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Improving healthcare decisions

What can Health Economics learn from Operations Research?

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SECTION

1

Introduction

Praveen Thokala
University of Sheffield

Purpose of Workshop

- There are a variety of available approaches available to researchers for approaching different types of health economic evaluation problems.
- However, most training sessions at ISPOR focus on very specific techniques and certain types of problems
- This workshop will present the approaches from operations research (OR) and focuses on the higher order issue of choosing the correct approach in the first place.

What is Operations Research?

- Operations Research (OR) is a discipline that applies mathematical techniques to help institutions (private, public, non-profit) and individuals make better decisions.
- OR has recently been called "the science of better" http://www.scienceofbetter.org
- OR focuses on finding ways to allocate scarce resources to activities
- Number of different techniques under OR umbrella

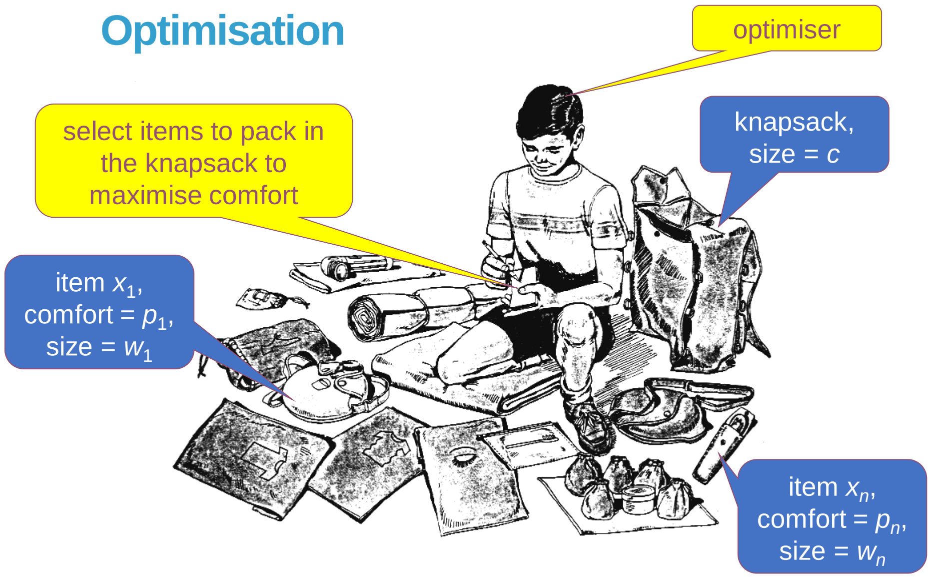
Methods to be covered in this session

- Simulation modelling
- Optimization modelling
- Multi criteria decision analysis

Simulation modelling

- Most health economic modelling approaches assume
  - every patient is the same (cohort models)
  - no interactions between patients
  - that there are no resource capacity issues
- Simulation modelling techniques such as discrete event simulation, system dynamics and agent based modelling can help with capturing these issues

Optimisation



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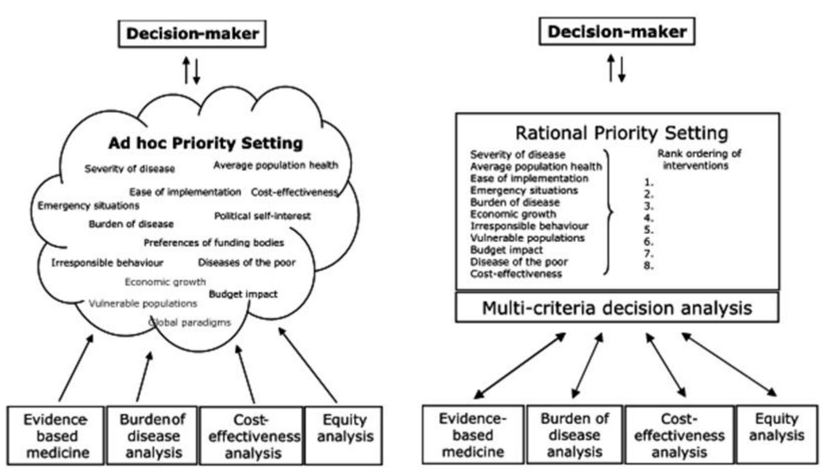
Multi criteria decision analysis



* *Priority setting of health interventions: the need for multi-criteria decision analysis*, Rob Baltussen, Louis Niessen, Cost effectiveness and resource allocation (2006)

These approaches differ in terms of their

- Aim and Purpose
- Types of applications
- Key concepts
- Outputs
- Resources/skills needed

Plan for the session

- Simulation modelling – Deborah Marshall
- Optimization modelling – Alec Morton
- Multi criteria decision analysis - Janine van Til
- Audience polling - all

