Enhancing Healthcare Through Clinical Decision Support Systems

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Abstract

In recent years, the healthcare industry has experienced a revolutionary shift with the utilization of Clinical Decision Support Systems (CDSS). This tool empowers healthcare professionals to gain access to real time insights for informed decision-making in clinical contexts. This article explores its contributions to enhance healthcare services, while also examining the benefits and drawbacks with its solutions of Clinical Decision Support systems (CDSS).

1. Introduction and Context

A Clinical Decision Support system (CDSS) is a computer program that relies on evidencebased clinical guidelines, with or without AI (Chien, S et al., 2022). As the healthcare sector undergoes major transformation, the focus shifts from technological superiority to the significant influence on patient outcomes, diagnostic accuracy, and medical research developments. CDSS was designed to help physicians stay up to date on the latest research by reducing the challenges of reviewing many journals and papers daily. CDSS improves clinical processes by offering intelligent tools for diagnosis, treatment planning, and outcome prediction for healthcare professionals. Several healthcare providers utilize CDSS to identify patients who were misdiagnosed or were given the wrong medicine dose. These inaccuracies are addressed in Population Health Management (PHM) reports, which may be used to guide improvement programs.

CDSS is being implemented in most high-tech healthcare centers. The use of CDSS was raised after the passage of the HITECH Act (Health Information Technology for Economic and Clinical Health Act), which required providers to show the meaningful utilization of health IT by 2015 or they would be at risk of having their Medicare costs reduced the following year. In the USA, a CDSS, especially under the categories of basic preventive reminders and drug interaction alerts, is used routinely between 68% and 100% in primary care if a practice is entirely Electronic Medical Records (EMR)/Electronic Health Records (EHR) based (Jing, Himawan, and Law, 2019).

Key Notations

CDSS	Clinical Decision Support Systems
EHR	Electronic Health Records
DDI	Drug-drug Interaction
AI	Artificial Intelligence

2. Information System Management Issue

As we explore the application of healthcare technology, various challenges arise. These challenges are relevant to the introduction of new advanced technologies aimed at improving healthcare procedures. Every element needs to be carefully considered to guarantee a smooth and successful transition.

2.1 Workflow Fragmentation

As healthcare professionals utilize CDSS in their clinical processes, it potentially leads to disruptions in the workflow. If CDSS is not seamlessly integrated, it may cause problems in decision-making processes, which will impact patient's care quality. CDSS is often developed for a particular clinical workflow, and a lack of interoperability restricts information flow across systems. Many early CDSS were designed to force providers to document or source information outside of their usual workplace. Thus, CDSS can potentially interrupt productivity if they are created without considering human information processing and behaviors.

2.2 Alert Management

Alerts are the most common way for a CDSS to communicate with practitioners (Chien, S et al., 2022). The effectiveness of these alerts may be compromised if they are perceived as insignificant or overwhelming. Alert management is crucial to ensure the healthcare professionals can efficiently utilize CDSS insights without irrelevant alerts. Alerts fatigue happened due to the frequent use of poorly designed CDSS. (Wong, A et al., 2023). Meanwhile, most CDSS alerts are not designed appropriately based on human factor methods.

2.3 Reliability of Data

Accurate data is crucial for CDSS effectiveness. The information used to inform CDSS, and the underlying data integrated into the logic must be assessed and approved by clinical and operational managers both during and after implementation. Maintaining CDSS updated is difficult due to the rapid advancement of research and scientific proof, and the spread of new medical knowledge. CDSS system typically brings together multiple information providers. As an example, EHR may supply the technical framework for CDSS, however, it will frequently interact with a third-party information source to give complete CDSS features. Strong provider management and a clinically driven organization monitoring committee are required for CDSS to be effectively controlled and maintained over time.

3. Discussion and Argument

It is critical to understand the core workings of the innovative technology while exploring the CDSS environment. CDSSs are designed to be flexible and can be used in various departments in healthcare centers including primary care, specialty care, pharmacy, radiology, emergency department, and laboratory.

