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Pharmacist Staffing and the Use of Technology in Small Rural Hospitals: Implications for Medication Safety

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A partnership of the University of Minnesota Rural Health Research Center and the University of North Dakota Center for Rural Health

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TABLE OF CONTENTS

Tables and Figures

EXECUTIVE SUMMARY

This paper reports the results of a national study that assesses the capacity of rural hospitals to implement medication safety practices, with particular focus on pharmacist staffing and the availability of technology. The primary data for the project was collected through a telephone survey of a national random sample of small rural hospitals conducted from March to May 2005. A total of 387 hospitals responded out of 409 eligible hospitals, for a response rate of 94.6%. The survey respondents included pharmacists (89%) and Directors of Nursing (11%). For the analyses, the survey data were linked to secondary data on hospital organizational characteristics, utilization, level of rurality, financial indicators, and case mix.

To fill gaps in current knowledge about pharmacist staffing and the use of technology in rural hospitals, the survey data were first analyzed using descriptive statistics. Chi-square tests were used to test the significance of bivariate relationships between key variables. Second, multivariate analyses were conducted to examine the relationships between hospital organizational characteristics and financial indicators and 1) the amount of pharmacist staffing; 2) the use of pharmacy computers for medication safety activities; and 3) the implementation of medication safety practices.

The results of this study indicate that many small rural hospitals have limited hours of on site pharmacist coverage. In hospitals with limited pharmacist coverage, pharmacists may not be able to take an active leadership role or spend significant time on medication safety activities. The amount of pharmacist staffing is significantly and positively related to patient volume, case mix, JCAHO accreditation, and financial status.

Technology use varies by type of technology and hospital characteristics, with 77% of the hospitals reporting use of a pharmacy computer for one or more clinical purposes, but only 3% of hospitals using bar code technology for bedside medication administration. Factors that are significantly and positively related to the use of a pharmacy computer for clinical purposes include patient volume, JCAHO accreditation, and financial status.

Cost is a major reason given by survey respondents for not implementing specific medication safety-related technologies. Other reasons for not using technology include computer system and software problems; limited pharmacy hours/pharmacist time; and belief that the hospital is too small and technology is not needed or not a priority. These results support a continuation of efforts to encourage the use of information technology in rural hospitals, such as the Agency for Healthcare Research and Quality health information technology initiative, which is targeting grant funds and other resources to rural health care systems. Investment in health information technology also is a key component of the Institute of Medicine Committee on the Future of Rural Health Care's strategy to address quality challenges in rural communities.

The majority of hospitals have implemented key medication safety practices including a do-not-use-abbreviations list, a policy of using two patient identifiers for administering medications, a policy of having two health professionals independently check doses of high alert medications, and a high alert drug list. However, only half of the hospitals have implemented all four practices. Three factors are significantly and positively related to implementation of the four practices: JCAHO accreditation; having a medication safety or patient safety committee with active pharmacist participation; and net operating margin.

The survey findings suggest that implementation of protocols related to medication use and key medication safety practices are areas where small rural hospitals could improve. While achieving full compliance with medication safety practices is challenging, all hospitals should be working towards implementation, and multiple resources are available on the Internet to help hospitals assess and improve their medication use systems (see list below).

Of particular interest to policymakers, two factors - JCAHO accreditation and hospital financial status - are significantly related to pharmacist staffing, use of a pharmacy computer, and implementation of four key medication safety activities. Improving implementation of key medication safety practices among non-accredited hospitals will likely require a comprehensive approach that includes increasing awareness of the importance of implementing the practices, as well as targeted provision of technical assistance and financial incentives.

The finding of significant relationships between financial status and pharmacist staffing, use of technology, and implementation of medication safety practices supports a continuation of Medicare policies to help ensure financial stability for small rural hospitals through cost-based reimbursement as a means of helping to support quality and patient safety activities.

Figure 1

Selected Resources to Help Hospitals Assess and Improve Medication Use Systems

American Society of Health-System Pharmacists (ASHP). "ASHP Best Practices Self-Assessment Tool." 2005. Available at http://www.ashp.org/practicemanager/self-assessment.cfm?cfd=1088724&CFToken=4754166

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ISMP. "ISMP's List of High-Alert Medications." 2005. http://www.ismp.org/Tools/highalertmedications.pdf

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INTRODUCTION

Nationally, medication errors account for a large proportion of adverse events in hospitals (Institute of Medicine, 2000). Adverse drug events (ADEs) are associated with increased lengths of stay, additional costs, and increased mortality among hospitalized patients (Bates et al., 1997; Classen et al., 1997). Research has shown that pharmacists can play an important role in implementing medication safety initiatives in hospitals (Kaushal and Bates, 2001; USDHHS, 2000). Computer programs that allow pharmacists to check for appropriate dosing, contraindications, and drug interactions have also been demonstrated to significantly reduce ADEs (AHRQ, 2001; Silverman et al., 2004).

Several national and state level quality organizations have recommended that hospitals implement medication safety practices addressing the roles of pharmacists, other health care professionals and technology in preventing medication errors. The Institute for Safe Medication Practices (ISMP) developed a comprehensive self-assessment tool for hospitals to assess their medication use processes, and has worked with the American Hospital Association (AHA) to disseminate it to hospitals. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) revised its accreditation standards to reflect a greater focus on medication safety, and medication safety is the major focus of three of its 2005 National Patient Safety Goals (JCAHO, 2004a). The National Quality Forum (NQF) endorsed several medication-related "safe practices," and Leapfrog advocates adoption of Computerized Physician Order Entry systems.

Federal and state policymakers are encouraging or, in some cases, requiring hospitals to implement medication safety practices. The Agency for Healthcare Research and Quality is funding several initiatives to plan, implement, and demonstrate the value of health information technology to improve patient safety (AHRQ, 2004). The Food and Drug Administration has required pharmaceutical companies to add bar-codes on medication packaging (USDHHS, 2004). The state Legislature required each California hospital to submit a plan to substantially reduce medication-related errors, and implement it by January 1, 2005 (Spurlock et al., 2003).

Medication safety is clearly an important quality issue for rural hospitals. However, rural hospitals face special challenges implementing medication safety practices in terms of their staffing, financial and technical resources. Patient safety organizations generally have taken two approaches to rural hospitals: 1) exempting them from standards (e.g., rural hospitals were exempted from the Leapfrog CPOE standard and the technology portion of the California medication safety requirement); or 2) assuming that rural hospitals have or will be able to obtain sufficient staffing and technology to implement the standards [e.g., NQF safe practice # 5 recommends "active participation" by pharmacists in the medication-use process, minimally defined as being available for consultation with prescribers on medication ordering, interpretation and review of medication orders, preparation, dispensing, administration and monitoring of medications (NQF, 2003)].

The Medicare Conditions of Participation for hospitals do not specify a minimum level of pharmacist staffing. They require a hospital to have "pharmaceutical services that meet the needs of the patients," and "a pharmacy directed by a registered pharmacist or a drug storage area under competent supervision" (42CFR482.25). The regulations further specify that "a full-time, part-time, or consulting pharmacist must be responsible for developing, supervising, and coordinating all the activities of the pharmacy services," and that the pharmaceutical service must have "an adequate number of personnel to ensure quality pharmaceutical services, including emergency services." The Conditions of Participation for CAHs do not address pharmacist staffing. CAHs are required to have "policies for the storage, handling, dispensation, and administration of drugs and biologicals" and "a drug storage area that is administered in accordance with accepted professional principles" (42CFR485.635).

JCAHO accreditation standards for hospitals and for CAHs encompass the respective Medicare Conditions of Participation requirements for the two types of hospitals, but are more comprehensive. Accredited hospitals and CAHs must meet JCAHO medication management standards, which assign specific roles and responsibilities to the hospital pharmacist and require accredited organizations to develop processes for managing high-risk medications (Rich, 2004). They must also implement JCAHO's National Patient Safety Goals, including requirements to use two patient identifiers for administering medications and to implement a standardized list of abbreviations that are not to be used in the organization (JCAHO, 2004a, 2005b).

Although many medication safety recommendations assume that a hospital will have a certain level of pharmacist staffing and technological capacity, national data on pharmacist staffing and the availability of technology to support medication safety initiatives in rural hospitals are limited. The AHA Annual Survey of Hospitals does not ask about pharmacist staffing. The American Society of Health-System Pharmacists (ASHP) conducts an annual mail survey of pharmacy practice in hospital settings; however, response rates tend to be lower for hospitals under 50 staffed beds (32% in 2004) and rural hospitals (38% in 2004) than larger and urban hospitals (Pedersen, Schneider, and Scheckelhoff, 2005). ISMP has conducted two rounds of hospital medication safety self-assessment surveys in 2000 and 2004. In 2000, only 23 percent of hospitals responded, and respondents tended to be larger hospitals (Smetzer et al., 2003). National data from the 2004 self-assessment surveys are not yet publicly available (ISMP, 2005a).

