COMPARISON OF MARKOV AND DISCRETE EVENT SIMULATION MODELING TECHNIQUES WITH APPLICATION TO COST EFFECTIVENESS ANALYSES

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OBJECTIVES

To assess the bias introduced to absolute costs, absolute QALYs and the incremental cost effectiveness ratio (ICER) associated with Markov models, compared with discrete event simulation (DES) models. To investigate how such biases are a function of cycle length and half-cycle correction.

METHODS

A hypothetical three health state model was constructed in TreeAge Pro version 13.2 using both Markovian and DES approaches (Fig. 1). Four hypothetical treatment strategies were evaluated with varying probabilities of recovery and mortality and different treatment costs to assess the range of bias (Tbl. 1). Cost and utility were assigned to each health state and the ICERs between treatment strategies were estimated. Twenty-four Markov models using different cycle lengths (1 month, 3 month, 1 year), and with and without half cycle correction were constructed. Differences in the absolute costs and QALYs generated between each Markov model were compared with the DES approach, and the ICERs generated by each model were compared for each pair-wise scenario.

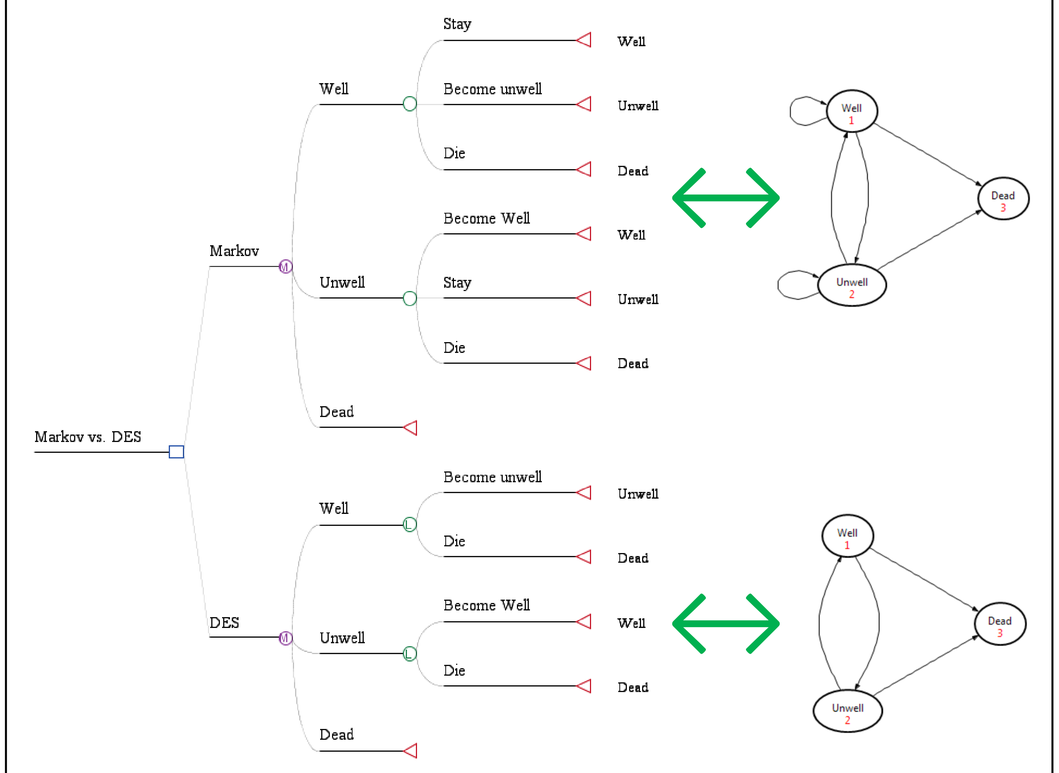


FIGURE 1

RESULTS

Markov model simulation was shown to introduce biases in the absolute costs and QALYs when compared with a DES approach Fig. 2,3,4. The bias was related to the duration of the time cycle with the results converging to the DES values as the time cycle was reduced. The initial bias in cost fell from 14% to less than 1%; QALY bias was consistently below 1%. The ICERs show bias between 2.2% and 9.7% when using a 1 year cycle and between 0.8%-0.9% when using a 1 month cycle (Table 2). The half-cycle correction reduced absolute bias from 12%-1% for Effectiveness, 13% - 12% for Cost and the ICERs were not affected for 1 year cycle length (Table 3). For shorter time cycles the ICERs were less biased and very similar suggesting that importance of HC diminishes with shorter time cycles.

