ctmm

Center for Translational Molecular Medicine

Translating science into better healthcare

# SMAA-CEA: a method for representing decision uncertainty in cost-effectiveness analysis

**Douwe Postmus**, PhD; Tommi Tervonen, PhD; Hans Hillege, MD, PhD; Erik Buskens, MD, PhD

University Medical Center Groningen, The Netherlands
University of Groningen, The Netherlands

umcg

# Introduction

- In cost-effectiveness analysis (CEA), two or more medical interventions are evaluated in terms of their costs and effects
- Decision uncertainty is represented through the cost-effectiveness acceptability curve (CEAC)
- CEACs only provide a partial picture of the uncertainty surrounding the decision problem
  - it shows the probability of making the correct decision when a certain alternative is selected
  - it does NOT provide any information about the alternative's probability distribution over the other ranks when making a wrong decision

# SMAA-CEA

- Consider *n* health care interventions that are to be evaluated with respect to their costs (*c*) and effects (*e*)
- It is assumed that the decision maker's preference structure can be represented by the NMB function

$$\mathrm{NMB}(e, c, \lambda) = \lambda e - c$$

- The costs and effects of the different alternatives are uncertain and represented by the random vectors $\mathbf{C} = [C_1, \ldots, C_n]^T$ and $\mathbf{E} = [E_1, \ldots, E_n]^T$

# Preliminaries cont'd

- For given realizations **c** of **C** and **e** of **E**, the alternatives are ranked in descending order by means of a ranking function

$$\text{rank}(i, \mathbf{c}, \mathbf{e}, \lambda) = 1 + \sum_{k=1}^{n} I(\text{NMB}(e_k, c_k, \lambda) > \text{NMB}(e_i, c_i, \lambda))$$

| | cost | effect | NMB (λ=25) |
|---|---|---|---|
| alternative A | 100 | 5 | 25 => rank 3 |
| alternative B | 120 | 6 | 30 => rank 2 |
| alternative C | 80 | 7 | 95 => rank 1 |

# Rank acceptability indices

- Define, based on this ranking function, the sets of favorable cost and effect measurements as

$$M_i^r(\lambda) = \{(c,e) \in R^n \times R^n : \text{rank}(i, \mathbf{c}, \mathbf{e}, \lambda) = r\}$$

  - Any realization (*c,e*) in $M_i^r(\lambda)$ results in such values for the different alternatives that alternative *i* obtains rank *r*

- The *rank acceptability index* $b_i^r(\lambda)$ describes, for a given value of $\lambda$, the share of all possible realizations of **C** and **E** for which alternative *i* is ranked at place *r*

$$b_i^r(\lambda) = \int\int_{(c,e) \in M_i^r(\lambda)} f_{CE}(\mathbf{c},\mathbf{e}) d\mathbf{c} d\mathbf{e}$$

# Rank acceptability indices cont'd

| | cost | effect | NMB (λ=25) |
|---|---|---|---|
| alternative A | 100 | 5 | 25 => rank 3 |
| alternative B | 120 | 6 | 30 => rank 2 |
| alternative C | 80 | 7 | 95 => rank 1 |

| | Cost | effect | NMB (λ=25) |
|---|---|---|---|
| alternative A | 80 | 7 | 95 => rank 1 |
| alternative B | 120 | 6 | 30 => rank 2 |
| alternative C | 100 | 5 | 25 => rank 3 |

$b_1^1(25) = 0.5$, $b_1^2(25) = 0$, $b_1^3(25) = 0.5$



triumph
a ctmm project

# Cumulative rank acceptability indices

- Favorable alternatives are those with high probabilities for the best ranks and low probabilities for the worst ranks
- This information can be obtained from the *cumulative rank acceptability indices*

$$t_i^k(\lambda) = \sum_{r=1}^{k} b_i^r(\lambda)$$

- $t_i^k(\lambda)$ describes the fraction of all possible realizations of **C** and **E** for which alternative *i* is assigned at any of the *k* best ranks
  - $t_i^1(\lambda) = b_i^1(\lambda)$
  - $t_i^n(\lambda) = 1$

# How to use the SMAA-CEA descriptive indices

- Case 1: λ is established a priori of the CEA
  - The general concensus is that a decision maker should select the alternative with the highest expected NMB
  - The rank acceptability indices can be used to provide a complete picture of the uncertainty surrounding the treatment selection decision

