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Use of State Discharge Abstract Data to Identify Hospitals Performing Similar Types of Operative Procedures

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INTRODUCTION: A hospital or anesthesia or surgical group that is making decisions to expand its practice benefits from knowledge of the types of surgical procedures performed at other hospitals.

METHODS: Discharge abstract data were used to study 1 hospital in each of 3 states. A similarity index provided information on which other hospitals in each state were competitors and/or peer institutions. To reveal potential growth opportunities, Clinical Classifications Software (CCS) grouping of specific types of procedures into broad categories was combined with the similarity index. The internal Herfindahl index was used to quantify the heterogeneity of procedures within each CCS category.

RESULTS: Although the similarity index between many pairs of hospitals was highly influenced by the common orthopedic procedures performed at most hospitals, the similarity index was dominated by a large number of different types of procedures. For some pairs of hospitals, there was considerable overlap between the different types of procedures performed at each institution. For other pairs of hospitals, the overlap was small. Consequently, large hospitals were not always similar to each other because of the wide range of procedures performed. Smaller community hospitals were not always similar to each other either. Some small hospitals were sometimes similar to large metropolitan hospitals.

CONCLUSIONS: The similarity index is a robust and valid method for quantitatively comparing the numbers and types of inpatient surgical procedures performed at different hospitals. The similarity index, when combined with CCS categories, is useful for identifying opportunities that enable surgeons and anesthesiologists to better meet the needs of their communities. (Anesth Analg 2010;110:1146–54)

Hospitals that are interested in expanding their surgical practices need to be aware of surgical patterns at hospitals that may be considered competitors and/or peer institutions. State discharge abstract data are one source of information that can be analyzed to determine surgical practice patterns at hospitals within a state, and have been used previously to compare hospitals with respect to pediatric,[1] geriatric,[2] and thoracic surgery.[3] State discharge abstract data are available to the public through participating hospitals or states or from the federal government. Accounting data have been used to assess the financial implications[4] of performing certain types of procedures and have shown that contribution margin varies among subspecialties.[5] Opportunities for operating room expansion[6] have been studied using data envelopment analysis.[7] Other methods have estimated the returns on investment associated with the provision of coronary artery bypass graft surgery[8] and ambulatory surgery center procedures.[9] Growth of surgical practices is relevant to anesthesia groups because additional anesthesia staff members, some with specific skills, may need to be recruited. Furthermore, growth in the caseload of some subspecialties may balance declines in other subspecialties.

When contemplating expansion of surgical care, not only should community needs be considered but also financial aspects must be considered. Important areas of concern include the market effects of different health insurers,[10] the effects of hospital competition on the growth of freestanding ambulatory surgery centers,[11,12] and the impact of specialty hospitals owned by physicians.[13] Specialty hospitals may siphon financially lucrative patients from full-service hospitals.[14,15] In 1 geographical area, the entry of physician-owned specialty hospitals was followed by substantial increases in the incidence of complex spinal fusion surgery in the market area.[16]

We report herein the use of a similarity index for quantifying similarities and differences between the types of surgical procedures performed at pairs of hospitals. This novel application for hospitals is analogous to our previous use of the similarity index to compare the number of thoracic procedures performed in different regions of a

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Table 1. Sample of Input Data from Dataset 1 for Hospital #1

Hospital		Procedure	Comments
219	,	"4501"	Duodenal incision
219	,	"7852"	Internal fixation—humerus
219	,	"8152"	Partial hip replacement
219	,	"0124"	Other craniotomy
219	,	"8051"	Excision intervert disc
219	,	"2001"	Myringotomy tube insertion
•		•	•
•		•	•
•		•	•
712	,	"8051"	Excision intervert disc
712	,	"0780"	Thymectomy
712	,	"1359"	Cataract extraction
712	,	"562"	Uretotomy
•		•	•
•		•	•
•		•	•
219	,	"9904"	Packed cell transfusion
219	,	"562"	Uretotomy

Input data were a text file with 2 columns. "Hospital" is the code number of a hospital in the state from which discharge abstract data were available. "Procedure" is the ICD-9-CM (International Classification of Diseases Clinical Modification, Version 9) procedure code of a procedure performed at that hospital. Procedure codes must be enclosed in quotation marks to preserve leading zeros. Not all procedures listed are surgical procedures. CPT codes (Current Procedural Terminology) could be used instead of ICD-9 codes. The "Comment" column is for informational purposes only and is not part of the input file. Dots indicate gaps in the data, because the sample data shown are not sequential.

state.[3] Input data are contained in a text file derived from state or provincial discharge abstract data (shown in Tables 1 and 2). Computer software generates output (shown in Fig. 1) that relies heavily on a similarity index to provide insight into which other hospitals in the state may be competitors, which are peers, which may serve patients who represent opportunities for growth, and which may be potential collaborators for quality-improvement activities. We also tested the assumption that 1 small community hospital is similar to almost all other small community hospitals and different from almost all large tertiary hospitals.

We previously used a similar methodology to study surgical and anesthesia groups involved in thoracic surgery and to identify opportunities for growth through expansion into different regions of a state. We now extend our methods of analysis to study all types of inpatient surgical procedures. In contrast to the previous article, we focus on differences between individual hospitals and identify opportunities for growth through expansion at the expense of both peer and competitive institutions.[3] Our new article expands our previous work by automatically identifying specific surgical specialties to target for growth, compared with specifying either individual specialties or large groups of patients (e.g., pediatrics) to study before analysis.

