The Impact of Standardized Order Sets on Quality and Financial Outcomes

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Abstract

Objective: The objective of this project was to valuate impact of a standardized order set on quality and financial performance. **Methods:** We conducted an observational study to examine order set use by hospital, discharge month, severity of illness and risk of mortality for pneumonia patients between March 2006 and September 2007. We also assessed impact on in-hospital mortality and 30-day readmission rates using four measures: (1) Cox proportional hazards regression, (2) Joint Commission Core Measures compliance using logistic regression, (3) length of stay, and (4) financial indicators using robust regression methods for highly skewed data. **Results:** A total of 3,301 patients met the inclusion criteria. Over 19 months, order set use increased by 55 percent. Order set use significantly improved in-hospital mortality [hazard ratio (95 percent confidence interval (CI): 0.66 (0.45; 0.97) or 0.67 (0.46; 0.98); and Core Measures compliance (relative risk, 95 percent CI: 1.24 (1.04; 1.48) or 1.22 (1.02; 1.45)] following covariate or propensity score risk adjustment. **Conclusion:** Evidence-based pneumonia order sets can reduce inpatient mortality and increase delivery of important care processes.

Introduction

Baylor Health Care System (BHCS), an integrated health care delivery system located in North Texas, is engaged in a multiyear process and organizational redesign project that includes the implementation of an electronic health record (EHR) system supporting computerized physician order entry (CPOE) and point-of-care decision support. This process is intended to increase the overall standardization, quality, and efficiency of care. As an intermediate step—partly to achieve some of the quality of care benefits associated with the standardization and streamlining of care offered by CPOE, and partly to familiarize physicians with the use of standardized orders—BHCS is developing system-wide standardized order sets to be made available through the physician intranet portal at all BHCS locations. Ultimately, these order sets will serve as the core library of order sets supporting the CPOE system.

Since its introduction in 2001, the intranet physician portal has provided secure access to patient health information from any location via the BHCS Network. Using the portal to disseminate order sets simplifies the process of applying updates universally in a timely manner and eliminates the need to provide printed copies at all physical locations. Additionally, this system introduces an intermediate level of computer use, which is intended to ease the transition from

handwritten orders to CPOE. The Medical University of South Carolina pursued a similar strategy and reported success, both in attaining some CPOE-related benefits before implementing a full CPOE application and in achieving some of the cultural changes necessary for the successful implementation of CPOE.[1]

Previous research suggests that implementation of standardized order sets, templates, or protocols can improve compliance with recommended processes of care—such as early administration of aspirin, prescription of angiotensin converting enzyme inhibitors, and use of β-blockers for acute myocardial patients,[2, 3, 4, 5, 6]—and improve patient outcomes.[3] The impact of such tools on resource use appears more variable, depending in part on the clinical area or type of care targeted. For instance, introduction of standardized order sets, care protocols, or critical pathways has been found to reduce overall length of stay, postoperative length of stay, and total charges for multiple surgical procedures, including total knee arthroplasty,[7] appendectomy,[8] total laryngectomy,[9] cholecystectomy,[10] carotid endarterectomy,[11] gastrectomy,[12] inguinal hernia repair,[13] and colon surgery.[14] In contrast, interventions to standardize treatment of conditions requiring inpatient medical rather than surgical management—such as pneumonia,[15, 16, 17] congestive heart failure,[13] and conservative management of acute appendicitis[8]—have had variable effects on length of stay and costs.

BHCS is in the process of developing and implementing more than 50 standardized order sets in a variety of clinical areas. The first of these—the adult pneumonia order set—was made available system-wide through the physician intranet portal in 2006. We investigated the effect of this order set on in-hospital mortality, compliance with evidence-based recommendations for pneumonia care, length of stay, cost of care, and fiscal operating margin.

Methods

Study Setting

BHCS is a not-for-profit, multihospital system in Dallas-Fort Worth, TX, that incorporates 20 owned, leased, affiliated, and short-stay hospitals with an annual total of more than 103,000 admissions. Only the eight acute care hospitals, where most patients with community-acquired pneumonia are treated, were included in this study.

