Seton Family of Hospitals

February 18, 2014

Allison Benz,
Director of Professional Services
Texas State Board of Pharmacy
William P. Hobby Building, Suite 3-600
333 Guadalupe Street
Austin, Texas 78701

RE: Petition for Approval to waive a rule

Dear Allison Benz:

The following regulation: TAC 291.72 states that in a Class C pharmacy in a facility with 100 beds or less, a pharmacist licensed in Texas may electronically supervise pharmacy technicians or pharmacy technician trainees to perform the duties specified in §291.73(e)(2) of this title provided that certain criteria stated in the regulations are met.

Project Manager:

Patrick D. Garrett R.Ph.
TSBP License # 18356
601 E. 15th Street
Austin, TX 78701
Phone: 512 324-7365

Pharmacies include:

- Seton Medical Center Austin; 1201 W. 38th Street; Austin, TX 78705 License# 1284
- Seton Medical Center Hays; 6001 Kyle Parkway; Kyle, TX 78640 License# 26504
- Seton Medical Center Williamson; 201 Seton Parkway; Round Rock, TX 78665 License # 25815
- Seton Northwest Hospital; 11113 Research; Austin, TX 78759 License # 12826

Seton Northwest Hospital is a 124 bed hospital located in Austin; Seton Medical Center Williamson is a 135 bed hospital located in Round Rock; and Seton Medical Center Hayes is a 112 bed hospital located in Kyle. All are owned by the Seton Healthcare Family, a not-for-profit organization that is the leading provider of healthcare services in Central Texas. These hospitals, even though licensed for more than 100 beds, each have an average daily census less than 100 beds (ranging from 47 – 93).

Services provided at these hospitals include:

- Emergency Services
- Maternity
- Neo-natal Intensive Care Nursery
- Surgery
- Cardiovascular
- Imaging
- Rehabilitation

The pharmacies at these hospitals are currently open 24 hours per day. Pharmacists enter medication orders in to the hospital computer system. Medications are dispensed from the hospital pharmacy with a pharmacist on duty to supervise dispensing, or obtained by nursing from an automated dispensing cabinet.

The shortage of pharmacists and budget constraints make it not feasible to have a pharmacist on-site 24 hours per day in a small hospital. We would like to have a registered pharmacy technician staff in each hospital pharmacy from 2300 – 0700 Monday through Friday, and 2000 - 0800 on weekends and holidays. We would use the current telepharmacy regulations to remotely monitor and supervise the pharmacy technician's work electronically including the supervision of sterile and non-sterile product preparation and dispensing. This would provide better patient care while enhancing patient safety by shortening pharmacy process time and providing 100% oversight of all parts of the pharmacy tech's process. The pharmacy technician would process the orders that have been remotely entered into the pharmacy computer system by a pharmacist at Seton Medical Center Austin. Digital in process images will be transmitted to the pharmacist for documented approval or rejection. The pharmacy tech and pharmacist would follow all the current Texas State Board of Pharmacy Rules that allow for electronic supervision of pharmacy technicians in a Class C pharmacy in a facility licensed for 100 beds or less.

We would like to implement this process by April 1st, 2014 and continue it for a period not less than 18 months.

The Current Rule: 291.72 (44) Supervision (B) Electronic Supervision:

In a Class C pharmacy in a facility with 100 beds or less, a pharmacist licensed in Texas may electronically supervise pharmacy technicians or pharmacy technician trainees to perform the duties specified in 291.73(e)(2) of this title (relating to Personnel) provided:
(i) the pharmacy uses a system that monitors the data entry of medication orders and the filling of such orders by an electronic method that shall include the use of one or more the following types of technology:

(I) digital interactive video, audio, or data transmission;

(ii) the pharmacy establishes controls to protect the privacy and security of confidential records;

(iii) the pharmacist responsible for the duties performed by a pharmacy technician or pharmacy technician trainee verifies:

(I) the data entry; and

(II) the accuracy of the filled orders prior to release of the order; and

(iv) the pharmacy keeps permanent digital records of duties electronically supervised and data transmissions associated with electronically supervised duties for a period of two years.

References: Please see six enclosures

In order to accomplish this, we request a waiver from the 100 beds or less requirement for electronic supervision of pharmacy technicians for Seton Northwest Hospital, Seton Medical Center Williamson and Seton Medical Center Hayes so a pharmacist at Seton Medical Center Austin can electronically supervise the work of the remote pharmacy techs.

We ask that this request be placed on the agenda for the next Quarterly Business Meeting so that we can discuss any questions that the board members may have and that we can provide any additional information needed for the Board to grant this waver.

Sincerely,

Shewan Aziz, R.Ph., Ph.D., BCOP
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Current State of IV Workflow Systems and IV Robotics

Section of PHARMACY INFORMATICS AND TECHNOLOGY

Prepared by AHSP Section of
Pharmacy Informatics and Technology, Section Advisory Group on Pharmacy Operations Automation

Questions or comments about this document can be directed to Sections@ashp.org.

This document contains the following sections:

Introduction

Despite the fact that errors in intravenous (IV) compounding are among the most likely pharmacy errors to cause patient harm, the typical pharmacy IV room remains one of the last places to be touched by advances in pharmacy automation. However, new IV automation technologies promise to change this. This white paper outlines technologies currently available, offers a list of key questions to consider when evaluating IV automation for your institution, and summarizes early implementation experiences. Please note, TPN compounders are outside the scope of this white paper.

Overview of Available Technologies

Two primary types of automation technologies exist within the IV room: IV robotics and IV room workflow systems. When compared with the traditional method of IV compounding, these technologies offer additional safeguards and advantages that result in decreased errors, decreased waste, operational efficiency, a retrievable electronic audit trail, and even increased employee safety through reduced exposure to hazardous materials.

IV robotic systems are able to compound a combination of IV syringes and/or IV bags depending on the system. In many cases, IV syringes can be compounded in sizes ranging from 0.5 ml to 60 ml. Faster fill rates of up to 600 doses per hour can be achieved if volumes are relatively small (<12ml) and a single syringe size is used. Utilizing a wider range of volumes and syringes will dramatically decrease throughput rates. A broad range of sizes are also possible for IV bags with output ranging from 25-1000 ml per bag and a rate of up 50-60 doses per hour. Production of IV products in an IV robotic system is initiated with validation of stock items through a combination of either gravimetric or volumetric measurement and barcode verification. Following verification, stock items are disinfected and transferred to an IV bag or syringe based on order information collected from the native pharmacy computer system through either an HL7 interface or a print stream interface. Depending on the system, compounded doses are then verified through gravimetric measurement before a final barcoded label is applied to the completed dose for final verification and delivery. With some systems, hazardous materials (e.g. chemotherapy) can be compounded in the IV robotic system thus reducing exposure and subsequently improving employee safety.

IV room workflow systems can be used to compound anything from high-risk, high-cost medications to single-drug antibiotics and even oral medications. IV room workflow systems follow a similar process as described in the previous robotics example but manual steps replace automated steps that were completed by the robot. As orders transfer across from the pharmacy system, they populate into a workflow queue allowing the technician to group and prioritize doses to process. As the technician proceeds with compounding each dose, a compounding label is generated, products are verified via either barcode scan or a gravimetric check, and images are captured of all relevant steps in the compounding process. When doses are ready to be verified, a pharmacist accesses the system reviewing each step the technician took to prepare the product and verifying the images associated with each dose for accuracy. The pharmacist is able to complete this verification process remotely from any workstation with access to the IV workflow system. As doses are verified as correct, a single barcode label is produced and applied to that dose indicating the dose is ready for delivery. Verified doses then can be scanned during subsequent steps of the delivery process which then creates an audit trail and allows pharmacy staff to view status and/or location of the dose during the compounding and delivery processes.

Evaluating IV Workflow Systems and IV Robotics

A detailed comparison of available systems (IV robotics or IV workflow) is a critical first step when these technologies are being considered. While many will share common functionality, the implementation details and vendor approach to sterile compounding operations can vary widely. This comparison can help narrow the list of systems that will potentially satisfy an institution's needs. Examples of comparison points are listed in table 1.

Table 1. Points to consider when evaluating IV workflow systems and IV robotics

Technology Assessment	Institution Needs
Size and special requirements	Training requirements
Interface requirements	Staff needs to operate
Workflows supported	Operating costs
Manufacturer support	Space renovation Need
Production mode (batch vs. patient specific)	Downtime requirements
	Law and quality requirements
	State vs. federal laws
	Accreditation/licensure bodies
	Supply needs
	Database maintenance

Besides comparing different systems on the market to identify which will serve the institution's needs, justifying the addition of these technologies is the next step for many institutions. Cost savings, quality improvements, and patient-safety advancements are examples early adopter institutions have utilized in their justifications. Specific patient-safety advantages that have been reported are positive identification of products through barcode technology (both), elimination of contamination sources (IV robotics), and increased accuracy in preparing pediatric patient specific doses (both).

Key Questions to Consider

The following sections suggest key questions in several categories that pharmacy leadership should consider and answer. This careful evaluation and planning will help determine the best path to improving the quality and safety of intravenous product preparation. These categories include:

- Workflow impact
- Financial impact
- Project management requirements
- Vendor assessment and service level agreements
- Requirements for new quality control measures
- Integration and interoperability with existing information systems and technology

Workflow Impact

The impact of IV preparation automation on workflow is generally anticipated to have a positive impact by increasing productivity and assuring accuracy during routine preparation of medications. To have the best impact on workflow, new IV preparation automation technology should be easy to learn and manage. Key workflow questions

include:

- How will automation of IV preparation change current processes?
- What is the new workflow?
- Does the new workflow make the process lean or add extra steps?
- How does the new technology impact the time to perform the task?
- Will there be a need to adjust other preparation or distribution workflows to enable incorporation of the new technology into daily, weekly or off-shift use?
- Does the new workflow require an increase or decrease in number of technician and/or pharmacist staff during automation operations?
- Will the pharmacy department be able to repurpose staff assignments as result of implementation of the new technology?

A key point regarding workflow assessment is to consider the entire process. Some steps in the process might take more time, but reduce wasted time at other points in the process. Defining the workflow analysis too narrowly (i.e. only focusing on technician compounding time) may produce misleading results.

Financial Impact

Pharmacy department leaders must manage their financial resources with skill and assist in meeting the decisions of their institutions. The cost of IV preparation automation and other new technologies to improve medication safety and productivity must be evaluated with the organization's financial goals, along with objectives and other strategic plans in mind. Key financial questions include:

- What is the return on investment?
- What are the annual costs to maintain?
- What are the supply costs associated with the automation?
- What infrastructure, set-up and operating costs will be incurred?
- Will the volume of currently outsourced manufactured products be able to be reduced because the cost reduction associated with the new technology is significant?
- Are there other products that may be considered to be prepared by the new technology for additional future savings?
- Will new staff compensation levels be required for increased skill sets?
- What are the construction and/or remodeling costs associated with the installation of the technology? Will new heating/ventilation/air conditioning (HVAC) or electrical modifications be required?
- What will be associated costs (upgrades, product improvements, etc.), if any?

Project Management

Successful implementation of IV preparation automation is the result of contributions of the right department staff with the right combination of skills, coordination of many tasks, and requires sufficient resources to meet goals. Key questions related to project management include:

- How long will the project development, testing and implementation take?
- What has been learned from early adopters of IV automation?
- How can these lessons be applied to current automation project?
- What criteria will be used to determined staff participation in the project and eventual users of the new technology?
- How will you approach change management for your staff?

- Will a temporary staffing increase be necessary?
- How long might it take to reach a 'new normal' with the new system?
- What level of project support will be provided by the vendor?
- Does the vendor provide sample policies, procedures, or quality assurance best practices?
- Will there be necessary training to any users outside pharmacy?
- Is on-site training offered and what does it entail? Evening and Night shifts?
- Who is in charge of making the final decisions (director vs. administration, etc.)?

Vendor assessment and service level agreements

Implementation of new technologies like robotic IV preparation or workflow management tools requires a successful engagement with the technology vendor. The pharmacy department and institution will need to set realistic, appropriate vendor performance expectations and establish operational responsibilities to implement the technology. Key vendor assessment and service level agreement related questions include:

Based on the department's experience or experience from other institutions, how good of an implementation partner is the vendor? ☐Who will maintain the productive operation of the automation – vendor, pharmacy department, biomedical department? ☐What is expected from the vendor over the next three years regarding product improvements, updates, upgrades or new features? ☐What is the experience of vendor staff providing customer support? Is there a problem triage process in place at the vendor's customer support?

What are the hours of customer support?

What level of customer support will be agreed on?

What level of automation repair and replacement will be available from the vendor? What will

the expected turn-around time for technology equipment replacement?

What will be the role of the pharmacy department or the institution in repair and replacement

of the automation?

What will be agreements associated with level of automation productivity?

What will be considered extraordinary downtime or significant automation failure requiring

financial penalty or rebates from the vendor?

How much involvement will be needed by the institution's IT department?

Quality Control Measures

Introducing new IV preparation technology will require new quality control processes and measures to assure the accuracy and safety of the products being distributed to patients. Validation of robot operation and end product testing requires new training for technical staff and integration into the staff's daily or weekly workflows. Key questions for new quality assessments programs include:

☐s there any evidence-based data supporting the use of the new technology?
☐What regulatory or quality standards can be addressed by implementing the new technology?
☐What new quality assurance procedures will be required to monitor accuracy of the new technology? How often will quality control measure be required – daily, weekly, monthly, etc.?

- ☐ Will new methods and/or equipment be required to assess accuracy, e.g., spectroscopy, refractometry?
- ☐ What record keeping will be required to meet regulations associated with implementing the new technology?

☐ Will stability and sterility testing be necessary to meet USP 797 requirements?

☐ Does new technology impede/enhance the ability to maintain USP 797 compliance?

☐ What additional process and procedural assessments or validations will be required because of new technology use?

☐ What is the automated system's reporting capabilities on performance?

Integration and Interoperability

Introduction of any new technology that includes use of information systems usually requires new levels of integration and interoperability between systems, while hoping to maintain flexibility in practice and workflows. Key questions in IV workflow systems allow for standardization and automation of the IV preparation by technicians. The systems create a work queue that produces a priority list controlled by either the pharmacist or technician. The standardization of this automation prevents technicians from falling into bad habits, i.e. preparing multiple doses at the same time. This technology also gives pharmacists the advantage of remote verification of products, preventing them from being confined to the sterile preparation areas. Other advantages of these systems include a status board that indicates where each dose is in the preparation process, returned-dose scanning which alerts technicians when there is a dose with appropriate expiration dating that can be re-used for a new dose, and extensive reporting capabilities.

