

# Equal Value of Life-Years Gained: Comparison of Methodologies for a Cohort Markov Model

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## BACKGROUND

- The quality-adjusted life-year (QALY) outcome has a well-established role in cost-effectiveness (CE) analyses of new health technologies due to its ability to capture both quantity and quality of life.<sup>1</sup>
- Despite these advantages, stakeholders have expressed concern that use of the QALY may discriminate against patients with lower quality of life, thus restricting access to life-prolonging treatments for these patients.<sup>2,3</sup>
- The equal value of life-years gained (evLYG) outcome, which replaces condition-specific utility values with a general population utility for all incremental life-years (LYs) due to a new health technology, has been proposed as an alternative.<sup>4</sup>
- While the evLYG outcome has been described conceptually and implemented in economic evaluations,<sup>5,6</sup> the specific methodology for estimating the evLYG outcome, particularly in cohort models where outcomes are not modeled on an individual patient level, has not been well described.
- Furthermore, we did not identify any studies in the published literature describing the extension of the evLYG concept to outcomes such as caregiver quality of life that are included in current value frameworks.<sup>7</sup>



## OBJECTIVE

This study describes and compares potential methods for estimating the evLYG outcome for a cohort Markov CE model and evaluates extending the approaches to caregiver disutilities.

## METHODS

- We propose two methods to estimate the evLYG outcome for a cohort model based on when incremental LYs are considered to be accrued:
  - Only after cumulative LYs for the new technology exceed total cumulative LYs for the comparator (evLYG1)
  - In all years based on annual incremental LYs (evLYG2)
- The mathematical formulas for estimating the evLYG outcome using the evLYG1 and evLYG2 methods from traditional LY and QALY outcomes for two hypothetical treatments are presented in Table 1.
  - After assigning a general population utility value to incremental LYs in a given model cycle (estimated according to the respective methods), an approach is required for assigning utility values to the remaining LYs in that cycle.
  - For both the evLYG1 and evLYG2 methods, we assumed that the health state utilities would be applied in the same proportion reflected in the traditional QALYs accrued by the new technology in the given cycle.
- To compare these methods, we developed a hypothetical Markov model for a progressive disease with three health states (mild disease, severe disease, and death) (Figure 1) and used the model to conduct a CE analysis for a treatment for mild disease compared with no treatment.
- The assumed model parameters for disease progression, treatment effect, costs (disease and treatment), and quality of life (patient and caregiver) are presented in Table 2.
- To implement the evLYG methods, a general population utility value of 0.90 was assumed for the incremental LYs estimated for the evLYG1 and evLYG2 alternatives. When extending the evLYG methods to caregiver utilities, no caregiver disutility was applied during the incremental LY periods.
- The model was used to estimate incremental CE ratios (ICERs) for the QALY, for the evLYG1 and evLYG2 methods applied only for patient utilities, and for the evLYG1 and evLYG2 methods extended to caregiver disutilities.
- To assess the generalizability of our findings, scenario analyses were conducted for alternative utility values for the disease states and the general population.

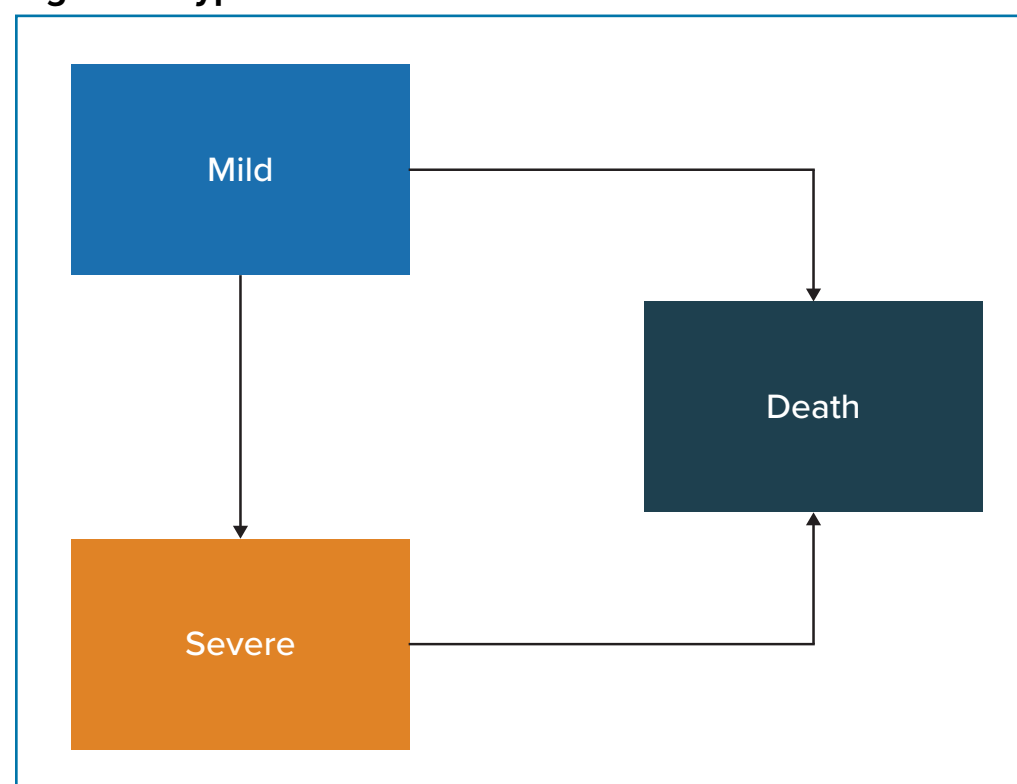
**Table 1. Methods for Estimating the Equal Value of Life-Years Gained Outcome**

