Newcastle University

NHS
The Newcastle upon Tyne Hospitals
NHS Foundation Trust

Robot-assisted surgery for orthopaedic procedures: an early economic model using *rdecision*

R for HTA Workshop

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RA O'Leary, K Keltie, E O'Sullivan, Dr AJ Sims, Prof L Vale

Healthcare at its best
with people at our heart

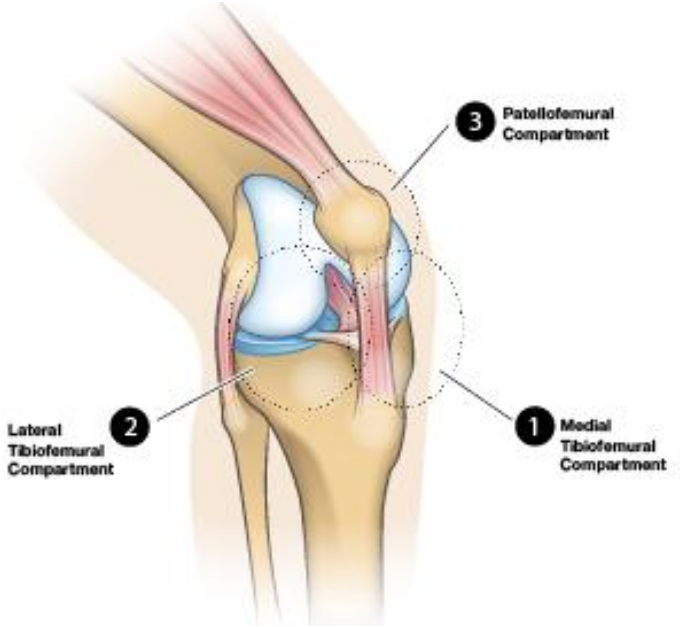
Context and aims

- Commissioned to undertake an Early Value Assessment (EVA) of robot-assisted surgery (6 devices) for orthopaedic procedures:
  - Total knee arthroplasty (TKA)
  - Partial knee arthroplasty (PKA)
  - Total hip arthroplasty (THA)

- To **rapidly** develop an early economic model, comparing robot-assisted surgery with conventional surgery, to inform further evidence generation.

Clinical area

- Arthroplasty typically used in cases of osteoarthritis
- Surgical procedure to cut away the damaged or worn-out joint, and replace it with a prosthetic joint
- For knees, this may be total (all 3 compartments) or partial
- Robot-assistance is intended to enhance the work of the surgeon

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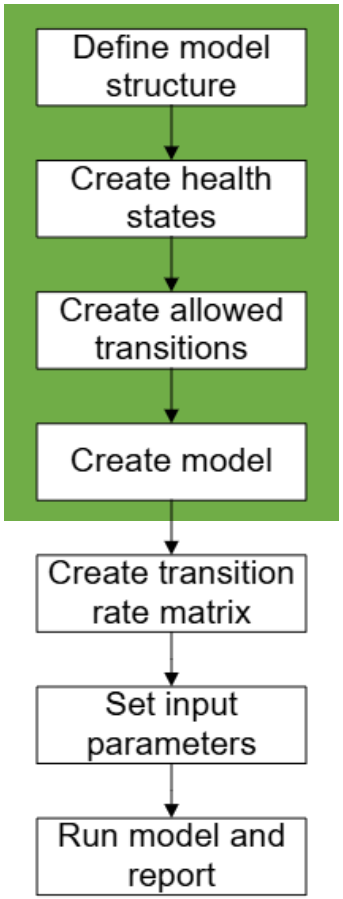
Introduction to *rdecision*

- https://cran.r-project.org/package=rdecision

rdecision: Decision Analytic Modelling in Health Economics

Classes and functions for modelling health care interventions using decision trees and semi-Markov models. Mechanisms are provided for associating an uncertainty distribution with each source variable and for ensuring transparency of the mathematical relationships between variables. The package terminology follows Briggs "Decision Modelling for Health Economic Evaluation" (2006, ISBN:978-0-19-852662-9).