BHCS is engaged in a multiyear process and organizational redesign project that is supported by the implementation of health information technology. The long-term goals for this project include:

- Creating a culture that fosters interdisciplinary collaboration.
- Eliminating unnecessary variability in patient care.
- Developing and deploying the best evidence-based operational and clinical models.
- Providing clinical decision support at the point of care.
- Providing caregivers with the opportunity to spend more time with patients.
- Significantly improving quality and reducing errors.

The first phase of this redesign project has been paper-based for the most part, predominantly involving the establishment of monitoring and feedback systems to track performance on quality indicators that facilitate the design and implementation of targeted quality improvement initiatives. These indicators include clinical preventive services delivery in the ambulatory care setting and Joint Commission Core Measures in the hospital setting. Introduced in 2004, the "Accelerating Best Care at Baylor" (ABC Baylor) class was designed to teach physicians, hospital administrators, nurse managers, and others the skills needed to actively lead quality improvement efforts and to facilitate process redesign.

The second phase of this multiyear project, currently ongoing, involves the standardization of care and the practice of evidence-based medicine through the development and implementation of standardized order sets and protocols. Although these tools are essentially paper-based, increasing technologic support (e.g., order set deployment via the intranet physician portal) is being introduced.

The third phase will involve the implementation of EHRs and CPOE, which will integrate the process redesign and order sets introduced during earlier phases.

Development of Order Sets

The identification of the most necessary order sets has been based on Diagnosis Related Group (DRG) data (particularly patient volumes), the Institute of Medicine's 20 Priority Areas,[18] BHCS performance on the Joint Commission Core Measures,[19] and information from individual service lines (e.g., vascular, oncology, and radiology) about areas in which they feel the use of standardized order sets would have the greatest potential to improve quality of care.

The available evidence is reviewed, and a "straw model" is developed once a condition or procedure is identified as a target for a standardized order set. Appropriate leaders, physician champions (i.e., clinicians with dedicated BHCS-funded time for promoting quality improvement initiatives within BHCS), and other care providers and staff are identified and recruited for the development team. Sources used to identify the available evidence have included the National Library of Medicine, the Baylor Health Science Library, the Cochrane Database of Systematic Reviews, EMBASE, the University of Toronto Center for Evidence-Based Medicine, the Agency for Healthcare Research and Quality (AHRQ) Evidence-Based Practice Center program, the AHRQ National Guideline Clearinghouse™ (NGC), UpToDate®, and Zynx™.

Additionally, through physician town hall meetings, departmental meetings, and direct contacts, all BHCS physicians have the opportunity to contribute to the content and format of the order set. Based on the information thus gathered and on their knowledge of local practices, a subspecialty team develops a working draft of the order set and pilots it within their own practices/departments. At minimum, this team includes a representative from each BHCS hospital, a pharmacist, a nursing representative, and a relevant BHCS physician champion. Following revisions to address any issues identified through the pilot testing, the order set is reviewed by the BHCS Pharmacy and Therapeutics Committee and the Patient Safety Committee. Following their approval, it is reviewed by the Physician Design Team, which includes physician champions, a BHCS pharmacist liaison, the BHCS Partnership Council

leader, the Physician Team leader, and ad hoc physician leaders as needed. The Physician Design Team has final control over all order set content.

Finally, each order set is reviewed by the Quality and Fiscal Impact Committee and then sent to the Best Care Committee, a system-wide entity made up largely of hospital presidents, chief nursing officers, health care improvement directors, and physicians with specific quality improvement leadership roles. The order set is then deployed via the portal. Education on using the order sets has been provided to relevant care providers through "academic detailing"[20] by physician champions.

Each order set is reviewed and updated annually by subspecialty teams, physician champions, and the Physician Design Team. Changes are reviewed by the BHCS Pharmacy and Therapeutics and Patient Safety Committees. In addition, new evidence from research and local experience is monitored, facilitating ad hoc review and revision of the order set. This ensures that the standardized order sets are consistent with the practice of high quality, evidence-based medicine.

