VBA and R to Automate Health Economic Model Programming

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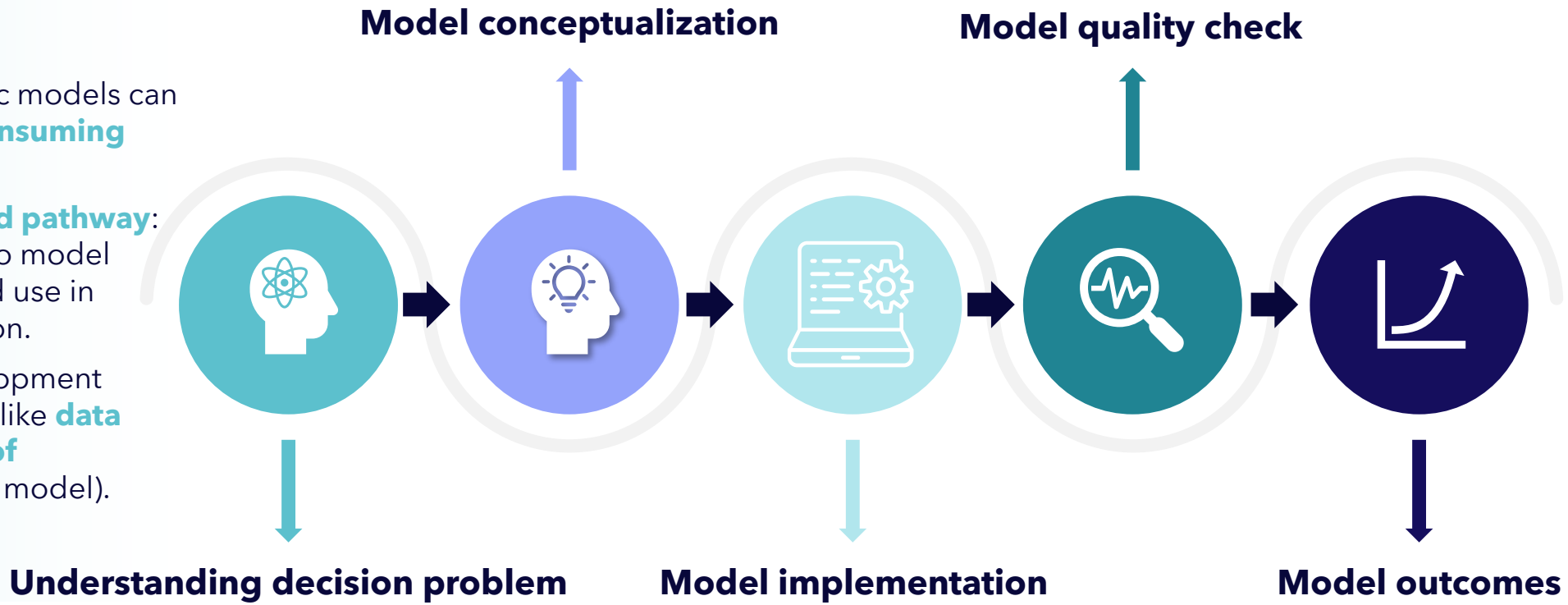
Background