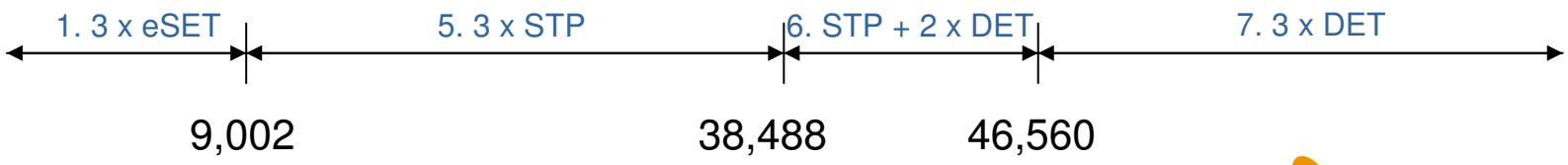
- Case 2: the value of λ is not exactly known by the DM
  - The cumulative rank acceptability indices can be used to identify compromise alternatives that have reasonable cost-effectiveness profiles across wide λ ranges

# Case study in IVF treatment selection

- We considered a previously published cost-effectiveness decision problem relating to infertility treatment (Fiddelers et al., 2009)
- The objective of the original study was to compare the cost-effectiveness of seven IVF strategies
- Effects were quantified in terms of the mean live birth probability for a couple starting IVF treatment
- Costs were analyzed from a societal perspective
- Uncertainty was accounted for by specifying probability distributions for the model parameters

# Results of the probabilistic cost-effectiveness analysis

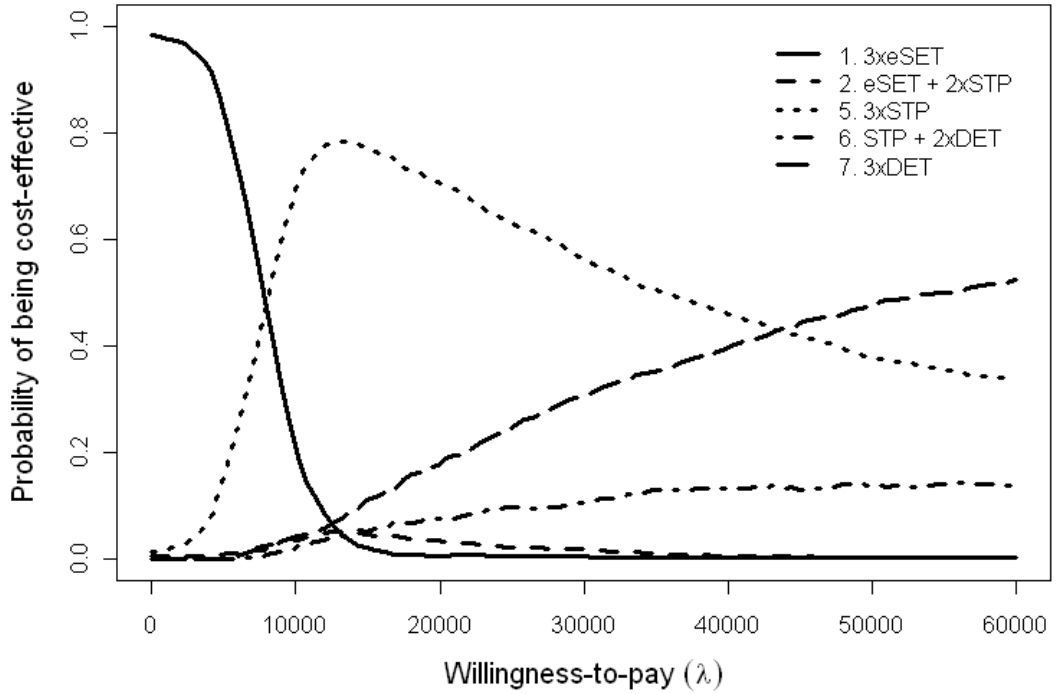
| Strategy | Mean effect | Mean Cost | ICER | Dominated by |
|---|---|---|---|---|
| 1. 3 x eSET | 0.374 | 14,154 | | |
| 2. eSET + 2 x STP | 0.458 | 15,157 | | 1-5 |
| 3. eSET + STP + DET | 0.470 | 15,609 | | 5 |
| 4. eSET + 2 x DET | 0.490 | 16,423 | | 5 |
| 5. 3 x STP | 0.523 | 15,498 | 9,002 | |
| 6. STP + 2 x DET | 0.552 | 16,567 | 38,488 | |
| 7. 3 x DET | 0.575 | 11,700 | 46,560 | |