Development and Deployment of the Adult Pneumonia Order Set

Beginning in early 2005, the BHCS Adult Pneumonia Order Set was developed by a system-wide multidisciplinary team including pharmacists, nurses, respiratory therapists, care coordinators, health information management staff, and physicians specializing in infectious diseases, pulmonology, internal medicine, and family practice. Since this was the first effort at system-wide standardization of care processes, the development of the Adult Pneumonia Order Set highlighted the need for much of the supporting structure for such efforts, including a good internal communications process and system-level groups in which stakeholders are brought together with their counterparts from other hospitals (e.g., the Pharmacy and Therapeutics Committee, which was formed in response to this need). It has been intertwined with substantial organizational learning and development of the necessary infrastructure, especially the creation and tasking of teams and committees that play key roles in the order set development process.

From November 2005 to February 2006, the Adult Pneumonia Order Set was piloted by the providers involved in its development at several of the BHCS acute care hospitals. Although no widespread effort was made to inform other care providers about the order set or to encourage its use during the pilot stage, the order set was available to all providers through the BHCS intranet.

Subsequent order sets have not been made generally accessible during the pilot stage because the appearance of the pneumonia order set on the intranet with no preceding education or information about its use created some confusion. Based on pilot experience, minor changes were made to the Adult Pneumonia Order Set prior to its system-wide deployment in order to increase its effectiveness and user-friendliness. These included the addition of passive decision support reminders related to the use of the analgesic Darvocet,® the addition of a default care coordination consult, and a formatting change to eliminate confusion involving the separation of antibiotic groupings.

In March 2006, the Adult Pneumonia Order Set was deployed system-wide via the physician portal. At this time, "order set use" was made a required field in the integrated outcomes, resource, and case management system used for pneumonia patients at all BHCS hospitals

(MIDAS+™), facilitating the tracking of order set use. Strategies to increase awareness and encourage use of the order set included:

1. A high-profile awareness campaign, which was presented to the Best Care Committee and made available to frontline care providers through the BHCS intranet.
2. Just-in-time training provided to nursing units at some BHCS acute care hospitals.
3. Incorporation of the order set into the Baylor University Medical Center order entry system.
4. Academic detailing by physician champions.

Anecdotally, this last strategy was perceived as the most effective in raising awareness of and knowledge about the order set.

The Adult Pneumonia Order Set was the first standardized tool BHCS made a concerted effort to implement system-wide. For this reason, there was no preexisting method or infrastructure for widespread deployment. To increase standardization and improve quality of care, such tools and strategies are under development for the deployment of future order sets and other system-wide initiatives.

Patients for Evaluation of Pneumonia Order Set

All adults (>18 years) discharged from one of the eight BHCS acute care hospitals between March 1, 2006 and September 30, 2007, who had been admitted with a working diagnosis of pneumonia and who met the Joint Commission definition of pneumonia[21] (based on ICD-9-CM diagnosis codes) were eligible for this study. Patients were excluded if "for comfort measures only" was recorded in their admitting physician orders or note, consultation notes, emergency department record, history and physical, physician orders, or progress notes.

Outcome Measures

The primary outcome measure was a difference in performance for clinical quality and financial indicators between pneumonia patients who were treated with or without the BHCS standardized Adult Pneumonia Order Set. Clinical quality indicators included inpatient mortality, readmission within 30 days, and compliance with the Joint Commission Core Measures for pneumonia, as indicated by the pneumonia composite compliance index. The core compliance index was based on eight of the national quality measures for pneumonia:

1. PN-1 oxygenation assessment.
2. PN-2 pneumococcal vaccination.
3. PN-3b blood culture before first antibiotic.
4. PN-4 adult smoking cessation advice/counseling.
5. PN-5b initial antibiotic received within 4 hours of hospital arrival.
6. PN-6a initial antibiotic selection for community acquired pneumonia (CAP) in immunocompetent ICU patients.
7. PN-6b initial antibiotic selection for CAP in immunocompetent non-ICU patients.
8. PN-7 influenza vaccination.

The core compliance index was calculated as the proportion of pneumonia patients eligible for the above measures who receive all the measures for which they are eligible.[21] Financial indicators included length of stay, direct cost of care, expected payment (based on payer type), and contribution margin (calculated as expected payment less direct cost of care).

