Decision Rules in Cost-effectiveness/Cost-utility Analysis of Healthcare Programs

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Abstract

The objectives of this study were: 1) to identify alternative decision rules of threshold incremental cost-effectiveness ratio (ICER) used in cost-effectiveness/cost-utility analysis of healthcare programs and 2) to compare advantages and disadvantages of those alternatives with the threshold ICER.

The research methods used were described as follows. Literatures were reviewed to identify alternative decision rules. Their advantages and disadvantages were compared with the threshold ICER including both theoretical and considerations. Experiences from countries with publicly-funded healthcare system were reviewed. Secondary data were used to compare performances of those decision rules.

Major findings were presented as follows. 1) Alternative to the threshold ICER, the decision making (DM) plan should be applied under fixed budget. The modified league table should be applied under the situation where budget expansion was possible. Information from ICER was still useful and should be included in the league table. ICER was more informative as a part of league table than compared with the threshold ICER. 2) The threshold ICER had shortcomings compared to other alternatives. Current application of the threshold ICER potentially led to uncertain situations. The threshold approach could be misleading and might not ensure economic efficiency. Finally, a new framework was constructed in which policymakers must recognize their budget situation before making decision.

Keywords: Decision rule, Incremental cost-effectiveness ratio, Cost-effectiveness analysis, Cost-utility analysis

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CHAPTER I
INTRODUCTION

1. Rationale and Justification

After the Universal Healthcare Coverage (UHC) policy was fully implemented in 2002, Thailand's healthcare system has been financed mainly via public funding (Bureau of Policy and Strategy, 2009; Tangcharoensathien et al., 2010). Recent data from the World Bank showed that public funding accounts for 80.1% of total health expenditure in Thailand (The World Bank, 2015). Public funding sources primarily consist of general government health expenditures and social health insurance (Tangcharoensathien et al., 2010). Three major public health insurances include Universal Coverage Scheme (UCS), Civil Servant Medical Benefit Scheme (CSMBS), and Social Security Scheme (SSS). This substantial contribution of the government means that the healthcare market is not a conventional competitive market; one shortcoming is the lack of information about market prices of healthcare programs. This warrants the need of economic evaluation of healthcare programs (also called health technologies) to support decision making regarding the inclusion of certain packages in the public schemes.

There are three major types of economic evaluation (EE) in healthcare: cost-benefit analysis (CBA), cost-utility analysis (CUA), and cost-effectiveness analysis (CEA). CEA and CUA are popular methods used in the health technology assessment (HTA). CEA and CUA assess a price per a unit of health outcome. In CEA, health outcomes are measured in common units, e.g., life year gained, number of new cases avoided, length of hospital stay. In CUA, generic outcomes—i.e., a single measure that incorporates both quantity and quality of life—are employed. Examples of generic outcomes include quality-adjusted life year (QALY), disability-adjusted life year (DALY), and healthy year equivalent (HYE). Because of difficulties in assigning monetary value to health outcomes, CBA is less applied technique in EE of healthcare. (Drummond, Sculpher, Torrance, O'Brien, & Stoddart, 2005).

Conventionally, to be considered as cost-effective in the context of CEA/CUA, a healthcare program has to have its incremental cost per one unit of its incremental effectiveness/utility (compared with referent program) less than a particular value—critical ratio. A ratio of an incremental cost to an incremental effectiveness/utility is referred to as an incremental cost-effectiveness ratio (ICER). The critical ICER value, which defines cost-effectiveness of a health program, is called a threshold ICER. This threshold ICER is a decision rule commonly used in CEA/CUA. Figure 1.1 shows a relationship between types of EE and corresponding decision rules.

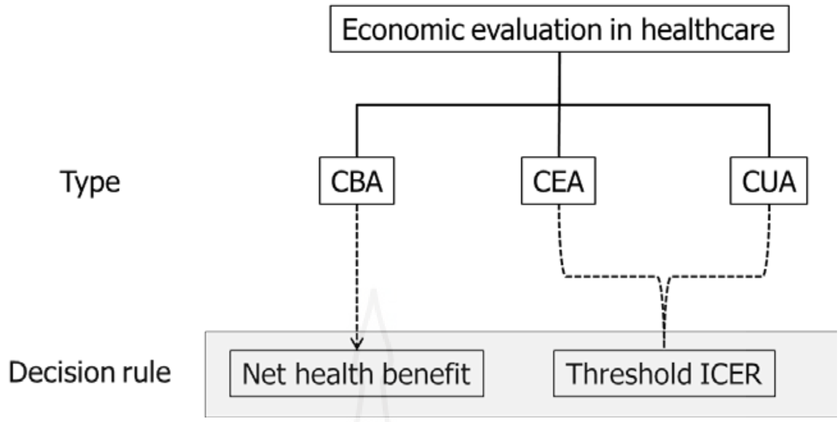

Figure 1.1. Economic evaluation in healthcare and corresponding decision rules.

Note. CBA = cost-benefit analysis; CEA = cost-effectiveness analysis; CUA = cost-utility analysis; ICER = incremental cost-effectiveness ratio.

The idea of the threshold ICER was proposed by Weinstein and Zeckhauser (M. Weinstein & Zeckhauser, 1973). Originally, a threshold ICER is established by ranking all relevant programs by their ICERs in ascending order; those programs were then selected for adoption from the first in the list (one with the lowest ICER) until all resources are used up. *The ICER of the last program selected which uses up all the remaining resources is a threshold ICER.* This method of identifying a threshold ICER is called a 'league table' approach. In practice, however, individual rather than all relevant programs are evaluated; hence, a threshold ICER is not actually identified from the league table, but being arbitrarily set. For example, the widely-used $50,000-per-QALY threshold in literatures from US is not backed by any evidence, but rather being employed because it is a convenient figure (Neumann, Cohen, & Weinstein, 2014).

Accordingly, validity of employing threshold ICER as a decision rule was questioned. Arguments against the use of threshold ICER includes ignorance of opportunity costs, unrealistic assumptions of constant return to scale and perfect divisibility, and its inconsistencies with welfare economics (Birch & Gafni, 1992; Pedram Sendi, Gafni, & Birch, 2005). Furthermore, the application of threshold ICER is suspected to cause a sharp rise in healthcare expenditures without ensuring maximized health benefits for the society (Gafni & Birch, 2006).

In Thailand, health policymakers have also employed the threshold ICER as one of decision making criteria for adoption of health technologies as evident in the Universal Health Coverage Benefit of Thailand website (International Health Policy Program & Health Intervention and Technology Assessment Program). This usage of threshold ICER might partly explain an increase in Thailand's healthcare expenditure. An increase in Thailand's total health expenditure (THE) per capita during 2000–2012 is shown in Figure 1.2. In a monetary term, the per capita expenditure increased from 2,701 Thai baht (THB) in 2000 to 7,949 THB in 2012; as a proportion of gross domestic product (GDP), it increased from 3.5% in 2000 to 4.5% in 2012.

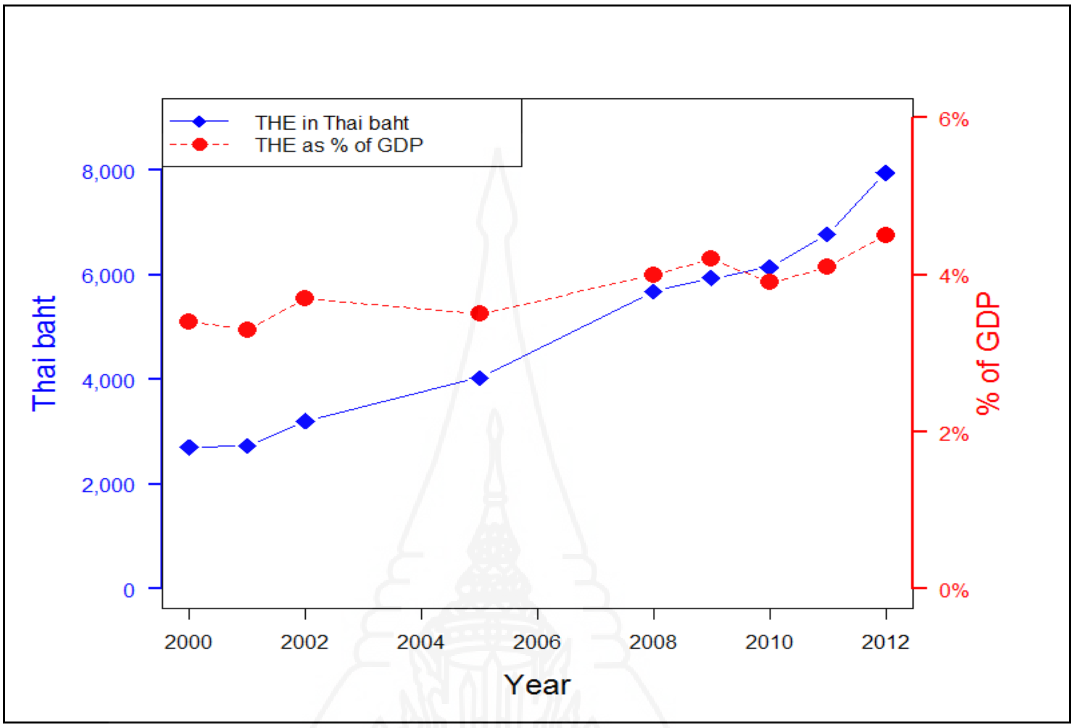

Figure 1.2 Thailand's per capita total health expenditure (THE) from 2000 to 2012.

