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Multi-criteria decision analysis (MCDA) in health care: A bibliometric analysis

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ABSTRACT

Decision support is a discipline that is becoming increasingly important in health care decision making. Many jurisdictions are exploring the use of multi-criteria decision analysis (MCDA) as a decision support framework. Indeed, health care decision makers still face complex choices while being urged to provide more comprehensiveness, structure, and transparency to the existing decision-making framework.

This paper documents MCDA applications in health care and aims at identifying publication patterns as well as the range of topics to which MCDA have been applied. Therefore, a bibliometric analysis was conducted on articles reporting MCDA applications in health care published from 1960 to 2011. Articles identified through a literature search of health databases were categorized by year of publication, research topics, corresponding authors, country of residence of corresponding authors, and journal titles. The analysis of citation data was conducted in Matheo Analyzer 4.062. Over the time horizon of the analysis, the number of MCDA applications in health care has shown a significant and steady increase, with health care resource allocation being the most prevalent research topic. We also found that the top ten corresponding authors were responsible for 28% of the overall articles, with corresponding authors from the United States being the most prolific. The journal 'Health Economics' ranked first among the top ten journals. The results of this bibliometric analysis are concordant with the overall publication trends of MCDA methods described in other fields. Further research is needed, within jurisdictions, to select the most appropriate MCDA method to be applied to health care.

Contents

1. Introduction

Health care decision making does not conceptually differ from decision making in other fields. In fact, the allocation of finite resources between competing alternatives and interests occurs every day in different fields. The main difference in health care is that health is an irreplaceable and priceless good. This unique feature makes it more difficult for health care decision makers to make the right choices. Indeed, health care decisions have huge consequences on patients' quality of life and society as a whole. As an example, granting access to a potentially harmful drug will undoubtedly put patients' lives at risk. The opposite case is not without consequences, as patients may be denied access to effective cures, which in turn may aggravate their health status. Both cases would leave society to bear the losses of productivity costs (hidden costs of presenteeism and absenteeism).

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When confronted with these complex choices, health care decision makers tend to use an ad hoc [1–3] or deliberative process [4]. This type of decision-making process has raised concerns about transparency, structure, and comprehensiveness, as it fails to explicitly incorporate patient preferences, unmet needs, and societal and ethical values [5]. In this complex environment, operation research and decision support have become areas of investigation in many health jurisdictions. In particular, multi-criteria decision analysis (MCDA), which is a supportive decision-making tool that simultaneously appraises multiple streams of unrelated, often conflicting information, has been purported to be a valuable decision support tool for health care decision making [6].

In its application, MCDA involves a variety of methods. It is generally admitted that the basis of any analysis using multiple decision criteria is the performance matrix, which is comprised of rows and columns; rows represent alternatives to be classified, while columns represent criteria or attributes, which are actually the outcomes used to assess the performance of alternatives being compared. According to Baltussen et al. [6], the difference between MCDA methods lies in how the information, drawn from the matrix, is aggregated. In other words, different underlying assumptions concerning measurements and preferences may be involved [7]. According to Belton and Stewart [7], these methods can be broadly classified into three categories: value measurement models, goal programming and reference point models, and outranking models. For in-depth technical discussion of MCDA methods, different books and reviews are available. A non-exhaustive list of these references includes Keeney and Raiffa [8], Saaty [9], Belton and Stewart [7], Doumpos and Zopounidis [10], Figueira et al. [11], Dolan [12], Eisenführ et al. [13], and Ehrgott et al. [14].

To date, guidelines or approaches to select the most appropriate MCDA methods to be applied in health care do not exist. Furthermore, the diffusion of MCDA in health care is hardly documented. Therefore, the aim of this paper is to document the penetration of MCDA in health care. We also want to identify publication trends in the application of MCDA in this field as well as research topics to which it has already been applied. Hence, a bibliometric analysis is conducted to analyze the occurrence frequency of MCDA applications in health care. Further details are provided in the methods in Section 2.

The outline of this paper consists of four sections. Section 2 presents the methods used to document the penetration of MCDA in health care. Section 3 is dedicated to the results of the bibliometric analysis, while a discussion of these results is given in Section 4.

