Hosp Pharm 2013;48(9):744–752

www.hospital-pharmacy.com
doi: 10.1310/hpj4809-744

Original Article

Impact of a Clinical Decision Support System on Pharmacy Clinical Interventions, Documentation Efforts, and Costs

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Abstract

Health care organizations are turning to electronic clinical decision support systems (CDSSs) to increase quality of patient care and promote a safer environment. A CDSS is a promising approach to the aggregation and use of patient data to identify patients who would most benefit from interventions by pharmacy clinicians. However, there are limited published reports describing the impact of CDSS on clinical pharmacy measures. In February 2011, Good Shepherd Medical Center, a 425-bed acute care community hospital in East Texas, implemented a CDSS (*TheraDoc* clinical surveillance system). Prior to CDSS implementation, clinicians struggled with obtaining and documenting the data needed to support clinical initiatives. The value of having both clinical and staff pharmacists utilizing the CDSS has improved communication and knowledge among staff and improved relationships with medical staff, nursing, and case management. The department of pharmacy increased its clinical interventions from an average of 1,986 per month to 4,065 per month; this represents a 105% increase in the number of interventions. The annual estimated cost savings after CDSS implementation is $2,999,508, representing a 96% increase per year and translating into a $1,469,907 annual return on investment.

Key Words—antibiotic stewardship, clinical decision support system, costs, documentation, interventions, pharmacy, surveillance

Hosp Pharm—*2013;48(9):744–752*

The US health care system faces numerous challenges, including the dynamic nature of medical information, clinical practice guidelines, and mandatory reporting requirements interwoven against a background of cost containment. New federal requirements have been put in place for electronic health records, clinical decision support, and critical patient safety issues such as the reduction of health care–associated infections, antibiotic-resistant infectious diseases, and medication errors.

It is difficult to address all these challenges due to the fragmentation of medical information; data are spread across various databases and systems within an organization. The use of electronic medical records, computerized order entry, and electronic decision support has been shown to improve the quality of care within the hospital environment.[1-3] These clinical information systems can be divided into 4 principal subdomains: notes and records, test results, order entry, and decision support.[1] Because these systems are not typically integrated, hospital-based clinicians are unable to efficiently retrieve relevant and timely information that they need to provide quality patient care.

The clinical decision support system (CDSS) systematically integrates patient data from a variety of hospital information sources to assist clinicians in maximizing the benefits of clinical surveillance throughout an organization.[4,5] CDSS provides tools for automated, near real-time surveillance, alerting, analysis, and reporting. Additionally, CDSS integrates evidence-based medicine and clinical guidelines into the delivery of high-quality patient care.[4,5] Research has indicated that the use of a CDSS within a hospital system is associated with fewer patient complications, lower mortality rates, and lower costs.[6]

Improving antibiotic use is a key priority for hospitals nationwide, and antimicrobial stewardship plays

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a critical role in fighting antimicrobial resistance by ensuring appropriate drug selection, dosing, and duration. According to the Centers for Disease Control and Prevention (CDC), almost half of antimicrobial use in hospitals is unnecessary or inappropriate.[7] CDSS integrates electronic medication administration records with medical administration records, allowing hospitals to monitor antimicrobial utilization. This technology has greatly improved the productivity of antimicrobial stewardship programs. Combining available technology with expert knowledge in infectious diseases is necessary to ensure the continued efficacy of current antimicrobial agents.[8] CDSS can enable pharmacists to compare and leverage patient data in near real-time from the different systems within the hospital, for example, pharmacy and microbiology. CDSS provides tools to aid in the timely identification of potential adverse drug events, intravenous (IV) to oral (PO) conversion opportunities, drug-bug mismatches, and discontinuation or de-escalation opportunities.

Although CDSS is a highly promising approach for identifying patients who would most benefit from interventions by pharmacy clinicians, there are few reports comparing clinical pharmacy measures pre and post CDSS implementation. We conducted a comparative analysis to identify the impact of this system on pharmacy clinical interventions, clinical documentation, and costs.

