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SPECIAL ARTICLE

Role of the anesthesiologist in the wider governance of healthcare and health economics

Le rôle des anesthésiologistes dans la gouvernance élargie des soins de santé et de l'économie de la santé

Janet Martin, PharmD · Davy Cheng, MD

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Abstract

Purpose *Healthcare resources will always be limited, and as a result, difficult decisions must be made about how to allocate limited resources across unlimited demands in order to maximize health gains per resource expended. Governments and hospitals now in severe financial deficits recognize that reengagement of physicians is central to their ability to contain the runaway healthcare costs. Health economic analysis provides tools and techniques to assess which investments in healthcare provide good value for money vs which options should be forgone. Robust decision-making in healthcare requires objective consideration of evidence in order to balance clinical and economic benefits vs risks.*

Principal findings *Surveys of the literature reveal very few economic analyses related to anesthesia and perioperative medicine despite increasing recognition of the need. Now is an opportune time for anesthesiologists to become familiar with the tools and methodologies of health economics in order to facilitate and lead robust decision-making in quality-based procedures. For most technologies used in anesthesia and perioperative medicine, the responsibility to determine cost-effectiveness falls to those tasked with the governance and stewardship of limited resources for unlimited demands using best evidence plus economics at the local, regional, and national levels. Applicable cost-effectiveness, cost-utility, and cost-benefits in health economics are reviewed in this article with clinical examples in anesthesia.*

Conclusions *Anesthesiologists can make a difference in the wider governance of healthcare and health economics if we advance our knowledge and skills beyond the technical to address the "other" dimensions of decision-making – most notably, the economic aspects in a value-based healthcare system.*

Résumé

Objectif *Les ressources en soins de santé seront toujours limitées, c'est pourquoi des décisions difficiles doivent être prises quant à l'allocation de ressources limitées pour des demandes illimitées, afin d'optimiser les gains en santé par ressource dépensée. Les gouvernements et les hôpitaux, aujourd'hui en déficit financier grave, reconnaissent qu'une implication nouvelle des médecins est cruciale pour pouvoir restreindre des coûts des soins de santé incontrôlables. L'analyse de l'économie de la santé fournit des outils et des techniques permettant d'évaluer la rentabilité des investissements dans les soins de santé, et de déterminer lesquels devraient être abandonnés. Pour prendre des décisions éclairées en soins de santé, il faut considérer de façon objective les données probantes afin de soupeser les avantages cliniques et économiques eu égard aux risques.*

Constatations principales *Les recherches dans la littérature révèlent qu'il existe très peu d'analyses économiques liées à l'anesthésie et à la médecine*

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J. Martin, PharmD
Department of Anesthesia & Perioperative Medicine and Department of Epidemiology & Biostatistics, Western University, London, ON, Canada

D. Cheng, MD (✉)
Department of Anesthesia & Perioperative Medicine, Western University, London Health Sciences Centre, University Hospital, 339 Windermere Road, C3-172, London, ON N6A 5A5, Canada
e-mail: davy.cheng@lhsc.on.ca

périopératoire et ce, malgré la prise de conscience croissante de ce besoin. Le moment est opportun pour que les anesthésiologistes se familiarisent avec les outils et méthodologies de l'économie de la santé afin de faciliter et de mener des prises de décision robustes dans des interventions fondées sur la qualité. La responsabilité de déterminer la rentabilité de la plupart des technologies utilisées en anesthésie et en médecine périopératoire incombe aux personnes dont la tâche est la gouvernance et l'intendance de ressources limitées pour des demandes illimitées en se fondant sur les meilleures données probantes et l'économie aux niveaux local, régional et national. Les rapports coût-efficacité, coût-utilité et coût-avantage en économie de la santé sont passés en revue dans cet article, avec des exemples cliniques d'anesthésie à l'appui.

Conclusion *Les anesthésiologistes peuvent faire une différence dans la gouvernance élargie des soins de santé et de l'économie de la santé, si nous faisons progresser nos connaissances et nos compétences au-delà de leur dimension technique pour aborder les 'autres' dimensions pertinentes à la prise de décision – et tout particulièrement les aspects économiques d'un système de soins de santé fondé sur la valeur.*

> *"Doing things right is only half the story – it is also essential to use our limited resources most effectively by identifying and discontinuing lower value activities."* Gray M[1]

In value-based healthcare transformation, anesthesiologists are key partners in the perioperative outcomes and costs in acute care settings. We must embrace the opportunity to engage in evidence-based knowledge translation and health economics analysis in order to take an active part in decision-making and policymaking.

Anesthesiologists must engage in the wider governance of healthcare

Canada is the tenth largest economy in the world.[2] Despite heightened efforts to stem the rise of government expenditures since the 2008 fiscal crisis, our government suggests its deficits are unlikely to be balanced before 2017. Over $200 billion is spent on healthcare each year in Canada. While Canada spends proportionately less on healthcare than the United States, its average expenditures are more than those of member countries in the Organisation for Economic Co-operation and Development (OECD), whether expressed as a percent of gross domestic product (GDP) or average expenditure per capita, as seen in Fig. 1.[3] Every year, the proportion of the GDP devoted to healthcare rises further, showing that healthcare is consuming an ever-increasing portion of the total resources available within the country. The beginning of what some have termed the "healthcare tsunami", i.e., the added healthcare consumption by the rising tides of "baby boomers", compounds this ever-increasing demand.

