The Cost-Effectiveness of a Novel Scalp Cooling Device to Alleviate Chemotherapy-induced Alopecia in Patients with Early Breast Cancer

Y. OUYANG[1]; Y. CAI[1]; E. POON[2,3]; S. LIEW[2]; N. GRAVES[1]

[1]Health Services and Systems Research, Duke-NUS Medical School, Singapore 169857
[2]Division of Medical Oncology, National Cancer Centre Singapore, 30 Hospital Boulevard, Singapore 168583
[3]Singapore Society of Oncology, Singapore

Introduction

Chemotherapy-induced alopecia is the thinning or loss of hair caused by the cytotoxic effects of chemotherapy. It typically occurs within one to three weeks after the start of treatment. It is a common and distressing side effect with significant psychological impacts. Up to 14% of patients may decline chemotherapy due to concerns over hair loss.[1]

Scalp cooling therapy is an effective method to mitigate hair loss, mainly through automated systems and manual cold caps. Automated systems are costly and bulky, whereas cold caps need to be changed manually every 20-30 minutes. These drawbacks limit their availability in the public cancer care centres in Singapore despite increasing patient demand.

To address this gap, a novel long-lasting and portable scalp cooling cap ("Product X") was developed with the goal to reduce hair loss and improve chemotherapy adherence. It is designed to be cordless to allow patients to leave the chemo chair once chemotherapy is finished.

Objective

The aim of our study was to evaluate the potential cost-effectiveness of adopting Product X compared to existing practice (no scalp cooling), in female patients with early breast cancer receiving cytotoxic chemotherapy at a Singapore tertiary cancer centre, from a health system perspective.

Rather than claim definitive evidence, our goal was to provide preliminary insights into the likelihood of cost-effectiveness of Product X under different clinical scenarios.

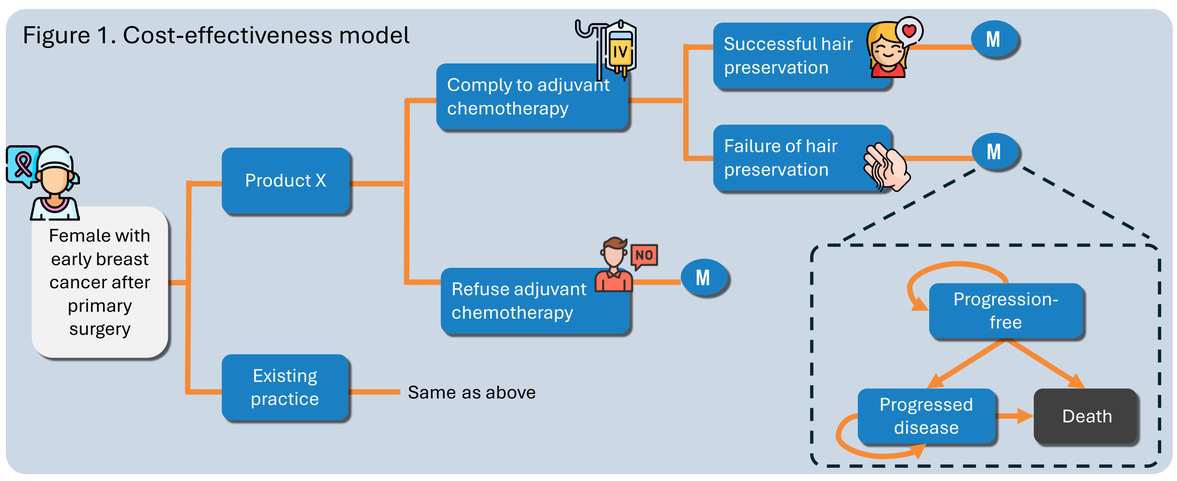
Methods

Overview: We developed a decision-analytic model consisting of a decision tree followed by a lifetime Markov model, to estimate the costs and health outcomes associated with the adoption of Product X compared to no scalp cooling, from a health system perspective.

First part of the model: The decision tree models the impact of scalp cooling on adjuvant chemotherapy uptake and its effectiveness in preventing hair loss during the first year after diagnosis. All patients were assumed to enter the Markov model via 'progression-free' state at the end of the decision tree.

Second part of the model: The Markov model describes disease progression after one year since diagnosis, with three states: 'progression-free', 'progressed disease' and 'death'. The model used one-year cycle length over a 32-year time horizon.