2. Material and methods

A bibliometric analysis was carried out to describe and analyze the trends and publication patterns in MCDA applications in the health sector, via a quantitative analysis of citation data. These citation data, identified through a literature search of Ovid Medline and Embase, the US National Library of Medicine's PubMed, and ISI's Web of Knowledge (see the Appendix), were categorized by year of publication, research topics, corresponding authors, country of residence of corresponding authors, and journal titles using the following key words: multi criteria/multicriteria objective programming, multi-criteria priority, multiple decision, MCDA/MCDM, analytic hierarchy process, evolutionary multiobjective/multi-objective/genetic multiobjective/evolutionary multi-objective, preference-based ranking, criteria-based scoring system/criteria based scoring system, Conjoint Analysis, clinical or health (clinical or health used in conjunction with the MCDA keywords only for the ISI's Web of Knowledge database search). The time horizon of the search encompassed the period between 1960 and 2011. The records obtained from the literature search, usually containing basic bibliographic information, including title and abstract, were screened for relevance. First of all, studies conducted in non-humans (animals and plants) were excluded. Then, the abstracts of the remaining articles were reviewed and those considered out of scope (dealing with the application of MCDA in fields other than health) of this review were rejected. Then, full-text versions of the remaining articles were obtained and perused. At this step, articles that did not report MCDA original research or discuss MCDA methods were discarded. From this point forward, the papers were categorized into three subtopic groups: *articles reporting applications of MCDA for clinical purposes*, meaning articles relating to the determination of patient preferences in the treatment of a single disease, *MCDA methodological articles*, meaning articles discussing improvement in or issues with MCDA methods, and those dealing with applications of MCDA for health care system-related issues, meaning articles reporting the use of MCDA in Health Technology Assessment (HTA), formulary-listing decision making, or health services resource allocation. This categorization, used elsewhere [15], served as a criterion to report publication trends according to respective research topics, namely clinical, methods, and health care system-related issues. Furthermore, the citation data obtained from articles were used to map the top-ten list of corresponding authors, their country of residence, and journal titles within which these articles were published. Citation data were analyzed in the software Matheo Analyzer 4.062. The results were exported into Microsoft Excel 2010 to build illustrative graphs and compute statistics such as Pearson correlation and determination coefficients.

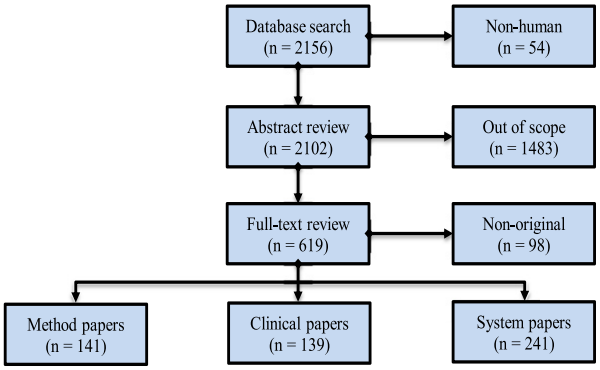

Fig. 1. Flow diagram describing study selection.

3. Results

3.1. Literature search

The literature search resulted in 2156 bibliographic database records (including records obtained from *citation alerts*) (see Fig. 1). From this initial set of records, 54 studies conducted in non-humans were excluded. Then, 1483 articles were rejected following the abstract review, as they were considered out of scope. As for the full-text review, 98 articles that did not conduct MCDA original research or discuss MCDA methods were removed from the initial set of records. As a result, the final set that was used for this review was composed of 521 articles.