Impact of Time Cycle on Bias of Markov vs. DES models

Input Parameters

	Cost Of Unwell State	Cost of Well State	Prob Unwell to Dead	Prob Unwell to Well	Prob Unwell to Unwell	Prob Well to Dead	Prob Well to Unwell	Prob Well to Well	Utility Well	Utility Unwell
Strategy 1	100	5	0.300	0.050	0.650	0.100	0.200	0.700	0.95	0.60
Strategy 2	120	5	0.280	0.075	0.645	0.100	0.200	0.700	0.95	0.60
Strategy 3	200	5	0.250	0.090	0.660	0.100	0.200	0.700	0.95	0.60
Strategy 4	150	5	0.280	0.080	0.640	0.100	0.200	0.700	0.95	0.60

TABLE 1

ICER Differences

Markov vs DES ICER % Changes	Markov Model Cycle Length		
	1 Year	1 Quarter	1 Month
Strat 2 v 1	+2.23%	+0.12%	+0.91%
Strat 4 v 2	+4.04%	+7.84%	+0.87%
Strat 4 v 1	+5.05%	+1.34%	+0.89%
Strat 3 v 1	+6.72%	+1.56%	+0.82%
Strat 3 v 2	+9.74%	+2.59%	+0.90%
Strat 3 v 4	+8.87%	+1.86%	+0.80%