Growth in healthcare expenditures consistently outpaces economic growth due to the vicious cycle of increasing demands, increasingly complex and costly therapies and interventions, and finite resources to meet the demands, and at this rate, it has become unsustainable. Limits must be applied at some points along the increasing demand-curve for healthcare, since our society is interested in more than providing just healthcare from within our limited set of resources (whether defined as dollars, time, or people).

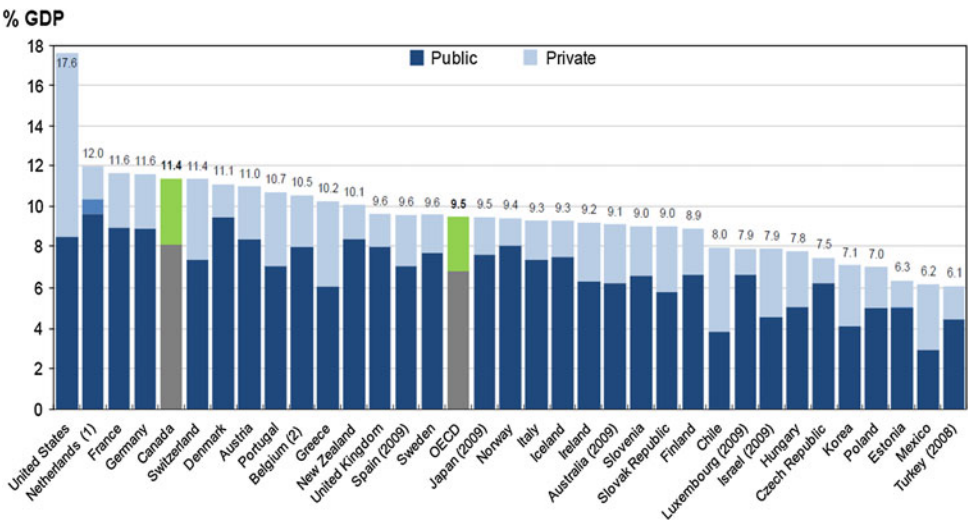

Fig. 1 Health expenditure as a percent of gross domestic product (GDP) in member countries of the Organisation for Economic Co-operation and Development (OECD), 2010 (reproduced with permission from reference #3: www.oecd.org/Canada/briefingnoteCANADA2012.pdf)

Other needs and opportunities, including education, security, governance, infrastructure, and environment, also require resources to maintain a thriving society. In Canada, the federal government has begun to draw the line, as the growth in transfer of healthcare dollars to the provinces will be linked to the rate of inflation by 2015 (http://www.fin.gc.ca/fedprov/cht-eng.asp). This will soon limit the annual increase in healthcare budgets from 6-8% to 3% or less of GDP, indicative of healthcare transfer payments within the next several years.

Addressing these issues will demand knowledge and skill in quality of care and health economics, with facile application to the imperfect world of real-world decision-making. It is essential that all physicians become engaged in the wider governance of healthcare through their hospitals or academic health science centres or their provincial and national medical organizations in order to achieve a sustainable healthcare system for present and future generations. As anesthesiologists and perioperative medicine experts, we are uniquely poised to contribute meaningful input. The paradigm of anesthesia clinical delivery is expanding from the conventional operating room service to the anesthesia care team model within and outside of the operating room, including diagnostic and interventional procedures, preadmission and pain clinics, perioperative blood management, and critical care units. Increasingly, we are engaging in hospital administration and research with clinical impact. With such a broad scope of practice, we have the opportunity and obligation to become increasingly involved in the deeper questions about how to achieve efficiencies while maintaining or enhancing the value of care as we enter an era of limited growth in the set of resources for healthcare expenditures.[4]

The Institute for Healthcare Improvement Triple Aim framework for the simultaneous pursuit of better care for individuals, better health for populations, and lower per capita costs has now become the organizing principle for a new healthcare model based on delivering value.[5] Bill 46, the "Excellent Care for All Act" passed by the Legislative Assembly of Ontario in 2010[6] declared that quality is the goal of everyone involved in healthcare delivery in Ontario. This resulted in funding reform for health systems with support (payment, policy, and planning) for quality of care and efficient use of resources in a patient-based funding model, e.g., the Quality-Based Procedures initiative. Although there has been a tendency in recent years for physicians to disengage from the administrative structure of hospitals in healthcare delivery, now that governments and hospitals are in severe financial deficits, they recognize that reengagement of physicians is central to their ability to contain healthcare costs.