Figure 1. Cost-effectiveness model



Model parameters: We included health resource costing items relevant to uptake of scalp cooling: equipment for scalp cooling, nursing time incurred, initial chemotherapy, and treatment for cancer recurrence. Patients' outcome was measured by quality adjusted life-years (QALYs). Costs and outcomes were discounted at 3% per cycle.

Probabilities in the decision tree and transition probabilities in the Markov model were derived from the best available published local data and other official sources such as the Singapore Lift Tables[2] and the Singapore Joint Breast Cancer Registry Report[3]. Table 1 shows some of the key model parameters.

Probabilistic sensitivity analysis: Monte Carlo simulation with 1,000 iterations was performed to account for parameter uncertainties.

Scenario analysis: A two-way scenario analysis was conducted by varying two key assumptions: (1) the improvement in chemotherapy adherence (0%, 1%, 5%) and (2) the efficacy of Product X relative to reported efficacy of existing scalp cooling therapies (50%, 75%, and 100%). This resulted in a matrix of nine scenarios exploring the combined effects of these assumptions on cost-effectiveness. The base-case assumed 1% reduction in non-compliance and 100% relative efficacy.

Table 1. Key model parameters

Variables	Estimate (Distribution)	Variables	Estimate (Distribution)
Scalp cooling duration, mins	96 – 144[4], Uniform	Hazard ratio of mortality of non-compliant breast cancer patient	1.25[5], Log-normal (0.223, 0.061)
Non-compliance to recommended chemotherapy	31.56%[5], Beta (3482, 7552)	Relative risk of mortality in patient with cancer recurrence	4.2[8], Log-normal (1.44, 0.155)
Efficacy of scalp cooling services	61.0%[4], Beta (38,24)	Utility of patient with invasive breast cancer undergoing surgery, radiation therapy and/or chemotherapy (first year)	0.73[9], Beta (1124, 414)
Probability of patients suffered from alopecia without scalp cooling	94.7%[6], Beta (1385, 78)	Utility of patient at progression free state	0.80[10], Beta (92, 23)
Annual probability of progression in early breast cancer (age 60 above)	20.1%[3], Beta (6693, 76)	Utility of patient at progressed disease state	0.46[10], Beta (44, 52)
Hazard ratio of progression-free survival of patient without adjuvant chemotherapy	1.71[7], Log-normal (0.536, 0.105)	Utility value of chemotherapy-induced alopecia	-0.11 – -0.05[11,12], Uniform

Results

In 1,000 Monte Carlo simulations, the mean change in cost was S$265 (95% UI: S$251 – S$281) and mean change in QALYs was 0.0717 (95% UI:0.0705 – 0.0729) when compared to existing practice (Figure 2).

When Willingness-to-pay threshold exceeded $4,000 per QALY, probability of cost-effectiveness of Product X outweigh that of existing practice (57.9% vs 42.1%, Figure 3).

At Willingness-to-pay of S$45,000 per QALY, incremental net monetary benefits (INMB) was estimated at S$2,961 (95% UI: S$2,906 – S$3,015) with 100% likelihood that adoption of Product X is cost-effective.

Figure 2. Cost-effectiveness plane

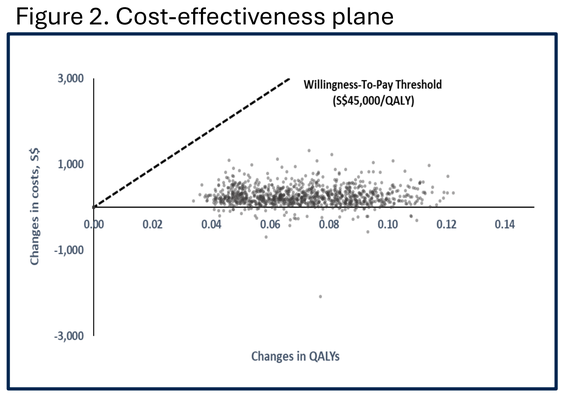
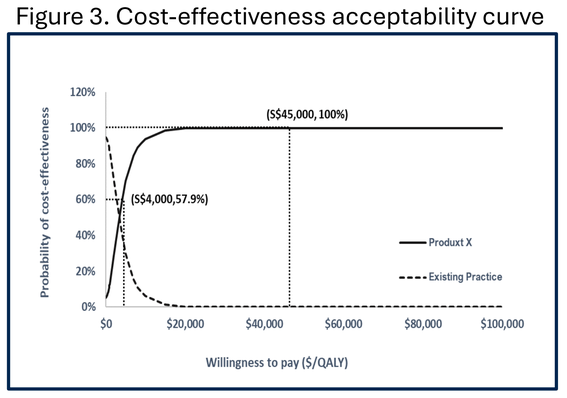


