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# CDS System Clinical Decision Support Systems [Drug Interaction]

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***Abstract* —Working in health institutions is a continuous and challenging matter that requires effort due to its humanitarian importance. Because of many visits, medicines dispensing to patients, and the lack of an electronic system that manages drug interactions, it was essential to choose this project because it contains human values that protect people from health setbacks or death.**

**The main goal is to create a system that helps the medical staff make quick decisions and avoid drug conflicts. In short, the CDS system works in conjunction with other systems (health systems) to provide some essential data for the analysis process, and the CDS system analyzes it and returns the final result.**

**In the report, I conducted surveys, analyzed data and pulled the results out; system requirements and check for drug interactions were determined. The system works according to the studies conducted and to the experiences during development to achieve the project's main objective. Despite that, the system needs a more practical audit to ensure that no errors may negatively affect this primary goal; a group of the medical staff must carry out this from various specialities (doctors and pharmacists).**

**Finally, working on systems requires many experiences, especially systems that relate to people's lives, such as medical systems and related to them. There is a second phase of the project that I will work on after achieving several things, such as providing an integrated team of information technology and medical staff and obtaining a sponsor to save material expenses.**

## I. INTRODUCTION

Working in health institutions always requires constant focus because any mistake, even a simple one, may cost us a person's life. Health institutions receive a large number of visits daily, amounting to 15,660,209 visits to outpatient clinics, with an average daily rate of 42,905 visits, and an increase of 0.94% over the year 2018, and that in 2019, according to the statistics of the Omani Ministry of Health (Ministry of Health (MOH), 2019). Therefore, doctors perform many medical diagnoses and prescriptions based on these statistics.

According to this and some information deduced from some health sector workers, there is always a possibility of an unintended mistake in prescribing a drug that conflicts with the patient's medical diagnosis, which may cause a danger to his health. And medication error is defined as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer" (Administration, n.d.). The serious harmful results of a medication error may lead to Death, Life-threatening situations, Hospitalization, Disability, and Birth defects. etc.

An electronic system that contributes to and helps the medical staff identifies any drug conflicts before prescribing them to the patient may greatly help protect the patient and preserve his life. For this reason, an application project was chosen as MSc Project to find a practical solution that would allow the medical staff to make the appropriate decision regarding patient prescriptions.

## II. AIM

The aim of the project is to develop a system that helps medical staff make quick and informed decisions and avoid prescribing medications that contradict the patient. The objectives of the project include developing an integrated system to analyze patient data, collecting patient information, analyzing data in an orderly manner, returning clear results, and allowing users to check prescriptions one by one or all at once.

## III. LITERATURE REVIEW

The literature review that is enclosed in this section emphasizes how the usage of decision support systems helps in assessing drug interactions whilst prescribing medication to a patient.

### *A. An Overview of Clinical Decision Support System*

Clinical Decision Support Systems (CDSS) aid healthcare practitioners in making accurate medical decisions by incorporating patient medical records, clinical knowledge, and other health-related facts. CDSSs use decision support software based on patient information and computerized knowledge to recommend appropriate decisions to clinicians. The integration of CDSSs with Electronic Health Records (EHR) and Computerized Provider Order Entry (CPOE) has enhanced the accuracy of medical decisions. CDSSs can be categorized into knowledge-based and non-knowledge-based systems, with non-knowledge-based systems using Artificial Intelligence (AI) and statistical patterns to arrive at recommendations. The use of non-knowledge-based CDSSs is increasing rapidly, despite the challenges in comprehending the reasoning patterns used by AI to arrive at recommendations (Deo, 2015; Dias, 2018; Middleton et al., 2016; Osheroff et al., 2012; Sutton et al., 2020).

