Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/vhri

Economic Evaluation

From Research to Policy Implementation: Trastuzumab in Early-Stage Breast Cancer Treatment in Thailand

Ronnachai Kongsakon, MD[1], *Surasit Lochid-amnuay, PhD*[2,*], *Nattiya Kapol, PhD*[2], *Oraluck Pattanaprateep, PhD*[3]

[1]*Department of Psychiatry, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand;* [2]*Department of Community Pharmacy, Faculty of Pharmacy, Silpakorn University, Nakhon Pathom, Thailand;* [3]*Section for Clinical Epidemiology and Biostatistics, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand*

ABSTRACT

Objectives: To evaluate the adjuvant therapy of trastuzumab cost and quality-adjusted life-years (QALYs) in lifetime horizon and describe the use of an economic evaluation in supporting policy-making decisions in the treatment of early-stage breast cancer in Thailand. **Methods:** A Markov model was used to evaluate the cost effectiveness of 1-year adjuvant trastuzumab for patients with early-stage breast cancer who were considered human epidermal growth factor receptor 2/neu-positive with a societal perspective and lifetime horizon. The research variables were probability of health state change, health utility, and cost of treatment. A sensitivity analysis was conducted using probabilistic methods. A budget impact analysis was also performed. **Results:** The results revealed that the treatment cost and QALYs in the trastuzumab group yielded 4.59 QALYs. The incremental cost-effectiveness ratio was $3387 (THB 118 572; THB = Thai baht) per QALY. On the basis of the willingness-to-pay threshold in Thailand, a 1-year adjuvant trastuzumab treatment for breast cancer was a cost-effective therapy. **Conclusions:** A combination therapy that includes trastuzumab is a preferable choice and should be used in early-stage breast cancer treatment. The Thai government has listed trastuzumab on the National List of Essential Medicines to be used for the early stages of breast cancer since 2014.

Keywords: cost effectiveness, early stages of breast cancer, Thailand, trastuzumab.

Introduction

Breast cancer is one of the most commonly diagnosed cancers among women and has high incidence and mortality rates in both developed and developing countries [1]. Breast cancer alone was expected to account for 231 840 cases, or 29% of all new cancer cases, and 40 290 deaths in the United States in 2015. In 2012, there were an estimated 1.7 million cases and 521 900 deaths worldwide [2]. In Thailand, the Cancer Registry Unit of the National Cancer Institute reported that breast cancer ranked first between 2010 and 2012 with an age-standardized incidence rate of 28.5 per 100 000 persons, and was even higher in Bangkok with an incidence rate of 35.1 per 100 000 persons. About 50% of patients were in the early stages of breast cancer [3]. Furthermore, the breast cancer mortality rate in Thailand was reported to be 7% per year from 2000 to 2006, and is experiencing an increase when compared with other nations in the Asia-Pacific region [4]. Nevertheless, about 20% to 30% of patients with early-stage breast cancer have overexpression of human epidermal growth factor receptor 2 (HER2), which has been correlated with metastatic breast cancer and death.

In Thailand, only those medications that are in the Thai National List of Essential Medicines (NLEM) can be reimbursed with public healthcare insurance. Before 2014, the NLEM contained doxorubicin, cyclophosphamide, and drugs in the taxane group for treatment of early-stage breast cancer. The average cost of treatment was more than $2857 (THB 100 000 [THB = Thai baht]; $1 = THB 35 in 2012) per case per year, and healthcare costs for breast cancer treatment represented a significant proportion of the national budget.

Trastuzumab is a synthetic monoclonal antibody that targets HER2 proteins, acting to decrease tumor size, inhibit tumor metastasis, and slow disease progression [5] Trastuzumab has been approved for the treatment of HER2-positive early-stage breast cancer [6] Several studies of adjuvant trastuzumab showed substantial benefits in disease-free survival among HER2-positive patients with

Conflicts of interest: The authors have indicated that they have no conflicts of interest with regard to the content of this article.

* Address correspondence to: Surasit Lochid-amnuay, Department of Community Pharmacy, Faculty of Pharmacy, Silpakorn University, Nakhon Pathom 73000, Thailand.

Email: lochidamnuay_s@su.ac.th.

