A Scoping Review of Resource Modelling in HTA using Discrete Event Simulation

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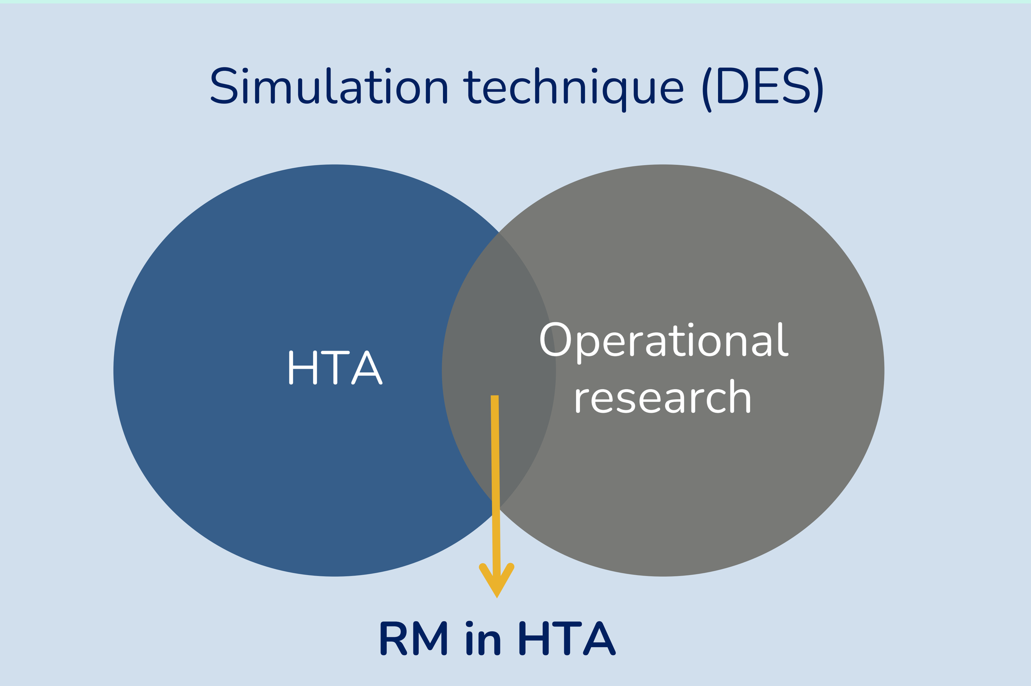
BACKGROUND

Context: In health technology assessment (HTA), resource modelling (RM) refers to explicitly capturing how limitations in resources, such as hospital beds, doctors, and nurses affect the delivery of care. Discrete event simulation (DES) is a powerful method to represent these constraints and is widely applied in operational research, but its use in HTA has been limited. Without RM, HTA models may fail to reflect real-world feasibility, overlooking issues like capacity bottlenecks that can delay or restrict the adoption of new technologies **(Figure 1)**.

Objective: To review the recent literature on DES for RM in HTA by:

1. Mapping applications across healthcare settings and resource types
2. Collate data on modelling methodology, assumptions and outcomes
3. Identifying gaps and areas for improved implementation

Figure 1: Integrating RM in HTA



Notes.

- HTA comprises of economic evaluation techniques, such as cost-effectiveness analysis (CEA), cost-utility analysis (CUA), and budget impact analysis (BIA), etc..
- Operational research simulates service delivery to optimize resources and reduce constraints, such as waiting time, long queues, etc.

METHODS

- A targeted literature review (TLR) was conducted to identify studies from the PubMed database that incorporated RM in HTA, with no country-specific restrictions applied. Following is the list of inclusion and exclusion criteria used for the review:

Inclusion criteria	Exclusion criteria
Discrete event simulation	Non-English publications
Resource constraint	Published prior 2019
Resource modelling	No cost analysis
Cost-effectiveness analysis (CEA)	Review/systematic review
Budget impact analysis (BIA)	

PubMed database (January 2019-April 2025) was searched to identify studies incorporating RM in HTAs.

- 219 records identified from database → 23 review/systematic review removed
- 196 records imported for screening → 186 records excluded based on title/abstract screening
- 10 records imported for full text screening → 5 studies excluded
- 5 studies included (all CEA, no BIA)

RESULTS

- The search yielded 219 potentially relevant citations. After the screening, five studies (all CEA, no BIA) were included. Three studies were organizational-level[1-3] models, while two were national-level[4,5] (based in the UK).
- **Figure 2** presents key conditions for essential RM use identified in the review.

Studies showing impacts of RM

- Four studies reported process-related impacts (e.g., delays in service flow and associated costs).
- One study reported health-related impact.

Outcomes reported

- All studies reported traditional CEA outcomes.
- Reported RM outcomes: waiting time, queue length, resource utilization.

Data sources for constraints

- Literature reported mainly constraints.
- Two studies reported using medical records for constraints.
- Two studies reported using modeler's assumptions.