The deployment of CDSS and EHR databases has gained recognition from various governments and healthcare institutions worldwide. In the United States, the health and medical act of the government has provided financial incentives to access the EHR databases, resulting in 41% of

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healthcare centers implementing EHR and CDSS in 2013. In Canada, 62% of clinicians have adopted CDSS and EHR, while the UK government invested 20 billion euros in the development of IT healthcare systems, leading to widespread adoption of CDSS in most hospitals. Australia, Denmark, Estonia, and other countries have incorporated national health records into their CDSSs and EHR databases to enhance clinical decision-making accuracy. CDSS offers a wide range of features, such as early diagnosis of clinical ailments, drug control, and prescriptions, among others, resulting in increased patient safety, cost reduction, effective drug administration, and advanced decision support. However, there are associated risks, such as too many alarms and suggestions, which clinicians may avoid or dismiss, and the initial implementation cost of CDSS and EHR databases being high. Furthermore, content maintenance is difficult in systems that are powered by CDSS as they do not support changes in content or knowledge rules. (Health Information Privacy, 2010; HIMSS, 2017; Zikos and DeLellis, 2018; Nøhr et al., 2017; Omididan and Hadianfar, 2017; Dias, 2018; Sutton et al., 2020; Middleton et al., 2016; Deo, 2015).

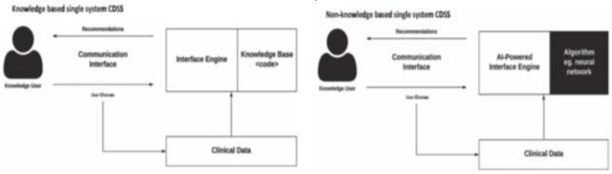


Figure 1 Knowledge-Based and Non-Knowledge Based CDSSs (Source: Sutton, et al., 2020)

*B. Adverse Drug Reactions*

The use of multiple drugs to treat chronic diseases increases the likelihood of adverse drug reactions (ADR) in patients, which can lead to deteriorating health and high medical expenses. Patients with multiple diseases are especially vulnerable to drug interactions and medication errors. To address this issue, information sciences such as clinical software, decision support systems, and artificial intelligence can aid medical practitioners by providing information on patient medical history, prescribed medication, and potential drug interactions. The use of such tools can help to reduce the number of hospital admissions, ICU visits, and mortality rates caused by ADRs (Chen et al., 2018; Spanakis et al., 2016; Dechanont et al., 2014).

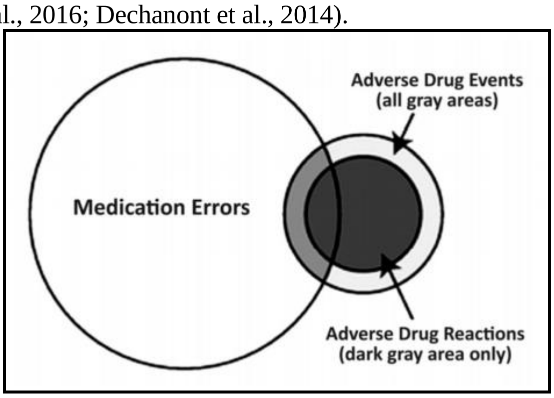


Figure 2 Adverse Drug Reactions (Source: Chen et al., 2018)

*C. Drug-Drug Interactions*

Drug-Drug Interactions (DDIs) occur when one or more drugs interact with each other in ways that were not intended or predicted, and can be caused by prescription errors, self-medication, or a patient's use of alternative medicines. DDIs are common in chronic diseases where patients are prescribed multiple medications, and can lead to catastrophic results and increase the risk of Adverse Drug Reactions (ADR). To avoid undesirable consequences, doctors should avoid prescribing medications that increase the risk of ADR, and patients should avoid taking alternative medicines or self-medicating with Over The Counter (OTC) drugs. DDIs can be diagnosed by searching biomedical databases or studying medical literature. (Chen et al., 2018; Phansalkar et al., 2013; Spanakis et al., 2016; Vizirianakis et al., 2010; Wen et al., 2020).