SECTION

2

Simulation Modelling

Deborah A Marshall

University of Calgary, Canada

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VALUE IN HEALTH 18 (2015) 5–16

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/jval

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ISPOR TASK FORCE REPORT

Applying Dynamic Simulation Modelin
Care Delivery Research—The SIMULAT
ISPOR Simulation Modeling Emerging G

Deborah A. Marshall, PhD[1,2,3,*], Lina Burgos-Liz, MSc, MPH, BS
Nathaniel D. Osgood, BS, MS, PhD[5,6], William V. Padula, PhD,
Peter K. Wong, PhD, MS, MBA, RPh[9], Kalyan S. Pasupathy, PhD

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Science of Health Care Delivery, Rochester, MN, USA; [11]Health Care Policy & Re
Mayo Clinic, Rochester, MN, USA

ABSTRACT

Health care delivery systems are inherently complex, consisting of multiple tiers of interdependent subsystems and processes that are adaptive to changes in the environment and behave in a nonlinear fashion. Traditional health technology assessment and modeling methods often neglect the wider health system impacts that can be critical for achieving desired health system goals and are often of

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ISPOR TASK FORCE REPORTS

Selecting a Dynamic Simulation Modeling Method for Health Care Delivery Research—Part 2: Report of the ISPOR Dynamic Simulation Modeling Emerging Good Practices Task Force

CrossMark

Deborah A. Marshall, PhD[1,*], Lina Burgos-Liz, MSc, MPH, BSc Ind Eng[2], Maarten J. IJzerman, PhD[3], William Crown, PhD[4], William V. Padula, PhD, MS[5], Peter K. Wong, PhD, MS, MBA, RPh[6], Kalyan S. Pasupathy, PhD[7], Mitchell K. Higashi, PhD[8], Nathaniel D. Osgood, BS, MS, PhD[9,10], the ISPOR Emerging Good Practices Task Force

[1]Health Services & Systems Research, Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; [2]Cumming School of Medicine, University of Calgary, Calgary, AB, Canada; [3]Department of Health Technology & Services Research, University of Twente, Enschede, The Netherlands; [4]Optum Labs, Boston, MA, USA; [5]Section of Hospital Medicine, University of Chicago, Chicago, IL, USA; [6]HSHS Illinois Divisions and Medical Group, Hospital Sisters Health System, Belleville, IL, USA; [7]Health Care Systems Engineering Program, Mayo Clinic Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery, Rochester, MN, USA; [8]GE Healthcare, Barrington, IL, USA; [9]Department of Computer Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; [10]Department of Community Health & Epidemiology and Bioengineering Division, Saskatoon, Saskatchewan, Canada

ABSTRACT

In a previous report, the ISPOR Task Force on Dynamic Simulation Modeling Applications in Health Care Delivery Research Emerging Good Practices introduced the fundamentals of dynamic simulation modeling and identified the types of health care delivery problems for which dynamic simulation modeling can be used more effectively than other modeling methods. The hierarchical relationship between the health care delivery system, providers, patients, and other stakeholders exhibits a level of complexity that ought to be captured using dynamic simulation modeling methods. As a tool to help researchers decide whether dynamic simulation modeling is an appropriate method for modeling the effects of an intervention on a health care system, we presented the System, Interactions, Multilevel, Understanding, Loops, Agents, Time, Emergence (SIMULATE) checklist consisting of eight elements. This report builds on the previous work, systematically comparing each of the three most commonly used methods to add value to informed decision making, with an emphasis on stakeholder engagement, starting with the problem definition. Finally, we identify areas in which further methodological development will likely occur given the growing "volume, velocity and variety" and availability of "big data" to provide empirical evidence and techniques such as machine learning for parameter estimation in dynamic simulation models. Upon reviewing this report in addition to using the SIMULATE checklist, the readers should be able to identify whether dynamic simulation modeling methods are appropriate to address the problem at hand and to recognize the differences of these methods from those of other, more traditional modeling approaches such as Markov models and decision trees. This report provides an overview of these modeling methods and examples of health care system problems in which such methods have been useful. The primary aim of the report was to aid decisions as to

Simulation Modelling: Definition

"Simulation modelling methods are used to design and develop mathematical representations of the operation of processes and systems to experiment with and test interventions and scenarios and their consequences over time to advance the understanding of the system or process, communicate findings, and inform management and policy design."

- Banks J. Handbook of Simulation. Wiley Online Library,1998.
- Sokolowski JA, Banks CM. Principles of Modeling and Simulation: A Multidisciplinary Approach. Hoboken, NJ: John Wiley & Sons, 2011

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Key Concepts: Why ***Systems*** Perspective and ***Simulation Modelling*** in Health Care?