METHODS

State discharge abstract data were used to compare the types of surgical procedures performed by a hospital with those performed by other hospitals in the state. State discharge abstract data are available from state hospital associations that collect the data.[17] The data are often available on a complimentary basis to participating hospitals. Databases may also be purchased from the Healthcare Cost and Utilization Project (HCUP),[18] which is sponsored by the federal Agency for Healthcare Research and Quality, or commercial data consolidators. All analyses were performed using Excel 2003 Visual Basic for Applications (Microsoft, Redmond, WA).

Input Data Format and Summary of Analyses for Each Study Hospital

We studied 3 hospitals, identified as Hospital #1, #2, and #3, located in 3 different states. Input data for each hospital came from its own state. The analyses performed for each hospital were different and unrelated. The hospitals were not compared with each other, but with other hospitals in their own states.

Dataset 1 from Hospital #1 (n = 9279 surgical procedures): Input data were derived from hospital inpatient discharge data from a single state within the US for the period July 2006 through June 2007. More than 90% of the nonfederal hospitals in this state belonged to the American Hospital Association and reported their discharge data. Each hospital discharge listed up to 15 ICD-9-CM (International Classification of Diseases Clinical Modification, Version 9) procedure codes. The data were reformatted into a plain text file consisting of 2 columns and 782,872 rows (Table 1). The first column was a 3-digit code representing a hospital and the second column was one of the ICD-9-CM procedure codes performed at that hospital. Consequently, 1 to 15 rows in the text file (Table 1) were created for each discharge. The order of the lines was unimportant. This transformed file provided the input for the analysis.

Dataset 2 from Hospital #2 (1252 surgical procedures): Input data for Hospital #2 were derived from hospital inpatient discharge data for its state during the period October 2007 through September 2008. Each hospital listed 1 discharge per line, with up to 15 procedure codes per line in a comma delimited text file (Table 2). The file contained 1,054,000 lines.

In addition to a similarity analysis, Hospital #2 was interested in identifying those categories of procedures for which patients residing in the county of the hospital were having their surgery in another county.[19] That analysis was performed as described and validated previously.[19] We used an additional data file that had 1 discharge per line and included only those patients residing in the county of the hospital. Other data fields included the county in which each procedure was performed.

Dataset 3 from Hospital #3 (20,060 surgical procedures): Hospital inpatient discharge data from a third state were from January 2001 to December 2001.

Identification of Surgical Procedures and Grouping into Categories

Procedure lists from HCUP were used to identify surgical procedures and to group them into categories. HCUP Procedure Classes software[20] classifies each ICD-9-CM procedure code as minor diagnostic, major diagnostic, minor therapeutic, or major therapeutic. Major therapeutic procedures are operating room procedures performed for therapeutic reasons. They were considered synonymous with surgical procedures. Only ICD-9-CM codes

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Table 2. Sample of Input Data from Dataset 2 for Hospital #2

Hospital	Proc 1	Proc 2	Proc 3
10456	"4501"		
10456	"7852"		
10379	"8152"		
384	"0124"		
972	"8051"		
10456	"2001"	"2001"	
•			
•			
•			
10379	"8051"		
10456	"0780"		
10456	"1359"		
384	"562"	"5671"	"5679"
•			
•			
•			
10456	"9904"		
10456	"562"		

Input data are a file with 16 columns separated by commas. "Hospital" is the code number of a hospital in the state from which discharge abstract data were available. "Procedure" is the ICD-9-CM (International Classification of Diseases Clinical Modification, Version 9) procedure code of a procedure performed at that hospital. Fifteen columns are available for procedure codes. Procedure codes must be enclosed in quotation marks to preserve leading zeros. Not all procedures listed are surgical procedures. Dots indicate gaps in the data, because the sample data shown are not sequential.