The surveys that have been conducted indicate that many small rural hospitals have part-time pharmacists. The median number of pharmacist hours per week on site in Critical Access Hospitals (CAHs) is 20 hours, and 63 percent of the hospitals have a pharmacist on site for less than 40 hours per week (Casey, Moscovice, and Klingner, 2004). Only four of the 77 rural hospitals in Idaho, Nevada, Utah and Washington surveyed by Stevenson et al. (2004) have 24 hour onsite pharmacist coverage; coverage for the remaining hospitals is provided for a median of 26 hours per week. A survey of rural retail pharmacies in Minnesota, North Dakota, and South Dakota found that a substantial number of rural pharmacists provide pharmacy services part-time in

hospitals and nursing homes in addition to their retail pharmacy responsibilities (Casey, Klingner, and Moscovice 2002).

PURPOSE

The purpose of this project was to: 1) assess the capacity of rural hospitals to implement medication safety practices that reduce the likelihood of serious adverse drug events, and 2) to identify factors that facilitate successful implementation of medication safety practices in rural hospitals. The project focused on two key aspects of rural hospitals' capacity to implement medication safety initiatives: pharmacist staffing and the availability of technology. The study addressed the following research questions:

- What is the current capacity of small rural hospitals to implement medication safety practices, in terms of pharmacist staffing and the availability of technology such as computerized pharmacy systems and bar-code scanners?

- What key facility and environmental factors – such as hospital size, system membership, accreditation, and degree of rurality – are related to rural hospitals' pharmacist staffing, their use of technology, and implementation of medication safety practices?

METHODS

Survey of Rural Hospitals

The primary data for this project were collected through a national telephone survey of rural hospitals. The survey was developed based on a review of the literature on medication safety practices in hospitals and input from a rural hospital pharmacist advisory group that included five practicing rural hospital pharmacists. Survey questions addressed pharmacy staffing, use of technology, implementation of protocols and medication safety practices, and medication safety priorities.

A sample of 400 rural hospitals with 100 or fewer staffed beds in the FY 2003 American Hospital Association Annual Survey database was randomly selected to participate in the survey. The sample was limited to non-federal, general medical/surgical hospitals. (Approximately 82% of rural hospitals have 100 or fewer staffed beds. Rural hospitals with more than 100 beds are more similar to urban hospitals in terms of their scope of services and resources and thus were of less interest for this study.) This sample represents one-fifth of all rural hospitals of this size and gave us policy-useful levels of statistical power to test our hypotheses concerning differences in the proportions of hospitals with key variables of interest across different size ranges.

An initial letter explaining the importance of the project was sent to the director of pharmacy at each hospital. The survey interviews were conducted by the Survey

Research Center at the University of Minnesota. The vast majority of respondents were pharmacists, including pharmacy directors (82%) or another pharmacist who worked in the hospital (7%). In 11 percent of the hospitals, the Director of Nursing was interviewed usually because the pharmacist worked at the hospital so little time that it was not practical to interview him or her.

The survey instrument was pre-tested with ten hospitals in February 2005 and revised based on the pre-test results. Fielding of the final survey began in early March and was completed in early May 2005. Nine hospitals were added to the sample to replace refusals prior to the deadline for the survey. A total of 387 hospitals responded out of 409 eligible hospitals, for a response rate of 94.6 percent. The response rate for CAHs was slightly lower (92.3%) than for non-CAHs (96.4%).

Secondary Data

For the analysis, the survey data were linked to four sources of secondary data: 1) data on hospital organizational characteristics and utilization from the American Hospital Association Annual (AHA) Survey; 2) data from the USDA Economic Research Service on the level of rurality for the county where the hospital is located; 3) Medicare cost report financial data from the Centers for Medicare and Medicaid Services; and 4) the hospital's case mix index for Medicare discharges from CMS.

The Fiscal Year 2003 AHA data used included measures of hospital size (staffed beds, number of admissions and number of inpatient days for the total facility, hospital unit and long term care unit, if any); system membership; Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) accreditation status; ownership (grouped into public/non-federal government, private non-profit, and for-profit); critical access hospital (CAH) status; and registered nurse FTE staffing. The data on system membership and JCAHO accreditation were updated using 2005 AHA data available through the U.S. News and World Report hospital data website (U.S. News and World Report, 2005).

The USDA data used were the 2003 county Urban Influence Codes (USDA, 2004). Non-metropolitan (rural) counties are assigned to one of 10 UICs based on their population size, adjacency to metropolitan or larger non-metropolitan areas, and whether or not they have their own town of at least 2,500 residents. To ensure sufficient sample sizes for the multivariate analyses, counties were grouped into two categories based on whether or not they are adjacent to a metropolitan county.[1]

The Medicare cost report data used included measures of operating income, operating margin, other (non-operating) income, and overall profit margin. These data were from

[1]The initial survey sample was selected using non-metropolitan county designations in the 2003 Area Resource File. Based on the USDA Economic Research Service updated 2003 UICs, 39 surveyed hospitals are now located in counties designated as metropolitan, including several CAHs that are requesting reclassification to rural by the federal government. These hospitals were grouped with those in rural adjacent counties for purposes of the analyses.

the most recent fiscal year available for each hospital. Of the 387 hospitals in the survey, 348 hospitals had cost report fiscal year end dates that ranged from June 30, 2003 to June 30, 2004. Thirty-eight hospitals had earlier dates and one hospital did not have cost report data available for FY 2002 or later.

The hospital's case mix index is a measure of patient acuity. It represents the average diagnosis-related group (DRG) relative weight for the hospital, and is calculated by summing the DRG weights for all Medicare discharges and dividing by the number of discharges. Of the 387 hospitals in the survey, 235 hospitals had case mix data for FY 2004, 133 hospitals did not have data for FY 2004 or FY 2003 but did have FY 2002 data, and 19 hospitals did not have case mix data for FY 2002, 2003 or 2004. Since the case mix indexes were highly correlated over this time period (.85 for 2002 and 2004), FY 2002 data were used for hospitals that did not have FY 2004 or FY 2003 data. (The case mix index is created as part of the prospective payment system, so hospitals that become CAHs and are no longer paid under the PPS system do not have case mix index data after conversion. The 19 hospitals without data are CAHs that converted early in the program.)

Data Analysis

Statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC) and Stata version 9 (Stata Corp, College Station, TX). To fill gaps in current knowledge about pharmacist staffing and the use of technology in rural hospitals, the survey data were first analyzed using descriptive statistics. Chi-square tests were used to test the significance of bivariate relationships between key variables. Second, multivariate analyses were conducted to examine the relationships between hospital organizational characteristics and financial indicators and 1) the amount of pharmacist staffing; 2) the use of pharmacy computers for medication safety activities; and 3) the implementation of medication safety practices. Specifically, we used an ordinary least squares regression model for the pharmacist staffing response variable, and logistic regression models for the use of computers and implementation of safety practices response variables.

In all three models a number of covariates could be expected to be and were in fact highly correlated, since to a large degree they all reflect the 'scale' of operation of the facility. Because of this, we explored a number of alternative specifications for subsets of these variables to reduce the amount and consequences of such multicollinearity. For the financial variables, because dollar amounts of net operating income and "net other (non-patient) revenue" were highly correlated over the sample hospitals, we selected the net operating margin and the dollar amount of "net other (non-patient) revenue." For the same reasons, we also used the ratio of RN FTEs to total inpatient days. Among the included covariates for the three models, correlation coefficients for the independent variables are below 0.5, indicating that multicollinearity is not a problem. The highest correlations are between hospital inpatient days and case mix (.49); case mix and accreditation (.49); hospital inpatient days and accreditation (.48); and accreditation and having a pharmacist actively participate on a medication/patient safety committee (.48).

DESCRIPTIVE RESULTS

This section presents the descriptive results of the survey, including data on pharmacy staffing, use of technology, implementation of protocols and medication safety practices, and medication safety priorities.

Characteristics of Survey Hospitals

Forty-three percent of the responding hospitals have 25 or fewer staffed beds; 33 percent have between 26 and 50 beds, and 25 percent have over 50 beds (Table 1). Ten percent of the hospitals are for-profit; the rest are government (46%) or not-for-profit (44%) hospitals. Forty-three percent are designated critical access hospitals. Forty percent are members of multi-hospital systems, and 47 percent are accredited by the Joint Commission on Accreditation of Healthcare Facilities (JCAHO).

Management and Staffing of Hospital Pharmacy

Survey respondents were asked about management of the hospital and staffing by pharmacists and pharmacy technicians. The vast majority of small rural hospitals surveyed (89.9%) report that their pharmacy is managed internally by the hospital. A small number of hospitals report contracting for pharmacy services with a pharmacy management company (7.8%) or another hospital (1.6%).

