# IMPROVING CYCLE CORRECTION FOR TIME-HOMOGENEOUS MARKOV MODELS

Tushar Srivastava[1]; Mark Strong[1]; Matthew D Stevenson[1]; Peter J Dodd[1]

1. School of Health and Related Research, University of Sheffield, UK

## BACKGROUND

- Markov models are widely used within health economic modelling[1]
- These models specify transition probabilities between discrete health states at each time step[1]
- Changes in health states occur at fixed intervals which may approximate an underlying continuous-time process
- Frequently, correction methods are applied to discrete-time outputs to yield a closer approximation to an underlying continuous-time Markov chain[2]

## OBJECTIVE

- To introduce a *novel* correction method based on **Gaussian Quadrature (GQ)**
- Comparison of existing cycle correction methods and new proposed GQ method with exact continuous-time process outcomes (gold standard) in a simulation case study

## EXISTING CYCLE CORRECTION METHODS

- "Standard" Half Cycle Correction (HCC) Method
- Trapezoidal Method
- Simpson's 1/3 Method
- Simpson's 3/8 Method

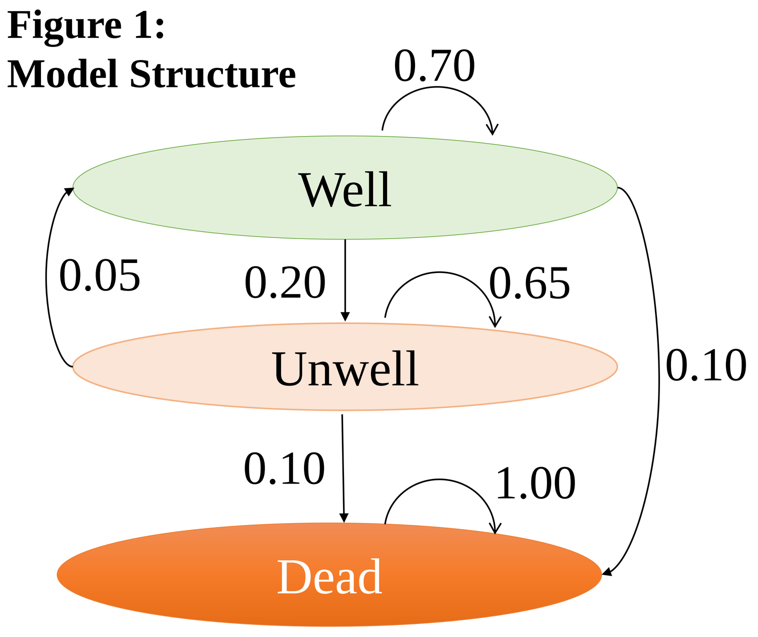
These methods are based on approximating the integrals over time that define outcomes of interest

## PROPOSED NEW METHOD

- Correction based on applying a numerical integration technique - **Gaussian Quadrature (GQ)** – to an exact formula for continuously calculated quantities
- GQ is a set of methods approximating integrands as a sum of $n$ orthogonal polynomials; larger order $n$ leads to better approximations.
- **First order GQ** method is found to be *identical* to **standard HCC** & **Second order GQ** method is found to be *identical* to **Simpson 1/3**
- The **Third order GQ** method is a *novel* cycle correction method

## SIMULATION CASE STUDY

**Figure 1: Model Structure**




Cycle length: 1 year
Time Horizon: Lifetime

Probabilistic sensitivity analyses was undertaken using Latin hypercube sampling experimental design to draw 10,000 parameter sets with each input parameter following a specified distribution

We considered a uniform distribution over Well vs Unwell as the initial state, and assumed each of the four transition rates (Well-to-Unwell, Well-to-Dead, Unwell-to-Well, Unwell-to-Dead) were exponentially distributed with rate parameter = 1

**Table 1: Model Inputs**

| Model Inputs | Mean Value | Standard Deviation | Distribution used in PSA |
|---|---|---|---|
| 'Well' State Cost | £5 | £1 | Log Normal (1.6,0.198) |
| 'Unwell' State Cost | £100 | £20 | Log Normal (4.61,0.198) |
| 'Dead' State Cost | £0 | £0 | N/A |
| 'Well' State Utility | 0.95 | 0.19 | Beta (0.3,0.016) |
| 'Unwell' State Utility | 0.6 | 0.12 | Beta (9.4,6.27) |
| 'Dead' State Utility | 0 | 0 | N/A |