3.1 CDSS Mechanisms

The CDSS processes are complex since it evaluates a large amount of patient data, aligning it with medical literature, case histories, and additional information through advanced algorithms. CDSSs are typically classified into knowledge-based and non-knowledge-based.

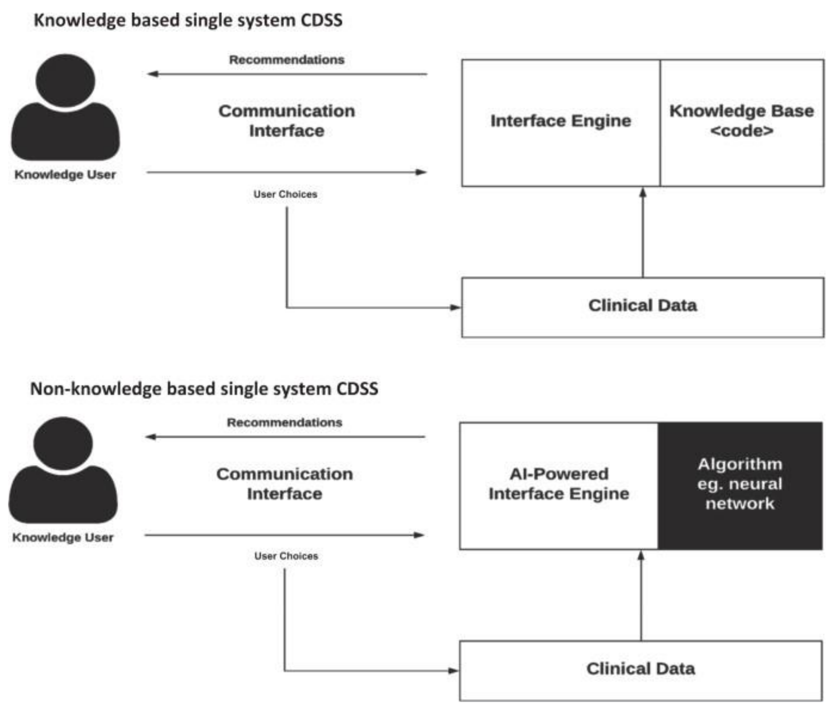

Figure 1: Interactions in knowledge-based and non-knowledge-based CDSS.

Knowledge-based CDSSs employ logical procedures to provide suggestions to help physicians. There will always be knowledge sources and rules obtained from medical literature, patient-centered procedures, guidelines, and expert knowledge. It is commonly used to handle complex decision-making cases. Meanwhile, non-knowledge based CDSSs use complex algorithms to make medical decisions and are usually used when a medical case has not explicitly happened in any past scenarios. One of the algorithms used is neural networks, which is a branch of AI to teach computers the way the human brain processes information and learns.