Data Collection

Data on order set use ("BHCS order set," "personal order set," or "no order set"), age, sex, race/ethnicity, admitting BHCS hospital, All Patient Refined Diagnosis Group (APR DRG) Severity of Illness (SOI) and Risk of Mortality (ROM), and delivery of the Joint Commission Core Measures for Pneumonia were collected from MIDAS for each patient. "Personal order sets" were those developed by individual physicians, physician groups, or hospitals that had not undergone the full development and review process described above for the BHCS order sets. Length of stay, inpatient mortality (including time from admission to death), readmission within 30 days (including time from discharge to readmission), direct cost of care, expected payment, contribution margin, and diagnosis codes used to calculate Greenfield comorbidity scores were determined from administrative data.

Statistical Analysis

To ensure the statistical assumption of independent observations was met, the analysis considered only first hospital admission for pneumonia for patients with multiple admissions during the study period. Due to the continuous decline seen in personal order set use over the study period, the analysis focused on comparing BHCS order set use vs. no order set use.

Univariate analyses were conducted to examine the association between order set use and patient characteristics/outcomes of interest. Chi-square tests and Fisher's exact tests were used to assess the association of order set use with categorical characteristics/outcomes (sex, race, facility, mortality, core measure compliance, and readmission within 30 days). For ordinally scaled measurements (APR DRG risk of mortality, severity of illness, Greenfield comorbidity score, and month of discharge), trend tests were also performed. Two-sample t-tests were used for mean comparisons of continuous outcomes or characteristics that did not violate the assumption of normality. Robust estimation and regression approaches were used for continuous outcomes that were highly skewed.[22, 23]

Multicollinearity of all covariates to be included in the adjusted analysis was assessed prior to performing multivariable analysis. No evidence of multicollinearity was observed, and the adjusted analysis was conducted following two approaches: covariate adjusted and propensity score adjusted. In the covariate-adjusted analysis, all covariates of interest (age, sex, race, physician specialty [hospitalist vs. other], Greenfield comorbidity score, APR DRG risk of mortality/severity, payer type, admission source, hospital, and discharge month) were included in the regression model, and the adjusted effect of order set use was estimated.

The propensity score approach involved the creation of propensity scores to determine the conditional probability of a patient being treated with an order set given the set of the patient's characteristics (age, sex, race, physician specialty [hospitalist vs. other], Greenfield comorbidity score, APR DRG risk of mortality/severity, payer type, admission source, hospital, and discharge

month). Regression analysis with order set use and propensity score as covariates was then performed to determine the adjusted effect of the order set. APR DRG Risk of Mortality was used in the models for safety and effectiveness indicators, while APR DRG Severity of Illness was used for efficiency and fiscal indicators.

The effects of order set use on in-hospital mortality and on readmission within 30 days were assessed using Cox proportional hazard regression. Time to death during the hospital stay was considered for the in-hospital mortality model, while time to readmission from discharge date was considered for 30-day readmission. The adjusted effect of order set use on core measure compliance was modeled using logistic regression. However, since the outcome measure of interest (core measure compliance) was frequent in the study population (>70 percent), the resulting odds ratio overestimates the risk ratio.[24] We therefore applied a simple approximation[24] to obtain a better estimate of the true adjusted relative risk. Length of stay and cost data were modeled using robust regression methods. Analyses were conducted using SAS® 9.1 (SAS Institute, Cary NC) and S-Plus® 7.0 (Insightful Corp, Seattle, WA).

Results

Between March 1, 2006 and September 30, 2007, 4,032 adult patients admitted with a working diagnosis of pneumonia who met the Joint Commission definition of pneumonia and were not admitted for comfort care were discharged from the eight BHCS acute care hospitals (Figure 1). Average age among the patients meeting study inclusion criteria was 67 ± 17 years. About half (55 percent) were female, 75 percent white, 18 percent black, and 6 percent other.