2212-1099/$36.00 – see front matter © 2018 ISPOR–The professional society for health economics and outcomes research. Published by Elsevier Inc.

https://doi.org/10.1016/j.vhri.2018.08.004

early-stage breast cancer compared with the standard therapy [7-11] A 1-year adjuvant therapy that includes trastuzumab and chemotherapy can delay time to death among patients [10-12]

Because of the rising costs of caring for patients with early-stage breast cancer together with limited healthcare budgets and the availability of effective medications to treat the disease, this study reports on an economic evaluation that was prepared at the request of the National Health Security Office when considering whether trastuzumab should be included in the NLEM for treatment of early-stage breast cancer.

This research aimed to conduct an economic evaluation and budget impact analysis of adjuvant therapy with trastuzumab and paclitaxel compared with paclitaxel alone for the treatment of early-stage breast cancer among women in Thailand. The results of this study provided information for policy and decision making with respect to whether trastuzumab should be included in the NLEM.

Methods

Markov Model

This study was a model-based economic evaluation. A Markov model design using a societal perspective, in compliance with the Thai Health Technology Assessment Process Guidelines [13], was performed to estimate the cost per quality-adjusted life-year (QALY). The study population was a hypothetical cohort of 1000 patients with early-stage breast cancer. The economic evaluation was based on a joint analysis comparison of studies by Perez et al. [5,14] Data of long-term survival and consequences were projected from the 4-year joint analysis and extrapolated to a lifetime horizon on the basis of a cohort simulation model. In the base-case analysis, costs and health outcomes were discounted at 3% annually [15].

A Markov model of early-stage breast cancer was developed using Microsoft Excel. The model structure and all the parameters were approved by experts during an expert consultation meeting. The simulation health states in the Markov model are shown in Figure 1 and include 3 health states: (1) disease-free health state, (2) metastatic disease or distant disease relapse, and (3) death. Arrows represent the probability of transition from one health state to another. With a 3-week cycle length, patients could remain in the same state or move to another health state, as indicated by the arrows. The cycle would run until the individual reached the time of death. This study used the definition of the willingness-to-pay (WTP) threshold of the Thai Subcommittee for Development of the NLEM: 1 time the per capita gross domestic product (GDP). Thailand's per capita GDP in 2012 was $3428 (THB 120 000), and thus the WTP threshold was considered to be $3428 (THB 120 000).

Model Assumptions

All patients entered the model in a nonmetastatic breast cancer health state at the beginning of the treatment. Patients receiving adjuvant chemotherapy would move to the metastatic breast cancer state if cancer was detected again, with either local or distant metastasis. Patients could move to the death state from either the nonmetastatic or the metastasis breast cancer health state. On the basis of clinical information and practice, assumptions regarding the analytical model were addressed and included the following: all patients enrolled in the trial were 50-year-old women with a weight of 60 kg and a body mass index of 1.6 m^2 at the beginning. Their tumors were HER2-positive as defined by an immunohistochemistry score of 3+ or fluorescence in an in situ hybridization test, but no testing costs were calculated because they were performed for both treatments. Patients had a normal left ventricular ejection function of 50% or more as shown in a 2-dimensional echocardiogram or a multiple-gated acquisition scan. No cardiac event treatment cost was therefore calculated. Patients were not able to use anthracycline.

Treatment Regimen

Two treatment policies were examined. The first was a nontrastuzumab group defined as a traditionally used chemotherapy regimen: paclitaxel alone. The second was a trastuzumab group defined as receiving a 1-year adjuvant therapy with trastuzumab combined with paclitaxel.

The patient dosage regimen for each treatment policy was as follows. Paclitaxel alone: 175 mg/m^2 intravenously (IV) every 3 weeks for 6 cycles; adjuvant therapy with trastuzumab and paclitaxel: trastuzumab first dose with 8 mg/kg IV followed by 4 mg/kg every 3 weeks for 1 year and paclitaxel 175 mg/m^2 IV every 3 weeks for 6 cycles. In cases of cancer progression or no drug response, the patient would be switched to oral capecitabine alone: 1250 mg/m^2 twice a day.

