What Would Be the Effect of Referral to High-Volume Hospitals in a Largely Rural State?

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ABSTRACT: ***Context:*** *Volume of certain surgical procedures has been linked to patient outcomes. The Leapfrog Group and others have recommended evidence-based referral using specific volume thresholds for nonemergent cases. The literature is limited on the effect of such referral on hospitals, especially in rural areas.* ***Purpose:*** *To examine the impact of evidence-based referral by volume standard for 5 hospital procedures (abdominal aortic artery repair, coronary angioplasty, coronary artery bypass graft, esophageal cancer surgery, and pancreatic resection) in a largely rural state.* ***Methods:*** *Healthcare Cost and Utilization Project Iowa State Inpatient Dataset was analyzed to identify hospitals meeting the volume standard versus those not meeting the standard.* ***Findings:*** *Relatively few hospitals perform these procedures in Iowa. Hospitals performing the procedures at a volume above the threshold standard set by the Leapfrog Group tend to be larger, receive more transfers from other hospitals for these procedures, and perform fewer of these procedures on an emergency basis. In Iowa, hospitals that met the volume standard did not differ from hospitals that did not meet the volume standard in risk-adjusted mortality rates. The impact of evidence-based referral would be substantial in terms of travel time for some procedures (ie, coronary artery bypass graft, pancreatic resection, and esophageal cancer surgery) and produce considerable lost revenue for some hospitals.* ***Conclusions:*** *Evidence-based referral would be associated with substantial burden for some patients and hospitals in Iowa. This negative impact does not appear to be offset by improvement in in-hospital mortality rates. These initial findings suggest that there are a number of issues that need to be considered, especially in a rural state, before evidence-based referral is embraced as a means to enhance patient outcomes.*

Intuitively, one might expect that better patient outcomes will positively be associated with the greater frequency a procedure is provided by a clinician or hospital. The issue of whether "practice does make perfect"[1] has been considered for some time in the scientific literature and represents a growing body of published work. In fact, 5 recent reviews[2-6] summarized this literature and all reported support for the hypothesized positive volume-outcome relationship for a number of procedures.

Based on this research evidence, the Agency for Healthcare Research and Quality (AHRQ) has included surgical volume among its hospital quality indicators.[7] Numerous foundations and consumer groups accept that higher surgical volume enhances patient safety. Organizations such as the Leapfrog Group have encouraged the use of volume-based referral by employers purchasing health care and patients selecting providers. The Leapfrog Group is a coalition of public and private organizations that provide health care benefits. Evidence-based hospital referral (EHR) is 1 of the 3 safety standards the Leapfrog Group has endorsed to influence employers' future purchases of health care. The EHR standard states that when time allows (ie, for elective as opposed to emergent situations), patients should be referred to those hospitals that meet volume standards for specific procedures where there is support for doing so in the scientific literature.[8] The Leapfrog Group has identified conditions/procedures and associated patient care volumes that it has encouraged its member organizations to use in making future health care purchasing decisions (Table 1). The Leapfrog Group's recommended conditions/procedures and volume thresholds change from time to time; pancreatic

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Table 1. The Leapfrog Group's Evidence-Based Hospital Referral (EHR) Procedures* and Recommended Volume Cutoffs† on Which To Base Referrals

Procedure	Recommended Volume Threshold
Coronary artery bypass graft	≥450/year
Coronary angioplasty	≥400/year
Abdominal aortic aneurysm repair	≥50/year
Esophageal cancer surgery	≥13/year
Pancreatic resection	≥11/year

* A sixth condition/procedure involving neonatal intensive care was not analyzed because data were not available to compute average daily census in neonatal ICUs.
† The Leapfrog Group revises their EHR recommendations periodically. These were the recommendations in effect as of January 1, 2004.

resection recently replaced carotid endarterectomy, and the volume thresholds were lowered for 1 condition and raised for 2 others.

Recognizing that implementing the EHR standard in isolated rural areas could cause travel burdens for patients and their families, the Leapfrog Group applies the EHR standard only to hospitals in metropolitan areas. However, the pressure on businesses to apply volume standards in metropolitan areas and the links to the Leapfrog Group's Web site by HealthGrades.com,[9] Selectqualitycare.com,[10] Subimo.com,[11] and other organizations purporting to measure health care quality creates the potential for carrying the debate to rural markets. Application of EHR policies should have demonstrated positive effects in quality in the population studied. Besides imposing a travel burden for patients and their families, the EHR policy is likely to have other effects. Many hospitals are so financially constrained that implementation of the EHR standard may have serious consequences on their ability to implement other patient safety and quality initiatives that may have greater positive effect. Ultimately, the goal is to increase quality and safety in all hospitals. In-hospital mortality rates for specific procedures are only 1 limited measure that may be associated with quality. Even though an inverse association between volume and in-hospital mortality has repeatedly been shown, the mechanism behind the association remains elusive and subject to speculation.[12,13] Moreover, the reliance on in-hospital mortality as the sole proxy for quality has long been criticized.[14]

The purpose of this study is to evaluate the potential effects in Iowa of implementing the EHR patient safety standards developed by the Leapfrog Group. The effect is evaluated by comparing hospitals that currently meet the EHR volume standard for 5 conditions against hospitals that perform the procedures but do not meet the EHR volume standard in terms of in-hospital mortality, additional travel distance for patients, and hospital revenues.