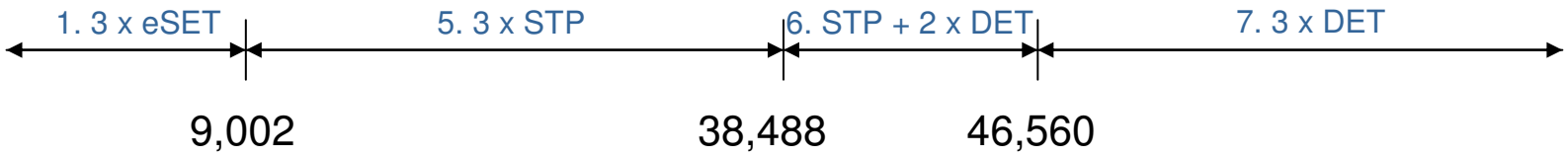





triumph
a ctmm project

# Cost-effectiveness acceptability curves

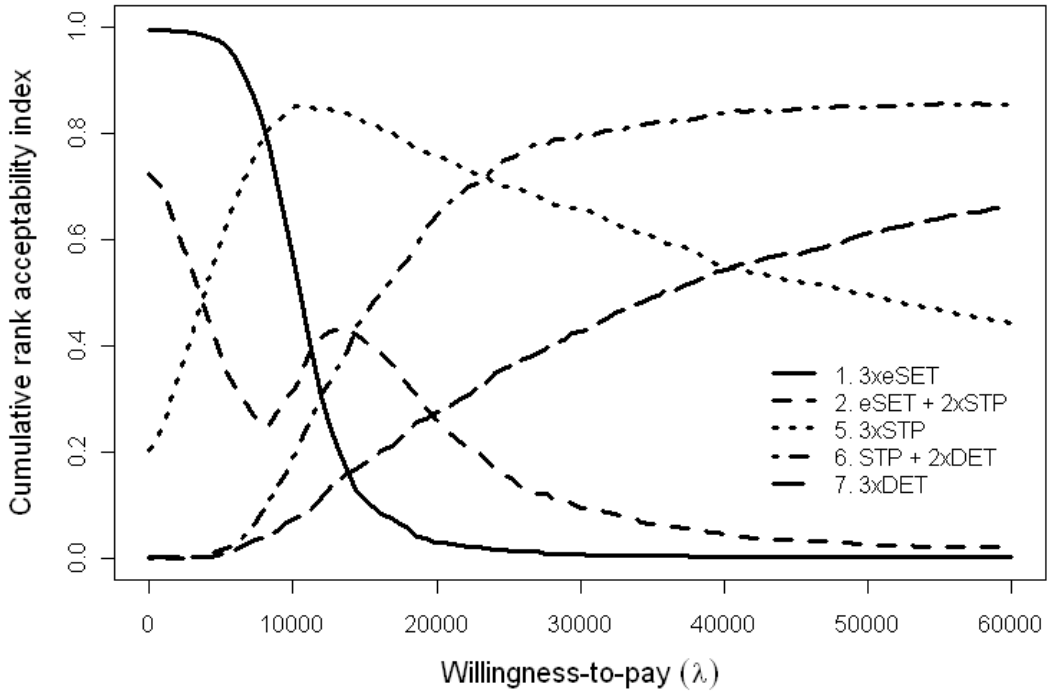


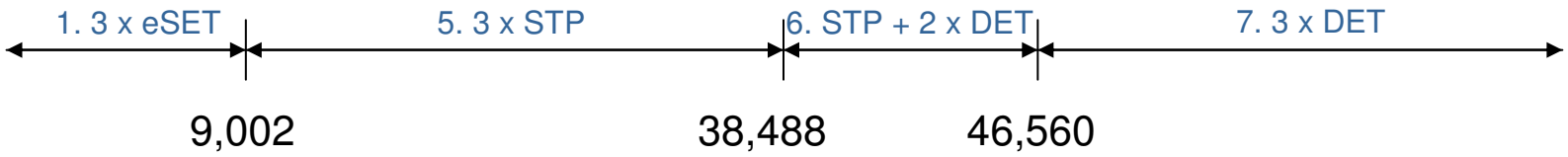






triumph
a ctmm project

# Cumulative rank acceptability curves for ranks 1 and 2

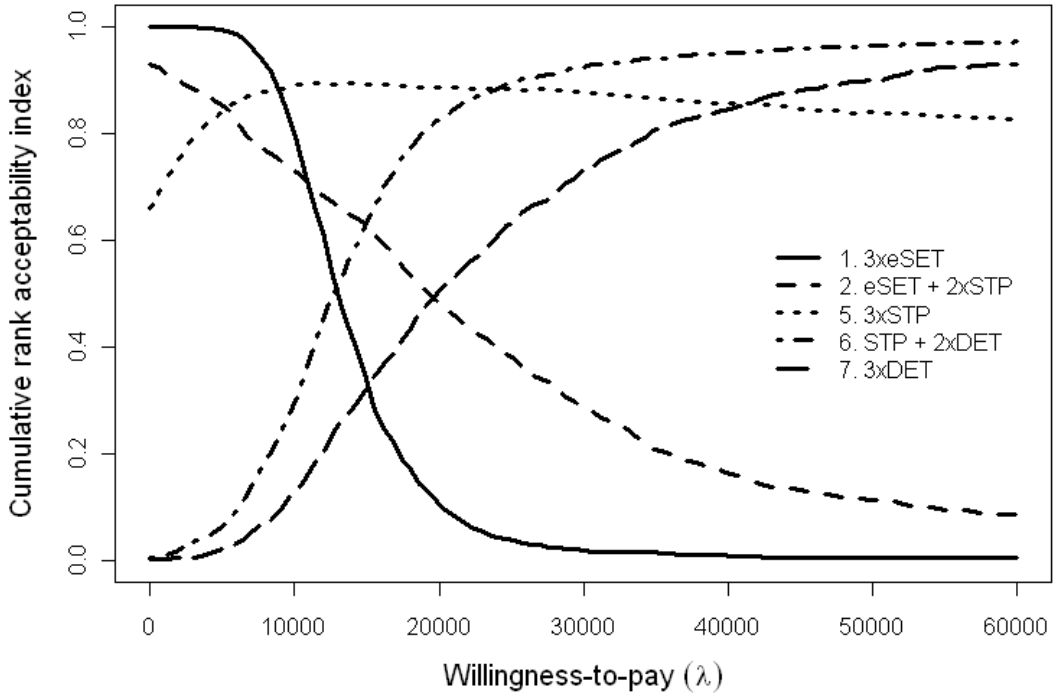


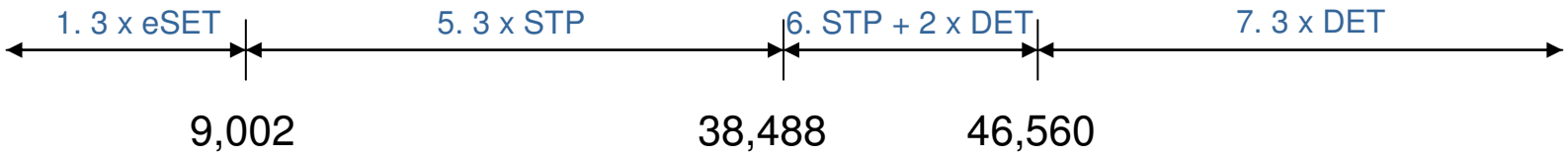






triumph
a ctmm project

# Cumulative rank acceptability curves for ranks 1, 2, and 3






triumph
a ctmm project

# Conclusion

- By describing an intervention's rank distribution, the SMAA-CEA descriptive indices provide a complete picture of the uncertainty surrounding the cost-effectiveness decision problem
- We therefore believe that the (cumulative) rank acceptability curves will be a useful extension of the CEAC, which only provides information on the probability that a given intervention is the optimal one

# CTMM - A public-private partnership for translational molecular medicine