Respondents were asked how many pharmacists and pharmacy technicians regularly worked at the hospital; how many hours each worked; and if the hospital had any vacancies in these positions. The survey also asked how many hours per week the hospital had a pharmacist on site, whether the hospital shared one or more pharmacists with another hospital, and how medical and nursing staff consulted with a pharmacist when no pharmacist was on site.

Over one-third of the hospitals (35%) report having a pharmacist on site for less than 40 hours per week, including 31 hospitals (8%) where a pharmacist is on site for two hours or less per week (Table 2). Slightly more than half (52%) have more than 40 hours of on site coverage, while 52 hospitals (13%) have 40 hours of on site coverage. Based on a 40 hour work week, 46 percent of the hospitals have 1.0 or less full time equivalent (FTE) pharmacists. Seventeen percent of hospitals share a pharmacist with another hospital, and 13 percent have one or more vacant pharmacist positions. Sharing of pharmacists is most common among smaller hospitals; one-third of the hospitals with 0.5 or less FTE pharmacists share a pharmacist with another hospital. The vast majority (88%) of hospitals rely on a staff pharmacist on call as their primary means of after-hours pharmacist consultation (Table 3).

Eighty-four percent of hospitals employ one or more pharmacy technicians (Table 4). Based on a 40 hour work week, 33 percent of the hospitals have 1.0 or less full time equivalent (FTE) pharmacy technicians. Seven percent of hospitals report one or more pharmacy tech vacancies.

Table 1

Characteristics of Survey Hospitals (n = 387)

	Number (Percent) of Hospitals
Staffed Hospital Beds[1]	
25 or fewer beds	165 (42.6%)
26 – 50 beds	126 (32.6%)
Over 50 beds	96 (24.8%)
Average Daily Census (inpatients only, including swing beds, but not nursing home beds) (n = 382)	
8 or fewer	116 (30.0%)
9 to 15	94 (24.3%)
16 to 25	91 (23.5%)
Over 25	86 (22.2%)
Ownership[1]	
Government, non-federal	178 (46.0%)
Non-government, not-for-profit	169 (43.7%)
For profit	40 (10.3%)
Census Division[1]	
Northeast	27 (7.0%)
Midwest	156 (40.3%)
South	140 (36.2%)
West	64 (16.5%)
Critical Access Hospital designation[1]	167 (43.2%)
JCAHO accredited[2]	181 (46.8%)
System membership[2]	156 (40.3%)

[1]Based on data from the AHA FY 2003 Annual Survey of Hospitals. A critical access hospital (CAH) can have up to 25 beds designated as either acute care or swing beds. The number of CAHs is slightly greater than the number of hospitals that reported 25 or fewer staffed beds; this may be either because some facilities included non-acute care or swing beds in their bed count or because the number of beds was obtained from previously reported data or estimated for non-respondents in the AHA Survey.
[2]Accreditation and system membership updated with 2005 AHA data from the *US News and World Report* Directory of America's Hospitals.

Table 2

Pharmacist Staffing
(n = 387)

	Number of Hospitals (Percent)
Number of pharmacists who work at the hospital	
One	184 (47.6%)
Two	71 (18.4%)
Three	72 (18.6%)
Four	30 (7.8%)
Five or more	30 (7.8%)
Pharmacist Full Time Equivalents (FTEs) (based on a 40 hour work week)	
0.5 FTE or less	107 (27.7%)
0.6 to 1.0 FTE	69 (17.8%)
1.1 to 2.0 FTEs	77 (19.9%)
2.1 to 3.0 FTEs	78 (20.2%)
More than 3.0 FTEs	56 (14.5%)
Hours per week that the hospital has at least one pharmacist on site	
2 hours or less	31 (8.0%)
3 - 10 hours	51 (13.2%)
11 - 20 hours	28 (7.3%)
21 - 39 hours	24 (6.2%)
Total less than 40 hours	134 (34.6%)
40 hours	52 (13.4%)
41-50 hours	40 (10.4%)
51-60 hours	37 (9.6%)
61-70 hours	57 (14.7%)
71-80 hours	32 (8.3%)
More than 80 hours	35 (9.1%)
Total more than 40 hours	201 (52.1%)
Hospital shares pharmacist with another hospital	66 (17.1%)
Hospital has vacant pharmacist position(s)	51 (13.2%)
One full-time position	32
Two or more full-time positions	6
A part-time position	14

Table 3

Arrangements for After-Hours Pharmacist Consultation (n = 386)[1]

	Number of Hospitals (Percent)
Primary means of consultation	
Staff pharmacist on call	341 (88.3%)
Pharmacist from a contract pharmacy service	15 (3.9%)
Pharmacist at another hospital	17 (4.4%)
Retail pharmacist	8 (2.1%)
Another arrangement	5 (1.3%)

[1]One hospital reported 24/7 pharmacist coverage.

Table 4

Pharmacy Technician Staffing (n = 387)

	Number of Hospitals (Percent)
Number of pharmacy technicians who work at the hospital	
None	64 (16.5%)
One	103 (26.6%)
Two	79 (20.4%)
Three	62 (16.0%)
Four	41 (10.6%)
Five or more	38 (9.8%)
Pharmacy technician full time equivalents (FTEs) (based on a 40 hour work week) (n = 323)	
Less than 1.0 FTE	42 (13.0%)
1.0 FTE	64 (19.8%)
1.05 to 2.0 FTEs	86 (26.6%)
2.1 to 3.0 FTEs	63 (19.5%)
More than 3.0 FTEs	68 (21.1%)
Pharmacy technician vacancies (n = 323)	22 (6.8%)
One full-time position	5
Two full-time positions	1
One part-time position	16
Two part-time positions	1

Medication Dispensing

The median number of monthly medication doses dispensed by the hospital pharmacy is 10,000 (Table 5). Forty-one percent of pharmacies routinely dispense take-home medications for emergency or other outpatients, and 16 percent dispense medications for nursing home patients. The use of unit doses whenever possible is recommended by ASHP and is a JCAHO standard (ASHP, 1995; Rich, 2004). In 55 percent of the surveyed hospitals, respondents report that all oral medications for inpatients are dispensed in unit dose form. Reasons given for not dispensing all oral medications in unit dose form include that unit doses are not available for some medications; unit doses are too expensive; and the pharmacist does not have time to repackage medications into unit doses. Respondents that report dispensing all oral medications in unit dose form are significantly more likely to be JCAHO accredited and to be members of multi-hospital systems.

Purchasing intravenous solutions pre-mixed or having a pharmacist prepare i.v. admixtures reduces the potential for medication errors and is a JCAHO medication management standard (Rich, 2004). In the surveyed hospitals, the average percentage of intravenous solutions that is purchased pre-mixed is 49 percent; prepared by a pharmacist is 24 percent; and prepared by a nurse is 26 percent. Automated medication dispensing cabinets are used in 43 percent of hospitals; the majority of these cabinets have open access bins and drawers that may allow a nurse to remove more than the specified drug. Over half of the hospitals do not provide any chemotherapy, while 30 percent provide it at least once a week.

Implementation of Protocols and Medication Safety Practices

Implementation of drug protocols that include dosing scales as appropriate is most common for emergency medications (87%), anti-coagulants (86%), and insulin (73%) (Table 6). Less than half of the hospitals that provide chemotherapy have implemented protocols for chemotherapy drugs. Factors that are significantly related to implementation of chemotherapy protocols include the volume of chemotherapy provided, having a medication safety committee in the hospital and having active pharmacist participation in the committee. Similarly, implementation of protocols for pre-surgical antibiotic prophylaxis is significantly related to the annual volume of surgical procedures done in the hospital, having an infection control committee, and having active pharmacist participation in the committee.

The survey respondents were asked if their hospital has implemented four medication safety practices: 1) a do-not-use-abbreviations list; 2) a policy of using two patient identifiers for administering medications; 3) a high alert drug list; and 4) a policy of having two health professionals independently check doses of high alert medications. As of 2003, hospitals seeking JCAHO accreditation were expected to implement the first two practices to comply with JCAHO National Patient Safety Goals (JCAHO, 2004a; 2005b). JCAHO standards require accredited organizations to develop processes for managing high-risk medications (Rich, 2004). The National Quality Forum endorsed set

Table 5

Medication Dispensing
(n = 387)

	Mean	Median
Number of medication doses dispensed in last month (n = 268)	15,691	10,000
Percent of IV solutions used in the hospital that are: (n = 379)		
Purchased pre-mixed	49.2%	
Prepared by a pharmacist	23.7%	
Prepared by a nurse	26.3%	
Prepared by other means	0.8%	

	Number of Hospitals (Percent)
Hospital pharmacy routinely dispenses the following types of medications:	
"take home" medications for ER or other outpatients	158 (40.8%)
retail-type prescriptions for clinic patients	17 (4.4%)
medications for nursing home patients	60 (15.5%)
All oral medications for hospital inpatients are dispensed in unit dose form	212 (54.8%)
Reasons why hospitals do not dispense all oral medications in unit dose form (n = 175)[1]	
Unit doses are not available for some medications	119 (68.0%)
Unit doses are too expensive	26 (14.9%)
Don't have enough time to repackage medications	21 (12.0%)
Another reason	36 (20.6%)
Use of any automated medication dispensing cabinets	164 (42.2%)
Cabinet has open access bins and drawers	146 (89.0%)
Frequency of chemotherapy provision	
At least once a week	118 (30.5%)
At least once a month	28 (7.2%)
At least once every 6 months	22 (5.7%)
At least once a year	14 (3.6%)
Never	203 (52.4%)

[1]Some respondents gave more than one reason.