3.2. Publication pattern

3.2.1. Overall publication trends

Fig. 2 shows the number of published articles, by year of publication, on MCDA in health care. Graphically, we can observe a general increasing tendency in the number of published articles

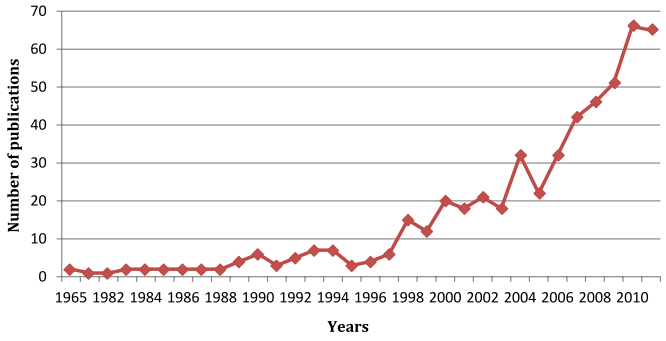

Fig. 2. Publication pattern of MCDA applications in health over the years 1960–2011.

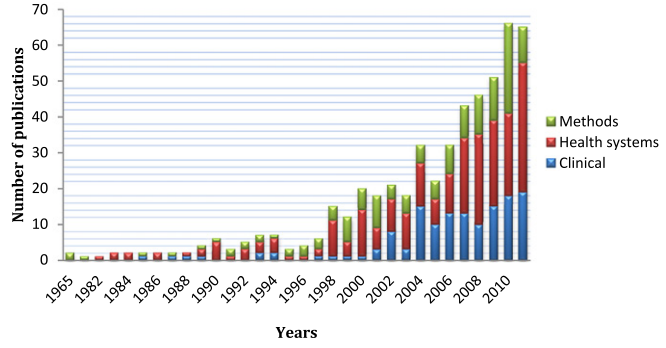

Fig. 3. Number of publications by research topic on MCDA in health over the years 1960–2011.

over the years 1981–2010 with some fluctuations between years. Indeed, this trend was particularly marked over the years 1996–2010. Furthermore, the overall Pearson correlation coefficient, which expresses the degree that the variables 'number of published articles' and 'year' change correspondingly, was 0.81 ($p < 0.01$). As a result, the determination coefficient value was 0.66. These indicators suggest a statistically significant and steady increase in the number of published articles over the review time horizon and that the exponential model derived from the curve (Fig. 2) explains 66% of the variation in the citation data.

3.2.2. Publication trends by research topic

Among the 521 articles analyzed in this review, 27% ($n = 139$) dealt with clinical applications of MCDA, another 27% ($n = 141$) reported on methods, and 46% ($n = 241$) addressed health care resource allocation-related issues. Over the analysis period, the number of MCDA applications has increased at a similar pace in all three categories (clinical, methods, and health care system-related issues), with applications of MCDA in health care resource allocation being the predominant research topic, as shown in Fig. 3.

3.2.3. Top-ten lists of corresponding authors, their countries of residence, and the journals

Fig. 4 provides information about the top-ten lists of corresponding authors. The top ten corresponding authors have contributed to about 28% of MCDA applications in the health care field, over the years 1960–2011. Additionally, over the same time horizon, corresponding authors from the United States (US) have been the most productive, as their contribution represented 23.4% of the overall papers. Amongst the top ten countries of residence of corresponding authors, the US ranked first, followed by the United Kingdom (UK), the Netherlands, Canada, Germany, Australia, Spain, Japan, and China (see Fig. 5).

Over the review time frame, MCDA applications were mostly published in the following journals (see Fig. 6).

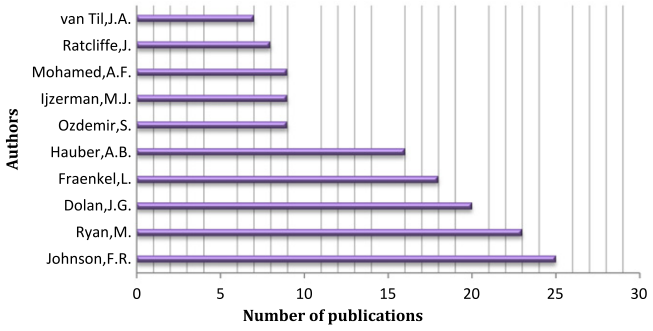

Fig. 4. Top ten corresponding authors of MCDA studies in health over the years 1960–2011.