- ☐ How does the new system handle user login information? Can it use current active pharmacy authorization accounts, or is separate system independent login required? ☐ What new information system enhancements will be required, e.g., interfaces to practitioner order entry or pharmacy information systems? ☐ What will be the expected level of institution involvement in interface development? What will be the vendors interface development responsibility? ☐ Does the new technology interface/integrate with current EHR systems?

Early Implementation Experiences

As institutions gain experience with IV robotics they have reported issues surrounding the use of such technologies. Examples from University Health-System Consortium (UHC) include volume left in tubing, label appearance differing from other production labels, volumes have greater accuracy than previous human production, and lack of supplies that comply with protect from light standards. One institution reported that there was extensive database build prior to implementation and recommended institutions consider this when planning the implementation timeline. This same institution experienced issues with the robot puncturing pieces of the vial stopper into the solution due to multiple needle insertions into the same site. Remedies for this issue include switching product manufacturers and utilizing different needle types in the robot.

A challenge with implementing IV workflow technology has been staff push back and resistance to change. One institution observed this when they implemented an IV workflow system. Just because a project has obvious patient-safety improvements and/or workflow efficiency improvements doesn't mean staff will be in support immediately. Working with the frontline staff and gaining their trust before implementation is vital to the success of the new automation. There will be challenges but if you have your frontline staff support those challenges can be easier to work through.

Conclusion

IV robotics and workflow systems offer long awaited solutions to enhance patient safety sterile products compounding. As with all new technologies, institutions must carefully assess the impact of these systems and plan for the substantial change management efforts associated with their implementation.

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Acknowledgements

Special thanks to the Section Advisory Group members who completed this document:

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CASE STUDY

Impact of telepharmacy in a multihospital health system

JAMES C. GARRELTS, MARK GAGNON, CHARLES EISENBERG, JANELL MOERER, AND JOE CARRITHERS

Purpose. The impact of telepharmacy in a multihospital health system was evaluated.

Summary. Telepharmacy services were implemented at five hospitals within a Catholic, nonprofit, integrated delivery network health system. Telepharmacy services were provided by seven pharmacists employed by the health system. Using a virtual private network or terminal server, pharmacists directly accessed hospital servers and information systems to conduct their work. Telephone calls were automatically routed to the telepharmacist so that handling of nursing and other calls would be transparent to staff. Hours of telepharmacy service were 5 p.m. to 2 a.m. Monday through Friday evenings at four of the hospitals and 8 p.m. to 10 p.m. at the rural hospital. Order-processing time for routine orders was reduced from 26.8 to 14 minutes ($p < 0.0001$), while stat order processing was shortened from 11.6 to 8.8 minutes ($p = 0.007$). For routine orders, turnaround times greater than 60 minutes became almost nonexistent after telepharmacy services were implemented. The number of clinical interventions documented increased by 42%, from 619 to 881, equivalent to a net annualized saving of $1,132,144. A significant improvement in nurses' global satisfaction with pharmacist availability for unit consultations was reported (3.0 versus 4.0 on a 5.0 Likert scale; $p = 0.028$).

Conclusion. The implementation of telepharmacy services in a multihospital health system expanded hours of service, improved the speed of processing of physician medication orders, and increased clinical pharmacy services and cost avoidance. Surveys of health care staff found that telepharmacy services were well received.

Index terms: Clinical pharmacy; Computers; Economics; Health professions; Hospitals; Hours; Interventions; Medication orders; Pharmaceutical services; Pharmacists, hospital; Telepharmacy

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A national shortage of pharmacists is widely recognized, with a 5.9% vacancy rate in health-system pharmacies.[1] Most experts predict that the shortage of pharmacists and other health care professionals will become more acute as the baby-boom generation reaches retirement age. In 2008, inpatient pharmacy services in hospitals were provided for a mean of 106.1 hours per week.[1] This number was 86.1 hours for hospitals with 50–99 staffed beds and only 57.4 hours per week for those with fewer than 50 beds. Only 1.1% of hospitals with fewer than 50 staffed beds in 2008 provided 24-hour inpatient pharmacy services.

The impact of the pharmacist shortage is particularly severe in rural areas. In rural states, some counties do not have a pharmacist or pharmacy, and many counties have only one pharmacist or pharmacy. The severe shortage of pharmacists in rural areas has led some states, such as Alaska and North Dakota, to create a coalition to leverage available resources to help provide services for rural and remote areas of their states.[2,3] Telepharmacy, defined as the "dispensing of medication and information and the provision of pharmaceutical care to patients from a distance," has been used to provide services in such states.[4] We implemented and evaluated a telepharmacy system in selected institutions in our health system.

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Problem and background

Via Christi Health is a Catholic, nonprofit, integrated delivery network in Kansas. It includes hospitals of varying sizes and types, located in both urban and rural areas. The smallest hospital provides rehabilitation services to approximately 35 patients, while the largest hospital is a tertiary care facility serving approximately 350 patients. Three hospitals are community facilities serving 100–250 patients each. These hospitals use a cartless model of drug distribution with automated medication storage cabinets. Bar-code-assisted medication administration (BCMA) is implemented in all of the system's hospitals studied for this article. We are in the process of replacing a self-developed computerized prescriber-order-entry system with a commercial product that is integrated with our other hospital information systems. While we are able to provide onsite pharmacy services 24 hours a day at our two largest hospitals, staffing allows only partial-day onsite coverage at other facilities. Provision of pharmacy services for only part of the day is not optimal and can result in safety, efficacy, and cost challenges. For example, BCMA provides the greatest safety when there is 24-hour pharmacist order review and profiling, which allow the nurse to scan the medication bar code against the pharmacist-approved medication order. Also, regulatory agencies such as the Joint Commission have restrictions on nurse access to a closed pharmacy due to the risk of medication errors and other concerns. Therefore, even small hospitals are actively exploring ways to expand pharmacy services. In addition to expanding hours of service in our small rural hospitals, we were interested in finding ways to increase the level of clinical services provided in both large and small hospitals.

Analysis and resolution

The largest hospital involved in the telepharmacy project has 410 beds and serves all types of complex and critical patients (e.g., trauma, burn, oncology, adult and pediatric intensive care, cardiac, medical, surgical). The smallest hospital in the project is a rehabilitation facility that typically runs a patient census of around 40 patients. A total of five separate hospitals, in a range of types and sizes, were included in this evaluation.

Telepharmacy services were provided by seven pharmacists employed by the health system and overseen by the program director. We defined telepharmacy as the review and profiling of physician-ordered medications by a pharmacist from a remote site (in this case, from the pharmacist's home). These pharmacists were provided with a computer system and hospital telephone access; each worked from a home office using a home Internet cable connection. Using a virtual private network or terminal server, the pharmacists directly accessed hospital servers and information systems to conduct their work. The Siemens pharmacy information system (Malvern, PA) was used at four of the hospitals, with Meditech (Medical Information Technology, Inc., Westwood, MA) used at the rural hospital. Written physician orders were digitally scanned and processed using an electronic medication-order-management system. Telephone calls were automatically routed to the telepharmacist so that the handling of nursing and other calls would be "transparent" to staff. Hours of telepharmacy service were 5 p.m. to 2 a.m. Monday through Friday at four of the hospitals and 8 p.m. to 10 p.m. at the rural hospital. Outside of these hours, services were provided by one or no pharmacist, depending on the size of the hospital.

A great deal of planning occurred before we implemented our telepharmacy program. A full-day "decision accelerator" multidisciplinary planning meeting was held, followed by a series of weekly conference calls involving the health system's directors of pharmacy. These planning sessions allowed us to establish policies, expectations, and standard operating procedures. One of the challenges was to establish secure access to hospital information systems for telepharmacists, enabling them to work from home, which our information technology department was able to overcome. Another challenge was more specific to the telepharmacists themselves: to become proficient with two different pharmacy information systems and to learn hospital-specific policies and practices. Hiring telepharmacists from within our health system largely obviated this concern. At the four urban hospitals, telepharmacy expanded the hours of pharmacy service by 45 hours per week. Most of these hours were covered by existing staff, who were offered the opportunity to work from home and to be paid for doing so. For 25 of these hours, the telepharmacist satisfied enough order-entry duties to allow us to reassign an onsite pharmacist to our anticoagulation service and to other clinical duties, supporting our ability to meet the Joint Commission's National Patient Safety Goal 3E for improving anticoagulation safety. The other 20 hours per week of coverage were provided from 10 p.m. until 2 a.m. to assist with third-shift pharmacy staffing, where the workload for the one onsite pharmacist covering our largest hospital had become too demanding to allow us to meet our service goals. At the small rural hospital (99 staffed beds), telepharmacy expanded the hours of pharmacy service by 10 hours per week. This decreased the overnight medication orders that the morning pharmacists needed to review. As a result, the rural hospital was able to implement a pharmacist-led medication reconciliation process on its largest nursing unit, the medical nursing unit.

Program evaluation. We conducted a study to evaluate the impact of the new telepharmacy program on our health system. The study was conducted using a prospective preintervention and postintervention study design. The lengths of the preintervention and postintervention study periods were equivalent and were determined by sample-size calculations. To ensure consistency, we needed to collect data for at least a week during each of the study periods. Based on the amount of orders processed by the pharmacies during a week (approximately 40,000 orders), any clinically relevant change in turnaround time was determined to be important. Ninety-five nurse satisfaction scores with a least difference of interest (LDI) of 0.5 of the standard deviation, with a 0.15 increase in the LDI to correct for the nonparametric nature of the data, were required for both the before and after surveys. The study protocol was submitted to the local institutional review board for approval. The study was conducted at selected hospitals within the Via Christi Health. The objectives of the study were to evaluate the impact of telepharmacy services on staffing and workload, clinical quality and patient safety, and costs and cost savings or cost avoidance.

For the staffing and workload evaluation, we determined (1) total number of hours per week of pharmacist coverage, (2) specific times of the day and week of pharmacist coverage, (3) total hours per week of onsite pharmacist time redeployed from medication order entry to other clinical service activities, (4) number of medication orders profiled, (5) turnaround time for medication order entry, and (6) level of satisfaction among pharmacists and nurses with telepharmacy services.

For the clinical quality and safety evaluation, we determined (1) total number of pharmacist-initiated therapeutic interventions, (2) total number of therapeutic interventions, separated by category, and (3) number of therapeutic interventions likely to have prevented a medication error or adverse drug event (ADE).

For the cost evaluation, we determined the average salary cost per hour for staffing the telepharmacy service and cost savings or cost avoidance resulting from pharmacist-documented clinical interventions. We used the dollar amounts for each clinical intervention category from the ACTION O-I benchmarking system (Thomson Reuters, Chicago, IL). Each time a pharmacist identified a drug-related problem and a resultant change occurred, the pharmacist documented the intervention in the appropriate category. The number of interventions and resultant cost impact were tabulated for each study period.

Whenever possible, study data were collected using electronic hospital systems (e.g., pharmacy information system, electronic medication-order-management system). Staff surveys (appendix) were administered electronically and by hard copy. Continuous data were transformed to achieve normality, if necessary, and then evaluated using appropriate statistical tests. Ordinal data were tested using nonparametric tests.

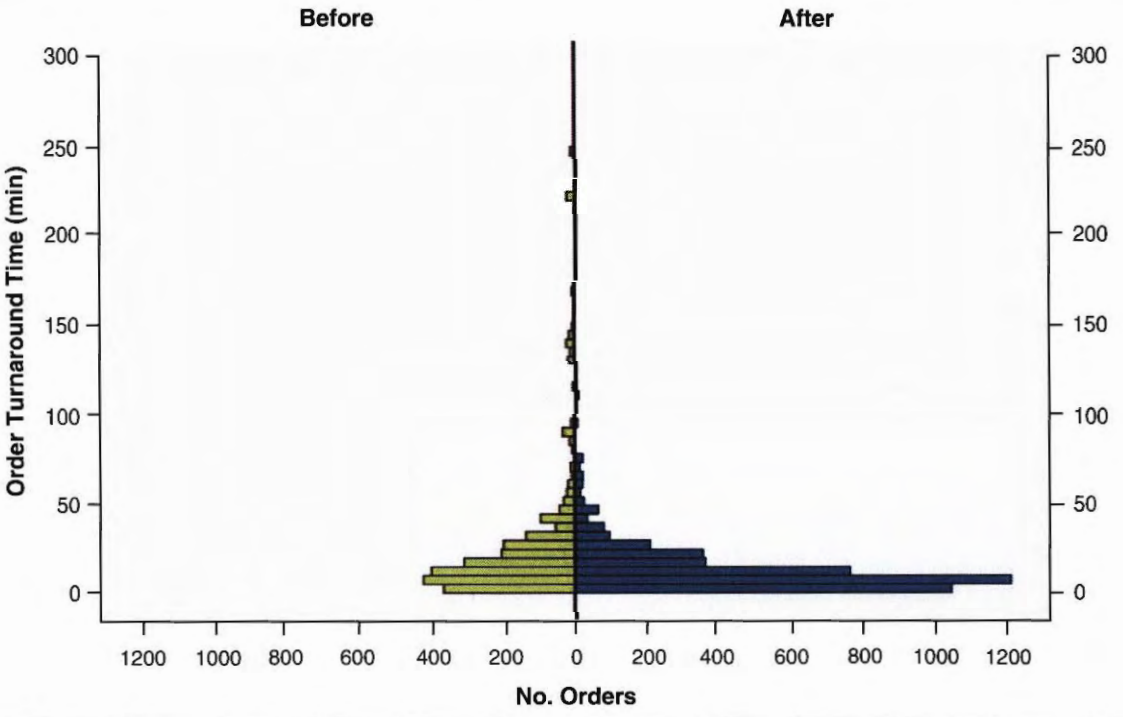
SPSS, version 16, was used to conduct all statistical testing and to generate graphs. The a priori level of significance was 0.05.

