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Health economics: capacity modelling

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Outline

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- Health economic modelling – the typical approach
- What about capacity constraints?
- The method: Discrete Event Simulation (DES)
- An example
- Thoughts?

Health economics

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- Health economics is about providing information to assist in the **efficient allocation of scarce healthcare resources**
- We can use **decision analytic models** to represent the clinical pathway and assess the impact of a new intervention on that pathway

Typical health-economic models

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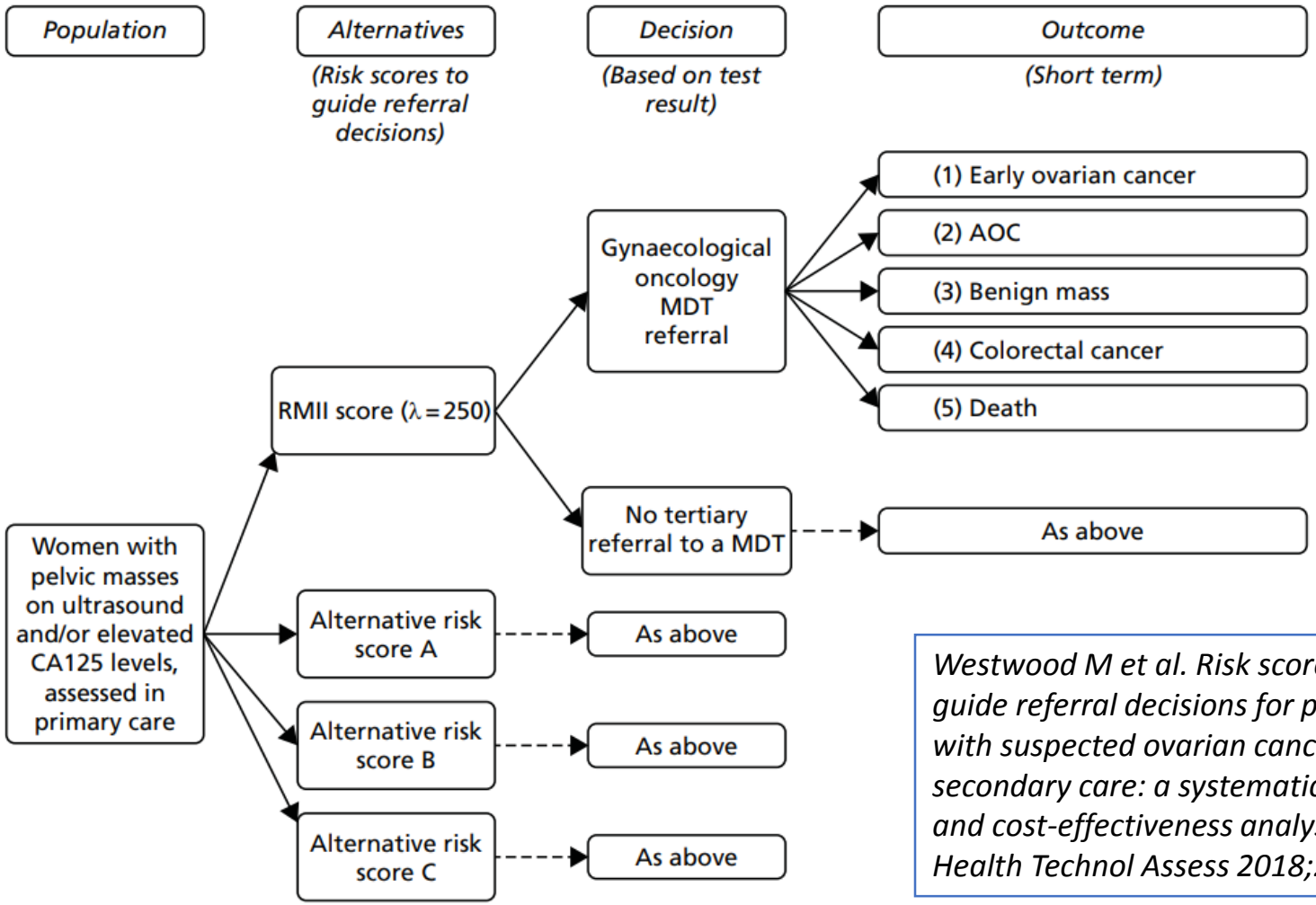

Westwood M et al. Risk scores to guide referral decisions for people with suspected ovarian cancer in secondary care: a systematic review and cost-effectiveness analysis. Health Technol Assess 2018;22(44).