Opportunities to impact the governance of healthcare

It has never been more important for physicians to become involved in healthcare management and to challenge some of the attitudes on hospital and healthcare management. Many potential levels of engagement exist for anesthesiologists to impact the governance of healthcare. At the hospital level, we should increasingly seek opportunities to engage or take the lead in decision-making and oversight on committees for perioperative care, blood transfusion, pharmacotherapeutics, preadmission clinics, pain clinics, quality and safety, technology acquisition, technology assessment, critical care, women and children care, health informatics, etc. At the provincial level, we should seek opportunities to engage and take a lead on ministry of health committees to provide evidence-based evaluations and policy impact assessments, and at our provincial colleges and medical associations, we should use our skills and knowledge to improve healthcare policy. At the national level, we should engage and take a lead in developing best practice guidelines and healthcare policies in partnership with professional societies and other healthcare associations. Many anesthesiologists have taken the lead to apply their skills in health governance and have been awarded opportunities as senior medical leaders in such positions as Vice President, Medical Affairs; Chair, Medical Advisory Committee; CEO in the hospital setting; and Dean of Medicine in the university setting.

Health economics is a prerequisite skill for managing today's healthcare challenges

As the growing demand on limited resources in healthcare mounts and as economic crises become the new norm, it is clear that any opportunity for real success and a meaningful rightful impact in these roles will require knowledge in health economics. This is a clear area of opportunity as reflected by the limited number of publications. But, what exactly is health economics, and how is it relevant to decision-making?

Economics provides a transparent framework with which to address the issue of insufficient resources using objective tools and fair-minded techniques to prioritize available alternative courses of action.[7] The concept of opportunity costs is central to economics. Since every decision to do one thing is potentially a decision not to do another, and since each dollar can be spent only once, the real cost of choosing one option over another is what was essential to forgo. Therefore, while we often think about costs in terms of price tags and dollars, instead, the real cost of any course of action should be measured in terms of

the value of the next best alternative foregone in our healthcare system.

Opportunity cost is the real cost

Since opportunity cost reveals "the basic relationship between scarcity and choice",[8] it can play a pivotal role in ensuring that scarce resources are used more effectively and efficiently (i.e., that resources are applied to the best of all alternative options in order to minimize opportunity cost).[8] Opportunity and cost are two sides of the same coin, just as scarcity and choice are two sides of the same coin. You can't have one without the other. When cost is thought of in these terms, it becomes obvious that opportunity costs are not restricted to financial costs. Rather, the real cost is measured in the sum total of lost time, lost productivity, lost pleasure, divided attention, or any other benefit forgone in choosing one alternative over another. When we say resources are limited, this refers not only to restricted tangibles, such as physical space, people, drugs, devices, and hospital beds, but also to the limited intangibles, including time, desire, and even attention.

If opportunity cost is most important, where then does the price tag feature in health economics? Financial costs, or dollars, are a type of proxy for the price of opportunity, but they are only one small part of the equation. Generally, economic analysis is not about achieving cost savings. Rather, the ultimate goal is improving value for money by releasing resources back into the system for the "best possible" use elsewhere in healthcare.[9] Both practitioners and patients alike cry foul when costs play into decisions about healthcare. At one time or another, many of us have claimed that health economics is irrelevant to clinical practice and that making healthcare decisions based on financial costs is perverse.[10,11] While it is true that we, as practitioners, are responsible for choosing the best possible treatment options for our patients, it is also true that we cannot offer the utmost in every situation, and we should not always try to do so. It is not always worthwhile to seek out exceedingly small margins of benefit.[12] Opportunity costs are too great if there are better things we could do with our limited time, resources, and attention to provide more health elsewhere in the system.

Imagine the following scenario to bring this concept into perspective. While every hospitalized patient could potentially benefit from continuous surveillance, we place only a subset of critically ill patients in intensive care units. This is based on economics and specifically the scarcity of intensive care beds, monitoring equipment, and nurses. Nonetheless, this form of "rationing" leads to a small margin of deaths that could have been avoided if we had provided continuous monitoring for all patients. Yet, we don't aspire to monitor all patients continuously, since we know the margin of benefit is too small to warrant the amount of resources we would need to devote to monitoring. Instead, we monitor only the most severe patients and reserve the remaining resources for other (presumably better) uses.

The threshold between "severe enough to warrant continuous monitoring" *vs* "safe enough to forgo monitoring" (e.g., in postoperative care of patients with obstructive sleep apnea) is defined as much as possible by the evidence but also in close consideration of the available capacity to provide monitoring compared with what we would have to give up to make it feasible for patients across the risk spectrum. This is an example of everyday rationing that we all accept as common sense, especially at either end of the risk spectrum. Health economics helps us to deal with the scenarios that require choices that are not so obvious, for instance, when the tradeoffs between benefit and costs are in the grey zone between what is obviously worth the cost and what is clearly not worthy of its associated cost and effort.

