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The Impact Of Integrating Pharmacy And Laboratory In Reducing Errors And Improving Care

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ABSTRACT

Introduction: *The improper interaction between the pharmacy and clinical laboratory information systems results in many errors and lost opportunities for advancement. Pharmacotherapy could be improved by strengthening the connection between laboratories and pharmacies in the following areas; selecting the appropriate drugs based on laboratory-based indications and contraindications, adjusting drug dosages based on renal or hepatic function and blood levels, monitoring for toxicity using laboratory tests, both initially and continuously, interpreting laboratory results that may be affected by the drugs being used, and enhancing overall quality by monitoring for unknown toxic effects and identifying delays in clinician response.*

Aim of work: *To explore the impact of integrating pharmacy and laboratory in reducing errors and improving care*

Methods: *We conducted a comprehensive search in the MEDLINE database's electronic literature using the following search terms: Integrating, Pharmacy, Laboratory, Reducing, Errors, Improving and Care. The search was restricted to publications from 2020 to 2024 in order to locate relevant content. I performed a search on Google Scholar to locate and examine academic papers that pertain to my subject matter. The selection of articles was impacted by certain criteria for inclusion.*

Results: *The publications analyzed in this study encompassed from 2020 to 2024. The study was structured into various sections with specific hea[1]dings in the discussion section.*

Conclusion: *Even with an extensive amount of research on "managed care," clinical laboratory and pharmacy data still need to be better integrated in order to manage clinical care for both inpatients and outpatients. There is sufficient information to conclude that the existing state of data is not being fully used. On the other hand, there are easily accessible substitutes that might significantly improve the standard of care. Given the potential benefits for the laboratory, pharmacy, doctor, and patient, as well as the shown and predicted benefits, there is strong incentive to move quickly to link laboratory and pharmacy data, especially in light of the hopeful developments in technology in the future.*

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Keywords: *Integrating, Pharmacy, Laboratory, Reducing, Errors, Improving and Care*.

INTRODUCTION

Many errors and opportunities for improvement are lost when clinical laboratory as well as pharmacy systems of information cannot communicate with one other effectively. In order to improve pharmacotherapy, laboratories and pharmacies should work together more closely in the following areas: (1) choosing the right medications based on laboratory-based indications and contraindications; (2) modifying the dosage of drugs depending on blood levels and renal or hepatic function; (3) monitoring for toxicity via laboratory tests, both at the beginning and during treatment; (4) interpreting laboratory results that may be impacted by the medications being used; and (5) setting quality enhancement strategies into place, such as keeping an eye out for unknown toxic effects and spotting delays in clinician response. Relationships may be made in real time or in the past. Several businesses may now benefit from merging their current laboratory and pharmaceutical data. Utilizing electronic order entry with real-time decision support that incorporates linked laboratory and pharmacy data might result in a significant improvement. There is a great need for further knowledge and evidence in this area even if there are several guidelines, cautions, and limits for drugs and laboratory procedures (Eldooma et al., 2023). Our goal is to take care of these unfulfilled requests and the related logistical issues.

For instance, if a patient's blood potassium levels are too high, a doctor might prescribe potassium supplements. If a patient has impaired kidney function, a doctor might fail to adjust the dosage of gentamicin. A patient receiving intravenous theophylline might continue to receive the drug despite the patient's blood cultures indicating that the patient is resistant to a particular antibiotic. These are some instances of common errors that may have been avoided if pharmacy and laboratory information systems had interacted more successfully (Palmer and Clegg, 2022).