- Health Care is a **Complex System with relationally dependent events with unpredictable outcomes -** multiple stakeholders and interactions, feedback loops, non-linearities, uncertainty, etc.
- Simulation models support the design of systems by enabling a better understanding of the complexity and behaviour of the system that is modelled. This can translate into quality and healthcare improvement.
- Simulation models are means to synthesize data when direct experimentation is not possible or feasible.
- Mechanism to logically and systematically examine a policy problem. Evaluate intended and unintended consequences of an intervention using alternative "what if…?" scenarios BEFORE implementing.
- Identify need for additional data – what are the gaps?

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Aim/Purpose of Simulation Models

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What is Dynamic Simulation Modeling Used for?

Health Care Delivery Research in Complex Systems

- Model building process and simulation are learning processes themselves
- Identify critical functional and relational aspects in complex systems.
- Understand why a system behaves the way it does as a function of its organization (structure).
- Shift paradigms and mental models

Design and Evaluation of Health Care Delivery System Interventions

- Evaluate intended and unintended consequences of an intervention using "what if...?" scenarios
- Tool for designers (e.g. policy design, system design and re-design) that is more prescriptive in nature by informing decision making.

Why do we build simulation models?

- **Identify critical functional and relational aspects of a system**
- **Understand the system as a function of its organisation and relationships**
- **Suggest how to intervene to achieve desired goals and outcomes**

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Applications: Examples of Problems Addressed with Simulation Modelling Methods

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System Level	Types of Problems	Potential Approaches	Intervention Example
Strategic Level	Policy	System Dynamics Agent Based Modeling	Informing regional policy regarding implementation of a centralized intake system for referral to an appropriate provider for assessment and specialist consultation for patients with musculoskeletal pain.
Tactical Level	Management	Agent Based Modeling Discrete Event Simulation	Wait time management for referral for a specific service e.g., consultation with orthopaedic surgeon or rheumatologist
Operational Level	Logistics	Agent Based Modeling Discrete Event Simulation	Scheduling surgical dates for joint replacement in the operating room Evaluating the change in hospital services due to a delay of total joint replacement in cases of severe osteoarthritis.

Three Main Approaches to Simulation Modelling

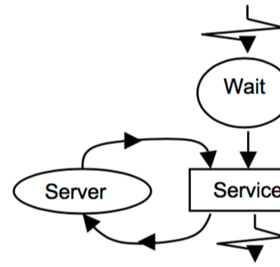
- System dynamics – e.g. facilities for cancer treatment
- Discrete event simulation – e.g. surgical planning and scheduling
- Agent (Individual) based modelling - infectious disease control

System Dynamics Simulation

– E.g. utilization of a system of hospital(s) (departments)

- Core elements: Stocks and Flows
  - **Feedback:** Feedback processes infer that effect is not proportional to the cause i.e. nonlinearity
  - **Accumulations** (stocks): Accumulation or aggregation of something (e.g.,people, beds)
  - **Rates** (flows): Flows feed in and out of stocks and have the same units of stocks per time unit (e.g., people per hour, beds per year, and oxygen per minute)
  - **Time Delays**: People accumulate in stocks if the rate of flow out is less than in to the stock

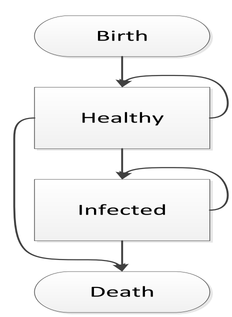
Discrete Event Simulation



– E.g. surgical planning

- Core elements: Queues
  - **Process**: representing the system that is being studied
  - **Entities:** flowing through the process and have work done on them
  - **Resources:** used in the workflow to process entities
  - **Events:** cause changes in the state of the entity and/or system

Agent Based Simulation



– E.g. infectious disease modelling

- Core elements: Interactions
  - **Entities:** transition between states based on events and interactions
  - **Interactions:** dynamic behavior of the entities and their environment
  - **Network:** set of (dynamic) rules to determine the interactions
  - **Space:** entities' behavior is influenced by their spatial location

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Example: System Dynamics Model of Osteoarthritis

Journal of Simulation (2015) 1–14

www.palgrave-journals.com/jos/

Modelling the complete continuum of care using system dynamics: the case of osteoarthritis in Alberta

SA Vanderby[1]*, MW Carter[2], T Noseworthy[3] and DA Marshall[3]

[1]University of Saskatchewan, Saskatoon, Canada; [2]University of Toronto, Toronto, Canada; and [3]University of Calgary, Calgary, Canada

Estimating how many patients will require care, the nature of the care they require, and when and where they will require it, is critical when planning resources for a sustainable health-care system. Resource planning must consider how quickly patients move among stages of care, the various different pathways they may take and the resources required at each stage. This research presents a preliminary long-term, population-driven system dynamics simulation developed to support resource planning and policy development relating to osteoarthritis care. The simulation models osteoarthritis patients as they transition through the continuum of care from disease onset through end-stage care, and provides insight into the size and characteristics of the patient population, their resource requirements and associated health-care costs. Although the model presented is specific to the osteoarthritis care system in the Province of Alberta, Canada, similar methods could be applied to develop simulations relating to other chronic conditions.
Journal of Simulation advance online publication, 20 February 2015; doi:10.1057/jos.2014.43

Keywords: system dynamics; simulation; strategic planning; health systems

<u>'What if' scenarios:</u>

- Provide insight into relative effects of changes in care processes and/or resource use
- Demonstrate intended and unintended consequences

Case Example: What if we implemented a maximum 14 week wait time target for joint replacement surgery?