Evaluation findings. Ongoing tracking revealed that the telepharmacist profiled around 19% of all orders during his or her hours of duty. This translated to an average of 42 orders per hour. The mean order-processing time for routine orders was reduced from 26.8 minutes (95% confidence interval [CI], 25.4–28.3 minutes) to 14 minutes (95% CI, 13.6–14.5 minutes) ($p < 0.0001$), while stat order processing was shortened from 11.6 minutes (95% CI, 10.2–13.1 minutes) to 8.8 minutes (95% CI, 7.6–10.0 minutes) ($p = 0.007$) (Figure 1). For routine orders, turnaround times greater than 60 minutes became almost nonexistent in the postimplementation study period, and there was a shift toward very short turnaround times.

Pharmacist-initiated clinical interventions were recorded and examined over a one-week period before telepharmacy implementation and then again for one week after initiation of the service. Clinical interventions documented during the measurement period increased by 42%, from 619 to 881. As shown in Table 1, the categories with the largest increases in clinical interventions included chart review (no dollar value), clarification of the medication order (no dollar value), dose adjustment by pharmacy, medication teaching and discharge education, and warfarin follow-up. As another measure of quality, we surveyed nurses and pharmacists to assess their perception of the effect of telepharmacy on overall pharmacy services provided. A significant improvement in nurses' global satisfaction with pharmacist availability for unit consultations occurred (3.0 versus 4.0 on a 5.0-point Likert scale, $p = 0.028$). While pharmacists expressed an improvement in global job satisfaction (3.0 versus 3.5), the difference was not statistically significant.

Because pharmacists' salaries are moderately high, we were interested in determining whether the cost could be partially or fully offset by the savings associated with increased clinical interventions. At an estimated salary of $55 per hour and 30 hours of work weekly, the cost of the service would be $1,650 per week. The cost avoidance associated with the increased clinical interventions documented (881 versus 619) was $23,422 ($86,064 versus $62,642) (Table 1). Therefore, the telepharmacy service generated a saving of $21,772 for one week. If this saving were extrapolated to one year, the annualized saving would be $1,132,144.

Figure 1. Distribution of turnaround times for routine orders before and after implementation of telepharmacy services.



Discussion

Pharmacists have unique knowledge and experience that qualify them to help minimize the risk of medication errors and ADEs and to optimize medication-related outcomes in hospitalized patients. Pharmacists create these improvements by instituting medication management systems and controls that guide other health care personnel to use medications safely and optimally. In many instances, the pharmacist improves patient outcomes simply by double-checking the physician's medication order, the medication to be administered, or the treatment plan. The Joint Commission has recognized the value of the pharmacist in providing a safe and effective medication management system and requires pharmacists to prospectively review each medication order before the medication is administered to the patient.

In a landmark series of studies evaluating thousands of U.S. hospitals and outcomes in several hundred thousand patients, Bond and coworkers[5-9] demonstrated a correlation between the provision of selected clinical pharmacy services and improvements in patient care and financial outcomes. Increases in pharmacist staffing and the provision of clinical services were correlated with reductions in mortality, medication errors, length of hospital stay, drug costs, and the total cost of care.

Other investigators have demonstrated the impact and value of expanded pharmacist involvement in the medication-use system. Leape and colleagues[10] showed that clinical pharmacist participation during patient care rounds in the intensive care unit lowered the rate of preventable ADEs by 66%. Kucukarslan et al.[11] extended this observation by demonstrating a 78% reduction in ADEs on general medicine units when a clinical pharmacist joined the physician's rounding team. Clinical pharmacist participation during patient care rounds has also been shown to reduce medication errors by 51%.[12] The percentage of patients in the study without a medication error during their hospitalization increased from 22.9% in the control group to 40% in the clinical pharmacy group. Similarly, a pharmacist working on the cardiovascular wards prevented 24 medication errors per 100 patient admissions.[13]

In addition to reducing ADEs and medication errors, clinical pharmacy services have been shown to produce substantial cost savings and cost avoidance.[14-24] Formal reviews of the literature have shown the cost:benefit ratio for clinical pharmacy services to range from 4.68:1 to 16.7:1.[14,15] Clinical pharmacists can reduce drug expenses in a variety of ways, such as selecting a less expensive but equally effective agent, switching from the i.v. to the oral route of administration when appropriate, and tailoring

Table 1.
Clinical Pharmacy Interventions During One-Week Periods Before and After Implementation of Telepharmacy Services[a]

Intervention	Before Telepharmacy		After Telepharmacy	
	No. Interventions	Associated Cost Avoidance ($)	No. Interventions	Associated Cost Avoidance ($)
Chart review	59	0	98	0
Chemotherapy order review	39	4,290	30	3,300
Clarify order	318	0	378	0
Dosage adjustment	4	448	116	12,992
Change from i.v. to oral route	24	600	20	500
Teaching about medications	20	4,160	59	12,272
TPN consultation	13	1,560	17	2,040
TPN follow-up	53	1,590	41	1,230
Warfarin dosing	17	12,563	15	11,085
Warfarin follow-up	18	3,330	57	10,545
Medication history	53	34,026	50	32,100
Medication reconciliation	1	75	0	
Total	619	62,642	881	86,064

[a]Thomson Reuters, ACTION O-I pharmacy clinical intervention documentation, 2009. TPN = total parenteral nutrition.

a reduced dose to a patient's needs based on renal function. Finally, reductions in the cost of hospitalization may occur through prevention of medication errors or ADEs. These latter types of cost reductions typically dwarf other types of cost reductions in the amount saved and range from $2000 to $6000 per incident prevented.[25-27]

We used telepharmacy to expand the scope and availability of pharmacy services in hospitals within our health system. While we did not specifically explore the impact of these services on the prevention of medication errors and ADEs, it is reasonable to expect that such an impact did occur based on previous reports in the literature. Similar to the reports of other investigators, we found that our pharmacists were able to produce and document a higher rate of clinical pharmacy interventions after the implementation of the telepharmacy program. The financial and patient care outcomes made possible by implementing telepharmacy services were likely substantial.

A variety of models have been explored and developed for using telepharmacy to meet the needs of patients and health care entities. Most of the early work done with telepharmacy occurred in rural states and focused on the community pharmacy setting.[2,3,28-30] However, a few reports have described the implementation of telepharmacy services to assist rural critical access hospitals[31-33] or a specific area of a larger hospital.[34,35] Critical access hospitals have generally reported implementation of telepharmacy services to expand hours of coverage and to reduce medication errors related to nurses accessing a closed pharmacy. The primary challenges to implementing telepharmacy in critical access hospitals are purchase of information technology equipment and finding pharmacist resources to provide the service. In some instances, federal grants have been used to purchase information technology equipment. In the absence of a locally available pharmacist, critical access hospitals have sometimes contracted with a larger regional hospital for service provision. At larger hospitals, telepharmacy services have been implemented to improve patient safety, either by increasing hours of pharmacist coverage or by expanding the scope of services provided to include additional clinical expertise.

Our integrated delivery network successfully implemented telepharmacy services and expanded pharmacy services for a broad range of hospital sizes and types. Similar to other reports, we were interested in using telepharmacy to improve patient safety and expand clinical pharmacy services. One of the challenges we faced was a lack of standardization in pharmacy information and order transmission systems, as well as policies and practices. Our telepharmacists had to adjust to these differences, requiring us to create a structured training program. We recognize that our health system's entities must work toward standardization in order to optimize our services. However, we have found that our telepharmacy services have been relatively seamless from the perspective of frontline practitioners. In fact, nursing satisfaction increased significantly after the implementation of telepharmacy services. We also documented significant improvements in

pharmacist processing of medication orders and in the provision of clinical pharmacy services. Both of these activities are widely accepted as making important contributions to improving patient safety and health-related outcomes. We continue to use telepharmacy services in our hospitals and foresee continued expansion in the future, so the model we have implemented seems sustainable. In addition, some small hospitals that are not a part of our health system have contracted with us to provide telepharmacy services.

There are several important limitations to our study. First, using a preintervention and postintervention study design does not mitigate against the introduction of other factors that might have contributed to the results we obtained. However, our data collection periods for the preintervention and postintervention periods were close to each other, and we are not aware of any other significant system changes that might have affected our results. Since we were unable to blind the study, we cannot rule out unintended bias in some areas of data collection. For instance, pharmacists could have altered their documentation of clinical pharmacy interventions or their speed of medication order profiling. However, we did not inform staff when data collection would be occurring, and such data were collected from computerized documentation systems. Because data collection for this study occurred over a relatively short time period, the impact and sustainability of telepharmacy in our health system over an extended period of time are yet to be determined. However, we have yet to see any substantial problems, and interest in this service by hospitals outside our health system has been strong.

Conclusion

The implementation of telepharmacy services in a multihospital health system expanded hours of service, improved the speed of processing of physician medication orders, and increased clinical pharmacy services and cost avoidance. Surveys of health care staff found that telepharmacy services were well received.

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Appendix—Health professional survey questions

Nursing survey

1. During which time periods are physician orders most frequently written?
2. Does the presence or absence of a pharmacist ever affect when you enter the doctor's orders into the pharmacy system?
3. What would be the effect of having a pharmacist available after normal pharmacy hours?
4. What would be the effect for your unit of having a pharmacist available on the floor to review orders?
5. How do you feel about administering medications before/without a pharmacist's review?
6. What would be the effect for your unit of having a pharmacist present at patient admissions or discharges for medication consults?
7. Do you feel the pharmacy does a good job providing patient medication care?
8. How satisfied are you with the present pharmacy service? If dissatisfied, why?

Pharmacist survey

1. What level of need is there for increased pharmacist coverage at your institution during specific periods of time? Please specify the time periods.
2. What would be the effect of having a pharmacist available after normal pharmacy hours?
3. What would be the effect on hospital service delivery of having a pharmacist available on the floor to review orders?
4. How satisfied are you with the present pharmacy service?

CASE STUDY

Implementation of a telepharmacy service to provide round-the-clock medication order review by pharmacists

DOUGLAS S. WAKEFIELD, MARCIA M. WARD, JEAN L. LOES, JOHN O'BRIEN, AND LEEVON SPERRY

Purpose. The implementation of a telepharmacy service to provide round-the-clock medication order review by pharmacists is described.

Summary. Seven critical access hospitals (CAHs) worked collaboratively as part of a network of hospitals implementing the same electronic health record (EHR), computerized prescriber-order-entry (CPOE) system, and pharmacy information system to serve as the health information technology (HIT) backbone supporting round-the-clock medication order review by pharmacists. Collaboration permitted standardization of workflow policies and procedures. Through the HIT backbone, both onsite and remote pharmacists were given access to the medication orders, the pharmacy information system, and other patient-specific clinical data in patients' EHRs. Orders are typically reviewed within 60 minutes of when they are entered into the system. The reviewing pharmacists have remote access to the EHRs in each CAH. After completing the clinical review, the pharmacist selects the appropriate medication to dispense from the CAH's formulary. If the medication order is not made using the CPOE system, the order is scanned into a document and sent via e-mail to remote pharmacists. The pharmacist enters the necessary information into the EHR and pharmacy information system. The medication order review process from this point forward is identical to that used for medications ordered via CPOE. The new medication order is then entered into the EHR, and the CAH nurse can proceed with the order.

Conclusion. The implementation of a telepharmacy model in a multihospital health system increased access to pharmacy services, allowing for round-the-clock medication order review by pharmacists.

Index terms: Computers; Hours; Medication orders; Pharmaceutical services; Pharmacists, hospital; Pharmacy, institutional, hospital; Telepharmacy

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Effective execution of all aspects of the medication-use process, including prescribing, dispensing, and administration, is necessary to ensure high-quality, safe medication practices. Many regulatory, advisory, and purchasing groups have established numerous requirements and recommendations for improving medication safety.[1-3] Chief among these is the need for pharmacist review of medication orders before medications are dispensed and administered to patients.

Approximately half of all medication errors occur in the prescribing stage of the medication-use process and may be attributed to the prescriber's lack of knowledge of a drug, the prescriber's failure to adhere to accepted practices and procedures, or general slips and memory lapses during the ordering process.[4] Pharmacist review of medication orders reduces

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prescribing errors, as the pharmacist screens the orders for incorrectly prescribed medications (e.g., wrong drug, wrong dose, wrong frequency), interactions, and contraindications.[5-7] The potential advantages of medication order review in acute care facilities have been previously discussed in-depth.[2,3,8-12]

Problem

Despite the recommendations and evidence of the benefits, very few rural hospitals have sufficient pharmacist coverage to ensure adequate prospective pharmacist review of medication orders. A 2008 study found that almost half (48%) of 410 small rural hospitals had pharmacists onsite fewer than five hours per week, and the lack of pharmacist coverage was magnified on nights and weekends, where approximately 90% of hospitals reported that nurses were responsible for dispensing and administering the medications.[13] With such limited pharmacist availability, most rural hospitals do not use prospective medication order review. Only 20% of rural hospitals review orders before the medication is dispensed, and only about half review orders within 24 hours after medication administration.[5,13] Other barriers to pharmacist review of medication orders in rural hospitals include cost and lack of patient volume to support a full-time pharmacist.[6]

Background

Small rural hospitals have developed a number of ways to increase pharmacist availability through loan forgiveness and rural training programs, as well as through contracting with community pharmacists or sharing a pharmacist with another health care institution.[13-15] Despite these and other efforts, onsite availability of pharmacists to routinely provide medication order reviews before medication administration to patients is usually limited to a few hours per day. As a result, there has been increasing attention directed toward the use of health information technology (HIT) to review medication orders when no onsite pharmacists are available.

A number of telepharmacy models have been implemented by rural hospitals, the most common of which is a "hub and spoke" system.[11-27] The hub is the entity responsible for supplying the rural hospital with round-the-clock pharmacist medication review. A hub is usually a larger hospital that either has contracted with the rural hospital or is a part of the same health system, though the use of outsourcing to a telepharmacy organization has also been documented. The rural hospital, through the use of information technology, sends orders to the hub pharmacy for review when its own pharmacist is unavailable. The level of technology associated with a telepharmacy model may vary, ranging from communication via fax to two-way video conferencing. Evidence of the effectiveness of telepharmacy systems in decreasing the rate of medication errors at rural hospitals is sparse, but initial research suggests that telepharmacy systems have been generally well received by patients and staff.[12,18,24,25,27]

There is also growing interest by rural and critical access hospitals (CAHs) to implement HIT-based solutions that allow the reviewing pharmacist, regardless of location, to have real-time access to the patients' electronic health records (EHRs) and the hospital's pharmacy information and ordering systems. However, high purchase and implementation costs, limited local expertise in implementing HIT, a need for significant process redesign to take advantage of potential HIT functionality, and the limited number of pharmacists make this approach particularly challenging. The shortage of pharmacists in rural hospitals and CAHs is particularly problematic because of the reduced opportunity for pharmacist input in HIT system workflow design and implementation. This article describes the creation of a HIT-based process for obtaining round-the-clock pharmacist review of medication orders in seven CAHs and a large rural hospital. These hospitals collaborated in implementing the same EHR, computerized prescriber-order-entry (CPOE) system, and pharmacy information system to serve as the HIT backbone supporting round-the-clock prospective medication order review by pharmacists.