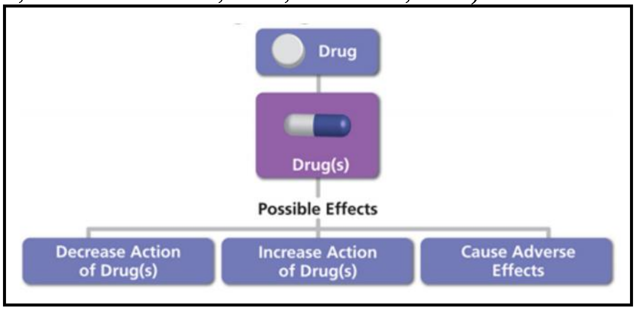


Figure 3 Drug-Drug Interactions (Source: Chen et al., 2018)

*D. Drug-Food Interactions*

Drug-Food Interactions (DFIs) occur when food modifies the therapeutic effect of prescribed drugs. The interaction mechanism can be antagonistic or synergistic, with either pharmacodynamic or pharmacokinetic action. DFIs can be evaluated on the intensity of pharmacological severity through clinical studies regulated by FDA and EMA, which are used to control and manage DFI interactions. DDI tools like Medscape, Drugs.com, and MyHealthAvatar are integrated into information systems to enhance the decision-making capabilities of doctors, especially for chronic ailments (Spanakis et al., 2016). (Citation: Spanakis, M., & Kondylakis, H. (2016). Semantic Interoperability and Electronic Health Records: A Roadmap to Understanding the Current Landscape. J Med Syst, 40(11), 256.)

## IV. IMPLEMENTATION AND TESTING

*A. UML diagrams*


Figure 4 USE CASE DIAGRAM (integration CDS SYSTEM and Health system)

The above diagram describes the integration of the CDS system with the health system involves several steps to ensure the safety of the patient. The health system user opens the patient's health file and provides necessary data such as patient information, allergy data, and family history. The doctor then enters the medical diagnosis and prescription for the patient. This data is sent to the CDS system for analysis in three stages, which include checking medication with patient history, diagnosis, and other medications. If any issues are found, an alert message will show to the user in the health system. This process aims to ensure that the prescribed medication is safe and effective for the patient.

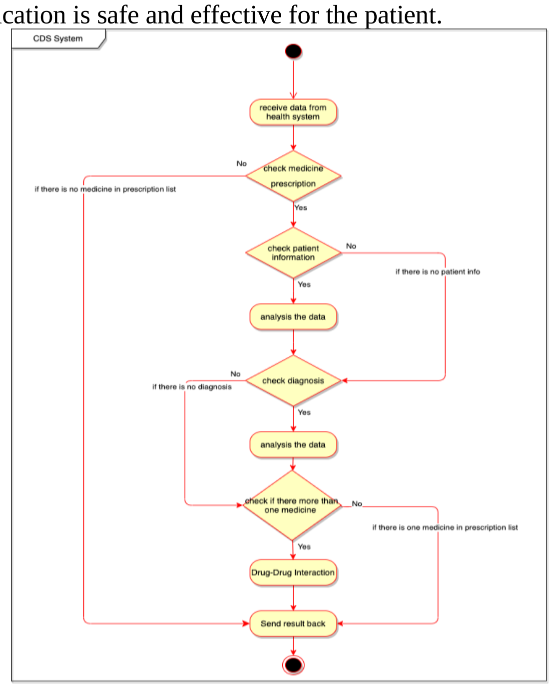


Figure 5 (Activity Diagram, CDS System)

The CDS system's activity process follows a sequential flow, as depicted in the figure above. The system begins by receiving a request and checking if there is a prescription in the request data. Based on this, it will proceed to check each list (patient information, diagnosis, and others) separately. If data is found, the system will cross-reference it with the prescription and generate a result. Ultimately, the CDS system will send the result back to the health system.