Uncertainty analysis

- OWSA + PSA reported in all
- Two studies reported stochastic uncertainty analysis (simulation replications with fixed parameters to avoid pathway bias).

RM enhances the realism of HTA by addressing capacity and process constraints that traditional economic evaluations often ignore.
Despite its value in informing feasible and coordinated decision-making, the wider application is constrained by methodological variability and limited guidance for routine integration.

Resource modelling is essential when there is a new technology[6]:

Figure 2: Conditions under which RM is essential

- Resource constraints can be classified into either throughput or capacity constraint **(Figure 3)**.
  - A **throughput constraint** limits the number of patients or cases a system can handle within a given time, for e.g., a clinic capped at 36 patients per day due to staff or time limits.
  - A **capacity constraint** restricts service delivery based on the finite availability of resources, for e.g., doctors, nurses, hospital beds.
- Constraints can also be **fixed** (constant over time for e.g., maximum appointment slots per day) or **time-varying** (changing with shifts or periods for e.g., shift based staffing like 3 doctors in the morning shift and 1 at night) **(Figure 4)**.
- In this review, most studies implicitly modelled fixed throughput constraints. Only one study incorporated a time-varying throughput constraint (annual increase in patients at a radiation therapy clinic), while another study explicitly modelled a fixed capacity constraint (the maximum number of students evaluated by school psychologists per week).

Figure 3: Type of constraint

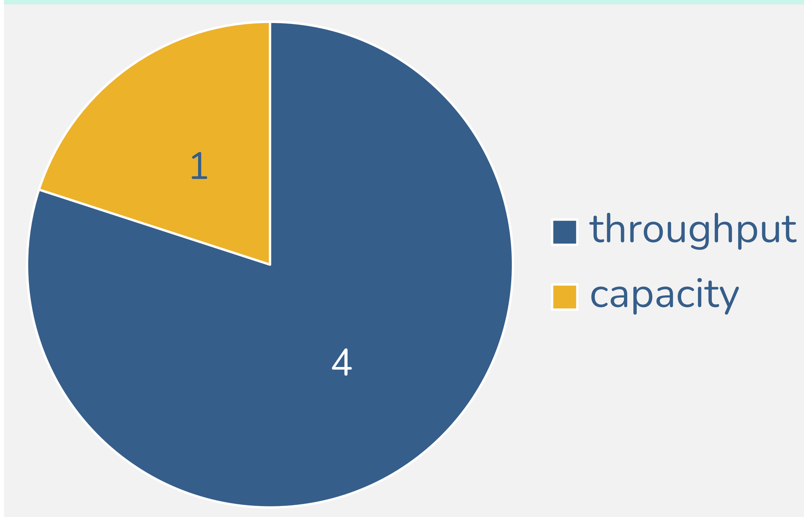
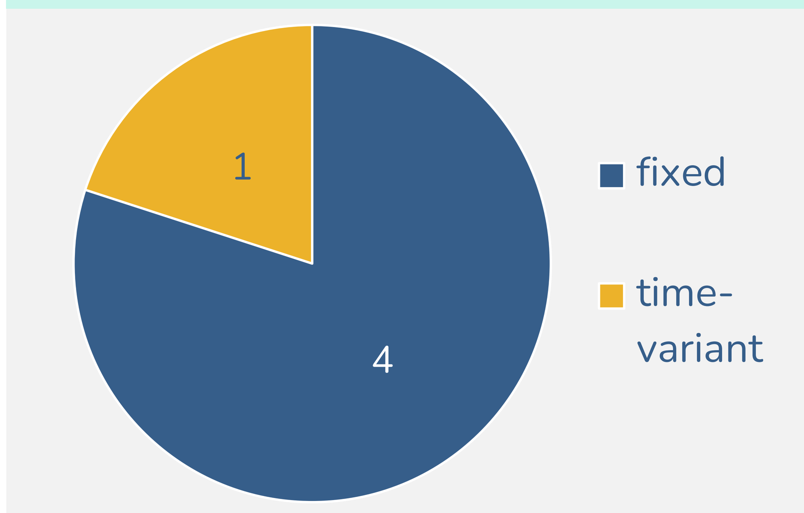


Figure 4: Nature of constraint



DISCUSSION

- Economic evaluations often assume unlimited resources (e.g., hospital beds, doctors, nurses, CT scanners), ignoring real-world limits on supply and demand.
- RM assesses technology uptake, resource requirements, and capacity limits. Its application depends on the context of decision-making and identified constraints. While not always feasible for rapid assessments, it can support coordinated planning and reduce duplication.
- Findings from RM show whether a technology is practical to implement.
- This review found that RM in HTA most often models process-related impacts using literature-based constraints, with outcomes like waiting times, queue length, and resource utilization, though studies largely assume fixed throughput with only rare examples of time-varying or explicit capacity limits.
- RM in HTA highlights real-world feasibility, but use of DES remains limited. Clearer guidance is needed to standardize methods and support its routine integration into economic evaluations.

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