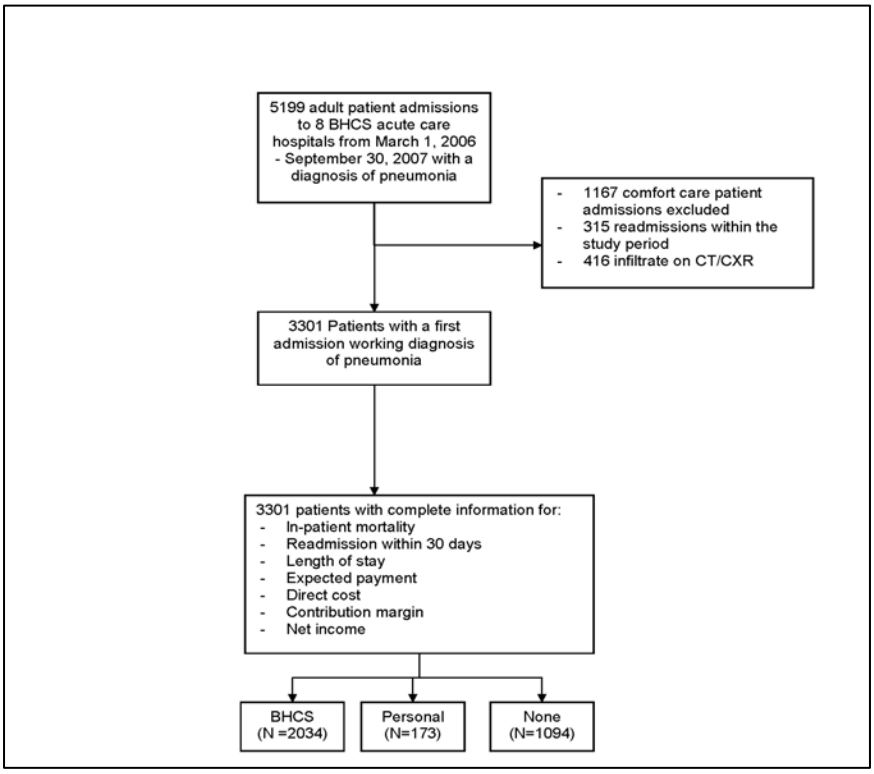

Figure 1. Identification and exclusion of patients included in the evaluation of the Baylor Health Care System Adult Pneumonia Order Set

Significant variation in order set use was observed by age ($P = 0.01$) but not by sex or race. When variation in order set use by APR DRG classes and Greenfield Comorbidity Score was examined using mean score statistics that take into account the ordinal nature of these categorizations, there was a significant association between order set use and APR DRG severity of illness ($P < 0.01$) and APR DRG risk of mortality ($P < 0.01$). Sicker patients were less likely to receive the order set. No significant difference was seen using the Greenfield comorbidity score ($P = 0.42$).

Order set use by month is shown in Table 1. For first pneumonia admissions, BHCS order set use increased from 27 percent in March 2006 to 82 percent in September 2007 (P <0.01); no order set and personal order set use declined (from 51 percent to 18 percent, and from 22 percent to 0 percent, respectively). Despite system-wide promotion of the Adult Pneumonia Order Set, dramatic variation in use was seen among hospitals (P <0.01), with use ranging from 43 percent of first admission pneumonia patients at one hospital to 91 percent at another.

Table 1. Order set use by month for first pneumonia admissions of adult patients to Baylor Health Care System acute care hospitals: March 1, 2006 - September 30, 2007

Discharge Month	Total (N)	BHCS Order Set N (%)	No Order Set N (%)	Personal Order Set N (%)
March 2006	219	59 (27)	112 (51)	48 (22)
April 2006	159	48 (30)	73 (46)	38 (24)
May 2006	153	63 (41)	73 (48)	17 (11)
June 2006	107	51 (48)	47 (44)	9 (8)
July 2006	126	50 (40)	65 (52)	11 (9)
August 2006	110	51 (46)	57 (52)	2 (2)
September 2006	115	59 (51)	49 (43)	7 (6)
October 2006	160	82 (51)	68 (43)	10 (6)
November 2006	176	97 (55)	74 (42)	5 (3)
December 2006	228	135 (59)	84 (37)	9 (4)
January 2007	252	146 (58)	100 (40)	6 (2)
February 2007	233	174 (75)	55 (24)	4 (2)
March 2007	261	212 (81)	46 (18)	3 (1)
April 2007	209	159 (76)	49 (23)	1 (0)
May 2007	196	159 (81)	35 (18)	2 (1)
June 2007	158	133 (84)	24 (15)	1 (1)
July 2007	172	141 (82)	31 (18)	0 (0)
August 2007	143	113 (79)	30 (21)	0 (0)
September 2007	124	102 (82)	22 (18)	0 (0)
Total	3301	2034 (62)	1094 (33)	173 (5)