	Total N	similarity	SE similarity	CCS Category	Description	N Hosp #1	N 2nd Hosp	similarity of CCS Hosp #1 vs. 2nd Hosp	SE similarity	Herfindahl of CCS Statewide	SE Herfindahl	Herfindahl of CCS 2nd Hosp	SE Herf 2nd Hosp	national mean LOS	mean charges nationwide	discharges per week nationwide
Second Hospital	5,199	0.90	0.01													
				115	Circumcision	690	292	1.00	0.00	1.00	0.00	1.00	0.00	3.0	5 k	22,982
				3	Laminectomy; excision intervertebral disc	504	322	0.94	0.02	0.48	0.00	0.41	0.01	2.7	23 k	4,923
				158	Spinal fusion	467	423	0.89	0.00	0.22	0.00	0.15	0.01	3.9	60 k	6,388
				45	Percutaneous transluminal coronary angioplasty (P	431	289	1.00	0.00	1.00	0.00	1.00	0.00	2.7	48 k	14,415
				152	Arthroplasty knee	347	205	0.99	0.00	0.78	0.01	0.81	0.04	3.8	36 k	10,574
				153	Hip replacement; total and partial	315	343	0.76	0.00	0.29	0.00	0.19	0.01	4.9	41 k	7,333
				124	Hysterectomy; abdominal and vaginal	303	91	0.56	0.06	0.25	0.00	0.31	0.04	2.7	17 k	10,922
				44	Coronary artery bypass graft (CABG)	247	173	0.92	0.00	0.25	0.00	0.24	0.02	9.3	98 k	4,380
				147	Treatment; fracture or dislocation of lower extremity	192	88	0.90	0.00	0.33	0.01	0.43	0.06	4.0	27 k	3,478
				84	Cholecystectomy and common duct exploration	190	96	1.00	0.00	0.66	0.01	0.71	0.05	4.7	30 k	7,467
				119	Oophorectomy; unilateral and bilateral	180	80	0.96	0.00	0.40	0.01	0.40	0.05	3.4	21 k	1,360
				146	Treatment; fracture or dislocation of hip and femur	178	81	0.54	0.09	0.31	0.00	0.44	0.05	6.0	36 k	5,326
				80	Appendectomy	149	116	0.93	0.00	0.40	0.00	0.45	0.02	2.9	20 k	5,936
				67	Other therapeutic procedures; hemic and lymphatic	144	89	0.85	0.00	0.29	0.01	0.29	0.03	6.4	37 k	999
				142	Partial excision bone	132	81	0.85	0.00	0.18	0.01	0.23	0.04	7.2	38 k	767
				114	Open prostatectomy	127	42	0.98	0.00	0.83	0.01	0.74	0.09	2.9	25 k	1,207
				78	Colorectal resection	126	93	0.85	0.00	0.19	0.00	0.22	0.02	10.0	56 k	5,465
				169	Debridement of wound; infection or burn	103	57	1.00	0.00	1.00	0.00	1.00	0.00	10.2	42 k	4,502
				48	Insertion; revision; replacement; removal of cardiac	88	86	0.82	0.01	0.16	0.01	0.15	0.02	4.8	67 k	6,255
				43	Heart valve procedures	67	55	0.71	0.11	0.18	0.01	0.19	0.02	11.5	133 k	1,862
				52	Aortic resection; replacement or anastomosis	67	20	0.73	0.18	0.28	0.01	0.32	0.06	7.1	77 k	950
				112	Other OR therapeutic procedures of urinary tract	65	39	0.40	0.12	0.06	0.00	0.09	0.02	6.3	38 k	1,033
				113	Transurethral resection of prostate (TURP)	62	31	0.98	0.00	0.76	0.02	0.78	0.09	3.1	17 k	1,633
				51	Endarterectomy; vessel of head and neck	61	26	1.00	0.00	1.00	0.00	1.00	0.00	2.7	24 k	2,253
				172	Skin graft	58	10	0.68		0.33	0.01	0.24	0.09	10.2	56 k	912
				167	Mastectomy	52	44	0.92	0.06	0.30	0.01	0.31	0.02	2.2	20 k	1,337
				36	Lobectomy or pneumonectomy	50	18	0.86		0.36	0.01	0.34	0.08	8.5	56 k	1,443
				75	Small bowel resection	41	14	0.98		0.89	0.01	1.00	0.00	14.7	82 k	1,127
				104	Nephrectomy; partial or complete	29	21	0.99	0.00	0.70	0.02	0.76	0.11	5.5	38 k	1,106
				144	Treatment; facial fracture or dislocation	27	1			0.26	0.01			4.2	33 k	454
				72	Colostomy; temporary and permanent	26	9	0.62		0.37	0.01	0.41	0.07	13.8	69 k	175
				30	Tonsillectomy and/or adenoidectomy	25	12	0.90		0.41	0.01	0.72	0.14	2.1	12 k	430
				71	Gastrostomy; temporary and permanent	23	1			1.00	0.00			12.3	49 k	1,670
				103	Nephrotomy and nephrostomy	22	36	0.97	0.00	0.53	0.02	0.54	0.08	7.0	41 k	667
				60	Embolectomy and endarterectomy of lower limbs	22	3	0.99		0.50	0.00	0.56	0.18	6.6	47 k	312
				10	Thyroidectomy; partial or complete	21	16	0.95		0.35	0.01	0.41	0.08	2.0	19 k	1,154
				23	Myringotomy	20	1			1.00	0.00			4.1	21 k	155
				140	Repair of current obstetric laceration	4	20	0.99		0.63	0.02	0.91	0.09	2.2	7 k	13,348
				166	Lumpectomy; quadrantectomy of breast	3	10	0.93		0.66	0.04	0.66	0.18	2.7	18 k	268

Figure 1. Sample output for Hospital #1 redacted to show most important columns. The study hospital is Hosp #1 and the comparison hospital is called "Second Hospital" or "2nd Hosp." Some procedures have been deleted for brevity. The similarity between the 2 hospitals is 0.90 ± 0.01. Only a single comparison hospital is shown. A similar output was generated for every other hospital with more than a minimum number of surgical procedures. Note that the output also contains the similarity of procedures within each Clinical Classifications Software (CCS) category, the internal Herfindahl index of the CCS category statewide, the internal Herfindahl index of the CCS category for just the 2 hospitals being compared, and an indication of the charges that could be gained if Hospital #1 performed the procedures currently done by the Second Hospital. Values are blank when the number of procedures was insufficient to calculate a value or corresponding SE. Columns that have been omitted included X's to indicate potential competitors, opportunities for growth, and highlighting of accomplishments.

corresponding to major therapeutic procedures were included in this analysis. Major therapeutic procedures include any procedures performed in an operating room, including myringotomy tube placement and cataract extraction, and are not limited to inpatient procedures.

Related procedures were grouped together so that comparisons could involve specific surgical subspecialties. Clinical Classifications Software (CCS)[21] collapses ICD-9-CM procedure codes into a smaller number of clinically meaningful categories. Each ICD-9-CM major therapeutic procedure code was first grouped into 1 of 120 of the 231 CCS categories before some analyses. For example, procedures frequently performed by orthopedic surgeons are divided into 23 CCS categories, as shown in Table 3.