Table 6

Implementation of Medication Safety Practices
(n = 387)

	Number of Hospitals (Percent)
Hospital has implemented protocols that include dosing scales, as appropriate, for the following drugs:	
Anti-coagulants such as heparin	331 (85.5%)
Insulin	281 (72.6%)
Opiates	142 (36.7%)
Emergency medications such as epinephrine drip, dopamine, nitroglycerin	337 (87.1%)
Pre-surgical antibiotic prophylaxis	188 (58.0%)[1]
Chemotherapy drugs	86 (46.7%)[2]
Hospital has implemented:	
A high alert drug list	254 (65.6%)
A do-not-use-abbreviations list	302 (78.0%)
A policy of using two patient identifiers for administering medications	301 (77.8%)
A policy of having two health professionals independently check doses of high alert medications (e.g., RN, RPh, MD)	285 (73.6%)
Pharmacist review of medication orders	
Pharmacist reviews all medication orders before drugs are dispensed in the hospital (except in emergency cases)	79 (20.4%)
Upon return to hospital, pharmacist reviews all medication orders dispensed during his or her absence	360 (93.0%)

[1]Of hospitals that provide surgery
[2]Of hospitals that provide chemotherapy

of safe practices include a practice of using only standardized abbreviations and dose designations, and a practice of identifying all high alert drugs (NQF, 2003).

Over three-fourths of the hospitals have implemented a do-not-use-abbreviations list and a policy of using two patient identifiers for administering medications. Just under three-fourths of the hospitals have implemented a policy of having two health professionals independently check doses of high alert medications. Two-thirds have implemented a high alert drug list. Overall, half of the hospitals have implemented all four of these medication safety practices.

The ASHP minimum requirements for hospital pharmacies and JCAHO standards specify that all medication orders should be reviewed by a pharmacist before dispensing except in emergency situations. Pharmaceutical services should be provided on a 24-hour basis if possible; where that is not feasible, a pharmacist must be available on an on-call basis and a pharmacist must subsequently review all after-hours pharmacy activity (ASHP, 1995; Rich, 2004). In 20 percent of the surveyed hospitals, the pharmacist reviews all medication orders before drugs are dispensed except in emergency cases. For nearly all hospitals, the reason given for not reviewing all orders before dispensing is that a pharmacist is not available. Upon return to the hospital, pharmacists in 93 percent of the hospitals review all orders dispensed during their absence.

Pharmacist Participation on Hospital Committees

The majority of surveyed hospitals have pharmacy and therapeutics and infection control committees with active pharmacist participation (Table 7). Almost 70 percent of hospitals have a medication safety or patient safety committee, with pharmacist participation on the committee in 78 percent of those hospitals. Only 20 percent of hospitals report having a pain management committee. A significant positive relationship exists between the amount of pharmacist staffing in a hospital and active pharmacist participation on pharmacy and therapeutics, medication/ patient safety, and infection control committees.

Use of Technology in the Hospital Pharmacy

Of the 387 hospitals in the survey, 77 percent use a pharmacy computer for one or more clinical purposes: to screen for potential drug interactions, to automatically screen for patient drug allergies, to identify potential adverse drug events, and to help determine appropriate medication doses. Forty-one hospitals do not have a computer in the pharmacy and an additional 48 hospitals do not use the pharmacy computer for clinical purposes (Table 8).

The main reasons for not using a pharmacy computer include cost/budgetary constraints and a perception that a computer is not needed because the volume of medications is small or the hospital only has a medication room rather than a pharmacy. Twelve of the 41 hospitals without computers plan to obtain one in the next two years.

Table 7

Pharmacist Participation on Hospital Committees by Amount of Pharmacist Staffing (n = 387)

Committee	Number (Percent) of Hospitals with This Committee	Number (Percent) of Hospitals with Committee where Pharmacist Actively Participates on the Committee
Pharmacy and Therapeutics	364 (94.1%)	354 (97.3%)
Infection Control	348 (89.9%)	233 (67.0%)
Medication Safety/Patient Safety	270 (69.8%)	210 (77.8%)
Pain Management	76 (19.6%)	54 (71.1%)

Table 8

Computer Use in Hospital Pharmacy
(n = 387)

	Number (Percent) of Hospitals
Hospital pharmacy has a computer	346 (89.4%)
Uses of pharmacy computer (n = 346)	
Help determine appropriate doses, for example, based on patient weight and renal function	228 (65.9%)
Automatically screen for patient drug allergies	275 (79.5%)
Screen for potential drug interactions	284 (82.1%)
Identify potential adverse drug events	230 (66.5%)
Electronic access in the pharmacy to patient lab results	196 (56.7%)
Pharmacy computer is not used for any of the above uses	48 (13.9%)
Of those without a pharmacy computer (n = 41)	
Reasons for not having a computer	
Cost/budgetary constraints	20
Volume too low/not needed/only a medication room	12
No space for it	3
No staff expertise/hard to get staff to change	3
Have access to another computer (e.g., nurses' station, retail pharmacy)	2
Plan to obtain a pharmacy computer in next two years	12
Pharmacist uses a PDA	15

Pharmacists in 15 of the 41 hospitals use hand-held software devices or personal digital assistants (PDAs).

Over half of hospitals with computers (58%) report using computer-generated medication administration records (MARs) (Table 9). The main reasons for not using them include limited technology, computer system and software problems; costs/budgetary constraints; limited pharmacy hours/pharmacist time; nurses' resistance; and a belief that the hospital is too small and they are not needed. Two-thirds of hospitals without computer-generated MARs plan to implement them in the next two years.

Only 11 hospitals (3%) currently use bar code technology for bedside medication administration; an additional 30 hospitals are planning to implement it in the near future. The main reasons for not using bar code technology include costs/ budgetary constraints, limited technology and computer system problems.

Pharmacists in 45 percent of hospitals use hand-held software devices/PDAs (Table 10). They are used to help determine appropriate doses (90% of users) and screen for potential drug interactions (71% of users). Almost half of those who do not use a PDA report not using it because they do not need it – either because they use a computer or reference books, or because the hospital is too small. About one-fourth cite cost/budgetary constraints as their main reason for not using a PDA, while 11 percent say they are unfamiliar or uncomfortable with the technology or do not find it useful.

Medication Information Resources

Nearly all pharmacists report using multiple resources on a regular basis to obtain up-to-date medication information and alerts (Table 11). Over three-fourths of respondents use Internet sites and computerized drug information systems, and 43 percent use a PDA with medication information software.

Medication Safety Priorities

Nearly all survey respondents agree (28%) or strongly agree (71%) that medication safety is a high priority for their hospital (Table 12). About 65 percent of respondents agree or strongly agree that pharmacists and nurses have sufficient time to devote to medication safety initiatives; about 60 percent agree or strongly agree that physicians have sufficient time.

Financial Resources

Over half (57%) of respondents report that their hospital has allocated internal financial resources for medication safety initiatives, and 18 percent report that their hospital has received external funds such as grant funds for medication safety initiatives. Hospitals that report having allocated internal resources for medication safety initiatives have higher pharmacist staffing and are significantly more likely to be using a pharmacy

Table 9

Use of Computer-generated Medication Administration Records and Bar Code Technology for Bedside Medication Administration (n = 346)[1]

	Number (Percent) of Hospitals
Hospital uses computer-generated Medication Administration Records	199 (57.5%)
Of those without computer-generated MARs (n = 147)	
Reason for not using computer-generated MARs[2]	
Limited technology/system and software problems	49
Cost/budgetary constraints	36
Limited pharmacy hours/pharmacist time	22
In process, implementing in near future	17
Nurses' resistance/preference for paper	15
Hospital too small/don't need them/not a priority	10
Just haven't done it/don't know	4
Plan to obtain computer-generated MARs in next 2 years	98 (66.7%)
Hospital uses bar code technology for bedside medication administration	11 (3.2%)
Of those without bar code technology (n = 335)	
Reason for not using bar code technology[2]	
Cost/budgetary constraints	197
Limited technology/computer system	53
In process, implementing in near future	30
Hospital too small	19
Bar code technology not standardized/still changing	18
Waiting for system or corporate decision or testing	14
Not a high priority/administration doesn't support	11
Just haven't done it/don't know	10
Staff time (e.g., for repackaging unit doses)	7
It's not mandatory	6
Plan to implement bar-code technology in next 2 years	170 (50.8%)

[1]These questions were only asked if the pharmacy had a computer.
[2]Some respondents gave more than one reason.

