Towards machine learning for moral choice analysis in health economics: a literature review protocol

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1. Background

Many (public) health decisions that policymakers make have a moral dimension. Think about policy issues where scarce resources must be allocated due to rising expenditures, an ageing population, and high prices of new treatment options. These decisions have potential consequences in that one patient will die to save the life of another patient or, more generally, when one patient gains one or more life years while another does not. In such dilemmas, the moral dimension of decisions can be present explicitly – the framing of the decision contexts – while it can also be more implicit or latent[1–3]. Whatever form they take, decisions with a moral dimension can be categorised as either 'right' or 'wrong'. Moral decision-making is based on what those involved believe to be the right thing to do[4]. So, when facing such moral dilemmas, stakeholder involvement and support (e.g., medical professionals, patients, and society) are essential for policymakers to build effective and acceptable health policies.

Discrete choice models (DCMs), rooted in consumer choice theory, are widely advocated as a way to understand choice behaviours and inform health policy and clinical decisions[5]. However, moral decision-making processes are qualitatively at odds with traditional choice theory's core assumptions[6]. Moral decision-making is often based on heuristics and emotions rather than utility-maximising principles[7–9]. In many cases, trade-offs (e.g., between money

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and health) are considered taboo, which violates the core assumptions of choice theory[10]. Ignoring the discrepancy between moral decision-making and the assumptions of the traditional DCMs leads to erroneous model outcomes and misguided policy recommendations.

As a result, a new choice paradigm has to be developed and validated. We aim to develop moral decision-making models by combining choice modelling and machine learning (ML). By combining ML's ability to discover patterns from data with discrete choice theories, mathematical elegance and behavioural appeal holds the promise to uncover the complex mechanisms underlying moral decision-making. The first step is to generate a variety of (non-)overlapping insights into moral decision-making and the current state of using ML for discrete choice analyses. To do so, a review protocol must be developed that guides the systematic process of collecting, extracting insights, and synthesising the results of relevant articles.

2. Research objectives

To combine DCMs and ML to study moral decision-making more accurately and better inform policy decisions in healthcare and beyond, this review protocol will focus on conducting the necessary steps to guide the attempt to achieve the following research objectives. Firstly, we aim to identify the characteristics of moral decision-making essential to discrete choice analysis approaches for studying moral decision-making in (public) healthcare settings. Secondly, we describe the strengths and weaknesses of using DCMs and ML for moral choice analysis based on the identified characteristics of moral decision-making. The latter results in a research agenda that lays out the directions for future research to bridge the gap between both paradigms.

3. Methods

We will conduct a comprehensive review of studies focused on studies written in economics, machine learning, moral psychology, and empirical ethics. To capture all relevant studies, we will generate two datasets. First, the core dataset will be gathered by following a systematic search strategy. Second, the supplementary dataset will enrich the systematic searches by screening reference lists from eligible studies in the core dataset. With the latter approach, we want to gather as many data points as possible to validate the findings from the systematic search strategy and ensure that state-of-the-art developments in the field are identified. Where applicable, our review study will be reported according to the Preferred Reporting Items for Systematic and Meta-analyses (PRISMA) guideline, whilst this protocol has been prepared in accordance with the PRISMA 2015 checklist for systematic review protocols.

3.1 Systematic search strategy

3.1.1 Information sources

We will use four databases to gather articles: PubMed, Scopus, Web of Science, and Arxiv. Where PubMed focuses on clinical and biomedical literature, Scopus and Web of Science include interdisciplinary studies. All three databases contain peer-reviewed articles. Arxiv is an open-source database aiming to disseminate papers not necessarily published in peer-reviewed outlets. It is, therefore, expected that trends at the intersection of computer science, statistics, and economics can be detected earlier compared to other reference databases.

3.1.2 Search strategy

Given the objectives of our literature review, we have divided the search queries into five categories: (i) moral decision-making in healthcare, (ii) empirical ethics research regarding the distribution of scarce resources, (iii) moral dilemmas in policy analysis and economic evaluation, (iv) DCMs used for moral choice analysis, and (v) ML methods used for choice analysis in general. See Appendix A for an overview of the search queries.