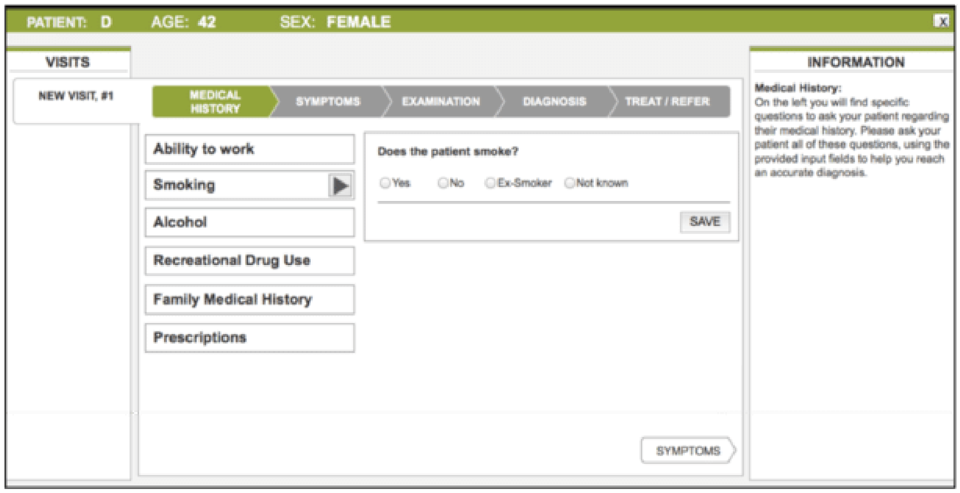

Figure 2: Example interface of the CDSS prototype

Firstly, CDSS gathering medical data from EHRs or other sources and entered CDSS via the communication interface and interface engine for knowledge-based CDSS, and via the communication interface and AI-powered interface engine for non-knowledge based CDSS. The only difference is in this stage, where non-knowledge based CDSS will require algorithm training. The AIpowered interface engine transforms and preprocesses the data for analysis using complex algorithms. Then, a neural network is used to train the CDSS algorithm to analyze patterns and correlations in medical data. When a new case is sent in, the algorithm evaluates the data to generate predictions or suggestions and adjusts its predictions based on ongoing data learning. In knowledge-based CDSS, the interface engine converts the data into a standard format to be processed consistently within the CDSS.

Both types of CDSSs work the same in knowledge processing stage. CDSS analyzes clinical data to provide recommendations or alerts such as diagnostic recommendations and treatment alternatives. It also considers user decisions and preferences to fit suggestions to the given case. Knowledge users may enter new data, modify their selections, or request for further explanation based on the CDSS output. Recommendations are given in an easy-to-understand format, providing practical insights, and supporting medical decision-making.

3.2 Benefits

CDSSs are essential tools in modern healthcare, offering several benefits for both patients and healthcare professionals. This system contributes significantly to the optimization of healthcare delivery and the improvement of patient care standards.

3.2.1 Patient Safety and Care Quality

The presence of CDSS not only assists healthcare providers but also yields a positive impact on the quality of services provided and enhances patient safety by mitigating errors in treatment, prescription, adverse medication reaction, and diagnostic inaccuracies. Patients could also get their personalized medicine based on CDSS analysis of their genotype and phenotype characteristics (Verboven et al., 2022).

A study conducted in Dutch highlights the pivotal role of CDSS in enhancing patient safety and care quality. Cardiac rehabilitation in 21 healthcare centers were examined. CDSS improved compliance with guideline-recommended treatment decisions in lifestyle-change therapy by 3.2%, exercise-therapy by 7.9%, relaxation-therapy by 25.3% and education-therapy by 25.7%. In this case, with CDSS, both overtreatment and undertreatment incidents were overcome.

3.2.2 Diagnostic Support and Improve Efficiency

A research study was carried out in Ottawa at the Bruyère Family Health Team. The study used artificial patient records to assess the effectiveness and precision of CDSS. The participants, comprising clinical staff and resident physicians evaluated the artificial patient to stimulate the manual decision-making process.

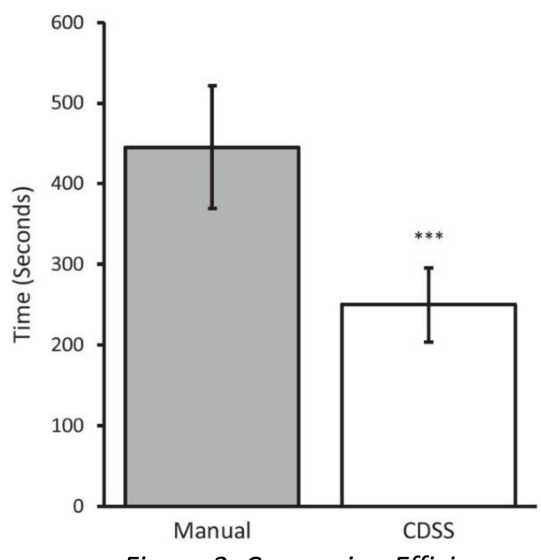

Figure 3: Comparing Efficiency

The result showed that manual completion took 445.1 ± 75s (95% CI) to complete the diagnostic, while CDSS took 249.5 ± 45.6s (95% CI). This clearly indicates that CDSS works significantly faster than manually. This suggests that CDSS could increase time efficiency.