Patients are often harmed by drug errors that are connected to laboratory problems, both within and outside of hospitals. According to one research, adverse pharmacological events happened in 6.5 out of 100 hospitalizations, and 28 percent of these were thought to have been avoidable. The most common causes of errors were selection issues pertaining to laboratory parameters and medication dosage (Zucker and Prendergast, 2020). Elshayib and Pawola found that drug-associated diseases may be present in 5% of 13 727 individuals using computerized screening; 44.9% of positive screens were attributable to drug-related laboratory irregularities. During another inpatient study of over pharmacist-detected drug errors, the most prevalent kind of error found (13.9% of all errors) was excessive dose for patients with impaired renal and hepatic function (Elshayib and Pawola, 2020). Adverse drug occurrences are also common in assisted living facilities, where an even higher percentage may be avoided. One of the main causes of inaccuracy in this situation is inadequate laboratory monitoring, particularly for anticoagulant medication. Medication-related issues are prevalent outside of hospitals, with monitoring shortcomings being particularly noticeable, despite the fact that data on outpatients are scarcer (Wong, 2020). According to a recent research, 79% of adverse drug events that were identified by associating medications with laboratory "signals" were often overlooked (Kim et al., 2022).

The clinical laboratory and pharmacy remain surprisingly unconnected, despite the fact that laboratory information is essential for choosing and maintaining drugs (Valdés-Garicano et al., 2022). The pharmacy handles order fulfillment and drug delivery, but the laboratory keeps an eye on the different impacts of these substances being supplied. Even though the clinical

laboratory and the pharmacy have a complimentary connection, there is not much communication between these two departments' staff, workflow, or, in particular, information technology. This is particularly true in the context of outpatient care, when most prescriptions for medications and diagnostics are filled (Wong, 2020).

This disparity also affects efforts to improve quality, which often fail to use laboratory and pharmacy data to reduce errors and improve patient care. For example, links with medications are barely discussed in a book edited by pharmacists from the Institute for Safe Medication Practices on preventing medication errors, and links with medications are not even addressed in recent symposia focusing on enhancing the clinical application of laboratory information (Witt et al., 2024). Another example is the topic of improved laboratory connection.

AIM OF WORK

To explore the impact of integrating pharmacy and laboratory in reducing errors and improving care**.**

METHODS

A systematic search was performed on reputable scientific platforms such as Google Scholar and Pubmed, using targeted keywords such as Integrating, Pharmacy, Laboratory, Reducing, Errors, Improving and Care, in order to compile all pertinent research publications. The articles were selected based on certain criteria. After thoroughly analyzing the abstracts and significant titles of each publication, we removed case reports, duplicate papers, and publications that did not have complete information. The reviews analyzed in this study were published between the years 2020 and 2024.

RESULTS

The current investigation concentrated on the impact of integrating pharmacy and laboratory in reducing errors and improving care between 2020 and 2024. As a result, the review was published under many headlines in the discussion area, including Importance of integrating pharmacy and laboratory, Laboratory Interference and Interpretation, Current approaches of integrating laboratory and pharmacy, Future challenges.

DISCUSSION

Importance of integrating pharmacy and laboratory

The occurrence of medication errors may be significantly reduced if there was effective communication and integration between laboratory and pharmacy information systems. Nevertheless, blatant mistakes are only the surface manifestation of a much larger problem. The potential for enhancing the quality of medical treatment is vast when these two systems communicate with one other using proper knowledge-based rules. By establishing strong connections, the occurrence of medication toxicity may be effectively averted and rapidly identified and resolved (Al-Worafi, 2020).

Establishing a link between medical treatments and diagnostic tests has the potential to improve outcomes and knowledge acquisition, as well as increase the efficacy and efficiency of pharmacotherapy and laboratory testing. These connections may be made in real time using new intelligent order-entry systems, or they can be made retrospectively by integrating lab and pharmacy data that has already been obtained. Although most hospitals and health systems are not able to link data in real time, they may potentially do so by retrospectively connecting laboratory and pharmacy data using current technologies. Unfortunately, many fail to take

advantage of this opportunity, resulting in missed chances for improvement using the data already available (Awad et al., 2021).

- **Drug Selection**

A sophisticated program has been created to verify whether a patient's medication prescription contradicts the list of approved drugs by their insurance company, however the advantages of this, if any, are mostly financial (Fulmer et al., 2021). However, even if there is evidence of its effectiveness in medical treatment, only a limited number of institutions have the capacity to verify safety restrictions based on test results. According to a recent survey, none of Chicago, Illinois's major hospitals or clinics had put in place automated systems to stop prescribing potassium when there was high serum potassium, inhibitors of angiotensin-converting enzyme when a documented positive pregnancy test was obtained, or metformin hydrochloride when azotemia was present (Poly et al., 2020).

