

Introduction to multi-criteria decision analysis (MCDA) in Health Technology Assessment

Melody Ni, Katerina Savva

NIHR London In Vitro Diagnostics Co-operative

Imperial College London

18th May 2023

Plan for today

- Who we are
- What is multi-criteria decision analysis and why do we need it in innovation
- Steps of MCDA using SMART
- Case study of applying MCDA to biomarker development



Faculty introduction



Melody Ni

Melody Ni specialises in decision analysis, risk analysis and health technology assessment especially in the context of supporting clinical decision making and appraisals of diagnostics. She has over a decade experiences working with industry, researchers and innovators to develop innovative, safe, and cost-effective health technologies to bring tangible benefits for patients, clinicians and the healthcare providers.

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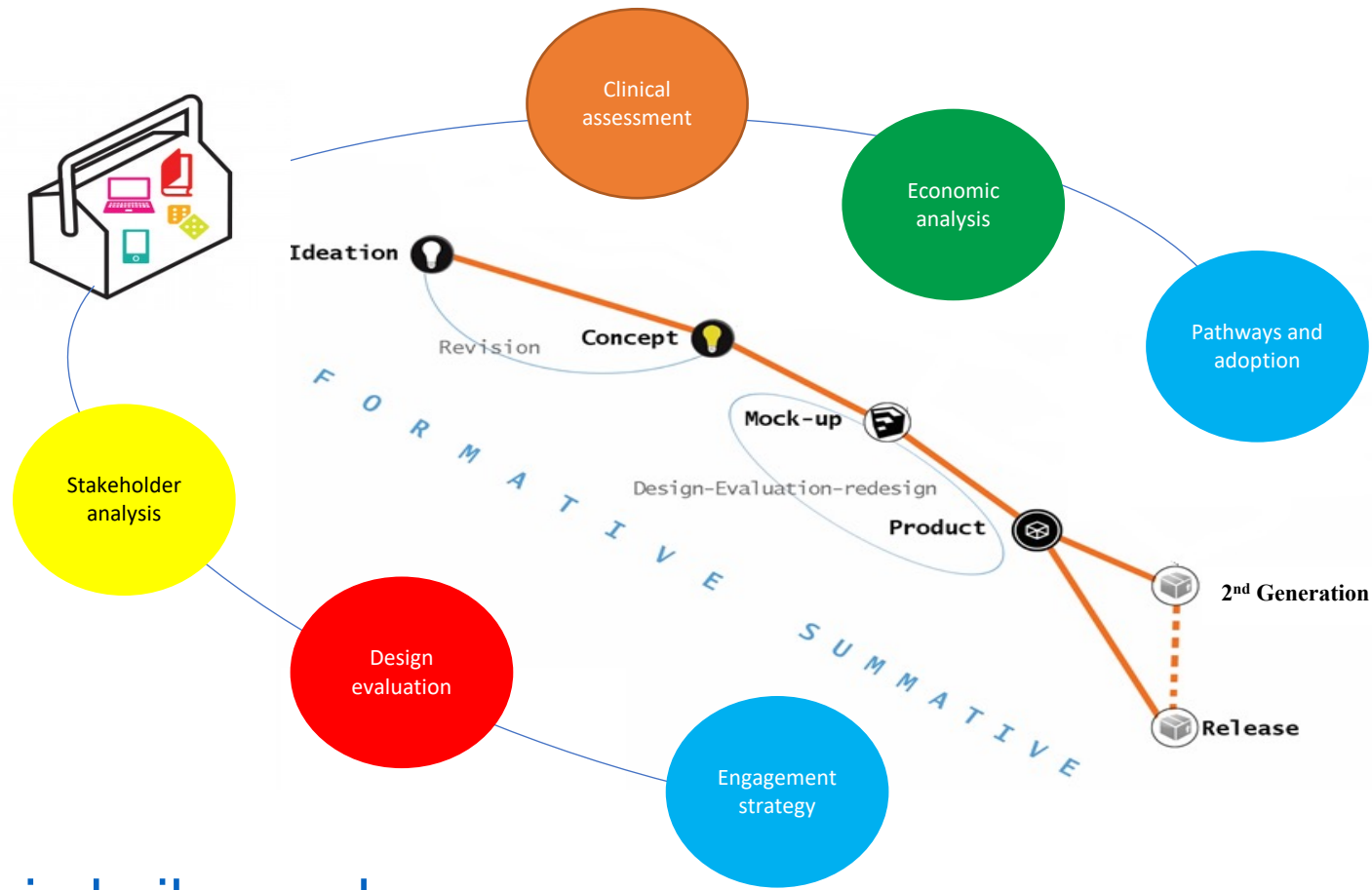
Katerina-Vanessa Savva

Katerina Vanessa Savva is a Research associate in NIHR London In-Vitro Diagnostic Co-operative, specialising in biomarker translational research and cost evaluation of innovations. Due to her role in the group she has collaborated with academia and industry to promote the clinical utilisation of innovations. Her background is in Biomedical Sciences and the focus of her PhD was to develop the Biomarker Toolkit, a tool that would mediate the translation of biomarkers from bench to bedside; thus reducing the costs and time associated with excessive biomarker discovery research.

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NIHR London In Vitro Diagnostics Co-operative (London IVD)

We generate multi-dimensional evidence to support commercialisation

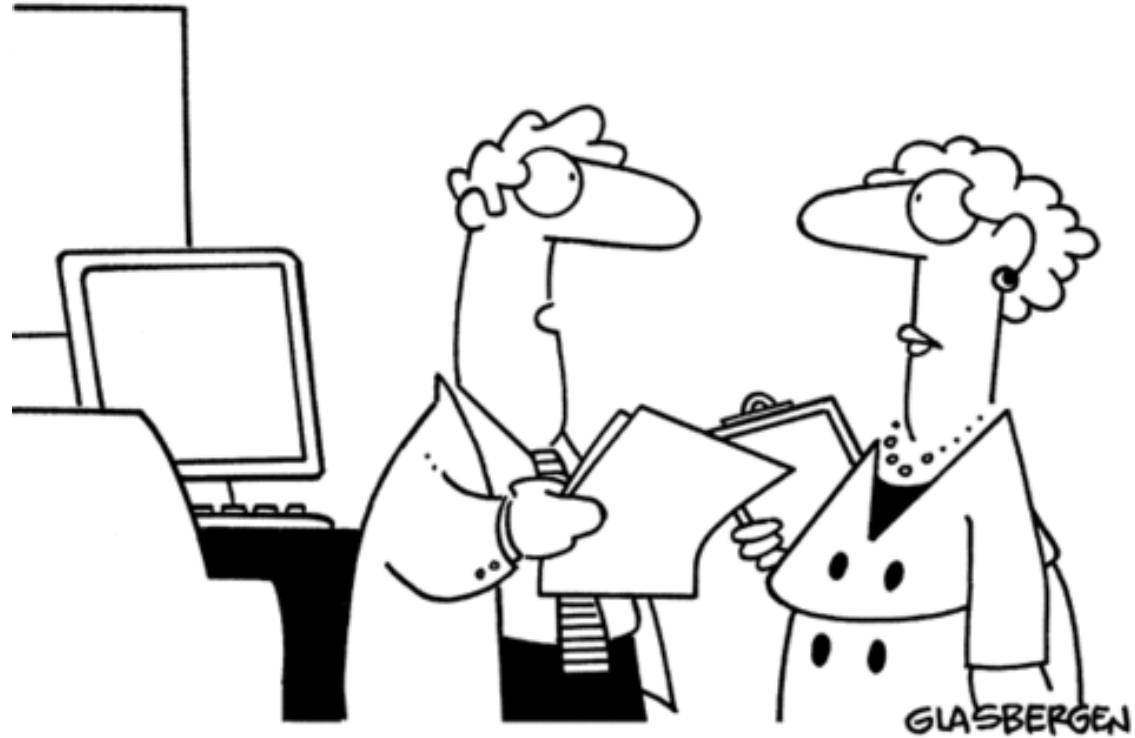


<http://london.ivd.nihr.ac.uk>

What is multi-criteria decision analysis and why do we need it?