METHODS

Good Shepherd Medical Center (Good Shepherd) is a 425-bed acute care community hospital in East Texas. The pharmacy department uses a decentralized staffing model with 7 pharmacists on site, along with 2 remote pharmacists during the day shift and 2 during the night shift. These pharmacists are decentralized to serve the intensive care unit (ICU), neonatal ICU (NICU), telemetry units, medical/surgery units, central pharmacy, and IV admixture room. Additionally, 2 clinical pharmacists specializing in oncology/critical care and internal medicine address complex clinical questions and perform therapeutic drug monitoring of dangerous, high-risk, and high-cost drugs. These pharmacists fill in staffing roles when needed, attend daily multidisciplinary rounds, and perform hospital committee work.

Prior to implementing a CDSS (*TheraDoc*, Hospira, Lake Forest, IL) in February 2011, Good Shepherd defined institutional business goals relating to the CDSS. These goals included increasing capture and documentation of interventions; determining cost-savings as a result of pharmacist interventions; improving documentation of adverse drug reactions; performing Drug Utilization Review and satisfying The Joint Commission requirements; identifying and evaluating appropriate lab values pertinent to drug therapy; and performing benchmark comparisons between institutions.

Set-up and configuration of the new CDSS required discussions and decisions by the team of pharmacy clinicians and management. For example, they decided which clinical equations to load into the CDSS software. Although the CDSS application gives access to hundreds of alerts, the team chose to begin with just 20 alerts, with the staff pharmacists concentrating on the alerts for IV to PO conversion, renal dosing, and vancomycin greater than 72 hours. These alerts coincided with the clinical duties that the staff pharmacists were already performing. The targeted alerts for the clinical team were aimed at high-cost drugs and organisms that would be especially damaging to patients if left untreated or treated inappropriately. This introduced the team to the new workflow and helped them gain confidence in and accept the system. Once the staff and institution saw positive results with these alerts and had successfully adopted the new technology, more alerts were added.

The individual institution can stratify alerts into 3 tiers based upon the different functionality. Tier 1 alerts are considered "critical alerts" and display a red triangle next to the patient name in a patient search or roster list and in the patient banner. These alerts guide the clinicians to the patients who should be reviewed first in their given patient load. A critical alert may be defined in different ways by an organization; it could be a situation where the pharmacist needs to take immediate action to prevent patient harm or it could be related to key business goals (eg, IV to PO conversion). A Tier 2 alert is a "daily alert review" by function or location; this is less critical, but is still very important. A Tier 3 or "additional alert review" identifies concerns that may be followed less frequently (eg, weekly or as time permits). Good Shepherd defined alerts for staff pharmacists to review each shift and additional targeted alerts for the clinical team to review for monthly reporting purposes during the initial implementation of the CDSS (**Table 1**).

The system was configured to enable alerts to be sent to the pharmacists by e-mail and through the hospital paging system. A documentation and intervention tool that was provided by the CDSS vendor to track and report interventions (*TheraDoc* Intervention Assistant) was additionally utilized. The system provides robust intervention review capabilities and allows pharmacy managers to monitor and report

Table 1. Alerts defined for initial implementation of *TheraDoc* for all pharmacists

Daily alert	Critical alert
IV to PO conversion	Renal function alert
ADR alert	Drug level: Antibiotic level
Targeted drug: pipercillin-tazobactam; doripenem, tigecycline, daptomycin, erythropoietins, glycoprotein IIB/IIIA inhibitors, crotalidae polyvalent immune FAB, linezolid, or vancomycin > 72 hours	Drug level: Phenytoin
TAM: Susceptibility known, inpatient	Targeted organism: *Pseudomonas*, quinolone resistant
TAM: No positive bacterial cultures	Targeted organism: *Staphylococcus aureus*, resistant
TAM: No positive fungal cultures	Targeted organism: *Enterococcus*, vancomycin resistant