Source: The Kingdom of Thailand Health System Review (Jongudomsuk et al., 2015)

Accordingly, the adoption of threshold ICER should be scrutinized. Decision rules other than the threshold ICER should be identified. Alternative decision rules might offer policymakers better approaches for assessing healthcare programs and help overcoming its disadvantages.

2. Research Questions

2.1 What are alternative decision rules in an evaluation of healthcare programs other than the threshold ICER?

2.2 What are advantages and disadvantages of alternative decision rules in comparison with the threshold ICER?

3. Research Objectives

3.1 To identify alternative decision rules in an evaluation of healthcare programs other than the threshold ICER.

3.2 To compare advantages and disadvantages of alternative decision rules with those of the threshold ICER.

4. Research Hypothesis

Other decision rules (i.e., league table, decision making plane, program budgeting and marginal analysis, and integer programming) are more favorable than the threshold ICER.

5. Scope of the Study

5.1 To review theoretical concepts underpinning these decision rules—league table, decision making plane, program budgeting and marginal analysis, and integer programming—as well as their applications in resource allocation in comparison with the threshold ICER.

5.2 To review experiences from Thailand, the United Kingdom (UK), and New Zealand—where healthcare is primarily funded by government—in applying EE to resource allocation in the healthcare sector

6. Operational Definitions

6.1 Quality-adjusted life year (QALY): a measurement of health gain (life year) adjusted for quality of life of that health gain. One QALY is equal to one year with perfect health state.

6.2 Disability-adjusted life year (DALY): a measurement of health loss that incorporates a loss in quantity of life (life expectancy less age at death) and a loss in quality of life due to disability. One DALY is equal to a loss of one year with perfect health.

6.3 Heathy year equivalent (HYE): a measurement of health gain founded on the same principle as QALY but using the different estimating method.

6.4 Cost-effectiveness analysis (CEA): a method for economic evaluation of healthcare program using common health outcomes (effectiveness) as an outcome measurement.

6.5 Cost-utility analysis (CUA): a method for economic evaluation of healthcare program using generic health outcomes (often referred to as 'utility')—i.e., a measurement that incorporate both quantity and quality of life as such as QALY, DALY, and HYE—as an outcome measurement.

6.6 League table: a method to identify cost-effective programs by constructing a table consists of relevant programs ranked by their ICER in ascending order.

6.7 Decision making plane: a method to identify cost-effective programs by comparing benefits of the program of interest with opportunity cost of displaced program(s). It is originally introduced in a plane named by its proponents as the decision making plane.

6.8 Program budgeting and marginal analysis: a two-step method to identify cost-effective programs. Results from program budgeting are subject to the marginal analysis.

6.9 Integer programming: a well-known optimization technique being proposed as a solution for identifying cost-effective programs.

6.10 Budget impact: total revenue consumed by a program or project for a certain time period.

7. The Benefit of this study

To offer policymakers alternative decision rules in an evaluation of healthcare programs which might overcome disadvantages of the currently-used decision rule—threshold ICER.

CHAPTER II
LITERATURE REVIEW

1. Origin of threshold ICER

In an article published in 1973, Weinstein and Zeckhauser proposed the use of a critical ratio for allocating resources (M. Weinstein & Zeckhauser, 1973). Under a situation with limited resources, an efficient allocation of resources can be thought of as a constrained optimization problem. The problem is written in a mathematic form as follows:

$$maximize\ B = \sum_{i=1}^{n} a_i b_i$$

$$s.t. \sum_{i=1}^{n} a_i c_i \leq C$$

$$and\ 0 \leq a_i \leq 1$$

where *B* is a total benefit. *C* is a total resource available. b_i is a benefit from carrying out program *i*. c_i is resources consumed by program *i*. According to Weinstein and Zeckhauser, the solution to this problem involves calculating the critical ratio (λ)—equivalent to benefit-cost ratio (BCR) used in CBA. The value of a_i is 1 when $b_i/c_i > \lambda$; $a_i = 0$ when $b_i/c_i < \lambda$; and $a_i = \pi$ when $b_i/c_i = \lambda$. π is chosen so that resource is just exhausted—i.e., total resources used is equal to *C*.

In the context of project selection, the application of the critical ratio can be illustrated by the following example. Suppose there are five projects—A, B, C, D, and E—waiting for government's decisions on whether any of these projects will be funded. The government currently has 100 units of resources available. Benefits from and levels of resource required for implementing each project are presented in Table 2.1

Table 2.1 Levels of benefits and resources associated with implementations of program A, B, C, D, E (league table).

Project	Benefit (B_i)	Resource required (C_i)	B_i/C_i
A	45	30	1.5
B	45	15	3
C	30	20	1.5
D	120	50	2.4
E	90	45	2

The last column of Table 2.1 shows a ratio between benefit and resource associated with each program. The ratio represents an average level of benefit gained from investing one unit of resource on a particular project. The higher ratio means the higher gain per unit of resource consumed, hence, is preferred to the lower one. Based on the information from Table 2.1, the government has decided to invest in B and D, the first two projects with highest ratios. The government is then left with 35 units of resource and three alternatives—A, C, and E.

E is a project with highest ratio among the rest. However, it is impossible for the government to fully invest in E as the project requires 45 units of resource but only 35 units of resource are available. Nevertheless, E might still be the best alternative if the benefit-cost ratio of E is constant at the value of 2 when the project is partially implemented: investing 35 units of resource on E results in 70 units of benefit in return. For this to be valid, two assumptions must be met: perfect divisibility and constant return to scale. Perfect divisibility means that project E can be implemented at any size (e.g., one can invest one or even smaller than one unit of resource to achieve project E and get some return). The constant return to scale means that the return per one unit of resource invested on project E is constant regardless of the size of project; in this case, the ratio between benefit and resource required is constant and equal to 2.

The critical ratio is hence equal to the ratio between benefit and resource of the last program (a program with the lowest ratio) being funded. A project with its ratio lower than the critical ratio will not be implemented. This approach of identifying a critical ratio is also known as a 'league table' approach (Table 2.1). Note that this approach is based on two strong assumptions—perfect divisibility and constant return to scale.

For resource allocation in the healthcare sector, the widely-used ratio is a multiplicative inverse of the benefit-cost ratio demonstrated earlier—a ratio of cost to health gain from a healthcare program (M. C. Weinstein & Stason, 1977). A cost of resources consumed by the healthcare program is in a monetary unit. Health gain from the program can be expressed in either common units of health—such as mortality, life year gained, and number of new cases—or generic outcomes—such as quality-adjusted life year (QALY), disability-adjusted life year (DALY), and healthy year equivalent (HYE) (Drummond et al., 2005). Healthcare programs are commonly assessed in comparison with the current practice (status quo); both cost and health gain are expressed in an incremental manner (Drummond et al., 2005; M. C. Weinstein & Stason, 1977) as follows.

$$ICER = \frac{C_i - C_0}{E_i - E_0}$$

where ICER = incremental cost-effectiveness ratio

C_i = Cost of program i

C_0 = Cost of benchmark scenario

(status quo or another alternative program)

E_i = Effectiveness of program i

E_0 = Effectiveness of benchmark scenario.

The ratio is referred to as an incremental cost-effectiveness ratio (ICER). It can be interpreted as the price per an additional unit of health gain from the program. The lower ICER represents a better value of the healthcare program: a payer purchases a unit of health gain with a lower price. The threshold ICER is an equivalent version of the critical ratio formerly described. A healthcare program with an ICER higher than the threshold ICER should not be funded.

2. Applications of threshold ICER

Healthcare market inherently differs from a perfectly competitive market model in many aspects. Main reasons include uncertainties in demand, high degree of information asymmetry between consumers (patients) and providers, and limited supply of providers (especially licensed doctors) (Arrow, 1963). Therefore, governments in many countries including Thailand have intervened to ensure efficiency and equity in the healthcare market (Morris, Devlin, & Parkin, 2007; Tangcharoensathien et al., 2010). Governments become the biggest player—as third party payers and/or main providers—in the healthcare market. With this substantial contribution from the government, market information (especially market prices) of healthcare is lacking. Hence, to guide whether or not a particular healthcare program provides good value for tax-payers' money, the government needs the information from EE of that healthcare program (frequently referred to as HTA).

EE is a simultaneous assessment of cost (resource usage) and outcomes (benefits) of a healthcare program with respect to a benchmark scenario (a current program, an alternative program, or no program). Major types of EE in healthcare include cost-benefit analysis (CBA), cost-utility analysis (CUA), and cost-effectiveness analysis (CEA) (Drummond et al., 2005). Specifically in CUA and CEA, the threshold ICER is employed as a decision rule to indicate whether the program in question is cost-effective. ICER of the healthcare program is compared to the threshold ICER. In the strict sense, only healthcare programs with ICER equal or lower than the threshold are considered cost-effective.