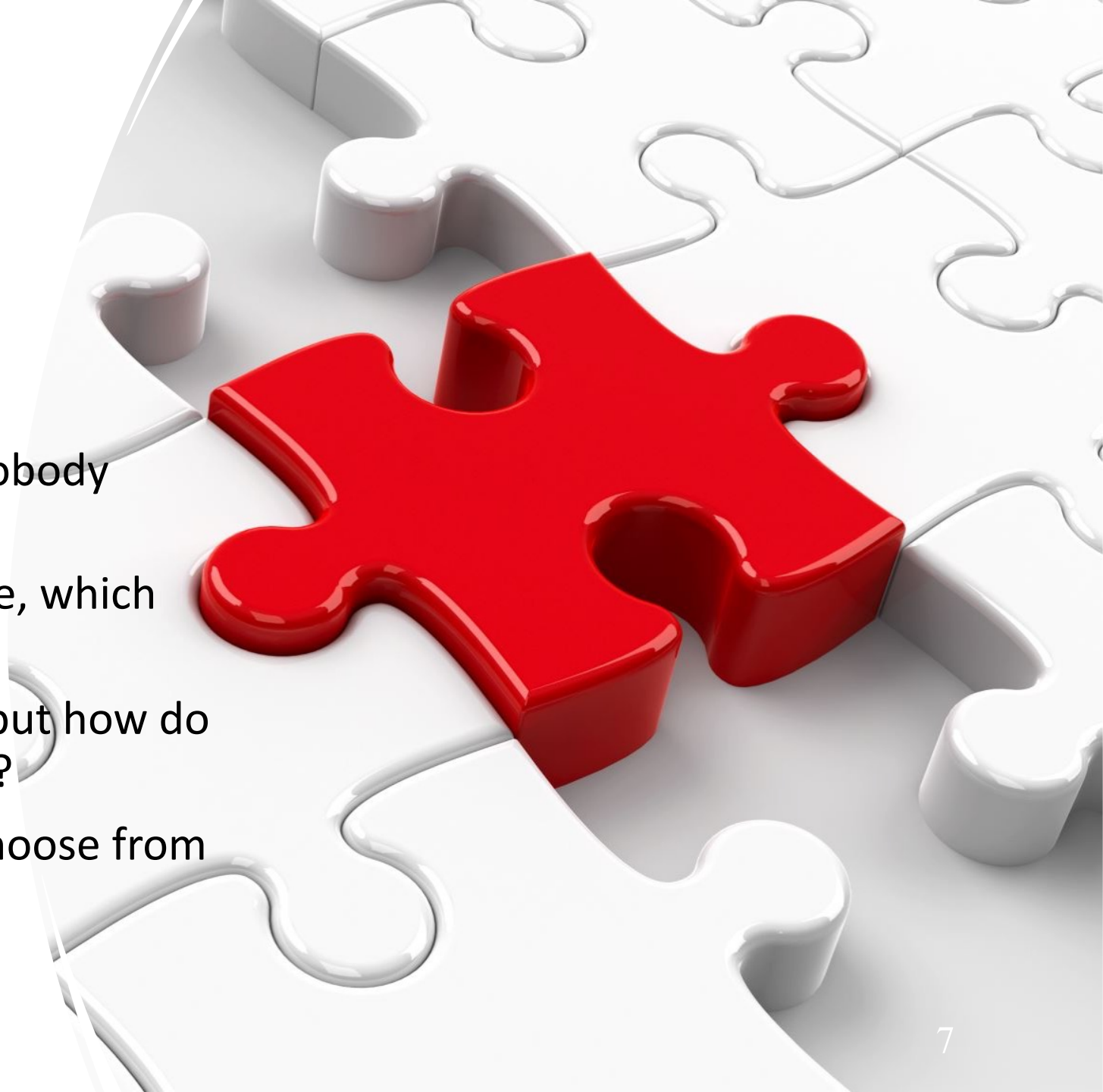
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**“My team has created a very innovative solution,
but we’re still looking for a problem to go with it.”**

Challenges for innovators and decision makers

- We have developed a device but nobody wants to use it
- We only have a limited budget/time, which project shall we work on?
- We've got a great idea to work on but how do we make sure it is value for money?
- We have many design options to choose from - which one to take?
- etc