It is also important to understand "over-monitoring"; hence, "over-investigations" which have been known to lead to harm, e.g., in preoperative intervention for non-cardiac surgical patients. To achieve net benefits, the postoperative morbidity/mortality outcomes of the major non-cardiac surgery must be "better" with the preoperative intervention (with delay of surgery, preoperative non-invasive tests with additive complications from coronary interventions, pharmacological interventions) than without the preoperative intervention. A population-based retrospective propensity-matched cohort study showed that preoperative stress testing was associated with a moderate improvement in one-year survival in high-risk patients based on the Revised Cardiac Risk Index (RCRI 3-6; hazard ratio [HR] 0.80; 95% confidence interval [CI] 0.67 to 0.97), with a favourable number needed to treat of 38. In contrast, stress testing was associated with only minor benefits for intermediate-risk patients (RCRI 1-2; HR 0.92; 95% CI 0.85 to 0.99) and was associated with harm in low-risk individuals (RCRI 0; HR 1.35; 95% CI 1.05 to 1.74).[13] The cumulative evidence points to the recommendation for a preoperative noninvasive stress test only in high-risk patients, but the subsequent coronary interventions in these high-risk patients may not have shown net benefits for non-cardiac surgery. The evidence whether a preoperative stress test provides prognostic benefits in specific groups of intermediate-risk patients is still lacking. Evidence-based best practice and pay-for-performance in the healthcare systems are focused toward patient-centred care and cost-effective management; but first we must do no harm.[14]

Measuring value for money

Since price tags and financial transactions in healthcare do not necessarily reflect the value of healthcare, we need trusted techniques to convert costs and outcomes into estimates of "value". Health economics provides us with these tools and techniques.[9,15,16] There are four main types of economic analysis: cost-minimization analysis (CMA), cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), and cost-utility analysis (CUA) (see Table 1). *Bona fide* health economic analysis is always a *comparative* analysis[7] and defines value as the ratio of the *difference in costs* between the new technology *vs* the next best comparator (usually standard of care) and the *difference in outcomes* between the new technology under consideration *vs* the next best alternative (standard of care), which is also known as the incremental cost-effectiveness ratio (ICER) or the incremental cost-utility ratio (ICUR):

$$\text{Value} = \frac{\text{Cost}_{\text{intervention}} - \text{Cost}_{\text{comparator}}}{\text{Effect}_{\text{intervention}} - \text{Effect}_{\text{comparator}}} = \text{ICER } \textit{or } \text{ICUR}$$

While many practitioners mislabel cost analyses or budget impact analyses as cost-effectiveness analyses, the former considers only the cost side of the equation without calculating the incremental cost per incremental outcome between competing alternatives. (Table 2: grid of economic analysis) Cost analyses and budget impact analyses represent the most frequent type of publication in the anesthesia and surgical literature but do not represent economic analyses *per se*. In true economic analyses, the value of the outcomes is also incorporated into the analysis, as in the ICER.

The CMA is a special form of economic analysis where the outcomes are (assumed to be) equivalent and the equation can be simplified to a consideration of differences in costs alone. Nevertheless, this type of economic analysis is rarely appropriate, since the outcomes between two

Table 1 Types of economic analysis in health care[7]

Name	Costs	Consequences	Metric
Cost minimization analysis (CMA)	Dollars	Identical between alternatives (assumed)	C_1-C_2 = ΔC
Cost-Effectiveness Analysis (CEA)	Dollars	Single effect of interest, expressed in natural units (ie, LYG, cases detected, stroke avoided)	$\frac{C_1-C_2}{E_1-E_2} = \frac{\Delta C}{\Delta E}$
Cost-Utility Analysis (CUA)	Dollars	Single or multiple effects which may be different between alternatives (converted to QALYs, where QALY = utility * LE)	$\frac{C_1-C_2}{QALY_1-QALY_2} = \frac{\Delta C}{\Delta QALY}$
Cost-Benefit Analysis (CBA)	Dollars	Single or multiple effects which may be different between alternatives, converted to dollars	ΔC:ΔE ($) or ΔC-WTP*ΔE

C = cost; E = Effect; LYG = life-years gained; LE = life expectancy; WTP = willingness to pay

Adapted with permission from Drummond *et al.*[7]

Table 2 Differentiating between economic analysis and cost analyses or effect analyses

		Are both costs and consequences considered?		
		No		Yes
		Consequences only	Costs Only	
Is there a comparison of 2 or more alternatives?	No	Outcome description	Cost description	Cost-outcome description
	Yes	Efficacy or Effectiveness evaluation	Cost Analysis	Full Economic Analysis CMA CEA CUA CBA

CMA = cost minimization analysis; CEA = cost-effectiveness analysis; CUA = cost-utility analysis; CBA = cost-benefit analysis. Adapted with permission from Drummond *et al.*[7]

interventions have rarely been studied sufficiently to prove them to be equivalent across all outcomes of interest. Consideration of different brands of the same drug (i.e., molecularly equivalent, but different manufacturers) represents one of the only scenarios where cost-minimization is an appropriate analysis. In the rare event that two interventions have been shown to be "equivalent" or non-inferior across all clinically relevant benefits and risks, with suitably tight confidence intervals that rule out any clinically important differences, CMA may be an appropriate analysis. Even so, this situation is especially rare, and for this reason, CEA or CUA represents the most suitable evaluation to inform decision-making in health care.

