Addressing uncertainty in MCDA for healthcare decisions: A scoping review of methods
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Objectives
Multi criteria decision analysis (MCDA) aims to support decision-making where decisions are based on multiple criteria. The use of MCDA in HTA, priority-setting and reimbursement decisions is growing, but mostly limited to research projects. A factor that might influence acceptance is a perceived difficulty to value an MCDA’s outcome when its inputs and outputs contain uncertainties. When this is the case, decision makers might not feel confident in accepting or rejecting its outcome. The objective of this study is to review how uncertainty is taken into account in MCDA methods in general, and to discuss which of the approaches is appropriate for the setting of reimbursement decision making in healthcare.

Methods
A scoping literature review was conducted using the Scopus database. Found abstracts were categorized by Taxonomy and methods of handling uncertainty were identified. Two independent reviewers. The most recent methodological articles were used to identify methodological details.

Results
The search strategy identified 500 abstracts, mostly from non-healthcare journals (Figure 1). A large variety of MCDA methods was found, confirming earlier indications of a heterogeneous MCDA nomenclature. Some combinations of MCDA method and method to deal with uncertainty were identified often, such as Fuzzy AHP. Themes identified were
- Deterministic framework (n=120)
- Probabilistic framework (n=71)
- Bayesian framework (n=11)
- Fuzzy set theory (n=230)
- Dempster-Shafer theory (n=75)
- Grey theory (n=15)
- Other (n=24)

Table 1: Distribution of themes over various MCDA methods. Note the large number of abstracts for which the MCDA method could not be identified, as well as the heterogenous nomenclature of MCDA methods.

Deterministic framework
Model parameters are varied manually, and the impact on model outcomes is assessed. The effect on outcomes can be shown in simple line plots or a tornado diagram.

Probabilistic framework
The uncertainty around model parameters is estimated with probability distributions that reflect reality. Impact on model outcomes can be assessed by varying all parameters simultaneously based on their probability distribution.

Bayesian framework
The two main ideas of the Bayesian framework are: 1) subjective probability i.e. belief in regard to model parameters, and 2) the updating of prior belief with acquired data. The latter is explored with Bayes’ theorem: P(H|D) = P(D|H) * P(H) / P(D). An example of using the Bayesian framework for MCDA is the construction of a so-called Bayesian net, which is a directed graph illustrating (conditional) links between model parameters.

Fuzzy set theory
Fuzzy sets are distinguished from regular sets in that elements in a set have a degree of membership instead of a binary (yes/no) membership. Propagation of fuzzy set theory argue that human judgments are often fuzzy, and that assessments in decision analytic models should incorporate this. We found fuzzy set theory was contended a surprisingly large number of times (n=121) with the MCDA method AHP. In most of these studies, the conventional societal value judgment work was replaced with fuzzy triangular numbers to indicate the fuzziness of judgments.

Dempster-Shafer theory
Dempster-Shafer (a generalization of Bayesian theory) theory is applied to MCDA in means to deal with unknown, internal valued, multicolored or ambiguous alternative performances. Experts make probability statements over frames of discernment that are mapped with mass function μ: 2^I → [0,1]. Lower and upper bounds of this, called belief and plausibility, are defined. Probability assignments are combined with Dempster’s rule of combination. Probability assessments of alternative performances are combined with preferences to make statements about (probable) alternative performance.

Grey theory
Grey numbers are numbers whose exact value is not known [7]. They are instead represented with ranges, for example grey numbers G_i (x) = [x_L, x_H]. Black numbers are totally unknown, i.e. black number G_i (x) = [x_L, x_H]. Black numbers are totally known, i.e. white number G_i (x) = [x_L, x_H]. Greyness as a concept can also be applied to the ambiguity present in decisions, where most decisions are grey, i.e. under some but not complete uncertainty.

The setting of healthcare market authorization and reimbursement decisions
Despite the development of many methods to deal with uncertainty, there seems to be a gap between theory and implementation for healthcare settings. Identified methods vary greatly in complexity. Methods for use in real-life decision making decisions should strike a balance between comprehensiveness and understandibility. It is our assessment that because of the background of most stakeholders, the probabilistic framework is most understandable and feasible. However, the choice of method to deal with uncertainty also highly depends on regulator needs and the chosen MCDA method.

References

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