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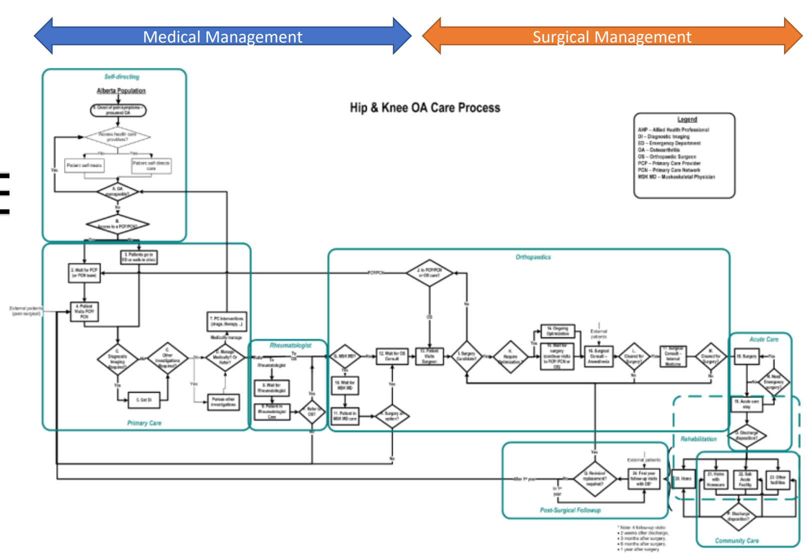
Example: System Dynamics Osteoarthritis (OA) Model Process Diagram



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- <u>Vanderby SA</u>, Carter MW, Noseworthy T, Marshall DA. Modeling the complete continuum of care using system dynamics: the case of osteoarthritis in Alberta. J Simulation 2015; 9(2): 156-169

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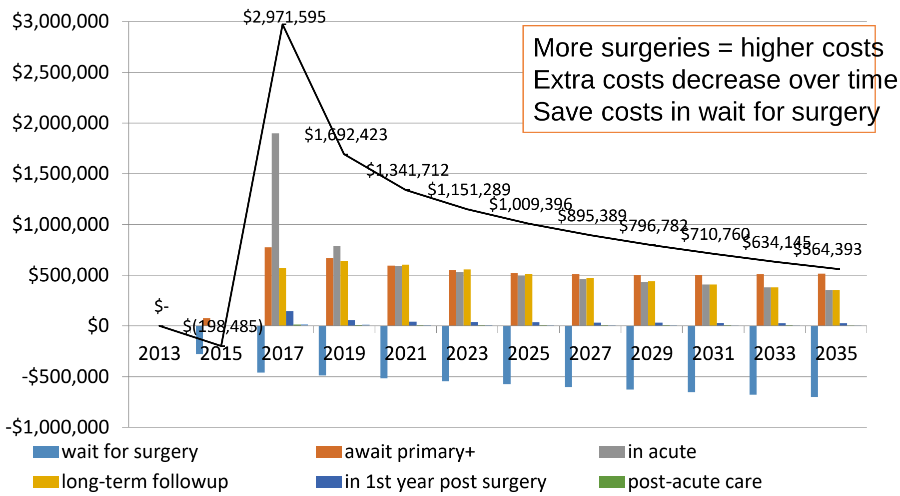
Cost Output: 14 Week Target for Joint Replacement



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Simulation Modelling: Resources and Skills Needed

- Software
  - Mostly need specialised software for the specific modelling approach (of course everything can be done in Excel, but not efficiently)
- Skills
  - Need quantitative and modelling skills
  - Recommend working with someone who has experience in specific modelling approach
- Data and Analysis
  - Consider carefully the research question and problem
  - Consider the level of detail required for the data inputs and what will be data inputs vs outputs.
  - Need clinical and decision maker input on model structure and interpretation of results – validate with stakeholders
  - Some modelling approaches need a lot of data e.g. DES need individual level data; ABM needs behavioural data

SECTION

3

Optimisation

Alec Morton
University of Strathclyde, Glasgow, UK

Optimisation: Definition

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What is Optimization?

