ANALYSIS PAPER

Using HQI's Hospital Similarity Clusters Improves Quality Comparisons

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EXECUTIVE SUMMARY

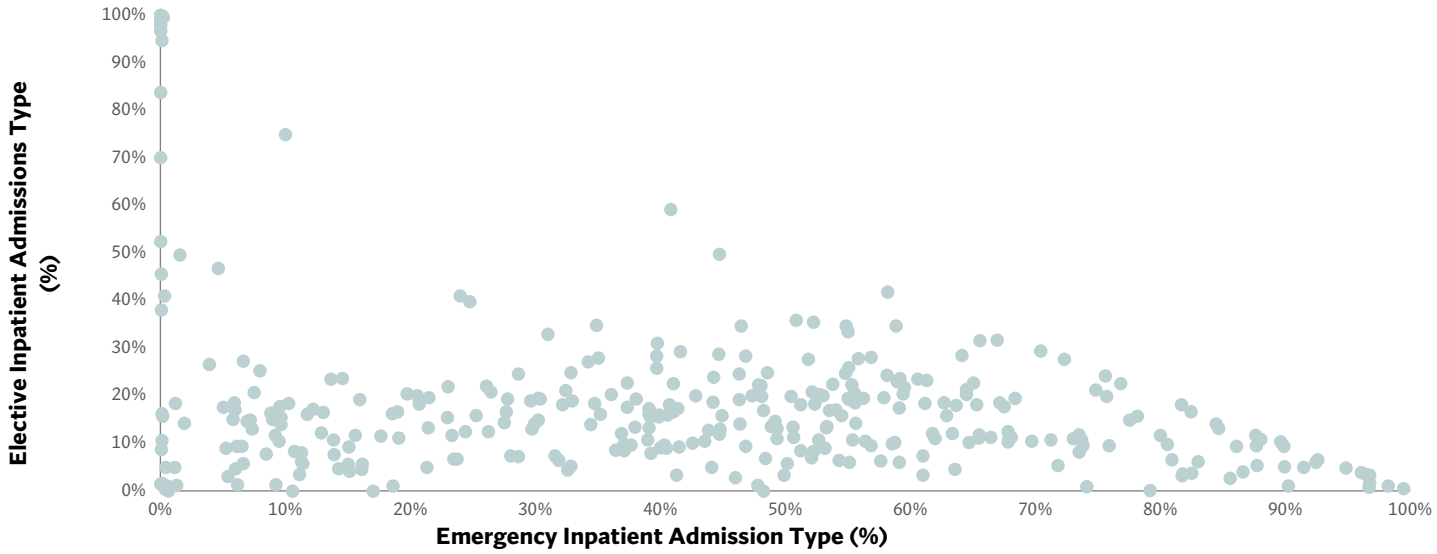
Comparing quality metrics among hospitals helps evaluate performance against peers. The Hospital Quality Improvement Platform (HQIP) offers more than two dozen comparison groups for member hospitals, such as county, Medicare quartile ranking, rural hospitals, and teaching hospitals. However, defining peers can be challenging since each hospital serves a unique population with distinct circumstances, such as age distribution, common procedures, and economic factors. For instance, inpatient encounters are categorized by admission type: emergency, urgent, elective, newborn, or trauma. Comparing a hospital with mostly emergency admissions to one with mainly elective admissions might not be optimal. This article introduces new peer groups aimed at providing accurate comparisons. We first examine factors affecting care quality, then identify similar hospital groups for meaningful comparisons.

To illustrate the diverse nature of admission types across California hospitals, the chart on page 2 presents a dot for each hospital, with the X-axis representing the percentage of admissions that are elective and the Y-axis representing the percentage of admissions that are emergency.

KEY POINTS

- Evaluating a hospital's performance against its peers by comparing hospital quality metrics is important, but identifying appropriate peers can be complex.
- Clustering hospitals based on their similarity across multiple characteristics — such as inpatient admission volume and hospital type — can help identify more comparable peers.
- The Hospital Quality Institute's (HQI) Hospital Similarity Clusters allow for comparisons and provide insights, as demonstrated in a recent article on sepsis mortality rates.

