Beyond Cost and QALYs: Integrating the App Score to Improve Cost-effectiveness Analysis of Digital Health Technologies

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Navya Khanna, Anubhav Patel, John R. Cook | Peritia, Morrisville, NC, USA

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BACKGROUND

Digital Health Technologies (DHTs) - including mobile health applications, wearable devices, remote monitoring tools, digital therapeutics and telehealth platforms - are gaining broad population reach and are projected to triple in market size by 2028.[1,2] Increasing smartphone penetration, internet accessibility and demand for personalized healthcare have accelerated adoption of these technologies across patients, providers and payers.[3]

Despite this rapid growth, their economic evaluation remains a challenge. Traditional cost-effectiveness analysis (CEA) evaluates technologies using two core outcomes i.e., costs and quality-adjusted life years (QALYs). While these parameters remain fundamental, they may not fully capture the value for DHTs.[4] Unlike traditional CEA, the success of DHTs depends significantly on user-centric parameters i.e., user engagement, data privacy, technical stability etc. as specified in the table below.[5]

The "App Score" based on user review in real world or clinical trial is often considered to fairly represent the overall performance of an app.[6] This also provides an accessible and scalable summary measure that indirectly captures user-centric parameters.

Evaluation of Conventional Interventions and DHTs: Comparative Framework

Components	Conventional Interventions	Digital Health Technologies
Patient Role	Mostly passive recipient	Active participant
Evaluation Metrics	Costs, QALYs	Costs, QALYs, user engagement, user experience, data privacy, technical stability and content validity etc.
Data Source	Real-world data and clinical trials	Real-world data and clinical trials
Examples	Drugs, vaccines	Mobile apps, wearables, telehealth

OBJECTIVE

To develop three methodological approaches for incorporating the **"App Score"** into conventional cost-effectiveness analysis of DHTs, enabling a more comprehensive, user-inclusive value assessment to inform HTA and payer decisions.

METHODS

We explore the following 3 approaches for evaluating two DHTs, where DHT A is the new 'Intervention' and DHT B is the 'Comparator'.

Approach 1: 3-D Evaluation Framework

Traditional CEA evaluates interventions in a two-dimensional framework consisting of incremental costs and incremental QALYs and the resulting incremental cost-effectiveness ration (ICER). This approach expands the evaluation into a third dimension by incorporating the App Score as an additional value component along with the ICER. The decision rule depends on the following cases and is summarized in the table below:

- **Case 1:** If DHT A has a lower App Score and is not cost-effective, then DHT B is preferred.
- **Case 2:** If DHT A has a higher App Score and is cost-effective, then DHT A is preferred.
- **Case 3:** If DHT A has (i) a lower App Score but is cost-effective or (ii) a higher App Score but is not cost-effective, then the preferred DHT is not immediately clear. In these cases, decision-making should rely on **Approach 2** or **Approach 3** for further evaluation.

(Note: As typically measured, we have assumed a higher App Score represents better performance.)

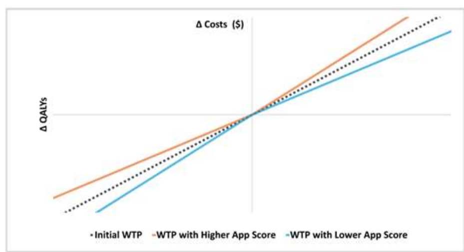
DHT Decision Matrix: Cost-effectiveness and the App Score

		Is DHT A Cost-effective?	
		No	Yes
App Score of DHT A (versus DHT B)	Lower	Prefer DHT B	Use Approach 2 or 3
	Higher	Use Approach 2 or 3	Prefer DHT A

Approach 2: WTP Threshold Adjustment

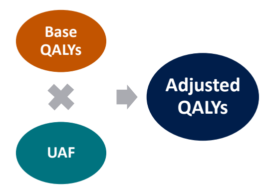
Traditionally, decisions are made by comparing the ICER against a willingness-to-pay (WTP) threshold. For decisions concerning DHTs, those with higher user engagements may justify additional value recognition. Therefore, the decision maker's WTP threshold is modified based on the App Scores.

Because the decision rule for cost-effectiveness differs for interventions in the NE quadrant (ICER < WTP) vs SW quadrant (ICER > WTP), the corresponding adjustment to the WTP must reflect an increase (orange line) or decrease (blue line) in the acceptance region for DHTs with higher or lower App Scores, respectively.



