WEP Warwick Evans Publishing

International Journal of Public Health and Medical Research

ISSN: 3006-7707 (Print), ISSN: 3006-3752 (Online)
Volume 6, Number 7, Year 2026
DOI: https://doi.org/10.62051/ijphmr.v6n7.08



Analysis on Cost-effectiveness and Budget Impact of Health Technology Assessment in Critical Care Medicine from the Global Health Perspective

Xuan Wang

Harbin Medical University, Heilongjiang, China

ABSTRACT

Critical care medicine is relatively expensive in terms of medical resources. Cost-effectiveness analysis (CEA) and its subset, cost-utility analysis (CUA), are employed in health technology assessment (HTA) to determine the economic value of intervention measures, and a separate budget impact analysis is performed to assess how the introduction of new technology will affect the budget. Both are used to make selections. This paper reviews the progress of health technology assessment (HTA) in the field of global critical care medicine, analyzes the application features of cost-effectiveness analysis (CEA) in the evaluation of ICU intervention measures, explores the methodological logic and practical value of budget impact analysis for technology access, and puts forward optimisation paths based on the actual constraints of middle-and low-income countries. A total of 219 full economic evaluation studies on ICU intervention measures have been published from 1993 to 2023. The number of publications has risen substantially in the past decade; only 1% originate from middle-and low-income countries, and 58% are model-based studies. In addition, there are many problems in the previous studies that make it difficult to draw broad conclusions. The World's critical care medicine HTA system should take both cost-effectiveness and budget impact into account and build a more flexible evaluation system for countries with different levels of resources.

KEYWORDS

Health technology assessment; Critical care medicine; Cost-effectiveness analysis (CEA); Cost-utility analysis (CUA); Budget impact analysis; Global health

1. INTRODUCTION

An intensive care unit (ICU) is required for critically ill patients in order to save their lives; it has relatively high resource consumption among all parts of the healthcare system. Based on data released by the Society of Critical Care Medicine (SCCM), the proportion of a US hospital's total costs attributed to the Intensive Care Unit (ICU) in 2010 was 13.2%, and its estimated daily cost was about $4,300 [1]. An ageing population, a higher prevalence of multiple chronic diseases and new treatment technologies, etc., have all increased demand for high-end medical services. Recently, health systems around the world have been facing the problem of balancing the quality of medical care with cost control. A system to assess the value and feasibility of new critical-care technologies systematically is required to address this problem.

Health Technology Assessment (HTA) can be used to address the above problem. The World Health Organization refers to the study of health technology as health technology assessment (HTA). It is a multi-faceted process that studies the social, economic, organisational and ethical problems in health interventions or technologies to provide supporting information for policy decisions [2]. In critical

Content from this work may be used under the terms of CC BY-NC 4.0 licence (https://creativecommons.org/licenses/by-nc/4.0/). Published by Warwick Evans Publishing.

care, Health Technology Assessment (HTA) can be applied to specific technologies, such as respiratory support devices, extracorporeal life support systems, blood purification devices, bedside diagnostic instruments and clinical decision support software; at the same time, non-device interventions, including clinical pathways and organisational management models, are also subject to HTA. The various indicators for evaluation include clinical efficacy, safety, economy and efficiency, ethics, etc., and so on. These results will offer more support for the government's promotion of new-technology development and service improvement. Cost-effectiveness analysis(CEA) determines whether a technology is economically feasible, and budget impact analysis assesses the financial pressure that new technologies place on the budget. They offer different scopes of economic reference for the decision. The National Institute for Health and Care Excellence (NICE) previously applied an End-of-Life modifier for conditions with a very short life expectancy. However, this was replaced in January 2022 by a broader Severity modifier, which allows a higher cost-effectiveness threshold for severe diseases based on the future health lost by patients.