Methods

The authors used Iowa hospital discharge abstract data for 2001 to assess current volumes. The Iowa Hospital Association (IHA) collects standardized hospital discharge summaries, which are included in the AHRQ Healthcare Cost and Utilization Project (H-CUP) dataset. The IHA State Inpatient Database (IHA-SID) contains approximately 360,000 records per year of patient identity–protected information.

Using combinations of diagnosis (ICD-9) codes and clinical procedure terminology (CPT) codes, each hospitalization for one of the Leapfrog Group volume-sensitive procedures was identified. The Leapfrog Group has set specific recommendations for volumes of the volume-sensitive procedures. For example, it recommends that patients who need coronary artery bypass graft have it performed at a hospital that does at least 450 such procedures per year. These volume recommendations were used to categorize hospitals based on whether they met these recommendations. For hospitals in the state of Iowa that performed these procedures, 2 catergories were created: those that met the Leapfrog Group standard for volume-sensitive procedures and those that performed any of a volume-sensitive procedure but did not meet the volume standard (2001 data were analyzed, but the pattern was nearly identical for 2000 and 1999 data).

The IHA-SID discharge abstract data were linked to the American Hospital Association (AHA) annual survey, so the specific location of each hospital was identifiable and organizational data on each hospital could be analyzed. Using the AHA 2001 annual survey, the 2 categories of hospitals were characterized in terms of bed-size, annual number of admissions, full-time equivalent (FTE) staff per bed, teaching status (member of Council of Teaching Hospitals or not), ownership (government, church, other nonprofit, for-profit), membership in a health care system, and location of hospital (urban or rural). Urban hospitals were defined as located in a metropolitan statistical area (MSA), whereas rural hospitals were not located in an MSA. In

addition, a subset of nonmetropolitan hospitals was identified as "rural referral hospitals" based on the Iowa Hospital Association's classification of these as rural hospitals with operating characteristics similar to those of a typical urban hospital. The patient population for each category of hospital was characterized in terms of age, sex, length of stay, type of admission (elective, urgent, emergency), source of admission (physician referral, admission from the emergency department, transfer from another hospital, transfer from a nonacute health care facility), disposition code (discharge to home, transfer to a health care facility, expired), and payer source (Medicare, Medicaid/other government, HMO/group, self-pay/no charge). These analyses were calculated within the patient pool that had each procedure.

A crucial question was whether Iowa patients who had these procedures performed at hospitals that did not meet volume standards had any worse outcomes than patients who had them performed at hospitals that did meet the volume standards. To make this comparison, observed in-hospital death rates were calculated and then risk-adjusted death rates, adjusting for age, sex, and comorbidity, were calculated using the Charlson Comorbidity Index.[15,16] This permitted risk-adjusted mortality rates to be compared for hospitals that met the volume standards vs hospitals that performed the procedures but did not meet the Leapfrog Group volume standards.

To examine the potential impact of implementing the evidence-based hospital referral (EHR) patient safety standard developed by the Leapfrog Group on access and hospital revenues, it was assumed, hypothetically, that the Leapfrog Group's EHR purchase decision strategy was being applied statewide and was in effect for all hospitalizations in the study year. To explore access issues, the authors examined the residence of each patient who was hospitalized for a volume-sensitive procedure. The IHA-SID included the ZIP code of residence of each patient. The specific location of the hospital was also available from linking to AHA data. The distances patients traveled for hospitalization were computed using the latitude and longitude values associated with the ZIP codes of the patients' residences and the specific hospital location. For patients treated in the hospitals that did not meet volume standards, the authors estimated the incremental travel distance they would have had to travel to be cared for in the next closest Iowa hospital that met the volume standards.

The financial effect on hospitals projected to lose or gain patient volume if the Leapfrog Group's EHR recommendations were to be applied statewide were then examined. The IHA-SID includes the total inpatient charges for each hospitalization and expected source of payment. Using the estimated number of each procedure that would migrate from a hospital that did not meet the volume standard to the nearest hospital that did meet the standard if the Leapfrog Group's recommendations were implemented, the amount of revenue that would be lost by the hospitals losing patients and gained by the hospitals receiving the transfers was estimated. Charges were converted to estimated net revenue (payments) using the average contractual allowance rate by payer category (Medicare, Medicaid, self-pay/no-pay, Blue Cross/Blue Shield, and other private payers) for each of 3 hospital categories (urban, rural referral, rural). For each hospital that would lose patients if the standard were implemented, the average charges (adjusted for contractual allowances for each payer group) were computed and were summed to identify the potential amount of revenue lost for each procedure. Likewise, for each hospital that would gain patients, the authors computed the average charges (adjusted for contractual allowances by payer group) gained.