Figure 1. *California Hospitals by Percentage of Emergency and Elective Inpatient Admission Types*



For some quality metrics, comparing a hospital from the upper left of this graph (with inpatient admissions that are mostly elective) to a hospital from the lower right of this graph (with inpatient admissions that are mostly from emergency) may not be ideal because, broadly speaking, more negative outcomes likely occur in hospitals with a higher number of emergency visits than those with a higher number of elective visits — meaning the comparison is essentially unfair. This consideration motivates finding hospitals that are similar based on certain characteristics (in this case, type of inpatient admission).

Comparisons can then be made within these groupings (referred to as "clusters") for a fair and robust comparison. While no comparison will be entirely equitable given the uniqueness of each hospital, this process can complement the existing family of comparison groups.

METHODOLOGY

Clusters group hospitals by their similarity in a specific characteristic. To illustrate the clustering process, we start with a simple example: the percentage of inpatient admissions from various admission types, shown in Table 1 below. More specifically, this table shows California hospitals divided into six clusters (A-F), listing the number of hospitals per group and the average percentage of inpatient admissions for each admission type in those clusters.

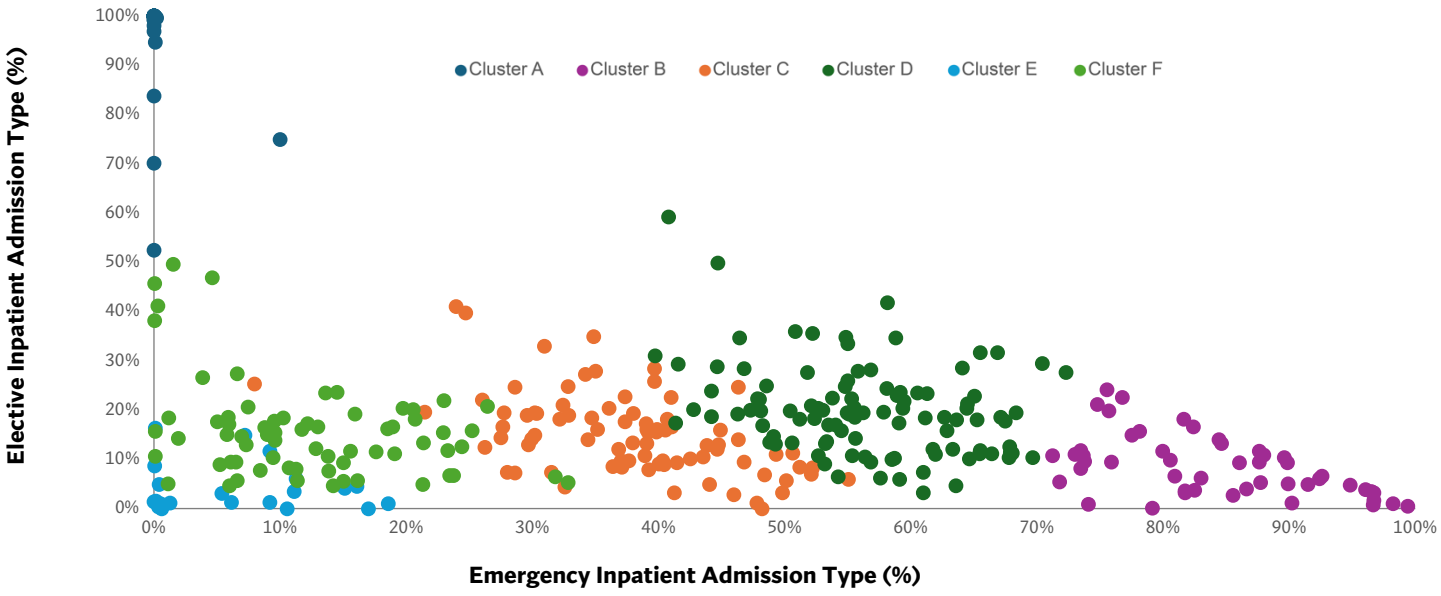
Table 1. *Clusters of California Hospitals by Percentage (%) of Inpatient Admission Types*

Cluster	*N*	Emergency	Urgent	Elective	Newborn	Trauma
A	36	8	82	7	3	0
B	52	83	4	9	4	1
C	80	38	33	15	12	1
D	55	13	54	17	15	1
E	100	56	12	20	10	2
F	30	0	3	96	1	0

This table shows the variability in admission types among California hospitals. One cluster of 36 hospitals averages 7% elective admissions, while another cluster of 30 hospitals averages 96% elective admissions. Comparing hospitals within the same cluster can provide valuable insights.