Examples of government agencies that prepare this information for policymakers are the National Institute of Health and Care Excellence (NICE) in UK (Earnshaw & Lewis, 2008) and the Health Intervention and Technology Assessment Program (HITAP) in Thailand (Mohara et al., 2012). NICE implements two effective thresholds £20,000 and £30,000. A health technology with ICER lower than £20,000 is usually classified as cost-effective; those with ICER between £20,000 and £30,000 are subject to additional considerations such as degree of certainty, innovative nature of the technology, and impacts on non-health objectives. With ICER higher than £30,000, the health technology is subject to more intensive considerations—having a higher chance to be classified as not cost-effective (Earnshaw & Lewis, 2008). In Thailand, the current threshold used by HITAP is 1–1.2 times one per-capita GDP per QALY that is equal to 120,000–160,000 Thai baht (THB) per QALY (Teerawattananon, Tritasavit, Suchonwanich, & Kingkaew, 2014). The World Health Organization (WHO) recommends the use of three times per-capita GDP per one DALY averted as an appropriate threshold (World Health Organization, 2001). This was based on annual productivity of individual in his/her heathy year. *It is worth noting that threshold ICERs used in practice are not identified from the league table as originally proposed by Weinstein and Zeckhauser, but is exogenously, and likely, arbitrarily set.*

A recent CUA conducted by HITAP provides an example of EE and threshold ICER application in decision making process in Thailand. The study aimed to assess cost-utility of six strategies of flu vaccination in school-age children (Meeyai et al., 2013). These strategies varied in types of vaccine used and age range of the target children. Cost and utility of each strategy were compared with a no-vaccination scenario. The CUA result is presented in Table 2.2; the result was based on 40,000 simulated samples.

Table 2.2 CUA result of six flu vaccination strategies in school-age children in Thailand (based on 40,000 simulated samples).

Strategy	Incremental cost* (million THB)	DALYs averted* (years)	ICER (THB/DALY averted)
Strategy 1	5,775	331,817	17,403
Strategy 2	7,140	352,757	20,239
Strategy 3	9,330	376,534	24,780
Strategy 4	3,914	313,945	12,468
Strategy 5	3,138	274,372	11,438
Strategy 6	2,090	302,136	6,918

Note. THB = Thai baht; DALY = disability-adjusted life year; ICER = incremental cost-effectiveness ratio.
*For the referent scenario (no vaccination), total cost is 157.2 million baht and total DALY is 453,340 years.

This study employed the threshold of 120,000 THB/DALY averted—i.e., one per capita GDP per DALY averted at the time the study conducted. Applying this threshold made all strategies cost-effective (ICERs of all strategies were lower than the threshold). Strategy 6 provided best value for money, requiring smallest budget for a DALY averted. Strategy 3 yielded the greatest total DALYs averted with the largest incremental cost.

3. Criticisms of threshold ICER

The application of threshold ICER described above was questioned. Obvious arguments were that the concept of ICER, as described earlier, relies heavily on two strong assumptions: perfect divisibility and constant return to scale. These two assumptions were regarded as unrealistic by some authors (Birch & Gafni, 1992; Gafni & Birch, 2006). For demonstrating the first point, suppose a new lung cancer treatment requires an investment in a novel machine that has capacity to treat 500 cases per year. The hospital has, on average, 100 lung cancer cases per year. It is impossible for the hospital to purchase only one-fifth of the whole machine in order to use only one-fifth of its capacity. This situation is not uncommon in healthcare sector. Hence, the assumption of perfect divisibility is somewhat impractical.

On the latter point, constant return to scale implies constant marginal return (benefit) as well as marginal cost for an additional unit of treatment. Whereas, economists usually assume diminishing marginal return—as reflected in the downward-slope demand curve—and increasing marginal cost—as reflected in the upward-slope supply curve. Therefore, ICER, which is basically marginal cost divided by marginal return, should increase with size of the project rather than being constant. There is no good explanation why healthcare should differ from other goods in this aspect.

The other argument against the threshold ICER is related to its application in CUA and CEA. When the usage of a critical ratio in resource allocation was first introduced, the league table approach was used to identify the critical ratio. Basically, a league table consists of possible alternatives that potentially consume the limited pool of resources. Projects are chosen based on their benefit-cost ratios, which is equivalent to the ICER approach, until that pool of resources just exhausted—sizes of projects are considered at this step. This league table approach hence takes into account the opportunity cost of using resources.

Unlike the league table, the current application of CUA/CEA that employs threshold ICER is often conducted to evaluate an individual program against the current program—not all possible alternatives. Whereas the opportunity cost is benefit forgone from the 'best' alternative use of the same amount of resource, comparison only with the current program, which is unnecessarily the best alternative, does not comply with the notion of opportunity cost in economics (Pedram Sendi et al., 2005). Moreover, threshold ICERs used in practice are not identified from the league table as originally proposed by Weinstein and Zeckhauser, but being exogenously, even arbitrarily, set. Therefore, current practice of comparing a program's ICER with the arbitrarily-set threshold totally ignores the size of the program—merely ratios are compared. It is also unclear how much does the pool of resource left to be utilized and where that pool of resource come from. Hence, the comparison between the size of project and the remaining pool of resource does not occur in the current practice of employing the threshold ICER as a decision rule. This approach obviously does not take into account the principle of opportunity cost, which is one of the most important considerations in economics of resource allocation.

Threshold ICER opponents further suspected that this approach can lead to a sharp rise in healthcare expenditures (Birch & Gafni, 1992; Gafni & Birch, 2006). When the threshold ICER employed, a program with a positive lower-than-threshold ICER is likely to be funded. A positive ICER means that additional resources are required to fund the program, entailing a rise in expenditures. When it is not obvious where such resources come from, it is possible that the program partly consumes the resource from other existing programs. If those existing programs are more cost-effective than the newly funded program, this process involves replacement of cost-effective programs by a less cost-effective program. Therefore, it is possible that the employment of threshold ICER results in simultaneous increase in healthcare expenditure and decrease in total health benefits to the society.

As mentioned earlier, the level of threshold itself is also a subject of discussion especially in EE literature from US. In US, the threshold of $50,000 per QALY is widely cited as a decision rule for assessing cost-effectiveness. The $50,000 threshold is the most popular value from 1990s in US literature and still the most popular value used today (Neumann et al., 2014). This obviously shows that the threshold is not even adjusted for inflation over a long period of time. Grosse (2008) tried to trace back the origin of this threshold. It turned out that the $50,000 threshold is arbitrarily set, rather than based on 1980s cost-effectiveness literatures as widely understood. It became popular just because it is a convenient round number (Grosse, 2008). The £20,000-30,000 threshold used by NICE suffers from the similar problem (McCabe, Claxton, & Culyer, 2008).

In conclusion, there are four main arguments against the application of threshold ICER. First two arguments are against the assumption of perfect divisibility of healthcare programs and the assumption of constant return to scale of investment in healthcare, which are theoretical foundations of ICER. The other two arguments are lacking consideration of opportunity cost and a sharp rise in healthcare expenditures as a result of this approach. Moreover, levels of threshold used in many countries are arbitrarily set rather than established on sound theoretical foundations.

CHAPTER III
METHODOLOGY

1. Data source

Decision rules other than the threshold ICER were reviewed from health economic textbooks and literatures. Literatures were search from the online databases primarily via the Google Scholar website (https://scholar.google.co.th/) and the PubMed website (http://www.ncbi.nlm.nih.gov/pubmed). The followings were primary search terms used: 'decision rule', 'economic evaluation', 'health technology assessment', 'cost-effectiveness analysis', 'cost-utility analysis', 'ICER', and 'incremental cost-effectiveness ratio'. Relevant articles cited in reviewed articles were also followed and reviewed.

In testing whether different decision rules lead to different conclusions, this study used secondary data. All economic evaluation reports in 2012, the most recent year with all reports being accessible, were retrieved from the Universal Health Coverage Benefit Package of Thailand (UCBP) website (http://www.ucbp.net/). The UCBP is a working group that gathers relevant information on healthcare programs under evaluation to be included in the benefit package of the Thailand's UCS, then making recommendations to the National Health Security Office (NHSO) that makes a final decision. Each report is an economic evaluation of each healthcare program that is a potential candidate for including in the benefit package of UCS. Incremental costs, incremental benefits, and budget impacts of health technologies in assessment were obtained from result section of each report and used in further analysis.

2. Analytical framework

Secondary data obtained from published reports are used to validate each decision rule. Information on CUA or CEA was extracted from reports. Data were reconstructed to fit frameworks of those decision rules. Results were compared with respect to total health gain between decision rules.

3. Data analysis

Alternative decision rules identified from the review process were compared. Their methodologies as well as advantages and disadvantages were compared with the threshold ICER.