Slides thanks to ISPOR Constrained Optimization Taskforce

- **Optimization** is a key tool in the ***analytics armamentarium.***
  - "**Optimization:** Narrowing your choices to the very best when there are virtually innumerable feasible options" INFORMS, The Science of Better http://www.scienceofbetter.org/what/index.htm
  - "In a mathematical programming or **optimization** problem, one seeks to minimize or maximize a real function of real or integer variables, subject to constraints on the variables." The Mathematical Programming Society http://www.mathprog.org/mps_whatis.htm
- **Take home**: Optimization is an ***applied, practical*** subject, but also a ***highly technical*** one that uses cutting edge math and computation.

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Optimisation: Aim/purpose

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"To identify the 'best' solution"

- Example: your health center serves **Regular** or **Severe** Patients
- Some info:
  - Regular patients can achieve **2 units** of health benefits, Severe patients can achieve **3 units** of health benefits
  - Each patient takes **fifteen minutes** to be seen
  - Regular patients require **$25** of medications, severe patients require **$50** of medications
  - Total consultation time available is **one hour** (can only see one patient at a time) and total medication money available is **$150**
- Question: What's the max. unit of health benefits that can be achieved?

Optimisation: Types of applications

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Typical Health Care Decisions in Which Constrained Optimization is Used

	Type of health care problem	Typical decision makers	Typical decisions	Typical objectives	Typical constraints
Case study at ISPOR Boston	Resource allocation within or across disease programs	Health authorities, insurance funds	List of interventions to be funded	Increase population health	Overall health budget
Case study in TF paper 2	Resource allocation for infectious disease management	Public health agencies, health protection agencies	Optimal vaccination coverage level	Ensure disease outbreaks can be rapidly and cost effectively contained,	Availability of medicines, disease dynamics of the epidemic
Case study at ISPOR Vienna	Allocation of donated organs	Organ banks, transplant service centers	Matching of organs and recipients	Matching organ donors with potential recipients	Every organ can be received by at most one person
Case study in TF paper 2	Radiation treatment planning	Radiation therapy providers	Positioning and intensity of radiation beams	Minimizing the radiation on healthy anatomy	Tumor coverage and total average dosage
Case study in TF paper 2	Disease management Models	Leads for a given disease management plan	Best interventions, timing for the initiation of a medication, best screening policies	Identify the best plan using a whole disease model, maximizing QALYs	Budget for a given disease or capacity constraints for providers
	Workforce planning/ Staffing / Shift template optimization	Hospital managers, all medical departments (e.g., ED, nursing)	Number of staff at different hours of the day, shift times	Increase efficiency and maximize utilization of healthcare staff	Availability of staff, human factors, state laws (e.g., nurse-to-patient ratios), budget
	Inpatient scheduling	Operation room/ ICU planners	Detailed schedules	Minimize waiting time	Availability of beds, staff

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ISPOR **Optimisation: Key concepts** www.ispor.org

Optimization terminology

- **Decision variables** - mathematical symbols representing the inputs that can be changed to achieve optimal solution
- **Objective function** - a mathematical relationship describing an objective, in terms of decision variables - this function is to be maximized or minimized
- **Constraints** – requirements or restrictions placed on and stated in functions of the decision variables
- **Parameters** - numerical coefficients and constants used in the objective function and constraints

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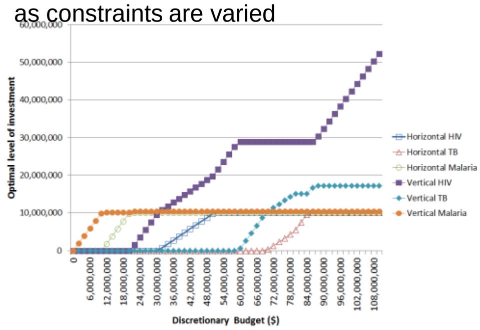
ISPOR **Optimisation: Outputs** www.ispor.org

Optimal solution; and list of final decision variables

- Example: your health center serves **Regular** or **Severe** Patients
- Some info:
  - Regular patients can achieve **2 units** of health benefits, Severe patients can achieve **3 units** of health benefits
  - Each patient takes **fifteen minutes** to be seen
  - Regular patients require **$25** of medications, severe patients require **$50** of medications
  - Total consultation time available is **one hour** (can only see one patient at a time) and total medication money available is **$150**
- Output: We can achieve **10 units health benefits** by treating **2 regular patients** and **2 severe patients**

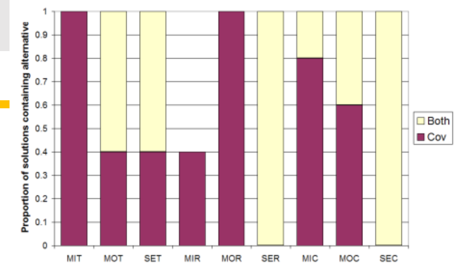
More on outputs

Explore how decisions change as constraints are varied



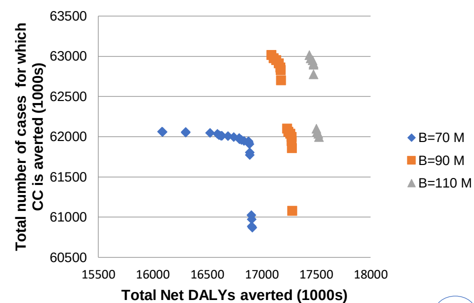
Morton A., Thomas R., Smith P. C. (2016) Decision rules for allocation of finances to health systems strengthening. *Journal of Health Economics*. 49: 97-108.