Table 10

Use of Hand-Held Software Devices/PDAs by Pharmacists (n = 387)

	Number (Percent) of Hospitals
Pharmacist uses hand-held software device/PDA	174 (45.0%)
Uses of PDA	
Help determine appropriate doses, e.g., based on patient weight and renal function	158 (90.3%)
Screen for potential drug interactions	124 (70.9%)
Of those who do not use PDA (n = 213)	
Reason for not using PDA[1]	
Don't need it - use computer/Internet	51
Don't need it – no specific reason	24
Don't need it – hospital is too small, limited pharmacist hours	16
Don't need it – use reference books	10
Don't have it because of cost/budgetary constraints	51
Don't have it/don't know why	33
Unfamiliar/uncomfortable with PDA/technology	17
It's not useful	7
No time to research it/get trained on how to use it	5
Pharmacy techs/physicians/other staff use it	3
Plan to obtain PDA in next two years	41 (19.2%)

[1]Some respondents gave more than one reason.

Table 11

Resources Used by Pharmacists on a Regular Basis to Obtain Up-To-Date Medication Information and Alerts (n = 387)

	Number (Percent) of Hospitals
Drug reference textbooks	354 (91.5%)
Pharmaceutical literature	365 (94.3%)
Internet sites such as FDA.gov	305 (78.8%)
A PC with a computerized drug information system such as MicroMedex or Facts and Comparisons	296 (76.5%)
A hand-held software device or PDA with software such as Epocrates or Lexi-comp	168 (43.4%)

Table 12

Pharmacists' Assessments of Medication Safety Priorities and Staff Time (n = 387)

	Percent of Hospitals				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Medication safety is a high priority for this hospital	71.1%	27.9%	0.8%	0.3%	0.0%
The pharmacist(s) has (have) sufficient time to devote to medication safety initiatives	16.5%	48.1%	14.7%	1.4%	2.1%
Nurses have sufficient time to devote to medication safety initiatives	9.8%	55.6%	16.5%	14.5%	2.6%
Medical staff have sufficient time to devote to medication safety initiatives	8.8%	50.7%	20.9%	16.3%	1.6%

computer for clinical purposes and to have implemented four medication safety practices: a do-not-use-abbreviations list, a policy of using two patient identifiers for administering medications, a high alert drug list and a policy of having two health professionals independently check doses of high alert medications.

Pharmacists' Assessments of Support for Medication Safety Technology

Survey respondents were asked about their agreement with a series of statements about whether health professionals in their hospital, federal and state regulations, and accreditation requirements supported the use of medication safety technology (Table 13). The majority of respondents strongly agree or agree that all four types of health professionals support the use of medication technology; the highest level of agreement is for pharmacists and the lowest for medical staff. Nearly all respondents, whether their hospital is JCAHO accredited or not, rate accreditation requirements as being supportive of medication safety technology; the majority also rate Federal and state regulations as supportive.

Top Priorities for Improving Medication Safety

In response to an open-ended question about what they would do if they could do one thing to improve medication safety in their hospital, over one-quarter of respondents say they would implement bar code technology (Table 14). Other top priorities include increasing pharmacist staffing (17%); implementing or improving an automated medication dispensing system (14%); and obtaining a pharmacy computer system or improving their existing computer system (11%).

MULTIVARIATE MODELS

Three regression models were developed to examine the relationships between hospital characteristics and 1) the amount of pharmacist staffing; 2) the use of pharmacy computers for medication safety activities; and 3) implementation of medication safety practices.

The first ordinary least squares regression model examines factors related to the amount of pharmacist staffing in a hospital. The dependent variable is pharmacist full time equivalents (FTEs), calculated by dividing the total number of pharmacist hours in a hospital by 40, to determine a pharmacist staffing measure based on a 40 hour work week. The independent variables in the first model include measures of hospital size, case mix**,** JCAHO accreditation, system membership, type of ownership, financial status, and degree of rurality.

Hospital size was expected to be positively related to pharmacist FTEs because larger hospitals have a greater need for pharmacist services as well as more resources to devote to pharmacist staffing. Case mix was expected to be positively related to pharmacist staffing as well, since a higher level of patient acuity likely generates additional need for medications and pharmacy services. Hospitals that are system

Table 13

Pharmacists' Assessments of Support for Use of Medication Safety Technology (n = 387)

Extent to which Pharmacist Agrees that the Following Support the Use of Medication Safety Technology	Percent of Hospitals					
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Pharmacist(s)	69.3%	26.9%	2.1%	1.0%	0.3%	0.5%
Nursing staff	38.0%	50.7%	8.0%	2.1%	0.5%	0.8%
Medical staff	31.5%	48.8%	15.0%	3.1%	0.0%	1.6%
The hospital administration	39.8%	47.0%	9.3%	2.8%	0.3%	0.8%
Federal pharmacy and hospital regulations such as FDA and CMS	43.7%	47.0%	3.6%	2.6%	0.3%	2.8%
State pharmacy and hospital regulations	39.3%	49.9%	7.0%	2.3%	0.3%	1.3%
Accreditation requirements such as JCAHO	58.9%	33.3%	3.9%	1.3%	0.3%	2.1%

Table 14

Pharmacists' Top Priority to Improve Medication Safety in their Hospital (n = 387)[1]

	Number (Percent) of Hospitals
Implement bar code technology	102 (26.4%)
Increase pharmacist staffing/increase pharmacy hours	66 (17.1%)
Implement/improve automated medication dispensing system	54 (14.0%)
Improve pharmacy computer system/get pharmacy computer	44 (11.4%)
Expand nurses' education regarding medication safety/ technology	33 (8.5%)
Implement electronic MARs	24 (6.2%)
Implement computerized physician order entry (CPOE) system	16 (4.1%)
Expand use of unit doses/have all medications unit dosed	14 (3.6%)
Implement double or triple checking of medications	9 (2.3%)
Review all medication orders prior to administration	8 (2.1%)
Implement/increase pharmacist time on patient care floor	7 (1.8%)
Improve communication with MDs/involve MDs in med safety	7 (1.8%)
Get accurate patient medication histories/provide patient education regarding medications	6 (1.6%)
Increase nurse staffing	6 (1.6%)
Implement telepharmacy/remote order entry	3 (0.8%)
Other	15 (3.9%)
Don't know/we're doing everything we can/don't have many errors	12 (3.1%)

[1]The number of priorities is greater than 387 because some respondents gave more than one top priority.

members, have for-profit or private non-profit ownership, and are in better financial condition were expected to have more potential resources to devote to pharmacist staffing and thus be more likely to have higher pharmacist FTEs. JCAHO accreditation was expected to be positively related to the amount of pharmacist staffing because of the roles and responsibilities assigned to pharmacists by the JCAHO medication management standards. Hospitals located in rural areas that are not adjacent to a metropolitan area were expected to have lower levels of pharmacist staffing, because of potential difficulty recruiting and retaining pharmacists in these areas.

The second model is a logistic regression model comparing hospitals that use a pharmacy computer for clinical purposes with those that do not. For the dependent variable, hospitals are classified depending on whether or not the hospital pharmacy has a computer that is used for at least one of the following clinical purposes: to help determine appropriate medication doses; to automatically screen for patient drug allergies; to screen for potential drug interactions; and to identify potential adverse drug events. The independent variables in the second model include measures of hospital size, JCAHO accreditation, membership in a multi-hospital system, type of ownership, financial status, and degree of rurality.

Hospital size was expected to be positively related to use of a pharmacy computer for clinical purposes, because of the potentially greater need for a pharmacy computer to handle larger volumes of medication doses, as well as more resources to devote to purchase and operation of a computer system. Hospitals that are members of a multi-hospital system, have for-profit or private non-profit ownership, and are in better financial condition were also expected to have more potential resources to devote to purchase and maintenance of a pharmacy computer system. JCAHO accreditation was expected to be positively related to use of a pharmacy computer because documentation of compliance with the JCAHO medication management standards would be facilitated by the use of a pharmacy computer system**.** Hospitals located in rural areas that are not adjacent to a metropolitan area were expected to be less likely to have a pharmacy computer, because rural areas overall lag behind urban areas in establishment of an information and communications technology infrastructure (IOM, 2005).