These included both theoretical considerations and pragmatic issues. Furthermore, to clearly understand their applications in the real world, experiences of using economic evaluation in healthcare resource allocation from certain countries with publicly-funded healthcare systems—i.e., Thailand, UK, and New Zealand—were reviewed.

It is important to state explicitly criteria for judging which alternative is better in this study context. The primary objective of using economic evaluation in resource allocation is efficiency. This study therefore adopted efficiency as the main criteria for judging alternatives: an alternative of which application leading to a higher level of health gain by utilizing the same pool of resources is thought to be the better one. This seems straightforward. However, there exist other considerations in resource allocation, namely, equity issue and political pressure. This study did not take those two factors into consideration. Although it is duly acknowledged that those factors might influence decision making.

The other key issue needed to be clearly stated is what decision rules were for. In this study, a decision rule is a rule or a set of rules used to determine whether a healthcare program should be adopted to achieve the primary goal of efficiency, given limited resources available. This is different from determinants of how final decision is made. As mentioned earlier, others factor such as political pressure and equity consideration play a role in the decision making as well. Effects of those factors on decision making were beyond the scope of this study.

To illustrate how alternative decision rules work, all economic evaluation reports in 2012 from the UCBP website is reviewed. ICER for each healthcare program under evaluation and other relevant information had been extracted from each report. This information was then reconstructed to be compatible with the framework of each alternative decision rule.

The final outcomes of which healthcare program should be funded were compared across decision rules including the threshold ICER. The difference emerging from the comparison was noted and discussed. The recommendation of which decision rule should be applied in place of the threshold ICER was then made.

CHAPTER IV
RESULTS

1. Alternative decision rules

Four distinct alternatives to the current practice of threshold ICER were identified from the literature review. Those alternatives included league table, decision making plane, program budgeting and marginal analysis, and linear programming. Some alternatives were referred to using different terminologies in different literatures.

1.1 League table

As mentioned in the introduction chapter, the application of league table in healthcare resource allocation was introduced by Weinstein and Stason (1977) (M. C. Weinstein & Stason, 1977). The league table includes a range of healthcare programs ranked in ascending order of corresponding cost-effectiveness ratios. As cost-effectiveness ratio represents an average cost per a QALY gained from utilizing a healthcare program, the lower cost-effectiveness ratio means the lower cost per a unit of health benefit. In this approach, therefore, healthcare programs are chosen from the top of the table (a program with the lowest cost per QALY); decision makers go down the list until available resources are used up. Table 4.1 is an example of league table comprising six different healthcare programs. These six healthcare programs are programs for treating six different diseases, competing for a constrained public budget.

Table 4.1 League table of six healthcare programs (A–F).

Healthcare program	Cost (THB)	QALY gained (years)	Cost-effectiveness ratio (THB/QALY)
A	30,000	4	7,500
B	100,000	4	25,000
C	500,000	5	100,000
D	75,000	0.5	150,000
E	1,000,000	5	200,000
F	60,000	0.25	240,000

Suppose that an available budget is 530,000 THB for utilizing these programs. Using the league table approach leads policy makers to choose program A, B, and partial implementation of program C. At the point that the budget just exhausts, program C is implemented at 80% of its full capacity. Total cost is 30,000 + 100,000 + 0.8*500,000 = 530,000 THB; total QALY gained is 4 + 4 + 0.8*5 = 12 years.

However, the calculated result is only possible if program C can be partially implemented (divisible) and the return to scale of program C is constant even though partially implemented (constant return to scale). As discussed earlier, this approach faces major challenges for the last program being adopted. It relies on divisibility and constant return to scale assumptions. Healthcare programs typically do not follow the assumptions. For example, if a patient gets tonsillitis and needs a 10-day course of antibiotic, it is unlikely that he should take a 5-day course instead if he can only afford that. He is unlikely to gain half benefit from the treatment; he might instead develop antibiotic resistance in the future, and only gets small benefit from the incomplete course of treatment.

However, we argued that this approach can be modified. A more realistic alternative for policy makers is perhaps choosing program A and C. This option leads to 5 + 4 = 9 QALYs gained, and using up the budget. Program B, although more cost-effective by the cost-effectiveness ratio, is excluded from implementation. An advantage of this is that divisibility and constant return to scale assumptions are not required; although, this alternative results in a lower level of health gain. Therefore, for the original league table to be effectively applied, the last program being funded is needed to be, to some extent, consistent with divisibility and constant return to scale assumptions. Nevertheless, the modification can make this approach more practical and is still better than the current practice of applying arbitrarily-set threshold.

What would the decision be if the threshold ICER was applied? Suppose the current threshold ICER of 160,000 THB per is employed. This threshold is compared to the ICER of each individual program. As a result, program A, B, C, and D are regarded as cost-effective. This suggests policymakers adopting all four programs, which in total cost 705,000 THB, exceeding the available budget. It is clear that the threshold ICER when individually applied ignores amount of resources available. Moreover, in this example the excess budget of 705,000 - 530,000 = 175,000 THB is likely to be taken from resources currently used by existing programs. If those existing programs are more cost-effective than newly funded programs, total benefit from the healthcare system will decrease. Hence, applying the threshold ICER has a potential to re-allocate resources from existing cost-effective programs to new less cost-effective programs, which in turn decreases, not increase, total benefits of the healthcare system.

In conclusion, the advantage of the league table over the threshold ICER is that it takes into account an amount of resources available. This, at least, ensures that newly-funded programs have sufficient resources available for, not taking resources from existing programs. The disadvantage of the league table is its reliance on divisibility and constant return to scale assumptions. Some modifications can improve this approach.

1.2 Decision making (DM) plane

The DM plane was introduced by Sendi et al. (2002) (P. Sendi, Gafni, & Birch, 2002). The decision making plane is sometimes known as the replacement approach. Its concept is that a currently funded program (program X) must be identified and replaced by the new program (program Y). For program Y to be indicated as cost-effective, the cancellation of program X must release sufficient resources to fund program Y and the benefits of program Y must be equal to or higher than program X. This is graphically presented in a plot called 'decision making plane' (the approach is named after this plot.) (Figure 4.1).

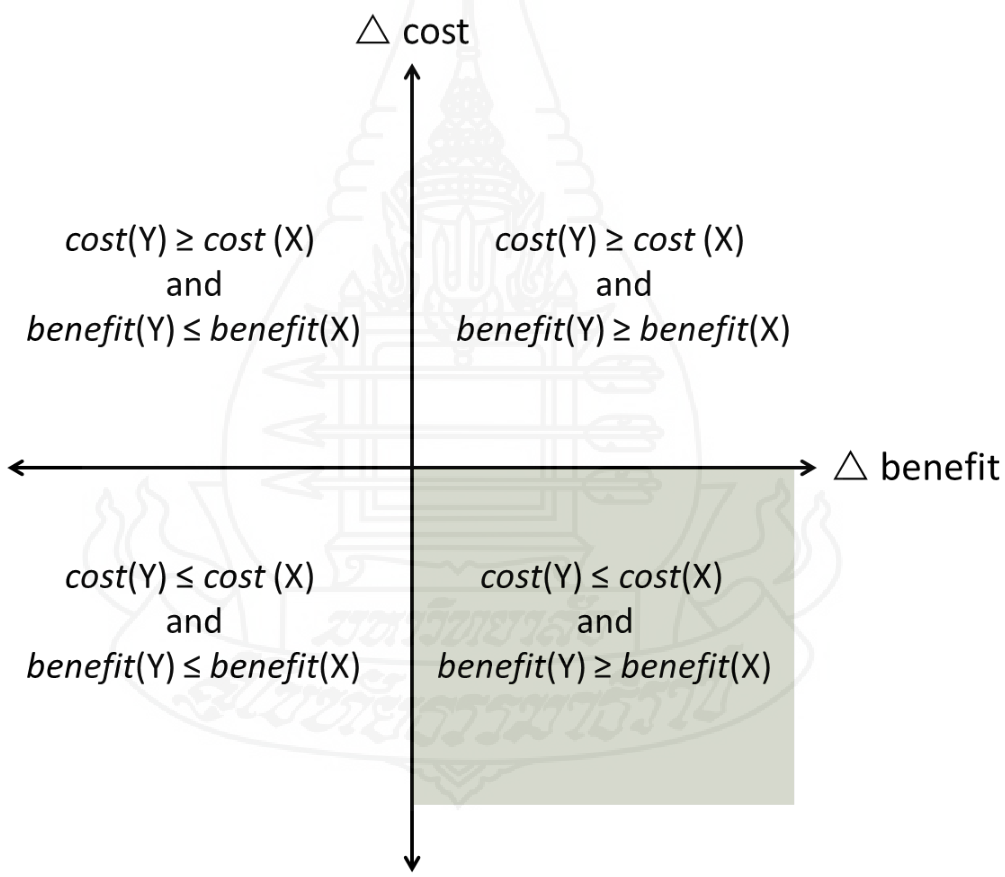

Figure 4.1 Decision making plane.