Note: ADR = adverse drug response; IV to PO = intravenous to oral; TAM = therapeutic antibiotic monitoring.

interventions by user with customizable time range selection. The system documents the exact intervention, the total number of interventions, total time spent, average time spent, total savings, and average savings. This objective data about interventions can be used in employee evaluations. Documentation of clinical interventions is 1 portion of a 5-tiered annual employee evaluation, with an average of 5 interventions per shift set as standard and an average of 8 interventions per shift set as above standard. One criterion reads, "Ensures safe, appropriate, cost-effective medication therapies for patients according to established policies, procedures, and protocols." Interventions are reviewed to assess whether the pharmacist has achieved some of the other domains of this objective, which are as follows: (1) detects and reports suspected adverse drug reactions and medication errors in a timely manner, (2) assists with pharmacokinetic consult service and drug dosing per organization protocol, (3) provides drug information and clinical consultation and clarification to practitioners, (4) sustains the formulary by utilizing therapeutic substitution protocols, and (5) reviews and interprets culture and susceptibility data for antibiotic appropriateness and recommends changes as needed.

A standard operating procedure (SOP) is being created at Good Shepherd to ensure that all interventions are documented in a consistent and fair manner and to standardize which activities should be documented as an intervention rather than as regular activities of the job. For example, a renal dosing intervention can be entered after screening a patient's profile for medications that need to be adjusted, even if no changes were made. SOP calls for this to be documented as a medication profile review, which is set at 5 minutes and $15 cost savings, versus a dose adjustment by pharmacy, which is set at 15 minutes and $75 cost savings. It is important to review the interventions and maintain the integrity of the data being collected and reported. SOP discourages a pharmacist from documenting a medication profile review intervention during the course of order entry, because this is a normal step of proper order entry procedure. Monthly reviews of the system are conducted at Good Shepherd, and those users with disproportionately few interventions are encouraged to meet the department goals.

Another program offered by the CDSS vendor is the Rounds Assistant that is used by clinical pharmacists. A general pharmacy view was designed and is used as a default so that all pharmacists use the same general pharmacy view. The most important information is identified and included in this view (**Figure 1**).

Prior to the implementation of the CDSS, pharmacists who attended multidisciplinary rounds would perform time-consuming pre-rounding functions, in

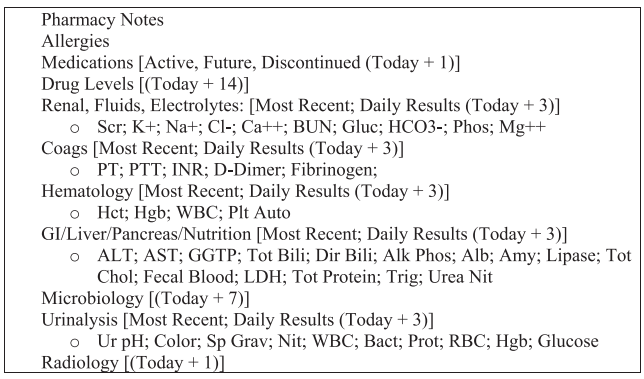

Figure 1. Set-up of rounding view information for pharmacists.

which they would print out patients' medication profiles and lists of patients to follow. On a daily basis, 3 clinical pharmacists meet on each unit with a multidisciplinary care team (MDT) consisting of representatives from social work, case management, dietary, respiratory, nursing, and physical therapy to discuss individual patients in order to optimize their care and expedite discharge. Prior to the introduction of computer-based services into the MDT, a paper-based record system was used to provide case summaries and to document the team's discussion and decisions. These records contained free (unstructured) text rather than coded and structured data. The process of recording discussions in an unstructured form (ie, free-text clinical notes, scanned documents, pdfs) hindered accurate measurement of the MDT performance, as computer-based data analysis and auditing tools cannot be used on unstructured data.[9] There are a number of challenges that the MDT faces in utilizing the CDSS. These include:

1. Ensuring and documenting adherence with standards (eg, evidence-based guidelines),
2. Identifying patients who are eligible for recruitment into clinical trials,
3. Ensuring the consistent collection of crucial data, such as disease staging and outcomes,
4. Establishing robust mechanisms for prospective assessment of MDT performance,
5. Ensuring MDT recommendations are followed in practice,
6. Achieving the right balance of educational and care delivery objectives of this forum,
7. Establishing reliable interfaces with primary care to ensure continuity of care.

