \$10,000 (note that development costs are typically not included in the net value calculation).

b) Benefit-cost ratio = 60,000/50,000 = 1.2

Therefore, for every \$1 invested, there will be a return (benefit) of \$1.20.

c) Break-even point = initial investment/net value = 30,000/10,000 = 3

Therefore, the break-even point is 3 years.

Example 4. Calculation of a cost-effectiveness ratio (CER) and incremental cost-effectiveness ratio (ICER)

A simulation activity currently costs \$50,000 to train a cohort of 100 students, with an average grade of 70% on post-class assessment. Two proposals are made aimed at improving the average grade. The first proposal is to purchase new virtual reality headsets, which will bring the total cost up to \$57,000 and is expected to increase the average grade to 80%. The second proposal is to purchase paper facemasks, which will bring the total cost up to \$53,000 and is expected to increase the average grade to 73%.

a) Average cost per student trained for the current (base case) approach = 50,000/100 = \$500

$$\text{b) } ICER(virtual\ reality\ approach)\ for\ average\ grade = \frac{57,000{-}50,000}{80{-}70} = \frac{7,000}{10} = \$700 \text{ per 1\% gain in average grade}$$

$$\text{c) } ICER(facemask\ approach)\ for\ average\ grade = \frac{53,000{-}50,000}{73{-}70} = \frac{3,000}{3} = \$1,000 \text{ per 1\% gain in average grade}$$

Interpretation: Both the virtual reality and the facemask approach are more costly and more effective than the current teaching approach. The virtual reality approach is more cost-effective than the facemask approach, as the cost per improvement in grade is lower. Nonetheless, if budgets are limited a decision-maker might still opt for the facemask approach since it is still an improvement to the base case (i.e. higher grade).

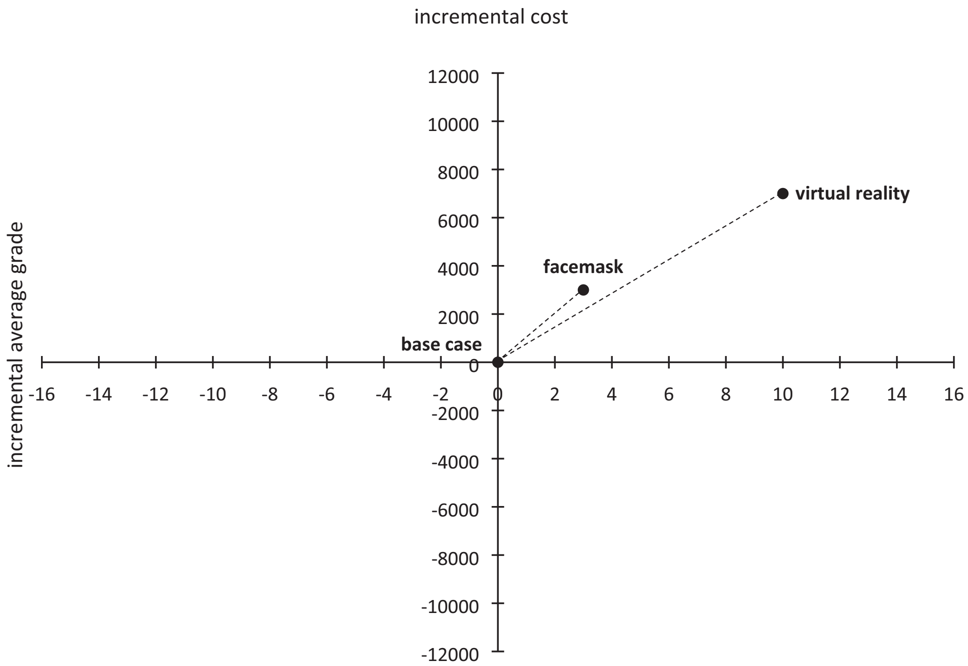

Figure 5. Incremental cost-effectiveness plane using data from Example 4.