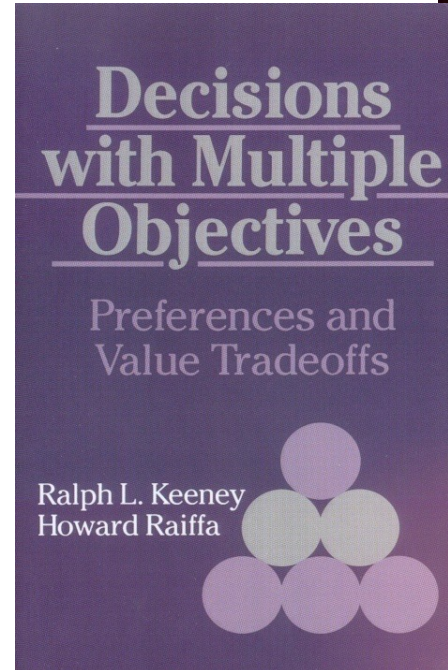


Challenges for innovators and decision makers

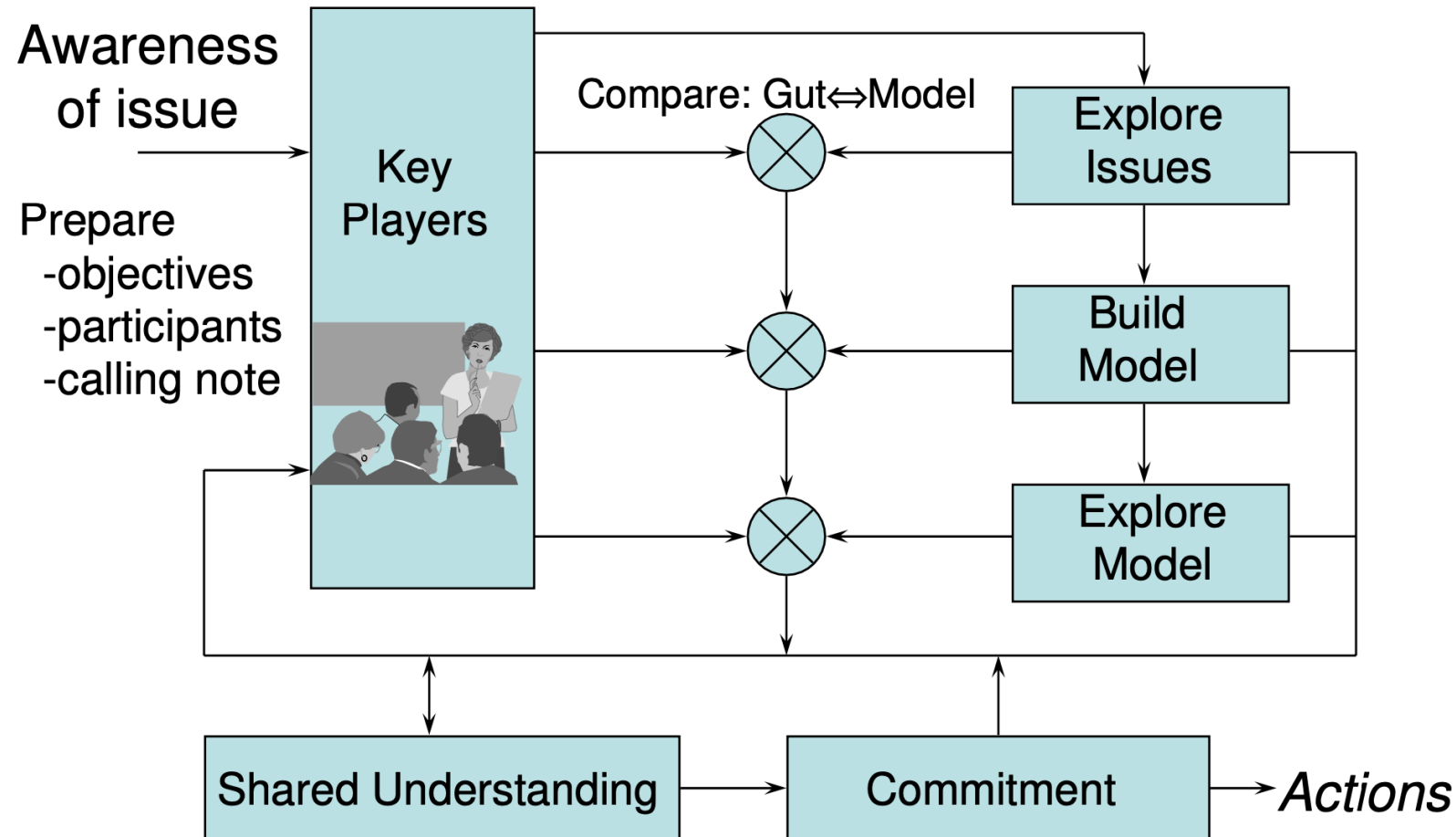
- Reflect the complexity of the healthcare eco-system
- Multiple stakeholders with different perspectives and preferences
- Complex decisions with many options and objectives
- Uncertainties are abundant
- Limited resources

A socio-technical solution

A methodology for a group of key players to appraise options on multiple criteria, and establish an overall prioritisation.



The Decision Conference Process



MCDM can be distilled into a number of simple steps

Iterate!

Iterative steps of MCDM are:

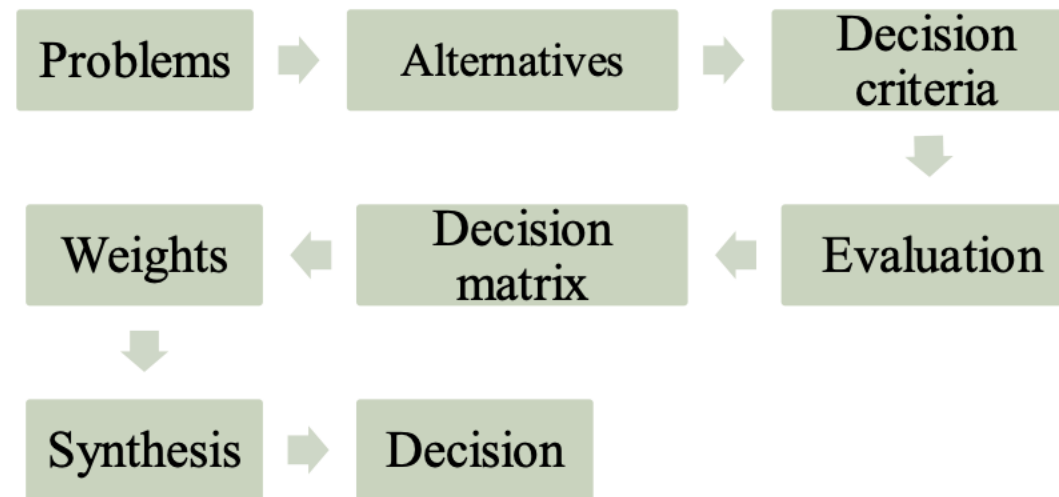


Fig.1 Iterative steps of MCDM method

Edwards, Ward, and F. Hutton Barron. "SMARTS and SMARTER: Improved simple methods for multiattribute utility measurement." *Organizational behavior and human decision processes* 60.3 (1994): 306-325.

SMART- Multi-criteria decision-making technique for use in planning activities, Patel, Meera Rameshkumar, Manisha Pranav Vashi, and Bhasker Vijaykumar Bhatt. "SMART-Multi-criteria decision-making technique for use in planning activities." *New Horizons in Civil Engineering (NHCE 2017)* (2017): 1-6.

Biomarkers of acute appendicitis: systematic review and cost–benefit trade-off analysis

Amish Acharya¹ · Sheraz R. Markar¹ · Melody Ni¹ · George B. Hanna¹

- Acute appendicitis is the most common surgical emergency
- The National Surgical Research Collaborative in the UK has estimated that the negative appendectomy rate is as high as 20.6 %
- A variety of biomarkers can be used as non-invasive tests to aid decision-making
- An ideal biomarker would simultaneously maximize clinical utility and minimise costs including time

Study design

WCC
CRP
Bilirubin
Pro-calcitonin
IL-6
5-HIAA

- Literature review to identify potential biomarkers
- Survey of consultant surgeons to understand the importance of performance criteria
- Extracted 6 biomarkers and 8 relevant performance criteria

Results from the literature review and survey

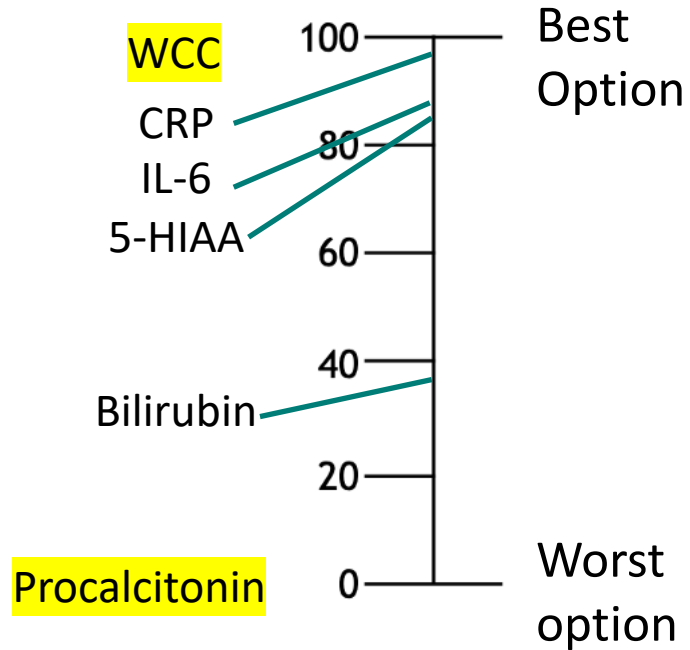
Table 2 Performance of various biomarkers with respect to the surgeon rankings