The third model is a logistic regression model comparing hospitals that have implemented four medication safety practices with those that have not implemented them. The four practices include: 1) a “do-not-use” abbreviation list, which is a list of medical abbreviations, symbols and dose designations that have often contributed to serious errors and should never be used. Examples include Q.D. (Latin for daily) and trailing zeros after decimals in drug dose amounts; 2) a policy of using two patient identifiers for administering medications; 3) a high alert drug list (High alert drugs are drugs that have a high risk of causing serious injury or death if misused. Examples include heparin, insulin, chemotherapy, concentrated electrolytes, and opiates. A hospital’s list should be based on the drugs it uses.); and 4) a policy of having two health professionals independently check doses of high alert medications. For the

dependent variable, hospitals are classified depending on whether or not they report implementing all four practices.

The independent variables in the third model include measures of hospital size, case mix, JCAHO accreditation, system membership, type of ownership, financial status, degree of rurality, and registered nurse staffing, as well as a measure of whether or not the hospital has a Medication Safety or Patient Safety Committee with active pharmacist participation.

Hospital size, case mix, registered nurse staffing, system membership, for-profit or private non-profit ownership, and better financial condition were all expected to be positively related to implementation of the four medication safety practices, because of potentially greater resources and staff time to devote to implementation. JCAHO accreditation was expected to be positively related to implementation of these practices because JCAHO medication management standards require hospitals to develop processes for managing high-risk and high-alert medications and the National Patient Safety Goals specify the use of two patient identifiers for administering medications and implementation of a standardized list of abbreviations that are not to be used in the organization (Rich, 2004; JCAHO, 2004a, 2005b).

Additional factors such as an organizational commitment to patient safety, strong hospital leadership, and medical staff support have been found to be related to the adoption of patient safety technologies such as Computerized Physician Order Entry (CPOE) systems (Poon et al., 2004). The survey data from this study includes respondents' assessments of whether their hospitals have allocated internal financial resources for medication safety initiatives, and the extent of support for medication safety technology among the hospital administration, medical and nursing staff, and pharmacists. However, we did not include these measures in the regression models because of concerns about endogeneity with the response variables (e.g., hospitals desiring to increase pharmacist staffing, use a computer for clinical purposes or implement medication safety practices would likely try to allocate internal financial resources to do so; having done so, they can then undertake these actions). Endogeneity would lead to ambiguous coefficients for these variables and could bias the coefficients of the other covariates included in the models.

Table 15 describes the variables in the regression models, how they are measured, and the data sources. Facility size can be measured several ways including staffed beds, admissions, and inpatient days. The number of annual hospital inpatient days is included in the models because it is a better measure of potential need for pharmacy services than bed size or admissions. We also included a measure of annual nursing home unit patient days, because having a nursing home unit and the size of the unit can affect the facility's overall financial status and staffing. Medicare regulations require nursing home facilities/units to employ or obtain the services of a licensed pharmacist who consults on the provision of pharmacy services in the facility; the regulations also require that the drug regimen of each resident be reviewed at least once a month by a licensed pharmacist (42CFR483.60). The survey data indicate that about 16 percent of

Table 15

Variables, Measures and Data Sources for Regression Models

Variables	Measures	Data Sources
Dependent		
Pharmacist FTEs	Total number of pharmacist hours/40	Survey of rural hospital pharmacists
Use of a computer for clinical purposes in the hospital pharmacy	Hospital pharmacy uses a computer for at least one of the following purposes: to help determine appropriate medication doses; to automatically screen for patient drug allergies; to screen for potential drug interactions; and to identify potential adverse drug events.	Survey of rural hospital pharmacists
Implementation of four medication safety practices	The hospital has implemented a do-not-use-abbreviations list, a high alert drug list, a policy of using two patient identifiers for administering medications, and a policy of having two health professionals independently check doses of high alert medications	Survey of rural hospital pharmacists
Independent		
Inpatient days for hospital unit	Annual inpatient days for hospital unit/10,000	AHA Annual Survey
Inpatient days for nursing home unit[1]	Annual inpatient days for nursing home unit/10,000	AHA Annual Survey
Medicare case mix index	Average diagnosis-related group (DRG) relative weight for the hospital	CMS
JCAHO accreditation	Hospital is accredited by JCAHO; 1 = Yes; 0 = No	Updated AHA data
System membership	Hospital is a member of a system; 1 = Yes; 0 = No	Updated AHA data
For-profit ownership	Hospital is investor-owned; 1 = Yes; 0 = No	AHA Annual Survey
Non-profit ownership	Hospital is church operated or other not-for –profit; 1 = Yes; 0 = No	AHA Annual Survey
Public ownership	Hospital is owned by non-federal governmental entity such as a city, county, or hospital district; 1 = Yes; 0 = No	AHA Annual Survey
Net other income	(Net profit – Net patient revenue)/10,000	Medicare cost reports
Net operating margin	Net operating margin	Medicare cost reports
Location in nonadjacent county	Hospital is located in a rural county that is not adjacent to a metropolitan county i.e., UIC codes 8, 9,10,11,12	USDA ERS 2003 Urban Influence Codes
RN ratio	FTE registered nurses/ total facility inpatient days	AHA Annual Survey
Pharmacist active on patient/ medication safety committee	Hospital has a patient/medication safety committee with active pharmacist participation; 1 = Yes; 0 = No	Survey of rural hospital pharmacists

[1]The AHA survey definition is a nursing home unit/facility that is owned and operated by the hospital and provides care for the elderly and chronic care in a non-acute setting including skilled nursing care, intermediate care, and residential care.

hospital pharmacies report dispensing medications to nursing home patients. We ran two sets of models: one including the number of annual nursing home unit patient days for all facilities and one only including the number of annual nursing home unit days for a hospital if the pharmacist reported on the survey that the pharmacy dispenses medications to nursing home residents. The results were very similar; because of concerns about endogeneity between pharmacist FTEs and the more limited nursing home patient day measure as well as a desire for the model results to be more generalizable, we include nursing home unit patient days for all facilities in the final models.

Two financial measures are included in the models: operating margin and the amount of net other income, which is defined as income from sources other than patient revenue. The net operating margin, measuring the financial status of the hospital arising from patient care, can be thought of as a reflection of the capacity to fund various *on-going* expenditures from the operation of the facility. Net other income, arising from governmental allocations, investment income and donations, is likely to vary to a greater degree than net operating income. As such, it might be more important for one-time expenditures rather than on-going ones.

Because our financial variables are for the most recent fiscal year for which CMS data were available, there is a lag of approximately two years between the survey date and the date these financial data reflect. However, we do not think this is an important limitation for this study since a priori we would expect that the impact of financial performance on changes in our response variables would take varying amounts of time to be realized.

The number of inpatient hospital and nursing home unit days, and net other income were divided by 10,000 for ease of reporting coefficients. Registered nurse full time equivalents (FTEs) were divided by total facility inpatient days to create a standardized staffing ratio.

Nineteen hospitals are excluded from the regression models because they are missing case mix data; one of these hospitals is also missing Medicare cost report data. One outlier hospital is excluded because it has a very small number of inpatient days that skew staffing results.

MULTIVARIATE RESULTS

Pharmacist Staffing

Table 16 presents the results of the first regression model regarding the amount of pharmacist staffing in the hospital. The overall model is highly significant, and several organizational and financial factors are significantly and positively related to the amount of pharmacist staffing in the hospital: the number of inpatient hospital unit days, the case mix index, and JCAHO accreditation (all at $p<.0001$); net other income ($p<.001$);

Table 16

OLS Regression Model
Dependent Variable: FTE pharmacist staffing in hospital pharmacy
(n = 367)

Independent Variables	Coefficient	Standard Error
Intercept	-2.3823****	0.4181
Inpatient days - hospital unit	1.7342****	0.1161
Inpatient days - nursing home unit	0.0959*	0.0440
Medicare case mix index	2.6722****	0.4297
JCAHO accreditation	0.4471****	0.1097
System membership	-0.1185	0.0987
For- profit ownership[1]	-0.4155**	0.1630
Non-profit ownership[1]	0.1523	0.0992
Net other income	0.0012***	0.0003
Net operating margin	0.7513**	0.2776
Location in nonadjacent county	0.0131	0.0880

[1]The omitted category was public (non-federal governmental such as city, county, hospital district) ownership.
* p < .05; ** p< .01; *** p< .001; ****p< .0001

Model Tests: R^2 = .714; Adjusted R^2 = .706; p <.0001.

Relative Importance of Significant Coefficients

Variables	Mean Pharmacist FTEs	FTE Change
Inpatient days - hospital unit		
20th percentile (1,795 days)	1.05	1.28
80th percentile (9,145 days)	2.33	
Inpatient days - nursing home unit		
20th percentile (0 days)	1.70	0.10
80th percentile (10,550 days)	1.80	
Medicare case mix index		
20th percentile (.94)	1.40	0.59
80th percentile (1.16)	1.99	
JCAHO accreditation		
Not accredited	1.53	0.45
Accredited	1.98	
Ownership		
Public	1.73	-0.42
For- profit	1.31	
Net other income		
20th percentile ($186,075)	1.54	0.35
80th percentile ($1,678,800)	1.89	
Net operating margin		
20th percentile (-.152)	1.69	0.13
80th percentile (.023)	1.82	

net operating margin and the number of nursing home unit days ($p < .01$). In addition, there is a significant negative relationship between for-profit ownership (compared to public ownership) and pharmacist staffing ($p<.05$). The amount of pharmacist staffing is not significantly related to membership in a multi-hospital system, non-profit ownership (compared to public ownership), or location in a non-adjacent rural county.