Morton A (2014) Aversion to health inequalities in healthcare prioritisation: a multiobjective mathematical programming perspective. *Journal of Health Economics*. **36**: 164-173.



Visualise the effects of uncertainty on decisions

Balance competing objectives through generating tradeoff curves



Ö. Karsu and A. Morton (in preparation) Trading off health and financial protection benefits with multiobjective optimisation

Resources and skills needed

- Software
  - For small models and linear programming, you can use MSExcel
  - Beyond that consider investing in specialised software
- Skills
  - You DON'T need to be a mathematician
  - You DON'T need to be a computer scientist
  - BUT it's probably a good idea to take a class or read a book
- Time and eyeballs
  - VALIDATE, VALIDATE, VALIDATE
  - Optimisation should complement stakeholders' informal knowledge, it doesn't substitute

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SECTION

4

Multi criteria decision analysis

Janine van Til

University of Twente, Netherlands

Definition

Multi-criteria decision analysis (MCDA)

- "an extension of decision theory that covers any decision with multiple objectives. A methodology for appraising alternatives on individual, often conflicting criteria, and combining them into one overall appraisal…" (Keeney & Raiffa, 1976)
- "an umbrella term to describe a collection of formal approaches, which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter." (Belton & Stewart, 2002)

Aim and Purpose

- Aim: an assessment of the relative desirability or acceptability of specified alternatives or choices among outcomes or other attributes that differ among alternative health interventions
- Purpose: to support a decision by:
  - Identifying which outcomes, endpoints, or attributes matter to stakeholders and why.
  - Determine how much different attributes matter to and the trade-offs that stakeholders are willing to make among them.

Key Concepts

- A preference is the choice of one thing over another with the anticipation that the choice will result in greater value, satisfaction, capability or improved performance of the individual, the organization or the society (stakeholders).
- Preference methods can reveal stakeholder values over both more relevant (higher priority) and less relevant (lower priority) endpoints or outcomes.

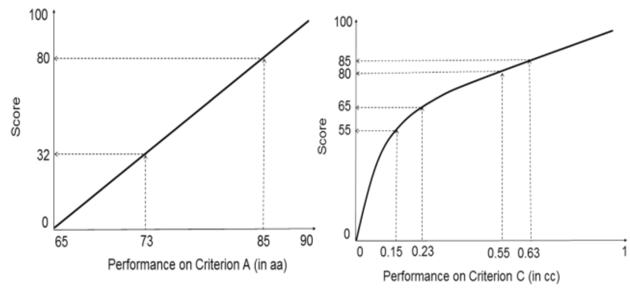
Key Concepts

- Criteria weight = a measure of the relative preference for changes in performance between criteria
- Can be seen as scaling factors

- Performance value = a measure of the relative preference (value) for performance outcomes within criteria
- Can be linear or non-linear

Currency Rates

	USD	EUR	GBP	CHF	CAD
1 USD =	1	0.7141	0.6164	1.0826	1.1006
1 EUR =	1.4004	1	0.8632	1.5160	1.5412
1 GBP =	1.6223	1.1585	1	1.7563	1.7855
1 CHF =	0.9237	0.6596	0.5694	1	1.0166
1 CAD =	0.9086	0.6488	0.5601	0.9836	1



Key Concepts

- Preferences between and within criteria are combined using an additive value function, to come to an overall value for each alternative solution to a decision problem

$$v(x) = \sum_{k=1}^{n} w_k \cdot v_k(x_k)$$

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Applications: MCDA in Priority Setting

International Journal of Technology Assessment in Health Care, 31:6 (2015), 390–398.