Biomarker	Sens. (%)	Spec. (%)	Ease of test	Predictive of perforation (%)	Cost (£)	Time for result (h)	Acceptability	Reproducibility
WCC	79	55	Easy	69	2.5	1	Good	92
CRP	76	50	Easy	78	30	1	Good	81
Bilirubin	51	78	Easy	71	2	1	Good	98
Pro-calcitonin	36	88	Easy	83	17.42	12	Good	96
IL-6	73	72	Easy	84	15.5	168	Good	91
5-HIAA	72	86	Easy	0	21	240	Good	93
Surgeon rank	1	2	3	4	5	6	7	8

Acceptability considered 'good' as all can be done routinely. Ease of testing all considered 'easy' as all are noninvasive

WCC White cell count, CRP C-reactive protein, IL-6 Interleukin 6, 5-HIAA Urinary serotonin, Sens Sensitivity, Spec Specificity

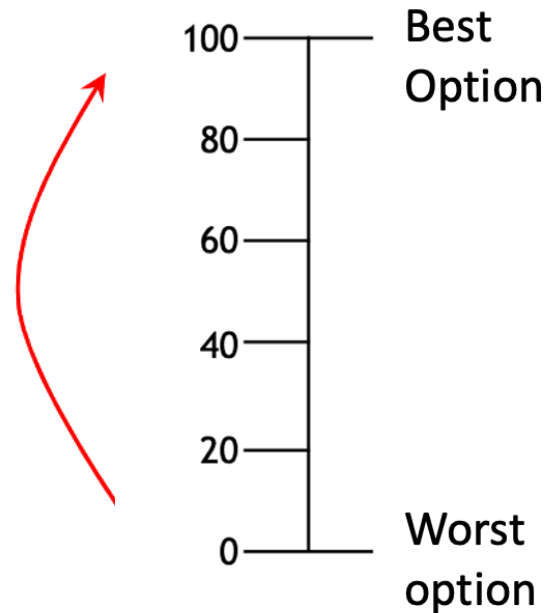
Scoring the options



- We used simple linear transformation

Biomarker	Sens. (%)	
WCC	79	Score = 100
CRP	76	
Bilirubin	51	
Pro-calcitonin	36	Score = 0
IL-6	73	
5-HIAA	72	

Weighting the criteria



- Not all criteria are created equal
- The weight on a criterion reflects both the range of difference of the options, and how much that difference matters.
- *How does the swing from 0 to 100 on one preference scale compare to the 0 to 100 swing on another scale?
=> Swing weights*

Results from the literature review and survey

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WCC White cell count, CRP C-reactive protein, IL-6 Interleukin 6, 5-HIAA Urinary serotonin, Sens Sensitivity, Spec Specificity

- All options performed the same on Ease of test and acceptability
- These two criteria were removed from the subsequent analyses (weight =0)

Synthesize

$$S_i = w_1s_{i1} + w_2s_{i2} + \dots + w_ns_{in} = \sum_{j=1}^n w_js_{ij}$$

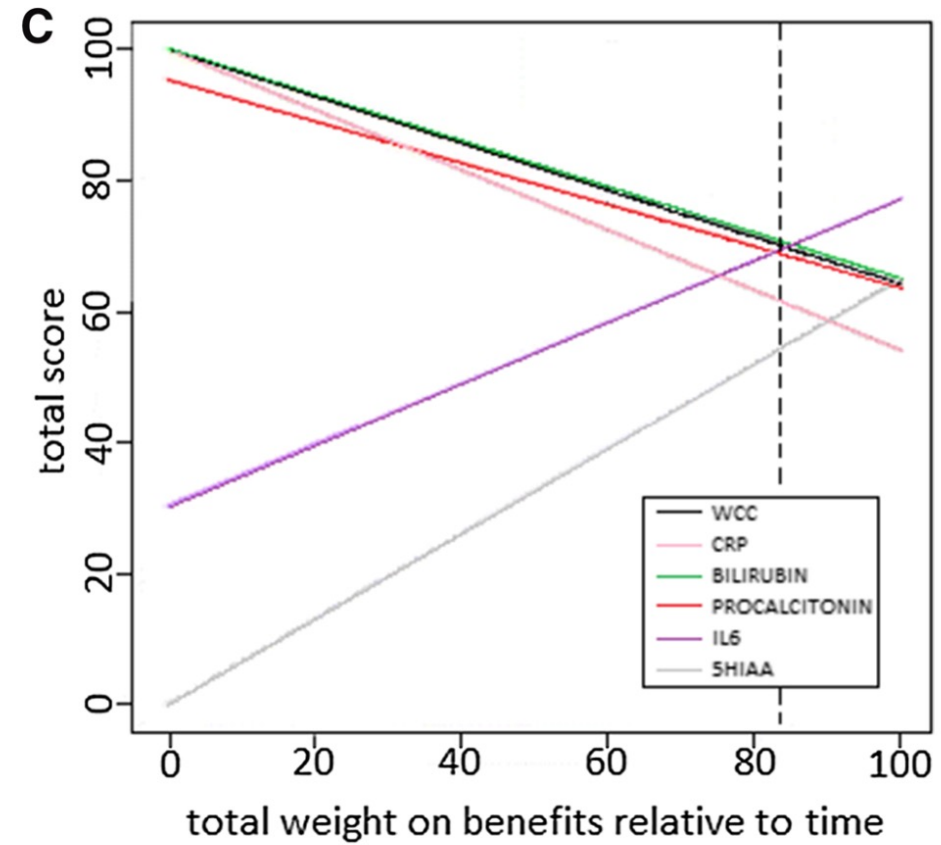
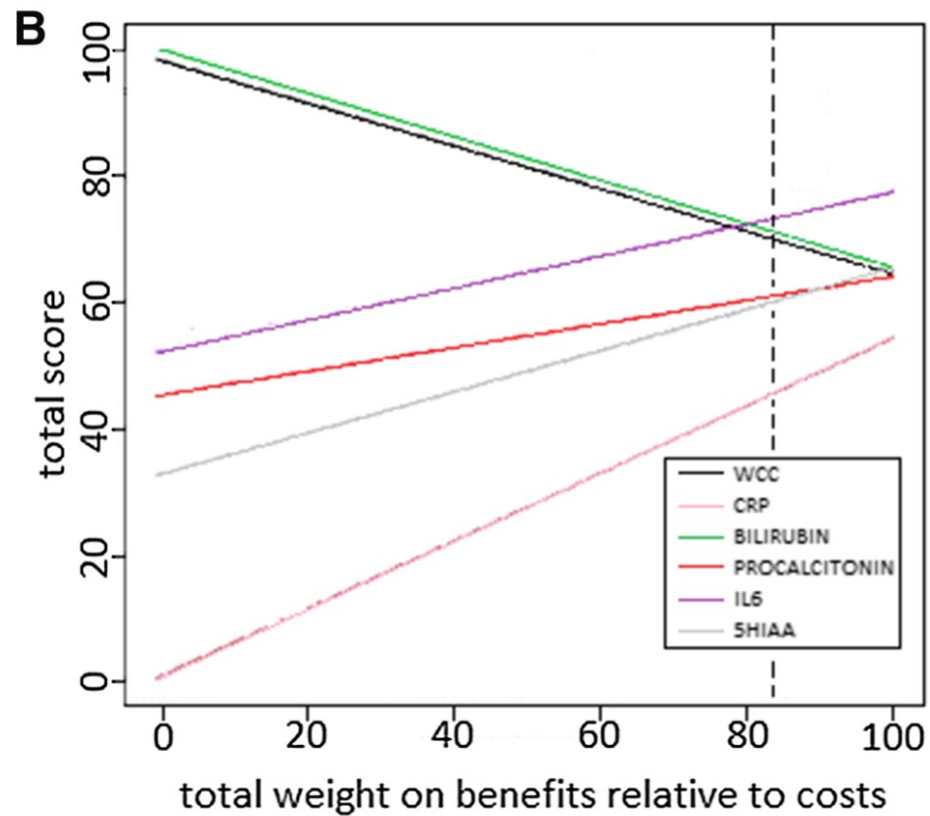
Table 3 Normalized scores (out of 100) for the six biomarkers with respect to financial cost, time, diagnostic benefit (composite of sensitivity, specificity, reproducibility and prediction of perforation) and overall performance