Model Development Process **in Theory**

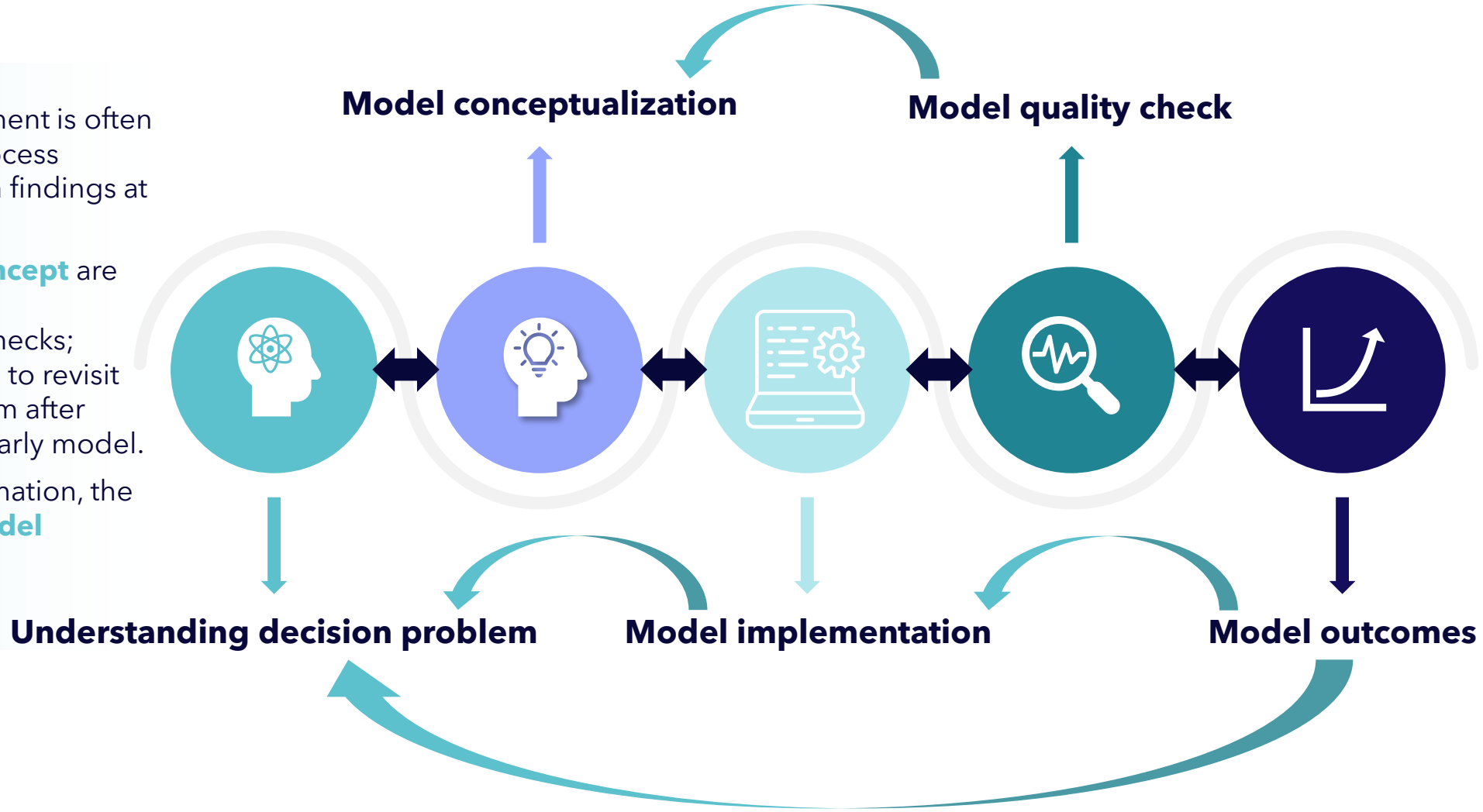
- Developing health economic models can be a **time- and resource-consuming process**.
- It typically follows a **standard pathway**: from the decision problem to model design, implementation, and use in healthcare resource allocation.
- The robustness of the development process depends on factors like **data availability and the stage of development** (early vs core model).



