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Cost-Effectiveness of Artificial Intelligence Assisted Brain Magnetic Resonance Imaging Interpretation in Advanced Lung Cancers

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Background

Brain MRI is routinely performed in patients with advanced non–small cell lung cancer (NSCLC) for identifying brain metastases (BM). Accurate MRI image interpretation directly influences timely cancer treatment strategies. This study evaluated the cost-effectiveness of DeepBT®, an AI -based decision-support SaMD for brain MRI interpretation in stage III–IV NSCLC from the Taiwan National Health Insurance perspective.

Method

A diagnostic decision tree linked to a four-state Markov model—no brain metastasis, brain metastasis, end-of-life supportive care, and death—was used to simulate clinical pathways after brain magnetic resonance imaging (MRI) interpretation with or without DeepBT®. The diagnostic component classified patients as true negative, true positive, false positive, or false negative, which then determined subsequent Markov pathways. Improved diagnostic accuracy with DeepBT® was assumed to influence health-state transitions, whereas false-positive and false-negative interpretations were associated with unnecessary costs, delayed or inappropriate treatment, disease progression, and reduced quality of life. Outcomes included incremental quality-adjusted life-years (QALYs), costs, and incremental cost-effectiveness ratios (ICERs), evaluated against a willingness-to-pay (WTP) threshold of twice Taiwan's 2024 gross domestic product (GDP) per capita. Uncertainty was assessed using probabilistic and deterministic (PSA & DSA) , and scenario analyses testing alternative survival assumptions, a longer time horizon, and higher discount rates.

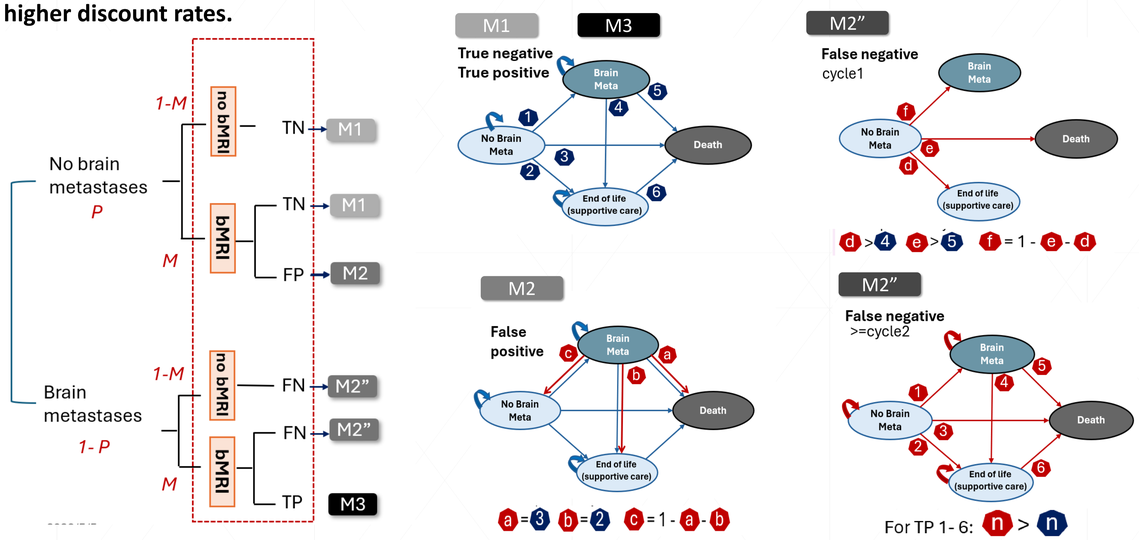

Figure 1. Diagnostic Decision Tree and Markov Disease-Progression Model for Brain Metastasis in Stage III and Stage IV NSCLC

BM = brain metastasis; MRI = magnetic resonance imaging; P = probability of having BM; M = probability of receiving MRI; TN = true negative; FP = false positive; FN = false negative; TP = true positive; Blue transitions 1–6 represent disease-state transitions under correct diagnostic classification. Red transitions represent pathways affected by diagnostic misclassification. Red transitions a–c denote false-positive pathways, in which patients are incorrectly classified as having BM, resulting in additional cycle 1 costs and altered subsequent treatment decisions. Red transitions d–f denote false-negative pathways, in which BM is initially undetected, potentially delaying BM diagnosis and treatment and leading to poorer survival and lower utility. Red transitions 1–6 represent subsequent disease-state transitions after delayed BM detection in the false-negative pathway; these transition probabilities were assumed to be higher than the corresponding blue transitions 1–6 to reflect the poorer prognosis associated with delayed diagnosis and treatment.