From Figure 4.1, cost-effectiveness criteria are fulfilled when cost and benefits of program Y, in comparison with program X, falls into the southeast quadrant of the plane (shaded area). Cost of program Y is equal to or less than that of program X and benefits of program Y are equal to or higher than that of program X in this quadrant. This involves an explicit comparison between benefits foregone from disinvesting program X (opportunity cost of investment in program Y) and benefits gained from implementing program Y.

Advantages of this approach are that opportunity cost is explicitly considered and it does not rely on divisibility and constant return to scale assumptions. Moreover, this approach ensures that the new program produces at least an equal level of benefits compared to the replaced program; total health benefits of the healthcare system increase or being unchanged. However, identification of program X is difficult in the real world. Even such program is identified, it is not easy to cancel a healthcare program already included in the benefit package (like program X) because of pressure from patient groups as well as physicians. The situation in which this approach being most relevant is when new programs are yet to be funded without budget expansion. Under this scenario, replacement of existing programs is inevitable. This approach provides a framework for transparent consideration of adopting new programs.

The threshold ICER can also be shown in the graph—which is quite similar to the DM plane—called the cost-effectiveness (CE) plane (Figure 4.2). The vertical axis represents a difference in costs; the horizontal axis represents a difference in benefits. The difference is that the new program Y in the CE plane is typically compared to an existing program for the same health conditions as Y—i.e., Y_0. If there is no current program for treating the same health condition, ‘no treatment’ scenario is served as a referent program. Whereas, in the DM plane approach, the comparator X can be a program for treating any disease and X is to be replaced when Y is adopted.

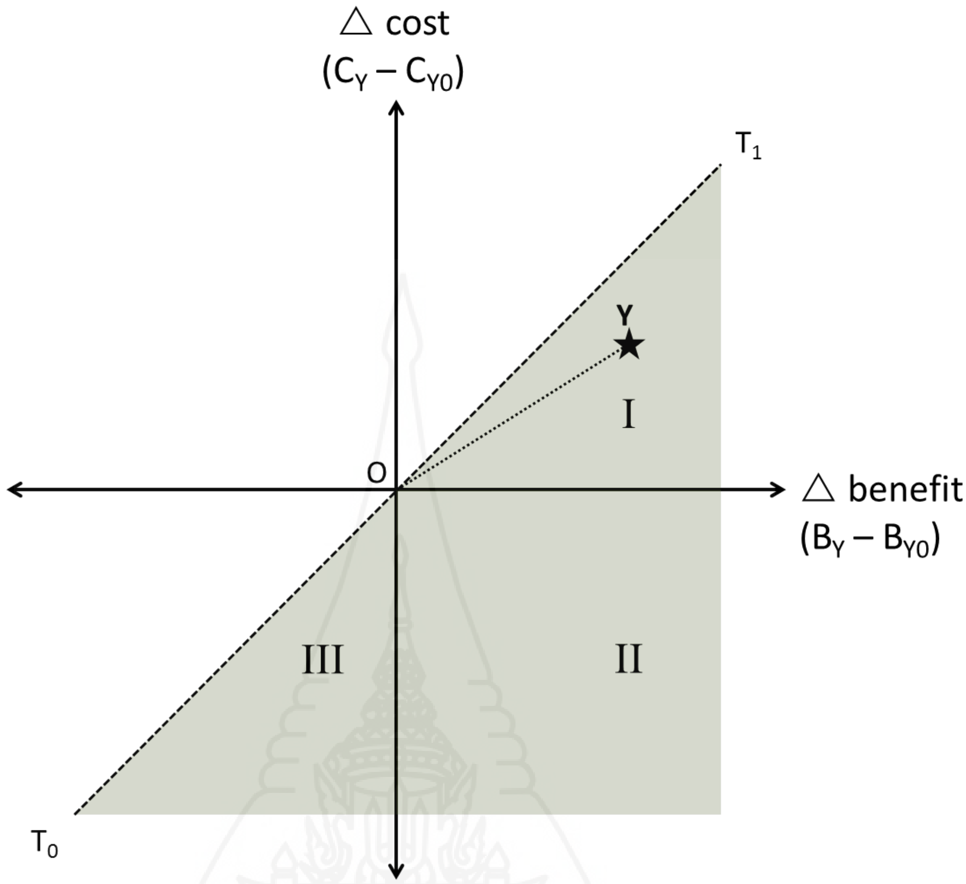

Figure 4.2 Cost-effectiveness (CE) plane.

Figure 4.2 is an example of CE plane. The threshold ICER is represented by, of which slope is equal to the value of threshold. Using the threshold ICER, program Y in Figure 4.2 is considered cost-effective because its slope (OY) on the CE plane is lower than the threshold T_0T_1. Based on this principle, all programs in the shaded area (I, II, and III), which have lower slopes than T_0T_1, are considered cost-effective.

Let assume that policymakers would like to replace an old treatment program with a new program; both are for treating the same disease. Therefore program X in the DM plane example is identical to the referent program Y_0 in the CE plane example. With this assumption, the DM plane in Figure 4.1 and the CE plane in Figure 4.2 are the same plane. The other difference between these two approach now becomes apparent: the DM plane endorses only programs in the right-lower quadrant (II in Figure 4.2), whereas the CE plane also includes areas on the right of the threshold line, T_1T_0, in right-upper and left-lower quadrants (I and III in Figure 4.2).

Without budget expansion, a program in area I, of which higher benefit comes with a higher cost compared to the program it replaces, needs additional resources from other existing programs. It is possible that the new program takes resources from existing more cost-effective programs. Hence, it is possible that adoption of programs in area I lead to a decrease in health benefits produced by the healthcare system.

The program in area III are less costly and has a lower level of benefits compared to a program it replaces. Adoption of a program in this area first decreases total benefits of the healthcare system. However, it releases resources that can be used by other programs. If these remaining resources are used by programs producing a heath gain exceeding an earlier decrease from adopting the first program, this adoption will produce a net gain. If this condition is not met, a net loss will occur. Therefore, adoption of programs in area I and III in the CE plane approach lead to uncertainty, does not ensure a net health gain, and possibly leads to a decrease in health of society.

The DM plane approach implicitly assumes no budget expansion in the healthcare sector. Under this condition, advantages of DM plane include ensuring an increase in health and no reliance on divisibility and constant return to scale assumptions. The threshold ICER, in contrast, cannot ensure a net health gain, and relies on those two assumptions as described earlier. The explicit disadvantage of the DM plane is difficulties in identifying and disinvesting an existing healthcare program, which is less cost-effective than the new program.

1.3 Program budgeting and marginal analysis (PBMA)

PBMA was adopted to deal with challenges stemming from different perspectives from various stakeholders (Craig, Parkin, & Gerard, 1995; Ruta, Mitton, Bate, & Donaldson, 2005). PBMA consists of two parts of analysis. Program budgeting is an output-based budgeting. It focuses on what budgets being used for (outputs), rather than inputs purchased. For instance, rather than listing costs of wage, electricity, capital investment, etc., program budgeting states how much budget is being allocated for mental health services, maternal and child services, cancer services, and so on. Comparing these budgets to burden of diseases provides a clearer link between budgets and needs. It helps all stakeholders understand clearly how the current budget is distributed across disease areas.

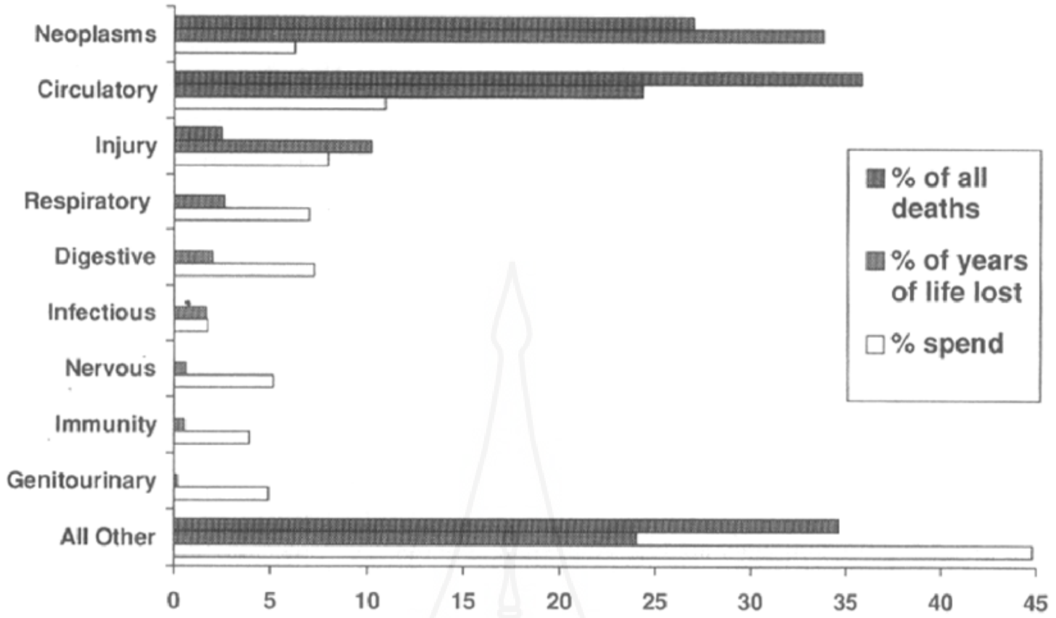

Figure 4.3 Example of program budgeting

Source: Taken from Miller et al. (1997) (Miller, Parkin, Craig, Lewis, & Gerard, 1997)

Figure 4.3 shows an example of program budgeting. The current resource allocation (% spend) was mapped and compared with indexes of healthcare needs (% of all deaths and % of years of life lost). Note that labels on the vertical axis are categories of diseases, not inputs. The graph indicates how much was spent on each disease area. Apparently, resources were over-used in some areas like genitourinary disorders, immune disorders, and nervous system disorders. Services for neoplasms and diseases in the circulatory system were likely to be underfunded.