Results

For hospitals in Iowa that performed these volume-sensitive procedures, 2 categories were created: those that met the Leapfrog Group standard for volume-sensitive procedures and those that did not. In 2001, 13 Iowa hospitals performed coronary artery bypass grafts, yet only 1 hospital met the Leapfrog Group standard for coronary artery bypass graft (450 or more procedures annually). Likewise, 14 hospitals performed esophageal cancer surgery, but only 1 hospital met the standard (a minimum of 13 procedures annually), and 13 hospitals performed pancreatic resection but only 1 met the Leapfrog Group standard (11 procedures annually). For abdominal aortic aneurysm repair, 24 Iowa hospitals performed the procedure and 2 met the standard (50 procedures annually). The only procedure where numerous Iowa hospitals met the Leapfrog Group volume threshold was coronary angioplasty: of 17 hospitals performing the procedure, 10 met the Leapfrog Group standard (400 procedures per year).

For both esophageal cancer and pancreatic resection, the 1 hospital that met the Leapfrog Group standard did 3 times the volume of procedures as the next highest volume hospital. For the coronary angioplasty procedure, even though half of the hospitals performing the procedure met the Leapfrog Group volume threshold, 2 hospitals had substantially higher volumes than the other hospitals performing this procedure. For coronary artery bypass graft, only 1

hospital met the volume standard, but the volume of procedures performed by a number of other hospitals was similar. For abdominal aortic aneurysm repair, many hospitals performed these procedures, with a relatively continuous range of volumes.

Table 2 shows the characteristics of both categories of hospitals in terms of beds, annual number of admissions, FTEs per bed, ownership, membership in a health care system, and location. Wilcoxon Mann-Whitney test for continuous variables and χ^2 exact test were used to test for significant differences in hospital characteristics between the 2 categories of hospitals. Tests of statistical significance were affected by the lopsided distribution of hospitals, as only 1 hospital met the Leapfrog Group volume threshold for 3 of the conditions. However, examining the raw values in Table 2 shows that the categories of hospitals differed on some variables. Hospitals that met the Leapfrog Group volume standards were larger than those hospitals that did the procedures but not at a volume meeting the standards (shown in number of beds set up and staffed and annual number of admissions). Both categories of hospitals performing the procedures tended to be located in urban areas. Only 1 hospital in Iowa was a member of the Council of Teaching Hospitals, and that hospital did all the procedures but only met the Leapfrog Group standard for some procedures (also, only 1 hospital in Iowa was a member of the Council of Teaching Hospitals, which precluded statistical analysis on this variable).

Table 3 shows patients' characteristics for hospitals that did the procedures and met the standard compared to hospitals that did the procedure and did not meet the standard. A number of comparisons reached statistical significance due to the large sample size, but the actual difference between the 2 categories of hospitals was small. In general, the 2 categories of hospitals differed little on patients' age, sex, length of stay, discharge disposition, or source of payment. The most obvious differences were in terms of source and type of admission. Hospitals meeting the EHR volume standard tended to have more patients transferred from other hospitals. In contrast, hospitals that did not meet the EHR volume standard but performed the procedure tended to have more emergency cases and ER admissions. Only 1 hospital in Iowa met the Leapfrog Group standard for esophageal cancer surgery, and patients having the procedure at that hospital had much longer lengths of stay.

An important comparison of hospitals that met the Leapfrog Group standard with those that did not meet the volume standard involved mortality rates. The top half of Table 4 shows the observed (raw) death rate for each procedure. For 2 of the procedures, the absolute number of deaths was very low (1 for esophageal cancer surgery and 3 for pancreatic resection), thus no conclusions can be drawn about the relationship between mortality and the Leapfrog Group volume standards for these procedures. For the other conditions, more procedures were done, and the absolute number of deaths was sufficient to conduct analyses examining the pattern of deaths by hospital category. In comparing in-hospital mortality for hospitals that met the standard vs those that did not, it is important to control for the risk profile of the patients prior to having the surgery. Thus, multivariable logistic regressions were performed that controlled for age, sex, and patient comorbidity. The bottom half of Table 4 shows the results of multivariable logistic regression with in-hospital mortality as the dependent measure. The logistic regression shows that hospital category (met Leapfrog Group volume standard vs did not meet the standard) was not significant for these procedures when age, sex, and patient severity were taken into consideration (because 1 category had 0 observations, the multivariable logistic regressions for esophageal cancer surgery and pancreatic resection did not yield valid results).