Analysis and resolution

Mercy Health Network—North Iowa serves 14 counties in north central Iowa with a combined population of over 200,000. This network comprises Mercy Medical Center—North Iowa (MMC-NI), eight CAHs contract-managed by MMC-NI, and one CAH owned by MMC-NI. MMC-NI's contract management activities principally include recruiting and hiring for key leadership positions in the CAHs and providing selected management services. Each CAH is its own legal entity with an independent governing board and separate medical staff bylaws and is organized as an independent hospital with its own clinical services and support departments (e.g., nursing, pharmacy, laboratory, billing). The majority of primary care physicians practicing in the seven CAHs studied are also affiliated with the primary care practice network managed by MMC-NI. The dominant referral pattern is between primary care providers practicing in the network CAHs and medical and surgical specialists working at MMC-NI.

At the time of initiating this project (2007), all CAHs had 25 or fewer acute care beds; one CAH included a 10-bed psychiatric unit, and two CAHs had attached nursing homes. Annual CAH inpatient admissions ranged between 350 and 1,795, and all but two offered obstetric services. Each CAH maintained an active outpatient department, with an-

nual visits averaging 16,000–60,600. The number of visits to the hospitals' emergency departments (EDs) ranged from 2,200 to 6,600 annually. The total number of surgical procedures performed in these CAHs ranged from 450 to 1,280 annually. The total number of full-time-equivalents ranged from 92 to 180. In contrast, MMC-NI, as a large rural referral hospital, had 241 staffed beds and provided approximately 13,000 inpatient admissions, 450,000 outpatient visits, 29,000 ED visits, and 7,000 surgical operations annually. Combined, the MMC-NI network had over 18,000 inpatient admissions, 53,000 ED visits, and 670,000 outpatient visits. CAH outpatient gross revenues ranged from $11.3 million to $21.6 million, accounting for 60–82% of total gross revenues. CAH total net revenues ranged from $11 million to $21.6 million. The cost of charity care ranged from $57,000 to $153,000. In contrast, MMC-NI's total net revenue was about $300 million, about 26 times that of the smallest network CAH. Combined total network revenues exceeded $415 million.

Pharmacist coverage. Before the system changes described herein, the CAHs used a variety of approaches to provide pharmacy coverage, including two full-time MMC-NI pharmacists shared among multiple CAHs, one full-time MMC-NI pharmacist, and three community-pharmacy pharmacists providing part-time service to different CAHs. Onsite pharmacist coverage was provided 15–40 hours per week (mean, 24 hours), with only one CAH regularly scheduling onsite pharmacist coverage for any portion of the weekend. Although two CAHs did not have pharmacy technician support, the other five did, and these technicians worked 24–70 hours per week. Pharmacists were responsible for verifying provider orders, dispensing medications, and providing general oversight of pharmacy operations. The pharmacy technicians predominantly assisted the pharmacists with medication dispensing and billing for medications administered to patients. As a large rural referral hospital, MMC-NI already had round-the-clock inhouse pharmacist staffing and medication-order-review capability.

HIT implementation. MMC-NI, a member of Trinity Health (Novi, MI), implemented its EHR and CPOE systems in July 2005.[28] Building on a tradition of collaboration centered around improving patient care and administrative processes, planning began in 2006 for a regional implementation of the same EHR, CPOE system, and pharmacy information system from the same vendor. In addition to the benefit of sharing clinical data for patients seen in more than one network facility, this collaborative network approach yielded major advantages, including (1) sharing clinical, HIT, and administrative expertise of the larger rural referral hospital across the CAHs, (2) use of similar HIT readiness assessment, workflow policies and redesign, planning, implementation and postimplementation maintenance processes to reduce the amount of trial-and-error learning, and (3) increased economies of scale from group purchasing opportunities.

All seven CAHs implemented the EHR, CPOE, and pharmacy information systems during the summer of 2008 using a strategy similar to that used by MMC-NI[28] to bring the HIT components online at approximately the same time. Three CAHs implemented the systems in July 2008, and the other four CAHs implemented them in September 2008. During the preimplementation, "go-live," and postimplementation stages, MMC-NI provided a significant amount of leadership, consultation, and planning and educational support. The resulting HIT-enabled changes in medication order review in the CAHs are discussed below.

Service implementation. Ideally, medication order review occurs before a medication is administered. To optimize both quality and safety, order review should occur soon after medications are ordered. Medication orders needing review include initial medication orders, orders resulting in changes to existing orders, discontinued orders, and orders resulting from changes in patient care status, which are handled in a special way in CAHs and rural hospitals. In particular, CAHs and rural hospitals under the Medicare program can use the same inpatient beds to provide acute inpatient care and skilled nursing care. By using these designated "swing beds," there can be a smoother transition to skilled nursing care without physically moving the patients. Rural facilities benefit from greater utilization of the facility as well as from an additional payment received for the skilled nursing care. However, Medicare requires that patients be discharged from the acute care bed and admitted to the swing bed. Even though patients remain in the same nursing unit and bed, the discharge and admission processes require discontinuing existing medications associated with the acute care stay and initiating new orders written as part of the admission to the swing bed.

Because of the limited onsite pharmacy coverage, implementing round-the-clock pharmacist review of medication orders was achieved by partnering with remotely located pharmacists. Through the HIT backbone, both onsite and remote pharmacists were given access to medication orders, the pharmacy information system, and other patient-specific clinical data in patients' EHRs. Pharmacists' ability to verify orders for various medications was facilitated by the development of a standardized formulary, accessible through the pharmacy information system. Development of the shared formulary by the CAHs

was discussed in-depth elsewhere.[29] After implementation of the EHR and CPOE systems, the pharmacists employed locally by the CAHs continued to provide initial medication order reviews during their usual scheduled work hours. In order to provide this service round-the-clock, the CAHs issued a request for proposal to potential institutions who could offer telepharmacy services. Six bidders responded, and the successful bidder was Mercy Medical Center—Dubuque (MMC-Dubuque).

MMC-Dubuque, like MMC-NI, is a member of Trinity Health and has the same EHR, CPOE system, and pharmacy information system. As of 2008, MMC-Dubuque has been providing remote medication order review for the seven CAHs affiliated with MMC-NI. Currently, all after-hours, weekend, and holiday reviews of first medication orders for acute care CAH inpatients (i.e., inpatients on the medical, surgical, obstetrics, and behavioral health units) are done remotely.

Medication order review. Orders entered by the provider are automatically received by the remote pharmacy during its hours of coverage through the integrated pharmacy information system (PharmNet, Cerner Corporation). The process for written medication orders is to have only pharmacists enter those orders into the system. This has been accomplished by an innovative, electronic method that eliminates the need to generate a paper copy for the pharmacist. In the e-mail program used by Trinity Health, a group e-mail account was created and is accessible to all regional pharmacists and pharmacists employed by the contracted pharmacy. Each network site has at least one scanner that can scan either stat or regular orders to the group e-mail account. Nurses scan written and signed orders, select the priority of the order, and send the order as an e-mail message to the remote pharmacy e-mail account. Messages are sent without leaving the internal network to which the CAHs and MMC-Dubuque belong and therefore do not require Privilege Management Infrastructure encryption. Security is managed through role-based access to patient information, which ensures Health Insurance Portability and Accountability Act compliance. This is the same system used for all other health information applications, in which the degree of access is determined by security position as well as authorization by the administrator of the group e-mail account. Users have their own unique usernames and passwords, and sites have methods of monitoring system usage. A dedicated computer screen at MMC-Dubuque is used to separately process all off-site medication order reviews. Pharmacists access their e-mail, noting the sending site's name and the phone number of the nurses' station. If the priority of the order is stat, the e-mail subject begins with "stat." Pharmacists open the e-mail, which contains the order as an attachment in portable digital format and process the order in the pharmacy information system without the need to print the order. Each order is then stored in site-specific folders where network pharmacists may review the orders when they return to work. The scanned orders remain in electronic storage and are deleted after seven days.

Orders are typically reviewed within 60 minutes of their entry into the system. The reviewing pharmacists have remote access to the EHRs in each CAH in order to review the patients' laboratory test results and other clinical data. If additional information is needed, they can call the prescribing physician or CAH nurses. After completing the clinical review, the pharmacist selects the appropriate medication to dispense from the CAH's formulary.[29] Each formulary item is represented by a unique stock-keeping unit (i.e., specific drug, dose route, dose) and has an associated National Drug Code (NDC). These NDCs, embedded in bar codes, are used for the subsequent dispensing and bar-code-assisted medication administration (BCMA) processes. An advantage for the reviewing pharmacists is the use of the same EHR, CPOE system, and pharmacy information system platforms and the same formulary across all facilities.

Order volume and costs. Initially, the CAHs estimated the expected annual volume of remote medication order reviews to range from 2,834 (about 9% of all medication orders) to 10,076 (33% of all medication orders). Experience to date suggests that these estimates were too low. For example, the CAH that estimated a total of 10,076 annual order reviews had 15,634 orders reviewed remotely through the first eight months of the year. The average number of orders reviewed monthly was 1,954, almost half of all medication orders being reviewed in that CAH.

Currently, the CAHs pay $4 per medication order reviewed via this HIT-based system. For example, in the case of a patient for whom there is just 1 order for 1 new medication, the charge is $4. Alternatively, for a patient with 10 different medication orders who is discharged from acute care status and admitted to skilled nursing care status, every order to discontinue and every order to start a medication is reviewed, generating a total charge of $80 (10 discontinuation orders × $4 and 10 admission orders as a swing bed patient × $4). While it is in the CAHs' financial interest to have changes in care level occur during weekdays when their local pharmacists are available to review the orders, such transfers frequently happen outside these hours, on weekends, and holidays. As expected, the volume of and costs for medication orders reviewed remotely varies widely among the seven CAHs, from approximately 700 orders ($2,800) to over 2300 orders ($9,200) per month.

Because the CAHs are reimbursed by Medicare on a cost-plus basis, the additional costs for the pharmacists' reviews for Medicare patients are directly reimbursable. The CAHs' cost-plus reimbursement model allowed them to receive significant funding to cover portions of the costs associated with purchasing computer hardware and software. This financial advantage available to CAHs is not available to larger hospitals receiving diagnosis-related group case-based reimbursements.

To gain a better idea of the value added by the pharmacists' reviews, the types of actions taken as a result of these reviews were evaluated between February–April, 2009. These included a total of 9163 orders that were approved, 2226 new orders, 1294 modified orders, 972 discontinued orders, and 179 orders voided by the reviewing pharmacists. Overall, about 58% of the total reviews were conducted by the remote pharmacists.

Discussion

The CAHs affiliated with MMC-NI have gone from very limited to round-the-clock pharmacist order review coverage in all but one hospital, with that one lacking coverage for only one hour per week. This has been accomplished by the direct use of HIT to connect remotely located pharmacists in near real time, generally within 60 minutes, to when a medication order is entered.

Critical to the success in establishing round-the-clock pharmacist review of medication orders were several key decisions made by each hospital's executive leadership toward standardizing medication-related policies and practices. The results of these decisions included standardization of the formulary system across all hospitals involved, creation of a regional pharmacy and therapeutics committee to oversee future formulary changes,[29] use of the same clinical software systems across all hospitals, development of policies and procedures requiring pharmacist review of first medication orders (except in emergencies), and use of the same equipment and software to support automated dispensing and BCMA devices. Further, before implementation of round-the-clock order review, most pharmacists working in the local hospitals had not previously met or worked with each other. In order to have a seamless review process, it was essential that these pharmacists work together not only to standardize the formulary but to help develop the review process to ensure consistency between local and remote pharmacists' reviews.

With few exceptions, remote pharmacist review of medication orders has been well received and is perceived to improve the quality and safety of patient care. Interviews with all of the CAHs' chief nurses and pharmacy directors revealed that physician response to the process has been positive. The potential to talk with a pharmacist, regardless of the time of day or day of the week, was also viewed as very positive.

One concern raised in one CAH was the occasional delay in obtaining the remote pharmacists' reviews. Such delays may be a result of how a medication order is sent from a particular CAH or a specific problem with receiving orders from that CAH. If there is a delay or an immediate need to dispense medication, the CAH staff still has the ability to dispense and administer the medications without the pharmacist's review. Another concern was that some nurses who previously acted immediately on a physician's medication order were frustrated that they now had to wait for the pharmacist's review before giving the patient the prescribed medication.

Although CAHs can pass the incremental costs of remote pharmacist review on to third-party payers, concern was raised by the CAHs about having the same charge applied to all orders, particularly for transitions in level of care, for which there may be no changes made to the actual orders. However, even when orders are rewritten without any changes, pharmacist review plays a key role in supporting medication reconciliation requirements, as well as providing an important check for potential transcribing errors.

One final concern is that because different remotely located pharmacists review the orders, the opportunity for these pharmacists to develop close working relationships with the physicians located in the CAHs is reduced. This potential negative effect is easily outweighed by the advantages associated with having round-the-clock pharmacist order review. One option to address this concern is to have the remote pharmacists visit the CAHs and meet the medical staff and nurses with whom they will be communicating.

The successful implementation of a HIT-enabled process that supports round-the-clock pharmacist medication order review is a major step forward in the CAHs' efforts to create safer and more-reliable medication processes. Combined with the introduction of automatic dispensing units and BCMA, the CAHs successfully implemented a closed-loop medication process. Critical to this success was the shared vision for improving patient care quality and safety, combined with the collaborative approach used to incorporate knowledge and skills from the larger rural referral hospital into their own facilities and patient care processes. This partnership approach allowed for the sharing of expertise and development costs, making this important transition less expensive, both in direct dollar costs and staff time. The shared bid process covering several CAHs and using the same information technology infrastructure to link remote pharmacists to the hospitals resulted in multiple bidders. While it

is not possible to estimate a specific economy-of-scale effect, this may have had a positive effect on both the number of bidders and bid prices. The study hospitals clearly demonstrated the potential for HIT solutions to address both work force and distance challenges faced by rural hospitals.