Model Parameters

In this study, we adopted the event rate from Perez et al [14] as representative of the most recent long follow-up report to date of trastuzumab plus adjuvant chemotherapy, and a joint analysis of data from the North Central Cancer Treatment Group N9831 intergroup trial and the National Surgical Adjuvant Breast and Bowel Project B-31 trial, where the number of disease-free patients was reported each year of follow-up for up to 4 years. We

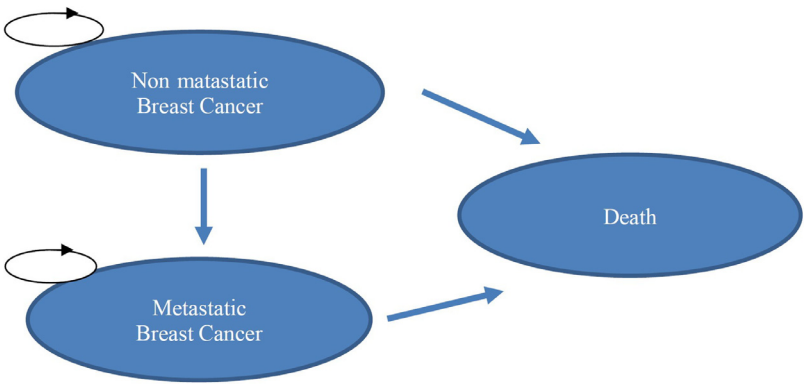

Fig. 1 – The health states included in the Markov model.

calculated the probability of transition from a disease-free state to metastatic breast cancer state using the following 3 equations:

$$R = \frac{\text{Number of events}}{\text{Number of patients at risk}},$$

where R is the risk rate every 1 year (52 weeks).

$$\text{Rate} = \frac{-\ln(1-P)}{\text{Time}},$$

where Rate is the risk rate of every 3-week cycle and Time represents the change in time from 52 weeks to 3 weeks.

$$P = 1-\exp(-\text{rate}),$$

where P is the probability of transition from disease-free state to metastatic breast cancer state.

After 5 years, the study used the annual rate of metastatic recurrence from the Early Breast Cancer Trialists' Collaborative Group [16]; hazard ratios were from Perez et al. [14] For the probability of transition from metastatic breast cancer to death, we followed the work of Slamon et al. [17] The model structure and all parameters were approved by experts during model validation meetings.

Costs

Because a societal perspective was used in this study, the total costs included direct medical costs, direct nonmedical costs, and indirect costs. All costs were adjusted with values for 2012 and used the consumer price index.

Direct medical costs were defined as healthcare costs directly related to breast cancer treatment, including acquisition costs of medication, which were retrieved from the reference prices of the Drugs and Medical Supplies Information Center database. The cost of inpatient service charges was taken from the Thai Diagnosis-Related Group reimbursement rate. Direct nonmedical costs were defined as traveling and extra food costs, and indirect costs were obtained from the Thai Standard Cost List for Health Technology Assessment [18] (Table 1). The quantity of resources used was retrieved from the literature[18] and confirmed by an expert panel.

Utilities

Utilities for each Markov health state were derived from a literature review of health utilities in cancer. Utility values ranging between 0 and 1 indicate health state values relative to full health. The utility values of disease-free and metastatic health states were 0.900 and 0.600, as reported by Oestreicher et al [19] and Hornberger et al, [20] respectively. All input parameters used in the model are presented in Table 1.

Sensitivity Analysis

The robustness of the results was assessed using a 1-way sensitivity analysis and a probabilistic sensitivity analysis (PSA). For the 1-way or univariate sensitivity analysis, the traditional approach to sensitivity analysis was to examine 1 variable at a time. Each parameter was varied individually across the plausible range and shown graphically as a tornado diagram. In addition, the PSA was carried out by varying all parameters randomly within the plausible range. A Monte-Carlo simulation was used to randomly select a value for each parameter 1000 times and to calculate expected costs and outcomes. The results of the PSA were presented as a cost-effectiveness plane and as acceptability curves.

Budget Impact Analysis

A budget impact analysis was presented by year from a third-party payer perspective for 5 years. In the first year, the cost of treatment was multiplied by early-stage breast cancer prevalence, whereas in the following years, cost of treatment was multiplied by early-stage breast cancer incidence.

Results

Base-Case Analysis

By design, the cohort simulation model results for rates of disease-free survival and overall survival at 4 years among patients with early-stage breast cancer were similar to rates reported by Perez et al [14]; cohort simulation model results were 0.857 and 0.735 for treatment with and without trastuzumab, respectively, and those of Perez et al were 0.857 and 0.737, respectively.