Approach 3: Utility Adjustment

This approach directly integrates the App Score into the effectiveness outcome by modifying base QALYs through a **Utility Adjustment Factor (UAF)** derived from the App's overall performance.[7]



For each DHT, the UAF is calculated as follows:

$$\textbf{Utility Adjustment Factor (UAF)} = 1 + \alpha * \left[\frac{\text{App Score} - \text{Average App Score}}{\text{App Score Range}}\right]$$

where α is a weight that contributes to the UAF and the Average App Score is the average of the scores for the "Intervention" and "Comparator".

Base QALYs for the DHT with the higher App Score will increase (UAF > 1) and will increase the incremental QALYs if the "intervention" App Score is higher and will decrease the incremental QALYs if lower. Decisions are based on the same WTP, but use of the UAF enables digital value to be reflected in the ICER.

RESULTS

We illustrate the three approaches using the following hypothetical data:

DHT	Cost ($)	QALYs	ICER ($/QALY)	App Score*
Intervention	8,000	0.80		4.7
Comparator	5,000	0.66		4.0
Incremental	3,000	0.14	21,429	0.7

** App Score is assumed to range from 0 to 5.*

Approach 1: 3-D Evaluation Framework

Assuming a WTP of $20,000/QALY, the Intervention is not cost-effective in the traditional analysis. However, because the Intervention has a higher App Score, this approach would require the decision maker to either adjust the WTP (Approach 2) or recalculate the ICER after adjusting the QALYs (Approach 3).

Approach 2: WTP Threshold Adjustment

This approach requires information on the relationship between the incremental App Score. While separate studies will be required to establish this relationship, we assume the following for illustration:

Change in App Score	Change in WTP Threshold
0.1	2%

Given the above, the decision rule is modified. The intervention is cost-effective (based on WTP of $20,000/QALY) if:

- ICER < 20,000 x [1 + (0.7 / 0.1) x 0.02] = 20,000 x 1.14 = 22,800 if ΔQALY > 0
- ICER > 20,000 x [1 – (0.7 / 0.1) x 0.02] = 20,000 x 0.86 = 17,200 if ΔQALY < 0

With the new thresholds, the Intervention is deemed cost-effective when incorporating the App Score, as the ICER (21,419) is less than the adjusted WTP (22,800) for ΔQALY (0.14) > 0.

Approach 3: Utility Adjustment

To implement this approach, α is required to calculate the UAF. As with Approach 2, a separate study(ies) would be needed to estimate α. For illustration purposes, we assume α = 0.2 in the following calculations of the UAF and adjusted QALYs:

DHT	QALYs	App Score	UAF	Adjusted QALYs
Intervention	0.80	4.7	1 + 0.2*[(4.7–4.35)/5] = 1.014	0.8112
Comparator	0.66	4.0	1 + 0.2*[(4.0–4.35)/5] = 0.986	0.6508
Incremental	0.14			0.1604

Based on the adjusted QALYs, recalculation of the ICER yields a value of $18,699/QALY. As the ICER is less than the WTP, the Intervention is deemed to be cost-effective when incorporating the App Score.

CONCLUSION AND NEXT STEPS

- We propose three methodological approaches to integrate App Score into the CEA of DHTs: (1) as an orthogonal decision dimension, (2) through threshold adjustment based on the App Score, and (3) through UAF applied to QALYs.
- Illustrative analyses demonstrate that incorporating App Score has the potential to meaningfully alter cost-effectiveness conclusions, especially in scenarios where competing DHTs show similar clinical outcomes but differ in user engagement and overall experience.
- However, to operationalize this framework, further empirical work is required. This includes establishing the construct validity of the App Score, calibrating the relationship between the WTP and App Score, estimating α through preference-based studies and extending the framework to comparisons between DHTs and non-digital interventions.
- In addition, uncertainty around the App Score should be formally incorporated into Probabilistic Sensitivity Analyses (PSAs) and Cost-effectiveness Acceptability Curves (CEACs), and the approach should ultimately be validated against real-world payer decision-making.

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Peritia, Morrisville, NC, USA | jcook@peritia.com | ISPOR US 2026