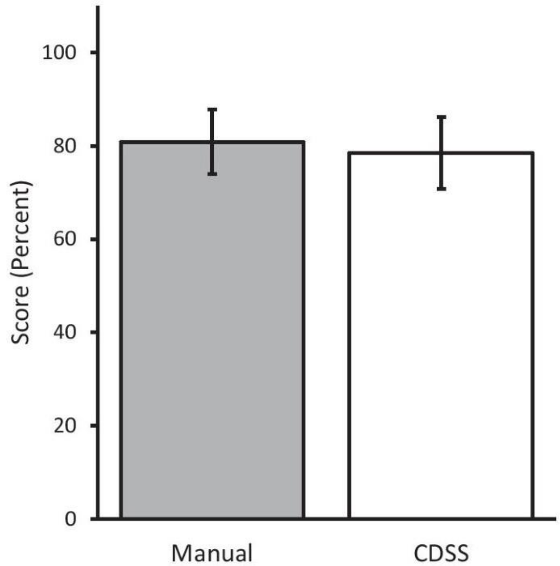

Figure 4: Comparing Accuracy

There was no significant difference in decision making accuracy in either CDSS (78.4 ± 7.6% (95% CI)) and manual (80.9 ± 7% (95% CI)). This means that clinical decisions are equally accurate, with no substantial advantage shown for both methods.

3.3 Drawbacks and Solutions

While there are drawbacks that may impact the overall performance of healthcare providers and the quality of patient care, ongoing advancements in CDSS technology demonstrate a commitment to minimizing errors.

3.3.1 Workflow Fragmentation

One common reason for workflow fragmentation is the absence of seamless integration with existing clinical systems. Sometimes, healthcare centers implement "one-size-fits-all" CDSS. While this approach is cost-effective, it fails to consider the unique workflows and needs of different healthcare practitioners. Also, since CDSS takes some contents outside EHRs, it might be overly challenging and hinder access to CDSS utilities. The implementation of CDSS in the Australian Healthcare System exemplifies these issues as it creates workflow fragmentation issue. This is indicated by a lack of integration between clinical and technological elements. Moreover, the lack of interoperability reduces information flow among systems.

To address these issues, CDSS developers may focus on enhancing system interoperability, like utilizing HL7, and incorporating application programming interfaces (APIs) to facilitate seamless integration with other clinical systems. Adopting a more user-centered approach can be helpful, including designing CDSS that are tailored to specific requirements.

3.3.2 Alert Management

The overwhelming number of alerts that clinicians receive daily may lead to a failure to respond appropriately to critical alerts. Given this issue, a study investigated the drug formulary alert, revealing alert fatigue.