While several examples of (inappropriate) use of CMA abound, we will focus on one published illustrative case. In a CMA of preoperative erythropoietin (EPO) *vs* autologous and allogeneic blood donation in total joint arthroplasty, the authors suggest that EPO and autologous blood donation have both been found to be effective for reducing allogeneic transfusions.[17] They reported that the least costly strategy was preoperative autologous blood donation; however, they make the assumption that these two options provide *equivalent* outcomes (including benefits and risks) when they proceed to perform a CMA. This assumption has not been proven either in the literature or by their institutional analysis of outcomes, and it has not been adequately tested in comparative clinical trials. In fact, there are important differences in clinical outcomes with EPO *vs* autologous donation, and a CEA or CUA that incorporates the potential for differences in outcomes across plausible ranges would be a more appropriate analysis.

Interpreting CEA

In CEA, the difference in costs per difference in effects is calculated for two interventions where the effects are measured in natural units. This allows us to calculate the ICER, which has intuitive meaning given its expression in natural units. For example, the incremental cost per heart attack avoided or the incremental cost per life year saved may be calculated.

Coyle *et al.* published an illustrative example of a comprehensive CEA of EPO to augment preoperative autologous donation (PAD) in cardiac surgery.[18] In conducting this analysis, they designed a decision analysis model that incorporated probabilities of clinical outcomes based on best available evidence from randomized trials (short term) and observational studies (longer term) of EPO+PAD *vs* PAD alone. Since clinical trials provided only short-term data on the benefits of EPO for preoperative use in cardiac surgery, they modelled the estimated benefits over a time horizon of expected survival using evidence applicable to a typical cardiac surgical cohort, and they varied their estimates over plausible ranges through sensitivity analyses to determine whether uncertainty in carryover effects would change their conclusions. The decision analysis incorporated the probabilities of receiving allogeneic blood products and the risks of complications (including transfusion-related lung injury, blood-borne infections, and potential effects on life expectancy based on observational evidence) together with the costs of blood products and associated costs of treating complications (based on real-world costing data).

Despite the significant reduction in need for allogeneic transfusion with EPO (from 31.6 to 12.7%), this CEA estimated that this translates to a very small incremental benefit (0.000035 life years gained). As a result, the ICER was $44.6 million/life years gained (Table 3). This estimate was robust over sensitivity analyses that varied estimates within the CEA, and in all scenarios, the ICER exceeded values that would normally be considered acceptable. While there is no consensus on what is the precise threshold ICER that definitely represents reasonable value for money, there is consensus that ICERS of the magnitude found in this study would be unreasonable uses of limited resources. The opportunity cost for using EPO to augment PAD for elective cardiac surgery is too great when compared with other uses of our limited resources that could "buy" more health gain.

Table 3 Cost effectiveness analysis of EPO+PAD *vs* PAD alone (Coyle *et al.*)[18]

Intervention	Cost*	ΔCost	Effect (LY)^	ΔEffect	ICER
EPO+PAD	$2579	$1559	13.10693	0.000035	$44,600,000/LYG
PAD alone	$1019		13.10689		

*Mean cost/patient in 1998 CAD

^0.74 units vs 1.74 units of blood required for EPO+PAD vs PAD alone, translates to 1 unit of blood saved on average with EPO, and an estimated difference in 0.000035 life-years gained due to avoidance of complications

Δ = change in (or marginal change); CAD = Canadian dollars; EPO = erythropoietin; LY = Life-years; LYG = Life-years gained; PAD = preoperative autologous donation, ICER = incremental cost effectiveness ratio

While the natural units of the ICER may be intuitive for clinicians to interpret, two key challenges for CEA limit its usefulness for prioritizing across multiple options in health care: 1) the inability to incorporate more than one clinical outcome in the ICER (i.e., usually there are several benefits and risks of relevance when choosing between alternatives), and 2) the inability to compare ICERs across interventions with different benefits (i.e., if different economic analyses reported different metrics, e.g., three different options, including cost per heart attack avoided *vs* cost per stroke avoided *vs* cost per life year gained, there is no common metric to rank and choose between alternative uses of resources). Cost-utility analysis has been developed to address these limitations.[7,15,16]

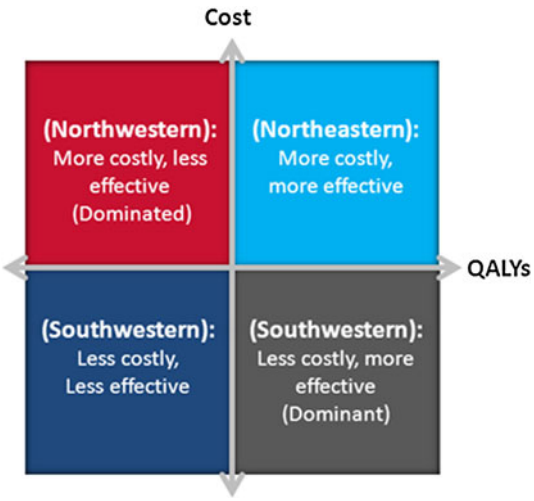

Fig. 2 Cost-effectiveness plane (reproduced with permission from reference #21: CEA: https://research.tufts-nemc.org/cear4/SearchingtheCEARegistry/Definitions.aspx)

