NICE National Institute for Health and Care Excellence

University of Glasgow School of Health & Wellbeing

EE598

Optimal Utilisation of Robotic-Assisted Surgery in the NHS: A System-level Economic Evaluation Model

Lai, T-J [1,2], **Heggie R** [2], **Chalkidou A**[1], **Boyd K**[2]

[1] National Institute for Health and Care Excellence

[2] University of Glasgow

Objective:

To develop a system-level economic model to evaluate the cost-effectiveness of robotic-assisted surgery (RAS) as a shared surgical platform, supporting investment justification and identifying optimal expansion strategies across specialties to maximise efficiency and utilisation in the NHS.

Background

Robotic-assisted surgery (RAS) is expanding rapidly across the NHS, yet adoption often outpaces evidence of cost-effectiveness. Traditional HTA methods assess single procedures but fail to reflect the system-wide nature of RAS platforms — characterised by high capital costs, shared use, and learning effects.

- **RAS diffusion**: Initially in urology (prostatectomy), now in multiple specialties.
- **Challenge**: Clinical and cost-effectiveness remain uncertain.
- **Gap**: Conventional cost-effective evaluations ignore interdependencies such as training, shared utilisation, and economies of scale.
- **Policy context**: Supported by national initiatives (e.g., Scottish Government RAS funding, NHS England robotics strategy).
- **Need**: A framework to evaluate not whether to invest, but how to use robotic platforms efficiently and equitably.

Figure 1: Overview of decision tree skeleton for the stage-one modelling

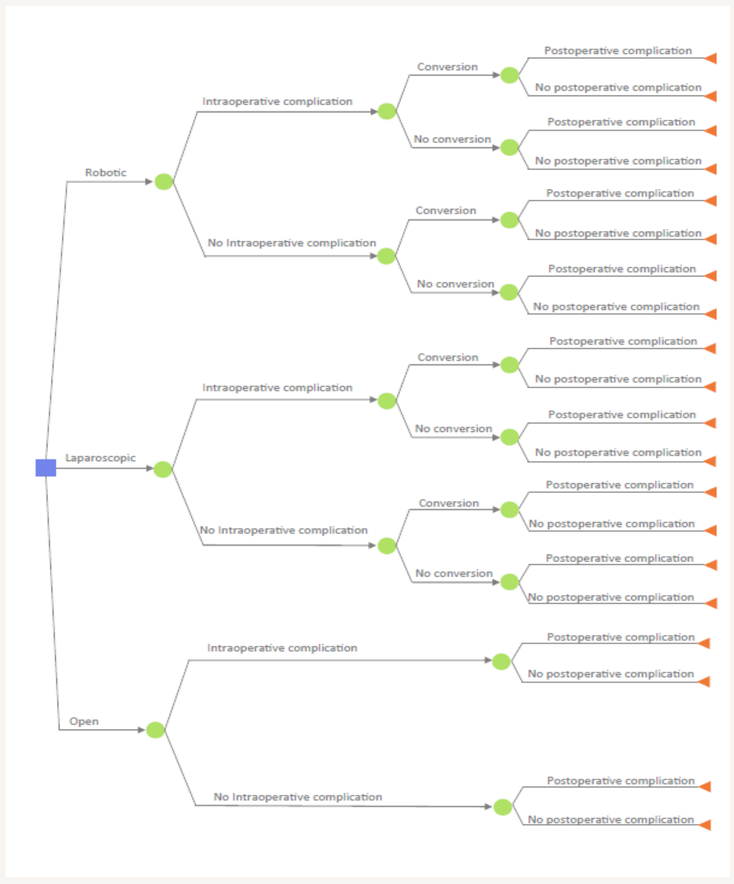
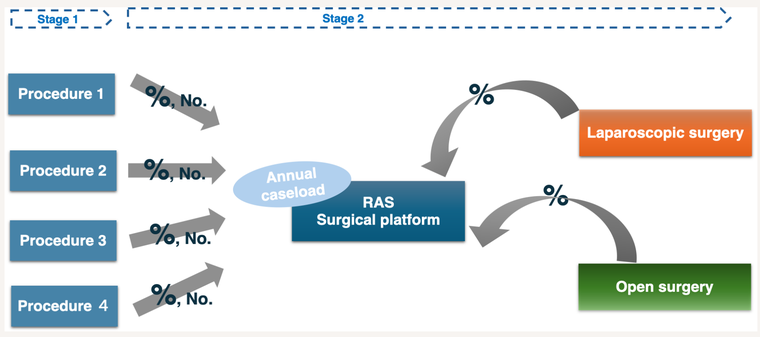