LY outcomes from cohort Markov calculations for two treatment arms (A vs. B)	
$LY_t^A$ = discounted LYs for treatment A in model cycle $t$	Assume treatment A improves survival in each cycle (i.e. $LY_t^A \geq LY_t^B$ for all $t$ )
$LY_t^B$ = discounted LYs for treatment B in model cycle $t$	
Formulas for incremental LYs in model cycle $t$ ( $\Delta LY_t$ ) for evLYG1 and evLYG2	
$\text{evLYG1: } \Delta LY_t^A = \begin{cases} 0 & \text{if } \sum_{i=1}^t LY_i^A \leq \sum_{i=1}^t LY_i^B \\ LY_t^A & \text{if } \sum_{i=1}^t LY_i^A > \sum_{i=1}^t LY_i^B \end{cases}$	Incremental LYs accrued only after cumulative LYs for treatment A exceed total cumulative LYs for treatment B <sup>a</sup>
$\text{evLYG2: } \Delta LY_t^A = LY_t^A - LY_t^B$	Incremental LYs accrued in all years
Formulas for evLYG outcomes <sup>b</sup> for treatment A in model cycle $t$ (evLYG <sub>t</sub> <sup>A</sup> )	
$\text{evLYG1}_t^A = \Delta LY_t^A \cdot U_{GP} + \frac{LY_t^A - \Delta LY_t^A}{LY_t^A} \cdot QALY_t^A$	Where $U_{GP}$ is the general population utility value and $QALY_t^A$ represents the discounted patient QALYs for treatment A in model cycle $t$
$\text{evLYG2}_t^A = \Delta LY_t^A \cdot U_{GP} + \frac{LY_t^A - \Delta LY_t^A}{LY_t^A} \cdot QALY_t^A$	

<sup>a</sup> Total cumulative LYs for treatment B should be estimated over the appropriate model horizon (cycle  $\infty$  in the summations reflects a lifetime horizon). When cumulative LYs for treatment A pass total cumulative LYs for treatment B in the middle of a cycle, an appropriate partial cycle adjustment should be made.

<sup>b</sup> The evLYG formulas presented are for patient utilities only. Similar formulas can be used for caregiver disutilities by replacing the general population utility with an appropriate caregiver disutility (e.g., 0) for incremental LYs.

**Figure 1. Hypothetical Model Structure**



Note: The model used an annual cycle length with half-cycle correction over a lifetime horizon.

**Table 2. Hypothetical Model Parameters**

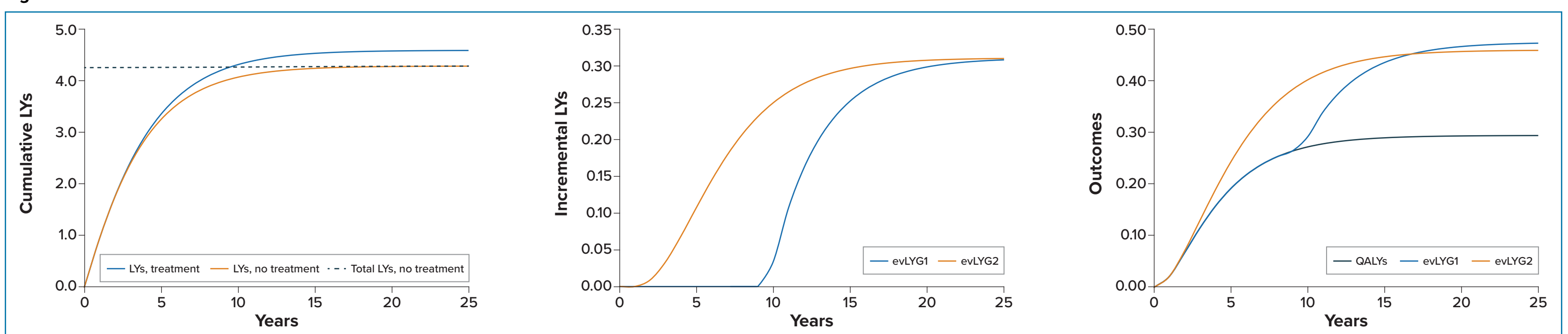
Parameter	Values	
Annual transition probabilities		
Mild to severe	0.40	
Mild to death	0.10	
Severe to death	0.25	
Treatment parameters		
Reduction in progression from mild to severe	30%	
Annual cost (mild only)	\$10,000	
Annual costs		
Mild	\$6,000	
Severe	\$20,000	
Utility values		
	Patient	Caregiver (disutilities)
Mild	0.75	-0.10
Severe	0.50	-0.20

Note: Model outcomes were discounted at a rate of 3.0% per year.