In the case of the CAHs affiliated with MMC-NI, local and remote pharmacist order review resulted in pharmacists taking actions beyond order review and approval (e.g., order modification or discontinuation) for approximately one third of the medication orders. However, this information does not allow for the exact measurement of the number of prescribing errors prevented or near misses identified as a result of the pharmacist order reviews. In addition, we could not document how the pharmacists' reviews may have improved the quality of the prescribing physicians' decisions related to medication type, dosage, frequency, or route of administration. However, the number of medication orders being reviewed and the frequency with which pharmacists took actions beyond just reviewing the orders in this case study suggest that pharmacist review of medication orders is an important value-added service.

Conclusion

The implementation of a telepharmacy model in a multihospital health system increased access to pharmacy services, allowing for round-the-clock medication order review by pharmacists.

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Telepharmacy and bar-code technology in an i.v. chemotherapy admixture area

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Purpose. A program using telepharmacy and bar-code technology to increase the presence of the pharmacist at a critical risk point during chemotherapy preparation is described.

Summary. Telepharmacy hardware and software were acquired, and an inspection camera was placed in a biological safety cabinet to allow the pharmacy technician to take digital photographs at various stages of the chemotherapy preparation process. Once the pharmacist checks the medication vials' agreement with the work label, the technician takes the product into the biological safety cabinet, where the appropriate patient is selected from the pending work list, a queue of patient orders sent from the pharmacy information system. The technician then scans the bar code on the vial. Assuming the bar code matches, the technician photographs the work label, vials, diluents and fluids to be used, and the syringe (before injecting the contents into the bag) along with the vial. The pharmacist views all images as a part of the final product-checking process. This process allows the pharmacist to verify that the correct quantity of medication was transferred from the primary source to a secondary container without being physically present at the time of transfer.

Conclusion. Telepharmacy and bar coding provide a means to improve the accuracy of chemotherapy preparation by decreasing the likelihood of using the incorrect product or quantity of drug. The system facilitates the reading of small product labels and removes the need for a pharmacist to handle contaminated syringes and vials when checking the final product.

Index terms: Antineoplastic agents; Codes; Compounding; Computers; Personnel, pharmacy; Pharmacists; Pharmacy, institutional, hospital; Quality assurance; Technology; Telepharmacy

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As toxic medications, chemotherapies should be treated as high-risk medications at all phases of the medication-use process (i.e., prescribing, transcribing, compounding and preparation, administration), with safeguards along the way to reduce the potential for error. Yet, while much attention has been given to improving the safety of chemotherapy prescribing and administration through the use of order forms and computerized prescriber-order-entry systems, relatively little attention has been given to chemotherapy preparation.[1-7] Robotics have the potential to improve preparation processes, but dissemination has been slow due to the high cost of this technology.[8]

In the meantime, there is still significant risk of errors in chemotherapy preparation. A review of chemotherapy preparation-error frequency in the literature revealed a wide range of error rates (0.2–7.4% of preparations).[9,10] Error rates across all parenteral medications were similar (1.6–9%).[11-13] Flynn et al.[13] studied the accuracy of i.v. admixture compounding in five hospitals. While observing for errors such as wrong dose, wrong base solution, and wrong preparation technique, they found a 7.4% error rate (15 errors per 202 doses) for antineoplastic admixtures. Given the toxic nature of chemotherapy and the potential for significant consequences of an error, pharmacies should strive to do everything possible to detect these dispensing errors before they reach the patient.

There are multiple risk points associated with chemotherapy preparation, with one of the most critical

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being the process of measuring the correct drug quantity and transferring it to a secondary container. To reduce errors during this process, the majority of academic medical center pharmacies employ the following three practices for preparing and checking chemotherapy:

1. A pharmacy technician prepares chemotherapy by withdrawing the drug from a vial and injecting into a bag while working in a biological safety cabinet. The plunger in the syringe used in the process is then pulled back to indicate the volume of drug that was injected into the bag. A pharmacist then checks the final product, along with the used vials and empty syringes. This practice may be referred to as the "syringe-pullback" method.
2. A pharmacy technician fills a syringe with the required volume of the drug needed for the dose and then summons a pharmacist to check the syringe before injecting it into a bag. The technician then injects the contents of the syringe, sometimes under the observation of a pharmacist, and the pharmacist checks the final product, along with the used vials.
3. A pharmacist prepares all chemotherapy, with a second pharmacist checking the final product, along with the used vials and empty syringes.

These practices are consistent with the American Society of Health-System Pharmacists (ASHP) Guidelines on Preventing Medication Errors with Antineoplastic Agents.[14] The guidelines recommend that a second individual confirm measurement before a solution is transferred from a measuring device (e.g., syringe) to a secondary container (e.g., fluid bag). This may be accomplished by visual inspection or other means, including use of the syringe-pullback method.[14] Although the ASHP guidelines do not endorse one medication-checking system over any other, the error frequencies associated with the three aforementioned practices are likely to differ.

The practices listed above are also in order of increasing pharmacist involvement, with the first having the least involvement of pharmacists to the third having full participation of two pharmacists. It could be assumed that the practice with the lowest level of pharmacist involvement would be the least desirable from a safety perspective. Nevertheless, a survey of academic medical centers ($n = 42$) indicated that 19 (45.2%) respondents have a pharmacist check an empty syringe that has been pulled back, 14 (33.3%) have a pharmacist check before or during injection of the syringe, and 9 (21.4%) have a pharmacist prepare the chemotherapy.[15] So why did only 55% of surveyed academic medical center pharmacies have a pharmacist directly observe or participate in a critical risk point of chemotherapy preparation—the injection of a correct quantity of a drug into the secondary container? The answer to this may be related to the high cost of pharmacist resources or to the desire to direct these resources to clinical functions.

Our institution uses the syringe-pullback method for chemotherapy preparation, a process requiring a fair amount of trust in the accuracy of the technician. Though we would have liked to switch to a different practice, our i.v. admixture area staffing model made this difficult, primarily because the pharmacists involved in the preparation process would need to gown appropriately for entry into the i.v. admixture area while forgoing their other duties (e.g., attending rounds with the neonatal medicine service, verifying orders, entering orders for total parenteral nutrition, checking medications before delivery to patients).

The initial objective of the program described in this report was to increase the presence of the pharmacist at a critical risk point during chemotherapy preparation while making the most efficient use of clinical pharmacy staff. As a plan was developed to meet this objective, additional goals were formulated: incorporate bar-code technology to reduce the risk of selecting the wrong chemotherapeutic medication and improve the readability of chemotherapy vial labels that appear in an extremely small font. We also hoped to reduce the potential for surface contamination and employee exposure to chemotherapy. Our concern with chemotherapy exposure stemmed from the practice of bringing the items used for preparation (e.g., empty vials, empty syringes) out of the chemotherapy preparation area into the anteroom for checking by a pharmacist. Although the items were double-bagged by the technician, the possibility of contamination was still real. Ideally, those products would never need to leave the chemotherapy preparation area.

Technology implementation

Concept presentation. ScriptPro (Mission, KS) provides automation solutions, such as robotic dispensing systems and telepharmacy, primarily geared toward outpatient pharmacies. Having some familiarity with ScriptPro's product line, pharmacy administrators at our institution thought we may be able to use its telepharmacy hardware and software to meet the objectives of this project. This application of telepharmacy involves the use of a digital camera to photograph a product that needs to be checked by a pharmacist. The pharmacist can then view this image from a remote location. Telepharmacy systems are intended to maximize the efficiency of pharmacists by allowing them to inspect a product without being onsite. The telepharmacy system also offered a webcam and microphone to allow for real-time conversation between the two remote sites.

Pharmacy administrators presented the idea of using telepharmacy in

the chemotherapy preparation process to ScriptPro representatives. We suggested that their inspection camera (Figure 1) could be placed in a biological safety cabinet and used to take digital pictures at various stages of the preparation process. A technician would photograph the vials to be used, including a view of the lot number and expiration date, diluent vial and diluent-containing syringe, and the fluid bag or other secondary container. Most importantly, the syringe containing the ordered volume of chemotherapy could be photographed before the transfer of its contents into the secondary container. The pharmacist could then view these pictures from a check station (Figure 2) in the anteroom while he or she was checking the finished product or, in some cases, while the product was being prepared. The concept was favorably received by ScriptPro representatives, and they agreed to provide the needed equipment, modified to meet the needs of the project.

Figure 1. Inspection camera within the biological safety cabinet.

Figure 2. Check station showing vials and medication-containing syringe that are in the biological safety cabinet.

Interface development. The first step in implementation of the system was to develop an interface between the hospital's pharmacy information system and the telepharmacy system. An interface was necessary so that chemotherapy orders could be queued in the telepharmacy system for processing, allowing the technician to tie the digital pictures to a patient name, medical record number, and specific details of the medication order. Rather than investing the time and money to develop a full-scale interface, a printer-based interface was selected. This interface uses a device that recognizes and captures orders as they travel from the pharmacy information system to the label printer. The device was configured so that it would identify and capture orders when the word *Cytotoxic* was present on the top line, indicating an order for a chemotherapeutic medication. These orders, containing the drug name, concentration, quantity, and

patient information, would be sent to the telepharmacy system's "pending work list."

Bar-code verification. After reviewing the hardware specifications, pharmacy administrators noticed that the system included an integrated bar-code scanner. We inquired as to whether that could be incorporated into the chemotherapy preparation process, knowing that bar-code verification of the correct drug vial at the point of preparation would bring great value to the project. Working with software developers, a method was implemented to link the drug name and concentration (identified through the printer interface) to a list of national drug codes (NDCs) within the system's medication database. Since the product was initially designed for the outpatient pharmacy setting, most of the medications used in chemotherapy preparation were not in the database, but these were added into the system in less than one week. The net result of this effort was a system in which the technician was able to scan the bar code on the medication vial at the point of preparation in an attempt to match this to the list of NDCs in the database. A mismatch would produce an error message, notifying the user that he or she had selected the incorrect medication or medication concentration.

Additional features. Other system benefits included electronic archiving of digital images of vials, syringes, and fluid bags. Based on a projected usage volume of 25 chemotherapy preparations daily, there is sufficient space on the system server to store these images for up to 55 years. This would allow for easy retrieval of information if questions arose as to whether a patient received the correct chemotherapy, or if there was a need to identify patients who had received a lot number of a recalled product. The software also featured reporting options that enabled tracking of order-processing times from the point of label creation, to technician preparation, to the final product check by the pharmacist. A feature that we have not used as often is the live audio and video feed, connecting the technician working in the chemotherapy preparation room to the pharmacist in the anteroom or central pharmacy via webcam. This feature can be used to allow the technician to ask a question of the pharmacist without leaving the chemotherapy preparation area.

Installation and obstacles. After identifying the locations for the two pharmacist check stations (the anteroom and central pharmacy), we received the hardware for installation just over three months after the original concept was presented to ScriptPro representatives. The following week, user-training sessions began and the system went live.

Obstacles encountered along the way were surprisingly few given that this implementation took place in such a short time frame. One obstacle was that we were unable to use the bar-code verification feature for multiple-ingredient chemotherapy preparations (e.g., intrathecal syringe containing methotrexate, cytarabine, and hydrocortisone). This is because the interface device worked by capturing the name of the drug on the third line of the pharmacy information system labels. Information on other lines was ignored, since it typically included information irrelevant to the process of bar-code verification for the chemotherapy vial (e.g., fluid vehicle name, volume). We chose to revert to our previous checking process for multiple-ingredient chemotherapy orders and plan to develop an interface in the future that will capture and enable bar-code verification of all chemotherapeutic drugs in the preparation. Another obstacle was that the bar-code scanner was unable to read two-dimensional bar codes. Unfortunately, several of the bar codes on the chemotherapy vials were two dimensional, forcing a return to the previous checking process. We recommended to ScriptPro that the company consider upgrading its scanning system to read a greater variety of bar codes.

A potential obstacle for health systems considering telepharmacy is the acceptance of this technology by state boards of pharmacy. At the time of system implementation, the state of Kansas did not allow the use of telepharmacy as a substitute for onsite pharmacist checking. State board approval was not an issue for this project since pharmacists were still involved in checking the final product; telepharmacy was merely being used to enhance the existing checking process.

United States Pharmacopeia chapter 797 compliance

Though not necessarily an obstacle, the effect that an inspection camera would have on airflow within our biological safety cabinet had to be considered. The inspection camera was installed just before certification of the cleanroom and biological safety cabinets, and the cabinets passed certification for International Organization for Standardization (ISO) class 5. We were also comfortable with placement of this device in the biological safety cabinet because the camera was cleanable and the syringes would be capped (i.e., critical surfaces not exposed to air) while sitting on the inspection camera's target area.

An airflow visualization and particle test was performed to further assess compliance with *United States Pharmacopeia* (*USP*) chapter 797, at the recommendation of *USP* chapter 797 consultants. This test involved the use of a neutrally buoyant smoke, which was released above the inspection camera. A video camera was used to capture the distribution pattern of the smoke around the inspection camera and the direct compounding area. To pass the test, there must be was no visible smoke passing to the direct compounding area, no

particle counts exceeding ISO class 5 levels during the test, and no particle levels exceeding ISO class 5 levels during a mock compounding session with no smoke generation. All three acceptance criteria were met.

Experience

After order review and entry, our chemotherapy preparation process begins with a pharmacist performing a "vial check" (i.e., a check of the medication vials' agreement with the work label) as the first step toward ensuring that the correct medication has been selected. The technician then takes the product into the biological safety cabinet, where the appropriate patient is selected from the pending work list (Figure 3), a queue of patient orders sent from the pharmacy information system. The technician then scans the bar code on the vial (Figure 4). Assuming a bar-code match, the technician photographs the work label, vials, diluents and fluids to be used, and the syringe (before injecting the syringe's contents into the bag) along with the vial, as shown in Figure 2. The pharmacist views all images as a part of the final product-checking process.

Using this system for chemotherapy preparation, our practice was enhanced in four areas.

1. Bar-code verification of the chemotherapy product is used to ensure that the correct drug is selected based on the order, as entered by the pharmacist and verified by a second pharmacist.
2. The pharmacist can visually inspect the syringe and its contents before injection into the secondary container to ensure that the technician withdrew the correct volume from the vial.
3. The small-pitch font on chemotherapy vials can be digitally enlarged to aid the pharmacist when checking the finished product (Figure 2).
4. Contaminated syringes and vials can be disposed of in the chemotherapy preparation area, avoiding the risk

Figure 3. Pending work list and order-processing queue as viewed by pharmacy technician preparing i.v. chemotherapy doses.