## RESULTS

- **Our new third-order GQ-Method outperforms other cycle correction methods**
- Second order GQ ≡ Simpson 1/3 were second-best method

**Figure 2 : PSA results (log-error of costs and QALY approximation by method)**

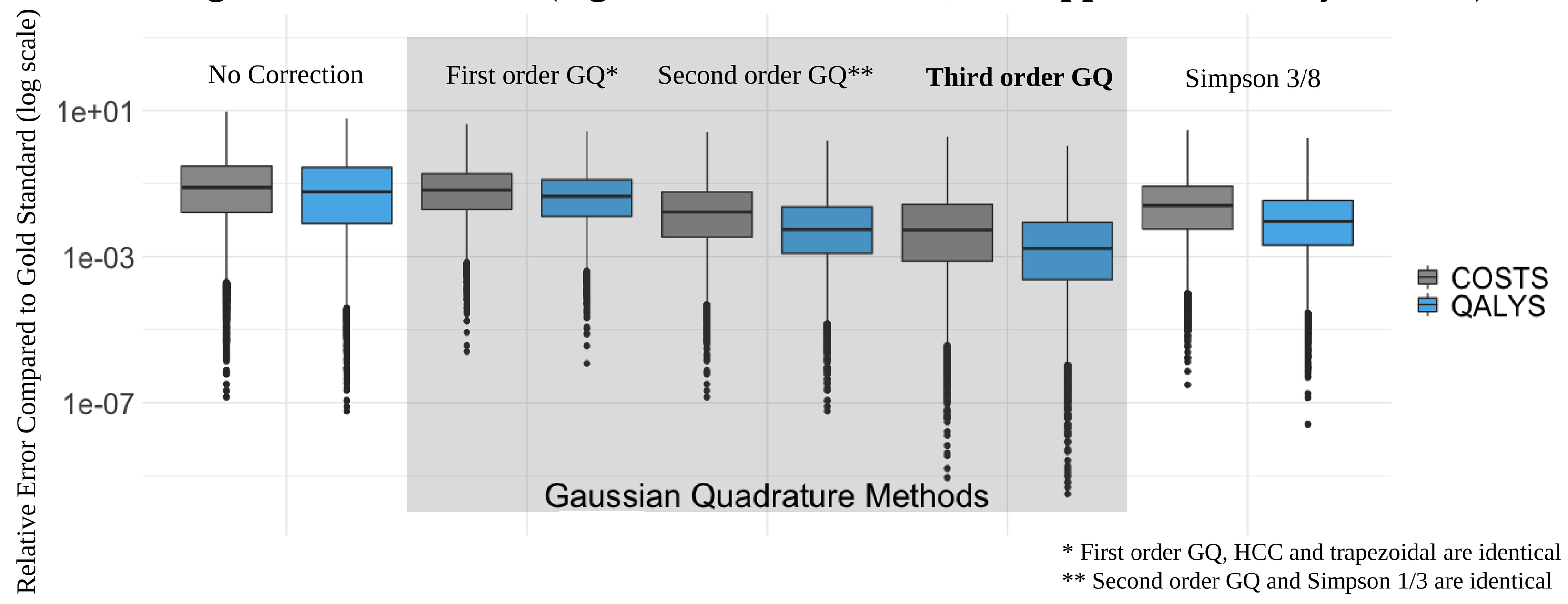



**Figure 3: PSA results (influence of rate on log-error by method)**

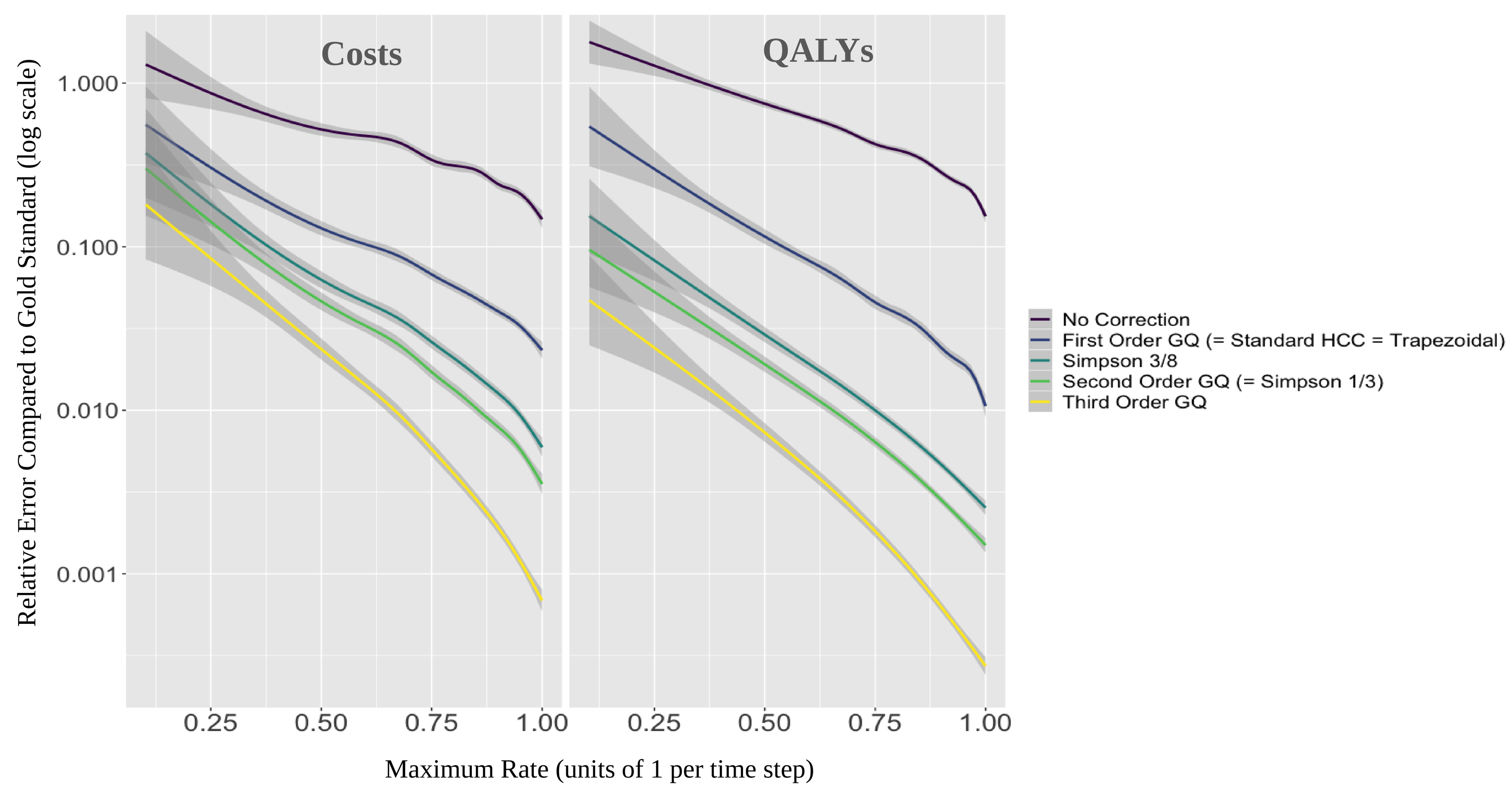



**Table 2: Results of Simulation Study**

| Correction Method | Total Costs | Total QALYs |
|---|---|---|
| Gold standard – Continuous model | **£228.762** | **4.27397** |
| No correction performed | £228.946 | 4.76314 |
| 1st order GQ method | £226.447 | 4.28816 |
| 2nd order GQ method | £228.682 | 4.27386 |
| 3rd order GQ method | **£228.760** | **4.27396** |
| Half cycle correction | £226.447 | 4.28816 |
| Trapezoidal method | £226.447 | 4.28816 |
| Simpson 1/3 method | £228.682 | 4.27386 |
| Simpson 3/8 method | £228.589 | 4.27374 |

## LIMITATIONS

- We have not computed the error bounds for relative errors & not guaranteed that GQ method would always be better. Future research is needed
- Model type considered for simulation study was one with constant transition matrix rather than time-varying transition matrix. Future research is needed

## CONCLUSIONS

- 3rd order GQ method can improve on existing within cycle correction approach
- It can be easily implemented in modelling software such as MS- Excel and R

**References:**

1. Siebert et al (2012) *State-Transition Modeling: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force-3*
2. Elbasha et al (2015) *Theoretical Foundations and Practical Applications of Within-Cycle Correction Methods*

**Disclosures:** *This work is based on independent research. There are no conflicts to disclose.*

**Contact Us:** t.srivastava@sheffield.ac.uk
https://www.sheffield.ac.uk/scharr/sections/heds

@Tushh27
@scharrheds

SCAN ME