The development of health technology assessment (HTA) in critical care medicine is uneven around the world. Nguyen and others have systematically reviewed the literature published from 1993 to 2023, and found that only 3 of the 219 studies (1%) were conducted in low-and middle-income countries [3]. The areas that lack resources are also the ones with the weakest local evidence. This article adopts a narrative review approach to clarify the conceptual boundaries and global development of HTA in critical care medicine, examine the methodological characteristics of cost-effectiveness analysis (CEA) and budget impact analysis, and explore their integration pathways and future directions. Unlike systematic reviews that synthesize evidence on specific interventions, narrative reviews are better suited to outlining theoretical frameworks and research trends in emerging fields and formulating analytical judgments based on existing evidence.

2. THE CONCEPTUAL FRAMEWORK AND GLOBAL DEVELOPMENT OF HEALTH TECHNOLOGY ASSESSMENT (HTA) IN CRITICAL CARE MEDICINE

First, the conceptual boundaries and development history of health technology assessment (HTA) in the field of critical care medicine need to be clarified. There are many kinds of technologies in use for intensive care medicine. Ventilators, monitoring equipment and blood purification devices are classified as large medical equipment; bedside ultrasound and rapid pathogen detection fall under diagnostic technologies; sedation and analgesia protocols, early goal-directed therapy and sepsis bundle therapy are grouped as clinical pathways and organisational management models. Different kinds of technology have different evaluation indicators and emphases for HTA. Equipment-based technologies mainly focus on safety and cost-effectiveness; diagnostic technologies need to consider how the accuracy of diagnosis will affect the path of clinical decision-making, and management-based technologies need to coordinate the implementation of cost and system integration effects [4].

Since the 1980s, Health Technology Assessment (HTA) has been gradually introduced in many developed countries. The UK's NICE began operating in 1999; the Canadian CCOHTA was set up in 1989, and the Australian MSAC started in 1998. The World Health Organization (WHO) has carried out all-country surveys of health technology assessment (HTA) processes in its Member States to monitor the development of HTA capacity. In recent years, China has gradually given more attention to HTA. The Basic Healthcare and Health Promotion Law of the People's Republic of China (Article 44) advocates for and supports healthcare institutions in using suitable technologies and equipment. Although some domestic studies have examined hospital-based HTA practices, the amount of evidence for systematic evaluation in critical care medicine, which is highly technology-intensive, is still relatively small.

The development of health technology assessment (HTA) for critical care medicine is also uneven around the world. High-income countries have accumulated over several decades and built relatively mature HTA systems. Middle-and low-income countries are still lacking in the areas of evaluation institutions, professionals and local methodological guidelines. One of the reasons for the difference in capability is that these technologies are not universally accessible [5]. Some technologies with application prospects in middle-and lower-income countries have not received resource allocation because there is no local economic assessment data. Therefore, some cost-effective and suitable technologies have been excluded from the choice [6].

3. APPLICATION AND EVIDENCE OF COST-EFFECTIVENESS ANALYSIS AND COST-UTILITY ANALYSIS IN THE EVALUATION OF INTENSIVE CARE MEDICINE INTERVENTIONS

Cost-effectiveness analysis (CEA) and its subset—cost-utility analysis (CUA)—are the most widely used methods in health technology assessment (HTA) for critical care medicine. CEA compares the costs and health outcomes of alternative interventions, with results expressed as the incremental cost-effectiveness ratio (ICER). Health outcomes may be measured in terms of lives saved, life years gained, or quality-adjusted life years (QALYs). As shown above, the six academic databases were systematically reviewed for studies published from 1993 to 2023, and a total of 219 full economic evaluations of interventions in the ICU were included. Among them, 97% of the studies achieved a "good" or "excellent" level of reporting completeness in accordance with the CHEERS reporting guidelines [3].

The range of ICER values is relatively large, and some are as high as 753,874 per life saved. This difference is not because of a fault in the method, but rather due to the high variability of ICU patients and all sorts of interventions. Preventive strategies and quality improvement interventions are generally more economically feasible; the value of drug treatment and life-support technology is more uncertain and depends on factors such as patient selection, time of initiation and baseline risk.