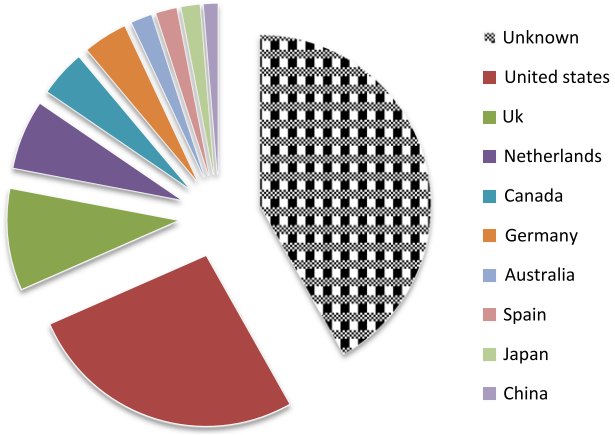

Fig. 5. Top ten countries of residence of corresponding authors of MCDA studies in health over the years 1960–2011.

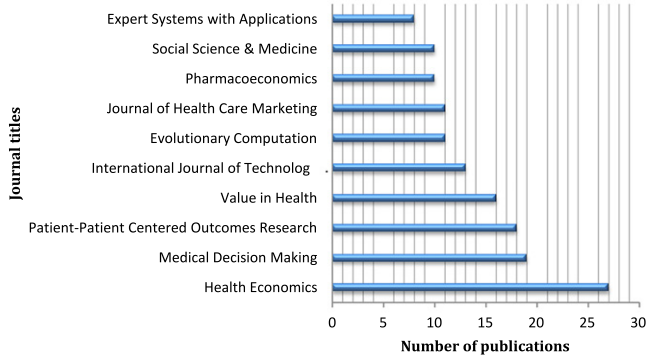

Fig. 6. Top ten journals reporting MCDA studies in health over the years 1960–2011.

- ✓ Health Economics
- ✓ Medical Decision Making
- ✓ Patient–Patient Centered Outcomes Research
- ✓ Value in Health
- ✓ International Journal of Technology Assessment in Health Care
- ✓ Evolutionary Computation
- ✓ Journal of Health Care Marketing
- ✓ Pharmacoeconomics
- ✓ Social Science & Medicine

4. Discussion

This review was initially conducted to describe and analyze the publication pattern of applications of MCDA in the health care field. To do so, a bibliometric study was conducted to retrieve

citation data and to report statistics on the publication trends by themes, over the years 1960–2011. The results of the bibliometric study suggest a near-exponential growth in MCDA applications in the health care field. In addition, the publication pattern of applications of MCDA in health care, based on the countries of residence of corresponding authors, underlines the fact that rational and transparent decision making is a common challenge faced by health care systems across the world. Along the same line, this publication pattern, based on the journals' audience and subject matter, is consistent with that of the research topics. In fact, these journals mostly published MCDA applications for health care resource allocation.

Wallenius et al. [16] conducted a bibliometric analysis of MCDA/Multi-attribute utility theory (MAUT) and discussed areas for improvement. The time frame of the review was 1970–2007. They reported a dramatic increase in the number of publications related to MCDA/MAUT since 2000. Another bibliometric analysis, conducted by Bragge et al. [17], on the same subject and time horizon showed similar results in terms of overall publication trends in MCDA applications. The results of the current review are concordant with those found in these previous bibliometric studies on MCDA [16,17], except that the current study focused on the health care field.

This study was based on structured search methods, which allowed the retrieval of relevant articles from a large number of databases over a comprehensive temporal framework. Moreover, the analysis of citation data was performed using text mining and visualization software, which allowed us to explore efficiently important volumes of data and convert them into structured and meaningful information. However, the main limitation of this review is related to the fact that the search was limited to databases of published literature (PubMed, Medline, Embase, etc.), potentially missing some applications of MCDA in health care. Indeed, these applications are conducted most of the time in a decision-making environment and are not systematically reported or published (publication bias). It would have been useful to search for these articles in the gray literature. Nonetheless, it is not unreasonable to say that the missed articles might have positively biased this study, as adding more articles to the corpus reviewed would have emphasized the publication trends identified through the current bibliometric analysis.