If the Leapfrog Group EHR standard were implemented, all nonemergency cases for the 5 procedures would need to travel to a hospital meeting the standard. Calculating the incremental travel distance to the next closest hospital that met the standard, the average additional travel distance would be 8.1 miles for coronary angioplasty, 60.7 miles for abdominal aortic aneurysm repair, 89.3 miles for coronary artery bypass graft, 104.9 miles for pancreatic resection, and 106.0 miles for esophageal cancer surgery. As demonstrated by these averages, patients having elective coronary angioplasty would have very little additional travel if referred to a hospital that met the Leapfrog Group EHR standard. In contrast, patients having coronary artery bypass graft, pancreatic resection, or esophageal cancer surgery would have substantial additional travel.

In addition, if the Leapfrog Group volume standards were implemented and all nonemergency cases were transferred to the nearest hospital meeting the standard, there would be substantial losses of revenue for some hospitals and substantial gains for others. For hospitals losing patients, the annual loss of revenue would total $809,000 for pancreatic surgery, $987,000 for esophageal cancer surgery, $6.2 million for abdominal aortic aneurysm repair, $10.1 million for coronary angioplasty, and $69.4 million for coronary artery bypass graft. A similar total amount of revenue would be gained by hospitals gaining patients for each

Table 2. Hospital Characteristics* for the 5 Procedures Based on the Leapfrog Group Criteria† for Evidence-Based Referrals

	Condition									
	Coronary Artery Bypass Graft		Coronary Angioplasty		Abdominal Aortic Aneurysm Repair		Esophageal Cancer Surgery		Pancreatic Resection	
Variables	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met
Number of hospitals	N = 1	N = 12	N = 10	N = 7	N = 2	N = 22	N = 1	N = 13	N = 1	N = 12
Beds set up & staffed										
Median	572	259	381	197	575	237.5	679	272	679	265
Range	572–572	151–679	151–679	62–372	471–679	47–572	679–679	87–572	679–679	112–572
	P-value = .2523		*P*-value = .0168		*P*-value = .0431		*P*-value = .1605		*P*-value = .1416	
Admissions										
Median	28,569	11,089	13,609	8,735	21,850	9,856	23,179	11,138	23,179	11,019
Range	28,569–28,569	3,261–23,179	6,783–28,569	1,456–11,272	20,522–23,179	2,404–28,569	23,179–23,179	3,261–28,569	23,179–23,179	3,261–28,569
	P-value = .1416		*P*-value = .0097		*P*-value = .0417		*P*-value = .2148		*P*-value = .2291	
FTEs per bed										
Median	6.44	5.08	5.77	3.97	7.04	5.08	7.34	6.40	7.34	5.79
Range	6.44–6.44	2.46–10.18	2.96–10.18	2.46–6.88	6.74–7.34	2.33–10.18	7.34–7.34	2.46–10. 18	7.34–7.34	2.46–10.18
	P-value = .5040		*P*-value = .2225		*P*-value = .1299		*P*-value = .3211		*P*-value = .2291	
	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)
Ownership										
Gov. non-federal	0 (0.0)	1 (8.3)	1 (10.0)	0 (0.0)	1 (50.0)	1 (4.5)	1 (100.0)	0 (00.0)	1 (100.0)	0 (0.0)
Non-govt. nonprofit	0 (0.0)	7 (58.3)	5 (50.0)	4 (57.1)	1 (50.0)	12 (54.5)	0 (0.0)	6 (46.1)	0 (0.0)	8 (66.7)
Church	1 (100.0)	4 (33.3)	4 (40.0)	3 (42.9)	0 (0.0)	9 (40.9)	0 (0.0)	7 (53.8)	0 (0.0)	4 (33.3)
	P-value = .4615		*P*-value = 1.000		*P*-value = .1630		*P*-value = .0714		*P*-value = .0769	
Membership in a health care system										
Yes	1 (100.0)	10 (83.3)	9 (90.0)	5 (71.4)	1 (50.0)	15 (71.4)	0 (0.0)	11 (83.3)	0 (0.0)	11 (91.7)
No	0 (0.0)	2 (16.7)	1 (10.0)	2 (28.6)	1 (50.0)	6 (28.6)	1 (100.0)	2 (16.7)	1 (100.0)	1 (8.3)
	P-value = 1.000		*P*-value = .5368		*P*-value = 1.000		*P*-value = .2308		*P*-value = .1538	