TABLE 2

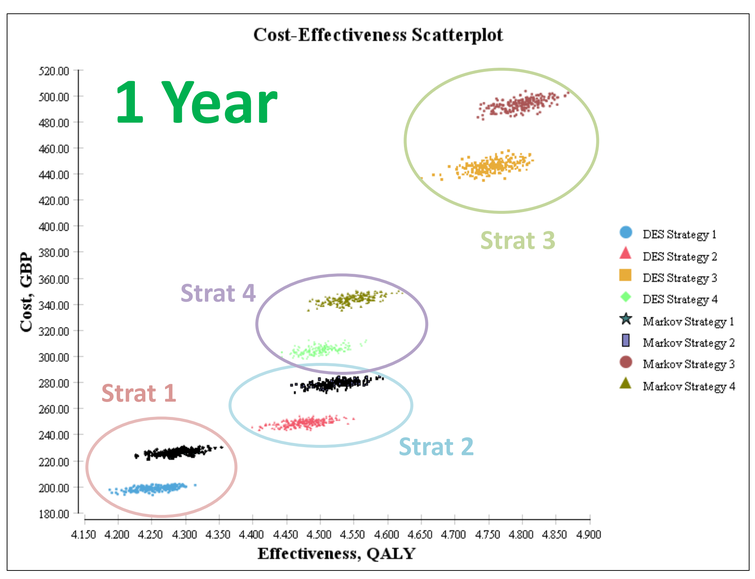


FIGURE 2

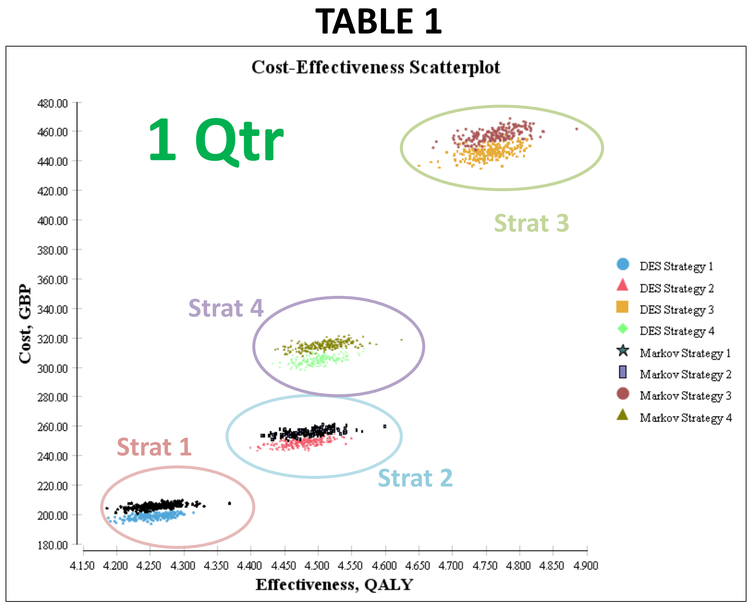


FIGURE 3

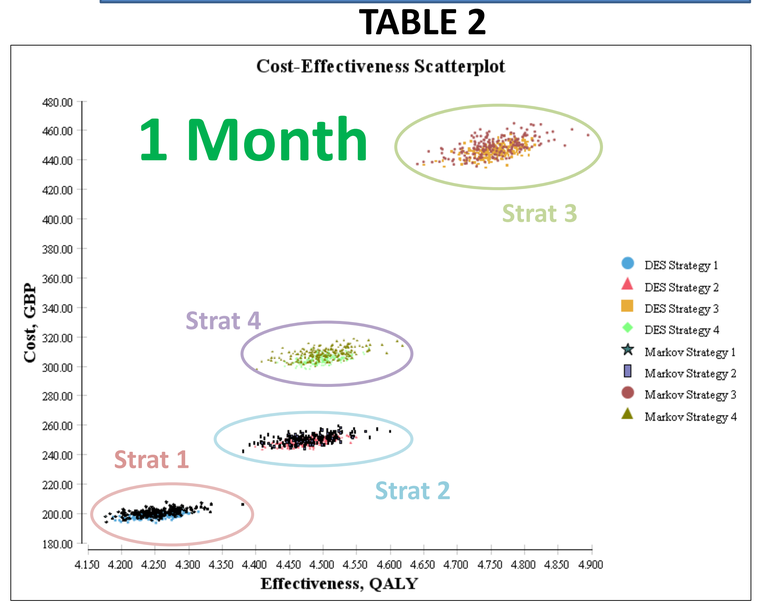
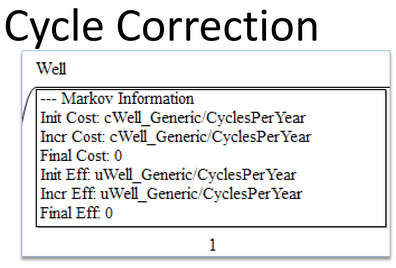


FIGURE 4

Impact of Half Cycle Correction

Markov information without Half Cycle Correction

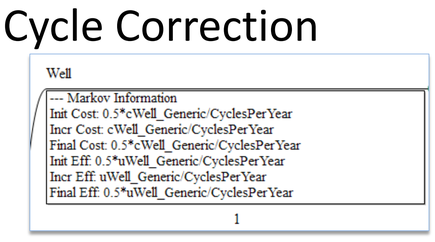


Cost, Effectiveness and ICER Results

Cycle Length	Average Bias Across 4 Markov Strategies vs. DES					
	No Half Cycle Correction			With Half Cycle Correction		
	Cost	Effect.	ICER	Cost	Effect.	ICER
1 Year	13.36%	11.52%	6.11%	12.45%	0.94%	6.11%
1 Qtr	3.35%	2.83%	1.78%	3.12%	0.19%	2.55%
1 Month	1.07%	0.92%	0.85%	0.99%	0.04%	0.87%

TABLE 3

Markov information with Half Cycle Correction



CONCLUSIONS

Markov models introduce bias due to the simplifying assumptions of fixed cycle length and half cycle correction; DES models do not suffer the same biases. Markov models in this study introduced positive ICER bias relative to DES models. It is suggested that when the ICERs produced are close to commonly reported cost-effectiveness thresholds, Markov models should be analyzed with a shorter cycle length or by adopting a DES approach to ensure conclusions are robust.

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