Result

The ICER for DeepBT®-assisted MRI interpretation was national Taiwan dollar (NTD) 2,243,160 per QALY, below the predefined WTP threshold of NTD 2,336,000 per QALY. PSA demonstrated a 99.2% probability of cost-effectiveness despite higher total costs, indicating robust results under parameter uncertainty. DSA indicated that findings were most sensitive to health utility values and costs associated with brain metastases, particularly BM-related utility and treatment costs. Scenario analyses varying transition probabilities, survival assumptions, time horizon, and discount rate consistently supported the base-case cost-effectiveness conclusion. Overall, DeepBT®-assisted MRI interpretation remained economically favorable across key uncertainty analyses.

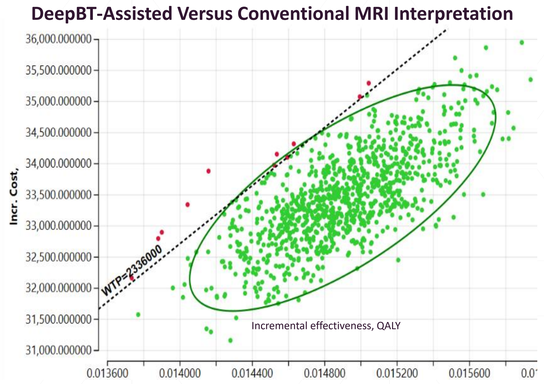

Figure 2. Incremental Cost-Effectiveness Scatterplot

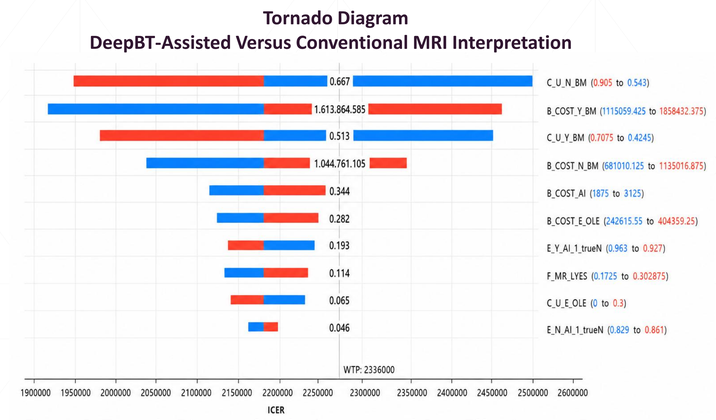

Figure 3. Tornado Diagram for the Incremental Cost-Effectiveness Ratio

Figure2: Green and red dots indicate cost-effective and non–cost-effective simulations, respectively.

Figure3:BM: brain metastasis; MRI: magnetic resonance imaging; C_U_N_BM: utility value for patients without BM; B_COST_Y_BM: treatment cost for patients with BM; C_U_Y_BM: utility value for patients with BM; B_COST_N_BM: treatment cost for patients without BM; B_COST_AI: cost of DeepBT; B_COST_EOL: end-of-life cost; E_Y_AI_trueN: true-negative value when AI-assisted interpretation is used; F_MRI_BM: frequency of MRI among patients with BM; F_MR_YES: frequency of MRI among patients with BM; C_U_E_EOL: end-of-life utility value; E_N_AI_trueN: true-negative value when AI-assisted interpretation is not used.

Table1. Base-Case and Scenario Analyses of DeepBT Cost-Effectiveness

Analysis	Scenario / Strategy	Incremental Cost (NT$)	Incremental Life Years	Incremental QALYs	ICER (NT$/QALY)	Incremental Net Benefit (NT$)
Base-case analysis						
	Best fiteed efficacy distribution	33,431.10	0.015	0.015	2,243,160.42	1,383.64
	5-year time horizon, 3% discount rate					
Scenario analysis						
	Scenarios for efficacy parameters					
	Most optimistic survival distribution	96,663.30	0.042	0.042	2,292,906.79	1,816.71
	Most pessimistic survival distribution	17,394.28	0.010	0.010	1,766,235.91	5,611.17
	Scenarios for different time horizons					
	Extended time horizon: 15 years	30,233.00	0.014	0.014	2,195,132.26	1,940.14
	Scenarios for discount rate					
	Increased discount rate: 4%	31,666.15	0.015	0.015	2,121,286.37	3,205.20
	Increased discount rate: 5%	31,265.79	0.016	0.016	2,012,871.94	5,019.12

QALYs: quality-adjusted life-years; ICER: incremental cost-effectiveness ratio; NT$: New Taiwan dollar.

Conclusion

DeepBT®-supported brain MRI interpretation represents a cost-effective diagnostic strategy for patients with advanced NSCLC, with relevance for reimbursement decisions and routine clinical practice.

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