Table 2. Continued

Variables	Condition									
	Coronary Artery Bypass Graft		Coronary Angioplasty		Abdominal Aortic Aneurysm Repair		Esophageal Cancer Surgery		Pancreatic Resection	
	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)
Location‡										
Urban	1 (100.0)	10 (83.3)	8 (80.0)	7 (100.0)	2 (100.0)	14 (63.6)	1 (100.0)	11 (84.6)	1 (100.0)	10 (83.3)
Rural referral	0 (0.0)	2 (16.7)	2 (20.0)	0 (0.0)	0 (0.0)	6 (27.3)	0 (0.0)	2 (15.4)	0 (0.0)	2 (16.7)
Rural	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	P-value = 1.000		*P*-value = .4853		*P*-value = .6522		*P*-value = 1.000		*P*-value = 1.000	

* Non-parametric Wilcoxon Mann-Whitney tests for significant differences between the 2 groups of hospitals (meet vs do not meet standard) was used for continuous variables. Exact χ^2 test was used to identify significant differences between the 2 groups for categorical variables.
† Leapfrog Group Evidence-Based Hospital Referral volume threshold: coronary artery bypass graft (450 patients/year), coronary angioplasty (400 patients/year), abdominal aortic aneurysm repair (50 patients/year); esophageal cancer surgery (13 patients/year), pancreatic resection (11 patients/year).
‡ Urban hospitals are in metropolitan statistical areas (MSAs), rural hospital are not in MSAs, and rural referral hospitals are not in MSAs but have characteristics of urban hospitals.
FTEs = full-time equivalent staff
N = number
Col % = column percent

procedure. However, the revenue from these procedures would be consolidated in far fewer hospitals. Across the 29 hospitals currently doing any of these procedures, 13 would loose in excess of $1 million in patient revenue (summed across conditions).

Discussion

The findings from the current analyses indicate that few hospitals in a largely rural state such as Iowa would meet the volume standards set by the Leapfrog Group. Using rates from an earlier analysis of volume standards in a national set of hospitals,[17] of the hospitals that performed these procedures, an estimated 48% met the volume threshold for coronary angioplasty, 25% for coronary artery bypass graft, 12% for abdominal aortic aneurysm repair, 10% for pancreatic resection, and 4% for esophageal cancer surgery. The rates in Iowa are roughly similar for all procedures except coronary artery bypass graft, which is much lower in Iowa.

When the hospitals that do meet the EHR volume standards for the procedures analyzed here are compared to the hospitals that do not meet the standards, significant differences are apparent only for size. Hospitals that meet the volume standards are larger in terms of number of beds set up and staffed and in terms of number of admissions annually. Iowa hospitals performing these procedures, whether they meet the volume standard or not, are largely in urban centers. Elixhauser and colleagues[17] performed a similar analysis using H-CUP data and found that ''low-volume'' hospitals nationally tend to be small institutions.

In addition to examining hospital characteristics, the authors examined patient characteristics among patients having these procedures at hospitals that met the volume threshold compared to hospitals that did not. In examining age, sex, type of admission, source of admission, disposition code, and source of payment, significant differences in patient characteristics were apparent between these 2 categories of hospitals, especially for the 2 procedures with more than 1 hospital meeting the EHR volume standard (coronary angioplasty and abdominal aortic aneurysm repair). The most consistent differences were for source and type of admission. Hospitals meeting the EHR volume standard had more patients transferred

Table 3. Patients' Characteristics for the 5 Procedures Based on the Leapfrog Group criteria for Evidence-Based Referrals