Background

Model Development Process **in Reality**

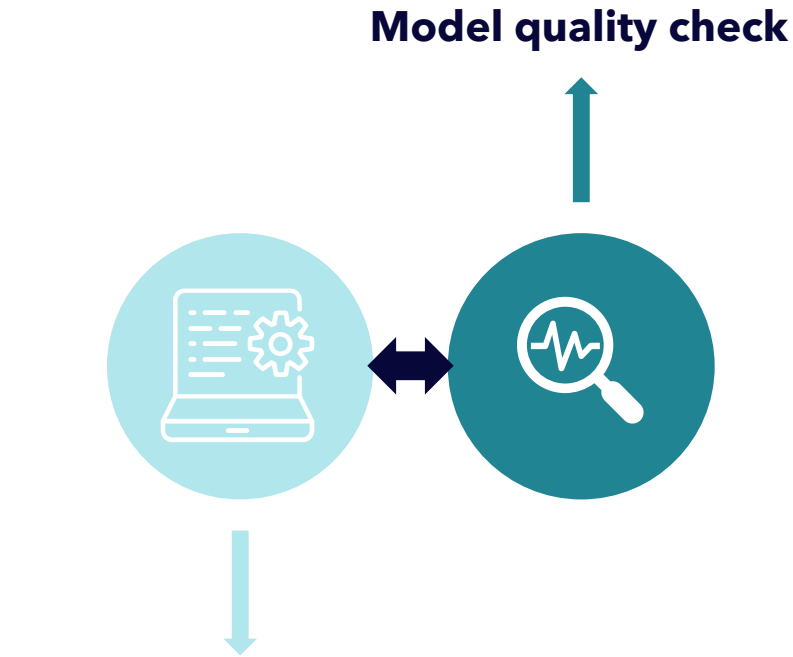
- In practice, model development is often **more complex**, with the process frequently iterated based on findings at each stage.
- **Revisions to the model concept** are commonly needed after implementation or quality checks; however, it's not uncommon to revisit the original decision problem after reviewing the results of an early model.
- In an era of increasing automation, the question arises: **can the model development process be accelerated?**



Objective

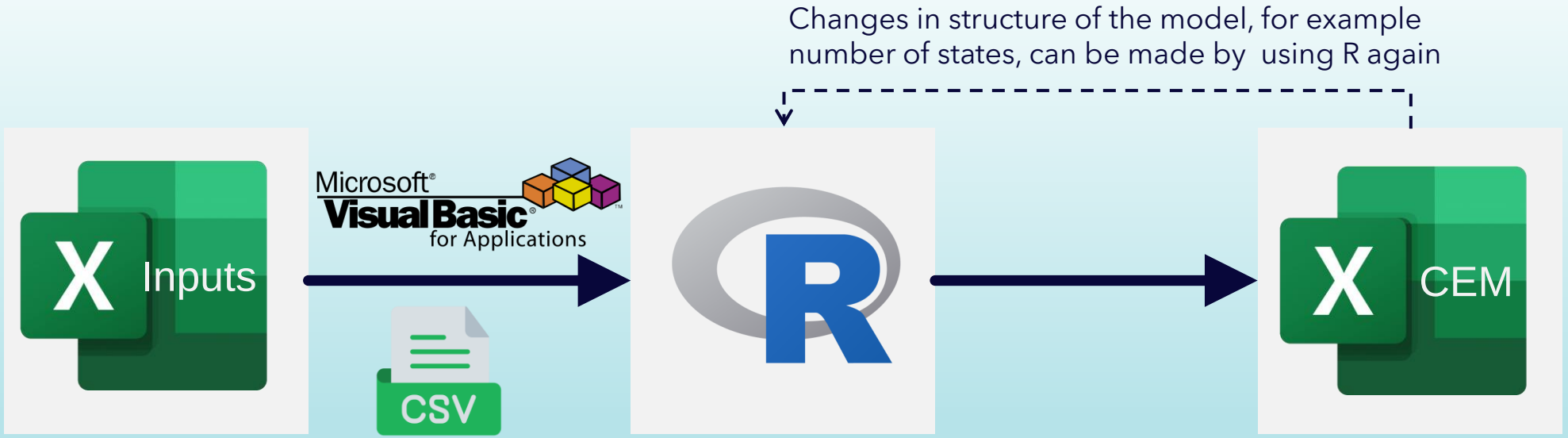
Model Development Process **Facilitated with New Tools**

- We aimed to explore the potential of a Microsoft (MS) Excel-based **tool for automation** of cost-effectiveness models programming.
- New tools, often powered by AI, are emerging to support model development, though their usefulness varies by development stage and remains under evaluation.
- Taking a **pragmatic approach**, we focused on creating a **practical tool** – the Model Generator.
- We used VBA and R, well-established languages in model development, to produce models in **MS Excel**, which remains the **standard format** for country submissions.