	WCC	CRP	Bilirubin	Pro-calcitonin	IL-6	5-HIAA
Cost performance	98	0	100	45	52	32
Time performance	100	100	100	95	30	0
Diagnostic benefit	64.3	45	44	58	53	87
Overall performance	74.6	52.0	75.1	65.0	68.3	52.2

WCC White cell count, CRP C-reactive protein, IL-6 Interleukin 6, 5-HIAA Urinary serotonin

Diagnostic benefit = sensitivity + specificity + prediction of perforation +reproducibility

Sensitivity analyses to examine the robustness of the results



Simple Multi- Attribute Rating Technique (SMART)

Generalize our approach

Iterative steps of MCDM are:

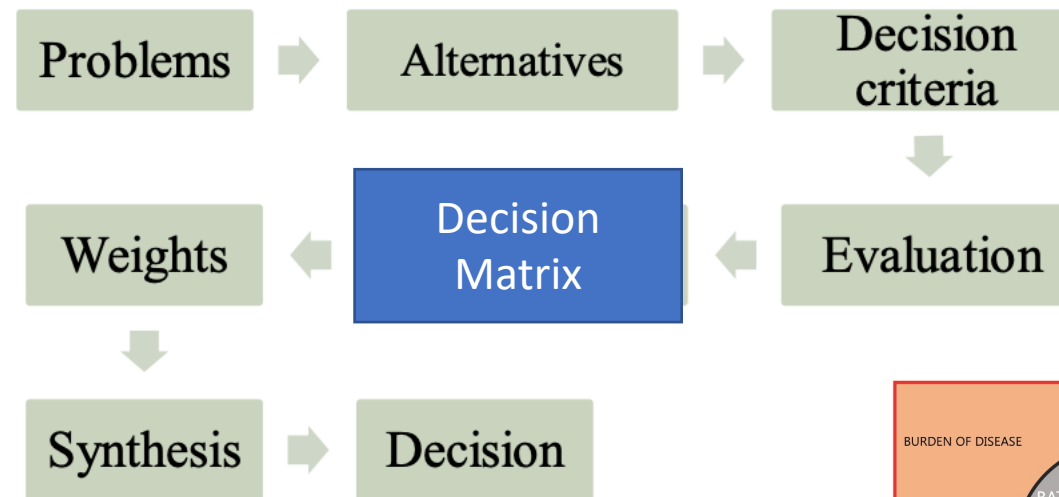
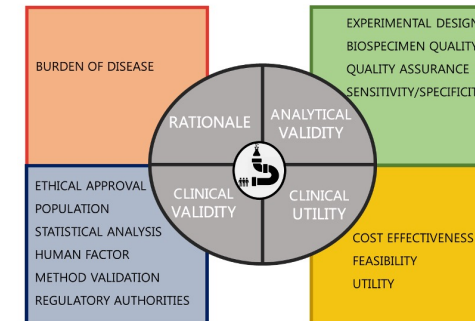


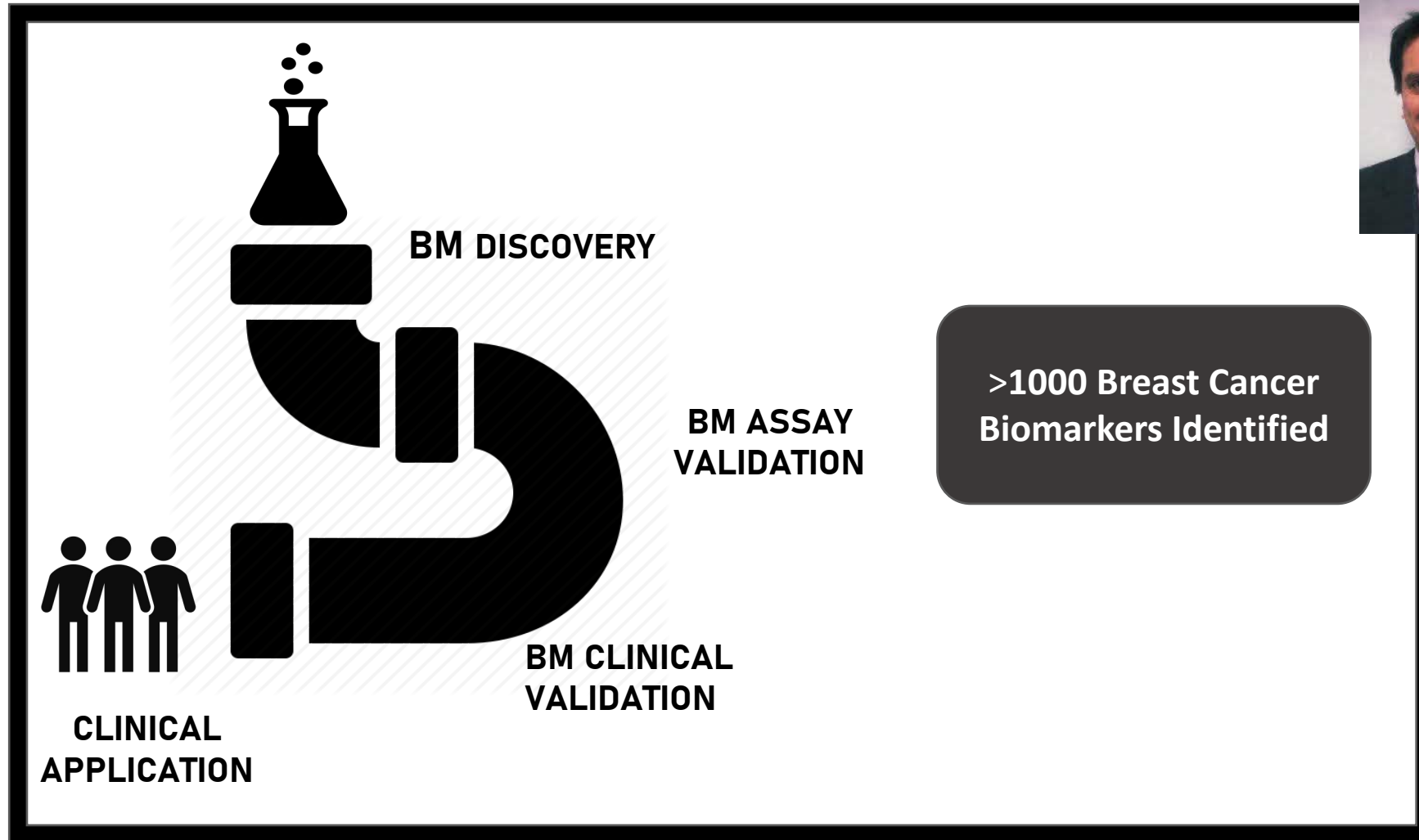
Fig.1 Iterative steps of MCDM method



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The Biomarker Toolkit: a Tool to Mediate the Successful Translation of Biomarkers from Lab to Clinic