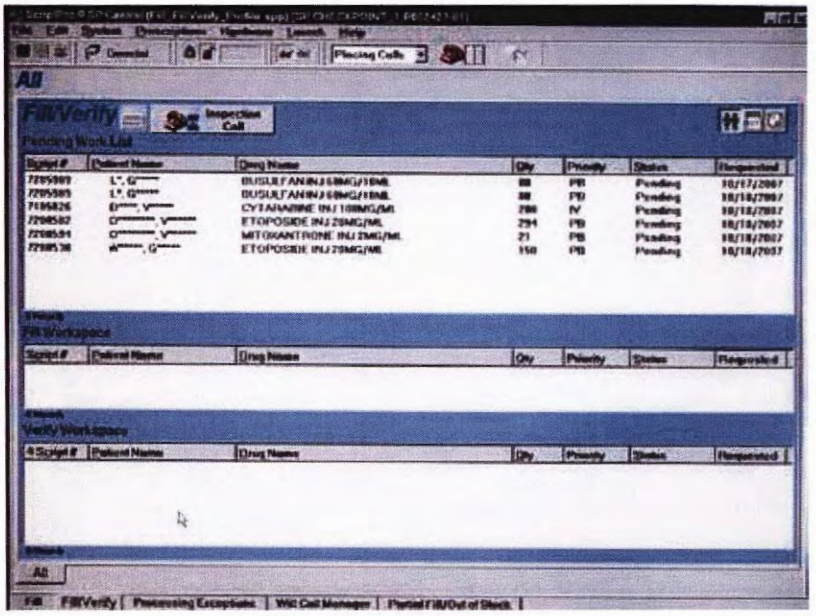

Figure 4. Bar code of medication vial being scanned by pharmacy technician. Monitor shows vials and medication label.

of contaminating other areas of the cleanroom.

Use of this system to verify the accuracy of chemotherapy preparation resulted in an intervention by the pharmacist in 4 (1.1%) of 363 doses prepared during one month. An intervention was defined as a request by the pharmacist to adjust (e.g., increase or decrease volume) or to remake the product. Of the four interventions, three involved incorrect volumes drawn into the syringe, and the fourth involved a syringe that contained approximately 2 mL of air bubbles. The incorrect syringe volumes may have been detected by our previous checking system (i.e., syringe-pullback method), but this is not a certainty. The new system has proven remarkably easy to use and has added very little time (less than 50 additional seconds of technician time per dose) to the chemotherapy preparation process. This would appear to be time well spent, given that we have prevented four potential errors that may have gone undetected by our previous checking system.

Discussion

A review of the Medmarx database revealed that 85% of the 310 reported pediatric chemotherapy errors reached the patient, and 15.6% of these reported errors required monitoring or therapeutic intervention.[16] If "wrong-time" errors (22.6% of all errors reported) were disregarded, the percentage of remaining errors requiring therapeutic intervention would likely be significantly higher. Improper dose or quantity, wrong time, omission error, and wrong administration technique or wrong route comprised almost 75% of reported chemotherapy errors. Though not a conclusion of the study, there was a noteworthy omission among the most commonly reported error types in that preparation or dispensing errors were not present. Perhaps this was because preparation errors tend to be underreported. Unfortunately, it is also possible that many hospitals are using a checking method (e.g., syringe-pullback method) that does not allow them to adequately detect preparation errors. A study of undetected errors found that 23.5% of undetected errors had the potential to cause an adverse drug event.[17] Of these errors, 36% were associated with an incorrect medication, 35% with an incorrect strength, and 21% with an incorrect dosage form. Telepharmacy and bar-code technology can be used to target and reduce these types of errors.

The primary objective of this program was to find an efficient way to allow the pharmacist to check the product-containing syringe before it was injected into a bag of fluid. Meeting this objective has effectively moved our checking practice from the syringe-pullback method, in which the pharmacist was absent at a critical risk point and the odds of error detection were unlikely, to a practice in which the pharmacist can observe this risk point without interrupting workflow. This improvement has allowed us to transition from a practice in which the compounding error rate was unknown and unidentifiable to one where we can demonstrate a 1.1% rate of detected errors.

The adoption of bar-code technology has had an enormous effect on the safety of medication dispensing and administration. A before-and-after study of bar-code-based dispensing revealed an 86–97% relative reduction in the frequency of potential adverse drug events.[18] The telepharmacy system has enabled our pharmacy to transfer the benefits of bar coding into the chemotherapy preparation area. Bar-code technology is currently commercially available to improve the accuracy with which oral and bulk medications are dispensed (e.g., robotics, carousel technology) and the accuracy of parenteral nutrition compounding. The high-risk nature of chemotherapy warrants the use of bar coding as a safeguard as well.

Conclusion

Telepharmacy and bar coding provide a means to improve the accuracy of chemotherapy preparation by decreasing the likelihood of dispensing the incorrect product or quantity of drug. The system facilitates the reading of small product labels and removes the need for a pharmacist to handle contaminated syringes and vials when checking the final product.

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Providing nighttime pharmaceutical services through telepharmacy

CHRISTOPHER A. KEEYS, KENNETH DANDURAND, JUSTINE HARRIS, LOLA GBADAMOSI, JOAN VINCENT, BLAIR JACKSON-TYGER, AND JYMEANN KING

Abstract: A nighttime telepharmacy service serving a community hospital is described.

At a 340-bed acute care community hospital, the level of nighttime activity related to medication use did not support the establishment of a full night pharmacy shift. After-hours access to medications was mostly the responsibility of nursing and medical staff using a separate night closet, automated dispensing machines, and limited floor stock. Pharmacists reviewed new orders and missing doses during the following day shift. An innovative practice model that combined an outsourced telepharmacy service and the traditional on-call pharmacist service was implemented to improve services at night. Prospective order review, drug information services, and clinical pharmacy consultations were all provided under the new model. Nurses and physicians used the service extensively. A total of 1039 drug orders were reviewed by the telepharmacy service during the first three months, with 29% of these orders representing high-risk therapies. Most orders were submitted by the critical care areas, the medical–surgical units, and the emergency department. Feedback from the hospital staff concerning the service was favorable, and physician leaders asked that the service be expanded to take oral orders from physicians at night.

A nighttime telepharmacy service was successfully implemented at a community hospital to provide medication order review, resolution of drug-related problems, and drug information and clinical pharmacy services.

Index terms: Contract services; Drug information; Hours; Pharmaceutical services; Pharmacy, institutional, hospital

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Although it is widely acknowledged that the presence of pharmacists is imperative for patient safety in a hospital, national surveys continue to reveal that a majority of hospital pharmacies operate less than 24 hours a day, seven days a week. In 1994, hospital pharmacies were estimated to operate an average of 15.6 hours a day, Monday through Friday; only about one third of hospital pharmacies operated around the clock.[1] Surveys conducted again in 1996 and 1999 revealed similar findings.[2,3] More than 3000 hospitals nationwide, including acute care, rehabilitation, and psychiatric facilities, close their pharmacy departments at night. Thus, in many hospitals, drug distribution during nighttime is carried out by night nursing supervisors, nursing and allied health staff, and on-call pharmacists. The traditional on-call pharmacist service allows medical and nursing staff to contact a pharmacist in emergencies to provide pharmaceutical support by telephone or in person. In Massachusetts, 68 (94%) of the 72 hospitals currently participating in a medication error prevention project provide on-call pharmacist services during hours when the pharmacy department is closed.[4]

The absence of a pharmacist in a hospital after hours may increase the risk of medication errors, but this issue has not been well studied so far. Intensive efforts are now being directed toward reducing medical errors

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and improving patient safety within the health care system. The Institute of Medicine (IOM), the Institute for Safe Medication Practices, the American Society of Health-System Pharmacists (ASHP), the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), the United States Pharmacopeia, and many other groups and individuals have spoken forcefully on the need for greater patient safety.[5] Over 50% of medication errors are due to prescribing errors, followed by administration errors, transcription errors, and dispensing errors.[6,7] Strategies for systematically reducing medication errors have been described, and prospective review of orders by pharmacists is recognized as an important measure.[8]

Innovative and cost-effective methods for providing after-hours pharmaceutical services are needed. Daunting obstacles exist, including staff shortages and budgetary constraints.[9] The vacancy rate for pharmacists in hospitals currently exceeds 20%.[10] IOM has challenged the pharmacy profession to develop real and lasting solutions to the problem of medication errors,[11] but pharmacy cannot provide meaningful contributions if not enough pharmacists are available.

This article describes the need for clinical pharmacy services at night at a community hospital and the innovative approach to provide such services through a contracted telepharmacy.

Background

Sibley Memorial Hospital (SMH) is a 340-bed acute care facility in Washington, DC. Approximately 16,000 inpatient admissions occurred at the facility in 2001, with about 4.7% of these patients admitted through the emergency department between 11 p.m. and 7 a.m. The hospital offers a wide array of services—medical, surgical, psychiatric, rehabilitative, obstetric, intensive care, and skilled care—to inpatients and outpatients. The patient population primarily consists of adults, many of them elderly.

The pharmacy department provides comprehensive pharmaceutical services, including unit dose, i.v. admixture, computerized records, decentralized services, clinical pharmacy services (including participation in multidisciplinary rounds), and automated medication dispensing. The pharmacy is open from 7 a.m. to 11:30 p.m. seven days a week, including holidays. An on-call pharmacist is available every night. A separate night closet, automated dispensing machines, and limited floor stock serve as sources for essential medications during the night. Nursing supervisors are authorized to obtain drugs from the night closet as needed. No one other than pharmacy personnel is authorized to access drug supplies stored within the pharmacy. The night nursing staff handled new medication orders and missing doses without access to the pharmacy profile. Historically, the on-call pharmacists were contacted by the night staff of the hospital less than once a day to provide drug information or resolve problems with drug orders and supplies.

Justification of using a nighttime telepharmacy service

In 2000 the hospital's level of nighttime activity related to medication use did not support the establishment of a full night pharmacy shift. The nursing, pharmacy, and medical staff members, along with hospital administration, however, were very interested in adopting new initiatives to reduce medication errors and modernize services, including provisions to better support the nurses on night shifts. The hospital's medication error reduction team identified prescribing errors as the most common type of error, accounting for 82% of all medication errors reported in 2000. Over 85% of the documented prescribing errors were identified by the pharmacists during routine review of orders on day and evening shifts. The prescribing errors were commonly related to dosing, drug allergies, incomplete orders, and illegible or misspelled orders. Over 95% of the prescribing errors were corrected by a pharmacist before the patients received the medications.

An alternative to the traditional 24-hour pharmacy service was discussed in September 2000 by SMH's pharmacy director and officers of the telepharmacy service firm MedNovations, Inc. The pharmacists in the department determined that the current on-call pharmacists could not prospectively review all new medication orders and handle existing duties during the day and evening shifts. Support for using the telepharmacy service was obtained from the hospital's senior administrators and the patient care services, medical staff, risk management, legal, and operations departments. Issues pertaining to patient confidentiality and pharmacy licensure were addressed in provisions of the contract between the hospital and the telepharmacy firm. The new service was approved in March 2001 by the pharmacy and therapeutics (P&T) committee.

Implementation of the service

The telepharmacy service began operating in April 2001. Services included prospective review of medication orders by a pharmacist, drug information, and clinical pharmacy consultations under a contract. The telepharmacy service, although capable of performing the function, did not enter medication orders into the computerized pharmacy profiles at the hospital. Rather, medications prescribed during the night were entered into the computerized profile by the hospital's pharmacists in the morning. The on-call pharmacist's role, primarily emergency dispensing of drugs locked in the pharmacy, was retained as a necessary component of the overall service.

MedNovations is staffed by clini-

cal pharmacists and pharmacy technicians. Additional on-call clinical support is available from pharmacists with advanced training in pediatrics, critical care, infectious diseases, and drug information. Remote access to the hospital's pharmacy computer system (DigiMedics, version 4.2.1, Mediware, Melville, NY) and medical information system (Affinity, version 8.0.5, QuadraMed, San Rafael, CA) was established at MedNovations's Greenbelt, Maryland, facility. Pharmacists from both organizations met and established and reviewed operational plans, policies and procedures, drug-use guidelines, clinical resources, on-call pharmacist schedules, clinical services, drug inventories, and drug-utilization patterns that would apply to the night shift. Information on the new service was disseminated to the nurses, physicians, and administrative staff through newsletter articles and postings throughout the organization. The availability of real-time access to the telepharmacy service was recorded on the main pharmacy telephone's voice mail to inform any staff member calling the main pharmacy at night.

Nurses were educated about the service through posters. They were instructed by the pharmacy to fax all new orders for inpatients to the telepharmacy service for review in the same way that orders were sent to the pharmacy department on the day and evening shifts. Emphasis was placed on targeted high-risk drugs, orders for new admissions, and orders for patients transferred into and out of the intensive care units. Additional reinforcement was provided at night by the nursing supervisors, who served as a clinical resource for all hospital staff. Each night, the telepharmacy service telephoned the night nursing supervisor to establish an oral dialogue between the two organizations. Hospital staff were told to forward new and other types of medication orders (e.g., requests for missing doses and emergency department orders for outpatients) for review by the pharmacist as necessary and wait for review confirmation from the telepharmacy before administering medicine. The pharmacy department instructed nurses and physicians to call the telepharmacy service for assistance with drug information questions or to obtain a clinical pharmacy consultation. No punitive measures were adopted for staff members who failed to forward new, nonemergency drug orders to the telepharmacy service.

A new standard for reviewing medication orders during the night shift was established for the nurses. This standard targeted high-risk orders, which were defined as orders for the following:

- Antiinfectives (systemic),
- Anticoagulants,
- Antiplatelet agents,
- Hematopoietic agents,
- Hemostatic agents,
- Miscellaneous blood agents,
- Antineoplastic agents,
- Drugs for newly admitted patients,
- Drugs for patients transferred to or from critical care areas,
- Drugs with many potential interactions or contraindications,
- Drugs with a narrow therapeutic index,
- Drugs for which a test dose is required,
- Drugs indicated for treating adverse drug events (e.g., naloxone),
- Drug identified by JCAHO as being associated with sentinel events, such as opiate agonists and i.v. potassium and other concentrated electrolyte solutions, and
- Restricted-use drugs and agents specified in hospital-approved protocols.