FIGURE 8 Decision tree structure.

Typical health-economic models

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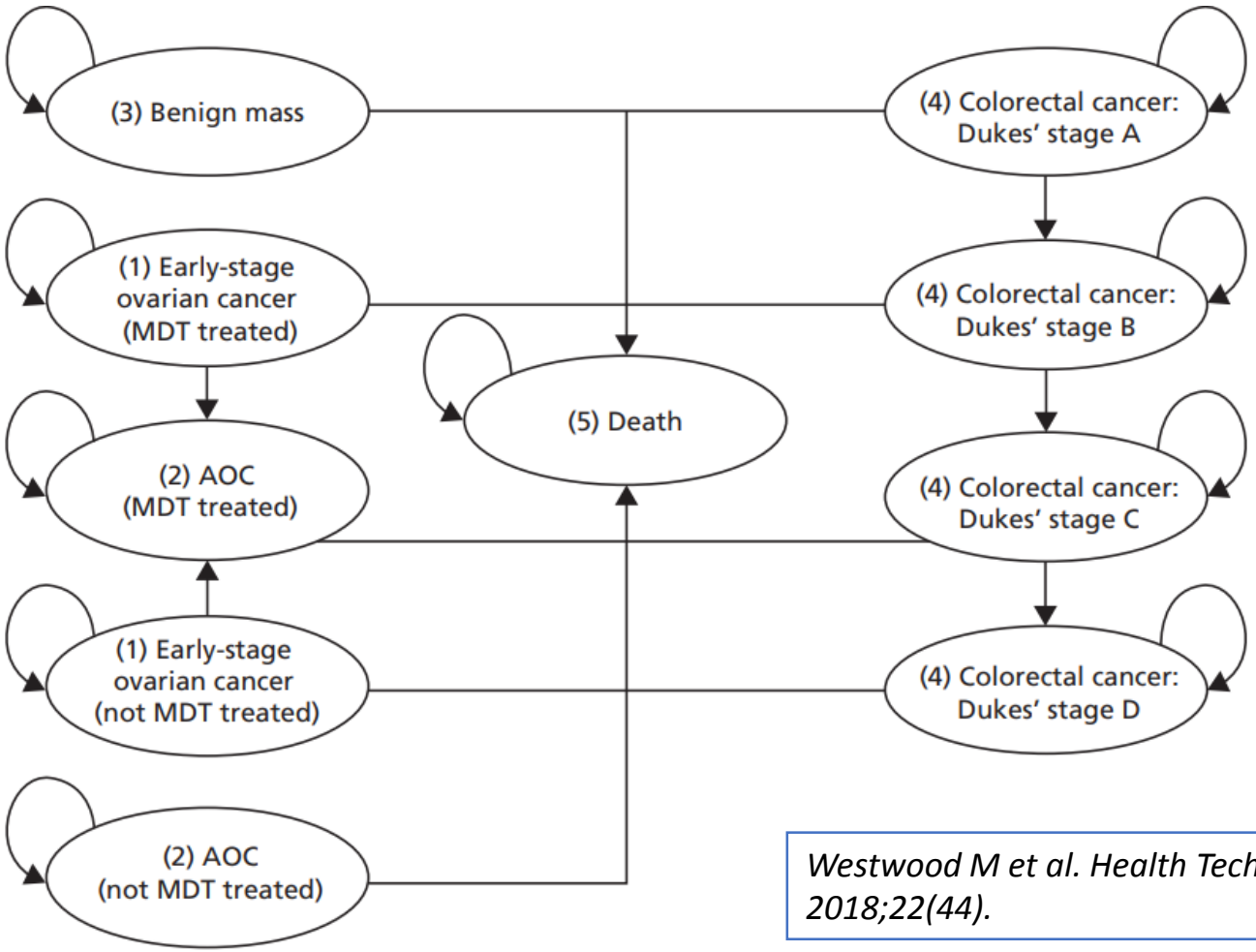

Westwood M et al. Health Technol Assess 2018;22(44).

FIGURE 9 Markov process structure.