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Table 3. CCS Categories for Surgical Procedures Commonly Performed by Orthopedic Surgeons

CCS category	Description
142	Partial excision bone
143	Bunionectomy or repair of toe deformities
144	Treatment, facial fracture, or dislocation
145	Treatment, fracture, or dislocation of radius and ulna
146	Treatment, fracture, or dislocation of hip and femur
147	Treatment, fracture, or dislocation of lower extremity (other than hip or femur)
148	Other fracture and dislocation procedure
150	Division of joint capsule, ligament, or cartilage
151	Excision of semilunar cartilage of knee
152	Arthroplasty knee
153	Hip replacement, total and partial
154	Arthroplasty other than hip or knee
157	Amputation of lower extremity
158	Spinal fusion
160	Other therapeutic procedures on muscles and tendons
161	Other OR therapeutic procedures on bone
162	Other OR therapeutic procedures on joints
164	Other OR therapeutic procedures on musculoskeletal system

OR = operating room.
Data are from 2008.[21]

Calculations

Several statistics were calculated. A similarity index (θ) compared the diversity or dissimilarity of 2 hospitals based on the relative frequencies at which different types of surgical procedures were performed. It is a correlation coefficient that varies between 0 and 1. Let A and B represent 2 hospitals being compared. The i's represent different types of procedures. Let P_{Ai} or P_{Bi} represent the proportion of total procedures performed that are of the ith type at hospital A or hospital B. Let N represent the number of different types of procedures, equal to the number of different i's. Then,

$$\theta = \frac{\sum_{i=1}^{N} p_{Ai}\, p_{Bi}}{\sum_{i=1}^{N} p_{Ai}\, p_{Bi} + \sum_{i=1}^{N} (p_{Ai} - p_{Bi})^2}$$

Formulae for calculating the SE of the similarity index are given in the Appendix of Ref. 22.

Similarities were used for 2 comparisons between pairs of hospitals. (1) Two hospitals were compared pairwise based on the number and types of individual procedures performed, independent of CCS categories. (2) Hospitals were compared pairwise based on the procedures within a single CCS category. Each hospital must have performed at least 20 procedures to calculate a SE for the similarity index between hospitals.

The internal Herfindahl (IH) index is a measure of the homogeneity or diversity of procedures performed at a single hospital or within a region. It is also a correlation coefficient that varies between 0 and 1. Let the variables have the same meaning as for the similarity index. Then,

$$IH = \sum_{i=1}^{N} p_i^2$$

The index equals the sum of the squares of the proportions of the different types of procedures. It equals the probability that 2 procedures selected at random will be the same type of procedure. SEs were calculated according to Taplin's method[23] as described in the Appendix of Ref. 22.

The IH index was used for several calculations. It was determined for (1) each CCS category statewide, and (2) each CCS category for the comparison hospital for which a similarity index was determined. A comparison of these 2 IH indices provided an indication of the heterogeneity of the CCS category for the comparison hospital relative to the statewide heterogeneity. Such information was useful for determining whether the procedures performed by the hospital were representative of those performed in the remainder of the state for that CCS.

Additional data were calculated for each CCS. A comparison hospital for which a similarity index was calculated was identified as a potential competitor if (1) it performed at least 75% of the total number of procedures within a CCS for the study hospital and comparison hospital combined, and (2) each hospital performed at least 50 procedures. A comparison hospital was identified as providing a potential growth opportunity if (1) the similarity between the study hospital and the comparison hospital was >0.6, meaning that the 2 hospitals were at least moderately similar in the types of procedures performed, (2) the similarity between the study hospital and the comparison hospital for the procedures within each CCS was ≥ 0.8, meaning that both hospitals were performing the same types of procedures in the CCS, (3) the study hospital performed at least 50 procedures within the CCS, and (4) the comparison hospital performed at least 100 procedures within the CCS. These criteria seemed appropriate for eliminating circumstances in which the study hospital was unlike the comparison hospital or did not perform the types of procedures done at the comparison hospital. For example, a hospital that does not perform cardiac surgery cannot suddenly begin a cardiac surgery program in the hope of attracting patients just because large numbers of cases are performed at a nearby hospital. Thus, a threshold of 50 was set to indicate that the hospital was already performing a given type of procedure. The value for the comparison hospital was chosen to be twice as great because large numbers of procedures within the CCS must be performed at the comparison hospital for the study hospital to have a realistic chance of recruiting significant numbers of patients.

In addition to the above analyses, the surgical expertise of a hospital could be highlighted if it performed at least 5 times (5/6 of the total) or 10 times (10/11 of the total) as many procedures in a CCS as a comparison hospital. Proportions were determined with 95% certainty, and 95% confidence intervals for the proportions were determined according to the Clopper-Pearson method.[24,25] Potential charges associated with growth opportunities were determined from HCUP mean charges.[26] Charges provided useful information because they differed more than 10-fold between CCS categories. Length of stay data were obtained from the same Web site.