Figure 2: Schematic diagram of the two-stage modelling framework



Methods

A two-stage modelling framework was developed:

Stage 1: Procedure-level analysis
Decision-analytic models with a one-year time horizon were constructed for four procedures—colorectal resection, hysterectomy, pancreaticoduodenectomy, and prostatectomy—to compare RAS with laparoscopic and open surgery. Incremental cost-effectiveness ratios (ICERs) were estimated based on costs and quality-adjusted life years (QALYs).

Stage 2: System-level integration
A platform model combined results across procedures, allowing exploration of:

- **Annual procedural volumes** (150–350 cases)
- **Case-mix strategies** across specialties
- **Replacement proportions** between open, laparoscopic, and robotic approaches

This structure enables simulation of different utilisation scenarios and identification of cost-efficient strategies for shared RAS platform use under varying capacity and investment constraints.

Table 1: Base case results of incremental cost-effectiveness analysis for RAS vs LS vs open

Comparison	Incremental Cost (£)	Incremental QALYs	ICER (£/QALY)	INMB @£20k	Conclusion
Prostatectomy					
RAS vs LS	£ 409	-0.005	£ -85,696/QALY	£ -505	Dominated
RAS vs Open	£ 851	0.067	£ 12,700/QALY	£ 489	CE
LS vs Open	£ 442	0.072	£ 6,156/QALY	£ 994	CE
Colorectal Resection					
RAS vs LS	£ 1,838	0.012	£ 156,127/QALY	£ -1,602	Not CE
RAS vs Open	£ 3,137	0.031	£ 101,149/QALY	£ -2,519	Not CE
LS vs Open	£ 1,300	0.019	£ 67,896/QALY	£ -917	Not CE
Hysterectomy					
RAS vs LS	£ 1,411	0.020	£ 71,551/QALY	£ -1016	Not CE
RAS vs Open	£ 776	0.021	£ 37,512/QALY	£ -362	Not CE
LS vs Open	£ -635	0.001	£ -661,146/QALY	£ 645	LS dominant
Pancreaticoduodenectomy					
RAS vs LS	£ 2,738	0.107	£ 25,470/QALY	£ -588	Not CE
RAS vs Open	£ 3,057	0.075	£ 40,940/QALY	£ -1,564	Not CE
LS vs Open	£ 320	-0.033	£ -9746/QALY	£ -976	Dominated

Figure 3: Tornado Diagram of one-way sensitivity analysis comparing RAS with LS and Open in prostatectomy

Figure 4: Tornado Diagram of one-way sensitivity analysis comparing RAS with LS and Open in colorectal resection

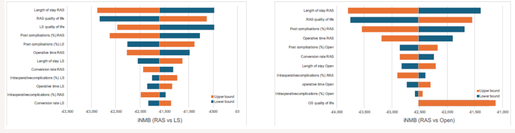


Figure 5: Tornado Diagram of one-way sensitivity analysis comparing RAS with LS and Open in hysterectomy

Figure 6: Tornado Diagram of one-way sensitivity analysis comparing RAS with LS and Open in pancreaticoduodenectomy