Ultimate project's impact



*Target Biomarker
Research*



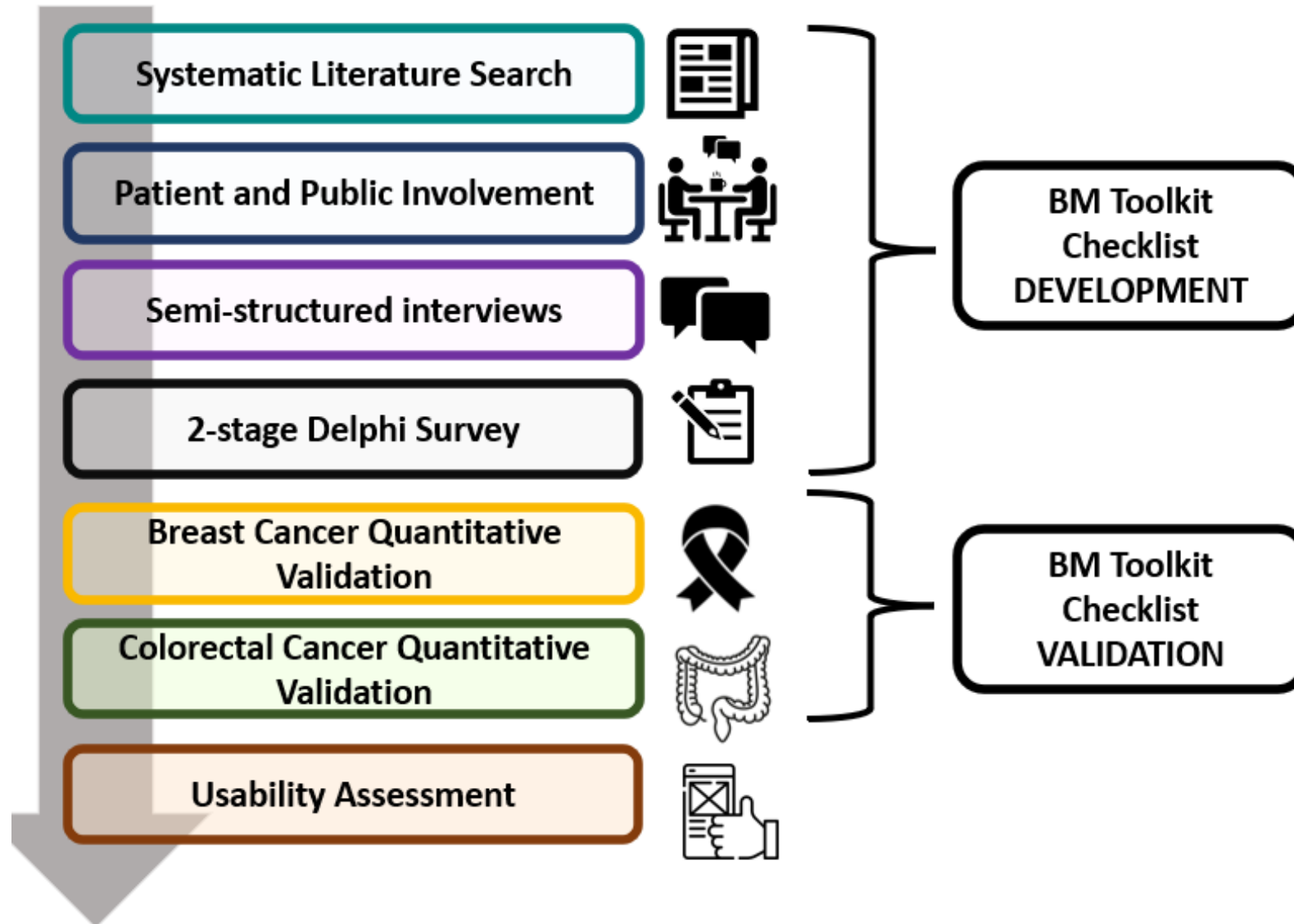
Reduce Costs



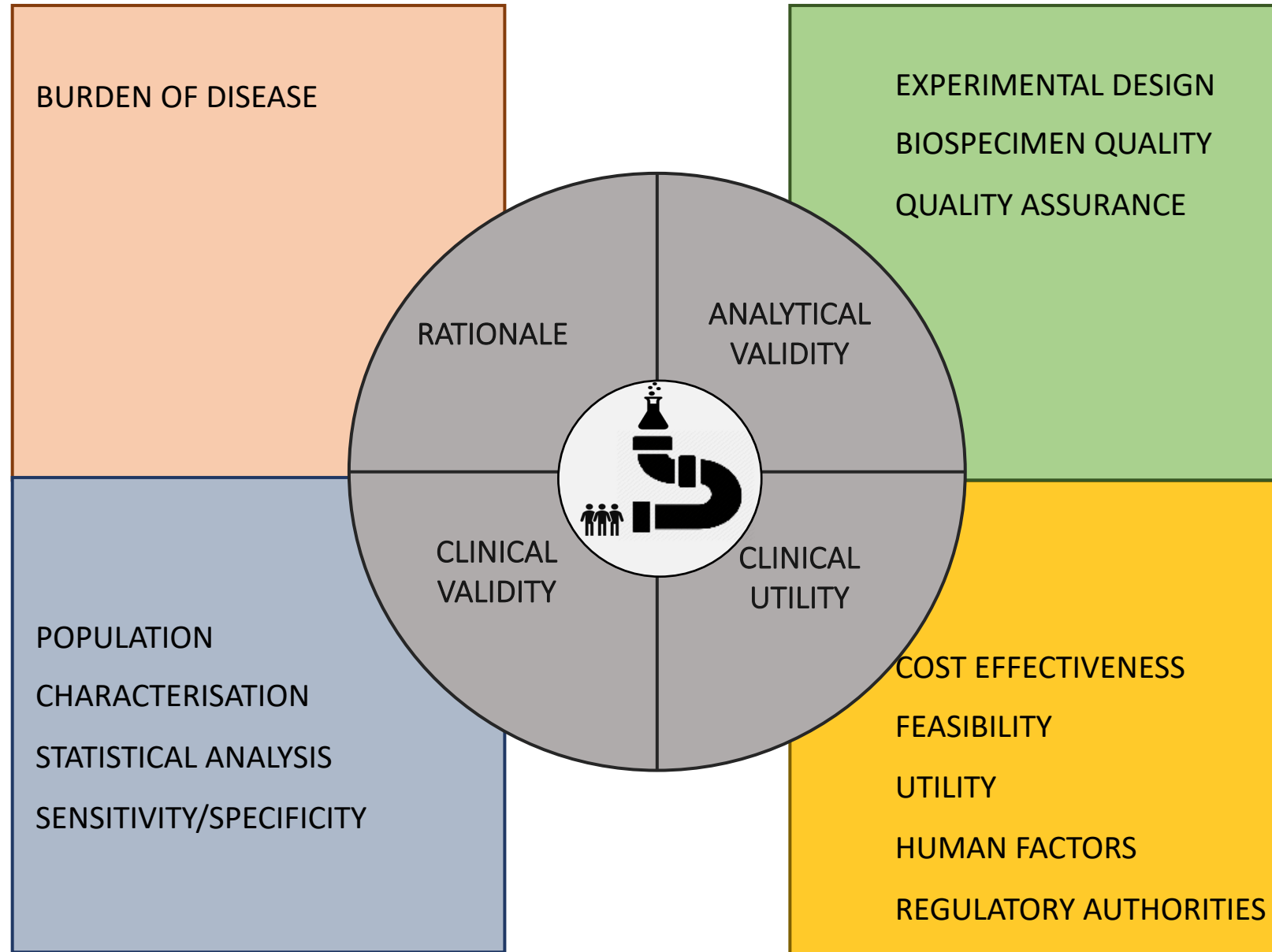
*Utilise Time More
Effectively*

*∴ More efficient Biomarker
clinical implementation*





RESULT SUMMARY: KEY BIOMARKER ATTRIBUTES REQUIRED TO MEDIATE BIOMARKER TRANSLATION THROUGH THE PIPELINE



Validate checklist using Biomarkers that have been successfully implemented in clinic



Successfully translated Biomarkers

Clinically Implemented



Stalled Biomarkers

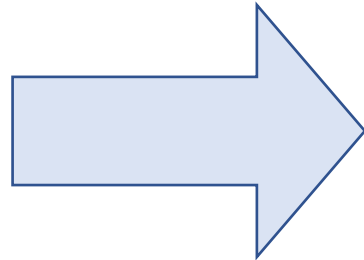
NOT Clinically Implemented



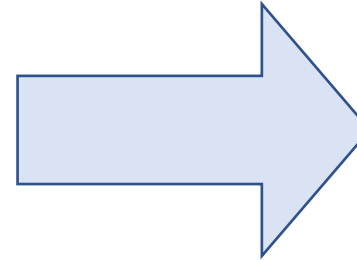
Validate checklist using Biomarkers that have been successfully implemented in clinic