Section 3: Sensitivity testing

As with most other quantitative research, in cost and value analyses we want to estimate the uncertainty in our results and by extension our confidence in the conclusions. In traditional research, we might use statistical tests of inference to calculate a p-value or 95% confidence interval (CI). Cost and value analyses are somewhat different; since the interventions are typically limited to only one or a small number of instances, the usual statistical tests do not work. However, it is still possible to estimate our uncertainty, and even calculate confidence intervals, through sensitivity testing. Curiously, sensitivity tests are conducted in only a small minority of cost and value analyses in HPE (Foo et al. 2019). We believe this reflects the nascency of the field and hope that, over time, sensitivity testing will be to cost and value analyses what 95% CIs are to traditional quantitative research.

Sensitivity analyses probe to see if results are robust to alternative versions of the evaluation (Levin et al. 2017). Alternative versions may arise due to parameter uncertainty, stochastic uncertainty, structural uncertainty, and heterogeneity (Briggs et al. 2012). Parameter uncertainty is the uncertainty in estimation of the parameter of interest (e.g. the volume of units, the price per unit, or the educational effect). Stochastic uncertainty (also known as variability) relates to the random variability in outcomes between presumably "identical" learners (i.e. learners similar in stage of training and other demographics). Structural uncertainty arises from assumptions made when specifying the cost model, this may relate to statistical processes (e.g. regression model specification) or assumptions around how an intervention generates outcomes (e.g. whether an intervention improves test scores because it encourages students to study more, or because it encourages students to seek more staff support) (Levin et al. 2017). Heterogeneity is variability among individuals that can be attributed to known characteristics. In education, heterogeneity reflects that not all learners are the same and will respond differently to educational interventions (Levin et al. 2017).

Using a general approach to sensitivity testing, uncertainty arising due to one or more of these factors can be tested (Levin et al. 2017). Sensitivity analyses can be broadly grouped under two statistical approaches: deterministic sensitivity analysis (using a defined set of predetermined variations) and probabilistic sensitivity analysis (using a random sample of conditions drawn from a range of possible variations).

Section 3.1: Deterministic sensitivity analysis

Deterministic sensitivity analysis involves defining specific ('determined') plausible alternatives for one (one-way sensitivity analysis) or more (multi-way sensitivity analysis) variables, and then substituting each of these alternatives and recalculating the economic result. The researcher can then evaluate the degree to which these alternatives alter the conclusions drawn (Levin et al. 2017). These alternative variables and corresponding values can be selected based on known uncertainties (e.g. trying a 6% or 3% discount rate, or considering a national versus local wage structure) or extreme-case scenarios (e.g. the best-case and worst-case scenario for a given resource cost and/or outcome, or the upper and lower 95% confidence limits). For example, Foo, Rivers, et al. (2017) in their study of the cost of student failure conducted a deterministic sensitivity analysis of three likely alternative models (structural uncertainty), considering changes in results if there was a different population group, different education process, and a different funding system.

The advantages of deterministic sensitivity analysis are that they are easier to conduct, and often more intuitive to read and understand, than probabilistic sensitivity analyses (described below). However, their shortcoming is that while they can address the range of plausible alternative results, they do not account for the likelihood of these alternatives occurring (for example, we do not know how likely it is that the best-case scenario might occur) (Neumann et al. 2016). Refer to Online Supplementary Appendix 2 Section 3 to see the application of a one-way sensitivity analysis to the running case-study.

Section 3.2: Probabilistic sensitivity analysis

Probabilistic sensitivity analysis substitutes one or more variables with plausible alternatives, as in the deterministic analysis; but in this case each alternative is represented by a pool of possible values rather than a few predetermined values. This pool of possible values (called a "distribution") is created by the researcher to reflect the probability of each value occurring. For example, the distribution might include a large number of values close to the point estimate used in the initial calculation; as values diverge from this central point estimate the relative representation in the distribution goes down. The "normal" distribution (with the initial point estimate as the centre) is perhaps the most common example, but other distributions might be more representative of reality in some situations.