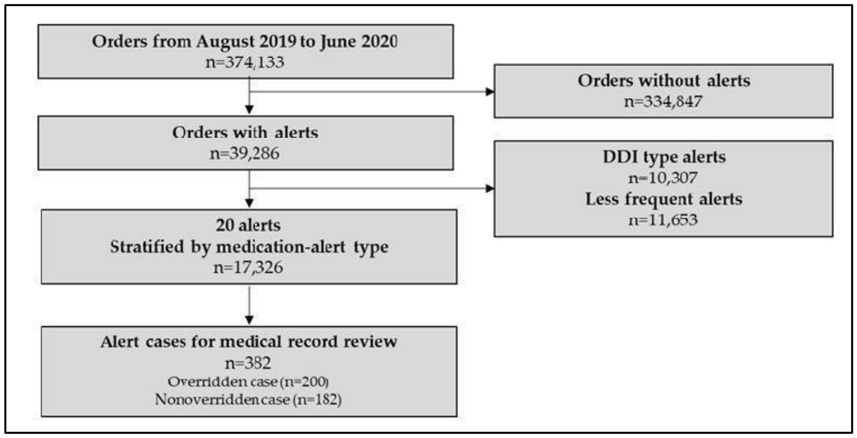

Figure 5: Selection process for DDI alert data

This study conducted at the Emergency Department of a university medical center in South Korea, examining medication orders between August 2019 to June 2020. Out of 374,133 orders, 20 commonly overridden medication alerts were identified based on the alert type. The quantity of alerts analyzed for medical record review was 382 with 200 overridden cases and 182 non-overridden cases. The override rate was 92.9% (n=355): [Physicians' non-adherence (n=15) + justifiable overrides (n=340)/total alerts (n=382)] (Park, H et al., 2022).

Alert clinical relevance	Physicians' response (N=382), n (%)		
	Appropriate	Inappropriate	Nondecidable
Appropriate	13 (3.4)[a]	15 (3.9)[b, c]	0 (0)
Inappropriate	340 (89)[c]	8 (2.1)[d]	6 (1.6)
Nondecidable	0 (0)	0 (0)	0 (0)

[a]Successful alerts.

[b]Physician's nonadherence.

[c]The override rate (355/382, 92.9%) was determined by the sum of these 2 values divided by the total number of alerts.

[d]Unintended adverse consequences.

Figure 6: Evaluation of alerts

Providing customizable alert settings that allow clinicians to tailor the system to their individual practice could help to improve alert relevancy. Regularly reviewing and updating the database is also recommended. And implementing a tiered alert system to prioritize alerts based on severity and clinical significance, might reduce the number of irrelevant alerts.

3.3.3 Reliability of Data

The reliability of data is crucial for providing high-quality patient care and making informed decisions. Some research found that patient data from EHRs are not entirely accurate, which is likely due to a lack of EHR usability (Dash et al., 2019). However, maintaining data reliability is a significant challenge. To input and update data manually requires time and energy, and is prone to errors, leading to inaccurate and incomplete data.

Conducting routine data audits can assist in verifying the precision and accuracy of the data. Also, healthcare providers might use automated data input and update processes to reduce errors and save time and energy. This includes using data import and export tools, integrating data systems, and implementing automated workflows.

	Mean Completeness Score	Mean Correctness Score
Hip Pain	.39	.91
Shoulder Pain	.32	.94
Knee Pain	.37	.96
Foot Pain	.30	.95
All cases combined	.34	.94

Figure 7: Completeness and Correctness Scores

Research conducted by internal medicine residents (PGY-1-3), shows that the core issue is completeness of data. Of the six elements, the data entered is only 30%-40% of the total data that should be entered. However, the data's average accuracy rate of 94%.

4. Conclusion

CDSS has provided transformative technological assistance in the health sector, helping physicians with intelligent tools and evidence-based insights. Although there are still several problems to be solved, there are strategic approaches that can help overcome these challenges. Both CDSS mechanisms hold the key to enhancing patient safety and diagnostic efficiency. Future innovations and the dedication to improving CDSS will continue to pave the way for CDSS to seamlessly integrate into health services, enhancing patient care and assisting decision-making.

5. Critical Reflections

As we examine the adoption of CDSS in healthcare, two additional information system aspects should be considered. Strategic planning is critical to connect CDSS deployment with overall healthcare goals. Likewise, ethical, legal, and social issues are crucial in guaranteeing the responsible and fair integration of CDSS.