- Why did we use it?
  - familiarity
  - transparency
  - speed (development and quality assurance)
  - automation



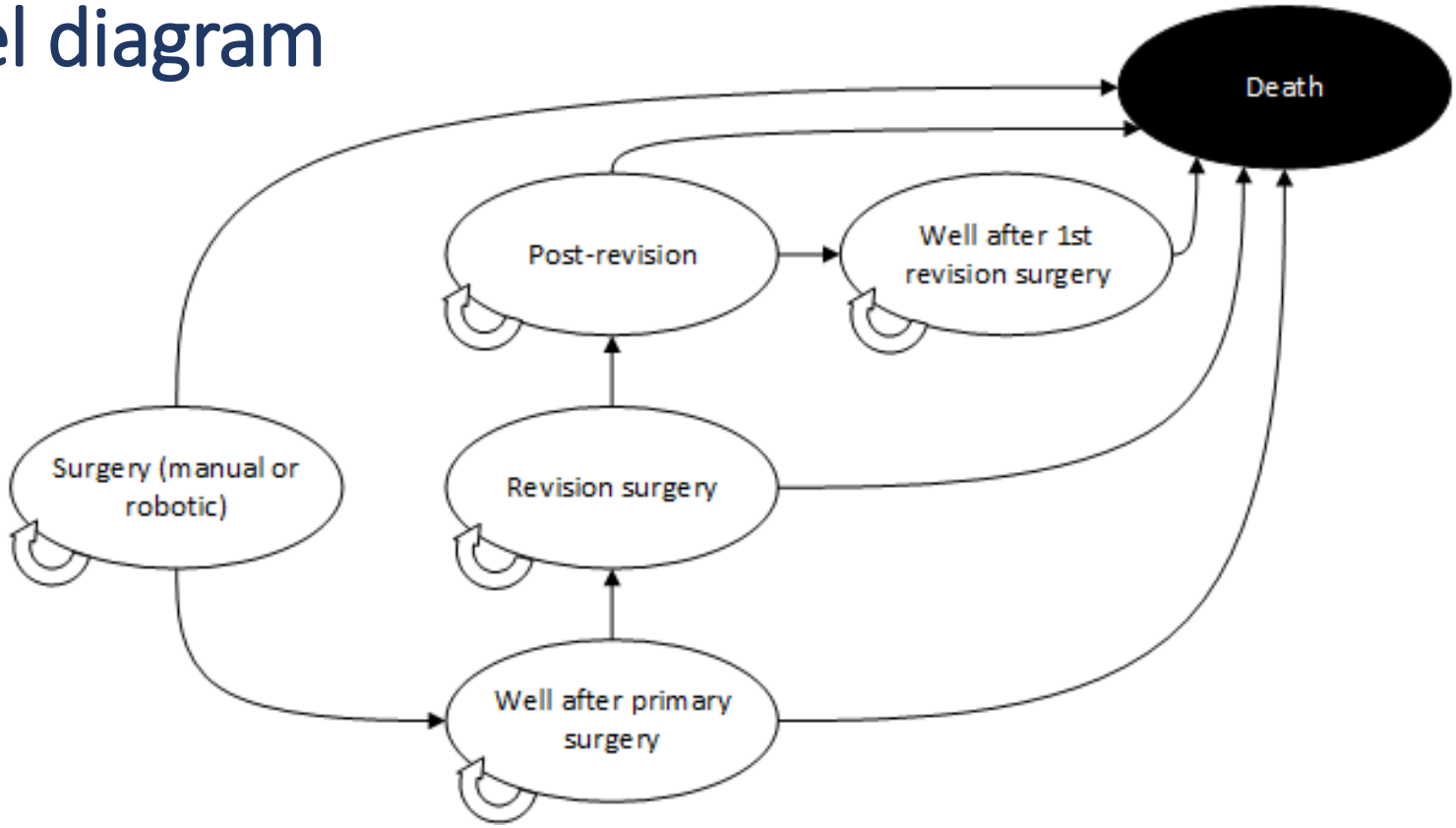
Workflow (TKA example)