As with deterministic sensitivity analysis, probabilistic sensitivity analyses can involve one variable (one-way) or multiple variables (multi-way), each with its own distribution of possible values. The probabilistic analysis randomly draws one value from each variable's distribution, recalculates the economic result, records this result, and then repeats this process numerous times – perhaps 1000 or more. The results of these repeated analyses can be used to calculate the confidence interval for the final cost estimate (and for derivatives such as the ICER and net value) (Neumann et al. 2016). This procedure is typically conducted using computerised approaches such as Monte Carlo simulation and bootstrapping.

Probabilistic sensitivity analyses are often presented as a scatterplot diagram, as demonstrated in Figure 6, with each point representing a possible ICER value based on the probability distribution of the effect (mean 9, standard deviation 6) and cost (mean 77, standard deviation 40). On visual inspection alone, we can see that the majority of ICER values fall into quadrant one (more effective and more costly), although there are also values falling into the other three quadrants. The probability of an ICER value occurring can also be plotted relative to a cost-effectiveness threshold (i.e. how much someone is willing to pay for a particular outcome) to reflect whether an intervention may be accepted by the users/payers – this is known as a

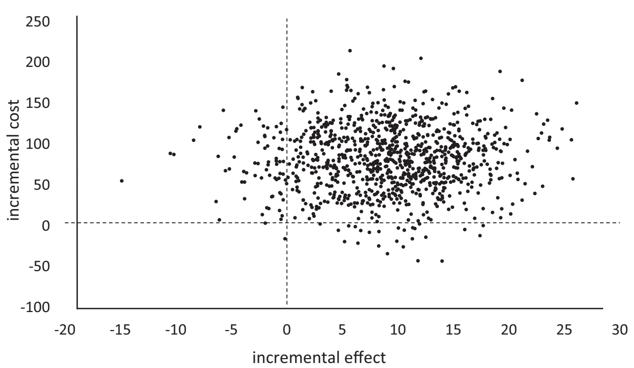

Figure 6. Probabilistic sensitivity analysis scatterplot diagram: using 1000 samples with replacement, x-axis using effect data with a mean of 9 (standard deviation 6), y-axis using cost data with a mean of 77 (standard deviation 40).

cost-effectiveness acceptability curve (see Tolsgaard et al. (2015) for an example).

Probabilistic sensitivity analyses offer the advantage of simultaneously considering both the range of plausible alternative results and the probability of these alternatives occurring. The difficulty with this type of analysis is the need to define the distribution for *all* variables under consideration, which can be difficult in HPE. To explore probabilistic sensitivity analysis further, we suggest referring to Neumann et al. (2016) Chapter 11, and Drummond et al. (2015) Chapter 11.

Section 4: Reporting results

High-quality reporting is necessary for useful communication of results. Reporting of cost and value analyses in HPE has historically been poor and has not improved over time (Foo et al. 2019). We recommend referring to guidelines on reporting of cost and value analyses; including the BMJ economic checklist (Drummond and Jefferson 1996), CHEERS statement (Husereau et al. 2013), Gates Reference Case (Claxton et al. 2014), and the reporting checklist from the Second Panel on Cost-Effectiveness in Health and Medicine (Neumann et al. 2016). Content of reporting guidelines may not apply to all study designs and methodological approaches. Therefore, it is important to understand the intent behind reporting recommendations and apply them discerningly. Table 4 illustrates how the content of this guide maps onto the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) reporting items.

As an emerging field of study, the onus is on researchers to report in a clear, complete, and transparent manner. In particular, economic concepts should be fully explained. Over time, such explicitness will become less necessary as the approaches become contextualised and accepted. However, it is not always appropriate, or possible, to provide full details of an evaluation in a research publication. As such, we recommend publishing technical appendices to supplement traditional publications (Sanders et al. 2016). Authors must also consider whether to report the education intervention separate from the cost and value analysis (e.g. Ilic et al. (2015) and Maloney et al. (2015)) or together (e.g. Knapp et al. (2011)).

