ISPOR Europe 2024 Acceptance Code: MSR86

syreon Middle East

Tradeoffs in Cohort vs. Patient-Level Markov Simulation Models in Economic Evaluations

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OBJECTIVE

Health economic modelers often face a decision between using a cohort-based or individual-level simulation approach, yet no definitive guidelines exist to inform this choice. This study examines the practical trade-offs between cohort (CH) and patient-level (PL) Markov simulation models within the context of a cost-effectiveness analysis framework.

METHODS

Model structure and assumptions

An eight-state disease model was developed for a hypothetical neurological disorder. The model horizon was selected as two years to capture different outcomes and costs. The model was incorporated two phases; an initial six-week phase with weekly cycles transition, followed by 12-week cycles. The treatment pathways included the first- and second-line treatments. The model allowed switching from first-line therapy to second line but not the opposite.

Data inputs and model design

Both CH and PL models were constructed using identical data and assumptions to assess disease progression and therapy switching. The CH model inputs were the mean patient characteristics (e.g., age), while in the PL model, patients' characteristics were sampled from the corresponding probability distributions using the mean values used in the CL model. Both models were developed in the same Microsoft Excel file. PL involved 10,000 iterations for each patient.

Analysis Techniques

Heat Maps were used for cross-validating patient pathways across both models. Also, deterministic (DSA) and probabilistic (PSA) sensitivity analyses were conducted on parameters such as utility values and cost assumptions. Moreover, comparative assessments across health states was done to ensure model accuracy.

RESULTS

Model performance and patient pathways

The base case incremental cost-effectiveness ratios (ICER) were similar in both models, with only minor variations due to stochastic factors in the PL model. Additionally, Net Monetary Benefit (NMB) was used due to its linearity, which provides a more straightforward and flexible measure compared to ICER

The heat maps revealed some computational errors (darker cells in figure 1) that were corrected (as shown in figure 2).

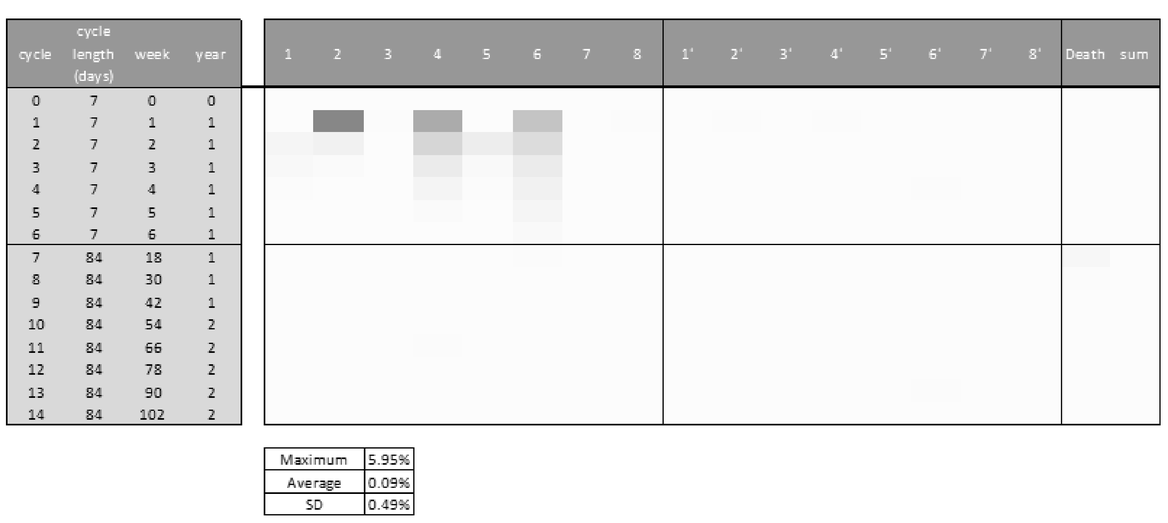

Figure 1: Treatment arm where a systematic computational error is evident

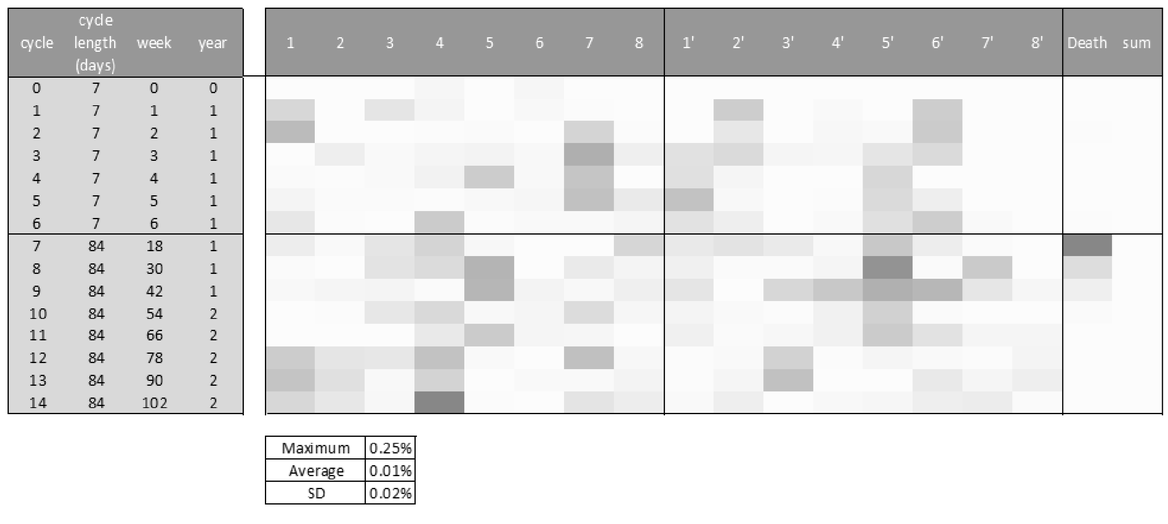

Figure 2: Treatment arm after correcting the error.