With the implementation of the CDSS, pharmacists use tablet computers on rounds. They can access the patients' profiles, identify and act on any drug-related problems, and document interventions (**Figure 2**). Pharmacists can screen patients for opportunities for IV to PO conversions, renal dosing, antibiotic streamlining, and any drug-related problems. While on the units, pharmacists can review the alerts that may have fired for patients and determine whether to leave a note on the patients' chart or call the physician. The use of tablet computers during rounds offers pharmacists the mobile platform to document interventions in real-time. This increases the probability of capturing more interventions than the practice of taking quick notes and then trying to find time to sit down and enter them after all other duties have been performed.

Clinical activities: Consultation
○ Pharmacokinetic consult
○ Major drug information consult
○ Minor drug information consult
○ Medication teaching/ discharge education
○ Antiemetic therapy consult
○ Pain consult
○ Peripheral parenteral nutrition (PPN)
○ Total peripheral nutrition (TPN)
Clinical activities: Therapeutic drug monitoring
○ Discontinuation of drug/order with no indication
○ Dose adjustment by pharmacist
○ TPN follow-up
○ Warfarin follow-up
Clinical activities: IV to PO conversion
○ Azithromycin IV to PO
○ *Bactrim* IV to PO
○ Clindamycin IV to PO
○ Doxycycline IV to PO
○ Famotidine IV to PO
○ Fluconazole IV to PO
○ Levetiracetam IV to PO
○ Levofloxacin/Ciprofloxacin IV to PO
○ Levothyroxine IV to PO
○ Metoclopramide IV to PO
○ Metronidazole IV to PO
○ Pantoprazole IV to PO
○ *Zyvox* IV to PO
Clinical activities: Pharmacist-initiated therapy
○ Adherence standards/ pathways/ guidelines/ protocols
○ Antibiotic streamlining
○ Anticoagulation monitoring
○ Deep vein thrombosis (DVT) prophylaxis
○ MAR reconciliation
○ Medication history/review
○ Heparin per weight-based protocol
○ Medication reconciliation – general ADE prevented
○ Medication reconciliation – major ADE prevented
○ Medication reconciliation – minor ADE prevented
○ New therapy recommendation/untreated indication
○ Nicotine protocol
○ Patient care rounds
○ Reorder home medications (major)
○ Reorder home medications (minor)
○ Stress ulcer prophylaxis
○ Therapeutic interchange
○ Vaccination recommendation/ administered
○ Warfarin dosing by pharmacist
Clinical activities: ADE prevention
○ Major ADE prevention
○ Minor ADE prevention
○ IV incompatibility (same as IV drug compatibility)
○ Drug interaction
○ Clarify drug order (same as clarification of incomplete order)
○ ADE inquiry and reporting
○ Medication error inquiry reporting
Clinical activities: Administrative duties
○ Committee/ team time and preparation
○ Policy/ procedure/ order set development/ revision
○ Medication use evaluation (MUE) participation
○ Miscellaneous activity
Clinical activities: Avoid inappropriate therapy
○ Discontinue erythropoietin (HgB > 10 in non-HD patient)
○ Discontinue *Lupron Depot* 7.5 mg
○ Discontinue *Natrecor* > 48 h
○ Discontinue *Neulasta* 6 mg

Figure 2. Clinical decision support system daily clinical activities worksheet.