	Condition									
	Coronary Artery Bypass Graft		Coronary Angioplasty		Abdominal Aortic Aneurysm Repair		Esophageal Cancer Surgery		Pancreatic Resection	
Variables	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met
Number of patients	577	2,951	7,577	1,345	135	356	18	26	18	21
Number of hospitals	1	12	10	7	2	22	1	13	1	12
Length of stay										
Median (days)	7.0	7.0	2.0	2.0	8.0	7.5	21.0	11.0	15.5	20.0
Range (days)	2–128	1–199	1–104	1–156	1–96	1–63	7–56	7–84	9–53	9–67
	P-value = .4521		*P*-value < .0001		*P*-value = .0813		*P*-value = .0076		*P*-value = .1581	
	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)
Age										
<65 years	227 (39.3)	1,087 (36.8)	3,422 (45.2)	666 (49.5)	36 (26.7)	73 (20.5)	6 (33.3)	12 (46.2)	6 (33.3)	9 (42.9)
65+ years	350 (60.7)	1,864 (63.2)	4,153 (54.8)	679 (50.5)	99 (73.3)	283 (79.5)	12 (66.7)	14 (53.9)	12 (66.7)	12 (57.1)
	P-value = .2547		*P*-value = .0032		*P*-value = .1425		*P*-value = .3951		*P*-value = .5422	
Gender										
Male	403 (69.8)	2,034 (69.0)	5,043 (66.6)	851 (63.3)	90 (66.7)	280 (78.7)	15 (83.3)	22 (84.6)	10 (55.6)	14 (66.7)
Female	174 (30.2)	917 (31.1)	2,532 (33.4)	494 (36.7)	45 (33.3)	76 (21.4)	3 (16.7)	4 (15.4)	8 (44.4)	7 (33.3)
	P-value = .6625		*P*-value = .0184		*P*-value = .0059		*P*-value = 1.000		*P*-value = .4771	
Type of admission										
Elective	448 (77.6)	1,512 (51.2)	3,757 (49.6)	386 (28.7)	73 (54.1)	248 (69.7)	10 (55.6)	18 (69.2)	7 (38.9)	12 (57.1)
Urgent	4 (0.7)	1,018 (34.5)	1,690 (22.3)	440 (32.7)	45 (33.3)	50 (14.0)	8 (44.4)	7 (26.9)	10 (55.6)	6 (28.6)
Emergency	125 (21.7)	421 (14.3)	2,126 (28.1)	518 (38.5)	16 (11.9)	58 (16.3)	0 (0.0)	1 (3.9)	1 (5.6)	3 (14.3)
Unknown	0 (0.0)	0 (0.0)	2 (0.0)	1 (0.1)	1 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	P-value < .0001		*P*-value < .0001		*P*-value < .0001		*P*-value = .4155		*P*-value = .2376	
Admission source										
Physician referral	453 (78.5)	1,945 (65.9)	4,127 (54.5)	777 (57.8)	107 (79.3)	274 (77.0)	17 (94.4)	26 (100.0)	15 (83.3)	17 (81.0)
Emergency dept.	115 (19.9)	445 (15.1)	2,264 (29.9)	534 (39.7)	16 (11.9)	57 (16.0)	1 (5.6)	0 (0.0)	1 (5.6)	2 (9.5)
Transfer from hospital	9 (1.6)	355 (12.0)	656 (8.7)	30 (2.2)	12 (8.9)	4 (1.1)	0 (0.0)	0 (0.0)	2 (11.1)	1 (4.8)
Unknown	0 (0.0)	105 (3.6)	339 (4.5)	0 (0.0)	0 (0.0)	16 (4.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.8)
Non acute HC facility	0 (0.0)	101 (3.4)	189 (2.5)	4 (0.3)	0 (0.0)	5 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	P-value < .0001		*P*-value < .0001		*P*-value < .0001		*P*-value = .4091		*P*-value = .9132	
Disposition code										
Discharged home	494 (85.6)	2,506 (84.9)	7,219 (95.3)	1,270 (94.4)	114 (84.4)	267 (75.0)	15 (83.3)	24 (92.3)	18 (100.0)	12 (57.1)
Transfer to health care facility	63 (10.9)	349 (11.8)	217 (2.9)	55 (4.1)	11 (8.2)	55 (15.5)	2 (11.1)	2 (7.7)	0 (0.0)	6 (28.6)
Expired	20 (3.5)	96 (3.3)	139 (1.8)	20 (1.5)	10 (7.4)	34 (9.6)	1 (5.6)	0 (0.0)	0 (0.0)	3 (14.3)
	P-value = .8046		*P*-value = .0391		*P*-value = .0637		*P*-value = .5820		*P*-value = .0030	
Payment source										
Medicare	346 (60.0)	1,858 (63.0)	4,294 (56.7)	695 (51.7)	95 (70.4)	285 (80.1)	13 (72.2)	17 (65.4)	12 (66.7)	12 (57.1)

Table 3. Continued

Variables	Condition									
	Coronary Artery Bypass Graft		Coronary Angioplasty		Abdominal Aortic Aneurysm Repair		Esophageal Cancer Surgery		Pancreatic Resection	
	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)	N (Col. %)
HMO/group	213 (36.9)	880 (29.8)	2721 (35.9)	593 (44.1)	34 (25.2)	64 (18.0)	5 (27.8)	8 (30.8)	4 (22.2)	9 (42.9)
Self-pay/no charge	9 (1.6)	71 (2.4)	292 (3.9)	24 (1.8)	2 (1.5)	5 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Medicaid/other govt.	9 (1.6)	142 (4.8)	268 (3.5)	33 (2.5)	4 (3.0)	2 (0.6)	0 (0.0)	1 (3.9)	2 (11.1)	0 (0.0)
	P-value < .0001		*P*-value < .0001		*P*-value = .0364		*P*-value = 1.000		*P*-value = .1553	

Col % = column percent
HC = health care

from other hospitals. In contrast, hospitals that did not meet the EHR volume standard but performed the procedure had more emergency cases.

Beyond examining hospital and patient characteristics, the impact of implementing the type of evidence-based referral recommended by the Leapfrog Group was examined. This was done by comparing mortality rates in hospitals that meet the volume thresholds vs those that do not and by examining impact in terms of additional travel distance and hospital revenue changes.