Under the cohort simulation model for lifetime (mean age at the beginning = 50 years), the benefit of trastuzumab was seen in both disease-free survival and overall survival. The median time to progression was 16 years in patients receiving trastuzumab, which was longer than in those who did not receive trastuzumab (6.4 years). Moreover, the median patient survival time was also longer in the trastuzumab group: 17.8 years and 8.4 years with and without trastuzumab, respectively.

The cost of treatment for each year of follow-up in both treatment groups was calculated, and annual treatment costs were lower with medication in the first year. The analysis showed that from a societal perspective, the expected lifetime cost of early-stage breast cancer treatment for the trastuzumab group was $43 168 (THB 1 510 886) compared with $27 608 (THB 966 306) for the nontrastuzumab group. For utility, life-years were gained and QALYs increased when adding trastuzumab to the treatment (by 5.01 and 4.59 years, respectively). When comparing the 2 treatment policies, the incremental cost-effectiveness ratio (ICER) was $3387 (THB 118 572) per QALY gained.

Sensitivity Analysis

The results of the 1-way sensitivity analysis are presented as a tornado diagram (Fig. 2). Only the 15 parameters that affected the model results the most are shown, from the greatest to the least. The key parameters of the model were the transition probability of metastasis from disease-free state (year 10 onward), transition probability of metastasis from disease-free state (years 6-9), cost of trastuzumab (subsequent cycle), cost of computed tomography scan (upper abdomen), and quality of life for metastatic disease.

The results of the PSA are illustrated in a cost-effectiveness plane. The WTP line per QALY is shown in the cost-effectiveness plane (Fig. 3) and the acceptability curves (Fig. 4). The transition from the nontrastuzumab group to the trastuzumab group was estimated at $3428 (THB 120 000).

Budget Impact Analysis

From a third-party payer perspective, with estimated prevalence and incidence of early-stage breast cancer in Thai women (Table 2), the cost of adding trastuzumab to treatment was $13 597 (THB 475 921) per case per year. The total costs were $7 546 581 (THB 264 130 336) per year for all new patients and $16 398 516 (THB 573 948 081) per year for all current patients.

Discussion

This research was the first study to assess the cost effectiveness of 1 year of adjuvant trastuzumab for the treatment of early-stage

Table 1 – Input parameters used in the model.

Parameters	Mean	Standard error	Distribution	Reference
Transition probability parameters				
Paclitaxel alone				
Nonmetastatic to metastatic year 1	0.0027	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 2	0.0055	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 3	0.0054	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 4	0.0040	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 5	0.0040	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic years 6-9	0.0028	0.00270	Beta	Murray et al [21]
Nonmetastatic to metastatic year 10 onward	0.0019	0.00190	Beta	Murray et al [21]
Nonmetastatic to death	0.0022	0.00010	Beta	Perez et al [14]
Metastatic to death	0.0223	0.00060	Beta	Early Breast Cancer Trialists' Collaborative Group [16]
Adjuvant therapy of trastuzumab and paclitaxel				
Nonmetastatic to metastatic year 1	0.0016	0.00003	Beta	Perez et al [14]
Nonmetastatic to metastatic year 2	0.0030	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 3	0.0028	0.00010	Beta	Perez et al [14]
Nonmetastatic to metastatic year 4	0.0015	0.00004	Beta	Perez et al [14]
Nonmetastatic to metastatic year 5	0.0015	0.00005	Beta	Perez et al [14]
Nonmetastatic to metastatic years 6-9	0.0014	0.00140	Beta	Perez et al [14], Murray et al [21]
Nonmetastatic to metastatic year 10 onward	0.0010	0.00100	Beta	Perez et al [14], Murray et al [21]
Nonmetastatic to death	0.0010	0.00003	Beta	Perez et al [14]
Metastatic to death	0.0223	0.00060	Beta	Early Breast Cancer Trialists' Collaborative Group [16]
Health utility				
Nonmetastatic	0.9000	0.09000	Beta	Oestreicher et al [19]
Metastatic	0.6000	0.24000	Beta	Hornberger et al [20]
Direct medical cost				
Trastuzumab: first dose	50 095.84	5009.58	Gamma	Drugs and Medical Supplies Information Center [22]
Trastuzumab: subsequent dose	25 047.92	2504.79	Gamma	Drugs and Medical Supplies Information Center [22]
Paclitaxel	21 571.20	2157.12	Gamma	Drugs and Medical Supplies Information Center [22]
Capecitabine	23 257.29	2325.73	Gamma	Drugs and Medical Supplies Information Center [22]
OPD visit	286.53	28.65	Gamma	Arthorn [18]
Admission	15 644	1564.40	Gamma	Arthorn [18]
Chest x-ray	50.62	5.06	Gamma	Arthorn [18]
CT scan (upper abdomen)	1687.48	168.75	Gamma	Arthorn [18]
Bone scan	1518.73	151.87	Gamma	Arthorn [18]
CBC test	122.51	12.25	Gamma	Arthorn [18]
Bilirubin test	33.92	3.39	Gamma	Arthorn [18]
Liver function test	67.84	6.78	Gamma	Arthorn [18]
Direct nonmedical cost				
Traveling cost	148.11	12.05	Gamma	Arthorn [18]
Cost for food	54.56	5.56	Gamma	Arthorn [18]
Indirect cost				
Income loss	83.42	14.28	Gamma	Arthorn [18]