Table 2 shows the unadjusted results for the effect of order set use on quality of care and fiscal indicators. In-hospital mortality was significantly lower among patients for whom the order set was used (P <0.01), as were expected payment (P <0.01) and contribution to margin (P = 0.02). Compliance with pneumonia core measures with order set use was significantly higher

(P <0.01). Decrease in readmissions within 30 days (P = 0.24) and length of stay (P = 0.11) were not significant, but direct cost (P = 0.06) was significantly lower for patients who received the order set.

Table 2. Unadjusted results comparing quality of care and financial indicators for first pneumonia admissions to Baylor Health Care System acute care hospitals that used vs. did not use the order set: March 1, 2006 - September 30, 2007

	Order set			
Safety and effectiveness indicators	**All (N = 3128) N (%)**	**BHCS (N = 2034) N (%)**	**None (N = 1094) N (%)**	***P*-value**
In-hospital mortality	138(4.4)	67 (3.3)	71 (6.5)	<0.01[a]
Pneumonia core measure compliance	2376 (76.0)	1585 (77.9)	791 (72.3)	<0.01[a]
Readmission within 30 days	349 (11.2)	217 (10.7)	132 (12.1)	0.24[a]
Efficiency and fiscal indicators	**Mean (±SD)[c]**	**Mean (±SD)[c]**	**Mean (±SD)[c]**	
Length of stay (days)	5.3 (3.7)	5.2 (3.6)	5.8 (4.4)	0.11[b]
Direct cost ($)	5418 (4488)	5092 (3918)	6022 (5432)	0.06[b]
Expected payment ($)	7131 (4483)	6642 (3794)	8105 (6004)	0.01[b]
Contribution to margin ($)	1797 (3879)	1592 (3616)	2229 (4453)	0.02[b]

a Based on Chi-square test

b Based on robust ANOVA test

c Robust mean ± standard deviation

Table 3 shows the effect of order set use on quality of care and fiscal indicators following adjustment. The reduction in inpatient mortality with use of the BHCS order set, compared to no order set use, remained statistically significant. The magnitude of this reduction was approximately 34 percent under both covariate- and propensity score-based adjustments. The increase in core measures compliance also remained significant following adjustment, with patients for whom the order set was used being 22 to 24 percent more likely than patients for whom the order set was not used to receive all pneumonia core measures for which they were eligible [relative risk, RR (95 percent CI) = 1.24 (1.04; 1.48) using covariate adjustment and 1.22 (1.02; 1.45) using propensity score adjustment]. Following adjustment, no significant effects of order set use were observed on readmission within 30 days, direct cost, expected payment, or contribution margin.

Table 3. Adjusted effect of order set use vs. no order set used on quality and financial performance measures for first pneumonia admissions discharged from acute care hospitals: March 1, 2006-September 30, 2007

Outcome	Covariate adjusted[a]	Propensity score adjusted[b]
Safety and effectiveness indicators		
In-hospital mortality [HR (95% CI)] [c]	0.66 (0.45; 0.97)	0.67 (0.46; 0.98)
Pneumonia core measure compliance [RR (95% CI)] [d]	1.24 (1.04; 1.48)	1.22 (1.02; 1.45)
Readmission within 30 days [HR (95% CI)][c]	0.86 (0.67; 1.10)	0.85 (0.67; 1.09)
Efficiency and fiscal indicators [Reg est (95% CI)][e]		
Length of stay (days)	0.02 (-0.21; 0.25)	0.06 (-0.20; 0.33)
Direct cost ($)	-68 (-273; 137)	-25 (-277; 226)
Expected payment ($)	-87 (-197; 23)	-5 (-192; 181)
Contribution to margin ($)	-57 (-300; 185)	-64 (-358; 231)

a Adjusted for age, sex, race, type of physician (hospitalist), Greenfield comorbidity, APR DRG (risk of mortality or severity), payer type, admission source, hospital and discharge month.

