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In silico evaluation of algorithm-based clinical decision support systems: A scoping review

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KEY TAKEAWAYS

- **Scoping review** about **in silico evaluation of clinical usefulness** for Artificial Intelligence-based clinical decision support systems.
- Establishing a classification scheme to give insights into **what and how** in silico evaluation methods can be used **for different clinical decisions**.

INTRODUCTION

- Integrating **AI in clinical decision-support (CDS)** presents challenges and yet the **real-world implementation has been limited** [1].
- **In silico evaluation** methods which extend the model evaluation to consider **clinical workflows** aligns with the renewed focus of healthcare that includes care provider well-being among patients' experience improvement, better health of populations, and cost reduction [2].

Objectives

Our study investigates the scope by which in silico models have been used to evaluate CDS systems. Specifically, we provide the insights into: (1) in silico modeling paradigms, (2) clinical decision-support domains, (3) in silico evaluation metrics.

METHODOLOGY

Review Framework

The **Arksey and O'Malley framework** was the foundation of this scoping review, including (1) identifying the research question, (2) searching and identifying relevant studies, (3) study selection, (4) data extraction, (5) collection, summarising, and reporting of findings, and (5) consultation with stakeholders revolved around the concepts shown in Table 1 [3]. Searched databases include **PubMed, Embase, CINAHL, PsycINFO, and Cochrane, Web of Science, IEEEXplore and Arxiv**.

Table 1. Review Key Concepts

Concepts	Matching keywords
Clinical decision support (CDS) systems	Machine learning, deep learning, artificial intelligence, reinforcement learning, supervised machine learning, unsupervised machine learning, semi-supervised machine learning, self-supervised machine learning, expert system
Objective of the CDS models	Clinical decision support, clinical decision-making, prognosis, diagnosis, screening, triage
Evaluation objective	patient, process, provider, cost-effectiveness outcomes
Evaluation strategy	In silico, computer simulation, digital twin, simulation, pre-implementation, pre-deployment, computational simulation

RESULTS

Search and screening process follows the **PRISMA-ScR** (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)[4] flowchart (Figure 1).

- Across the span from **2013 to 2023**, a total of **21 articles** were included.
- Common in silico simulation methods are shown in Figure 2.
- Clinical decision-support domains are shown in Figure 3.
- Considerations of in silico methods when measuring impact (A) and modeling (B) clinical workflows (Fig 4).
- Specific evaluation metrics used by the studies (Figure 5).

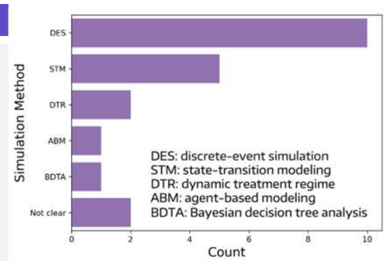

Figure 2. Common In Silico Methods

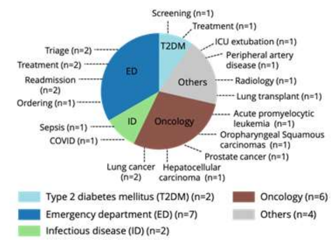

Figure 3. Clinical decision-support domains

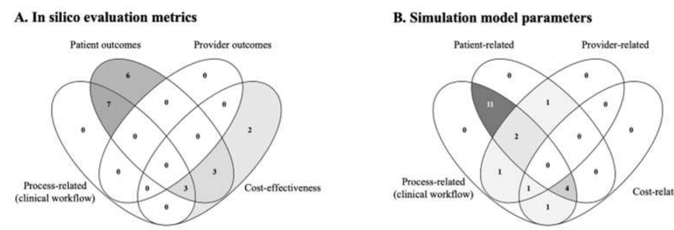

Figure 4. Number of (A) studies per metric group; (B) and studies per parameter type

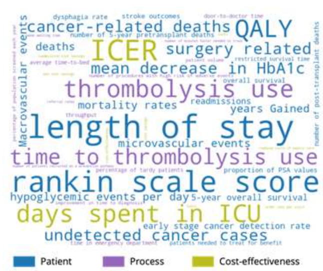

Figure 5. Specific metrics for impact

CONCLUSION

- Proposed simulation strategies for CDS models are largely **bespoke despite the prevalence of claims for generic, reusable models** across clinical domains.
- A detailed examination of the included articles reveal that **providers** were included as simulation parameters but not evaluation metrics.
- This review will **facilitate the creation of a framework that evaluates the impact across the Quadruple Aims** [2].

Identification		Screening	Eligibility	Included
Records identified through hand-searching and reference chaining (n = 84)	Records remaining after duplicate removal (n = 3006)	Articles screened by Title and Abstract (n = 3006)	Articles retained after Full-Text screening (n = 89)	Articles included in the review (n = 21)
Records identified through programmatic database search (n = 3223) Databases: PubMED, Embase, CINAHL, PsycInfo, Cochrane, IEEEXplore, Web of Science, Arxiv		Excluded articles after Title and Abstract screening (n = 2917)	Excluded articles after Full-Text screening (n = 68)	

Figure 1. The PRISMA-ScR Flow Chart

References

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