The research into new methods to support efficient decision making in health care is the rationale for the penetration and rise of multi-criteria decision analysis concepts and methods in health care. In this paper, the authors have documented the publication trends in multi-criteria decision analysis applications in health care. Over the time horizon of the study, we observed a sharp increase in the number of multi-criteria decision analysis applications, particularly during the period 1996–2011. As such, health care has become a neighboring discipline of operation research. While interest in the role of multi-criteria decision analysis in health is growing, considerable variation in its application exists. This is due to the fact that multi-criteria decision analysis uses a variety of methods with different underlying assumptions. Hence, further research is needed to select the appropriate multi-criteria decision analysis methods to be used in health care, and develop local guidelines within jurisdictions.

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Conflict of interest

None declared.

Appendix. Search methodology of the bibliometric study

1. *Search run in Ovid Medline.*

	Search Query	Records
1	(((Multicriteri* or multi-criteri* or multiple) adj2 (decision* or objective programming or priorit*)) or MCDA or MCDM).mp	542
2	(Analytic Hierarchy Process or Conjoint Analysis).mp	471
3	((Evolutionary or genetic) adj (multiobjective? or multi-objective?)).mp	21
4	(Preference* adj3 ranking).mp	65
5	(Criteria-based scoring system? or criteriabased scoring system?).mp	1
6	or/1–5	**1062**

2. *Search run in PubMed.*

	Search Query	Records
1	Multicriteri* decision*[tiab] OR multicriteri* objective programming[tiab] OR multicriteri* priorit*[tiab] OR multi-criteri* decision*[tiab] OR multi-criteri* objective programming[tiab] OR multi-criteri* priorit*[tiab] OR multiple decision*[tiab] OR multiple objective programming[tiab] OR multiple priorit*[tiab] OR MCDA[tiab] OR MCDM[tiab]	333
2	Analytic Hierarchy Process[tiab] OR Conjoint Analysis[tiab] OR evolutionary multiobjective*[tiab] OR evolutionary multi-objective*[tiab] OR genetic multiobjective*[tiab] OR evolutionary multi-objective*[tiab]	788
3	Preference-base* ranking[tiab]	10
4	Criteria-based scoring system*[tiab] OR criteriabased scoring system*[tiab]	1
5	or/1–4	**942**

3. *Search run in Web of Science (WoS).*

	Search Query	Records
1	TS = (((multicriteri* OR multi-criteri* OR multiple) NEAR2 (decision* OR objective programming OR priorit*)) OR MCDA OR MCDM)	1,760
2	TS = ("Analytic Hierarchy Process" OR "Conjoint Analysis")	6,531
3	TS = ((evolutionary OR genetic) NEAR (multiobjective? OR multi-objective?))	62
4	TS = (preference* NEAR3 ranking)	0
5	TS = (criteria-based scoring system? OR criteriabased scoring system?)	21

(*continued on next page*)

Search Query		Records
6	or/1–5	8,102
7	SG = (health* OR clinical*) OR SO = (health* OR clinical*) OR TS = (health* OR clinical*)	3,056,272
8	7 AND 6	**638**

4. *Search run in Biosis*.

Search Query		Records
1	TS = (((multicriteri* OR multi-criteri* OR multiple) NEAR2 (decision* OR objective programming OR priorit*)) OR MCDA OR MCDM)	141
2	TS = ("Analytic Hierarchy Process" OR "Conjoint Analysis")	422
3	TS = ((evolutionary OR genetic) NEAR (multiobjective? OR multi-objective?))	1
4	TS= (preference* NEAR3 ranking)	0
5	TS= (criteria-based scoring system? OR criteriabased scoring system?)	9
6	or/1–5	564
7	AD = (health* OR clinical*) OR GP = (health*OR clinical*) OR SO = (health* OR clinical*) OR TS = (health* OR clinical*)	4,203,785
8	7 AND 6	**236**

The database search was conducted on 27 October 2011. The total number of bibliographic records was initially **2878** (=1062 + 942 + 638 + 236). Once we merged the results of these individual searches into one database (Reference Manager 12), we ended up with **2156** bibliographic records. In other words, we were able to remove **722 duplicates**. Therefore, we reported 2156 retrieved bibliographic records in the manuscript.

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