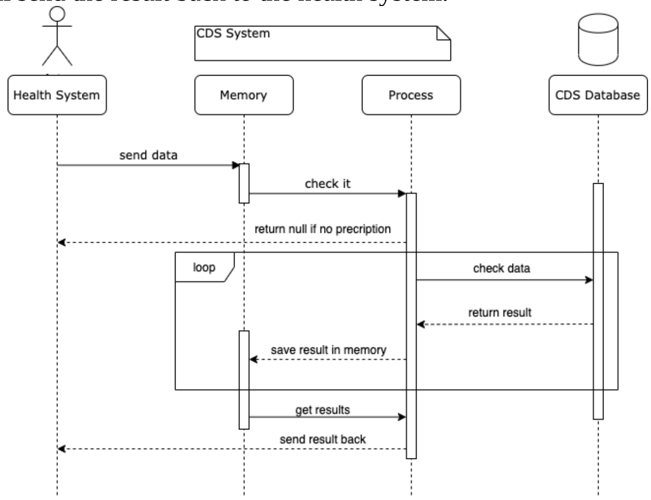


Figure 6 (Sequence Diagram)

The sequence diagram for the CDS system is illustrated in the figure above, depicting the interaction between four sequences across three layers. The presentation layer, located in the integration system (health system), sends the request to the CDS system. The CDS system stores the request in memory and checks if there is a prescription. If no prescription is found, the CDS system returns a null result. Then, the CDS system loops through each prescription, checking it against all requested data and saving the result in memory. Finally, the CDS system retrieves all results from memory, processes them, and returns them to the health system. The business layer includes two sequences: memory and process. The database layer contains the master data for the CDS system.

*B. API and Testing*

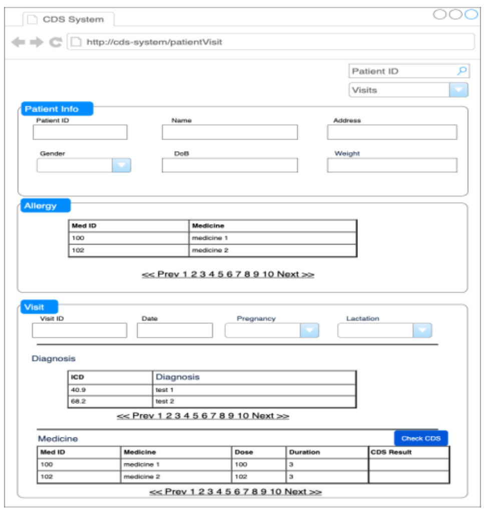


Figure 7 (UI for test purpose)

The CDS system was implemented as a web service that can be integrated with other systems. The main implementation of the system is an API service, which can be called by passing the requested data and responding with the result. For testing purposes, a prototype UI was designed (as shown in the figure above), which displays patient information and visit details. The system's business role involves creating a patient visit file that contains patient information, allergy details, diagnosis, and prescription. The integrated system sends requests to the CDS system with the required data in JSON format. The CDS system checks the data, performs analysis, and returns the result to the integrated system. The results are displayed according to each prescription.

During the testing phase of the CDS system, multiple testing methods were employed, including unit testing, integration testing, white box testing, and black box testing. The integration testing was performed using API calling tools, and all issues were resolved before conducting the test in an integrated environment.

The following tests were conducted:

- Send a request with empty data
- Send a request with the wrong JSON format
- Send a request in the correct data format

## V. CONCLUSION

In conclusion, the Clinical Decision Support System project was evaluated based on its relevance to healthcare and the fulfillment of its requirements. The system achieved its objectives, including handling multiple types of drug conflicts and integrating with other systems. However, the system requires improvement by adding more data and conducting further analysis. Recommendations for improvement include forming a team from the medical field, adding more types of drug interactions, creating an admin control panel, sharing the project with hospitals for testing, and conducting additional studies and tests. Overall, the project is essential for saving people's lives and needs ongoing maintenance and support from medical staff and a sponsor to cover material costs.

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