These high-risk orders, proposed by the telepharmacy service and approved by the P&T committee, were identified for three reasons. First, it was important to create a clinical rationale for the nurses to engage the after-hours pharmacist in reviewing new, nonemergency orders before the first dose was given to the patient. Second, hospital staff members needed to focus their efforts on reducing the risk of serious adverse drug events and medication errors. Third, the pharmacy sought to provide the same level of pharmaceutical services during the night shift for patients receiving high-risk drugs as when the pharmacy was open.

The telepharmacy firm maintained dial-up access to the hospital's computerized records, including pharmacy, laboratory, and medical information. Standardized communication tools were instituted, including a nurse–pharmacist communication form, a physician–pharmacist communication form, and a daily shift report for the pharmacy department. The nurse–pharmacy form was designed to provide information exchange via fax for the telepharmacy service, provide pharmacist verification of orders, and maintain documentation. The physician–pharmacist form was designed and used to provide timely, nonemergency information for the patient's physician via fax. The daily shift report established follow-up and peer review with pharmacy staff at the telepharmacy firm and hospital. The communication and shift report forms were not a part of the permanent medical record.

Nurses and physicians were advised to call the telepharmacy service for all initial pharmacy-related concerns and, if necessary, to request the assistance of the on-call pharmacist. The telepharmacy service contacted nurses and physicians directly to clarify orders or to provide timely recommendations or drug information. Patient-specific orders were changed only by the physician directly or by a telephone order to the nurse, with one exception: The telepharmacy service did facilitate changing orders with the nurse for hospital-approved therapeutic interchanges.

Experience with the service

During the first three months of the service, the hospital and the telepharmacy firm assessed reliability, workload, quality improvement, and staff feedback. Quantitative measurements were limited to workload and quality improvement.

Nighttime operations were provided without significant interruption. Remote computer access was disrupted only once, and fax transmission was only occasionally problematic for the telepharmacy staff. The hospital staff reported several orders that could not be sent from a specific patient care unit. The pharmacy department's own workload data for 2001 revealed that about 33 orders per day were generated during the night shift. About one third of the nighttime medication orders were for emergency use. Workload at the telepharmacy service was tracked daily and reported monthly to the hospital. A mean of 12 orders (range, 0–34) were reviewed daily during April to June, 2001. Most orders were submitted by the intensive care and medical–surgical units at the facility. The telepharmacy service reviewed a total of 1039 orders in the first three months. Reports were given to the hospital on (1) the number of orders requiring clarification or intervention, (2) the disposition of orders after clarification or intervention, (3) the reasons for order clarification or intervention, broken down by frequency, (4) the types and frequencies of high-risk orders, and (5) selected case summaries of orders requiring clarification or intervention. The telepharmacy firm did not distinguish between orders requiring clarification (e.g., patient allergy history lacking) and orders requiring intervention (e.g., no administration route specified). Order clarifications (or interventions) were recommended by the pharmacist on the night shift for 226 orders (21.7% of all orders reviewed). A total of 125 of the 226 orders clarified were resolved directly with a physician or nurse during the night shift. Twenty-seven problem orders were not clearly resolved, and 74 problem orders were left for resolution by the day-shift pharmacist.

The most common reasons for intervention by the telepharmacy service involved general order clarification (e.g., inadequate allergy information, lack of indications for use, lack of patient's weight) (n = 42), other problems (e.g., restricted drugs, drugs with hospital protocols or guidelines, operational issues) (n = 41), allergy cautions (n = 35), pharmacokinetic dosing (e.g., dosage adjustment for renal impairment or advanced age) (n = 25), therapeutic interchanges or formulary alternatives (n = 15), and illegible or incomplete orders (n = 11). Less frequent problems included duplicate therapy, drug–drug interactions, incorrect routes, and suspected adverse drug events.

High-risk and targeted medication orders accounted for 29% of all orders reviewed. Common, high-risk drug classes included systemic antiinfectives (50.7%), opiate agonists (30.6%), and hematologic agents (15.3%). All drugs with a narrow therapeutic index were antiinfectives, except digoxin. No chemotherapy orders were reviewed. Orders for concentrated i.v. electrolyte solutions and drugs requiring skin testing were infrequently encountered.

Drug information questions and requests for clinical pharmacy consultations were routinely submitted by the nurses and emergency room staff, with the number of calls per day ranging from zero to four for drug information and zero to two for clinical consultations. The most frequently asked drug information questions were related to drug availability, drug preparation and administration, drug dosing, and compatibility and stability of intravenous preparations. The telepharmacy service contacted the on-call pharmacist two or fewer times per week in the first three months. Occasionally, nurses contacted the on-call pharmacist directly. The on-call pharmacist had to come on site for medication preparation and dispensing once or twice a month.

A summary of selected clinical interventions by the telepharmacy service was provided to the hospital's P&T committee for review and discussion. Table 1 summarizes five such cases. The telepharmacy service allowed timely and appropriate order review, resolved erroneous orders, and promptly supported nurses and medical staff.

Feedback from the hospital staff, including pharmacists, nurses, and physicians, was mostly favorable. Nursing leaders exhibited strong and consistent support for the service and stressed its value to the night nurses in general and the night nursing supervisors specifically. The chief nursing officer noted that, before the service began, the night nursing supervisors were expected to provide medication order review and drug information services that would otherwise be performed by pharmacists on the day and evening shifts. Physician leaders at the hospital suggested that the telepharmacy service be expanded to take oral orders from physicians during the night shift.

On the basis of the first three months of experience with the telepharmacy service, the following changes at SMH were recommended or implemented:

1. Revision of the formulary to include therapeutic interchanges in other drug classes (e.g., nonsedating antihistamines),
2. Modification of drug stocks in night cabinets and automated dispensing machines,
3. Development of i.v. reconstitution guidelines for nurses,
4. Review of policies and procedures for handling missing medications after hours, including pharmacist-directed protocols for managing such drugs,

Table 1.
Summary of Selected Clinical Interventions by Telepharmacy Service

Case Description	Intervention and Rationale	Type of Intervention	High-Risk Category	Resolution
An 81-year-old man with manic-depressive episodes and chronic obstructive lung disease was prescribed albuterol 2 puffs q 4 hr–q 6 hr p.r.n. and Proventil 2 puffs b.i.d. p.r.n.	The nurse was notified that Proventil is the brand name for albuterol. The nurse then contacted the physician.	Duplicate order	No	The physician verified that the order for Proventil was in error. The order was stopped.
A 24-year-old woman with nausea, vomiting, dehydration, aseptic meningitis, and acute sinusitis was prescribed acetaminophen 650 mg i.v. q 6 hr p.r.n.	The nurse was notified, and a physician communication form was sent indicating that acetaminophen is available only in an oral or rectal formulation.	Route change	No	The physician changed the order to acetaminophen 650 mg p.o. q 6 hr p.r.n.
An 83-year-old woman with acute back pain was prescribed ketorolac 30 mg i.m. q 6 hr p.r.n.	The service recommended that the ketorolac dosage be reduced to 15 mg q 6 hr on the basis of the patient's age. The patient was noted to have an aspirin allergy. Ketorolac is contraindicated in patients with hypersensitivity to aspirin. The nurse was notified orally and the physician in writing.	Dosage change and allergy	Yes	The ketorolac dosage was reduced to 15 mg q 6 hr, and the aspirin allergy was noted in the patient's profile as to be clarified.
An 81-year-old man with arthritis of the right hip was prescribed enoxaparin 70 mg s.c. q 12 hr after hip replacement surgery.	A physician communication form was sent, since the order was not written on the preprinted standard post hip-replacement form and more information was needed about the indication. The dosage written is therapeutic, not prophylactic.	Dosage change	Yes	The physician was notified, only two doses were given, and the patient was continued on warfarin 2.5 mg p.o. daily.
A 69-year-old man diagnosed with renal insufficiency and agitation was prescribed meperidine 5–15 mg i.v. q 3 hr p.r.n.	The service recommended discontinuing meperidine in a patient on dialysis, given the potential for adverse effects from the normeperidine metabolite.	Adverse drug reaction	Yes	Meperidine was discontinued.

5. Expansion of the telepharmacy service to prospectively reviewing high-risk medication orders generated in the emergency room,
6. Submission to the service of the monthly updates of P&T committee actions, and
7. Development of i.v. preparation and administration guidelines for labeled and unlabeled uses of new and expensive drugs.

Discussion

The services provided by the nighttime telepharmacy service described in this article go well beyond those offered by the traditional on-call pharmacist. The success of this model requires multidisciplinary support and collaboration. The hospital's policy requiring order review by a pharmacist before administration of routine medications by nurses was for the first time fully enforceable. The hospital found that nurses' compliance with the policy was not 100%, but it improved markedly after the telepharmacy was implemented.

The telepharmacy service emphasized avoidance of medication errors, timely resolution of gaps in clinical data necessary for proper review of new orders and of missing doses, and enforcement of hospital policies and protocols (e.g., therapeutic interchanges and drug-use restrictions). A physician–pharmacist communication form enabled the telepharmacy service to clarify problematic orders on the morning shift more efficiently. (Occasionally, such orders were not verified or approved by the telepharmacy service, and resolution was not accomplished until the morning shift.)

The ASHP Leadership Agenda for 2001–2002 emphasized the roles of telemedicine and telepharmacy in the future of the pharmacy profession.[12] Combining the resources of an after-hours telepharmacy service with traditional on-call pharmacist support appears to be an effective innovation. This new model offers hospitals that do not operate a 24-hour pharmacy the services they need to ensure consistent pharmaceutical services during hours when the pharmacy department is closed. This is one approach to ensuring pharmaceutical services for patients on all shifts as recommended by pharmacy organizations, the American Hospital Association, accreditation bodies, and others.[13]

It is likely that cognitive telepharmacy services and remote order entry services will grow. Expanded use of computerization and automation will further fuel the use of telepharmacy as a supplement to onsite pharmaceutical services, especially after hours. As with other pharmacy practice innovations, issues such as pharmacoeconomics and compliance with professional standards, laws, and regulations will need to be further examined as the telepharmacy model attempts to deliver high-quality care and safety in hospitals when pharmacy departments are closed.

Conclusion

A nighttime telepharmacy service was successfully implemented at a community hospital to provide medication order review, resolution of drug-related problems, drug information and clinical pharmacy services, and other services.

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Evaluating the impact of telepharmacy

PHILIP J. SCHNEIDER

Purpose. The impact of remote pharmacist review of medication orders in three small community hospitals in California was evaluated.

Methods. A longitudinal study was conducted in three community hospitals without 24-hour pharmacy services before and after the implementation of telepharmacy services. Override reports from automated dispensing cabinets were reviewed. Charts were reviewed for errors and potential adverse drug events. Pharmacist interventions during times when the pharmacy was closed were evaluated. Cost estimates were based on a proprietary intervention tracking program. Surveys were administered to staff nurses and pharmacists to assess concerns about medication-use safety and job satisfaction.

Results. The number of times that nurses obtained and administered medications without pharmacist review declined by 35.3% after implementation of the telepharmacy service. There was a significant reduction in the percentage of high-risk medications obtained without a pharmacist review. Three potential adverse drug events were discovered before implementing remote order review versus none in the postimplementation period. The number of pharmacist interventions increased from 15 to 98 per week after implementing remote order review by pharmacists. Estimated cost savings resulting from preventing, identifying, and resolving medication-related problems were $261,109 per hospital in total cost saved or avoided. Nurses' survey scores reflected increased comfort with the medication-use system, patient safety, and job satisfaction.

Conclusion. Remote review of medication orders by pharmacists when the hospital pharmacy was closed decreased the number of potential adverse drug events reported and improved job satisfaction among nurses.

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Medication errors are common and can result in injury to patients if not intercepted and corrected.[1] These errors are pervasive throughout the medication-use process, with most errors that result in patient harm occurring in the prescribing stage.[2] In 1997, a one-year study of prescribing errors in a hospital revealed an overall prevalence of errors of 3.99 per 1000 medication orders.[3] This finding prompted a standard of practice that medication orders should be reviewed by a pharmacist before doses are made available for administration to the patient.[4]

Not all hospitals have pharmacists to review all medication orders. There may be some areas of the hospital to which pharmacists are not assigned (e.g., emergency room, procedure areas, operating rooms, labor and delivery, the entire hospital if the pharmacy is not open 24 hours per day). The percentage of hospitals in which pharmacists do not review medication orders round-the-clock has been decreasing over the years, with only 37% of U.S. hospitals not reviewing orders after-hours in 2011.[5]

Remote review of medication orders is now possible as new technologies such as automated dispensing cabinets and electronic health information systems have emerged. Remote review can be performed at an affiliated hospital with a 24-hour pharmacy service, by a national or regional telepharmacy company, or by an employee pharmacist on call or at a remote location. A 2011 national survey of pharmacy practice in hospitals found that 11.7% of hospitals used an affiliated hospital, 11.1% used a national or regional company, and 1.9% used an off-site employee to review medication orders.[5]

This study was designed to evaluate the impact of telepharmacy services on patient safety, cost, and nurse and pharmacist job satisfaction in three small community hospitals that did not have 24-hour pharmacy services.

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Background

Three community hospitals in California that did not have 24-hour pharmacy services and were planning to implement telepharmacy services (PipelineRx, San Francisco, CA) were identified. Before implementation of the telepharmacy service, medications were obtained either from automated dispensing cabinets or by the night nurse supervisor who entered the pharmacy to obtain the medication. Orders for medications obtained by the night nurse supervisor were reviewed by a pharmacist the next morning to detect potential errors after the fact. In each of these three hospitals, nurses could call the on-call pharmacist at home with questions about medications. The telepharmacy service provided a review of the medication orders before the dose was obtained from an automated dispensing cabinet, so that medication-related problems could be resolved before the dose was obtained and administered to the patient. A pharmacist was also available to answer drug information questions for nurses when the pharmacy was closed.

