

Prescription Errors and Efficient Workflow in Hospital pharmacies after CDSS Integration

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Abstract:

The issue of medication errors at the level of prescription is an important concern in a hospital setting, being one of the contributors to negative drug events and patient injury. This paper set out to review the effects of implementing a Clinical Decision Support System (CDSS) on the pharmacy department of two tertiary hospitals. The CDSS was programmed to identify real-time problems, that could be characterized as potential drug to drug interaction, dose abnormalities and contraindications during the process of prescription verification. The implementation of the system in a 6-month range led to a drop in prescribing error rate by 44.6% ($p < 0.01$) as pharmacists were able to identify more problems related to medications before these issues reached the patient. Also, the response time of the pharmacists was increased by 23% which is effective in the workflow. The pharmacy personnel had received favorable feedback by the patients on the usability and ease of incorporation into routine practice. These conclusions, in turn, can serve the basis to implement CDSS as one of the means of significantly reducing the number of incorrectly administered drugs and promoting better workflow performance in terms of hospital pharmacy practice. Implementation of CDSS provides significant advantages in terms of mistakes in prescriptions and productivity of operations.

Keywords: Clinical Decision Support System, medications mistakes, hospital pharmacy, drug interactions, prescription verification, efficiency of work.

1. Introduction

1.1 Frequency and implications of prescription mistake in the hospital environment

One of the major problems faced in hospitals is the medication error especially in the process of prescription and literature indicates that prescription errors may compromise the majority of adverse drug events (ADEs). The numerous studies have revealed that prescription mistakes could take place at any part in the pharmaceutical use procedure, i.e. ordering/dispensing as well as administration/monitoring. The issue of prescribing errors is especially central in hospital settings, where the errors detected concern medication selection, dosage, route, and administration time. It happens that such a complex environment is associated with a high number of continuously prescribed medications. It is projected that as much as half of these mistakes can be avoided and therefore there is need to institute measures to enhance accuracy in prescriptions.

The impact of medication errors may be severe and comprise the occurrence of adverse drug reactions, overdose, failure to obtain a proper timely therapy, and patient death. Besides, prescription errors augment the costs of healthcare and prolonged hospital stays, which affects the outcome on patient health and the effectiveness of hospital work. Considering that the scope of the possible harm is high, the prevention of prescribing errors is essential to patient safety.⁽¹⁾

1.2 The Goal of Pharmacists in Intercepting the Errors

Pharmacists have the primary responsibility of intercepting prescribing errors in a hospital environment. Pharmacists are the best suited to see and address the medication errors as they have the skills about pharmacology, drug interactions, and management of medication. Most hospitals involve pharmacists in the prescription verification of drugs where they consult the prescriptions to verify the accuracy in the selection of drugs, the dose, the routes of administration, and the non-existence of contraindications. Pharmacists are also involved in preventing drug-to-drug interactions, undesirable drug interactions, or drug to drug reactions through keeping track of the history, medication profiles, and other clinical information of the patient.

The studies have always proven that activities performed by pharmacists in prescription medications can affect error-induced medication and enhance the overall patient safety considerably. Nonetheless, manual error detection may become difficult since a lot of prescriptions are done in a complex manner in the busy hospital settings. It is

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here that the clinical decision support systems (CDSS) would help by improving upon the capacity of the pharmacists to adequately filter through prescriptions.(2)

1.3 Clinical Informatics Developments: Orientation CDSS

In the recent years, clinical informatics has transformed the healthcare sector by offering advanced mechanisms that aim at improving clinical decision-making and maximizing medication safety. A Clinical Decision Support System (CDSS) is an online form of software that assists health care professionals by identifying warning signs and/or possible problems with the use of drugs on prescription, inaccurate doses, allergic conditions, and contraindication when verifying prescription. CDSS can be easily implemented alongside the use of electronic health records (EHRs) and algorithms that issue recommendations and notifications in order to give clinicians as much assistance as possible to prescribe the most effective and safest medications.