Next, to more easily gauge the relative importance of the significant coefficients in this model, we calculate the separate impact of changes in each significant independent variable on mean pharmacist FTEs, holding all other variables constant. For the continuous variables, we measure the impact of moving from the 20th percentile to the 80th percentile value; for the categorical values, we measure the impact of moving from one category to the other. The largest changes in mean pharmacist FTEs occur as a result of changes in inpatient hospital unit days (1.28 FTEs), followed by the Medicare case mix index (.59 FTEs), JCAHO accreditation (.45 FTEs), ownership (-.42 FTEs from public to for-profit), and net other income (.35 FTEs).

Use of Pharmacy Computer for Clinical Purposes

Table 17 presents the results of the logistic regression model regarding the use of a pharmacy computer for one or more of the following clinical purposes: to screen for potential drug interactions, to automatically screen for patient drug allergies, to identify potential adverse drug events, and to help determine appropriate medication doses. The overall model is highly significant. Factors that are significantly and positively related to the use of a pharmacy computer for clinical purposes include the number of inpatient hospital unit days, JCAHO accreditation, and net other income (all at $p<.001$) as well as net operating margin ($p < .01$). Factors that are not significantly related to the use of a pharmacy computer include the number of nursing home unit days, system membership, location in non-adjacent rural county, and type of ownership.

Next, to help gauge relative impacts, we calculate the separate impact of changes in the significant variables on the likelihood of using a pharmacy computer for clinical purposes, holding all other variables constant. The largest changes in the likelihood of using a pharmacy computer for clinical purposes occur as a result of changes in inpatient hospital unit days (28%), JCAHO accreditation (20%), and net other income (12.7%).

Implementation of Medication Safety Practices

Table 18 presents the results of the regression model regarding implementation of four medication safety practices: a do-not-use-abbreviations list, a policy of using two patient identifiers for administering medications, a high alert drug list and a policy of having two health professionals independently check doses of high alert medications. The overall model is highly significant. Three factors are significantly and positively related to implementation of the four practices: JCAHO accreditation ($p<.0001$); having a medication safety or patient safety committee with active pharmacist participation ($p<.001$); and net operating margin ($p<.05$). Factors that are not significantly related to

Table 17

Logistic Regression Model
Dependent Variable: Use of a computer for clinical purposes in the hospital pharmacy
(N = 367)

Independent Variables	Coefficient	Standard Error
Intercept	-2.4674	1.7724
Inpatient days for hospital unit	4.8990****	1.0543
Inpatient days for nursing home unit	0.1873	0.2195
Medicare case mix index	1.6865	1.8323
JCAHO accreditation	2.3509***	0.6282
System membership	-0.4981	0.3953
For profit ownership[1]	-0.5613	0.7223
Non profit ownership[1]	-0.5230	0.4062
Net other income	0.0091***	0.0028
Net operating margin	2.6367*	1.0830
Location in nonadjacent county	-0.4433	0.3553

[1]The omitted category was public (non-federal governmental such as city, county, hospital district) ownership
* p < .05; ** p< .01; *** p< .001; ****p< .0001

Model Tests: Likelihood ratio: chi-square = 159.3; DF = 10; p <.0001.
Score: chi-square = 106.2; DF = 10; p <.0001.
Wald: chi-square = 56.2; DF = 10; p <.0001.

Relative Importance of Significant Coefficients

Variables	Likelihood of Using a Pharmacy Computer for Clinical Purposes	Change
Inpatient days - hospital unit		
20th percentile (1,795 days)	70.0%	28.0%
80th percentile (9,145 days)	98.0%	
JCAHO accreditation		
Not accredited	74.0%	20.4%
Accredited	94.4%	
Net other income		
20th percentile ($186,075)	74.6%	12.7%
80th percentile ($1,678,800)	87.3%	
Net operating margin		
20th percentile (-.152)	78.4%	4.4%
80th percentile (.023)	82.8%	

Table 18

Logistic Regression Model
Dependent Variable: Implementation of four medication safety practices[1]
(n= 367)

Variables	Coefficient	Standard Error
Intercept	0.3842	1.2976
Inpatient days for hospital unit	0.3646	0.3858
Inpatient days for nursing home unit	-0.0847	0.1604
Medicare case mix index	-2.2075	1.3742
Ratio of RNs to total inpatient days	0.5167	31.4687
JCAHO accreditation	1.9578****	0.3307
System membership	0.3527	0.2988
For profit ownership[2]	-0.2399	0.5204
Non profit ownership[2]	0.3277	0.2973
Net other income	0.0018	0.0012
Net operating margin	2.2141*	1.0361
Patient/medication safety committee with active pharmacist participation	0.9300***	0.2795
Location in nonadjacent county	0.2220	0.2733

[1]The four practices are a high alert drug list, a do-not-use-abbreviations list, a policy of using two patient identifiers for administering medications, and a policy of having two health professionals independently check doses of high alert medications.
[2]The omitted category was public (non-federal governmental such as city, county, hospital district) ownership

* p < .05; ** p< .01; *** p< .001 ****p< .0001

Model Tests: Likelihood ratio: chi-square = 143.9; DF = 12; p <.0001.
Score: chi-square = 128.9; DF = 12; p <.0001.
Wald: chi-square = 99.9; DF = 12; p <.0001.

Relative Importance of Significant Coefficients

Variables	Likelihood of Implementing Four Medication Safety Practices	Change
JCAHO accreditation		
Not accredited	31.5%	40.8%
Accredited	72.3%	
Net operating margin		
20th percentile (-.152)	48.2%	6.6%
80th percentile (.023)	54.8%	
Patient/medication safety committee with active pharmacist participation		
No	42.1%	16.9%
Yes	59.0%	

implementation of the four practices include the number of hospital and nursing home unit days, case mix, the RN staffing ratio, system membership, location in non-adjacent rural county, type of ownership, and net other income.

Finally, we calculate the separate impact of the significant independent variables on the likelihood of implementing all four medication safety practices, holding all other variables constant. The largest changes in the likelihood of implementing the four practices occur as a result of JCAHO accreditation (40.8%) and having a medication safety or patient safety committee with active pharmacist participation (16.9%).

DISCUSSION AND CONCLUSIONS

The results of this study indicate that many small rural hospitals have limited hours of on site pharmacist coverage. Over one-third of the hospitals report having a pharmacist on site for less than 40 hours per week, including 31 hospitals where a pharmacist is on site for two hours or less per week. These findings are consistent with survey data on CAHs (Casey, Moscovice, and Klingner, 2004) and ASHP data on small hospitals (Pedersen, Schneider, and Scheckelhoff, 2005) and have implications for the role of pharmacists in implementing medication safety initiatives in small rural hospitals.

In hospitals with limited pharmacist coverage, pharmacists may not be able to take an active leadership role or spend significant time on medication safety activities. Stevenson et al. (2004) found that onsite pharmacist hours in rural community hospitals were significantly associated with pharmacists being involved in initial ordering of antibiotics and providing active oversight of antimicrobial use. Based on the initial findings of a voluntary medication error reporting system in six Nebraska CAHs, Jones et al. (2004) concluded that limited access to pharmacists in CAHs results in: 1) fewer opportunities to learn about the medication use system from potential and near-miss errors; 2) greater opportunities for prescribing errors, unauthorized drug errors and improper dose/quantity errors to reach the patient; and 3) limited ability to independently double-check provider prescribing behavior. In the current study, the amount of pharmacist staffing in a hospital is significantly related to active pharmacist participation on key hospital committees that address medication issues. In turn, active pharmacist participation on an infection control committee is significantly related to implementation of protocols for pre-surgical antibiotic prophylaxis, and active pharmacist participation on a medication/patient safety committee is significantly related to implementation of four medication safety practices.

While these results indicate that expansion of pharmacist coverage in small rural hospitals would likely have a significant positive impact on medication safety, efforts to increase pharmacist staffing in rural hospitals must take into account evidence of a continuing national shortage of pharmacists, based on reports of vacancy rates and difficulty filling vacancies (USDHHS, 2000; Knapp et al., 2005) and the fact that rural hospitals have greater difficulty recruiting pharmacists than those in urban settings (ASHP, 2005a). A variety of strategies exist to achieve additional pharmacist coverage. Shared staffing across hospitals is one option that may allow smaller hospitals to obtain

the expertise of a hospital pharmacist, but may not be practical in isolated rural areas. Although 17 percent of the hospitals in the current study are sharing pharmacists with another hospital, many of these hospitals still have very limited hours of pharmacist coverage.