Typical health-economic models

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- Typically model a "**cohort**" of patients
  - Patient-level models can be used to capture impact of individual characteristics on risks
- Are **static** – patients in the model do not interact
- Key parameters:
  - Test accuracy
  - Baseline progression/ event risks
  - "Treatment" effectiveness
  - Costs of referrals, investigations, treatments
  - Health state utilities

Capacity constraints

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- In traditional HE models, the "system" (e.g. NHS, hospitals, etc.) is assumed to have **infinite capacity** to deal with additional patients/ procedures etc.
  - **Constrained resources** at the level of **staffing**, **beds, equipment**, **rooms**, and **infrastructure** are not considered
  - The possibility of **queues** forming in the system (and the subsequent impact that may have on **waiting times**, **costs**, **QALYs** and **staff**) is not considered
- For interventions expected to have an impact on referrals or patient workflow, this is a key limitation

Modelling capacity - DES

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Discrete event simulation (DES) can be used to capture system capacity constraints and patient interactions

- Model **individual patients** with different characteristics
- Model **patient interactions** (e.g. what happens to patient A, may depend on what happens to patient B)
- Model **resource dependent activities** (e.g. activities requiring limited staff, equipment, rooms etc.)
- The possibility of **queues** in the system can be captured, and waiting times recorded

Modelling capacity - DES

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- **Entities:** the components being simulated and tracked (e.g. patients)
- **Attributes:** individual characteristics which can be assigned to each entity using **labels**
- **Activities:** based on their attributes, individual entities pass through different activities that can alter their characteristics and influence future events
- **Resources:** items which may be required for activities to run (e.g. equipment, rooms, staff). Resource availability may be set according to **shift patterns**.
- **Queues:** depending on the availability of activities and resources, entities may be held in queues until they can be processed

Modelling capacity - DES

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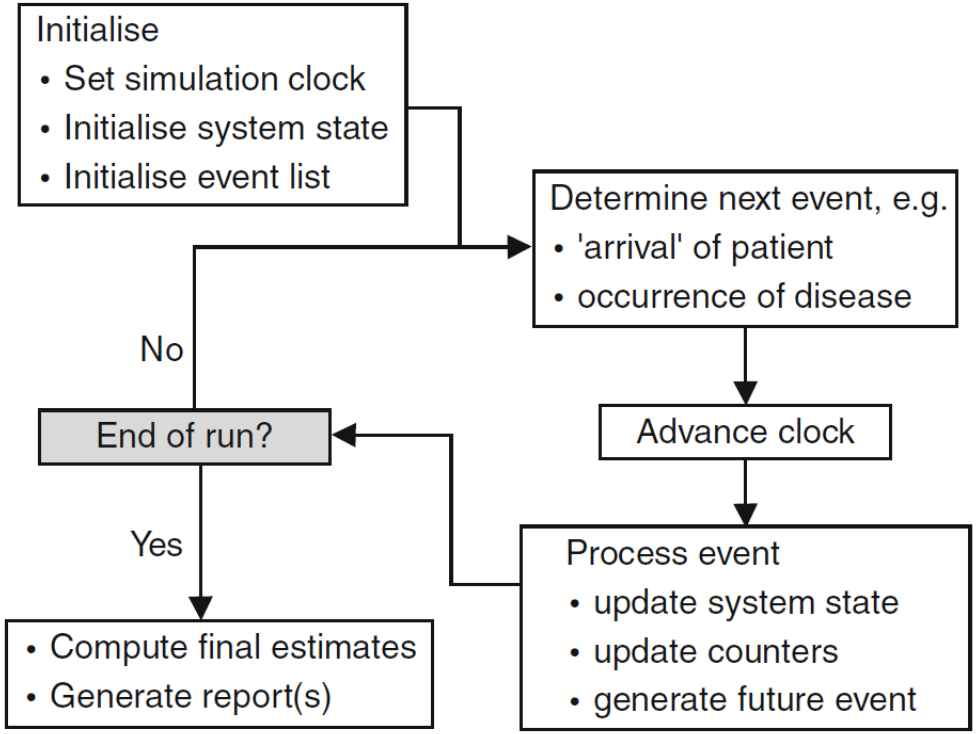

Fig. 2. Flow diagram of the computation process for a discrete event simulation.

Caro JJ. Pharmacoeconomic analyses using discrete event simulation. Pharmacoeconomics. 2005;23(4):323-32. doi: 10.2165/00019053-200523040-00003. PMID: 15853433.