Using CUA to estimate value for money

In order to allow for a common denominator, CUA incorporates multiple outcomes (benefits and risks) into one single metric, most commonly the quality-adjusted life years (QALY). The QALY incorporates utility weights associated with the health states provided by the intervention of interest and multiplies this quality-adjusted weight by the expected duration in that health state. For example, a person in perfect health who is expected to live 50 years would have 50 yr*1.0 utility = 50 QALYs. Then again, a person who is expected to live 50 years with an untreated chronic illness that provides a quality of life associated with a utility of only 0.5 would have 50 yr*0.5utility = 25 QALYs. If an intervention could restore this person with chronic illness to perfect health without interfering with life expectancy, then the intervention would provide an expected gain of 25 additional QALYs *vs* no intervention. The QALY transforms consequences into one single metric that can be compared across technologies and across departments or programs, even when the target outcomes of interest differ (i.e., cost-effectiveness of a technology that prevents myocardial infarctions and strokes can be compared with the value of a program that aims to reduce hospital length of stay in another program). For this reason, CUA has been suggested as the most useful type of economic analysis for prioritizing within and across programs in healthcare; however, as with all measures in healthcare, there remain limitations in existing methods for estimating utilities for different health states, and further work is ongoing to address these challenges.[7,15,16]

In a CUA of PAD, Etchason *et al.* used a decision analysis model to incorporate the costs and clinical consequences of blood transfusions and their complications for PAD *vs* no PAD using best available estimates of clinical effects from clinical trials supplemented by observational data from their own institution.[19] The ICURs ranged from $235,000/QALY for PAD *vs* no PAD in total hip replacement, to $494,000/QALY in coronary artery bypass graft, to $1.26 m/QALY in abdominal hysterectomy, and $23.6 m/QALY in transurethral prostatectomy. In sensitivity analyses that varied the uncertain variables across plausible ranges, the ICURs were generally well above what would generally be considered a reasonable use of resources. Again, the opportunity cost is too great, and there would be better use of our limited resources that could bring more health to patients through implementing other opportunities that have proven value for money.

In another illustrative CUA, Stroupe *et al.*[20] estimated the cost-utility of endovascular *vs* open repair of abdominal aortic aneurysm using clinical outcome data from the randomized Open Versus Endovascular Repair (OVER) trial and procedural and follow-up medical treatment costs from the perspective of the United States health system. Since each parameter for cost and benefit has an associated range of uncertainty, they used bootstrap methods to examine the range of costs and incremental effectiveness (measured in life years gained) or incremental utility (translated to QALYs using utility data from the quality of life data captured during the randomized controlled trial) over a time horizon of two years. Endovascular *vs* open aortic repair resulted in 0.04 incremental life years gained (95% CI −0.03 to 0.09), 0.006 incremental QALYs (95% CI −0.038 to 0.052), $5,901 in lower in-hospital costs (95% CI −12,135 to −821), and $5,019 in lower two-year total costs (95% CI −16,720 to 4,928). Thus, this analysis suggests that endovascular repair represents a life-saving and quality-enhancing procedure while also saving

resources at two years – and would definitely be considered a good use of health system resources (i.e., endovascular repair puts more resources back into the system than open aortic repair). In the bootstrap analysis using multiple scenario analysis, all plausible results varied across the full range of each 95% CI; there was a greater than 70% probability that endovascular repair would be less costly and more effective than open repair across all scenarios (as shown by the preponderance of dots in the southeastern quadrant in Fig. 2,[A] which is further explained below).

Visualizing cost effectiveness using the cost-effectiveness plane

The results of CEA or CUA can be graphically represented on a cost-effectiveness plane, where incremental costs are plotted on the vertical axis and incremental effects, such as life years gained for CEA or QALYs gained for CUA, are plotted on the horizontal axis. If the origin represents the reference treatment (i.e., the existing standard of care), then the new technology in question can be plotted on the cost-effectiveness plane in order to support clarity in decision-making.[4,21,22]

As shown in Fig. 2,[A] the northwestern quadrant is the area where the intervention increases costs and is less effective than the comparator. This situation represents an easy decision, whereby the new technology should be rejected on the basis that it is more costly and less effective. Ratios in the northwestern quadrant are referred to as "dominated" by the standard of care (which remains cheaper and more effective). The southeastern quadrant is the area where the intervention saves money and is more effective. This is an easy decision scenario: the new intervention should be considered good value for money and should be taken up into practice since it is expected to release money back into the system and bring more benefit than the comparator (i.e., as in the Stroupe analysis of endovascular *vs* open repair of abdominal aortic aneurysm).[20]

The northeastern quadrant is the area where the intervention is more costly and more effective than the comparator. This quadrant represents a grey area for decision-making, where judgements need to be made about whether the extra costs are worth the extra benefits. While we respect that there are certain increments in benefit for which we are willing to pay, we also respect that somewhere in this quadrant there lies a threshold above which we are no longer willing to pay extra money for exceedingly small increments in benefits. This threshold is often referred to as the willingness to pay threshold (i.e., the line marking the ICER above which we are no longer willing to pay for the extra margin of benefit). The southwestern quadrant also represents a decision quandary where tradeoffs must be made. The southwestern quadrant is the area where the intervention saves money but is less effective than the comparator. This is a controversial quadrant but should not be dismissed without serious consideration.[12] In a healthcare system where resources are sparse, interventions that are nearly as good as the alternative but would release significant money back into the system may be worth considering. In fact, these options should be considered when the released savings could be put to better use to bring more health into the system than the forgone benefits.