## RESULTS

- In our hypothetical comparison, the distinction between evLYG methods in the timing of when incremental LYs were accrued to the treatment translated to differences in the estimates for evLYG1 and evLYG2 over time (Figure 2).
- The difference between the estimates for the evLYG1 and evLYG2 methods could be explained by the shifting balance between mild and severe disease utility values being replaced by the general population utility over time.
  - Early in the horizon, when the incremental LYs for evLYG2 began accruing, the general population utility was replacing QALYs weighted more toward the mild disease utility value.
  - In contrast, the incremental LYs for evLYG1 began accruing later in the horizon, where the general population utility was replacing QALYs weighted more toward the severe disease utility value.
- The traditional CE outcomes, evLYG outcomes for each method, and associated ICERs over a lifetime horizon are presented in Table 3.
- For the analysis applying the evLYG1 and evLYG2 methods to patient utilities only, the resulting ICERs were \$62,580/QALY gained, \$44,497/evLYG1 gained, and \$45,767/evLYG2 gained.
- Extending the evLYG1 and evLYG2 methods to include caregiver disutilities had a greater impact on the ICERs (reduced to \$38,848/evLYG1 gained and \$40,212/evLYG2 gained) than the choice between methods.
- In scenario analyses, the impact of the evLYG outcome methods compared with traditional QALY-based analyses increased when the difference between the general population utility value and the health state utility values was larger (Scenarios 2 and 3 in Table 4).
- The difference between the two evLYG outcome methods was influenced both by the utility difference between disease health states and by the utility difference between the general population and the disease states (Table 4).
  - The larger the difference between the utility values for the general population and the disease states, the smaller the difference between the ICERs for the evLYG1 and evLYG2 methods (Scenarios 1 and 2).
  - The larger the difference between the utility values for mild and severe disease, the larger the difference between the ICERs for the evLYG1 and evLYG2 methods (Scenarios 3 and 4).

**Figure 2. Cumulative and Incremental LY Outcomes Over Time**



**Table 3. Model Outcomes**

Traditional CE Outcomes	No Treatment	Treatment	Incremental
LYs	4.275	4.585	0.309
QALYs	1.793	2.088	0.295
Costs	\$65,103	\$83,555	\$18,452
Incremental cost per QALY gained		\$62,580	
Comparison of evLYG Outcomes		evLYG1	evLYG2
evLYG (incremental) for Treatment <sup>a</sup>			
Applied to patient utilities only	2.207 (0.415)	2.196 (0.403)	
Applied to patient and caregiver utilities	2.268 (0.475)	2.252 (0.459)	
Incremental cost per evLYG gained			
Applied to patient utilities only	\$44,497	\$45,767	
Applied to patient and caregiver utilities	\$38,848	\$40,212	

<sup>a</sup> By definition, the evLYG outcome for No Treatment (i.e., the arm with lower LYs) equals the QALY outcome for No Treatment.

**Table 4. Scenario Analysis Results**

Scenario Inputs	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Utility values					
Mild disease	0.75	0.75	0.75	0.65	0.85
Severe disease	0.50	0.50	0.50	0.50	0.50
General population	0.90	0.80	1.00	0.90	0.90
Scenario Results <sup>a</sup>					
ICERs (\$/outcome)					
QALY gained	\$62,580	\$62,580	\$62,580	\$77,817	\$52,333
evLYG1 gained	\$44,497	\$48,083	\$41,409	\$51,470	\$39,188
evLYG2 gained	\$45,767	\$49,569	\$42,506	\$52,481	\$40,576
Differences in ICERs					
evLYG1 vs. QALY	-\$18,083	-\$14,497	-\$21,171	-\$26,347	-\$13,145
evLYG2 vs. QALY	-\$16,813	-\$13,011	-\$20,074	-\$25,336	-\$11,757
evLYG1 vs. evLYG2	-\$1,270	-\$1,486	-\$1,097	-\$1,010	-\$1,388

<sup>a</sup> The scenario analyses were conducted using the evLYG1 and evLYG2 methods applied to patient utilities only.

## CONCLUSIONS

- This study illustrates methodological considerations for implementing the evLYG outcome in cohort models and highlights the impact on CE results of extending the approach to caregiver disutilities.
- This comparison of proposed methods for the evLYG outcome in cohort Markov models provides a basis for future research examining approaches to operationalizing the evLYG outcome in other modeling approaches, such as decision trees and patient-level simulations.
- Detailing methods for estimation of the evLYG outcome in future model publications will improve the transparency and reproducibility of results. Similarly, as value frameworks continue to evolve, it would be beneficial for researchers and stakeholders to assess the appropriateness of extending the evLYG concept to other outcomes.

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