The search queries will be entered in the Advanced Search sections while specifying All Fields as the search domain. No restrictive Time Span will be set. Duplicates and articles without abstracts or identifiers (IDs) will be removed, such as DOIs and Arxiv IDs. The search strategy for DCMs used for moral choice analysis in Scopus is shown in Table 1. After initiating the searches, the selection of articles and full-text screening will be conducted.

Table 1. Scopus search strategy: discrete choice modelling used for moral choice analysis.

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1  TITLE-ABS-KEY((("moral*" OR "ethic*") W/2 ("dilemma*" OR "taboo*" OR
   "tradeoff*" OR "trade-off*" OR "choice*")) AND ((("econometric*" OR "discrete*") W/2
   (("choice*" OR "decision*") W/2 ("model*" OR "analys*" OR "experiment*"))) OR
   (("choice*" OR "decision*") W/2 ("model*" OR "analys*" OR "experiment*"))))
2  AND DocType(ar)
3  AND Language(english)
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3.1.3 Eligibility criteria

An article will be deemed eligible if it meets the following three inclusion criteria. First, the article must either empirically examine moral decision-making, focus on decision-making when encountering dilemmas in the distribution of (healthcare) resources, use DCMs to analyse moral decision-making or alternative decision rules, or use ML for discrete choice analysis in

general. Second, the article must be English-language articles. Finally, the article must be available in full-text. Table 2 shows the criteria we will use to screen articles for eligibility.

Table 2. Inclusion criteria to screen articles for eligibility.

Criteria	Inclusion criteria
Purpose of the study	Empirically examined moral decision-making OR focused on decision-making when encountering dilemmas in the distribution of (healthcare) resources OR used discrete choice models to analyse alternative decision rules OR used discrete choice models to analyse moral decision-making OR used machine learning for discrete choice analysis more generally
Written language	English-language text
Format of the study	Available in full-text

3.1.4 Data management

The search results from all reference databases will be exported into a Microsoft (MS) Excel spreadsheet version 16.69.1 using a scraper and pre-processing program coded in Python 3.9.7. Duplicates and articles without abstracts or IDs will be removed by the program as well. Data extraction will be completed in the same MS Excel spreadsheet.

3.1.5 Selection process

After removing all duplicates and articles without abstracts or IDs, the first and last authors will screen the title and abstract of all articles against the eligibility criteria. When there is disagreement about an article's eligibility, the second and third author and an independent external researcher will be consulted. Following the title and abstract screening, the procedure will be used for the full-text screening of the retaining articles.

3.1.6 Data collection process

The first author will conduct the data extraction by reading the full-text article and extracting the necessary information, as determined by the attributes for data extraction. The second, third, and fourth authors will crosscheck and confirm that all relevant data has been extracted. When there is disagreement, an independent external researcher will be consulted.

3.1.7 Attributes for data extraction

For all eligible articles, we will use a set of attributes, shown in Table 3, to ensure consistency in data extraction. The attributes for data extraction are defined by the outcomes of this review

and discussed among all authors. However, data extraction will be an iterative process whereby attributes can be added, adjusted, or removed throughout the process, as agreed by all authors.

Table 3. Attributes for data extraction.

No.	Description
C1	**Research metadata**
C1a	Field of research
C1b	Year of publication
C1c	Type of study
C1d	Nature of dataset
C1e	Sample size
C1f	Type of study population
C2	**Moral decision-making in healthcare**
C2a	Decision context
C2b	Type of moral dimension
C2c	Emotion, heuristic, value and/or norm used in moral choice
C3	**Discrete choice modelling for moral choice analysis**
C3a	Type of discrete choice model
C3b	Model specification
C3c	Model validation (i.e., internal and external validity)
C4	**Machine learning methods for choice analysis**
C4a	Type of machine learning paradigm
C4b	Type of machine learning algorithm
C4c	Model specification
C4d	Model validation (i.e., internal and external validity)
C5	**Behavioural analysis and economic evaluation**
C5a	Types of extracted behavioural indicators
C5b	Type of economic appraisal

3.1.8 Outcomes

The secondary outcomes of this literature review are:

1. To identify the characteristics of moral decision-making essential to discrete choice analysis approaches for studying moral decision-making in (public) healthcare settings.
2. To outline the strengths and weaknesses of using DCMs and ML for moral choice analysis based on the identified characteristics of moral decision-making.