CBC indicates complete blood cell count; CT, computed tomography; OPD, outpatient department.

breast cancer in a Thai context. The study results could therefore provide valuable information for decision makers considering whether trastuzumab should be included in the NLEM for treatment of early-stage breast cancer.

On the basis of the societal perspective in a Markov model, adjuvant therapy that includes a 1-year adjuvant trastuzumab in patients with early-stage, HER2-positive breast cancer is a cost-effective therapy according to the Thailand WTP threshold for a health intervention, which is considered to be 1 time the Thai GDP per capita. The Thai WTP threshold is less than the WTP threshold used in many countries, or suggested by the World Health Organization.

Treatment with adjuvant trastuzumab demonstrated improved life expectancy and a greater number of QALYs compared with nontrastuzumab treatment at an increased cost. The ICER was $3387 (THB 118 572) per QALY gained, which was less than 1 time the Thai GDP per capita at $3428 (THB 120 000). In 2014, the Thai government announced the inclusion of trastuzumab in the NLEM for the treatment of early-stage breast cancer because of the results from this study.

Our study findings agreed with those published in earlier studies, showing that treatment with trastuzumab had net societal economic benefits, with some differences in ICER per QALY in developed countries [23,24] Nevertheless, the results for developing countries remain uncertain. A 12-month treatment course of trastuzumab adjuvant therapy in Iran [25] and Columbia [26] was not found to be cost-effective working on 3 times the GDP; this treatment in

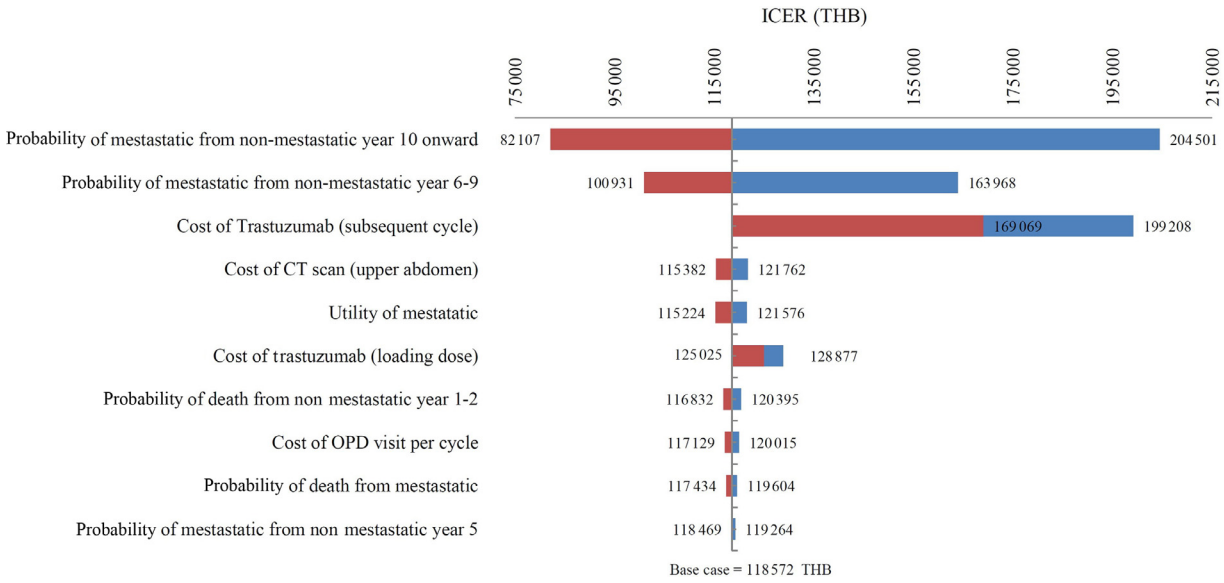

Fig. 2 – Tornado diagram. CT indicates computed tomography; ICER, incremental cost-effectiveness ratio; OPD, outpatient department; THB, Thai baht.