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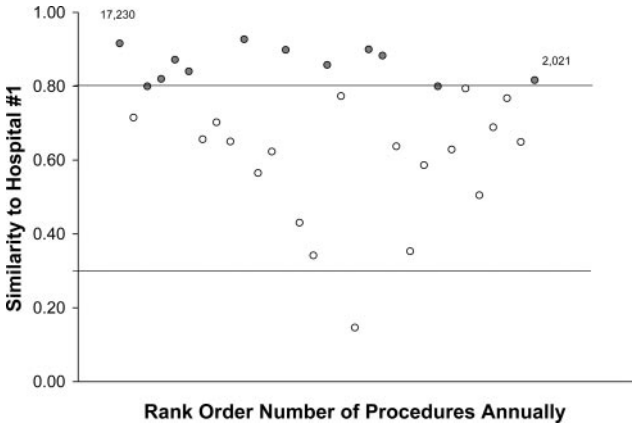

Figure 2. Similarity indices comparing the study hospital, which performed 9279 procedures, with 32 other hospitals in the state that performed at least 2000 surgical procedures in the year. Hospitals are shown in decreasing order based on the number of procedures performed in the year. Numbers adjacent to first and last points show number of procedures. Horizontal lines at similarities of 0.8 and 0.3 indicate cutoffs for similarities considered exceptionally high or low. Points with similarities above or below these cutoffs are shaded in gray. Note large number of hospitals with high similarities. All similarity SEs ≤0.02.

Validation of the Similarity Index

The validity of the similarity index for comparing hospitals was assessed in 2 ways. (1) Yue and Clayton showed that an infinitesimal change in the proportion of 1 procedure type had the largest effect when applied to the type of procedure with the largest sum of the proportions for each of the 2 hospitals. Similarities between hospitals were calculated after halving the number of procedures in the CCS category with the highest proportion of procedures for the 2 hospitals combined. (2) The change in similarities between hospitals was determined after sequentially omitting each individual procedure from the totals.

RESULTS

Based on previous findings for pediatric surgery,[1] we hypothesized that large hospitals with close to 10,000 procedures would have a low or at most moderate similarity to other large hospitals in the state, because each would be performing many relatively rare procedures.[4] We also hypothesized that smaller community hospitals would exhibit a high degree of similarity to each other, because almost all would be performing roughly the same types of procedures.

Figure 2 shows similarity indices comparing study Hospital #1, a large hospital, with other large and medium-sized hospitals (≥2000 procedures) in its state (Dataset 1). In contradiction to the hypothesis, we found that Hospital #1 was highly similar (similarity ≥0.8) to many other large and medium-sized hospitals (Table 4). It was similar to both large hospitals located in metropolitan areas and medium-sized community hospitals.

Figure 3 shows the similarity indices between Hospital #1 and small hospitals, specifically those performing <2000 surgical procedures annually. As hypothesized, no small hospital was highly similar to Hospital #1.

Table 4. Hospitals Highly Similar to Study Hospital #1

Hospital	Similarity	*N*	Population
A	0.92	17,230	375,000
B	0.80	12,731	Metropolitan
C	0.82	12,101	Metropolitan
D	0.87	11,560	135,000
E	0.84	10,594	30,000
F	0.93	8989	Metropolitan
G	0.90	8145	90,000
H	0.86	6576	105,000
I	0.90	5374	95,000
J	0.88	5253	85,000
K	0.80	3638	135,000
L	0.82	2021	15,000

Comparison hospitals with similarity indices ≥0.8 that performed at least 2000 surgical procedures. *N* is the number of surgical procedures performed at each hospital. Population refers to the city in which each hospital is located. Hospital #1 is a referral hospital in a city of 50,000. All SE ≤0.02.

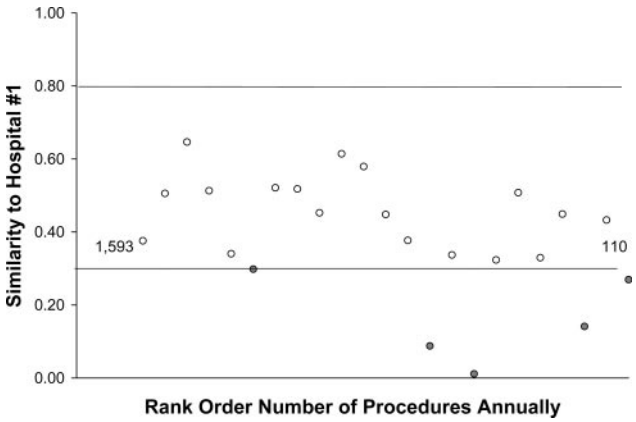

Figure 3. Similarity indices comparing study Hospital #1 with an additional 23 hospitals with at least 100 but <2000 surgical procedures in the year. Hospitals are shown in decreasing order based on the number of procedures performed in the year. Numbers adjacent to first and last points show number of procedures. Horizontal lines at similarities of 0.8 and 0.3 indicate cutoffs for similarities considered exceptionally high or low. Points with similarities ≤0.3 are shaded in gray. Note that no hospital exhibited a high similarity. All similarity SEs ≤0.04.

As a control, Figure 4 shows the similarity indices comparing the smaller community hospital in the same city as Hospital #1 with large, medium, and small hospitals in the state. No hospital was highly similar to the smaller community hospital, not even the one in the same city (similarity 0.30). Many hospitals had low values of the similarity index of ≤0.3. This result is again inconsistent with the hypotheses. The small community hospital studied was not even highly similar to other community hospitals. Furthermore, the 1 hospital to which it was moderately similar (0.68) was not another community hospital, but one located in a metropolitan area at the other side of the state and performing many types of procedures, including liver transplants. The reason the similarity was moderately high between these 2 hospitals was that the 2 most common CCS categories at both hospitals were total knee arthroplasty and hip arthroplasty. Despite the fact that the metropolitan hospital is a cardiac and transplantation institution, most of its surgical procedures were still common orthopedic procedures.