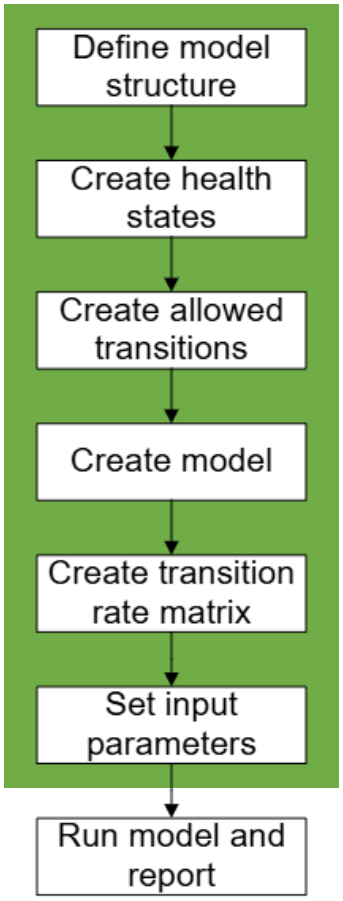
```
st_primary = MarkovState$new(name = "PrimarySurgery")
```

```
tr_primary_wellp = Transition$new(s = v$st_primary, t = v$st_wellprimary)
```

```
mm <- SemiMarkovModel$new
```

Model diagram





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```
qt <- matrix
```

```
e$tr_primary_wellp$set_cost(proc_primary_c)
```

General parameters

- Time horizon
  - ‘lifetime’ (assuming maximum life expectancy of 100 years old)
- Cycle length
  - 1 month
- Discounting
  - 3.5% for costs and utilities
- Revision and mortality
  - derived from National Joint Registry annual reports and extrapolated based on standardised mortality tables (assumed the same for conventional and robot-assisted surgery)

Cost parameters

- Per-patient device costs, based on:
  - cost of the robotic system (plus consumables, implant, servicing, training)
  - annual procedure volume
  - expected lifetime of system
  - CT imaging needed pre-surgery
- Other costs:
  - HRG procedural costs for replacement and revision (with and without infection)
  - length of stay, cost per day (assumed the same for both conventional and robot-assisted surgery)

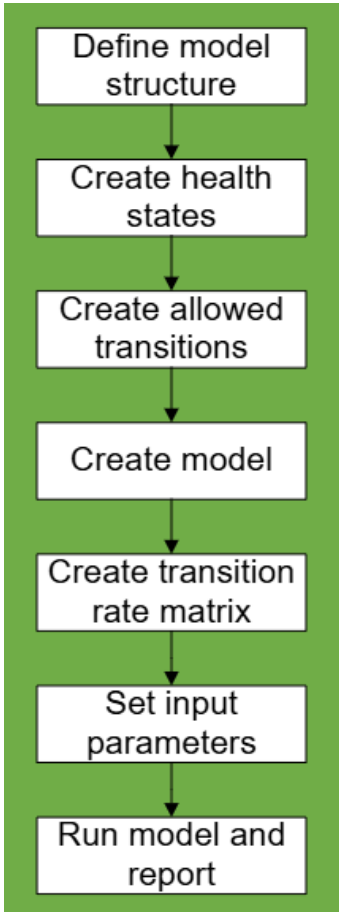
Utility parameters

- Baseline, 1 year
- Post-revision
- Decrement for 12 months post-revision (septic vs. aseptic)
- Also used the upper and lower confidence intervals for utilities

- Assumed utilities were the same for all robotic technologies

Sensitivity analysis

- Varied:
  - purchasing options
  - annual procedure volume
  - HRG cost (primary procedure only, not revision)
  - implant cost
  - reduction in length of stay
  - relative revision



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```