Methods

Workflow of Model Generator



The tool is based on a fully deterministic algorithm, meaning it always produces the same results for a fixed input!

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Methods

Key Assumptions

MARKOV MODEL

1. Each cycle, patients may stay in their health state or transition to another health state.
2. Patients can experience health events within each health state.

HEALTH STATES

1. To model main events having an impact on survival and risk of subsequent events.
2. Mutually exclusive, i.e. patient can be in only one health state at a time.
3. Defines patient's pathway.

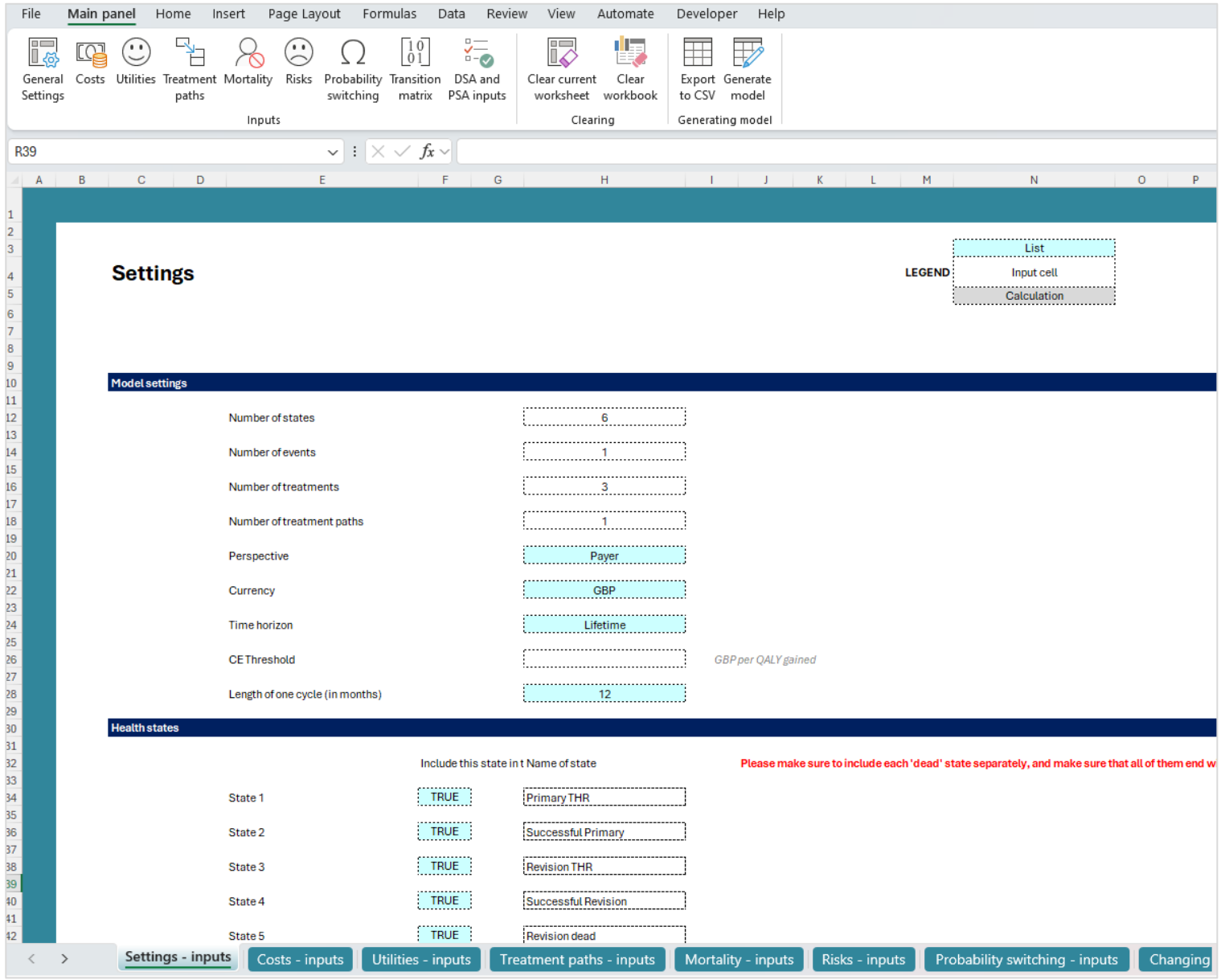
HEALTH EVENTS

1. To consider events having no impact on survival and risk of subsequent events.
2. Have impact only on costs and quality of life for a certain duration.
3. Multiple events can occur in the same cycle.

Methods

Model Inputs

- **The input file** is an MS Excel file with macros – it looks and **works like data collection sheet**, with some user-friendly features.



Methods

Stand-alone Excel Model

- The file with a generated model contains the same worksheets as input file together with Markov traces and results.
- The file is a **stand-alone model** – it does not need R to work, it **contains all the necessary formulas that are fully adjustable by hand.**

cycle	Mortality (probability)	Mortality (rate)	Mortality (rate), with SMR	Probability from Successful Prim	Probability from Successful Rev
1	0.00099	0.00099049	0.00099049		0.00099