A crucial comparison reported here is for in-hospital mortality rates. The issue of whether volume affects outcomes has been considered for some time in the scientific literature. Five independent reviews[2-6] recently summarized this literature, and all reported support for the hypothesized positive volume-outcome relationship for a number of procedures. In a recent examination of the Leapfrog Group volume thresholds in a national sample,[17] low-volume hospitals had significantly higher unadjusted in-hospital mortality rates for coronary angioplasty, coronary artery bypass graft, pancreatic resection, and esophageal cancer surgery, but not for abdominal aortic aneurysm repair. In contrast, the examination in Iowa hospitals, using rates that were adjusted for age, sex, and comorbidities, did not find any significant differences. The number of procedures and hospitals involved in Iowa is limited, so these findings are only suggestive. But they imply that in-hospital mortality may not be adversely affected by having these procedures performed in Iowa hospitals that do not meet the volume threshold. One possible factor to be considered in interpreting these findings is that the authors are unable to control for surgeon volume in this analysis. Prior studies suggest that surgeon volume is an important element of the general hospital volume-outcome relationship.[12] Thus, given that surgeons in rural hospitals often practice at several hospitals, a low hospital volume may not correlate strongly to low surgeon volume. Another possible explanation is simply that the quality of health care in Iowa rates among the best in the country (Iowa ranks eighth in terms of quality of medical care delivered to Medicare beneficiaries).[18] Thus, the low mortality rate in Iowa hospitals with lower volumes may not generalize to all hospitals across the country.

Research has shown that people have a strong preference for and tend to choose treatments that are available locally, regardless of their efficacy.[19,20] For example, nearly three quarters of patients indicated that they would prefer local surgery even when travel to a regional center would result in lower operative mortality risk. Moreover, about one quarter of patients indicated that they would accept very high levels of

Table 4. In-hospital Mortality for the 5 Procedures Based on the Leapfrog Group Criteria for Evidence-Based Referrals

	Condition									
	Coronary Artery Bypass Graft		Coronary Angioplasty		Abdominal Aortic Aneurysm Repair		Esophageal Cancer Surgery		Pancreatic Resection	
Variable	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met	Meet Leapfrog Group Standard	Do the Procedure, Standard not Met
Number of hospitals	1	12	10	7	2	22	1	13	1	12
Total number of patients having procedure	577	2,951	7,577	1,345	135	356	18	26	18	21
In-hospital deaths (number)	20	96	139	20	10	34	1	0	0	3
Observed death rate	3.5%	3.2%	1.8%	1.5%	7.4%	9.6%	5.6%	0.0%	0.0%	14.3%

Multivariable Logistic Regression Predicting In-hospital Mortality From Each Procedure

Variable	Beta	Odds-ratio (95% CI)	Beta	Odds-ratio (95% CI)	Beta	Odds-ratio (95% CI)	Beta	Odds-ratio (95% CI)	Beta	Odds-ratio (95% CI)
Intercept	−3.63		−4.46		−3.08		−16.87		−21.49	
Volume standard (met vs not met)	0.05	1.11 0.63–1.95	0.10	1.23 0.61–2.47	−0.19	0.68 0.26–1.81	5.24	N/A*	−5.08	N/A
Age (<65 vs ≥65)	−0.65	0.27 0.15–0.50	−0.58	0.31 0.18–0.54	−0.58	0.32 0.07–1.40	5.40	N/A	−5.24	N/A
Sex (female vs male)	0.38	2.12 1.39–3.24	0.04	1.09 0.70–1.70	0.78	4.75 2.03–11.08	−4.88	N/A	−5.04	N/A
Comorbidity index (0 vs ≥1 weight)	−0.13	0.77 0.49–1.21	−0.33	0.52 0.34–0.82	−0.11	0.81 0.35–1.88	0.26	N/A	4.74	N/A

*N/A indicates not applicable. The logistic regression results are not valid due to the fact that 1 cell had no observations.

local operative mortality risk rather than travel to a regional center.[19] The current research findings have serious implications for the quarter of the US population that resides in rural America.[21] Of the 116 hospitals in the state of Iowa, 20 have been characterized as urban (MSA), 89 as rural (non-MSA), and 7 as rural-referral (non-MSA but have characteristics similar to urban hospitals). Thus, the vast majority of hospitals in Iowa are rural and, as shown in the current analyses, do not perform these procedures at all. Thus, many Iowa residents travel to be hospitalized for these procedures. If evidence-based referral were implemented, the additional travel distance would be minimal (8.1 miles) for coronary angioplasty, as 10 of the 17 hospitals that perform the procedure meet the EHR volume standard. For abdominal aortic aneurysm repair, additional travel to 1 of the 2 hospitals (out of 24) that meet the EHR volume standard would be 61 miles. However, because only 1 hospital meets the EHR volume standard for each of the other procedures, the additional travel would be substantial for coronary artery bypass graft (89 miles), pancreatic resection (105 miles), and esophageal cancer surgery (106 miles). This presents not only a burden for the patient but also for their family. Recent research on patient travel time in metropolitan areas showed negligible effect of the Leapfrog Group recommendation,[22] but increased travel for some procedures in rural areas would not be trivial.