The secondary outcome of this literature review is:

1. To outline a research agenda with directions for future research to bridge the gap between DCMs and ML for moral choice analysis in healthcare and beyond.

3.1.9 Risk of bias in individual articles

All findings obtained by the eligible articles from the systematic searches will be quality assessed using the articles from the supplementary dataset. The supplementary dataset is used as a sensitivity analysis tool. By collecting as many data points as possible, we will validate the findings from the systematic search strategy and ensure that state-of-the-art developments in the field are identified.

3.1.10 Data synthesis

Based on the attributes shown in Table 2, the extracted data from the eligible articles were analysed in two ways. First, to create an overview of the variety of insights, the number of occurrences of each extracted attribute (as % of the relative number of studies in the respective category) was established. Second, the main conclusions related to attribute categories C2-5 in Table 2 of the eligible articles were analysed to obtain more in-depth insights.

3.2 Scoping search strategy

The supplementary dataset will be gathered to enrich the systematic (core) dataset. We will use forward and backward searches on the reference list from eligible articles in the core dataset. The articles we will include for the scoping search strategy study how decision-makers *actually* make moral choices. Moreover, we will consider articles on the intersection of DCMs and ML, and ML in general, to identify trends that still need to be validated in the field of DCMs (e.g., research endeavours related to explainable artificial intelligence and causal inference). An

article will be deemed eligible based on at least fifty citation counts in the databases used for this study, which all authors and an independent external researcher define.

3.3 Ethics

Since our study is a literature review, will be working with data freely available in the public domain, and will not directly involve human and animal subjects, formal ethical approval is not deemed necessary.

4. Discussion

In this review protocol, we outline the steps of a literature review study that aims to gather and synthesise the evidence to combine DCMs and ML to study moral decision-making more accurately and better inform health policy decisions when moral dilemmas occur. The findings of this review are intended to pinpoint directions for future research to bridge the gap between DCMs and ML, and increase their appeal and applicability in health economics, where humans and machines meet each other.

Appendix A. Systematic search strategy: search queries

Category	Database	Search query
Moral decision-making in healthcare	PubMed	(("moral reason*" OR "moral judgment*" OR "moral dilemma*" OR "moral decision*" OR "ethic reason*" OR ("ethic*" AND "judgment*") OR "ethic dilemma*" OR ("ethic*" AND "decision*")) AND ("healthcare" OR "health care") AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND eng[la]
	Scopus	TITLE-ABS-KEY((("moral*" OR "ethic*") W/2 ("reason*" OR "judgment*" OR "dilemma*" OR "decision*")) AND ("healthcare" OR ("health" W/2 "care")) AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND DocType(ar) AND Language(english)
	Web of Science	TS=((("moral*" OR "ethic*") NEAR/2 ("reason*" OR "dilemma*" OR "judgment*" OR "decision*")) AND ("healthcare" OR ("health" NEAR/2 "care")) AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND DT=(article) AND LA=(english)