On the other hand, abnormalities seen in clinical laboratory testing may indicate a need for a particular drug regimen. A consistently elevated glucose or hemoglobin A1c level without a prescription for hypoglycemic drugs, or a significantly elevated level of thyrotropin (TSH) without a subsequent prescription for levothyroxine sodium (or a repeat test), indicates a laboratory abnormality that needs to be addressed by the pharmacy and should set off alerts if left unchecked (Sun et al., 2022).

- **Dosing**

32% of patients with renal insufficiency developed digoxin toxicity, according to a review of those cases, often without the necessary dose adjustment (Adio et al., 2020). Recently, we analyzed prescription requests for individuals with reduced creatinine clearance. Out of the medications that are eliminated from the body via the kidneys or have the potential to cause kidney damage, 70% of prescriptions were issued for a dosage or frequency that was unsuitably high. Therefore, despite the extensive publication of recommendations that provide additional instructions alongside the specific information on each drug's package label, it is evident that clinicians want more dependable resources to assure accurate renal dosage (Birarra et al., 2022). It is impractical to expect practitioners to memorize the many medicines that need modified dosages, as well as to carefully consider which patients require these modifications and to what extent. To put dosing recommendations into practice, the calculation of the modified dosage and creatinine clearance—which depends on the patient's age, weight, and blood creatinine level—must be automated. Increases in aminotransferase, bilirubin, or albumin levels suggest that the dose of medications that the liver removes from the body should be lowered, even if there is no similar method to calculate hepatic clearance (Hui et al., 2020).

Many drugs need constant titration based on monitoring of blood drug levels or other clinical laboratory markers of their biological effects. These treatments include anticoagulants, anticonvulsants, and endocrine or hormonal medications (such as insulin, thyroxine, and erythropoietin). Apart from the first dosage selection procedure, this is also done. There are now notable variations in testing frequency, appropriateness, and target level achievement, according to Garcia-Cortes et al. (2020).

Computerized data that links drug laboratories allows for the creation of visual flow charts to display test findings and medication dosage. By using statistical process control, a well-established methodology in other sectors, medical practitioners may adopt a more rigorous and evidence-based approach to addressing fluctuations in test outcomes (Zaid et al., 2020). This approach enables doctors and patients to visually represent laboratory findings (such as glucose or anticoagulation tests) in connection to prescription doses over a period of time. These charts

may assist in deciding the appropriate time to adjust medication dosage by assessing whether the fluctuations in levels are random (indicating that the drug dose should not be altered) or really above acceptable limits (requiring a modification) (Berger and Hart, 2020). Statistical process control methods have proven to be more effective than the current hit-and-miss approach used by physicians in achieving target control levels for diabetic patients. Hemoglobin A1c concentration dropped from 10.5% to 7.2% and average fasting blood glucose level dropped significantly from 187 to 110 mg/dL (10.4 to 6.1 mmol/L) in one research (Gonzalo et al., 2022).

- **Monitoring**

The laboratory test result may be enhanced if it had knowledge about the specific medications being used by the patient. For instance, seemingly insignificant liver abnormalities become more significant when a patient is on a hepatotoxic medication (Reutemann and Gordon, 2023). Furthermore, the condition of having low levels of potassium in the blood, known as hypokalemia, has particular significance for a patient who is currently on digoxin medication (Koca et al., 2024). Drug-laboratory linkages need the integration of data on the initiation time and date of a prescription with the ability to analyze and understand variations in laboratory test findings over a period of time. Hence, the prior laboratory findings of patients assume significance in identifying alterations (beyond the scope of normal or abnormal) in laboratory parameters—subtle changes that could otherwise go unnoticed (Miller et al., 2023).