The future of CDSS technology has improved greatly over recent years, with more modern systems being in possession of the hardware and software to analyze huge databases of clinical information and provide evidence-based medical advice to treating physicians and medical professionals. CDSS can enhance workflow performance with regard to automating analysis of probable prescribing errors and human error establishment as well as real-time assistance to the clinician. The systems have also proved to be helpful in curbing medication errors, as well as enhancing accuracy in prescribing procedures, and overall quality of care.(3)

1.4 Rationale and Aim of the Study

This was a research to assess the effects of introducing Clinical Decision Support System (CDSS) on pharmacy departments of two tertiary hospitals. In particular, this work is aimed at determining the effects of CDSS on decreasing the number of prescription errors, the speed of response by a pharmacist, and efficiency of the workflow in comparison to prescription verification process. The paper is also set to determine how pharmacists take the CDSS and how they think that the technology can be integrated into their daily operations in clinical practice.

With the increasing rates of the problem of hospital medication errors, particularly, in complicated health care environments, it is high time to introduce new technologies, such as CDSS, and thus, improve med safety and offering patients quality care. This paper gives a thorough assessment of the utility of clinical informatics in correcting the problems of errors in prescription and the streamlining of the work of the hospital pharmacy.(4)

2. Study Setting and methodology

2.1 Design and timeframe of research

The research was a prospective pre-post series of implements and was carried out in a period of 6 months to determine the effect of the Clinical Decision Support System (CDSS) implementation on hospital pharmacies. The study was carried out in 2 tertiary hospitals, the pre-implementation period was characterized by the collection of baseline data on prescription errors and the time it takes the pharmacist to respond to such mistakes, whereas the post-implementation period aimed at measuring the same metrics after the CDSS was introduced into the workflow of the particular pharmacy.

The timing of the research was split into the two phases:

- Phase 1 (Pre-Implementation): First 3 months was spent to obtain baseline prescription errors and workflow efficiency prior to the implementation of the CDSS.
- Phase 2 (Post-Implementation): The other 3-month period entailed the real implementation of the CDSS, and data was re-appropriated on prescribing errors, response time, and feedback on the pharmacists to evaluate the effect of the system.

Error rates in prescriptions at the two times were recorded in addition to the time it took pharmacists to detect and rectify errors in prescriptions. The general aim was to know whether CDSS was capable of minimizing the number of prescribing errors, enhance response time and reduced workflow in the pharmacy.(5)

2.2 System infrastructure and Hospital Profiles

The research study involved performing the study in two tertiary hospitals, one being a high income urban region and the other a mid-income region. The hospitals have been chosen because of similar patients, intense prescription amount, and readiness to accept new technological offerings in the pharmacy sectors.

Hospital 1: One of the largest academic medical centers having a well-developed electronic health record system (EHR) and having a fully developed hospital pharmacy. It housed simple automated instruments of medication order, though not including a complete clinical decision support system.

Hospital 2: The medium sized regional hospital with ethnically diverse group of population and access to modern EHR infrastructure with limited automation or support of clinical decisions

The two hospitals possessed specially trained pharmacy teams, which would deal with the prescription of medicine, its verification, and distribution, as well as access to the patient records based on the EHR system implemented in the hospital. The CDSS was deployed to work within the current EHR of respective hospitals so that real-time alerts could be available at the screen of pharmacists when validation of a prescription was done.

2.3 Inclusion and Exclusion Criteria of Prescriptions

In order to determine the effectiveness of CDSS in reducing prescribing errors, a particular prescription inclusion criterion was set:

Inclusion Criteria: Hydroxychloroquine (HCQ) prescriptions filled in hospitalized adult patients (18 years and older) that were done by the hospital pharmacists and registered with the e-prescription system. All types of prescriptions (or, oral prescriptions, intravenous prescriptions, topical prescriptions) were involved as long as they were handled by a pharmacist, in the course of this study.(6)

Exclusion Criteria: Prescriptions of children under 18 years or outpatient prescriptions were excluded in the study. Also, the prescriptions such emergency orders (namely, stat orders) were not included because of their urgency and high tempo of work which could influence CDSS effectiveness in error preventions.