Empirical ethics	PubMed	(("empirical*" AND ("moral*" OR "ethic*")) AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND eng[la]
	Scopus	TITLE-ABS-KEY(("empirical*" W/4 ("moral*" OR "ethic*")) AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND Language(english)
	Web of Science	TS=((“empirical*” NEAR/4 (“moral*” OR “ethic*”)) AND ("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*")) AND DT=(article) AND LA=(english)
Policy analysis and economic evaluation	PubMed	((("moral*" OR "ethic*" OR "justice*" OR "fairness*") AND "dilemma*") AND (("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*") AND "resource*") AND ("healthcare*" OR ("health*" AND ("care*" OR "domain*")) OR "marketing*" OR (("transport*" OR "environment*") AND "economic*") OR "patient*" OR "consumer*" OR "user*") AND (("polic*" AND ("decision*" OR "choice*" OR "analys*")) OR ("cost*" AND ("effect*" OR ("benefit*" AND "analys*"))) OR ("economic*" AND "appraisal*"))) AND eng[la]
	Scopus	TITLE-ABS-KEY((("moral*" OR "ethic*" OR "justice*" OR "fairness*") AND "dilemma*") AND (("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*") AND "resource*") AND ("healthcare*" OR ("health*" AND ("care*" OR "domain*")) OR "marketing*" OR (("transport*" OR "environment*") AND "economic*") OR "patient*" OR "consumer*" OR "user*") AND (("polic*" AND ("decision*" OR "choice*" OR "analys*")) OR ("cost*" AND ("effect*" OR ("benefit*" AND "analys*"))) OR ("economic*" AND "appraisal*"))) AND DocType(ar) AND Language(english)
	Web of Science	TS=((("moral*" OR "ethic*" OR "justice*" OR "fairness*") AND "dilemma*") AND (("ration*" OR "priori*" OR "allocation*" OR "distribution*" OR "scarcit*") AND "resource*") AND ("healthcare*" OR ("health*" AND ("care*" OR "domain*")) OR "marketing*" OR (("transport*" OR "environment*") AND "economic*") OR "patient*" OR "consumer*" OR "user*") AND (("polic*" AND ("decision*" OR "choice*" OR "analys*")) OR ("cost*" AND ("effect*" OR

		("benefit*" AND "analys*"))) OR ("economic*" AND "appraisal*"))) AND DT=(article) AND LA=(english)
Discrete choice modelling for moral choice analysis	PubMed	((("moral*" OR "ethic*") AND ("dilemma*" OR "taboo*" OR "tradeoff*" OR "trade-off*")) AND ("discrete choice model*" OR "discrete choice analys*" OR "discrete choice experiment*" OR "choice model*" OR "choice analys*" OR "choice experiment*")) AND eng[la]
	Scopus	TITLE-ABS-KEY((("moral*" OR "ethic*") W/2 ("dilemma*" OR "taboo*" OR "tradeoff*" OR "trade-off*" OR "choice*")) AND ((("econometric*" OR "discrete*") W/2 (("choice*" OR "decision*") W/2 ("model*" OR "analys*" OR "experiment*"))) OR (("choice*" OR "decision*") W/2 ("model*" OR "analys*" OR "experiment*")))) AND DocType(ar) AND Language(english)
	Web of Science	TS=((("moral*" OR "ethic*") NEAR/2 ("dilemma*" OR "taboo*" OR "tradeoff*" OR "trade-off*" OR "choice*")) AND ((("econometric*" OR "discrete*") NEAR/2 (("choice*" OR "decision*") NEAR/2 ("model*" OR "analys*" OR "experiment*"))) OR (("choice*" OR "decision*") NEAR/2 ("model*" OR "analys*" OR "experiment*")))) AND DT=(article) AND LA=(english)
Machine learning for discrete choice analysis	Scopus	TITLE-ABS-KEY(("machine learning" OR "deep learning" OR "neural network" OR "deep neural network") AND ("choice model*" OR "discrete choice model*" OR "choice analys*" OR "discrete choice analys*")) AND DocType(ar) AND Language(english)
	Web of Science	TS=((“machine learning” OR “deep learning” OR “neural network” OR “deep neural network”) AND (“choice model*” OR “discrete choice model*” OR “choice analys*” OR “discrete choice analys*”)) AND DT=(article) AND LA=(english)
	ArXiv	"choice model*" OR "choice analys*" OR "discrete choice model*" OR "discrete choice analys*" [all fields]

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