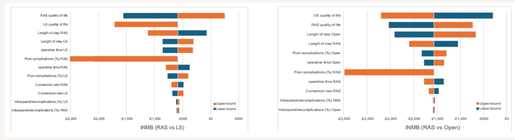
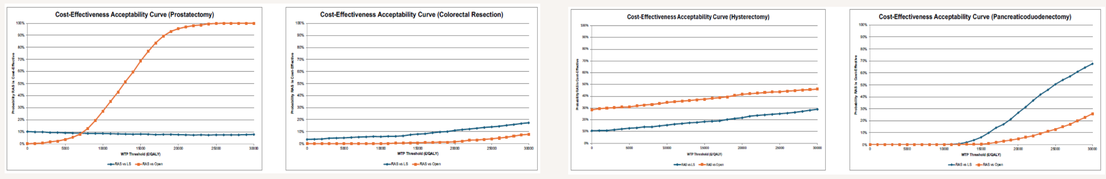


Figure 7: Cost-effectiveness acceptability curves for RAS vs LS and RAS vs open surgery in four procedures



Discussion & Conclusions

Key Insights

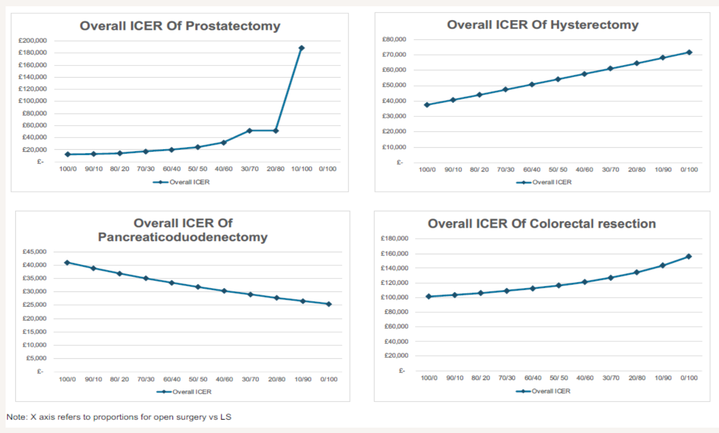
- RAS can be cost-effective when implemented strategically, particularly in high-volume or high-benefit procedures.
- Economies of scale are essential — per-case costs decline as volume increases and learning accumulates.
- Value improves when RAS replaces open surgery, where incremental clinical gains are greater, rather than laparoscopic surgery.

System-Level Planning and Implications

- The model supports strategic RAS expansion by identifying:
  - Optimal procedure mixes
  - Sustainable replacement strategies
  - Minimum volume thresholds for cost-efficiency
- Provides evidence to guide NHS investment, theatre scheduling, and service configuration, especially for emerging robotic hubs in Scotland and England.

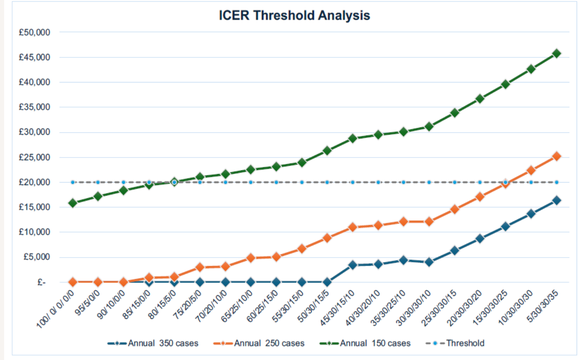
This system-level modelling framework provides a pragmatic tool for strategic planning, supporting health systems in optimising the utilisation of high-cost surgical innovations like RAS.

Figure 8: ICERs of RAS replacing different mixed proportions in four procedures



Note: X axis refers to proportions for open surgery vs LS

Figure 9: The ICER values across 20 allocative strategies by different annual volumes



Note: X axis refers to allocative proportions (%) for prostatectomy, pancreaticoduodenectomy, hysterectomy, colorectal resection respectively; y axis refers to incremental cost-effectiveness ratios

Relevant references

1. Lai (2024). Clinical Effectiveness of Robotic versus Laparoscopic and Open Surgery: An Overview of Systematic Reviews. BMJ Open
2. Lai (2024). Economic Evaluations of Robotic-Assisted Surgery: Methods, Challenges and Opportunities. Appl Health Econ Health Policy.

Dr. Tzujung Lai
Health Economist

National Institute for Health and Care Excellence
Email: tzujung.lai@nice.org.uk

nice.org.uk