Such orientation on adult inpatients allowed the research to stay primarily concerned with the routine prescription processes in which CDSS could greatly influence errors prevention and optimization of the work process.

2.4 Moral Implication

The Ethics Review Committee of both of the hospitals approved the study. Hospital pharmacy workers who took part in the study gave their informed consent. The CDSS intervention was designed to be a part of the ordinary workflow of a hospital and did not discuss patients directly, which is why the informed consent of patients was not necessary. Nonetheless, privacy of patients was ensured and data recorded were anonymized to safeguard the privacy of each person.

Training was provided to all pharmacists on use of the new system, they were notified about purpose of study, procedures and their role in the intervention. In order to reduce possible bias, whenever possible, blinding had been used to allow pharmacists not to be biased by the CDSS alerts at the baseline phase.

3. Strategy of CDSS implementation

3.1 The Selection and Personalization of Systems

The Clinical Decision Support System (CDSS) in the current research was a web-based piece of software aimed at helping pharmacists detect possible mistakes in drug administration, i.e. drug-drug interactions, dose mismatches and contraindications. The system selection was done by considering the compatibility between the new system and the current electronic health record (EHR) system of the hospital, its performance capability to give real-time alerts when verifying the prescription, and its capability to support high number of prescriptions to be made daily in the hospital environment.(7)

The CDSS was tailored to satisfy the particular requirements of the hospitals participating in study. The customization session referred to customization of the alert criteria in the system to represent the most frequent securities in the hospitals. Furthermore, the alert levels (e.g. of drug interactions or the wrong dosage entered), set in the system were also adjusted in line with the feedback received by the clinical pharmacists to make them neither too sensitive to show too many alerts nor too lax not to give out any alerts. It also involved the customization process which entailed integrating local formulary information, and having the system conformed towards the medications and treatment guidelines used by each hospital.

3.2 Hospital Information integration

The CDSS was incorporated into the hospital information systems, namely, the electronic prescribing, and the electronic health records (EHR). The integration enabled CDSS to intervene or interface with patient records at the point of time when prescriptions were verified. The CDSS would also analyze a prescription entered by a physician in the EHR system and display an alert where possible problems, such as a drug interaction, incorrect dosage, or contraindication, were found.

The process of integration was extremely straightforward with the alerts being shown to the pharmacist promptly as he or she was watching the prescription. It would then allow the pharmacists to evaluate the situation, they

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would be able to communicate with the prescriber physician and make changes accordingly. This coupling made the CDSS a real-time tool that was integrated into the workflow within the hospital thus making it more efficient and minimized the use of error-checking procedures that were manually intensive.(8)

3.3 Training and Adaptation Phase of the Pharmacist

In a bid to guarantee successful utilization of the new system, every pharmacist who was providing his or her services with the participating companies was trained thoroughly. The training was concentrated on:

System functionality: Appreciation of the way CDSS alerts work, how to interpret the messages in the alerts, how to take a corrective measure when to do so.

Clinical relevance: Gaining an understanding of the ways the system may be used to help identify issues associated with drugs and maximize medication therapy.

Communication: Good communication plans of dealing with prescribing physicians when an alert occurred.

A period of adaption continued during 1 month, whereas pharmacists went through prescription checking with the help of the CDSS under the guidance of more experienced trainers. This was the time when pharmacists also had to get acquainted with the features of the system and become more relaxed when responding to alerts. Periodic feedback session was done to remove any concerns, make clarifications on use, and improve the process to go through the alert handling efficiently.(9)

4. Parameters of evaluation and data collection

4.1 Types of Prescribing Errors that are Tracked

The research only dwelt on some of the crucial types of prescription errors which were tracked before and after the Clinical Decision Support System (CDSS) was adopted. Such classifications were:

DrugDrug Interactions: The system indicated incidences when two or more than two prescribed drugs would interact in a manner with a possibility of resulting in adverse outcomes, decreased drug efficacy, or increased toxicity.