Methods

To identify potential adverse drug events, records of overrides from automated dispensing cabinets (times when the nurse obtained a dose for administration to an inpatient before the medication order was reviewed by a pharmacist) for two weeks before and after the implementation of telepharmacy services were reviewed, and cases in which a high-risk medication was obtained were identified. High-risk medications were defined based on the Institute for Safe Medication Practices list of high-alert medications[6] as well as those with the potential to cause an adverse drug event based on considerations such as allergies and antidotes that might reflect an adverse drug event (appendix). Medical records for each of these cases were reviewed to determine if an error or adverse drug event had occurred. The following was reviewed: prescribed therapy, dose documented as administered, indication, and medication-related problems. The following medication-related problems were tabulated: drug allergy, overdose, underdose, route of administration, drug interaction, and no indication.

Pharmacist interventions were recorded for one week before implementation of telepharmacy services by asking pharmacists about telephone calls at home and retrospective interventions in the morning after an evening shift. Interventions after implementation of telepharmacy services were derived from records provided by the telepharmacy vendor. Interventions were categorized as follows: allergy addressed, dose issue addressed, drug route addressed, clarification of order, drug information provided, and drug interaction identified.

Estimates of cost avoidance were made using a proprietary intervention tracking system (Quantifi, Pharmacy OneSource, Bellevue, WA). Cost estimates associated with pharmacist interventions in this system are based on previously published studies of the cost of adverse drug events.[7-10]

Nurse and pharmacist attitudes regarding medication-use safety and job satisfaction were determined using a survey administered before and after the implementation of telepharmacy services. Separate survey instruments were developed for nurses and pharmacists. A 10-point Likert scale was used, with low scores indicating low satisfaction and high scores indicating high satisfaction with the system.

Statistical tests used included the z test (when there were sufficient numbers of observations), binomial distribution (when sample sizes were small), and the t test (when sample sizes were not equal). The a priori level of significance was 0.05.

Results

A total of 3888 medications were retrieved by nurses and administered to patients without a pharmacist review of the medication order during the two weeks before (preimplementation) and after (postimplementation) the implementation of telepharmacy services. Of these, 2361 occurred in the preimplementation period versus 1527 in the postimplementation period (difference of 35.3%) (Table 1). Of these 3888 events, 351 high-risk medications were obtained without pharmacist review (228 preimplementation [9.6%] versus 123 postimplementation [8.0%]) ($p < 0.05$, z test). While the availability of remote order entry could have theoretically eliminated overrides entirely, nurses still obtained some medications without order review by the pharmacist after telepharmacy was implemented.

Based on a review of the medical records of all overrides for high-risk medications, 37 medication errors were detected before implementation and 5 errors were detected after implementation of telepharmacy services ($p = 0.0004$, z test). A closer review of the medical records revealed that three potential adverse drug events were discovered in the preimplementation period. Two of these events were related to drugs prescribed for patients with a stated allergy to the drug prescribed. The third case involved a patient with hypokalemia for whom i.v. furosemide was prescribed. In none of these three cases were patients seriously harmed. No potential adverse drug events were detected after implementing the telepharmacy service. The reduction of potential adverse drug events was not statistically significant based on the binomial distribution.

A total of 15 interventions were made by pharmacists during a one-week interval before the telepharmacy service was implemented, either during the evening while oncall or retroactively in the morn-

ing when the pharmacy opened. No such interventions were made by employees of the hospitals after implementation of the service, but 386 interventions were made by the telepharmacy pharmacists during a four-week interval after the service was implemented. Adjusting to compare one-week intervals, there was an increase from 15 interventions per week preimplementation of telepharmacy services to 98 per week postimplementation. This suggests that drug-related problems go unsolved if a pharmacist is not readily available to identify and resolve them. Costs avoided by pharmacist's preventing, identifying, and resolving medication-related problems were an estimated $15,064 weekly or $783,328 annually for the three hospitals evaluated. If each hospital was considered equivalent, this represents an average of $261,109 per year in total costs avoided (Table 2).

A total of 154 surveys related to concerns about the medication-use process, patient safety, and job satisfaction were completed by nurses and pharmacists before and after implementing the telepharmacy service (Tables 3 and 4). Survey results were available from two of the three hospitals studied. In the survey responses, higher scores reflect less concern about medication errors and patient safety and increased job satisfaction. Average scores for the nurses increased from 6.6 before implementation of telepharmacy services to 7.3 postimplementation ($p < 0.05$, Welch's t test). Average scores for pharmacists decreased from 7.8 preimplementation to 5.4 postimplementation ($p < 0.05$, Welch's t test).

Discussion

The benefits of telepharmacy have been widely described in the medical literature. Boon[10] reported a reduction in the amount of time nurses spent locating medications and entering the pharmacy after-hours after the implementation of telepharmacy services in a critical access hospital. Witkowski[11] described the implementation of a decentralized "cartless" drug distribution system using automated dispensing cabinets and remote order review by pharmacists. One of the improvements noted was a faster

Table 1.
Results of Chart Review Before and After Remote Order Entry

Drug	Screening Criteria	Before Remote Order Entry		After Remote Order Entry	
		Charts Reviewed ($n = 227$)	Errors Detected ($n = 37$)	Charts Reviewed ($n = 123$)	Errors Detected ($n = 5$)
Ampicillin	Allergy	12	0	19	0
Augmentin	Allergy	0	0	1	0
Carvedilol	Prescribed therapy	0	1	0	0
Cefazolin	Allergy	41	7	22	0
Cefepime	Allergy	0	0	1	1
Cefoxitin	Allergy[a]	2	2	5	1
Ceftriaxone	Allergy	9	1	4	0
50% Dextrose injection	Alerting order	3	0	0	0
Digoxin	Dose	4	1	5	0
Furosemide	Potassium[a]	38	4	20	2
Gentamicin	Dose	1	1	7	0
Heparin	Dose	8	2	1	0
Hydralazine	Look-alike	8	4	7	1
Hydrocortisone	Alerting order	0	0	0	0
Meropenem	Allergy	0	0	5	1
Methylprednisolone	Alerting order	16	2	0	0
Penicillin	Allergy	3	3	7	0
Phytonadione	Alerting order	27	2	0	0
Piperacillin–tazobactam	Allergy[a]	21	3	1	0
Potassium chloride	Dose/rate	1	0	0	0
Sodium polystyrene sulfonate	Alerting order	1	0	0	0
Spironolactone	Potassium	9	0	0	0
Tobramycin	Dose	1	0	0	0
Vancomycin	Dose	19	3	7	0
Warfarin	Dose/interaction	2	0	0	0

[a]One error was detected in the preimplementation group.

turnaround time, with most doses available for administration within two to three minutes after the pharmacist verifies an order.

Pickette et al.[12] described the implementation of a standard pharmacy clinical practice model that included remote order entry through a telepharmacy program operated by an urban tertiary care center. Interventions associated with cost avoidance were documented using a Web-based, clinical documentation tool. They demonstrated a reduction in drug expense of $12.89 per case-mix-adjusted patient-day over time, representing an annual cost avoidance of $984,321 at a 623-bed tertiary care community teaching hospital and $611,595 at a 200-bed community hospital.

Table 2.
Comparison of Costs Avoided Before and After Remote Order Entry

	Before Remote Order Entry		After Remote Order Entry			
Intervention	No. Interventions per Week	Cost Avoided per Week, $	Actual No. Interventions per Month	Cost Avoided per Month, $	Estimated No. Interventions per Week	Cost Avoided per Week, $
Allergy	2	306	43	6,578	10.75	1,644
Clarification	9	1,377	53	8,109	13.25	2,027
Consultation	0	0	74	11,322	18.50	2,830
Dose	1	153	57	18,778	14.25	4,695
Drug	2	306	7	765	1.75	191
Duplication	0	0	21	3,213	5.25	803
Duration	0	0	2	306	0.50	76
Formulary	0	0	24	3,672	6.00	918
Formulation	0	0	1	153	0.25	38
Frequency	1	153	33	5,059	8.25	1,265
Interaction	0	0	2	306	0.50	76
Laboratory test	0	0	8	1,224	2.00	306
Preferred drug	0	0	57	8,721	14.25	2,180
Route	0	0	10	1,230	2.50	308
Total	15	2,295	392	69,436	98.00	17,359

Table 3.
Survey Results for Nurses Before and After Implementation of Telepharmacy Services[a]

	Hospital 1		Hospital 2		Average of Both Hospitals	
Survey Item	Before	After	Before	After	Before	After
I can obtain medications for my patient in a timely manner.	5.0	7.6	6.1	5.3	5.5	6.4
I am concerned about administering a dose of medication to my patient before a pharmacist review of the medication order.	5.9	8.0	5.3	5.9	5.6	7.0
I would like to have a pharmacist answer drug information questions.	7.0	8.7	8.9	9.3	8.8	9.0
The current medication-use system is safe.	6.1	7.9	6.7	6.6	6.4	7.2
I spend too much time with medication-related activities in my practice.	5.3	6.5	6.7	4.0	6.0	5.2
Overall, I am satisfied with pharmacy services at this hospital.	5.3	8.0	5.3	6.9	5.3	7.4
I am satisfied with my job.	8.0	8.7	8.6	9.4	8.3	9.0
Average	6.1	7.9	8.8	6.8	6.6	7.3

[a]Nurses were asked to rate their agreement with each statement using a 10-point scale, where 1 = low satisfaction and 10 = high satisfaction. These statements relate to times when the pharmacy is closed.

Garrelts et al.[13] evaluated the impact of telepharmacy in a multihospital health system and found that order processing was reduced from 26.8 to 14 minutes, stat order processing was shortened from 11.6 to 8.8 minutes, and the number of clinical interventions made increased by 42%. Further, a net estimated annualized savings of $1,132,144 was realized, and nurses' job satisfaction improved.

In his work on managing the risk of organizational accidents, Reasons[14] identified the factors by which hazardous conditions result in incidents in which harm occurs. Within systems of work, there are weaknesses that create the potential for harmful events when there are hazardous conditions. These weaknesses are termed latent conditions and active failures.[14] Studies of medication errors and adverse drug events have clearly revealed that medication use is a hazardous system and that harm occurs too often.[2,7] One of the methods for reducing the chance of accidents that result in harm is to create defenses: checks in the system to identify and correct latent conditions and active failures before mistakes become harmful events.

Having pharmacists review medication orders to identify potential harm before medications are administered to patients is a proven defense that is an evidence-based component to any medication-use system. Historically, this has required a pharmacy to operate 24 hours per day, 7 days per week and 365 days per year. This is only the case in approximately one third of U.S. hospitals.[5] Expenses and the availability of pharmacists have limited the growth of round-the-clock pharmacy services, particularly in smaller hospitals. Technologies such as automated dispensing cabinets and the availability of electronic health records have opened the door to services that resolve this problem.

This study was designed to determine the impact of implementing telepharmacy services that provide pharmacist review of medication orders before a dose is administered to a patient. Patients are at risk when a dose of a high-risk medication is prepared and administered before the order is checked by a pharmacist. By reducing the frequency of this unsafe practice, medication errors and adverse drug events are less likely. A reduction in adverse drug events results in avoiding the costs associated with the treatment of them and increases in length of stay. These costs have been estimated to be between $2013 and $5857 per event.[8,9,15] Concerns about patient safety can erode job satisfaction for nurses and pharmacists, affecting retention and recruitment. The results of this study demonstrated improvements in patient safety, costs avoided, and job satisfaction for nurses after implementation of telepharmacy services when the pharmacy was closed.

This study had several limitations. Despite reviewing a considerable number of medication records, no adverse drug events were detected. In two cases of patients receiving drugs

Table 4.
Survey Results for Pharmacists Before and After Implementation of Telepharmacy Services[a]

Survey Item	Hospital 1		Hospital 2		Average of Both Hospitals	
	Before	After	Before	After	Before	After
I am concerned about delays in the start of treatment after a drug order.	7.7	3.5	8.5	6.0	8.1	4.8
I worry about medications being administered to patients before a pharmacist review of the order.	9.4	3.0	9.5	7.3	9.4	5.2
I do not like reviewing medication orders after one or more doses have already been administered to patients.	7.2	5.0	6.8	5.7	7.0	5.0
I worry about patient safety when the pharmacy is closed.	8.3	4.0	9.1	6.0	8.7	5.0
I do not like to get called at home about medication-related problems when the pharmacy is closed.	6.4	5.5	8.2	2.3	8.2	3.9
Overall, I am satisfied with pharmacy services at this hospital.	6.6	6.5	5.6	5.0	6.1	5.8
I am satisfied with my job.	7.7	8.5	7.5	6.3	7.6	7.4
Average	7.6	5.1	7.9	5.5	7.8	5.4

[a]Pharmacists were asked to rate their agreement with each statement using a 10-point scale, where 1 = low satisfaction and 10 = high satisfaction. These statements relate to times when the pharmacy is closed.

to which they had an allergy history documented, the patients had either no allergic reaction or a minor rash. In both cases, alternative therapy was prescribed after the first dose was administered. Allergy histories are not always accurate, but an order for a medication to which a patient has an allergy documented in the medical record should be evaluated, and, except for very special circumstances, alternative therapy should be suggested. Fortunately, despite the common frequency of medication errors, very few of these errors actually result in an adverse drug event.[16] Studies of medication safety over shorter periods of time are therefore not likely to detect actual injury resulting from an error.

Annualized estimates of costs avoided were based on two two-week intervals. There could have been changes in census, case mix, severity, staffing, and other factors that affected the validity of these extrapolations. While longitudinal studies have their limitations, the design and conduct of a more-rigorous, randomized controlled trial would be a challenge and require careful matching of hospitals to ensure comparability that is easier to assume by performing this evaluation in the same hospital. Evaluating the impact of telepharmacy at only one time period soon after implementation of telepharmacy services may not reflect long-term changes.

Cost estimates are difficult to document. Because no actual adverse drug events were detected, an actual cost savings could not be determined. Based on larger population studies, estimates of the costs avoided by correcting medication errors before an event occurs have been derived. The proprietary system used to estimate cost avoidance is an example of such a system.

Conclusion

Remote review of medication orders by pharmacists when the hospital pharmacy was closed decreased the number of potential adverse drug events reported and improved job satisfaction among nurses.

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Appendix—List of high-risk medications used to identify cases to include in the analysis

Ampicillin
Augmentin
Carvedilol
Cefazolin
Cefepime
Cefoxitin
Ceftriaxone
50% Dextrose injection
Digoxin
Furosemide
Gentamicin
Heparin
Hydralazine
Hydrocortisone
Meropenem
Methylprednisolone
Penicillin
Phytonadione
Piperacillin–tazobactam
Potassium chloride
Sodium polystyrene sulfonate
Spironolactone
Tobramycin
Vancomycin
Warfarin