Figure 2 below illustrates these clusters based on their emergency versus elective inpatient admission percentages.

Figure 2. *Hospitals Clustered by Percentage of Emergency and Elective Inpatient Admission Types*



To support comparable evaluations for quality metrics, Table 2 shows the median sepsis mortality rates (SEP-3) for hospitals within each cluster.

Table 2. *California Hospital Inpatient Admission Type Clusters with Sepsis Mortality*

Cluster	*N*	Percentage (%) of Inpatient Admission Types					Sepsis Mortality
		Emergency	Urgent	Elective	Newborn	Trauma	
A	36	8	82	7	3	0	19.9
B	52	83	4	9	4	1	20.4
C	80	38	33	15	12	1	15.6
D	55	13	54	17	15	1	17.5
E	100	56	12	20	10	2	15.2
F	30	0	3	96	1	0	18.5

A cluster with high emergency rates and low elective rates, such as Cluster B, has a higher median sepsis mortality rate compared to clusters with lower emergency rates and higher elective rates. Additionally, clusters with a higher percentage of newborn admissions tend to have lower sepsis mortality rates. This indicates that organizing hospitals into clusters based on their characteristics can lead to insightful comparisons, supplementing the existing peer-based comparisons typically used.

HQI's Hospital Similarity Clusters — Multiple Attributes in Cluster Definitions

As the previous examples demonstrate, clusters can be formed based on hospital similarities for a single characteristic. Additionally, *multiple* characteristics can be integrated into the cluster formation process. This leads to broader cluster definitions that encompass a more diverse set of attributes, albeit at the expense of reduced commonality within any one characteristic. HQI has developed a set of hospital similarity clusters for use in HQIP that balances various patient characteristics, thereby offering new and potentially insightful ways for hospitals to compare to their peers.

Before assigning clusters, several criteria are used to exclude hospitals that significantly differ from most California hospitals. These exclusion criteria include hospitals:

- Not coded as primary reporters (e.g., utilization locations)
- With a principal service that is not general medical/surgical (e.g., drug/alcohol treatment hospitals or acute psychiatric hospitals)
- With more than 5% of inpatient encounters for skilled nursing, which are grouped into their own cluster (30 hospitals)

Following these exclusions, the 297 remaining hospitals were grouped using the following attributes:

- Total inpatient volume, which is used as a stratifying variable by first placing hospitals into five volume quintiles before any other clustering attributes are considered
- Centers for Medicare & Medicaid Services (CMS) Case Mix Index
- Percentage of encounters coded as having "no complication or comorbidity" and "no major complication or comorbidity" based on Medicare Severity Diagnosis Related Groups (MS-DRGs)

- Percentage of emergency inpatient admission type
- Percentage of elective inpatient admission type
- Percentage of newborn inpatient admission type

FINDINGS

Each hospital was grouped with others in its respective volume quartile. A statistical process known as *kmedians* was applied to evaluate five specific statistics and identify groups of hospitals that are the most similar. Three clusters were formed for each volume quintile, resulting in 18 HQI Similarity Clusters with six to 27 hospitals per cluster.

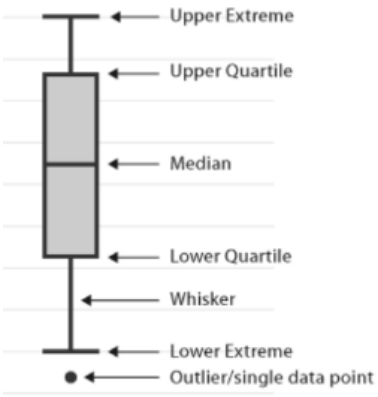
Determining the number of clusters was a blend of art and science. The "art" component involved applying contextual knowledge about the realities faced by hospitals and assessing whether these clustered peer groups appeared reasonable. The "science" aspect involved creating additional clusters until forming new clusters no longer provided significant benefit in terms of differentiation among hospital cluster members.

The assignment of hospitals to clusters via the statistical algorithm can be viewed as a weighting of these pre-selected attributes. For instance, if Hospital A and Hospital B are in the same cluster, it may be due to either their close similarity in just two of the five attributes or moderate similarity across all five attributes. The counts of hospitals in the resulting 18 clusters are presented in Table 3.