A concern in a rural state such as Iowa is hospital solvency. In 2001, 72% of Iowa hospitals had negative operating margins from patient care and 25% had negative total operating margins.[23] Thus, these hospitals are staying solvent by non-patient care revenues (eg, unrelated businesses, local property taxes, investment

income, donations). Consequently, another factor examined by the authors in evaluating the impact of the Leapfrog Group EHR standards was changes in hospital revenue. For hospitals losing patients, the annual loss of revenue would total $809,000 for pancreatic resection, $987,000 for esophageal cancer surgery, $6.2 million for abdominal aortic aneurysm repair, $10.1 million for coronary angioplasty, and $69.4 million for coronary artery bypass graft. For individual hospitals, the combined loss of revenue across these 5 procedures ranges from $5,000 to $10.3 million. Of course, providing a lower volume of these services also could reduce operating costs, to the extent variable costs associated with service provision are reduced. However, due to the high fixed costs in hospitals,[24] these cost savings would not be sufficient to offset revenue declines, thereby reducing operating margins, at least over the short term. For some hospitals, this could have an effect on their solvency. Though the purpose of the Leapfrog Group's recommendations is to enhance patient safety, the impact of evidence-based referral on hospital revenue could negatively impact patient safety more. The trade-offs in terms of patient safety need considerable investigation before determining whether evidence-based referral produces the overall positive effect it is hypothesized to generate.

The research literature is limited in terms of the range of conditions or procedures that have been studied and frequently by the study designs employed to examine the volume-outcome relationship.[4] The most common analytic procedure is to use regression analysis to examine the relationship between volume and outcome across the continuum of hospital volume. The literature is limited in that there is little empirical support for specifying procedure-specific minimum volume thresholds to assure high quality. Thus, there is little empirical support for identifying a specific threshold for volume. Because emergent cases would not be subject to referral, if volume does in fact have a positive impact on outcomes, then the hospitals that lost nonemergent cases but still had to perform procedures in emergencies would be at greater risk of negative outcomes.

The current findings should be interpreted with caution due to shortcomings in the data available. First, the number of hospitalizations for these conditions is limited in Iowa. Though 13 to 24 hospitals in Iowa perform each procedure, for 3 procedures (coronary artery bypass graft, pancreatic resection, and esophageal cancer surgery) only 1 hospital in Iowa meets the EHR volume threshold. Second, some important hospital characteristics such as teaching status could not be evaluated because only 1 non-VA hospital in Iowa is a member of the Council of Teaching Hospitals. Third, the data capture hospitalizations in all of Iowa's community hospitals, but they do not capture hospitalizations by Iowans in other states. Thus, the effects shown may be skewed by cross-border travel. Likewise, the model assumed that if EHR were implemented, procedures would be performed at the next nearest Iowa hospital that met the volume threshold. In reality, patients might travel out of state or might be referred by their physicians to a more distant hospital.

Although there are limitations in the data available, some interesting patterns do emerge. It is apparent that evidence-based referral would be associated with substantial burden for some patients and hospitals in Iowa. This negative impact does not appear to be offset by improvement in in-hospital mortality rates. These initial findings suggest that there are a number of issues that need to be carefully considered, especially in a rural state, before evidence-based referral is adopted. In particular, policy decisions involving hospital volume may be focused on the wrong target. Surgeon volume has been suggested to be a stronger predictor of outcomes than hospital volume.[12,25] Research on hospital and surgeon volume has been procedure-specific, yet there is likely a carryover or practice effect from certain procedures to other similar procedures (these have rarely been captured in the research). In rural areas, surgeons may perform surgeries at more than 1 hospital and thus be "high-volume physicians" operating at low-volume hospitals.

Regionalization of health care is a controversial issue, and the implications of such a policy are complex.[26] There are concerns not only about patient travel but also about delays or avoidance in seeking care and the fact that continuity of care is usually reduced. There is also concern about fostering incentives for inappropriate utilization (hospitals near the threshold performing unnecessary surgeries).[26] On the other side of the coin, there is no assurance that large volume hospitals can retain their quality as volume further increases.[26] Also, concerns have been expressed about the effect of regionalization on economic distortion, excessive contractual power for high-volume providers, reduced proficiency in low-volume hospitals, and the rising cost of health care.[26] Though there is clear evidence of a statistical relationship between volume and outcomes, the policy implications are complex. Certainly in rural areas, the issues need to be carefully considered before hospitals are caught in a trend of evidence-based referral. There could well be unintended harm in terms of access to care, continuity of care, and lost resources to enhance hospital quality and patient safety.

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