Example

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Evaluation of a **risk prediction test** to inform secondary care referrals for patients with **suspected breast cancer**

Expected to reduce unnecessary referrals by 20% - *but how might this translate to service improvements?*

1. A traditional HE model (decision tree) was developed to assess potential cost-effectiveness
2. A DES model was developed to seperately assess the potential impact on waiting times and patient workflow in secondary care

Example - model

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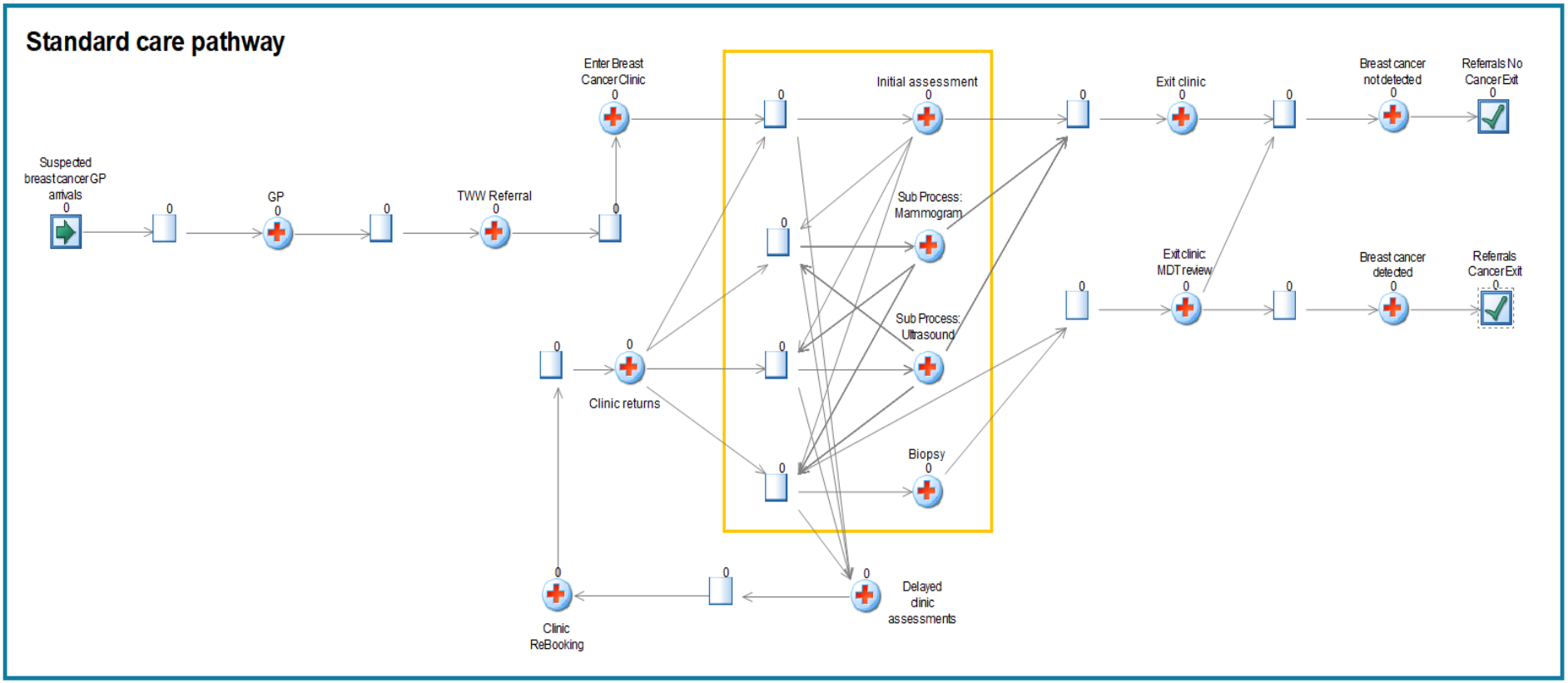