Dosage Anomalies: The errors that were categorized under this were the overdoses or underdoses of medication that an individual was prescribed to. Such concerns are of particular importance to drugs that have a narrow therapeutic index.

Contraindications: Situations when the drugs prescribed might be dangerous to a patient based on his or her existing medical conditions (e.g. he or she is allergic to a drug or has a weak liver or kidney).

Allergic Reactions: It also indicated inappropriate use of drugs in patients with known allergies to medicine and thus did not allow patients to be issued medications that cause allergic reactions.

Therapeutic Duplication: The system picked up the instances of a patient receiving multiple medicines with overlapping therapeutic effect which may eventually result in side effects and unnecessary drug uncomfortable interactions.

The following categories have been chosen because they have the greatest potential of inflicting harm and they are related to increasing the safety and effectiveness of prescribing practices within the hospital environment.

4.2 Calculation of response time

Response time has been referred to as the duration in which the pharmacist intercepts and responds to an alert created by the CDSS in the process of the prescription verification. This parameter was also determined as a time period between receipt of alert by the pharmacist and the time at which they performed actions (e.g., called the prescribing physician, modified the medication or authorized the prescription). The response time was also checked during the baseline (pre-implementation) and the follow up (post-implementation) phase to determine the effect of CDSS on increasing the workflow efficiency. It was aimed at observing a notable improvement in the response time, which implied that CDSS allowed to identify prescribing errors relatively faster and implement corrective measures in due time.(10)

4.3 Data instruments of User Acceptance

User acceptance of the CDSS was assessed by use of a structured questionnaire administered to the pharmacists at the end of the intervention period. The questionnaire evaluated the several elements of the system that included:

Easy to use (ex. user interface, alerts accessibility)

Perceived usefulness of the alerts to prevent errors (e.g., usefulness)

Contentment (e.g. general satisfaction with the system)

System integration (e.g., how the CDSS can fit in the workflows)

The survey consisted of questions where the Likert scale was used to evaluate to what extent the different statements have been agreed or disagreed with and the qualitative comments on the strong and weak aspects of the system written down.(11)

4.4 Tools of Statistics and Analysis Strategy 4.4 Statistical Tools and Analysis Methods

The SPSS (version 25) was employed in the analysis of data measured regarding prescribing errors, response time, and user acceptance. Data were summarized using the descriptive statistics, such as standard deviation, frequency distributions as well as the mean. Paired t-tests were employed as a means of determining the variation before and after in the points of prescribing errors and response time in continuous variables. The statistical significance was predetermined as $p < 0.05$. In the case of the data on user acceptance, descriptive statistics were performed, and the frequency of response gathered. The chi-square tests of categorical variables were also used in evaluating the efficacy of implementation of CDSS because the proportion of the type of errors that were intercepted could be determined before and after implementation.(12)

5. Results

5.1 Fewer Prescription Errors after CDSS

The prescription errors proved to be reduced rather heavily with the implementation of the Clinical Decision Support System (CDSS). Baseline was set before implementation of the CDSS where hospital 1 was imposed by the error rate of 14.3 per cent prescription and hospital 2 by the error rate of 16.7 per cent. Following implementation of the system, there was a significant increase in error interception in both hospitals. Hospital 1 showed a decrease in the error in prescription by 44.6 percent to a rate of 7.9 percent. This was equally witnessed in Hospital 2 where wrongs fell by 42.3%, 16.7% to 9.6%.