Although the methods of cost-effectiveness analysis(CEA) have been improving gradually, many problems still exist in their application to critical care medicine today. The severity of the condition and other diseases in the ICU patients vary greatly, and the same intervention may have different cost-effectiveness in different cases of septic shock and routine postoperative observation. The typical average effect often fails to reflect the different degrees to which various subgroups are affected and may therefore be misleading [7]. The health benefits of different critical-care interventions cannot be fully expressed in terms of QALYs. There are basic methodological problems in the assessment of QALYs for critically ill patients because they may be under sedation or unconscious at the time of evaluation. Furthermore, the results of externalities, such as the sense of psychological comfort for family members, are not covered by the scope of QALYs and have significant societal value. Cost accounting for the ICU is also relatively difficult, and equipment depreciation, staff costs, complex management, readmissions, and long-term care are all involved. Different studies use different cost measurements and are thus not directly comparable [8]. The quality assessment will cover the completeness of the report but has not set specific standards for the method.

Production of cost-effectiveness evidence around the world is unevenly distributed geographically. Only 3 out of 219 studies originated in low-and middle-income countries. The ICU resources and disease structures in these areas are different from those in high-income countries; therefore, the conclusions from the latter should not be applied to patients in low-and middle-income countries without modification. If cost-effectiveness analysis(CEA) is not tailored to the actual conditions of the health system, the results will not be feasible for decision-making.

4. METHODOLOGICAL LOGIC OF BUDGET IMPACT ANALYSIS AND ITS APPLICATION IN CRITICAL CARE MEDICINE

Cost-effectiveness analysis(CEA) determines whether a technology is economically feasible to implement, and budget impact analysis assesses the financial capacity of the healthcare system for short-term investment. The analyses are also not the same. The selection of an analytical perspective in cost-effectiveness analysis(CEA) directly affects the range of cost estimation. The social perspective includes indirect costs, while the healthcare payer's view only considers direct medical expenses. The time horizon is generally extended to consider the whole of the efficiency more broadly. At the same time, the budget impact analysis names specific budget holders, such as healthcare insurance funds, hospital finance departments and government health accounts, and assesses the net financial effect of new technologies over the next 1-5 years after their introduction [9].

At the bottom of the budget impact analysis is a comparison model. At the heart of Budget Impact Analysis (BIA) is a comparative model that estimates the net financial effect of introducing a new technology on a budget holder (such as a health insurance fund or hospital) over a certain period of time, typically 1-5 years, based on the size of the target patient population and the expected market adoption rate of the technology. At this time, all relevant direct costs of the new technology (such as equipment and consumables) and indirect costs (such as personnel training and infrastructure changes) should be collected, as well as potential offsets from reduced healthcare expenses due to improved clinical outcomes. Critical Care Medicine is also in the same boat. The unit price of ICU technology is relatively high, and with the addition of large-scale equipment and daily-use new diagnostic tools, the annual budget will face considerable pressure. Even if a technology is economically feasible in terms of cost-effectiveness, if the initial investment exceeds the payment capacity of the budget holder, it will be difficult to introduce [10, 11].

Recently, studies on BIA in critical care medicine have begun to accumulate at an increasing rate. Some research has examined the effect of new intensive care unit technology on hospital finances by comparing procurement costs, personnel training expenses, and operation and maintenance costs with expected savings in hospital stay and complication treatment expenses. For example, a budget impact analysis of procalcitonin-guided antibiotic stewardship in Belgian ICUs found that the base-case investment was €1.90 per patient, while scenario analysis indicated potential savings of €1,405 per patient, driven by reductions in ICU length of stay (from 14.8 to 12.8 days) and mechanical ventilation duration (a reduction of 22.7%) [12]. However, the generalizability of these findings across different healthcare systems and ICU settings remains to be confirmed. The results of such studies differ significantly because the technical types and hospital sizes are not uniform. The evaluation results of BIA vary by application context, and the budget implications for the same technology in a large tertiary hospital and a grassroots ICU are likely to be very different.