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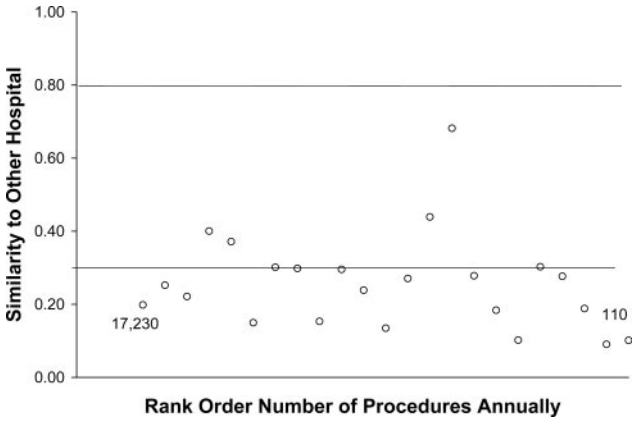

Figure 4. Similarity indices comparing another hospital in the same city as Hospital #1 with all 52 hospitals in the state with at least 100 surgical procedures in the year. This is a community hospital that performed slightly >1000 procedures in the year. The similarity to Hospital #1 was 0.30. Hospitals are shown in decreasing order based on the number of procedures performed in the year. Numbers adjacent to first and last points show number of procedures. Horizontal lines at similarities of 0.8 and 0.3 indicate cutoffs for similarities considered exceptionally high or low. Note low similarity with the majority of other hospitals, although 1 hospital did have a similarity of 0.68. All similarity SEs ≤0.04.

Usefulness of the similarity findings to Hospital #1 was assessed qualitatively during interviews with its administrators and found to be 4-fold. (1) Peer hospitals had previously been defined based on community size. The study hospital learned of several other hospitals in its state that it subsequently considered peer hospitals, although the hospitals had not previously been classified as such because they are not geographically close and are not in comparable sized communities. The hospital therefore defined a new peer group that combined community, suburban, and urban hospitals. The hospital considered identification of peer hospitals to be relevant for recruiting physicians and nurses, negotiating purchasing contracts and insurance reimbursement rates, comparing costs and charges, benchmarking lengths of stay and quality-improvement initiatives, and evaluating volume and market share. (2) The study hospital was able to identify opportunities for improvement by locating hospitals that would not be considered competitors in particular CCS categories and might therefore be willing to provide necessary expertise. For example, noncompeting hospitals that performed procedures the study hospital would like to start performing could arrange for nursing staff or technologists from the study hospital to observe the procedures and teach them how to perform them. Other hospitals could also assist with quality-improvement activities. (3) The study hospital learned that it had a low similarity to the small community hospital in its city. The 2 hospitals were not competing for patients undergoing the same types of procedures. (4) The study hospital learned about potential opportunities for growth. A few CCS categories were identified consistently across all 16 hospitals showing potential opportunities to grow its surgical workload (Table 5): spinal fusion (CCS category 158) and laminectomy (3), knee arthroplasty (152), and cesarean delivery (134) and circumcision (115). This analysis provided valuable information about the types of procedures to be targeted as the hospital attempts to expand its surgical practice. The analysis also provided important geographical data about patient origins and destinations to guide the hospital in expanding its regional presence.

The usefulness of performing the similarity analysis for different hospitals depends on the findings being heterogeneous among hospitals. In other words, if results were similar for most hospitals for which the analysis would be performed, it would not be necessary to perform the analysis, because data from another hospital could be used instead. Hospital #2, represented by Dataset 2, was compared with 134 other hospitals in its state (Fig. 5). Although several hospitals had moderately high similarity indices, the highest in the entire state (0.82) was observed for a hospital in the same county as the study hospital. The nearby hospital was a strong competitor of the study hospital.

Figure 1 shows an actual report for Hospital #1, including multiple columns not discussed earlier. The output contains (1) the similarity of procedures within each CCS to help ascertain whether the 2 hospitals are performing the same types of procedures within the CCS, (2) the internal Herfindahl index of the CCS category statewide as an indication of the heterogeneity of the CCS category and the number of different types of procedures that comprise it, (3) the internal Herfindahl index of the CCS category for the comparison hospital, and (4) the national mean length of stay, mean charges nationwide, and discharges nationwide to demonstrate the additional revenue that could be realized if the study hospital performed the procedures that were instead being done by the comparison hospital (Second Hospital).

Validation of the Similarity Index

We previously found a high sensitivity of the similarity index to 1 type of procedure when a hospital was performing large numbers of myringotomy tube insertion (ICD-9-CM 20.01).[1] Hospital #1 was compared with other hospitals in the state, except that the number of procedures was halved in each CCS category with the highest proportion of procedures in the 2 hospitals combined. Figure 6 indicates the sensitivity of the similarity index to the most common procedure type. Values of the similarity index were insensitive to halving the number of procedures of the most common procedure type. This result is consistent with information known about Hospital #1. Because it is a regional referral facility that performs many different types of procedures, its similarity to other hospitals does not depend on 1 type of procedure. Of the 12 hospitals with similarities of ≥0.8, the greatest reduction was 0.01. Thus, the similarity index was relatively insensitive to the presence of a few high-volume services.

Next, each procedure type was omitted sequentially to examine the maximal change in the similarity index (Fig. 7). Omission of the most frequent procedure that both hospitals had in common produced the largest decrease in the similarity index. Effects, both positive and negative, were relatively small, especially for hospitals with a high similarity to Hospital #1.