The use of CDSS provides an instant review of the susceptibilities of various bacteria to antibiotics in an antibiogram, which can be utilized to identify resistance problems. Prior to the availability of on-line electronic documentation, the compilation and documentation of antibiogram data was a cumbersome process and required approximately 7 to 14 days to complete. This workload was the responsibility of the clinical staff, including the microbiology technician, clinical pharmacist, and clinical pharmacy director. The microbiology technician downloaded the culture and sensitivity (C&S) report from the prior year into a worksheet, including information about total isolates tested, total patients per isolate, percent of isolates susceptible, and resistance. All the isolates were reported for both blood and urine. CDSS implementation allowed simple and easy antibiograms to be created in less than an hour for the entire institution or any floor within the institution.

Once resistance patterns have been identified, empiric therapy guidelines specific to the institution can be developed for various disease states. Information derived from the antibiogram can also justify the development of antibiotic restrictions. By running a quick antibiogram, the clinician can ascertain which susceptibilities are highest and choose an empiric treatment regimen that may result in improving patient outcomes by improving time to appropriate therapy.[10]

One example of this is the development of a community-acquired pneumonia (CAP) order set. By reviewing data from the institution's antibiogram, the clinical pharmacist can identify preferred antibiotic regimens for both non-ICU and ICU patients admitted to the hospital with CAP. A majority of CAP infections result from *Streptococcus pneumoniae, Haemophilus influenza, Moraxella catarrhalis,* and sometimes *Escherichia coli* bacteremia from another source.[11] The clinical pharmacy team performed an antibiogram that targeted those specific organisms and specific formulary drugs that serve as accepted empiric regimens for non-ICU patients (beta-lactam + macrolide) versus an antipseudomonal quinolone. The targeted antibiogram led to the team's decision to make ceftriaxone plus azithromycin the preferred regimen versus levofloxacin alone. This recommendation was based on the increasing evidence in the literature that overuse of quinolones promotes resistance and that *E. coli* susceptibility to levofloxacin is relatively low at 75% compared to ceftriaxone at 97%.

The CDSS targeted therapeutic antimicrobial monitoring alerts are useful for identifying bug-drug mismatches and positive cultures with no antibiotic orders on the patients' profile. Pharmacists are asked to keep track of culture results and days of therapy of antibiotics for the patients on their units to determine when to intervene for de-escalation and discontinuation of antibiotics. Dose optimization and IV to PO conversion play a large role in stewardship efforts. To ensure that patients are on the proper dose to optimally treat an infection, the dosage of some antibiotics may need to be increased. The renal dosing protocol allows pharmacists to automatically adjust medications, including certain antibiotics, to avoid adverse effects in patients with fluctuations in renal function.

The concept of trigger tools consists of identifying abnormal lab values or dispensing rescue type medications to ascertain a possible adverse drug event (ADE). For approximately 6 months prior to the implementation of the CDSS system, 2 to 3 pharmacists, a representative from the quality department, and a representative from the risk management department met and manually performed a double review of charts of discharged patients for these triggers using Institute for Healthcare Improvement Global Trigger Tool methodology. This review was performed every other week, on 50 charts per month, and took approximately 1 to 1.5 hours. ADEs were very rarely found during these chart review sessions. A better way to target this search for ADEs was found through the trigger tools alert. Investigation of ADEs was targeted and hours of high dollar personnel time was freed up by giving this function to one clinical pharmacist. Lab values in the trigger tool alert function may include the identification of abnormalities such as neutropenia, hypoglycemia, elevated international normalized ratio, elevated activated partial thromboplastin time, or elevated serum drug levels. The use of CDSS to identify these triggers and efficiently compile data in a simplistic and straightforward fashion makes this program invaluable to the pharmacist when attempting to identify trends of drug-related problems with a certain class of drug or in a particular unit of the hospital.

The CDSS software has been used to build alerts for a variety of hospital programs to identify a subset of the hospital's patient population. One example is the diabetes alert, which was built for the diabetes educator. This alert searches for patients who have lab results for hemoglobin A1C, blood glucose greater than 300 mg/dL, or an admit diagnosis of hypoglycemia, hyperglycemia, diabetic ketoacidosis, or hyperglycemic hyperosmolar state. This alert identifies newly diagnosed diabetics and patients who are undiagnosed by targeting blood glucose readings. The clinician can follow-up with the appropriate education or a diagnostic

test recommendation to facilitate improved care of these patients.