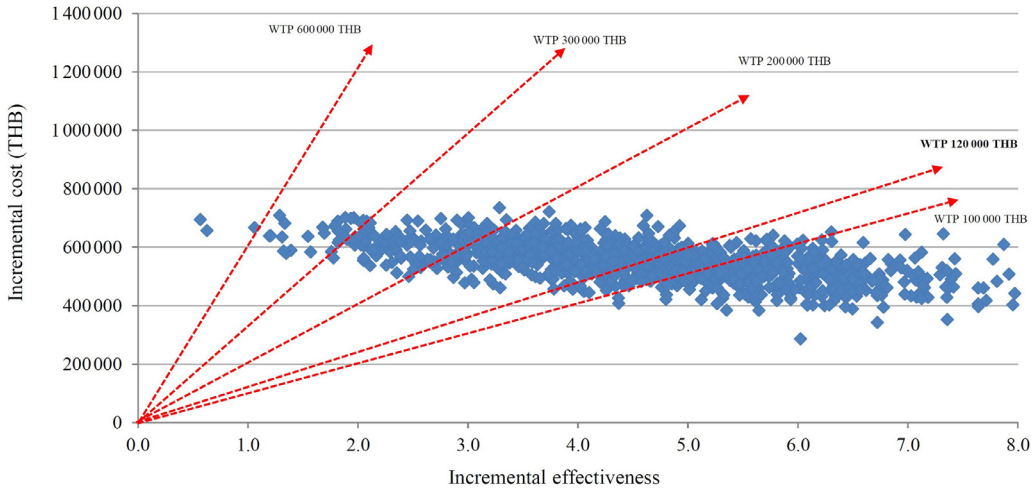

Fig. 3 – Cost-effectiveness plane. THB indicates Thai baht; WTP, willingness to pay.

Singapore, however, showed net societal economic benefits [27] as it also did in Taiwan [22] and Malaysia [28]. The differences in these results may originate from the different resources used, for instance, the probability of disease progression. Moreover, government affordability in relation to the economic evaluation in each country on the basis of WTP thresholds may also influence the differences in results [29]. This study used data from the North Central Cancer Treatment Group N9831 and the National Surgical Adjuvant Breast and Bowel Project B-31 trials, which were long-term studies of early-stage breast cancer. Nevertheless, the treatment costs in our study may be lower than in those studies because cardiac event treatment costs were not included in this study; our assumptions included only patients with normal left ventricular ejection function (≥50%). In addition, other direct medical and direct nonmedical costs in Thailand are relatively low.

In the sensitivity analysis, the factor most affecting the model results was the transition probability of moving from the disease-free state to metastasis. It should be noted that this factor was sensitive for decision making.

There are limitations of this study that must be mentioned. First, because of a lack of clinical and quality-of-life studies investigating the benefits of trastuzumab among patients in Thailand with breast cancer, we applied data derived from international clinical studies, which may differ from a Thai perspective. Second, trastuzumab-related cardiotoxicity has been raising concerns, but this study assumed that only normal patients could be the target population. These data were accepted after expert discussion and by the Subcommittee for Development of the NLEM.