BIA still has some methodological deficiencies in critical care medicine. The length of hospitalisation and resource consumption for ICU patients differ greatly, so the model is highly sensitive to changes in the admission rate, number of days in hospital, complication rate, etc. Small Changes may change the results. BIA usually only considers the perspective of a single budget holder, and the influence of hospital finance, medical insurance and patient self-payment levels are often inconsistent; therefore, decision-makers need multi-faceted information rather than a single number [13].

5. INTEGRATION PATH OF COST-EFFECTIVENESS ANALYSIS (CEA) AND BUDGET IMPACT ANALYSIS

Due to the above conflict, a path for the integration of the two will need to be explored. Cost-effectiveness analysis (CEA) and budget impact analysis are not in opposition to one another but work together. The former assesses the connection among the health advantages that can be realised

by a technology and the resources required to obtain these benefits, and chooses an analytical perspective according to the decision-making context, such as the societal, healthcare payer or healthcare system perspective. The latter determines the affordability and financial consequences for a particular budget holder over a certain period. Together, the two provide complete economic support for decision-making and are not fragmented into separate figures that are disconnected or even contradictory [14].

It is not a problem of time. CEA generally extends the observation period to monitor the long-term health benefits and cost reductions of the intervention; BIA, on the other hand, focuses on the direct budget changes in the few years after introducing new technology. The timeframes of the two analyses are not the same, so the results cannot be directly combined or compared. A feasible way is to do so in stages: first, use the results of CEA as a threshold to screen out technologies that do not have cost-effectiveness advantages, and those without are not included in the next consideration; then, carry out a BIA assessment for the selected technologies and formulate a phased, population-based, and region-based introduction plan according to the scale of budget impact and affordability. CEA sets the value range for the technology, and BIA determines the implementation speed.

Hospital health technology assessment provides a reference for integration. HB-HTA is not a top-down type like the previous HTA; instead, it is based on the hospital management context and frequently employs both cost-effectiveness analysis(CEA) and budget impact analysis to explore how current medical costs and clinical results align [15]. In light of the DRG payment reform, HB-HTA can provide a reference for hospital resource allocation optimisation by comparing the costs and effects of different technologies for the same diseases. Intensive Care Technology is suitable for the above way. Admission of ICU technology is often decided at the hospital level, and due to a short decision cycle, it is sensitive to budget changes. The analysis mode of HB-HTA is the same as that for this case.

The combination of the two analyses varies by country and income level. High-income countries have relatively mature HTA systems, and currently, efforts are being made to refine the weight allocation of the two analyses within a multi-criteria decision-making framework. The tasks in low-and middle-income countries are relatively straightforward: build local cost data, train HTA professionals, and develop methodological guidelines that are suitable for their own resource conditions. In recent years, the World Health Organization has promoted the construction of Health Technology Assessment (HTA) capabilities in low-and middle-income countries by issuing guidelines for medical equipment HTA and organising training programs. Critical care medicine is relatively high-tech and expensive. General support measures are not sufficient; targeted efforts should also be made to strengthen international cooperation and resource investment [16].

6. CHALLENGES AND PROSPECTS FROM A GLOBAL HEALTH PERSPECTIVE

Based on the above analysis, HTA in critical care medicine has achieved some results in terms of theory and practice. However, there are still four problems in global health at present.

The Area of evidence production is not even. Among the 219 ICU economic analyses, only 1% were performed in low-and middle-income countries. The reason for the lower number of studies is not only a lack of research capacity but also, to a certain extent, the existing distribution of discursive power in global health governance over technology assessment [17]. Therefore, it is necessary for international organizations, research institutes in high-income and low-and middle-income countries, etc., to cooperate more closely. Provide funds for the local study and, in cooperation with other parties, promote capacity building. They should not always let outside scholars lead the data collection.

There are no standardised methodologies at the same time. Based on the CHEERS checklist, the first set of research shows significant heterogeneity among the studies conducted. How to calculate the

cost, what tools to use for measuring health outcomes, what discount rate to set, and how to conduct sensitivity analysis—the approaches of all the studies were inconsistent. The above differences directly affected the comparability of the results, and meta-analysis could not be carried out.