An alert for drug reimbursement has been built at Good Shepherd to identify all patients who have been placed on a particular medication for which the drug recovery specialist can seek reimbursement, such as amphotericin B, daptomycin, or micafungin. Patients who may benefit from being placed on standard hospital protocols to ensure proper monitoring and treatment are also identified. For instance, some patients in the hospital would develop delirium tremens because their alcohol use was addressed with a onetime order for thiamine and folic acid and an "as needed" benzodiazepine order. The clinical pharmacy team developed an "alcohol withdrawal alert" that identifies patients who have been prescribed a benzodiazepine, thiamine, or folic acid; who have had any ethanol/alcohol blood level results; or who have an admit diagnosis that includes the terms "alcohol" or "intoxication." A recommendation could be made to the physician that such patients be placed on the Alcohol Withdrawal Protocol. These types of alerts can be tailored to suit numerous situations, depending on the target at the time. Alerts can be altered or deactivated when no longer needed.

RESULTS

Clinical interventions that were made through the use of the CDSS had a very high acceptance rate. For example, in March 2012, there were a total of 4,184 interventions made by pharmacists. Of those, 4,172 were accepted by physicians, and only 12 were denied. For intervention reporting, interventions can be included with the general intervention status of (1) any, (2) undetermined, (3) accepted, (4) canceled, (5) accepted modified, or (6) rejected and the follow-up status of (1) any, (2) pending, or (3) complete. The pharmacy department used the intervention reporting structure of completed and accepted, accepted modified, or rejected. Interventions that were ignored or not acted upon before the patient was discharged were not counted, as only those interventions that were reported as completed were captured. **Figure 3** breaks down the interventions by clinical category.

The average number of documented accepted interventions by the clinical pharmacy staff increased from 1,986 per month pre CDSS (February 1, 2010, through January 31, 2011) to 4,065 per month post CDSS (February 1, 2012, through January 31, 2013); this represents a 105% increase in the number of interventions per year.

Prior to implementing CDSS, cost savings were routinely documented as a result of the clinical pharmacy program by using intervention categories and predetermined cost savings per time and intervention. We used values of time and cost saving from our previous system (*Quantifi*) to maintain continuity during the system change. These numbers are derived from