Section 5: Cost and value analyses in context

Ultimately, cost and value analyses are a tool to support decision-making. The goal of cost and value analyses is to create an evidence base towards a HPE system that maximises educational attainment for a given spend – that is sustainable, equitable, accessible, and able to meet future healthcare requirements (Maloney et al. 2017). While important, these analyses are only one part of decision-making, and other factors such as institutional values may also be considered. As with any tool, cost and value analyses are only as effective as the person wielding it, and researchers must consider when and how to apply them. High-impact areas for applying cost and value analyses are likely to include education activities that are high-cost (e.g. simulation), high-volume (e.g. lectures), or related to priority areas (e.g. underrepresented minorities).

As the uptake of cost and value analyses in HPE grows, we can continue to draw on guidance from the fields of health economics and education economics to enhance

Table 4. Guide content mapped to Consolidated Health Economic Evaluation Reporting Standards (CHEERS) items.

CHEERS item	Item no.	Guide section
Title and abstract		
Title: Identify the study as an economic evaluation and describe the interventions compared.	1	n/a
Abstract: Provide a structured summary of objectives, perspective, setting, methods, results, and conclusions.	2	n/a
Introduction		
Background and objectives: Provide a statement of the context for the study, the study question, and its relevance for decision-making.	3	1.5
Methods		
Target population and subgroups: Describe the population(s) analysed.	4	1.4
Setting and location: State relevant aspects of the setting and location.	5	1.4
Study perspective: Describe the perspective(s) of the study.	6	1.2
Comparators: Describe the intervention(s) and why they were chosen.	7	1.3
Time horizon: State the time horizon(s).	8	n/a
Discount rate: Report and justify the choice of discount rate(s) used for costs and outcomes.	9	2.2
Choice of outcomes: Describe what outcomes were used as the measure(s) of output in the evaluation and their relevance for the type of analysis performed.	10	2.3
Measurement of effectiveness: Describe approaches used to measure the effect of education.	11	2.3
Measurement and valuation of preference-based outcomes: Describe the population and methods used to elicit preferences for outcomes.	12	n/a
Estimating resources and costs: Describe approaches used to estimate the volume of resource units consumed and to determine unit price.	13	2.1
Currency, price date, and conversion: Report the date and currency of monetary amounts. Describe methods used to adjust amounts to the reported year and currency.	14	2.2
Choice of model: Describe and justify the decision-analytical model used.	15	n/a
Assumptions: Describe assumptions underpinning the decision-analytical model.	16	n/a
Analytical methods: Describe analytical methods supporting the evaluation (e.g. methods for dealing with missing data, approaches to pooling data).	17	n/a
Results		
Study parameters: Report the values, ranges, references, and probability distributions for all parameters.	18	2.4
Incremental costs and outcomes: For each intervention, report mean values for the main categories of estimated costs and outcomes of interest.	19	2.4
Characterising uncertainty: Describe the effects of relevant sources of uncertainty.	20	3
Characterising heterogeneity: Report differences in costs and outcomes that can be explained by variations between subgroups.	21	3
Discussion		
Study findings, limitations, generalisability, and current knowledge: Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	22	n/a
Other		
Source of funding: Describe sources of funding.	23	n/a
Conflicts of interest: Describe any potential for conflict of interest.	24	n/a

Note that item descriptions have been modified and that not all items have been covered in this guide. n/a: not addressed in this guide

the usefulness of our research. Future areas of promise include the use of standardised cost models to enhance comparability (e.g. The Gates Reference Case), synthesis of studies (i.e. meta-analysis) and model-based approaches (Walsh 2010; Claxton et al. 2014). These will provide greater statistical power, precision, and improve generalisation. However, advances will require a greater number of studies with improved methodological quality and more complete reporting (Foo et al. 2019).