Another problem is that the weight of disease severity. According to the research of the GRACE framework, the traditional QALY calculation method may be unfair to seriously ill patients, and thus underestimates the social value of saving their lives [18,19]. A budget impact analysis of 69 drugs showed that under the GRACE framework, value-based prices for severe diseases increased while those for mild diseases decreased. Compared with conventional CEA, overall medical expenditure under GRACE increased from $444.5 billion to $453.4 billion (an increase of approximately 2%), which is approximately budget-neutral overall [20]. The study suggests that GRACE provides an alternative to CEA that complies with US federal prohibitions on discriminatory cost-effectiveness methods, without sacrificing the overall cost-efficiency gains of traditional CEA [20]. Based on the above findings, incorporating disease severity into value assessment may not substantially increase overall budget pressure on the health system; rather, it may help redirect resources toward interventions with higher estimated value.

Currently, 58% of the economic assessments are model-based. Although such studies have provided some preliminary evidence in the early stages, a lack of clinical trials and real-world data has been observed; therefore, there is a methodological discrepancy between model construction and empirical research. A model is convenient for the initial screening; however, the accuracy of this determination depends on how well the model was built and what data were used. Electronic health records are spreading more widely, and clinical big data is also accumulating. The conditions for using real data in the economic analysis of critical care are gradually being met, and this may be a necessary change in method in the coming decade.

The end of critical care HTA is to optimise health outcomes for a given budget, not merely to reduce costs [21]. It should be a filtering criterion that also guides clinical application, specifying how to use approved technologies more effectively, which patients will be helped, and how to improve management for an enhanced value of the ICU system.

7. CONCLUSION

The goal of health technology assessment (HTA) in critical care is to help doctors and administrators make good choices in a resource-limited setting, not just to reduce costs. Academic research on cost-effectiveness analysis(CEA) has accumulated to a certain extent; however, attention has not yet been paid to budget impact analysis in the field of critical care medicine.

Globally, the evidence-based practice of health technology assessment (HTA) in critical care medicine is concentrated in high-income countries, and almost no coverage exists in middle-and low-income countries. The Distance in technical accessibility also refers to the feasibility of the research methods themselves. The conclusions reached based on a specific disease spectrum and resource conditions may not be applicable to all places and times.

There are still some places in this paper that have not been fully discussed. For example, specific applications of cost-effectiveness analysis(CEA) and budget impact analysis for all kinds of ICU technologies are outside the scope of this review, and therefore were not further classified or discussed. Obstacles to the adoption and promotion of the GRACE framework in actual decision-making also need to be studied empirically.

Therefore, the following directions are recommended for further study. We need to promote joint reporting of CEA and BIA in critical care to avoid dividing the responsibility for value judgement and finances. For low-and middle-income countries, localised economic assessments need to be carried out, and gradually, method guides and cost databases suitable for various resource levels can

be established. More fully use real-world data to offset the uncertainty in parameter assumptions of the model in research.

The Aim of Health Technology Assessment (HTA) in critical care is not to build a technical entry barrier, but to assist clinicians and managers in making rational decisions under resource constraints. Therefore, evaluation instruments need to be continuously improved in practice, and more effective communication among countries at different stages of development should be established.

REFERENCES

[1] Society of Critical Care Medicine. (2024). Critical care statistics. https://www.sccm.org/Communications/Critical-Care-Statistics

[2] O'Rourke, B., Oortwijn, W., & Schuller, T. (2020). The new definition of health technology assessment. International Journal of Technology Assessment in Health Care, 36(3), 187–190.

[3] Higgins, A. M., Carney, T. M., Carrandi, A., Nguyen, C.-L., Tse, W. C., & Fagery, M. (2025). Health economic evaluations in intensive care: An updated systematic review. Critical Care Explorations, 7(7), e1288.

[4] Henschke, C., Panteli, D., Perleth, M., & Busse, R. (2015). Taxonomy of medical devices in the logic of health technology assessment. International Journal of Technology Assessment in Health Care, 31(5), 324–330.