2	0.00099	0.00099049	0.00099049	0.000949573	0.00099
3	0.00099	0.00099049	0.00099049	0.00165078	0.00099
4	0.00099	0.00099049	0.00099049	0.00208719	0.00099
5	0.00099	0.00099049	0.00099049	0.002432976	0.00099
6	0.0026	0.002603386	0.002603386	0.002727319	0.0026
7	0.0026	0.002603386	0.002603386	0.002987384	0.0026
8	0.0026	0.002603386	0.002603386	0.003222528	0.0026
9	0.0026	0.002603386	0.002603386	0.003438518	0.0026
10	0.0026	0.002603386	0.002603386	0.003639202	0.0026
11	0.0026	0.002603386	0.002603386	0.003827298	0.0026
12	0.0026	0.002603386	0.00		
13	0.0026	0.002603386	0.00		
14	0.0026	0.002603386	0.00		
15	0.0026	0.002603386	0.00		

Cohort without half cycle correctio

Treatment Standard

Primary THR	Successful Primary	Revision THR	Successful Revision
1	0	0	0
0	0.98	0	0
0	0.977412036	0.001617764	0
0	0.974404354	0.002040044	0.001583807
0	0.971068991	0.002434055	0.003516111
0	0.965895796	0.002789059	0.00574537
0	0.960498966	0.003115316	0.008226644
0	0.954906434	0.0034243	0.010921099
0	0.949140214	0.003720307	0.013802771
0	0.943218337	0.004006223	0.016851001
0	0.937155992	0.004284018	0.020048831
0	0.930966253	0.004555086	0.02338195
0	0.924660569	0.00482045	0.02683802
0	0.9182491	0.005080873	0.030406228
0	0.911740962	0.005336939	0.034076968

Cost-effectiveness analysis results

Undiscounted

	Standard	NP1	NP2
Costs	1982	735	719
QALYs	32.066	32.946	32.987
LYs	38.269	38.823	38.83
Incremental Costs	N/A	-1247	-1264
Incremental QALYs	N/A	0.881	0.922
Incremental LYs	N/A	0.554	0.562
ICER	N/A	Dominant	Dominant
evLYs	32.066	33.03	33.072
evLYGs	0	0.964	1.006