b Propensity scores based on patient's age, sex, race, type of physician (hospitalist), Greenfield comorbidity, APR DRG (risk of mortality or severity), payer type, admission source, hospital, and discharge month.

c HR (95% CI) = Hazard ratio (95% confidence interval).

d RR (95% CI) = Odds ratio (95% confidence interval).

e Reg est (95% CI) = Robust regression estimate (95% confidence interval).

Discussion

This study examined the impact of development and system-wide deployment of a standardized order set for adult pneumonia on quality of care and financial performance over a 19-month study period in the multihospital Baylor Health Care System.

Use of the BHCS Adult Pneumonia Order Set varied significantly and widely, by hospital and by month, with use for first admission pneumonia patients increasing from 27 percent in March 2006 to 82 percent in September 2007. The wide variation in use by hospital likely reflects variability in local physician leadership and their buy-in to implementation and use of standardized order sets (potentially influencing such factors as the degree to which local frontline providers were exposed to the order set awareness campaign) and differences from one hospital to another in the training provided to nursing units. Patients in higher APR DRG Severity of Illness and Risk of Mortality classes were significantly less likely to receive the order set.

Prior to adjustment, order set use showed a significant reduction in in-hospital mortality, expected payment, and contribution margin, as well as a significant increase in core measures compliance. Following adjustment for patient and provider characteristics, severity of illness, discharge month and hospital, the reduction in in-hospital mortality and the increase in core

measures compliance retained significance. The mortality effect was very large, with a 33 to 34 percent reduction in in-hospital mortality, depending on the risk-adjustment method employed. This mortality reduction translates into 32 patients that need to be treated with the order set to save one additional life, which is similar to the result reported for a pneumonia clinical pathway.[25] The increase in core measures compliance was also significant, with patients for whom the order set was used being 22 to 24 percent more likely than patients for whom it was not used to receive all the pneumonia core measures for which they were eligible, depending on the adjustment technique. No significant effects were seen on the efficiency and fiscal indicators examined following risk adjustment.

While we observed substantial and statistically significant mortality and core measures compliance benefits with order set use, no correspondingly large benefit with respect to length of stay or any financial indicator was evident. In a separate examination of APR DRG Risk of Mortality classes 1 to 3 and 4, the mortality benefit of the order set was sustained and even strengthened among patients with the highest mortality risk: for classes 1 to 3, in-hospital mortality was 1.4 percent with the BHCS order set vs. 2.0 percent with no order set [adjusted hazard ratio, HR (95 percent CI) = 0.87 (0.43-1.74)]; for class 4, in-hospital mortality was 19.0 percent with the order set and 31.4 percent with no order set [adjusted HR (95 percent CI) = 0.65 (0.42-1.02)].

An intranet portal had been shown in earlier research to be an accepted and effective means of disseminating a standardized order set throughout a multi-hospital health care system.[1] This intermediate level between fully paper-based order sets and CPOE avoids many of the identified problems with paper-based order sets[26] and is quicker and less expensive to implement than CPOE. The increased use of the Adult Pneumonia Order Set over time seen within BHCS is similar to the increasing "hits" the Medical University of South Carolina observed in tracking use of their order set intranet portal following its implementation in March 2002.[1]

The 82 percent order set utilization rate demonstrated for first pneumonia admissions 19 months after implementation was substantially higher than adoption rates previously reported for pneumonia order sets/clinical pathways, which have been < 30 percent.[25, 27, 28] Our observation that use of the order set decreased in-hospital mortality was consistent with previous studies examining the impact of order set use on mortality, both for pneumonia[29] and for other conditions,[30] as was the finding of increased pneumonia core measures compliance following implementation of tools to increase the standardization of care, such as order sets and protocols.[2, 4, 5, 30, 31, 32]