Some medications need initial or regular laboratory testing. Troglitazone was withdrawn off the US market due to its rare (1.9/100) but possibly lethal hepatotoxicity. Initially, the drug's maker and the US Food and Drug Administration contended that troglitazone posed no risk to patients as long as they were adequately monitored (Gale, 2020). Nevertheless, even though the drug's official label included four consecutive and progressively more severe alerts regarding the need for liver test monitoring, a study conducted at an academic hospital revealed that less than 5% of the patients underwent the monthly testing that the Food and Drug Administration emphasized as a prerequisite for the safe utilization of the medication (Park et al., 2022). A recent study found a lack of monitoring for statin cholesterol-lowering medications. For the proper management of drug-related laboratory monitoring, it is essential to have an integrated computerized scheduling and tracking system (Buclin et al., 2020).

Laboratory Interference and Interpretation

Prior research conducted by Hedayati et al. and van Balveren et al., as well as more recent studies, have emphasized the significance of the laboratory being aware of the medications that a patient is using. This knowledge is crucial in order to prevent any misinterpretation of results that may occur when certain drugs interfere with laboratory measurements (Hedayati et al., 2020; van Balveren et al., 2022). A study examining specimens submitted for hormone analysis revealed that 11% of the samples were obtained from individuals who were presently using one or more medicines that may possibly affect the results. Furthermore, around 40% of the patients who underwent TSH testing had similar drug-related issues (Gruson et al., 2022). The Finnish laboratory scientists addressed this significant problem by developing a database that records the medication profiles of their patients. They were able to show that this database greatly enhanced the accuracy of interpreting the test results from their laboratory.61 In other cases, the majority of conflicts between drugs and laboratories remain unnoticed, while other conflicts are not even recognized due to limited study on the intervention of in vitro laboratories or the biological impacts in vivo (Cadamuro and Simundic, 2023). When conflicts are found, we often don't have enough data about how big they are or how important they are for patient care.

It would be easier to do routine laboratory tests, such as figuring out whether to follow up urgently for a glucose level of 300 mg/dL, if we knew if the patient was known to have diabetes and whether they took any medications that decrease blood sugar. Anemia treated in a patient on erythropoietin should be managed differently from a patient on nonsteroidal anti-inflammatory drugs whose hematocrit is dropping. It is crucial for the laboratory to have knowledge of both the specific medications a patient is using and the precise timing of their administration. This information is essential for accurately interpreting drug levels and for ensuring that specimen collection is done at the appropriate times (Aícua-Rapún et al., 2020).

- **Learning and Improvement**

Utilizing robust search algorithms and extensive connected databases, data mining introduces a novel approach to scientific study that has the potential to greatly enhance clinical treatment. The advancements resulting from the Human Genome Project demonstrate the significant potential of what was formerly seen as haphazard data gathering. However, when combined with phenotypic data, it enables the discovery of new information (Powell, 2021). The linkage of laboratory to pharmacy may lead to similar advancements in understanding medication effects and outcomes. Although the connections between a clinical laboratory abnormalities and pharmacological drugs should be regarded as hypotheses for future investigation, these signals may be very beneficial for detecting undesirable medication effects at an earlier stage (Gaspar et al., 2022).

In a practical sense, the connections between labs and pharmacies may evaluate the effectiveness of patient monitoring during the administration of a certain drug, as well as the promptness with which abnormal laboratory results are dealt with. This quality assurance position has identified instances of inappropriate laboratory testing, such as ordering medication levels for patients who are not taking the medicine or are not in a stable condition, as well as unnecessarily repeating these tests without any adjustment in dosage. Additionally, it has been used to record instances when required monitoring was not achieved (Jarernsiripornkul et al., 2024). Patients who were taking antibiotics for conditions that were resistant to them or who were receiving therapy without proper collection of cultures have been identified as a result of inconsistencies between microbiology data and medication prescriptions. The data of pharmacists may be used to identify persons with diabetes who are using hypoglycemic medicines. These records can then be connected to track the renal function of the population and monitor the results of diabetes. Inquiries about a particular medicine, lab test, doctor, or time period (for assessing historical quality trends) may be evaluated if there is proper connectivity between laboratory-pharmacy databases (Tseng et al., 2020).