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Table 5. Examples of 2 Hospitals that Represent Opportunities for Growth at Study Hospital #1

Total *N* comparison hospital	Similarity	CCS category	CCS description	*N* hospital #1	*N* comparison hospital
5374	0.90	115	Circumcision	690	292
		134	Cesarean section	599	351
		3	Laminectomy; excision intervertebral disc	504	322
		158	Spinal fusion	467	423
		45	Percutaneous transluminal coronary angioplasty (PTCA)	431	289
		152	Arthroplasty knee	347	205
		153	Hip replacement; total and partial	315	343
		44	Coronary artery bypass graft (CABG)	247	173
10,594	0.84	115	Circumcision	690	1066
		134	Cesarean section	599	644
		3	Laminectomy; excision intervertebral disc	504	315
		158	Spinal fusion	467	690
		45	Percutaneous transluminal coronary angioplasty (PTCA)	431	420
		152	Arthroplasty knee	347	721
		124	Hysterectomy; abdominal and vaginal	303	455
		44	Coronary artery bypass graft (CABG)	247	180
		147	Treatment; fracture or dislocation of lower extremity (other than hip or femur)	192	122
		84	Cholecystectomy and common duct exploration	190	415

Opportunities were present for growth within the CCS category if (1) the similarity between the study hospital and the comparison hospital was >0.6, (2) the similarity between the between the study hospital and the comparison hospital for the procedures within each CCS was ≥0.8, (3) the study hospital performed at least 50 procedures, and (4) the comparison hospital performed at least 100 procedures. This method does not take into account geography, which must be considered by administrators to determine if a hospital truly has opportunities for growth at the expense of another hospital. *N* is the number of surgical procedures performed.

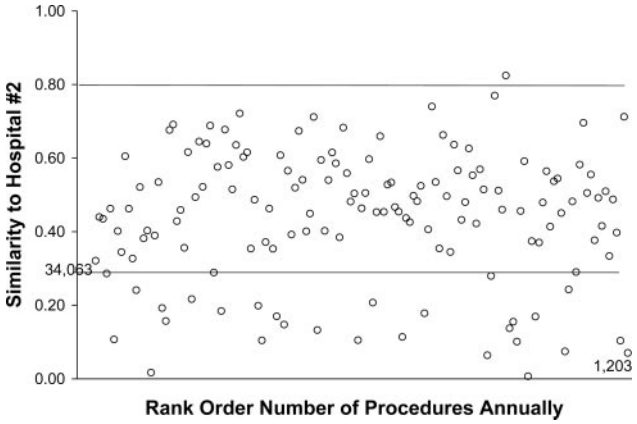

Figure 5. Similarity indices comparing Hospital #2, which performed 1252 procedures, with 145 other hospitals in the state that performed at least 1200 surgical procedures in the year. Hospitals are shown in decreasing order based on the number of procedures performed in the year. Numbers adjacent to first and last points show number of procedures. Horizontal lines at similarities of 0.8 and 0.3 indicate cutoffs for similarities considered exceptionally high or low. Only a single hospital, which was in the same county as Hospital #2, had a similarity ≥0.8. All similarity SEs ≤0.03.

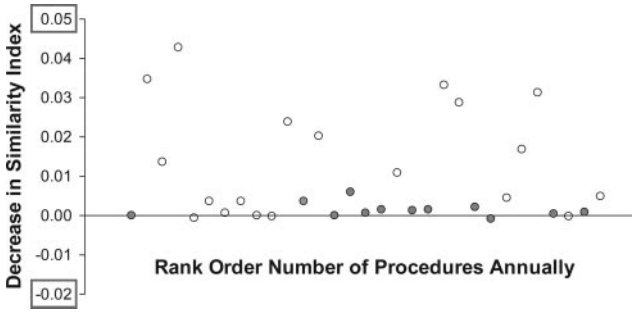

Figure 6. Decrease in the similarity index comparing Hospital #1 to other hospitals in the state upon halving the number of procedures with the highest overall proportion. Hospitals are shown in decreasing order based on the number of procedures performed in the year. Similarity indices ≥0.8 are shaded. High similarity indices were not changed, whereas lower ones were only slightly reduced by ≤0.04. All similarity SEs ≤0.02.

Additional comparisons were consistent with earlier results using different methods. Dataset 3 revealed a similarity of only 0.30 between Hospital #3 (20,060 surgical procedures) and the other hospital in the same city (4289 procedures). This finding is consistent with earlier studies showing that the other hospital performed only a few different types of procedures in children.[1] Hospital #3 is the busiest hospital in its state, with the most surgical procedures. When compared with the second and third busiest hospitals, the similarities were only 0.38 and 0.43, again consistent with earlier findings for pediatrics.[1,2]

DISCUSSION

Our study used case examples to show how the similarity index allowed each hospital to gain insight into its role in inpatient surgical care in its state (province). For example, Hospital #1 learned that it had many peer institutions across the state. Its peers were large or medium hospitals, but not small ones. It also learned that the smaller community hospital across town was not a competitor (i.e., the 2 were meeting different surgical needs in the community). Growth potential was identified in several CCS categories. Hospital #2 learned that the other hospital in the same county was a strong competitor. Hospital #3, which is the busiest hospital in its state, confirmed its impressions that it was not performing the same types of procedures as the other hospital in the same city. It was also not performing the same types of procedures as the second and third busiest hospitals in the state.