The next step is marginal analysis. This involves setting up a working group from various stakeholders. The working group reviews information from program budgeting process, then identifies which service should be expanded and which service should be disinvested to free up resources for the expansion. In this regard, the PBMA approach is quite similar to the replacement (DM plane) approach. However, the final decision regarding which program should be funded is made on the basis of programs' ICER (Mitton & Donaldson, 2009). Hence this approach shares the same disadvantages of the threshold ICER approach.

We argued that PBMA should be regarded as a decision making framework rather than a mere decision rule. Moreover, it shares some common features with the replacement approach (decision making plane) and the threshold ICER. Its primary advantage is that it makes the current resource allocation explicit to all stakeholders. The disadvantage is similar to those of the threshold ICER. As we regarded PBMA as a decision framework, not a decision rule and it shares disadvantages with that of the threshold ICER, PBMA was excluded from further analysis in this thesis.

1.4 Linear programming

In theory, linear programming is the most straightforward approach to achieve the efficiency objective (Birch & Gafni, 1992). The analysis can be constructed to maximize health gain conditioning on the budget constrain as well as other constraints. Maximizing health gain from the limited available resources is indeed a definition of efficiency. In this approach, divisibility and constant return to scale assumptions are not required. The following shows a mathematical construct of this optimization problem.

$$maximize\ B = \sum_{i=1}^{n} b_i$$

$$s.t. \sum_{i=1}^{n} c_i \leq C$$

where B is total health benefits. C is total resources available. b_i is benefits from carrying out program i. c_i is resources consumed by program i. Total n healthcare programs include currently funded programs as well as potential programs to be funded.

Note that benefits and costs in this approach are not in the incremental manner. Practically, this approach reviews all currently-funded programs as well as potential programs to be adopted. Linear programming identifies the best combination of these programs in order to maximize benefit of the system under resource constraints. This process is periodically undertaken, for instance every fiscal year. All programs are subject to disinvestment every round of revisions.

Obviously, benefits and costs of all healthcare programs are required to carry out linear programming. As a large part of this required information is not yet well-established, applicability of this approach is questioned (S. Simoens, 2010). Nevertheless, an increase in bodies of benefit and cost information over time with the help of information technology might enable this approach in the future. At present, there is still insufficient information to conduct this approach; hence, this approach was also excluded from further analysis in this thesis.

1.5 Summary

Of the four methods identified, this study excluded two from further analysis. PBMA was excluded because it employs the same decision rule as the threshold ICER. Linear programming was excluded because of insufficient information to adopt this approach. Accordingly, two distinct approaches were subject to further analysis: league table and decision making plane. To get insight how decision is made based on EE information in the real world, review of countries' HTA guidelines and experience are presented in the next section.

2. Experiences from Thailand, UK, and New Zealand

Like Thailand, healthcare systems in UK and New Zealand rely primarily on public funding. HTA guidelines as well as implementation experience of those countries were reviewed. The review focused on the decision rule used in EE of each country and final decision of whether to adopt a healthcare program.

2.1 Thailand

The recent Thai HTA manual was published in 2013 (*Thailand's health technology assessment manual*, 2013). The manual indicates three main steps in HTA in Thailand. The first step is efficacy/effectiveness assessment; the following step is efficiency assessment; and the last step is budget impact analysis. The decision rule is applied in the second step. The manual indicates the threshold ICER as a decision rule for EE. It suggests increasing the threshold from 120,000 to 160,000 THB/QALY, citing economic growth and evidence from a recent WTP study as reasons (Thavorncharoensap, Teerawattananon, & Nartanan, 2009). Accordingly, at present, the threshold of 160,000 THB/QALY is used in Thailand.

The manual also suggested policymakers considering an impact on budget from a healthcare program in the decision making process. The budget impact is total revenue required to adopt the program. The manual, however, did not clearly state how this information should be used. Should the budget impact of the program be compared with available fiscal space? Or should any cut-point be employed to indicate whether the program has too high impact on the overall budget? A hint of this was presented in an article published in 2012 (Mohara et al., 2012). Some authors of that article were an editor and co-authors of the manual. In the article, the arbitrary cut-point of 200 million THB was employed. A program with budget equal to or over this cut-point was considered high budget impact; a program was considered low budget impact otherwise.

Final decisions of adopting healthcare programs were made based not solely on ICERs and budget impact. Other criteria include future healthcare cost avoided, equity consideration, and availability of other alternative programs. According to a previous review, four out of nine cost-effective programs (44.4%) were not adopted (Mohara et al., 2012). Three were not adopted because they had too high budget impact; the reason was inequity in access for the other program.

2.2 UK

In UK, the recently revised version of guide to technology appraisal was issued by NICE in 2013 (NICE, 2013). Two decision rules were implicitly stated in the guide. Under fixed budget, it was stated that health benefits from the new program will be compared with benefits foregone from displaced programs. This is consistent with the DM plane approach. However, the guide did not provide details sufficient to implement this approach—for instance, how those displaced programs are identified and how the comparison should be made. The other decision rule is the threshold ICER. Although the guide emphasized that the threshold does not work in an automatic manner, it apparently suggested that a program with ICER below £20,000 is generally regarded as a cost-effective program. For a program with ICER above £20,000, other factors including degree of certainty of estimated value, innovative nature of technology, life-extending treatment at the end of life, and other non-health objectives including equity issue are taken into consideration.

Unlike Thailand's case, the UK guide stated that the budget impact does not affect the decision to adopt health programs. Dakin et al. (2014) modelled past NICE decisions (Dakin et al., 2014). The model shows that values of ICER were able to predict 82% of adoption decisions; other stated considerations contributed very little. It was also estimated that an effective threshold of NICE decision was between £39,000 and £44,000, much higher than £20,000 stated in the guide.

2.3 New Zealand

In New Zealand, the Pharmaceutical Management Agency (PHARMAC) is responsible for pharmaceutical funding assessment (PHARMAC, 2015b). Similar to Thailand, PHARMAC uses information from both EE (specifically CUA) and budget impact analysis. PHARMAC explicitly specified nine decision criteria that are simultaneously considered. Among those criteria, two are cost-effectiveness and budget impact. Other include health needs for all New Zealanders, particular needs for indigenous people (Maori and Pacific people), availability of existing medicine, clinical benefits and risks, direct cost to users, government priorities, and other criteria specific to the circumstance (PHARMAC, 2015b).

For the cost-effectiveness criterion, PHARMAC requires ICER of a health program. However, it indicated that there is no specific threshold ICER employed by PHARMAC. It was emphasized in many publications that PHARMAC considers those nine criteria simultaneously without threshold ICER (Metcalfe & Grocott, 2010; PHARMAC, 2012, 2015a, 2015b). Although, there was an argument on this issue between Metcalfe and Grocott

(2010) (Metcalfe & Grocott, 2010) and Simoens (2010) (Steven Simoens, 2010) on the original review article by Simoens (Simoens, 2009). A wide range of ICERs of programs recommended by PHARMAC provided solid evidence on this no-threshold assertion. Programs with ICERs ranging from $ -40,000 per QALY to $200,000 per QALY were recommended by PHARMAC between 1998–2007 (PHARMAC, 2012).

2.4 Summary

Decision making in all three countries was not based solely on economic decision rule. Rather, multi-criteria decision analysis was employed in healthcare decision making (Baltussen & Niessen, 2006); other criteria such as health of minorities and innovativeness of health technologies also affected the final decision. Economic decision rule was merely one of those criteria. Regarding economic decision rule, the one used in Thailand and UK is the threshold ICER. In New Zealand, the approach is closely related to the league table approach. Budget impact is considered in Thailand and New Zealand, but not taken into account in UK.

3. Applications of alternative decision rules across disease areas

This section demonstrates how decision rules are applied in choosing treatments across disease areas. Reports from 2012 on the UCBP website were used. In total, ten reports from 2012 were posted on the UCBP website. Only six reports are complete. Three out of six were not economic evaluation or not for adopting a new program. Consequently, three economic evaluation reports were reviewed (กิจวิธี et al., 2555; ธิบูรณ์บุญ, กุลเพ็ง, & ตีระวัฒนานนท์, 2557; สันตติวงศ์ไชย, กุลเพ็ง, สะพู, สุขอนันตชัย, & ตีระวัฒนานนท์, 2555).