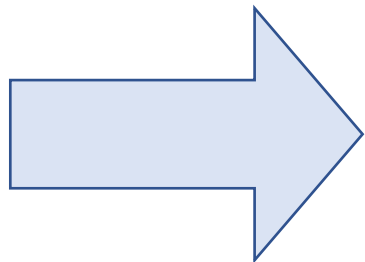
36 SYSTEMATIC SEARCHES



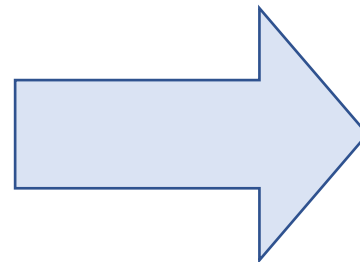
**IDENTIFY ELEGIBLE
ARTICLES**



**READ IDENTIFIED
ARTICLES**



**SCORE ARTICLES BASED ON THE
PRESENCE OF CHARACTERISTICS**

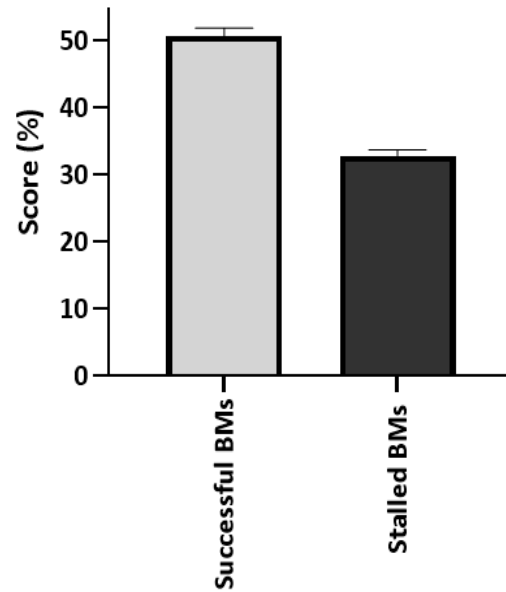


**COMPARE STALLED &
SUCCESSFUL BMs**

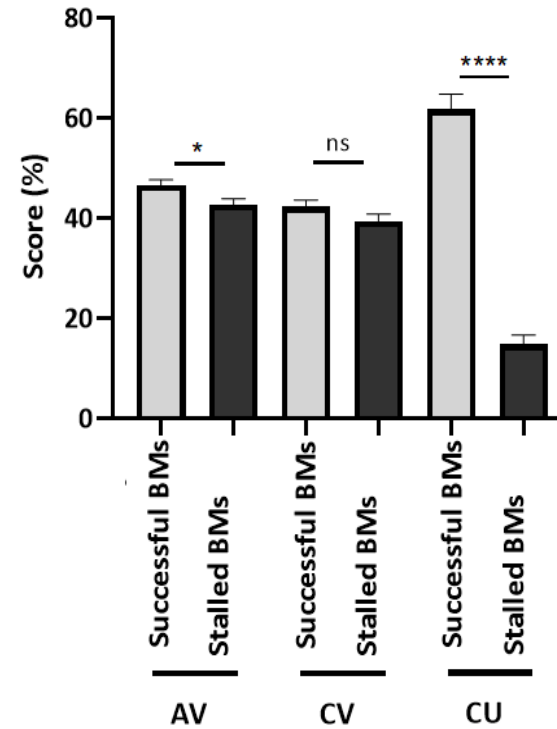
How did the Biomarkers perform?

Successful = 105
Stalled= 82

Total Scores in Stalled and Successful Breast
BMs

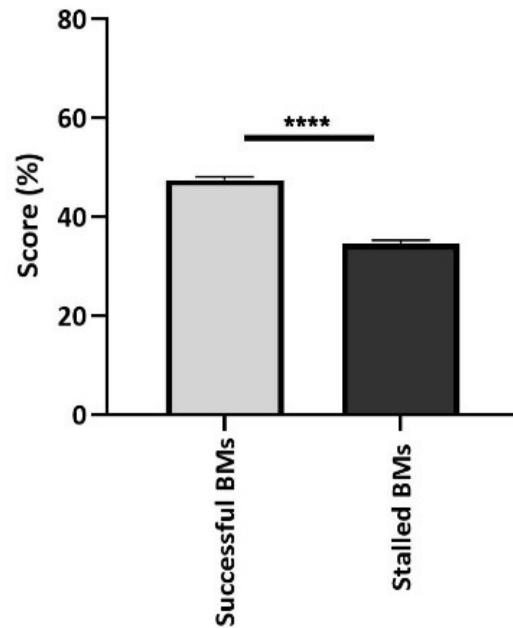


Score categories in Stalled and
Successful Breast Cancer BMs

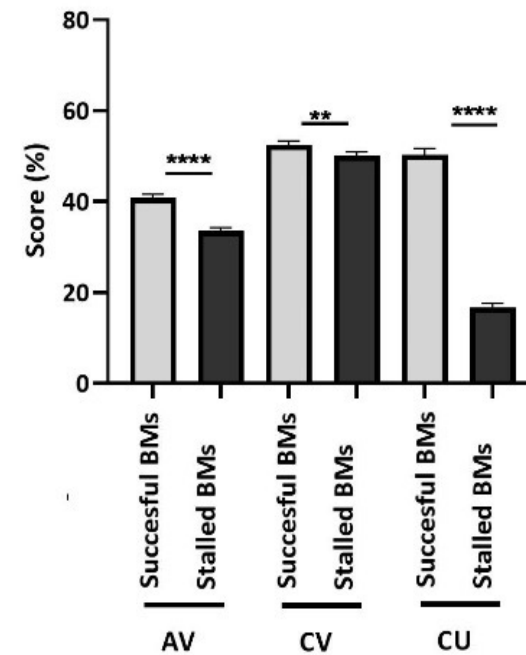


How did the Biomarkers perform?