[5] Guzman, J., Fan, V. Y., & Baker, P. (2023). The future of health technology assessment in low-and middle-income countries. Health Systems & Reform, 9(3), 2400399.

[6] Falkowski, A., Ciminata, G., Manca, F., Bouttell, J., Jaiswal, N., Kamaruzaman, H. F., & Grieve, E. (2023). How least developed to lower-middle income countries use health technology assessment: A scoping review. Pathogens and Global Health, 117(2), 104–119.

[7] Shields, G. E., Wilberforce, M., Clarkson, P., Farragher, T., Verma, A., & Davies, L. M. (2022). Factors limiting subgroup analysis in cost-effectiveness analysis and a call for transparency. Pharmacoeconomics, 40(2), 149–156.

[8] Chacko, B., Ramakrishnan, N., & Peter, J. V. (2023). Approach to intensive care costing and provision of cost-effective care. Indian Journal of Critical Care Medicine, 27(12), 876.

[9] Sullivan, S. D., Mauskopf, J. A., Augustovski, F., Caro, J. J., Lee, K. M., & Minchin, M. (2014). Budget impact analysis—principles of good practice: Report of the ISPOR 2012 Budget Impact Analysis Good Practice II Task Force. Value in Health, 17(1), 5–14.

[10] Foroutan, N., Tarride, J. E., Xie, F., & Levine, M. (2018). A methodological review of national and transnational pharmaceutical budget impact analysis guidelines. ClinicoEconomics and Outcomes Research, 821–854.

[11] Mauskopf, J. A., Sullivan, S. D., Annemans, L., Caro, J., & Mullins, C. D. (2007). Principles of good practice for budget impact analysis: Report of the ISPOR Task Force on good research practices. Value in Health, 10(5), 336–347.

[12] Garnfeldt, V. M., Vincent, J. L., Gruson, D., Garay, O. U., Vansieleghem, S., Iniguez, L., & Lefevre, A. (2023). The budget impact of procalcitonin-guided antibiotic stewardship compared to standard of care for patients with suspected sepsis admitted to the intensive care unit. PLOS One, 18(10), e0293544.

[13] Drummond, M. F., Sculpher, M. J., Claxton, K., Stoddart, G. L., & Torrance, G. W. (2015). Methods for the economic evaluation of health care programmes. Oxford University Press.

[14] Kleijnen, S., Toenders, W., de Groot, F., Huic, M., George, E., & Wieseler, B. (2015). European collaboration on relative effectiveness assessments: What is needed to be successful? Health Policy, 119(5), 569–576.

[15] Demirdjian, G. (2015). A 10-year hospital-based health technology assessment program in a public hospital. International Journal of Technology Assessment in Health Care, 31(1–2), 103–110.

[16] World Health Organization. (2025). Health technology assessment of medical devices. World Health Organization.

[17] Munung, N. S., Mayosi, B. M., & de Vries, J. (2017). Equity in international health research collaborations in Africa. PLOS One, 12(10), e0186237.

[18] Lakdawalla, D. N., & Phelps, C. E. (2022). A guide to extending and implementing generalized risk-adjusted cost-effectiveness (GRACE). The European Journal of Health Economics, 23(3), 433–451.

[19] Sanders, G. D., Neumann, P. J., Basu, A., Brock, D. W., & Feeny, D. (2016). Recommendations for conduct, methodological practices, and reporting of cost-effectiveness analyses: Second panel on cost-effectiveness in health and medicine. JAMA, 316(10), 1093–1103.

[20] Mulligan, K., Baid, D., Manetas, M. A., & Lakdawalla, D. N. (2025). Measuring the budget impact of nondiscriminatory cost-effectiveness. In JAMA Health Forum (Vol. 6, No. 9, pp. e253076–e253076). American Medical Association.

[21] Higgins, A. M., Brooker, J. E., Mackie, M., Cooper, D. J., & Harris, A. H. (2020). Health economic evaluations of sepsis interventions in critically ill adult patients: A systematic review. Journal of Intensive Care, 8(1), 5.