While there is no absolute cost per QALY that defines exactly the threshold between good *vs* poor value for money, we all accept that there is a limit to which we will pay for exceedingly small margins of benefit. In Canada, a number of thresholds that define our societal willingness to pay (WTP) have been inferred. For example, WTP from $20,000/QALY to $100,000/QALY has been suggested as a reasonable threshold range, based partly on a reflection of the ICERs for technologies that have typically been funded (such as dialysis, estimated to be valued at about $50,000/QALY).[23] Laupacis *et al.* proposed these thresholds whereby technologies with a cost per QALY less than $20,000/QALY might be considered as strongly supportive for adoption, those with a cost per QALY greater than $100,000 may be rejected, and technologies that fall within the grey area between these thresholds would require considered judgement regarding WTP. On the other hand, assessments of ICERs for drugs and technologies taken up into practice show that, in reality, technologies with lower ICERs are sometimes rejected and technologies with much higher ICERS are sometimes accepted; an exact WTP is difficult to define because factors beyond cost and effectiveness play into decision-making (i.e., ethics, equity, availability of alternatives, perceived "fairness" related to severity or rarity of the condition, etc).

In the example of the CEA for EPO+PAD *vs* PAD alone or the example of a CUA for PAD *vs* no PAD, the ICERs for intervention *vs* comparator would be in the northeastern quadrant (more expensive, slightly more effective); however, the ICERs for both of these examples were so high that neither of these was within the "grey zone" of areas where we might consider them to represent good value for money. On the other hand, in Fig. 3A,[A] the bootstrapped range of potential ICERS for endovascular *vs* open repair of abdominal aortic aneurysm shows that, even across all possible ranges of costs and effects, there is more

[A] CEA: Cost-Effectiveness Analysis Registry. Definitions: Intervention Impact. 2012. Available from URL: https://research.tufts-nemc.org/cear4/SearchingtheCEARegistry/SearchtheCEARegistry/definitions.aspx (accessed May 2013).

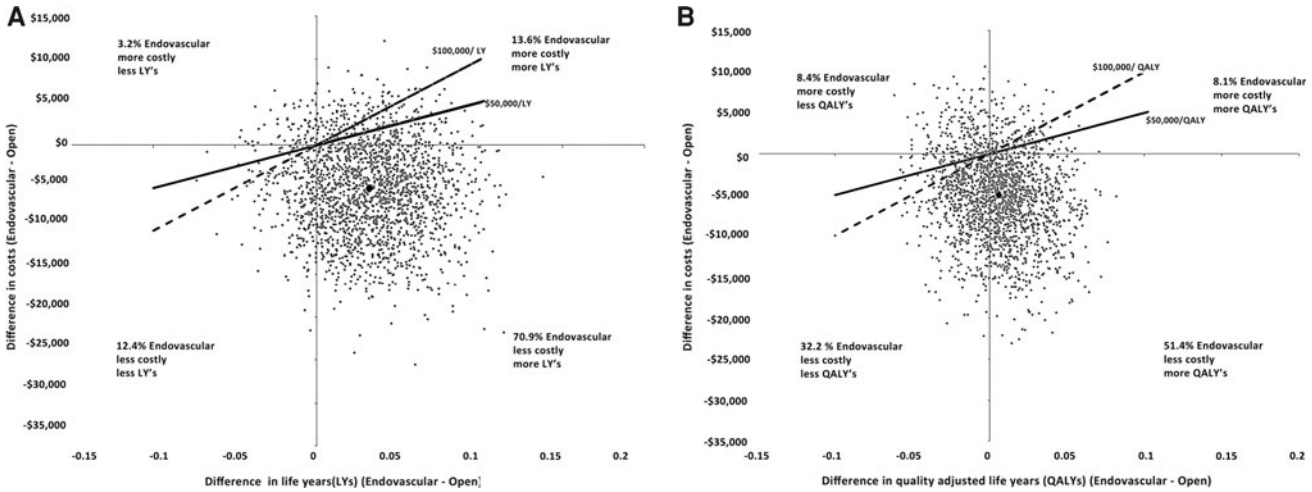

Fig. 3 Cost-effectiveness plane for endovascular *vs* open repair of abdominal aortic aneurysm. Reproduced with permission from reference #20: *Stroupe KT, Lederle FA, Matsumura JS, et al.; Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group*. Cost-effectiveness of open versus endovascular repair of abdominal aortic aneurysm in the OVER trial. J Vasc Surg 2012; 56: 910-9e2

than a 70% likelihood that endovascular repair saves money and gains improved life years.[A] Similar results were found in Fig. 3B[A] for the bootstrapped range of potential ICURS for cost per QALY of endovascular *vs* open repair of abdominal aortic aneurysm. In this example, most of the possible scenarios across the full range of uncertainty lie well below the value that would be considered to represent reasonable value for money (in this case, defined as $50,000-$100,000/QALY from the United States perspective).