Total scores in Stalled and Successful CRC BMs



Score categories in Stalled and Successful CRC BMs



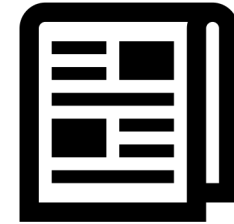
Successful (n=132)
Stalled biomarkers (n=123)

COLLABORATION: Automate the scoring process used in Biomarker toolkit, using Natural Language Processing

BM ATTRIBUTE	
SE BURDEN	RATIONALE
AL VALIDITY	EXPERIMENTAL DESIGN
	BIOSPECIMEN QUALITY
	QUALITY ASSURANCE
	SENSITIVITY/SPECIFICITY
AL VALIDITY	ETHICAL APPROVAL
	POPULATION

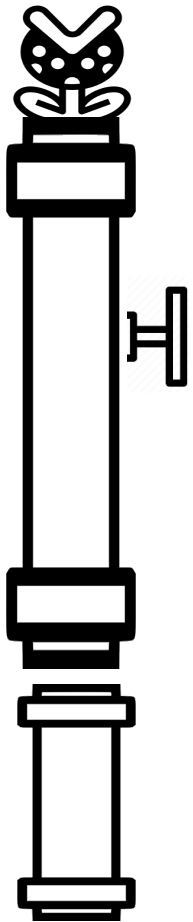
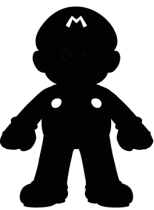


- Extract Keywords

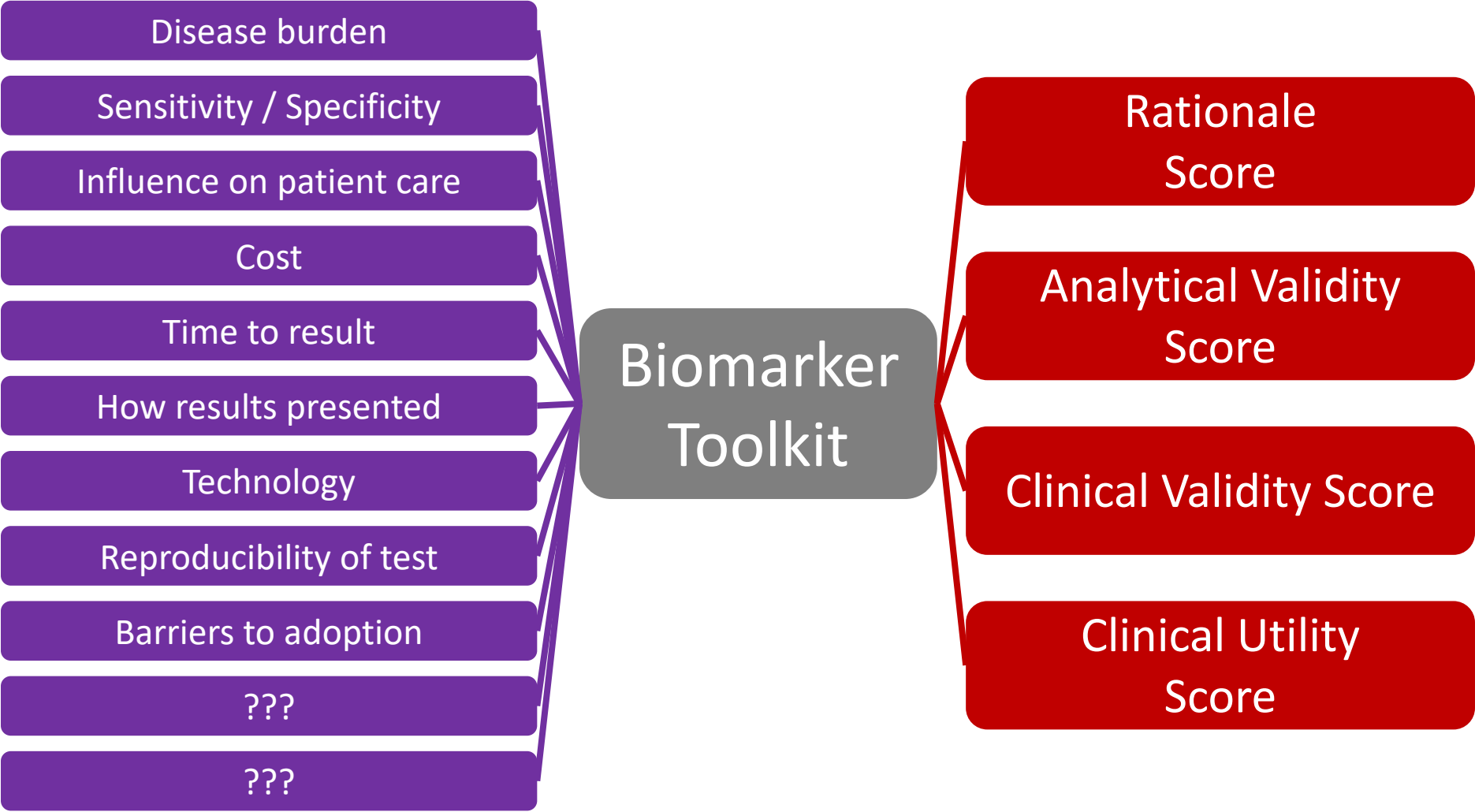


- Rank them (Attribute weightings)





Conclusion: Final Vision – What might it look like?



Take home message



MCDA is a useful framework for thinking about complex problems



Success ingredients = Stakeholders + Robust evidence



It's the **process** that matters (socio-technical) – convene a stakeholder group, develop a model to reflect the shared understanding, co-create ways forward.

Further readings

Ann Surg Oncol (2017) 24:1165–1173
DOI 10.1245/s10434-016-5717-y

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY



REVIEW ARTICLE – GASTROINTESTINAL ONCOLOGY

Use of Tumor Markers in Gastrointestinal Cancers: Surgeon Perceptions and Cost-Benefit Trade-Off Analysis

Amish Acharya, MRCS, Sheraz R. Markar, MRCS, Michael Matz, MRCS, MEd, PhD
and George B. Hanna, PhD

Surg Endosc (2017) 31:1022–1031
DOI 10.1007/s00464-016-5109-1



REVIEW

Biomarkers of acute appendicitis: systematic review and cost–benefit trade-off analysis

Amish Acharya¹ · Sheraz R. Markar¹ · Melody Ni¹ · George B. Hanna¹



https://eprints.lse.ac.uk/12761/1/Multi-criteria_Analysis.pdf

Thank you.

For questions/collaboration/project funding, please feel free to contact us:

- Melody Ni z.ni@imperial.ac.uk
- Katerina-Vanessa Savva k.savva17@imperial.ac.uk

To learn more about what we do, Visit <http://london.ivd.nihr.ac.uk>