Table 4. Priority for Targeting Certain Risk Group Given by Different Stakeholder Groups, Based on 5-Point Likert Scale Scores

All respondents (*n* = 155)				Policy makers (*n* = 22)		People living with HIV/AIDS (*n* = 49)		Health care workers (*n* = 41)		General population (*n* = 43)	
Rank	Risk group	Mean score	(SD)	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score
1	People who inject drugs	4.28	(0.74)	1	4.27	1	4.39	1	4.51	2	3.95
2	Female sex workers	4.20	(0.89)	4	4.09	2	4.20	3	4.27	1	4.19
3	Partners of HIV+ people	4.03	(0.90)	3	4.14	7	3.82	2	4.41	3	3.86
4	Clients of FSW	3.80	(1.09)	2	4.27	3	3.65	4	4.02	4	3.53
5	Prisoners	3.58	(1.19)	5	3.77	6	3.55	5	4.00	5	3.12
6	Men having sex with men	3.47	(1.19)	6	3.41	4	3.63	7	3.71	6	3.09
7	Transgender	3.40	(1.03)	8	3.18	5	3.45	6	3.85	7	3.05
8	People low at risk	2.74	(1.29)	7	3.32	8	2.94	8	2.51	8	2.43

FSW, female sex workers; SD, standard deviation.

All responder						
Rank, criteric						
1 Reduction						
2 Stigma red						
3 Health care						
4 Quality of care	4.50	(0.78)	9	2	2	9
5 Product and technology requirements	4.48	(0.75)	8	7	8	3
6 Individual effectiveness	4.47	(0.63)	1	3	6	10
7 Sustainable financing	4.46	(0.85)	4	10	4	4

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3)

/AIDS interventions in Indonesia.
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2) rated the importance of thirty-two criteria on a

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em (i.e., HCW, product, information, and service
are similar.
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cation of resources.

wise choice between HIV/AIDS in-

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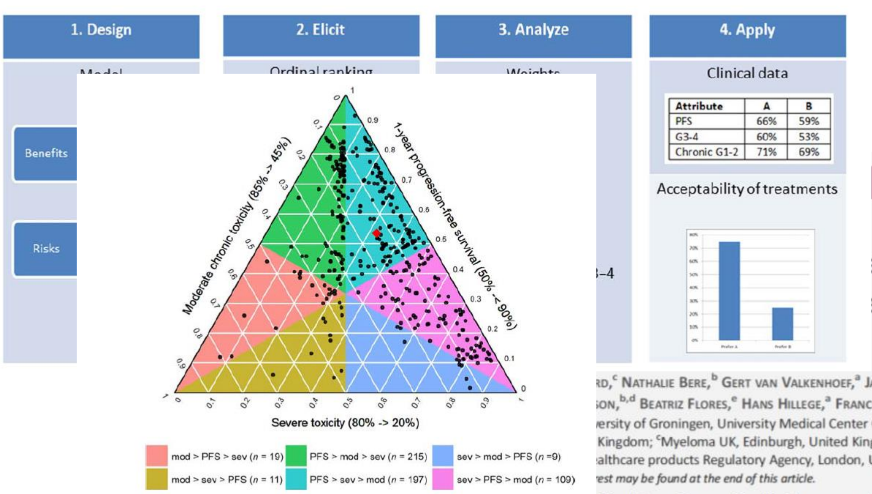
Application: MCDA in Benefit Risk Analysis



Health Outcomes and Economics of Cancer Care

enefits and Risks of Cancer
ence Study with Patients

RD,[c] NATHALIE BERE,[b] GERT VAN VALKENHOEF,[a] JAYNE GALINSKY,[c] ERIC LOW,[c] ISABELLE MOULON,[b]
SON,[b,d] BEATRIZ FLORES,[e] HANS HILLEGE,[a] FRANCESCO PIGNATTI[b]
ersity of Groningen, University Medical Center Groningen, Groningen, The Netherlands; [b]European
Kingdom; [c]Myeloma UK, Edinburgh, United Kingdom; [d]Läkemedelsverket Medical Products Agency,
althcare products Regulatory Agency, London, United Kingdom
est may be found at the end of this article.

Key Words. Patient preferences • Regulatory science • Benefit-risk assessment • Multicriteria decision analysis

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Application: MCDA in Shared Decision Making

ORIGINAL RESEARCH ARTICLE
Patient 2008; 1 (2): 127-135
1178-1661/08/0002-0127/$48.00/0

The Use of Multi-Criteria Decision Analysis Weight Elicitation Techniques in Patients with Mild Cognitive Impairment

A Pilot Study

Janine A. van Til,[1,2] *James G. Dolan,*[3,4] *Anne M. Stiggelbout,*[5] *Karin C.G.M. Groothuis*[1] and *Maarten J. IJzerman*[2]

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4 University of Rochester, Rochester, New York, USA
5 Leids Universitair Medisch Centrum, Leiden, the Netherlands

Review

MDM Medical Decision Making
Medical Decision Making
2018, Vol. 38(6) 746–755

DOI: 10.1177/0272989X18765185
journals.sagepub.com/home/mdm
SAGE

Individual Value Clarification Methods Based on Conjoint Analysis: A Systematic Review of Common Practice in Task Design, Statistical Analysis, and Presentation of Results