5.1 Strategic Planning

Strategic planning plays a crucial role in outlining the course of an organization and deciding how to allocate its resources to pursue that path (Reynolds, G.W., 2016). Implementation of CDSS can be classified as a growth or innovation project, which generates significant new revenue for the organization while exploring the use of new technology in a new way at the same time. With strategic planning, healthcare organizations can align their CDSS initiatives with their overall business objectives such as enhancing customer satisfaction and defining pricing strategies to sustain a competitive edge. Analyzing user feedback and satisfaction ratings can reveal areas for improvement in CDSS offerings. Furthermore, the CDSS market is expected to experience substantial growth in the future. Healthcare organizations can analyze data on the adoption rates of CDSS to inform pricing strategies.

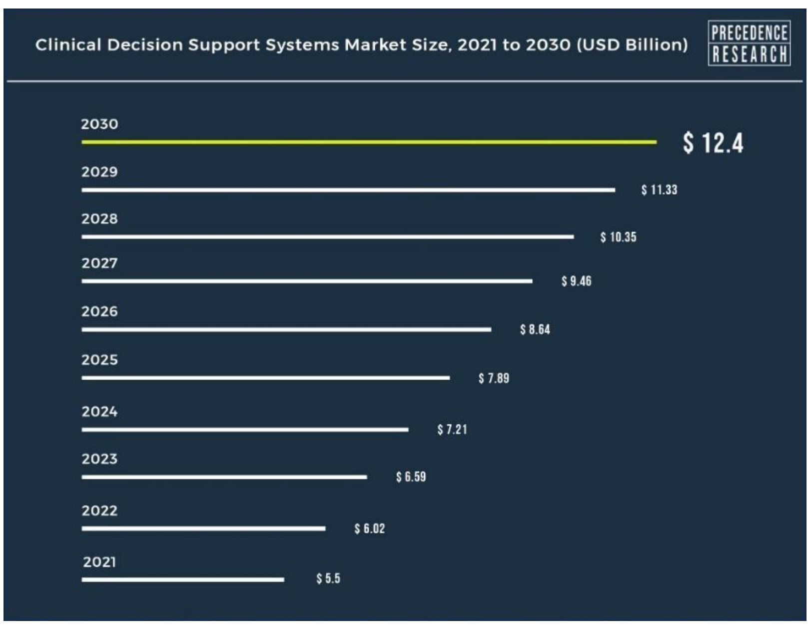

Figure 8: CDSS Market Size Prediction

For a hospital or clinic aiming to increase revenue and enhance customer satisfaction, the suitable planning approach is goals-based. This strategy entails establishing goals that are specific, measurable, achievable, relevant, and timebound (SMART), aligning with the organization's long-term vision. The goal-based approach is the most ideal choice because it helps define clear financial objectives for revenue growth and incorporating customer satisfaction by focusing on improving patient experience and engagement. It is also helpful to communicate the vision and break it down into achievable steps with measured and tracked progress.

5.2 Ethical, Legal, and Social Issues of IT

The use of CDSS involves the processing of confidential patient data, raising issues related to privacy and consent. Patients have the authority to oversee the collection and usage of their personal data (Tadajewski, 2006). Therefore, healthcare providers must ensure that patients understand the reasons for their data collection. To secure patient data, hospitals and clinics are bound by applicable laws, such as the Health Insurance Portability and Accountability Act (HIPAA) in the US. Regarding liability and accountability, healthcare providers must ensure that they are trained to use CDSS effectively and that they maintain clinical oversight and judgement when using CDSS (Reynolds, G.W., 2016). On the other hand, CDSS developers must ensure that their products are safe, effective, and follow the regulations and standards.

Moreover, CDSS depends on algorithms for examining patient data and delivering recommendations for physicians. Nevertheless, there is a possibility of bias in these algorithms, resulting in discriminatory results (O'Neil, 2016). In situations where the data employed to train the algorithm does not mirror the entire population, the suggestions made by the algorithm could be inaccurate. In addition, CDSS must be designed in a way that integrates seamlessly with existing workflows and is easy to use for healthcare professionals. CDSS project should adhere to a Code of Ethics, such as the principles set by the Association for Computing Machinery (ACM), to avoid discrimination and respect privacy.

Word count: 2,495

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