Greater incorporation and development of theory in cost and value analyses will also play an important role in advancing our understanding and improving the practice of HPE (Cleland et al. 2020). Theory helps us develop better studies and generalise results beyond their immediate settings (Rees and Monrouxe 2010). Some economic theories specifically relevant to HPE include human capital theory, screening theory, cost-of-production theory of value, theory of supply and demand, and cost and productivity theory (Walsh et al. 2019). We need to move towards clarification type studies that ask the 'how' and 'why' of phenomena; these studies start with a model or theory, make a prediction, and test these predictions (Cook et al. 2008).

Box 1. Summary of key steps to conducting a cost and value analysis

1. Develop focused economic research question
2. Determine study design
   a. cost analysis
   b. cost effectiveness analysis (and cost utility analysis)
   c. cost benefit analysis
3. Evaluate costs using the Ingredients Method
   a. identify resources (ingredients)
   b. measure volume (number of units used)
   c. assign prices (market price, shadow price) per unit
   d. calculate total cost of each resource (volume x price)
4. Evaluate outcomes (natural units, monetary units)
5. Adjust as required (currency conversion, inflation, discounting)
6. Combine costs and outcomes
   a. for natural outcome units: cost-effectiveness ratio, incremental cost-effectiveness ratio
   b. for monetary outcome units: net value, benefit-cost ratio, break-even
7. Sensitivity testing (deterministic analysis, probabilistic analysis)

Conclusion

In this guide we have provided practical steps to conducting simple cost and value analyses, introduced key terminology and concepts to enable informed discussions with economic specialists, and provided suggested readings to facilitate upskilling in more advanced topics. A summary of steps that readers should be able to complete at a basic level is provided in Box 1. Through application of this guide, we hope to see both a greater quantity and quality of cost and value analyses in HPE research.

Disclosure statement

The authors report no conflicts of interest. All authors are members of the Society for Cost and Value in Health Professions Education. The authors alone are responsible for the content and writing of the article.

Glossary

Term	Definition
Cost analysis	An analysis approach that evaluates only the cost, and not outcomes (Drummond et al. 2015).
Cost and value analyses	All forms of analysis that calculates economic cost, with or without a corresponding analysis of consequences/outcomes.
Cost benefit analysis (CBA)	An analysis approach that evaluates both cost and outcomes, where outcomes are measured in monetary units (Drummond et al. 2015).
Cost effectiveness analysis (CEA)	An analysis approach that evaluates both cost and outcomes, where outcomes are measured in natural units (e.g. exam scores, patient bed days) (Drummond et al. 2015).
Cost utility analysis (CUA)	A variant of the cost effectiveness analysis, an analysis approach that evaluates both costs and outcomes, where outcomes are measured in a utility metric (e.g. quality adjusted life year [QALY] or disability adjusted life year [DALY]) (Drummond et al. 2015).
Discounting	A method used to convert expected future incomes to present values (Rutherford 2013).
Economic cost (opportunity cost)	The total resources given up achieving an outcome. Formally defined as “the value of the alternative foregone by choosing a particular activity” (Rutherford 2013).
Explicit cost	Actual monetary transfers typically reported in accounting documents (e.g. payments of staff wages, purchases of textbooks). Formally defined as “actual money expenditure incurred to obtain a factor of production or a good or service” (Rutherford 2013).
Implicit cost	Costs incurred that are not reported in accounting documents (e.g. volunteer time, in-kind support). Formally defined as “a cost of production which is not included in the accounts of a business but nevertheless is incurred” (Rutherford 2013).
Inflation	The increase in the price of goods and services over time (Rutherford 2013).
Sensitivity analysis	Analyses conducted to see if results are robust to alternative versions of the evaluation (Levin et al. 2017).

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