Three healthcare programs include paternal chromosome screening, monitoring blood test for an anticoagulant drug, and pre-surgical evaluation of epilepsy surgery. The first program is a test for parents whose previous child has had chromosome abnormalities. The test aims to assess the risk of their next child being abnormal, which suggests whether they should have a next child or not. The second program is a test for patients who are prescribed an anticoagulant of which primary side effect is an increasing risk of bleeding. The monitoring test facilitates physicians to adjust the dose of anticoagulant for minimizing its risk. The last program is for evaluating patients with seizure (also called epilepsy) prior to the surgery aiming to remove electric foci, which causes seizure, in their brains. This pre-surgical evaluation determines whether benefit from the surgery outweighs the risk for an individual patient. Economic evaluation results of these three programs are presented in Table 4.2.

Table 4.2 Results of economic evaluation from UCBP reports in 2012.

	Program	Incremental QALY	Incremental cost (THB)	ICER (THB/QALY)	Simulated unit
1	Paternal chromosome screening*	203	17,274,000	85,094	1,000 couples with previous abnormal child
2	Monitoring blood test for an anticoagulant drug	0.15	3,844	25,627	1 patient with warfarin use
3	Pre-surgical evaluation of epilepsy surgery	14.89	1,070,586	84,752	1 patient with focal epilepsy

**The original evaluation used CBA; benefit in monetary unit was converted into QALY using then current threshold of 120,000 THB/QALY.*

3.1 Threshold ICER

At the time those studies conducted, the threshold ICER was 120,000 THB/QALY. All programs in Table 4.2 had ICERs lower than the threshold. Hence all were cost-effective according to the threshold ICER approach. Likewise, the UCBP recommended all of the three to be included in the benefit package. Authors of those studies estimated budget impact for first few years of each program. The first year budget impact of programs in Table 4.2 was 4,057,438, – 23,000,000, and 96,000,000 THB respectively (negative budget impact for the second program was a result of a decrease in traveling costs of patients and relatives and cost saving from less adverse health events occurring if the intervention was applied; hence, initial investment is still required in order to implement the intervention). Therefore, total first-year budget impact of those three programs was 4,057,438 – 23,000,000 + 96,000,000 = 77,057,438 THB. Note that for the second program result from CUA was somewhat inconsistent with result of budget impact analysis. CUA suggested an increase in cost from adopting the program—as indicated by a positive incremental cost, whereas the budget impact analysis suggested cost saving—as indicated by negative budget impact. This inconsistency between the two estimates made the result questionable, reflecting variation in estimation methods used in a costing part of CUA and the budget impact computation.

Three programs combined required the 77-million-THB increase in budget. Although not explicitly stated, it seemed that UCBP worked on the assumption of increasing budget. Moreover, even though budget impact of a particular program was computed, none of these studies attempted to compare this budget impact with available budget. Without such comparison, budget impact analysis is almost useless. It is like go shopping without knowing that how much money left in one's own pocket.

3.2 League table

In conducting the original league table, budget impact throughout project's lifetime, total QALYs gained for the whole population, and long-run budget available for funding healthcare programs are required. As all were not available in reports, budget impact of the first year of adoption, which can be extracted in reports, was used. Total extra QALYs gained were computed from an ICER times the first year budget impact. The league table takes into account total budget available. Since we did not have this information, for demonstration, *we assumed that 75 million THB was available in the first year of adopting new programs*. Hence, we came up with modified implementation of league table.

Table 4.3 League table of three healthcare programs.

	Program	Incremental QALY based on first year investment	Incremental cost for the first year of adoption (million THB)	ICER (THB/QALY)
1	Monitoring blood test for an anticoagulant drug*	0	-23	25,627
2	Pre-surgical evaluation of epilepsy surgery	1,133	96	84,752
3	Paternal chromosome screening	48	4	85,094

**The cost component of CUA conflicted with the budget impact result as mentioned earlier; calculation of total benefits based on the budget impact and ICER led to health loss, whereas CUA suggested health gain. Given that incremental benefit was small, this program was regarded as a mere cost-saving program without additional benefits.*

Table 4.3 shows the modified league table of the three programs. Programs were ranked in ascending order of ICERs. Using this modified league table approach, monitoring blood test and pre-surgical evaluation would be fully adopted. Two programs combined consumed 73 million THB, two million THB left for implementing the paternal chromosome screening program. Hence the last program can be implemented only half of its full scale. Total health gain was 0 + 1,133 + 0.5*48 = 1,157 QALYs.

If all programs were adopted in full scale as suggested by the threshold approach, initial total health gain would be 0 + 1,133 + 48 = 1,181 QALYs. However, required budget was 77 million THB, 2 million THB more than available budget. Therefore, that 2 million THB would be taken from resources used by existing programs. If health loss from those displaced programs was higher than 24 QALY, the threshold approach would lead to lower total health gain compared to the league table approach. Whether this is the case cannot be certainly known because the current practice of threshold approach does not consider such identification of displaced programs.

3.3 DM plane

The DM plane works on the assumption of no budget expansion. Hence, no budget expansion was assumed here. To adopt all three programs, currently funded programs are needed to be cancelled to release resources worth 77 million THB to fund those three programs. In addition, total health forgone from cancellation of programs is required to be equal or lower than 1,181 QALYs. Meeting those two criteria ensures an increase in health of population.

If the threshold approach was applied without budget expansion, 77 million THB would be taken from unidentified existing programs. How much health is foregone is unknown with a high level of uncertainty—arguably higher than the situation with budget expansion. Therefore, under the situation without budget expansion, the threshold ICER is obviously inappropriate to be applied.

3.4 Summary

This analysis suggested that, before making resource allocation, policymakers have to know the budget situation: whether it is with or without budget expansion. With budget expansion, the league table is better than the threshold ICER alone as it is more transparent regarding explicit consideration of budget available. It ensures maximization of benefits from alternative programs under budget constraint. Although, the original league table might be impossible as it requires loads of information currently unavailable, a modification of league table as shown in this thesis can be done to carry out this approach in the real practice. Note that ICER is also included as a part of league table.

Without budget expansion, displacement of existing programs to fund the new ones is inevitable. Policymakers hence should carry out the identification of displaced program(s) explicitly. The DM plane, also known as replacement approach, provides the framework for this process. Using the threshold approach under this scenario leads policymakers to highly uncertain territories.

In conclusion, considering the economic criteria, in making decision across disease areas, policymakers should first clarify budget situations before making decision on resource allocation. Under budget expansion scenario, a modified league table should be used instead of the threshold ICER approach. Nevertheless, ICER still provides useful information about healthcare program, but should be used as a part of league table rather than directly compared with the arbitrary threshold. Under no budget expansion scenario, the DM plane should be used instead of the threshold ICER approach. These alternatives at least ensure an increase in health of population; in contrast, the current practice of the threshold ICER had been shown in this thesis that it can lead to uncertain situations including those with decreasing population health. Application of the threshold ICER can be misleading and there exist better alternatives, although not without drawbacks.

4. Applications of alternative decision rules within a particular disease area

To demonstrate applications of decision rules in selecting one treatment among alternatives to treat a particular disease, the data presented in Table 2.2 were used. The data is replicated in Table 4.4, but here, to be clearly seen the point, strategies are ranked according to their ICERs in an ascending order (Meeyai et al., 2013). All strategies in Table 4.4 are flu vaccination strategies in school-age children with doses and intervals of vaccine varying between strategies.

Table 4.4 CUA result of six flu vaccination strategies in school-age children in Thailand (ranked according to ICERs).

Strategy	Incremental cost (million THB)	DALYs averted (years)	ICER (THB/DALY averted)
Strategy 6	2,090	302,136	6,918
Strategy 5	3,138	274,372	11,438
Strategy 4	3,914	313,945	12,468
Strategy 1	5,775	331,817	17,403
Strategy 2	7,140	352,757	20,239
Strategy 3	9,330	376,534	24,780

4.1 Threshold ICER

Firstly, note that only one program among those six strategies in Table 4.4 is going to be selected. The then threshold of 120,000 THB/QALY was applied. We treated one DALY averted as approximately equal to one QALY gained. ICERs of all strategies in Table 4.4 were less than the threshold ICER. Therefore, all strategies are considered cost-effective based on the threshold ICER approach.

As all programs were cost-effective according to the threshold criteria, strategies with lower ICERs are typically preferred and considered as more cost-effective. Strategy 6 is, hence, the most cost-effective program according to its ICER value and as also suggested in the original literature (Meeyai et al., 2013).

4.2 League table

The league table selects a program with the lowest ICER first and continues until resources are just exhausted. As only one program needed to be selected, only a program with the lowest ICER, i.e., strategy 6, is selected. Hence, in this context, the league table is equivalent to the threshold ICER approach.

4.3 DM plane

The application of DM plane, under no budget expansion scenario, indicates some current programs must be disinvested to provide sufficient resources for implement a new program. Hence, a choice of the best alternative relies heavily on how much resources are available from the disinvestment. Strategy 3, an alternative with the highest total health gain, is the best alternative if budget from cancelling current programs is equal or higher than 9,330 million THB and total health gain from programs cancelled is lower than 376,534 DALY averted, total health gain produced by Strategy 3. This ensures higher health gain for the population.