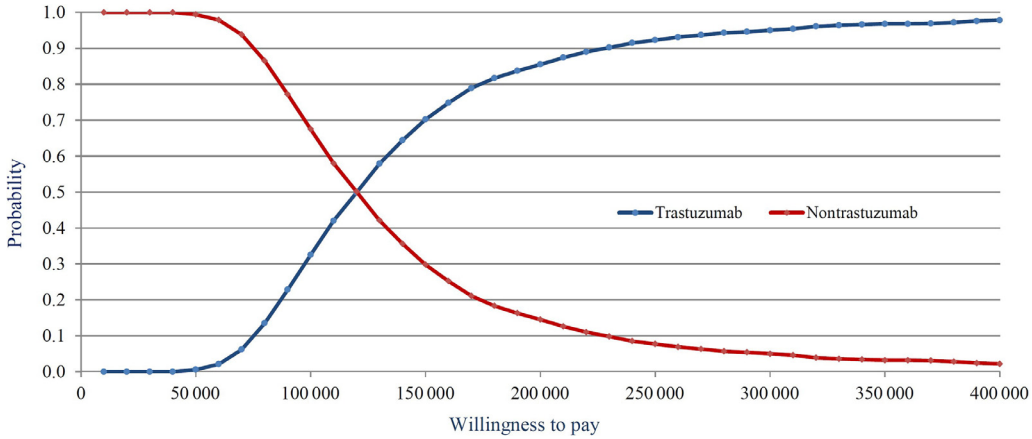

Fig. 4 – Acceptability curve.

Table 2 – Prevalence and incidence for early-stage breast cancer in Thailand.

	Rate	Prevalence (cases)	Incidence (cases)	References
Number of breast cancer patients	–	20,000*	10,018**	
Universal coverage	75.2 %	15,040	7,534	NHSO 2010
Early breast cancer (EBC)	70.0 %	10,528	5,273	
Diagnosis HER-2-test	95.0 %	10,002	5,009	Estimated
% HER-2 positive (IHC 3+)	20.0 %	2,000	1,002	
EBC Node positive	55.0 %	1,100	551	
EBC Node negative(ER/PR neg) tumor size> 2cm	12.0 %	240	66	Thailand OCPA criteria
Total patients	–	1,340	617	
FISH positive (90%) require in EBC	90.0 %	1,206	555	Estimated

EBC indicates early breast cancer; ER, estrogen receptor; FISH, fluorescence in an in situ hybridization; HER2, human epidermal growth factor receptor 2; IHC, immunohistochemistry; OCPA, oncology prior authorization; PR, progesterone receptor.
* Thailand Cancer Registry 2010.
** GLOBOCAN 2008.

Conclusion

Using a Markov model, PSA, and budget impact analysis, a combination therapy that included trastuzumab was found to be cost-effective during the early stages of breast cancer in Thailand. This study proposed that the Subcommittee for Development of the NLEM include trastuzumab in the Thai NLEM. In 2014, trastuzumab was subsequently approved to be included in the NLEM and covered by government insurance.

Source of financial support: The funding for this study was supported through the Health Intervention and Technology Assessment Program from the National Health Security Office, Thailand.

REFERENCES

[1] Torre LA, Bray F, Siegel RL, Ferlay J, Lortet-Tieulent J, Jemal A. Global cancer statistics, 2012. CA Cancer J Clin 2015;65(2):87–108.
[2] Siegel RL, Miller KD, Jemal A. Cancer statistics, 2015. CA Cancer J Clin 2015;65(1):5–29.
[3] Imsamran W, Chaiwerawattana A, Wiangnon S, et al. Cancer in Thailand: 2010-2012, VIII. Bangkok, Thailand: National Cancer Institute Thailand; 2015.
[4] Youlden DR, Cramb SM, Yip CH, Baade PD. Incidence and mortality of female breast cancer in the Asia-Pacific region. Cancer Biol Med 2014;11(2):101–15.
[5] Perez EA, Romond EH, Suman VJ, et al. Updated results of the combined analysis of NCCTG N9831 and NSABP B-31 adjuvant chemotherapy with/without trastuzumab in patients with HER2-positive breast cancer (abstract 512). J Clin Oncol 25 (18S), 2007.
[6] Lang HC, Chen HW, Chiou TJ, Chan AL. The real-world cost-effectiveness of adjuvant trastuzumab in HER-2/neu-positive early breast cancer in Taiwan. J Med Econ 2016;19(10):923–7.
[7] Goldenberg MM. Trastuzumab, a recombinant DNA-derived humanized monoclonal antibody, a novel agent for the treatment of metastatic breast cancer. Clin Ther 1999;21(2):309–18.
[8] Piccart-Gebhart MJ, Procter M, Leyland-Jones B, et al. Trastuzumab after adjuvant chemotherapy in HER2-positive breast cancer. N Engl J Med 2005;353:1659–72.
[9] Plosker GL, Keam SJ. Trastuzumab: a review of its use in the management of HER2-positive metastatic and early-stage breast cancer. Drugs 2006;66(4):449–75.
[10] Slamon D, Eiermann W, Robert N, et al. Adjuvant trastuzumab in HER2-positive breast cancer. N Engl J Med 2011;365:1273–83.
[11] Smith I, Procter M, Gelber RD, et al. 2-year follow-up of trastuzumab after adjuvant chemotherapy in HER2-positive breast cancer: a randomised controlled trial. Lancet 2007;369(9555):29–36.
[12] Joensuu H, Bono P, Kataja V, et al. Fluorouracil, epirubicin, and cyclophosphamide with either docetaxel or vinorelbine, with or without trastuzumab, as adjuvant treatments of breast cancer: final results of the FinHer Trial. J Clin Oncol 2009;27(34):5685–92.
[13] Chaikledkaew U, Kittrongsiri K. Guidelines for health technology assessment in Thailand—the development process. J Med Assoc Thai 2014;97:S4–9.