Figure 3. Cost-effectiveness acceptability curve



All nine scenarios suggested that adoption of Product X is cost-effective. INMB ranged from S$1,158 (95% UI: S$1,132 – S$1,184) to S$3,330 (95% UI: S$3,261 – S$3,398).

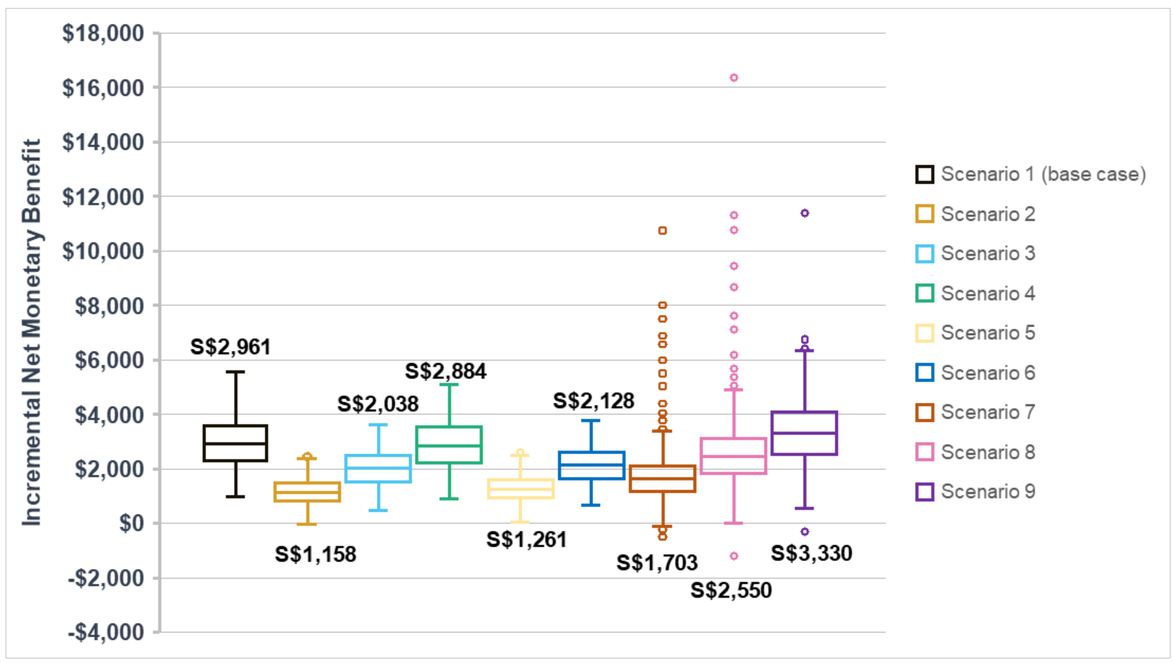


Figure 4. Box-and-whisker plot of results of scenario analysis. Nine scenarios were modelled, combining different assumptions on compliance improvement and scalp cooling efficacy:
Scenario 1: 1% improvement, 100% efficacy; Scenario 2: 0% improvement, 50% efficacy;
Scenario 3: 0% improvement, 75% efficacy; Scenario 4: 0% improvement, 100% efficacy;
Scenario 5: 1% improvement, 50% efficacy; Scenario 6: 1% improvement, 75% efficacy;
Scenario 7: 5% improvement, 50% efficacy; Scenario 8: 5% improvement, 75% efficacy;
Scenario 9: 5% improvement, 100% efficacy

Conclusion

Our early cost-effectiveness modelling study suggests that the adoption of a novel cold cap is likely to be 100% cost-effective at a Singapore tertiary cancer centre, from a health system perspective. Results from sensitivity analyses prove our model to be robust.

References

Please refer to the supplementary handout for detailed references.