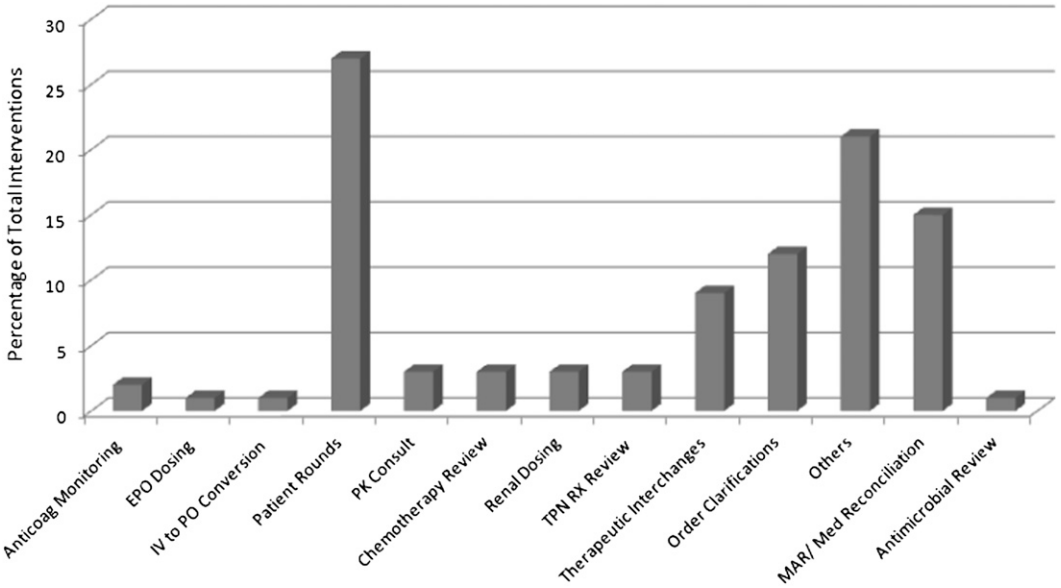

Figure 3. Clinical intervention breakdown. Anticoag = anticoagulation; EPO = *Epogen*; IV to PO = intravenous to oral; PK = pharmacokinetic; TPN RX = total parenteral nutrition prescription; MAR = medication administration record.

Table 2. Examples of intervention categories with time (minutes) and estimated cost savings (dollars)

Intervention	Description of intervention	Time	Cost
Pharmacokinetic consult	Initiating therapy per protocol or recommending therapy for drugs such as aminoglycosides, vancomycin, digoxin, etc. May include additional entries for follow-up when dose adjustments or labs above routine are required.	30	$300
Dose adjustment by pharmacy	A dose adjustment made by pharmacy based on patient-specific evaluation of clearance, such as renal or hepatic function. The reason for the dose change is to improve efficacy and/or to avoid toxicity. May be a recommendation for dose adjustment or a protocol-driven adjustment per pharmacy. Requires gathering and evaluating patient-specific clinical information. There may be multiple dose adjustments throughout a patient's stay, so this category may be used more than once per patient. Examples: acyclovir, allopurinol, ampicillin, ampicillin/sulbactam, cefazolin, cefepime, cefoxitin, ceftazadime, digoxin, dofetilide, enoxaparin, fluconazole, levofloxacin, meperidine, meropenem, metformin, metronidazole, nitroprusside, piperacillin/tazobactam, procainamide, propoxyphene, quinidine (same as renal dose evaluation/ change, subtherapeutic dose of frequency, supratherapeutic dose or frequency, and therapeutic recommendation more appropriate for drug or disease state)	15	$75
Medication reconciliation – general	When a pharmacist participates in the reconciliation process (admission, transfer, or discharge) and completes the appropriate reconciliation documents. May involve speaking with the nurse and/or physician. This field allows pharmacist to document a general medication reconciliation. No medication errors or adverse drug events (ADEs) noted during the process. The focus is on ensuring appropriate continuity of care, prevention of omitted medications, and addressing any unmet needs of the patient. Pharmacist may document actual medication errors and ADEs prevented in the other medication reconciliation categories in addition to this category.	20	$50
Medication reconciliation– major ADE prevented	When a pharmacist prevents a major medication error or ADE due to participation in the medication reconciliation process (admission, transfer, or discharge). May involve calling home pharmacy or outside physician office and speaking with the inpatient nurse and/or physician.	30	$100
Medication reconciliation– minor ADE prevented	When a pharmacist prevents a minor medication error or ADE due to participation in the medication reconciliation process (admission, transfer, or discharge). May involve calling home pharmacy, outside physician office, along with speaking with the inpatient nurse and/or physician.	15	$100
Therapeutic interchanges	Therapeutic interchanges: review and implementation	15	$15
Clarify drug order (Same as clarification of incomplete order)	To be used when patient is interviewed and/or the chart is reviewed to clarify allergy reactions, dosage clarifications, abbreviation clarifications, etc. Examples: You receive an order for *Percocet*, and an allergy alert to oxycodone appears. You clarify with the patient that the "allergy" is only an upset stomach. Physician orders all home meds to be restarted on the same doses; you clarify with the patient/family/pharmacy what the medications and doses were at home and write the clarification. An order for *Flovent* is missing the strength, so you clarify the strength with the patient and physician.	10	$50

(continued)

Table 2. Examples of intervention categories with time (minutes) and estimated cost savings (dollars) (CONT.)