[14] Perez EA, Romond EH, Suman VJ, et al. Four-year follow-up of trastuzumab plus adjuvant chemotherapy for operable human epidermal growth factor receptor 2 positive breast cancer: joint analysis of data from NCCTG N9831 and NSABP B-31. J Clin Oncol 2011;29 (25):3366–73.
[15] Permsuwan U, Guntawongwan K, Buddhawongsa P. Handling time in economic evaluation studies. J Med Assoc Thai 2008;97:S50–8.
[16] Early Breast Cancer Trialists' Collaborative Group. Effects of chemotherapy and hormonal therapy for early breast cancer on recurrence and 15-year survival: an overview of the randomised trials. Lancet 2005;365:1687–717.
[17] Slamon DJ, Leyland-Jones B, Shak S, et al. Use of chemotherapy plus a monoclonal antibody against HER2 for metastatic breast cancer that overexpresses HER2. N Engl J Med 2001;344:783–92.
[18] Arthorn R. Standard Cost Lists for Health Technology Assessment 2011. Bangkok, Thailand: Health Intervention and Technology Assessment Program; 2011.
[19] Oestreicher N, Ramsey SD, Linden HM, et al. Gene expression profiling and breast cancer care: What are the potential benefits and policy implications? Genet Med 2005;7(6):380–9.
[20] Hornberger J, Kerrigan M, Foutel V. Cost-effectiveness of trastuzumab (Herceptin) for treatment of metastatic breast cancer. Ann Oncol 2002;13:S52.
[21] Murray CJ, Evans DB, Acharya A, Baltussen RM. Development of WHO guidelines on generalized cost-effectiveness analysis. Health Econ 2000;9(3):235–51.
[22] Drugs and Medical Supplies Information Center, Ministry of Public Health. Reference drug price. 2012. Available from: http://dmsic.moph.go.th/dmsic. [Accessed August 10, 2012]
[23] Hedden L, O'Reilly S, Lohrisch C, et al. Assessing the real-world cost-effectiveness of adjuvant trastuzumab in HER-2/neu positive breast cancer. Oncologist 2012;17(2):164–71.
[24] Fagnani F, Colin X, Arveux P, Coudert B, Misset JL. Cost/effectiveness analysis of adjuvant therapy with trastuzumab in patients with HER2 positive early breast cancer [French]. Bull Cancer 2007;94:711–20.
[25] Aboutorabi A, Hadian M, Ghaderi H, Salehi M, Ghiasipour M. Cost-effectiveness analysis of trastuzumab in the adjuvant treatment for early breast cancer. Glob J Health Sci 2014;7(1):98–106.
[26] Buendia JA, Vallejos C, Pichon-Riviere A. An economic evaluation of trastuzumab as adjuvant treatment of early HER2-positive breast cancer patients in Colombia. Biomedica 2013;33:411–7.
[27] de Lima Lopes Jr G. Societal costs and benefits of treatment with trastuzumab in patients with early HER2neu-overexpressing breast cancer in Singapore. BMC Cancer 2011;11:1.
[28] Lee WC, Haron MR, Yu KL, Chong FLT, Goh A, Azmi S. Economic analysis of intravenous vs. subcutaneously administered trastuzumab for the treatment of HER2+ early breast cancer in Malaysia. *Adv Breast Cancer Res*. 5;1:1-13.
[29] Mustacchi G, Generali D. Cost-effectiveness and sustainability of breast cancer screening and new anti-cancer drugs. J Med Econ 2017;20(4): 405–8.