Marieke G.M. Weernink, Janine A. van Til, Holly O. Witteman, Liana Fraenkel, and Maarten J. IJzerman

Abstract
Background. There is an increased practice of using value clarification exercises in decision aids that aim to improve shared decision making. Our objective was to systematically review to which extent conjoint analysis (CA) is used to elicit individual preferences for clinical decision support. We aimed to identify the common practices in the selection of attributes and levels, the design of choice tasks, and the instrument used to clarify values. **Methods.** We searched

Outputs

- **Preference weights:** a measure of the relative importance of the different criteria that influence the decision
- **Performance values:** a judgement of the perceived value of (preference for) outcomes on each criterion
- **A rank order of options:** based on a broad evaluation of all relevant criteria that influence the decision

Skills/Resources

- Decision Analyst
- Decision Makers
- Time & Money

SECTION

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Discussion

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Comparison of the methods

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	Simulation modelling	Optimisation	MCDA
Definition	Mathematical representations of the operation of processes and systems	Using analytic methods to seek the best possible solution for a given problem	Support structured decision making involving trade-offs among conflicting criteria
Aim/purpose	Identify critical functional and relational aspects of a system and suggest how to intervene to achieve desired outcomes	To identify the 'best' solution	To compare alternatives on multiple criteria
Types of applications	Strategic, tactical and operational level planning	Resource allocation, scheduling, treatment planning	Priority setting, benefit risk analysis, shared decision making
Key concepts	SD: stocks/flows DES: entities/activities/ labels/resources ABM: agents, rules, interactions	Objective function, Decision variables, Constraints and Constant parameters	Options, Criteria, Weights and partial scores, Overall scores
Outputs	Process measures (e.g. wait times), health/cost outcomes	Optimal solution; and list of final decision variables	Rank order of alternatives based on overall scores
Skills needed	Software programming; conceptual modelling with mental models	Problem structuring; Programming; using optimisation software	Facilitation skills; survey design; statistical skills
Resources	Data, clinical experts, decision makers	Data; clinical experts	Access to decision makers

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Audience polling

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Polling and Q&A

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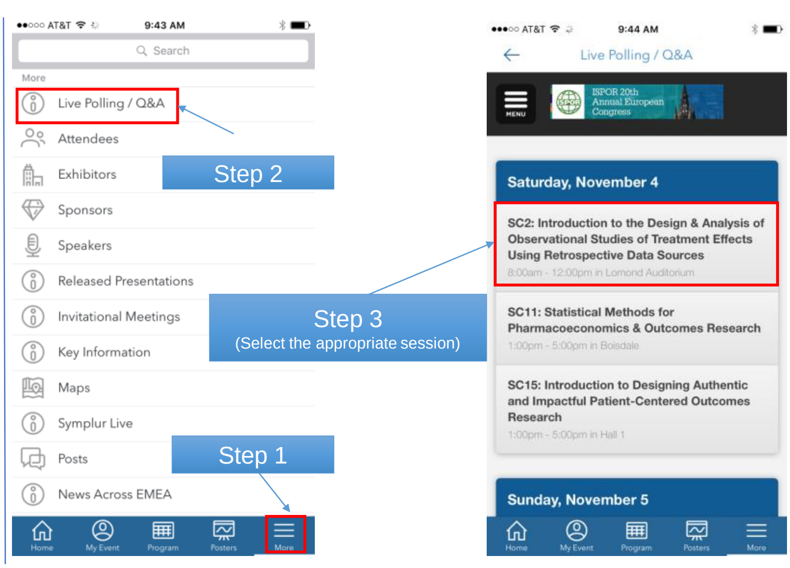

Live Content Slide

When playing as a slideshow, this slide will display live content

Poll: There is a given health care budget, of say £50m. There are a number of interventions, each with data on total costs, QALYs and other elements of value. Need to identify how to spend the budget, which technique will you use

Live Content Slide

When playing as a slideshow, this slide will display live content

Poll: You are the manager of a cancer hospital looking to reconfigure the services for breast cancer patients. Need to look at the whole pathway (i.e. from screening/diagnosis to treatment) to identify which interventions should be included in the pathway

Live Content Slide

When playing as a slideshow, this slide will display live content

Poll: At a HTA agency there are 100s of potential new technologies that need appraising, with only preliminary data on the technology, condition, disease burden, effectiveness, etc. The agency only has capacity to evaluate 25 of them, how will you select?

Conclusions

- Simulation modelling is useful when modelling complex systems and interactions to systematically examine a problem and evaluate intended and unintended consequences of changes to the system.
- Constrained optimization is useful when health system budgets and resources limit an ability to expand/deliver services
- MCDA is useful to prioritise from a range of alternatives that are conflicting on multiple criteria
- These methods can work in tandem (or alone) with existing economic evaluation methods to provide useful insight into the feasibility of health care delivery system value