Order set use may have effected larger improvements in delivery of certain indicators within the pneumonia core measures set than were observed for the composite score. It has been noted previously that tools—such as standardized orders, treatment guidelines, and critical pathways—are most effective in improving processes of care that are directly under physicians' control. They are less effective with respect to those that depend on a more complex series of interactions between individuals and components of the health care system.[15]

With regard to the impact of an order set on efficiency and fiscal indicators, previous research investigating the effects on resource use and costs of tools to standardize care for conditions

requiring medical rather than surgical management has shown variable results.[8, 13, 15, 16, 17] Looking specifically at pneumonia, one previous study of the implementation of a treatment guideline that included a standardized admitting order sheet demonstrated no change in length of stay.[29] On the other hand, other studies have shown a decrease in length of stay following implementation of a critical pathway or standardized order set plus intensive case management for pneumonia.[16, 17]

To obtain definitive answers regarding the effects of such tools on efficiency and fiscal indicators, studies specifically targeting and powered for these measures may be needed. A more complete financial analysis would include the cost of administering the pneumonia order set at the patient level, examining fixed costs (e.g., Zynx™ order set evidence-based information, physician champion meetings, staff training, and implementation at the hospital) and variable costs (e.g., costs of specific aspects of the order set at the patient level). However, without specific cost data (fixed and variable) at the patient level, computing the necessary cost-effectiveness ratios is problematic.

Since this was an observational study as opposed to a randomized trial, it is possible that order set use was influenced by patients' characteristics, potentially masking or exaggerating the impact of the order set. To account for the differences among the patients that did or did not receive the order set, we conducted adjusted analyses using both covariate and propensity score approaches. These analyses also accounted for the variation in order set use by facility and time observed in this study. Standard covariate risk adjustment is limited in that it does not ensure a balanced distribution of covariates among the study subjects,[33] an issue which becomes increasingly important as the number of covariates that need to be considered rises.[34] Propensity score-based risk adjustment ensures that measures of patient characteristics are properly balanced across the study groups by estimating the probability that a patient will receive the order set, given his/her covariate values.[35, 36, 37]

An additional aspect of this study design that cannot be discounted in interpreting results is the potential for contamination between study groups. Physicians and other clinicians may have been influenced by exposure to the order set in their care decisions, even for patients to whom the order set was not applied. Such contamination would attenuate differences between the study groups, underestimating the impact of the order set.

Another factor that must be considered and explored through future research is the inclusion of passive decision support and default care coordination consult in the BHCS Adult Pneumonia Order Set. Because the impact of individual components of the order set was not investigated in this study, the role of the passive decision support and the default care coordination consult in producing the observed improvements in outcomes is not known. Order sets that do not include analogous components may not have the same impact on care as was demonstrated here.

Our results show that important improvements in patient outcomes can be achieved through the implementation of a standardized order set throughout a health care system. This validation of improved patient outcomes is important, since order sets, like clinical performance measures, go beyond the relatively passive recommendations for care incorporated in clinical guidelines and work to actively ensure that patients receive certain processes of care. This is especially

important for patients (e.g., the elderly) who are likely to have been underrepresented in the randomized controlled trials that provided the bulk of the evidence on which evidence-based guidelines, order sets, and performance measures are based.[38]

The development and deployment of standardized order sets has been undertaken by BHCS in part to prepare for the implementation of CPOE; future research will investigate whether further reductions in mortality and/or improvements in other outcome measures are achieved following the introduction of CPOE. The substantial increase in use of the order set over the 19-month study period suggests that health care organizations considering similar initiatives to improve quality of care may need to anticipate a period of several months before use of the order sets is sufficiently integrated into clinical practice to achieve detectable changes.

Finally, our finding that the Adult Pneumonia Order Set was less likely to be used for sicker patients, for whom it was associated with a 35 percent adjusted relative reduction in mortality and a 12 percent unadjusted absolute reduction in mortality, underscores the importance of increasing order set use among the patients who are most likely to benefit from this care improvement tool.

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