Variability & Sample Size Impact

In PL model, NMB variability was reduced with increased sample sizes, where 10,000 patients achieved optimal balance between accuracy and computational burden (measured by the coefficient of variation - CV), as shown in figure 3 and figure 4.

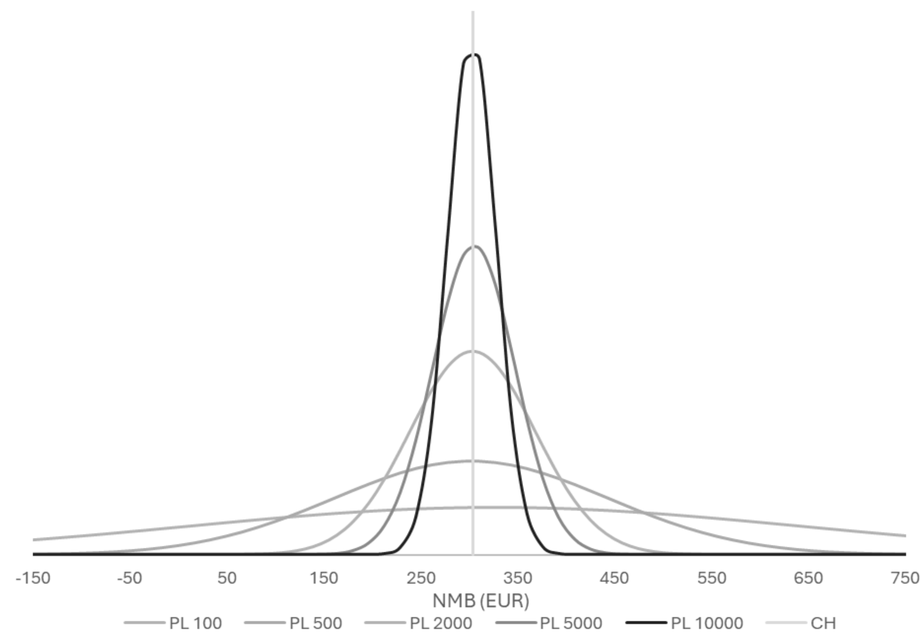

Figure 3: Probability distribution functions (PDFs) for net monetary benefit (NMB) from patient-level (PL) simulations compared to the cohort-based (CH) deterministic result.

Computation time

In PL model, computation times (for the model base case and sensitivity analyses) increase with increasing the sample size.

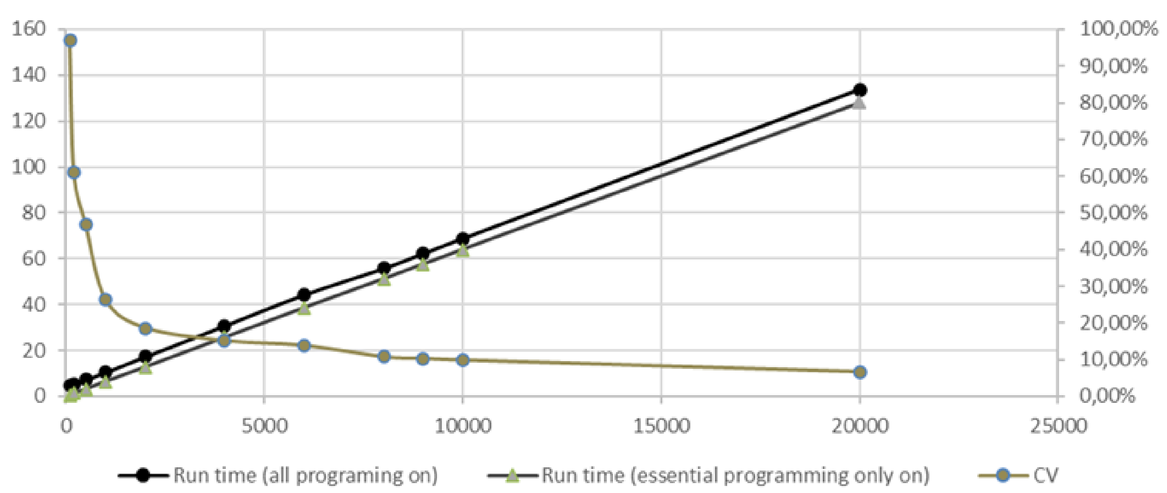

Figure 4: Average computation times for different sample sizes in the PL model.

Non-Quantifiable differences

While CH models are more straightforward, they are limited in their ability to accommodate complex pathways. Both models were transparent; CH model can be more transparent when the structure is simple. Validating the equations was more time-consuming in the CH model, while tracing the patients' pathways was more time-consuming in the PL model.

DISCUSSION

PL models offer superior adaptability for patient pathways and complex treatment scenarios. CH models excel in deterministic scenarios, while PL models require advanced programming and computational resources. Cross-validation with heat maps enhances model accuracy, particularly in complex disease states.

CH and PL models both offer the same results. The choice between CH and PL ultimately depends on factors such as disease complexity, input data variability, and specific economic evaluation goals.

ACKNOWLEDGMENTS AND FUNDING

Funding source: Supported by the Horizon EU IMMUTOL project, grant number 101080562.

Conflict of interest: None declared by authors