Current approaches of integrating laboratory and pharmacy

- **Retrospective integration**

Many functions have been performed using retrospective electronic data. Despite the lack of contemporaneous interfacing between independent laboratory and pharmacy systems, it is possible to retroactively integrate this data in order to improve patient treatment and protection. Some hospitals provide reports for patients who are given medications that need to be adjusted for renal function. These hospitals then manually search for the patients' creatinine levels (Zhukova et al., 2024). The drug-laboratory "bridging" role performed by clinical pharmacists has proven very helpful, despite its labor-intensive nature and the need for additional work that might be eliminated with a prospective approach. While retroactive in nature, these reports have been useful in detecting problematic orders and enhancing the quality of treatment (Collin et al., 2022).

Outpatient pharmaceutical data often lack intricate details. Thanks to the availability of software applications such as Microsoft Excel or Access, it is now feasible for any physician, pharmacist, or quality assurance nurse to import data files that have been obtained by IT personnel. Using fundamental sorting, filtering, and query methods, they may establish connections between pharmacy records and laboratory values for a particular patient, enabling the creation of spreadsheets or databases. Matching the two datasets gets simplified when both the laboratory and pharmacy use the same patient identification number. A quality analyst has the ability to identify and mark all records for patients who fulfill certain criteria. They can also generate tables that provide combined laboratory and medicine prescription data in chronological order. The approach we used revealed approximately 500 prescriptions in a span of one year for oral potassium supplements, which accounted for 2.4% of all potassium prescriptions. These prescriptions were specifically written and delivered for patients who already had high levels of potassium in their blood (≥5.3 mEq/L) (Rozenblum et al., 2020).

- **Real-Time Integration**

The implementation of physician order entry systems and the electronic integration of laboratory and pharmacy data provide greater benefits in all 10 conceptual areas, when compared to reflecting on earlier efforts. These advancements also give real-time decision assistance. (Kruse and Ehrbar, 2020). Presenting crucial laboratory data, such as the most recent phenytoin level, when a medicine is prescribed or entered into the computer by a pharmacist, might assist doctors in making more informed choices about prescription dosage adjustments. The computer can determine a suitable dosage by considering the patient's renal function, age, gender, and weight. A research assessing the effects of adjusting medication doses based on renal function in patients admitted to the hospital found that implementing decision support systems resulted in an increase in adequate dosage from 54% before to the intervention to 67% afterwards (Yoon et al., 2022).

Computerized decision assistance has been proven to be especially beneficial in the arena of titrating drugs based on laboratory testing findings. An instance of computerized help that is interactive and aids in administering warfarin has been shown to enhance the duration of time that a patient remains within the therapeutic range (Sennesael et al., 2020). Furthermore, for several drugs that allow for drug level monitoring, these findings may be used to provide recommendations for the appropriate timing for doing another level assessment. By calculating the proper monitoring period, decision support may decrease the number of duplicate levels (Gona et al., 2023). A research revealed that over 80% of antiepileptic medication levels were deemed unsuitable, and a significant number of these cases may have been prevented if real-time alerts had been provided throughout the ordering process (Karajizadeh et al., 2022).

Research has shown that automated warnings may effectively reduce the impact of medication toxicity by limiting the occurrence of adverse drug events and improving the speed at which remedies are implemented to prevent damage. When the computer identifies a crucial laboratory outcome for a patient who is taking a specific medication, it generates alerts for a pharmacist to take action. Alternatively, these results are promptly communicated to healthcare providers electronically through tools like 2-way pagers (Walker et al., 2023).

Research has shown that computerized decision assistance may enhance the probability of implementing proper monitoring. An analysis of "corollary orders" by Kumar et al. revealed that decision support significantly raises the probability of writing laboratory monitoring orders that are recommended. Physicians who received reminders and streamlined ordering screens for laboratory tests linked to medication orders saw increases in adherence rates to tracking

baseline and follow-up platelet counts and activated partial thromboplastin times in heparin-using patients, from 40.2% (control subjects) to 77.4% (Kumar et al., 2020).