Discounted

	Standard	NP1	NP2
Costs	530	354	421
QALYs	11.39	11.463	11.47
LYs	27.826	28.14	28.145
Incremental Costs	N/A	-175	-109
Incremental QALYs	N/A	0.073	0.08
Incremental LYs	N/A	0.315	0.319
ICER	N/A	Dominant	Dominant
evLYs	11.39	11.649	11.659
evLYGs	0	0.259	0.269

matrix - inputs | DSA-PSA inputs | Named_ranges | M trace - Standard | M trace - NP1 | M trace - NP2 | Results

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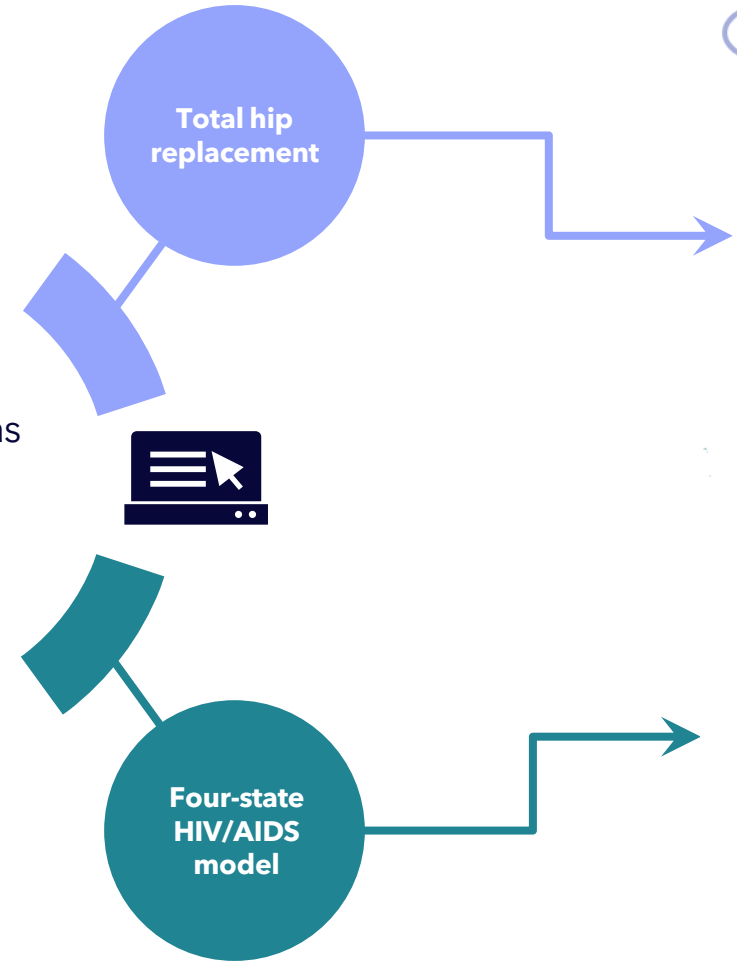
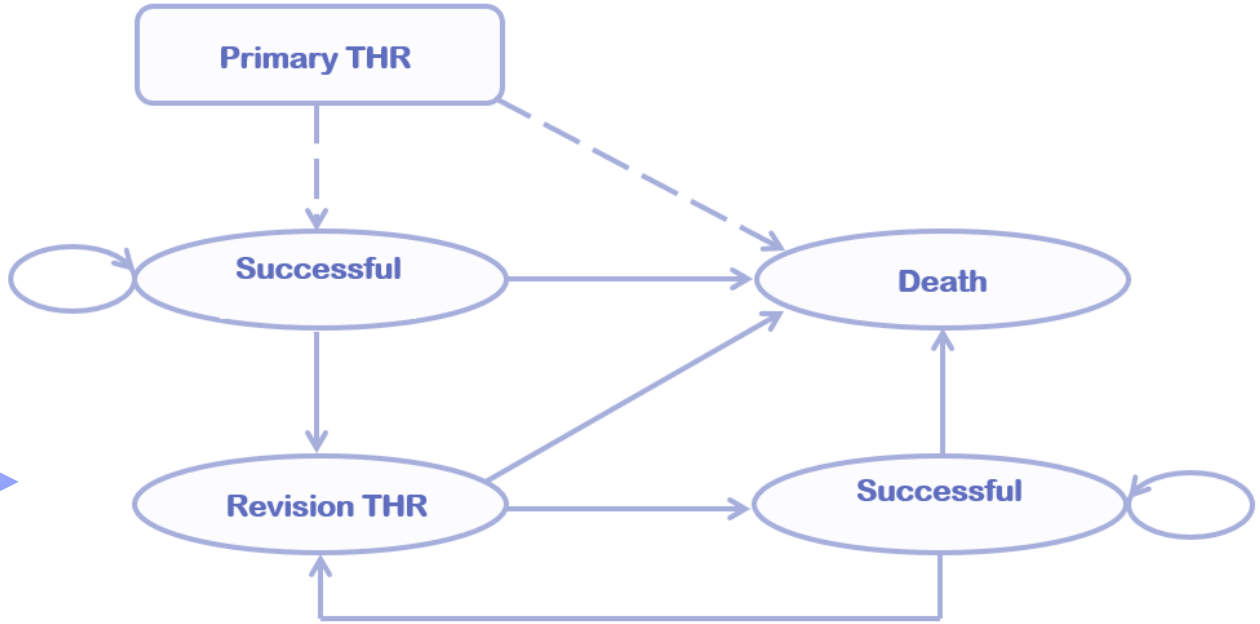
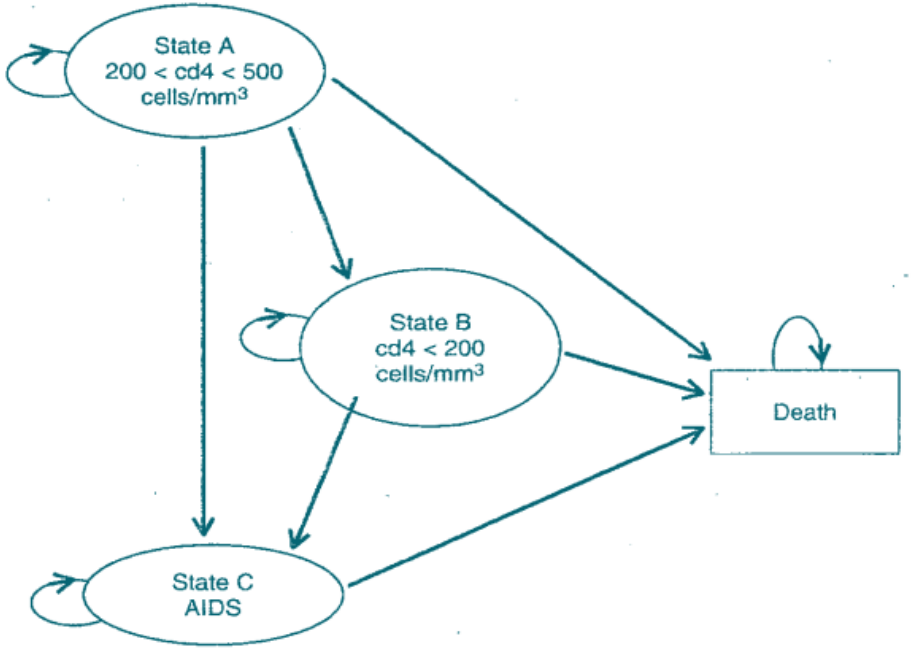
Methods

Model Generator in Practice

The model generator was employed to replicate 2 Markov models







Briggs, Andrew, Mark Sculpher, and Karl Claxton. 2006. *Decision modelling for health economic evaluation*. Oxford: Oxford University Press. ISBN 978-0198526629.