Intervention	Description of intervention	Time	Cost
Code participation	To be used for active participation in a code blue. This applies to neonatal codes as well.	25	$100
Chemotherapy order review	To be used whenever a chemotherapy order is received and reviewed for protocol, accuracy of doses, organ dysfunction, body surface area calculation, hydration, lifetime doses, etc. Additional categories should be utilized when interventions are made and antiemetics ordered as a result of this review.	20	$75
Identification of patients' own medication		15	$20

an intervention cost calculation model supported by previously published pharmacy intervention literature. The model contains variables and assumptions that include interventions that make the medication use more efficient, promote safety, and promote cost-effective care. We adjusted interventions related to direct drug costs such as IV to PO conversion or discontinuation of inappropriate therapy based on our actual drug costs. Currently, 77 intervention categories have calculated cost savings amounts. Examples are presented in **Table 2**.

The total cost savings are calculated on a monthly basis by adding all the completed and accepted interventions that month and tabulating the associated cost savings. These are tracked and compiled, and 12-month averages and projections are made for the pre-CDSS study period and the post-CDSS study period.

Cost savings related to pharmacist interventions increased from an average of $127,467 per month pre CDSS (February 1, 2010, through January 31, 2011) to $249,959 per month post CDSS (February 1, 2012, through January 31, 2013); this represents a 96% increase in cost savings per year. There was a $1,469,907 annual return on investment, which was calculated by subtracting the average monthly pre-CDSS intervention cost savings from the average monthly post-CDSS intervention cost savings.

DISCUSSION

Eighteen months prior to implementing CDSS and restructuring the clinical program at Good Shepherd, staff struggled with obtaining and documenting the data they needed to support clinical initiatives. Due to the ease of use of the software, new hires and pharmacy graduates were able to actively participate in the clinical program within their first few months on staff. The department of pharmacy increased its clinical interventions from an average 1,986 per month to 4,065 per month, representing a 105% increase in the number of interventions per month. The annual estimated cost savings of $2,999,508 post CDSS represents a 96% increase in cost savings per year and translates into a $1,469,907 annual return on investment.

There are several limitations to this study. We did not calculate or estimate all of the associated costs with the implementation of the new software as an expense against our reported savings. We could have attempted to quantify actual labor cost savings associated with the workflow optimization strategies described in the article. We chose to look at pre- and post-CDSS intervention savings only; we collected these data on a monthly basis. We did not collect the data needed to calculate implementation cost (ie, hours of set up meetings, staff training, alert building).

The hospital has made several changes that have allowed the pharmacy department to increase clinical interventions. The hospital started a medical residency program in July 2011, and began daily multidisciplinary rounds on all units in January 2012. The pharmacy department has been involved in the initiatives of the hospital to provide excellent patient care and ensure evidence-based clinical practice. The increase in the number of interventions is reflective of the time saved through workflow optimization with the CDSS. The documentation of clinical interventions by pharmacists demonstrated value and resulted in the approval and hiring of 2 additional full-time clinical pharmacists; funds have been budgeted for tablet computers for pharmacists to use with CDSS on daily multidisciplinary rounds. One of the new pharmacist positions specializes in medication safety, which satisfies The Joint Commission requirement for hospitals to designate an individual to carry out the safety responsibilities.[12] This individual is responsible for creating reliable team interactions, ensuring reliably designed processes, and promoting the value of a just culture.

CONCLUSION

Health care organizations and providers face many challenges associated with the delivery of quality medical care. Clinical information technologies, such as electronic medical records, computerized order entry, and electronic decision support, can improve the quality of care within the hospital environment. These systems integrate patient data from a variety of hospital information sources and offer tools for automated, near real-time surveillance, alerting, analysis, and reporting. At Good Shepherd Medical Center, the CDSS positively impacted pharmacy clinical interventions, clinical documentation, and costs.

ACKNOWLEDGMENTS

Conflict of interest: The authors report that they received no payment or financial support for this study. **Additional contributions:** The authors wish to acknowledge Anne Gentry, PharmD, for her assistance with manuscript preparation.

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