Decision support can be critical when a laboratory test contraindicates a certain medication. Angiotensin-converting enzyme inhibitors should not be used in pregnant patients. Nevertheless, the majority of systems fail to detect a positive pregnancy test, particularly when it is conducted by the patient in their own home. In order to ensure the material remains up-to-date, it is necessary to supplement it with basic guidelines (such as the fact that pregnancy does not exceed 10 months and that a woman is no longer pregnant after giving birth) (Manias et al., 2020).

Certain asynchronous circumstances are more difficult to manage electronically. For instance, a high TSH level often signals the need for action (such as raising the dosage of levothyroxine) but typically appears after an outpatient visit rather than during one. The median time delay to respond on key laboratory findings was reduced by 38% as a consequence of the implementation of a single inpatient ordering system that linked drugs and the laboratory (D'Cruz et al., 2020).

Ultimately, the integration of both retrospective and real-time decision support components has been beneficial in ensuring quality supervision and enhancement. Multiple studies have shown that combining drugs with laboratory tests is an effective method for recognizing negative reactions to drugs, both in hospital and outpatient settings. In their study, O'Mahony et al. found that by primarily relying on laboratory signals to detect adverse events, they were able to identify a much higher number of adverse medication events compared to the traditional method of spontaneous reporting. Specifically, they saw an 800% increase in the number of recognized adverse events. Due to its high efficiency in detecting adverse medication events with little effort, this strategy to screening has allowed continuous monitoring, which was previously not feasible, now conceivable (O'Mahony et al., 2020).

Establishing methods that guarantee the proper monitoring of a certain anomaly or signal from the laboratory or pharmacy is crucial for attaining accurate tracking and responsibility. Multiple studies indicate that aberrant findings often do not get prompt or suitable subsequent attention. Linked systems provide both individual provider assessment and systemwide quality supervision by establishing structured intervention processes for cases when doctors fail to follow up (Dunn et al., 2021).

Future challenges

The high expense of creating comprehensive interconnected information systems has hindered advancements in real-time ordering and feedback. A significant number of doctors have shown hesitancy in allocating extra funds and have expressed worries over anticipated increases in time constraints. Even in situations where computerized ordering systems are implemented, the task of creating and managing the knowledge base is difficult, particularly when trying to include more advanced decision assistance. According to a recent study conducted by Hamad and Bah (2022), it was revealed that fewer than 10% of institutions that had implemented commercial order entry systems were using "intelligent" rules that connect information from various systems, such as laboratory and pharmacy.

One significant issue is the absence of established and validated standards for drug-laboratory interactions, which leads to each institution having to start from scratch. Despite vendors promoting bundles of pre-made rules, none of these rules, whether individual or in sets, have

undergone official testing or peer review. The significance of maintenance effort must be emphasized, particularly considering the substantial influx of drugs launched annually. Therefore, a publicly accessible collection of rules that are supported by evidence would be very beneficial.

Pharmacogenomics, the latest rising field in laboratory science, will provide more levels of difficulty and intricacy in the future. Empirical data indicates that certain genetic variations, such as allelic forms of cytochrome P450, might significantly impact individuals' reactivity to warfarin or their susceptibility to experiencing a hypersensitive reaction to phenytoin. This study explores the extent to which laboratory-pharmacy interactions might redefine responses now considered "idiosyncratic" as "preventable errors." Additionally, it aims to advance the development of patient-specific targeting of medication activities (Mardhiani et al., 2023).

CONCLUSION

Although there is a significant amount of literature on "managed care," the efficient management of clinical care for both inpatients and outpatients requires improved integration of clinical laboratory and pharmacy data. There is enough evidence to suggest that current data is not being used to its full potential. However, there are readily available alternatives that may greatly enhance the quality of treatment. With the proved and anticipated advantages for the laboratory, pharmacy, physician, and patient, it is very tempting to make urgent efforts to connect laboratory and pharmacy information, considering the promising advancements in future technology.

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