Methods

Performance assessment

- Do the results of the replicated models **align with the original outcomes**?
  - Total and incremental costs
  - Total and incremental QALYs and LYs

- How **useful and reliable** the generated model is?

- **How much time** did it take to generate the model?

Results

Successful replication

- The model generator successfully replicated both models **on the first attempt.**
- The results of the replicated models **matched perfectly** those of the manually programmed models.

Saved time

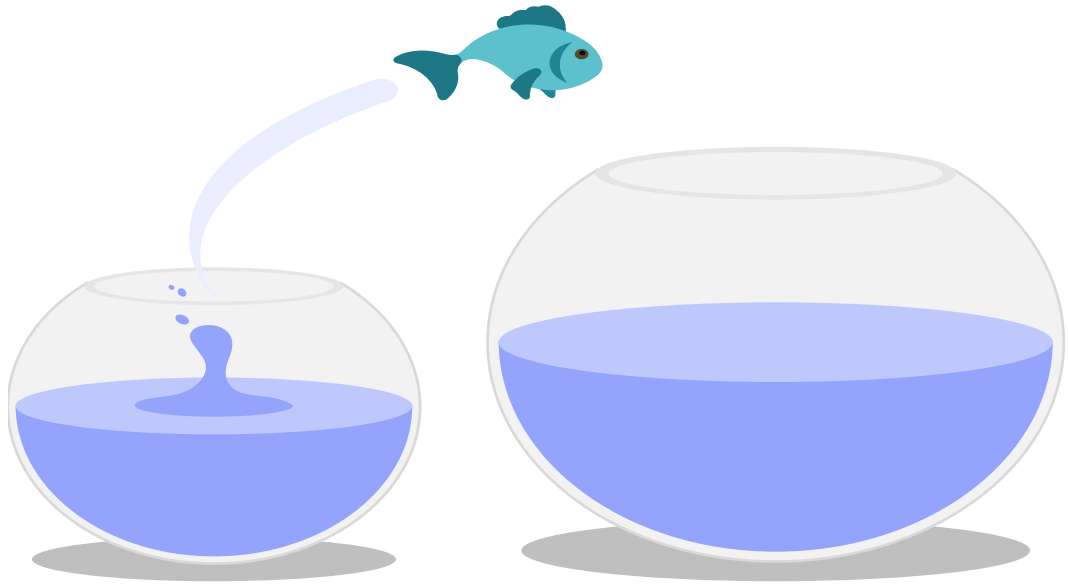
- The automated programming process for these models took **90 minutes** in the first example and **28 minutes** in the second example.

Error-free

- The replicated models were **error-free** and **fully functional**.
- Both models included **predefined, well-structured, and properly formatted** inputs, results, and parameter settings.
- They were capable of performing both **probabilistic and deterministic sensitivity analyses**.

Conclusions & Next Steps

- Utilizing the generator was relatively **fast, straightforward, and intuitive**.
- **Decreases risk of a human error** while being fully deterministic.
- **Increases confidence** in the produced results without the need for repeated testing.
- While AI may surpass this approach in the coming years, for now the generator **can serve as a viable compromise between manual model programming and its automation**.



Use in Practice & Improve

One practical use of the Model Generator is for QC of models, a practice that is becoming increasingly common.

EE491: Automating Health Economic Model Quality Check With a Model Generator
Poster Session: Poster Session 5
Session Date/Time: Friday, May 16, 9:00 - 11:30 AM
Discussion Period: 9:00 - 10:00 AM
Session Location: Poster & Exhibit Hall 220B-E

User Friendly Interface

Our ambition is to make the Model Generator widely accessible for non-programmers.

ISPOR Europe 2025
9-12 NOVEMBER 2025 | GLASGOW | SCOTLAND

To be ready for ISPOR EU!

Thank you!

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