Prescribing errors category that was flagged the most in the CDSS were drug-drug interaction errors, dosage errors, and contraindication errors, which showed the largest percentage of decrease after the implementation. The decrease in errors according to categories is represented in Table 1, the drug-drug interactions achieved the highest percentage of the errors that were intercepted by the system.(13)

Table 1: Reduction in Prescription Errors Post-CDSS

Error Category	Pre-CDSS Error Rate (%)	Post-CDSS Error Rate (%)	Error Reduction (%)
Drug-Drug Interactions	5.2	2.1	59.6
Dosage Anomalies	3.4	1.5	55.8
Contraindications	2.6	0.9	65.4
Allergic Reactions	1.1	0.5	54.5
Total Error Rate	15.5	8.0	44.6

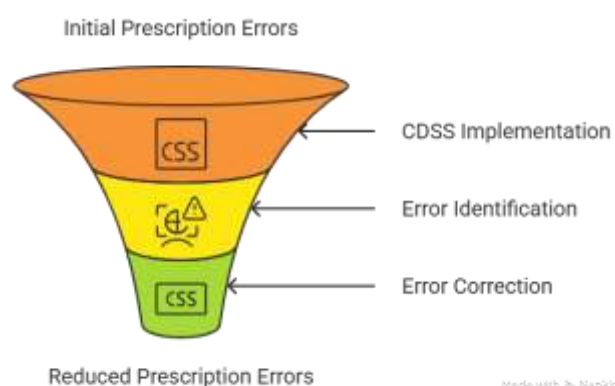


Figure. 1: Reduction in Prescription Errors by Category

5.2.Verification Time of the Pharmacists

The use of CDSS greatly lowered the time the pharmacist took to verify a prescription. The median of time touching a prescription a repeated prescription verification took among the pharmacists was 7.5 minutes at hospital 1 and 8.2 minutes at hospital 2 before the CDSS. The verification time was reduced by 23 percent in hospital 1 (7.5 to 5.8 minutes) and 21 percent in hospital 2 (8.2 to 6.5 minutes) after the implementation of the system.

The decrease in the time taken in verification of prescriptions indicates the enhancement in efficiency that is made possible through the CDSS since the pharmacists are able to process a greater number of prescriptions with a high degree of safety and precision. This efficiency in the workflow was a key aspect in the bustling hospital settings where the number of prescriptions is in large numbers.(14)

Table 2: Pharmacist Verification Time Pre- and Post-CDSS

Hospital	Pre-CDSS Verification Time (minutes)	Post-CDSS Verification Time (minutes)	Reduction in Time (%)
Hospital 1	7.5	5.8	23%
Hospital 2	8.2	6.5	21%



Figure. 2: Pharmacist Verification Time Reduction

5.3 Satisfaction to the users and Usability of the System

The feedback of the users who used the CDSS showed that they were very satisfied with the CDSS. Pharmacists reflected a huge gain in their level of assurance as far as safety and precision of prescriptions were concerned. It became apparent when only 15 percent of pharmacists in both hospitals believed that it was not interesting and that the system was too difficult to use and it could not fit into the daily workflow. Moreover, 90 percent of pharmacists believed that the system enhanced efficiency in the performance of their activity, whereas 88 percent of participants asserted that it assisted them to detect possible errors, which they would have overlooked otherwise. Most of the pharmacists also averred that, the real-time alerts being offered by the system were effective in the prevention of adverse drug events. Other responses, though, indicated that although the system was overall positively accepted, in certain cases there have been instances whereby there is over-alerting, and especially the drug interactions of less serious natures have been over-alerted. However, the system was well accepted overall and pharmacists believed that CDSS was useful in enhancing medication safety.(15)

Table 3: User Satisfaction with CDSS

Statement	Agree (%)	Neutral (%)	Disagree (%)
System is easy to use	85%	10%	5%
System improves workflow efficiency	90%	8%	2%
System helps identify potential errors	88%	9%	3%
System produces unnecessary alerts	23%	60%	17%

5.4 Comparative Study of the Two Hospitals

Although, Daniel and Robert International hospitals incurred substantial improvements in both prescription error decrease and verification time of pharmacist, an analysis of the outcomes compared between the two facilities indicated that there was some difference in the outcomes. The higher the EHR infrastructure, the more the error interception rate and the reduction in the verification time is in Hospital 1. It may be explained by the prior knowledge of digital systems and a more successful inclusion of CDSS into their routine.