Strategy 3 potentially provides the highest total health benefits. Nevertheless, this strategy was unlikely to be selected using the threshold criteria because it had the highest ICER among alternatives. Strategy 6, which was the best alternative by the threshold criteria, produced the second lowest total health gain. The DM plane approach is arguably more compatible with the notion of maximizing health gain. The threshold ICER ignores total benefits of the program. It considers only average cost per an extra unit of benefit.

4.4 Summary

In making decision within a particular disease area, with or without budget expansion, the threshold ICER only selected the cheapest cost-per-a-health-unit program instead of the program that potentially produced maximum health gain. With budget expansion, simple selection of the program that produces the highest gain and cost less than the available budget might be better than the threshold ICER approach. Under fixed budget, the DM plane is preferable to the threshold ICER.

CHAPTER V
CONCLUSION, DISCUSSION AND RECOMMENDATION

1. Conclusion and discussion

Four alternatives to the threshold ICER were identified from literature review including league table, DM plane, PBMA, and linear programming. PBMA and linear programming were later excluded from the analysis. The former is more appropriately regarded as a distinctive decision framework—rather than a mere decision rule—and the decision rule used in PBMA is similar to the threshold approach. The latter is still unlikely to be applied anytime soon because it requires tons of information. But surely for something as important as investing in health, it justifies the efforts that should be vested in getting the information. The league table and the DM plane were good candidate to carry out further analysis and compared with the threshold ICER.

Then country experiences from three publicly funded healthcare systems were reviewed. In effect, economic decision rules used in Thailand and UK are the threshold ICER as evident in literatures. New Zealand employs the other approach that can be classified as a modification of the league table approach. Those rules are related to economic efficiency criteria. All three countries indeed employed the multi-criteria decision analysis which included economic criteria as one of criteria used. Hence, other decision criteria are also applied in all three countries. All applies criteria related to distribution of benefits across its population—equity consideration. Additionally, UK also has a criteria regarding innovative nature of health technology that is not applied in the other two countries.

Using secondary data from Thailand, it was demonstrated how the threshold approach is inferior to the other alternatives. Policymakers have to recognize their budget situation before making decision. Without recognition of available budget, estimation of budget impact and making judgement based on the figure alone as in the case of Thailand is irrelevant.

For making decision across disease areas, the modified league table should be applied under the situation with budget expansion. ICER provides useful information as a part of the league table, but should not be directly compared with the threshold. The DM plane should be applied under the situation without budget expansion.

In making decision within a particular disease area, with extra budget available, decision makers can first exclude programs requiring resources more than the available budget. Among remaining choices, the program producing the highest health gain should be selected. This simple procedure is better than the threshold ICER. Under fixed budget, the DM plane should be used as it is more transparent about how resources are deviated from other programs and it ensures no decrease in population health if the new program is funded.

ICER provides useful information for decision makers. However, rather than comparing it with the arbitrary threshold as in the threshold ICER approach, it is more informative as a part of league table. The findings from this study demonstrated that application of the threshold ICER can be misleading with considerable uncertainties and does not necessarily ensuring economic efficiency. In many contexts, better alternatives exist and can be applied instead of the threshold ICER. However, this does not imply that other alternatives do not have their own disadvantages. The league table requires a substantial amount of information. Disinvesting healthcare programs as suggested by the DM plane, on the other hand, can be practically difficult.

2. Recommendation

We proposed an alternative framework that can be applied in place of the threshold ICER. The framework is illustrated in Figure 5.1 below. It combines modified league table and DM plane.

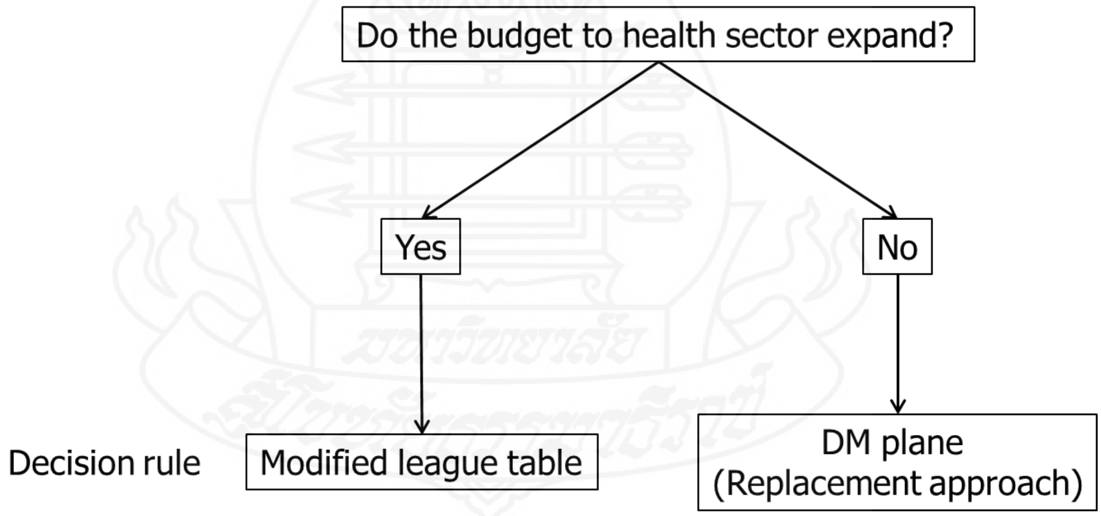

Figure 5.1 Alternative framework to the threshold ICER.

In this framework, budget situation for the next fiscal round is first specified. If the budget does not expand, the DM plane is employed. If the budget expands, the modified league table is employed. ICER, which provides useful information, is included in the league table. In making decision within a particular disease area, under budget expansion, simple selection of a program producing the highest gain conditioning on the available budget should be used.

An example of modified league table is Table 4.3. The modification from the original league table is that, instead of using lifetime budget requirement, the budget impact of the next fiscal round, e.g., fiscal year, is used. This enables practical comparison between budget needed to adopt programs during the next fiscal round and budget available for the next fiscal round. For the benefit part, total benefits to the whole population throughout program lifetime—not convenient numbers of simulation units like 1,000 or 10,000—is employed. This based on that assumption that policymakers will keep investing in the program throughout its lifetime if it is adopted in the next fiscal round. At least in short-run, this assumption is consistent with the reality that disinvestment of publicly-funded health programs is difficult as evident in Thailand's recent reintroduction of glucosamine in one of public schemes (Tantivess & Tangcharoensathien, 2016).

3. Limitations

In demonstrating applications of each decision rule, this study needed to use secondary data. However, availability of the data was limited. Complete information about programs being considered to be included in the UCS benefit package in each fiscal year was not publicly available. Although total budget allocated to NHSO was accessible, there was still a limitation about how much was actually used to funded new programs. This limitation of data was a major limitation of this study that prevented the demonstration of each decision rule in an elaborative way.

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APPENDIX

Quality-adjusted life year (QALY), disability-adjusted life year (DALY), and healthy year equivalent (HYE)

QALY (quality-adjusted life year), DALY (disability-adjusted life year), and HYE (healthy year equivalent) are measurements of utility used in health economics—especially, CUA (cost-utility analysis). The concept is to summarize health outcomes, which comprise two primary dimensions—length of life and quality of life, into a single index. Although with similar underpinning principle, these three measurements differ in their methodologies for assigning a utility value to health outcomes.

In computation of QALY, life years are adjusted by disability weight. The resulting value is equivalent to years with perfect health. The weight is obtained by asking patients with a certain health condition to rate the health condition as a proportion of a perfect health; hence, it ranges from 0 to 1. The weight is specific to a health condition. For instance, the disability weight for common cold is very low, close to zero (say 0.001), meaning that a healthy person who got a cold during a year is in a nearly perfect health (1 year with a common cold = 0.999 year in perfect health). In contrast, a patient living with lung cancer has very bad health status; the disability weight for lung cancer is high—say 0.8. One year with lung cancer is equivalent to 0.2 year in perfect health. QALY is the most popular outcome measurement used in CUA (Zweifel, Breyer, & Kifmann, 2009).

DALY measures a loss in perfect health. It sums up actual loss in life years due to premature dead from a disease and a decrease in quality of life during the period living with a disease. In addition to disability weight, DALY employs the age weight. Disability weight is similar to that used in QALY calculation except that the weight is obtained from experts rather than patients. For age weight, DALY assigns higher value to life in working age than life of elderly and children. DALY is used mainly by WHO to estimate global burden of diseases (Zweifel et al., 2009).

HYE employs a different method. Rather than comparing health condition and perfect health on one-year basis, it asks individuals to evaluate health profile—a scenario with whole consequences from a disease or intervention—that can be last for several years. The health profile is valuated to be equivalent to years in perfect health. To obtain this value, two-stage assessment is used. The first involves standard gambling procedure. The second stage uses the time trade-off procedure. Although, HYE is theoretically favorable, it is the least popular among the three because of its complex methodology (Morris et al., 2007; Zweifel et al., 2009).

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