Another option is greater utilization of telepharmacy arrangements that allow smaller rural hospitals to connect to the 24 hour pharmacist resources of larger hospitals (Lordan, Vorhees, and Richards, 2002; Casey and Moscovice, 2004; Rebhahn, 2005). An innovative model is being implemented in small rural hospitals in Minnesota that do not have sufficient patient volume to justify a full-time pharmacist; this model involves expanding the role of the pharmacist to include managing drug therapy in ambulatory care, long term care, hospice and home care patients, as well as in the inpatient setting (Sorensen, 2005). As with other health professions, a multi-faceted approach needs to be taken to development of the pharmacist workforce in rural areas over the long term, including recruitment of students from rural areas, development of rural-relevant curricula, and location of a meaningful portion of the educational experience in rural areas (IOM, 2005).

The survey results regarding technology indicate that the majority of small rural hospitals are using pharmacy computers, but a significant proportion (23%) either do not have a pharmacy computer or are not using it for clinical purposes such as helping to determine appropriate doses, or screening for patient drug allergies and potential drug interactions. The use of computer-generated medication administration records is lower among the survey hospitals (51%) than the overall rate for hospitals nationally (64%) in the 2002 ASHP survey (Pedersen, Schneider, and Scheckelhoff, 2003). The use of bar code technology for bedside medication administration is very low (3%), but similar to the national rate of 5% (Wright and Katz, 2005) and the percentage of Wisconsin hospitals that had fully implemented (2.6%) and partially implemented (5.3%) bar coding systems for medication packaging and administration in 2002 (Hoffman, Thielke, and Orlik, 2004).

Cost is a major reason given by survey respondents for not implementing specific medication safety-related technologies. These results support a continuation of efforts to encourage the use of information technology in rural hospitals, such as the Agency for Healthcare Research and Quality health information technology initiative, which is targeting grant funds and other resources to rural health care systems (AHRQ, 2004). Investment in health information technology is a key component of the Institute of Medicine Committee on the Future of Rural Health Care's strategy to address quality challenges in rural communities (IOM, 2005).

The survey findings suggest that implementation of protocols related to medication use is an area where small rural hospitals could improve. The proportion of survey hospitals that have implemented protocols addressing specific categories of drugs ranges from 27 percent for opiates to 87 percent for emergency medications. Less than half of the hospitals that provide chemotherapy services have implemented protocols for those

drugs, while 58 percent of hospitals that provide surgery have implemented protocols for pre-surgical antibiotic prophylaxis.

Nationally, 83 percent of hospitals overall and 74 percent of those with less than 50 beds reported using clinical practice guidelines that included medications in the 2002 ASHP survey (Pedersen, Schneider, and Scheckelhoff, 2003). Appropriate use of pre-surgical antibiotic prophylaxis falls short of long acknowledged-standards of practice nationally, but has been the focus of a successful National Surgical Infection Prevention Collaborative and efforts led by Quality Improvement Organizations in 29 states (Dellinger et al., 2005). In addition, two measures related to antibiotic prophylaxis for surgical patients are now in the quality measure set for the Hospital Quality Alliance (CMS, 2005). These efforts should focus attention on the potential for improving rural hospital implementation of protocols.

The majority of hospitals in the survey have implemented a do-not-use-abbreviations list (78%); a policy of using two patient identifiers for administering medications (78%); a policy of having two health professionals independently check doses of high alert medications (74%); and a high alert drug list (66%). However, only half of the hospitals have implemented all four practices. In 2002, 88 percent of Wisconsin hospitals had a written policy and procedure for the use of select high-risk medications, and 55 percent had a written policy to eliminate error-prone symbols and abbreviations (Hoffman, Thielke, and Orlik, 2004). Of the 1,528 hospitals surveyed by JCAHO during 2004, 75.2 percent were in compliance with the do-not-use-abbreviations requirement and 95.9 percent were in compliance with the requirement to use two patient identifiers (JCAHO, 2005b).

The survey findings suggest that these medication safety practices are an additional area where there is room for improvement among small rural hospitals. While achieving full compliance with medication safety practices is challenging (Traynor, 2004; Bates and Gawande, 2003), all hospitals should be working towards implementation. Multiple resources are available on the Internet to help hospitals assess and improve their medication use systems (ISMP, 2004; ASHP, 2005b; IHI, 2005); do-not-use abbreviation and high alert medication lists and guidance in implementing them (JCAHO, 2004b; ISMP, 2005b); Pathways for Medication Safety tools to develop an organization-specific strategic plan for medication safety and assess readiness for bedside bar-coding (AHA, 2002); and tools to evaluate and select technological solutions to address medication errors (California HealthCare Foundation, 2001).

Of particular interest to policymakers, two factors - JCAHO accreditation and hospital financial status - are significantly related to the response variables in all three multivariate models. The significant relationships between JCAHO accreditation and pharmacist staffing, use of a pharmacy computer, and implementation of medication safety activities are not surprising, given the emphasis on pharmacists' roles and responsibilities in ensuring medication safety in the JCAHO standards. The relationship between accreditation and three response variables in the models could be the result of *self-selection* (e.g., hospitals that seek JCAHO accreditation have more resources than

those that do not) as well as the *accreditation process* (e.g., hospitals make improvements in their pharmacist staffing, technology use, and implementation of patient safety activities to meet the accreditation standards). To reduce the likelihood that the differences between accredited and non-accredited hospitals are due to self-selection, we control for hospital size and case mix in the three models.

Qualitative research has identified JCAHO standards as a primary motivating force for implementation of patient safety initiatives among hospitals in 12 metropolitan areas around the country (Devers, Pham, and Liu, 2004). Additional evidence of the influence of the accreditation process on medication safety practices comes from pharmacists who report that medical staff in their hospitals are more likely to cooperate with pharmacists in not using do-not-use abbreviations when they know that it is necessary to meet the standard for JCAHO accreditation (Young, 2004).

Small rural hospitals historically have been less likely than larger urban facilities to be JCAHO accredited; cost is the most important reason given by small rural hospitals for lack of participation in the accreditation process (Brasure, Stensland, and Wellever, 2000). JCAHO has implemented a special accreditation process for CAHs and obtained input from small rural hospitals in the development of its new medication management standards (Rich, 2004). Nonetheless, it appears that many small rural hospitals continue to face challenges in meeting some JCAHO standards. Medication management standards cited by small rural hospitals as difficult to meet include requirements for a controlled work area to mix sterile preparations; separate space for a night pharmacy with limited access to drugs; and 24 hour on-call coverage by pharmacists (Young, 2004). Improving implementation of key medication safety practices among non-accredited hospitals will likely require a comprehensive approach that includes increasing awareness of the importance of implementing the practices, as well as targeted provision of technical assistance and financial incentives.

Cost-based Medicare reimbursement has contributed to the financial viability of CAHs (Stensland, Davidson, and Moscovice, 2003; 2004) and has been an important factor in the ability of CAHs to fund a range of post-conversion activities to improve quality of care and patient safety in small rural hospitals (Casey and Moscovice, 2004). Within-hospital declines in operating profit margins over time have been linked to an increase in the probability of adverse patient safety events in Florida hospitals (Encinosa and Bernard, 2005). The finding of significant relationships between financial status and pharmacist staffing, use of technology, and implementation of medication safety practices supports a continuation of Medicare policies to help ensure financial stability for small rural hospitals through cost-based reimbursement as a means of helping to support quality and patient safety activities.

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University of North Dakota Center for Rural Health Recent Publications

Rural Health Policy Briefs

- Suicide in North Dakota: A Dialogue Across State and Tribal Boundaries. North Dakota State and Tribal Health Policy Forums. (No. 3, Fall 2005)
- The Indian Health Care Improvement Act: Implications for North Dakota Tribes (No. 1, November 2004)
- North Dakota's Uninsured and Uncompensated Care: Costs and Coverage Options (No. 2, November 2004)

Rural Health Fact Sheets

- Primary Care Physicians (Summer 2005)
- North Dakota Health Professions: Oral Health - Dentists (Spring 2005)
- Health Care Access in North Dakota: Characteristics of the Uninsured (Winter 2005)
- Traumatic Brain Injury (Winter 2005)
- North Dakota Health Professions: Nursing (Fall 2004)

Native Aging Fact Sheets

- The Elder's obesity Challenge (Fall 2005)
- Nutritional Risks Among Native American Elders (Spring 2005)
- Informal Caregivers: Challenges in Providing Care (Spring 2004)

Working Papers

- King, B. & Moulton, P. (July, 2005). *Three-Year Comparison of North Dakota Nurses: Results and Implications*
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