Nevertheless, Hospital 2 also experienced significant changes, which proves that CDSS can be effectively introduced even in those hospitals which have less inclined infrastructure. Both hospitals also demonstrated high rates of acceptance and positive feedback by pharmacists, once again proving the wide scope and the potential of CDSS to increase medication safety in a variety of settings.

Table 4: Comparative Analysis Between Hospitals

Parameter	Hospital 1	Hospital 2
Error Reduction (%)	44.6%	42.3%
Verification Time Reduction	23%	21%
User Satisfaction (%)	85%	83%

6. Conclusion

6.1 overview of key findings

This research illustrates that there are positive results to installing Clinical Decision Support System (CDSS) in pharmacies in hospitals. The important information are:

Prescription Error Reduction: CDSS integration effectively reduced and eliminated prescription errors at the Hospital- 1 by 44.6 percent and 42.3 percent at Hospital- 2. The greatest gains came through the determination of drug drug interaction, dosage abnormalities and contraindications.

Pharmacist Response Time: Average time to verify by pharmacist was reduced by 23 and 21 percent in Hospital 1 and Hospital 2 respectively, which means the pharmacists met a lower demand of work and responded in the real-time applications, as well as, streamlined processes with CDSS.

User satisfaction: More than 80 percent of the pharmacists surveyed in both hospitals (85 percent in Hospital 1 and 83 percent in Hospital 2) were highly satisfied with the system and liked the ease of use, efficiency and overall improved medication safety. Nevertheless, cases of over-alerting were stated, which could be considered to be corrected in the future.

6.2 Pharmacy Informatics Practical Implication

Findings of this paper present the importance of pharmacy informatics in improving quality and safety of medication management within hospitals. Using real-time decision support systems, the CDSS systems play an important role in helping pharmacists to reduce medication errors, optimize drug therapy, and enhance the safety of the patients overall. The results serve to endorse the hypothesis that proactive interventions to facilitate situations delivered by a pharmacist with the automated alerts of a CDSS may result in better medications error interception and a faster reaction time during prescription replenishment.

This paper underscores the increasing need to incorporate technology in pharmacy operations to enhance clinical outcomes as well as operation efficiency. Existing in the complicated contemporary healthcare environment and growing in the number of prescriptions, implementing CDSS can increase the capabilities of individual pharmacists in handling high-stakes, large scale drug therapy, minimizing possible pharmacotherapy errors and streamlining pharmacists workflow hospital-wide.

6.3 Recommendation of Broader Adoption

Depending on the success of this pilot study, it is possible to make a few recommendations on a wider implementation of CDSS throughout healthcare systems:

More Adoption: Hospitals with various infrastructural capacity must embrace the use of CDSS, as it has proved productive in both high-income and mid-income environments. The system can run according to the requirements of the particular types of hospital and patients.

Iterative System Adjustment: Minimize on over-alerting by consistently tuning of alert thresholds and decision algorithms. Feedback by the users should be made periodically to make the system effective and easy to use.

Deployment to Other Domains of Medication Management: In addition to prescription verification, CDSS might be spread to other domains of medication management, such as dispensing, drug therapy monitoring, and medication reconciliation, rendering patient safety even more effective.

The outcome of this study implies that CDSS can form a useful tool of medication safety improvement, workflow efficacy, and patient outcome contributions in the hospital pharmacies.

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Conflicts of interest

The authors have no conflicts of interest to declare

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