The "right" threshold remains an area of significant controversy. Likely the "right" threshold depends on considerations beyond only the costs and consequences of the options under consideration. Since economic analysis does not capture a number of "other aspects" that should weigh on a decision (i.e., such as ethical considerations, including equity and whether alternatives exist for the condition at hand), the right threshold is likely highly dependent on these "other" factors that are difficult to define. This is an area that requires more exploration, since economic analysis aims to be fair and comprehensive yet cannot be fair and comprehensive without being all-encompassing in the factors that it incorporates in its measure of value.[24]

Cost-benefit analysis

The fourth and final type of economic analysis is cost-benefit analysis (CBA), which is used less frequently than CEA or CUA. Cost-benefit analysis requires that the effects of the interventions be transformed into dollar equivalents, and transforming benefits into dollar equivalents is sometimes controversial. In the most sophisticated form of CBA, a net-benefit analysis is performed using the societal WTP as the value to transform an incremental benefit into dollars.[16] In more simplistic CBAs, the monetary value of the health outcome is compared with the cost of implementing the intervention. If the costs of intervention are less than the benefits (i.e., averted costs), then the intervention represents a net gain.[25] For example, Waters *et al.* measured the cost of implementing the Michigan Keystone Patient Safety Program in the intensive care units in six hospitals in the United States.[26] The program prevented 29.9 catheter-related bloodstream infections and 18.0 cases of ventilator-associated pneumonia per hospital annually. Since the average cost of the intervention ($3,375/infection averted) was significantly less than the additional healthcare costs associated with treating these infections ($12,208-$56,167/infection), there was a net benefit of $8,833-$52,792. This provides impetus for implementing the program, since there is an estimated net benefit to the system that exceeds severalfold the cost to implement the program.

Scarcity demands tough decisions

For any who propose that health economics is irrelevant to front-line decision-making considering individual patients, we need only to consider that decision-making that is informed transparently by evidence and economics will benefit more patients individually and collectively within the healthcare system. A system cannot work well without respect and accountability to the whole population served

by that system. Tough decisions should be made transparently, consistently, and fairly where value for money, not price, is the key. Health technologies need to be considered as *investments* and not as expenses. In order to contribute to this debate, however, we need to build the skills to conduct and interpret economic analyses appropriately in order to bring better support to decision-making in an even more constrained future.

Increasing capacity for health economics in anesthesia

Health economics is a young field and will continue to grow in demand given the shrinking resources and contracting global economies juxtaposed against increasing technology-based capabilities to diagnose and treat disease. Surveys of the anesthesia, critical care, and perioperative literature reveal that there are very few economic analyses published in our field despite increasing recognition of the need.[19,27,28] It is an opportune time for anesthesiologists and clinical leaders to become familiar with the tools and methodologies of health economics in order to facilitate decision-making. When a drug, device, or procedure comes to market in Canada, there is no guarantee that it represents good value for money compared with the next best alternative. Entry to market means only that it is marketable, not that it is worth entry. The responsibility to determine cost-effectiveness of most technologies used in the hospital setting and to make well-informed decisions falls to those who are tasked with the governance and stewardship of limited resources for unlimited demands and are using best evidence plus economics – and this pursuit should be ours.[4]

Anesthesiologists can make a difference in the wider governance of healthcare and health economics if we advance our knowledge and skills beyond the technical to address the "other" dimensions of decision-making – most notably, the economic aspects. As aptly summarized by Sir J.A. Muir Gray, Chief CIO of the United Kingdom National Health Service, "Doing things right is only half the story – it is also essential to use our limited resources most effectively by identifying and discontinuing lower value activities."[1]

Key points

- Healthcare resources are limited regardless of one's place of practice. Difficult decisions must be made regarding allocation of limited resources across unlimited demands in order to maximize gains in health per resource expenditure.
- Unmet needs and limits on healthcare resources will continue to grow as the number of innovative technologies, procedures, and programs expands the options available for diagnosis, treatment, and prevention of disease in a growing aging population.
- Physicians are essential gatekeepers in healthcare costs, utilization, and expenditure.
- Health economic analysis provides tools and techniques to assess which investments in healthcare provide good value for money *vs* which options should be forgone.
- While economics alone should not drive decision-making, evidence-informed economic analysis will be an ever-increasing component of the multiple factors required for robust decision-making.
- Anesthesiologists should embrace the opportunity to become knowledgeable in performing and interpreting health economics analysis and should take an active lead in local, regional, provincial, and global decision-making and policymaking.

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