```
for (y in seq_len(p$horizon_years)) {
```

Results

- Robot-assisted surgery was dominated by conventional surgery.
- Point estimates lay close to the y-axis on the cost-effectiveness plane.
- Results changed direction across the 95% confidence interval of utility values.

- Robot-assisted surgery was dominated by conventional surgery, except when there were zero revisions in the robot-assisted arm.

Limitations

- Model sensitive to changes in primary procedure costs, which contribute most of the overall lifetime costs
- Utilities only available for single technology, from a small RCT
- No statistically significant differences in utilities between arms
- May be differences in mortality and revision between conventional and robot-assisted surgery (or between specific robots)

Limitations

- Model does not account for short term adverse events (for example, bleeding, infection not leading to revision)
- Model does not account for benefits of robot-assisted surgery for operating staff
- Model does not account for additional set up time in theatre
- Data did not allow for probabilistic sensitivity analysis

Strengths

- Rapid development
- Easy to re-run as new information came to light
- Tables could be outputted for inclusion in the report
- Highlighted key uncertainties
- Clear evidence gaps to be filled by future research

Shiny app

- Proof of concept, after submitting report to NICE
- Better accessibility and user-friendliness for non-R users
- Easier to justify moving away from Excel

HTE10043 - Robotic Assisted Surgery - Economic Model v0.0

Input Options

Type of procedure

TKA

Demographics

General

Cost of robotic technology (including implant)

£0 | £1,749.94 | £3,500

0 350 700 1,050 1,400 1,750 2,100 2,450 2,800 3,150 3,500

Utility decrement for 12m after septic revision

0 | 0.2 | 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Utility decrement for 12m after aseptic revision

0 | 0.1 | 1

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Proportion aseptic revisions

0% | 87% | 100%

0 10 20 30 40 50 60 70 80 90 100

Percentage robotic procedures revised

Model Values

Total costs per patient (conventional)	Total utilities per patient (conventional)	Incremental Cost Effectiveness Ratio (ICER)
8,553.66 £	8.406	-71.39 £ Dominated

Total costs per patient (robotic)	Total utilities per patient (robotic)
8,586.93 £	7.94

Markov Trace

Show 10 entries

Type	Years	PrimarySurgery	WellAfterPrimary	RevisionSurgery	WellAfterRevision	PostRevision	Dead
R	0	1000	0	0	0	0	0
C	0	1000	0	0	0	0	0
R	1	0	988.42	0.37	0.76	2.75	7.7
C	1	0	988.42	0.37	0.76	2.75	7.7
R	2	0	971.46	0.49	3.5	5.46	19.09
C	2	0	971.46	0.49	3.5	5.46	19.09
R	3	0	952.7	0.38	7.29	5.93	33.7
C	3	0	952.7	0.38	7.29	5.93	33.7

*** cost redacted due to commercial sensitivity

User Input Values

Label	Value
Procedure type	TKA
Male %	43
Startage (years)	72
Cost of robotic technology (including implant), £	1749.94
Utility decrement for 12m after septic revision	0.2
Utility decrement for 12m after aseptic revision	0.1
Proportion aseptic revisions, %	87
Percentage robotic procedures revised (relative to conventional), %	100
Utility after revision surgery	0.597
R: Utility 1 year after primary surgery	0.703
R: Utility 2 years after primary surgery	0.707
R: Utility 5 year after primary surgery:	0.71
Utility after revision surgery:	0.565
C: Utility 1 year after primary surgery	0.752
C: Utility 2 years after primary surgery	0.752
C: Utility 5 year after primary surgery	0.752

Conclusion

- Rapidly produced an early economic model using *rdecision*.
- Identified key uncertainties.
- Made recommendations for future evidence generation.
- Supported the NICE committee in their decision making and development of guidance (HTE22)

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Acknowledgement

National Joint Registry

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Questions?

rachel.oleary1@nhs.net