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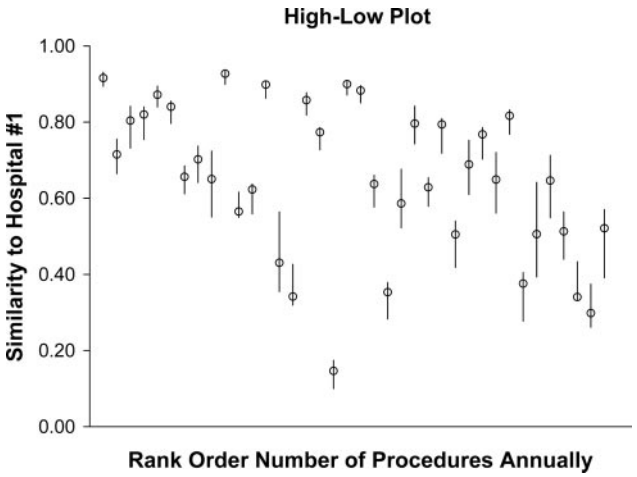

Figure 7. High-low plot showing maximum changes in similarities, both positive and negative, upon successive deletion of each procedure type. Hospital #1 is compared with other hospitals in the state. Hospitals are shown in decreasing order based on the number of procedures performed in the year. The plot shows the importance of those procedures that have the largest influence on the similarity index. Among the 48 hospitals compared with Hospital #1, 3 types of procedures produced the largest changes in the similarity index for 76% of the comparisons. The Clinical Classifications Software category corresponding to these procedures, each of which contained only a single procedure type, ranked first, second, and fifth in overall frequency at Hospital #1.

Our results show that the similarity index is a valid indicator of the relationship between the types of procedures performed at pairs of hospitals and provides important insights into surgical patterns at different hospitals. The results are robust statistically. Even halving the number of procedures in the most common CCS or deleting individual procedures entirely did not produce meaningful changes in the similarity index.

Chao et al.[27] proposed a correction to the similarity index for types of procedures performed 0 or 1 time at each or both hospitals. However, our results reveal that such a complex correction is not necessary for our application (Table 5, Fig. 7). The similarity index is insensitive to the relative proportion of even the most common procedures.

Previous work focused on comparing procedures by region for marketing purposes.[3] A hospital could advertise that it performed many more procedures than another hospital in a nearby region. Although results from our current article identify CCS categories in which a hospital is performing many more procedures than another hospital, the results are not intended as a marketing study.

Potential Competitors

Hospitals were identified as potential competitors if they had a high similarity and performed a certain minimal number of procedures (see Methods section). They may or may not be actual competitors, depending on factors such as location and insurance participation.[10]

The similarity index is useful even to smaller hospitals that perform only a limited number of types of surgical procedures. For 1 hospital that performed 178 procedures, the similarity index was still valid for comparing that hospital with others in the state that performed thousands of procedures.

Growth Opportunities

Table 5 is an extract from an actual report that shows 2 comparison hospitals at which procedures from several CCS categories were performed in large numbers. These represent opportunities for growth for Hospital #1, as defined in the Methods section. Routine orthopedic cases dominate these lists. Whether or not Hospital #1 could gain additional cases from these 2 hospitals depends on many factors, including geography, capacity, reputation, etc. Administrators must filter these data and apply their own judgment to these results. Potential opportunities for growth cannot be interpreted absent other factors which are known only to people familiar with hospitals in the state. Discharge abstract data do not contain this information.

For example, some types of procedures are correlated even when they seem unrelated based on CCS categories. An example would be cesarean delivery and circumcision (Table 5). A hospital cannot increase the number of 1 type of procedure independent of the other. In addition, constraints that limit growth at a hospital may not be patient demand as considered in this article, but lack of resources and/or expertise necessary to perform additional procedures of a certain type.

Growth opportunities were based on grouping of procedure types into CCS categories. The similarity of hospitals within each CCS and the IH index statewide provided information on the heterogeneity of the CCS category. For a category such as cesarean delivery (134), a hospital that performed 1 type of procedure within the category could likely perform all types of procedures. For laminectomy (3), however, a hospital might perform certain types of procedures, such as excision of an intervertebral disk (ICD-9-CM 80.51), but might not perform 84.xx, which involve disk prostheses. That is a limitation of grouping by CCS. For this reason, similarity indices were calculated directly from procedure types, not CCS categories.

We also analyzed growth opportunities by analyzing procedures for which patients left the region of the study hospital to have surgery elsewhere.[3] Such analysis was performed for Hospital #2. Compared with the number of procedures that remained in the county, relatively large numbers of patients left for laminectomy (3), spinal fusion (158), knee arthroplasty (152), hip replacement (153), coronary angioplasty (45), and thyroidectomy (10). Thus, orthopedic procedures are the specialty to target if the hospital wants to grow by preventing patients from leaving the county for their surgery. By performing this analysis, the hospital gained insight into the surgical specialty to target.

SUMMARY

The similarity index derived from state discharge abstract data provides information useful to hospitals and anesthesia and surgical groups that wish to expand. The index helps identify competitors, peer hospitals, and opportunities for growth.

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DISCLOSURE

The University of Iowa, Department of Anesthesia, performs statistical analyses for anesthesia groups and hospitals. REW and FD receive no funds personally other than their salaries from the State of Iowa. They have tenure with no incentive program tied to contracting entities and declare no financial conflicts of interest.

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