Example - model

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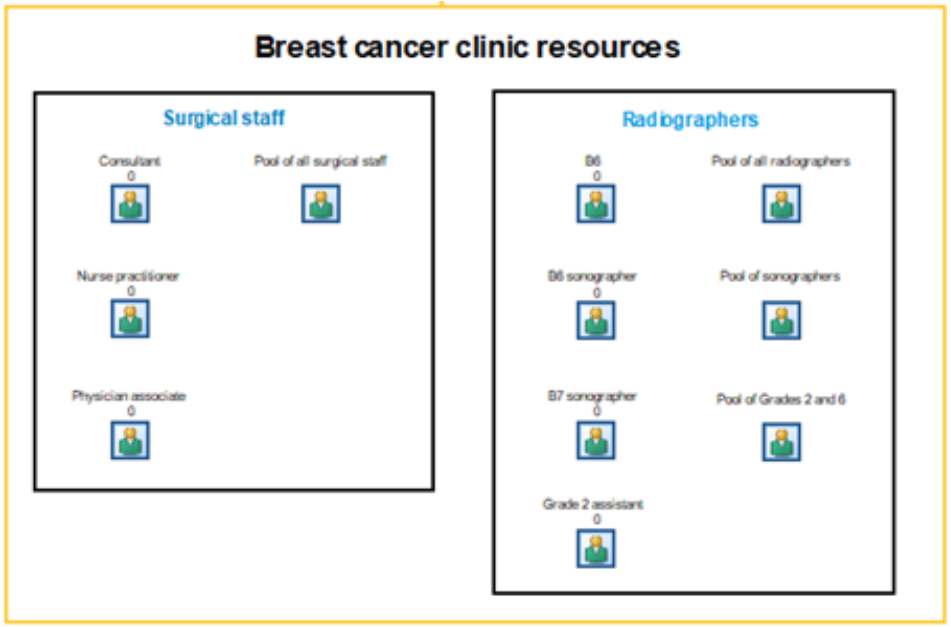
Constrained resources captured:

- Clinic opening times
- Staff numbers
- Staff availability (time spent on other tasks)
- Number of new/return patients booked in to each clinic (dependent on waiting list)
- Number of investigations that could take place at one time (dummy for rooms/ number of equipment)



Example - Results

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Strategy	N completed		% Referred to Clinic (immediate + delayed)		Time to Clinic [week days]		% Achieving TWW Target			N Overspill
	BC	No BC	BC	No BC	BC	No BC	BC	No BC	Total	
Standard care	503	10,026	100%	100%	9.81	9.81	**66.5%**	**66.4%**	**66.4%**	**1,672**
Test "best case" scenario	505	10,043	100%	80%	6.22	5.64	**98.1%**	**100%**	**99.9%**	**731**
Test "reasonable assumptions" scenario	505	10,045	100%	86%	6.27	6.36	**98.4%**	**98.1%**	**98.1%**	**886**

- The test has the potential to increase the % of patients reaching TWW target from **66.4%** to **98-100%**
- The test has the potential to significantly reduce the number of overspill generated, from **N=1,672** to **731-886**.

DES - summary

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- DES is a useful tool in scenarios where system **capacity constraints** are likely to be important
- Particularly relevant in current climate of immense NHS service pressures, waiting times and backlogs
- Requires **additional data** on system resources
- Not a routine evaluation approach in HE – cost and QALY outcomes are still key, but these can be evaluated together in the same DES model
- Can use specialised software (e.g. Simul8 - ££ but provides useful visual pathways), or R (free, but no visual pathway representation)

Further reading

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Karnon J, Stahl J, Brennan A, Caro JJ, Mar J, Möller J. Modeling *Using Discrete Event Simulation: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force–4.* Medical Decision Making. 2012;32(5):701-711. doi:10.1177/0272989X12455462

***Zhang**, X. Application of discrete event simulation in health care: a systematic review. BMC Health Serv Res 18, 687 (2018). https://doi.org/10.1186/s12913-018-3456-4*

Salleh S, Thokala P, Brennan A, Hughes R, Dixon S. *Discrete Event Simulation-Based Resource Modelling in Health Technology Assessment.* Pharmacoeconomics. 2017 Oct;35(10):989-1006. doi: 10.1007/s40273-017-0533-1. PMID: 28674845.

Wright SJ, Newman WG, Payne K*. Quantifying the Impact of Capacity Constraints in Economic Evaluations: An Application in Precision Medicine.* Med Decis Making. 2022 May;42(4):538-553. doi: 10.1177/0272989X211053792. Epub 2021 Oct 25. PMID: 34694170; PMCID: PMC9005833.

Questions/ thoughts?