Table 3. *Number of Hospitals (N) in each HQI Similarity Cluster*

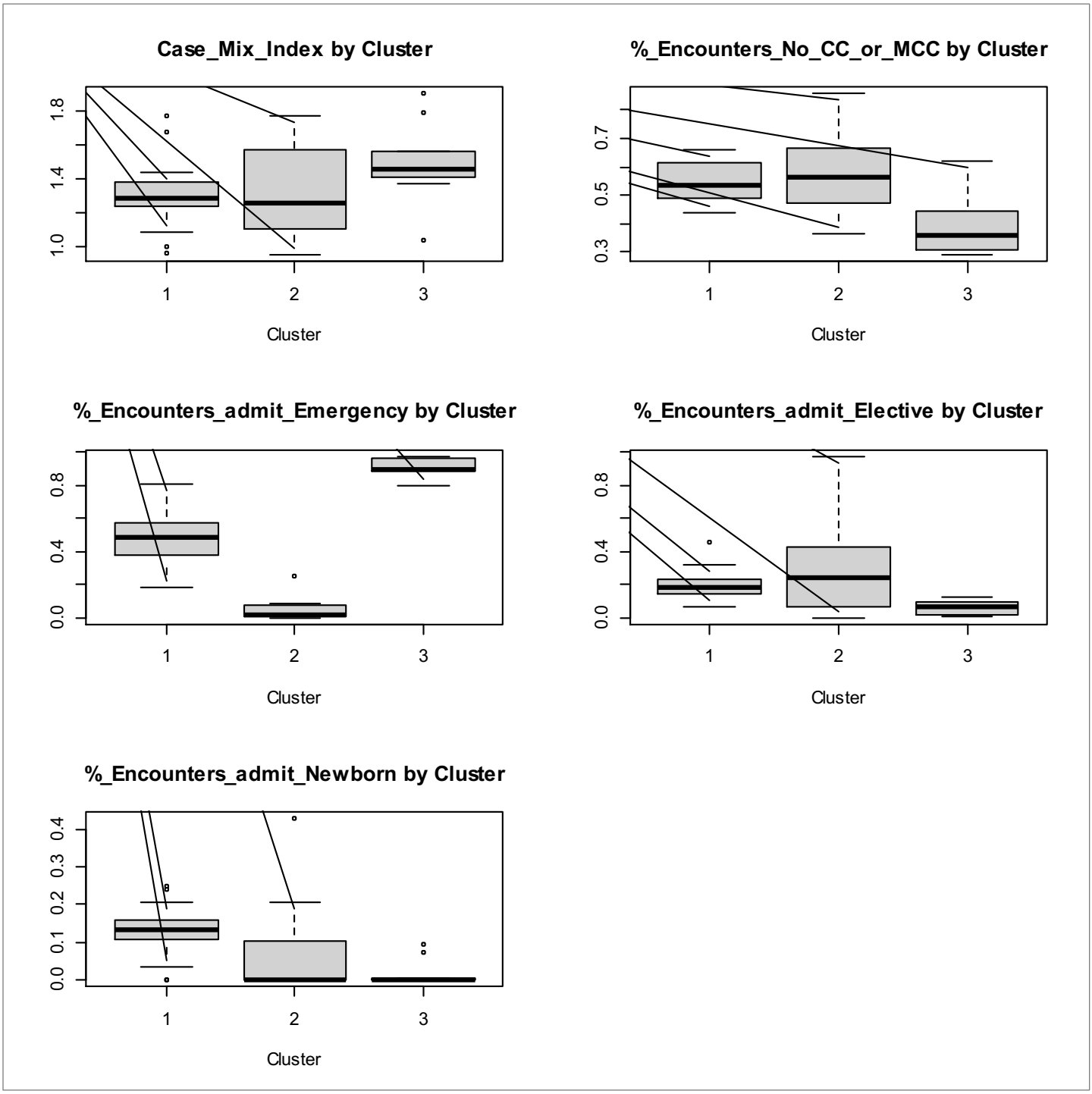
Inpatient Volume Quintile	Number of Hospitals (*N*)		
	Cluster 1	**Cluster 2**	**Cluster 3**
0 - 20th	18	6	11
20 - 40th	24	15	15
40 - 60th	27	10	21
60 - 80th	12	22	25
80 - 100th	25	25	9
> 5% Skilled Nursing	8	11	11

Box plots serve as an effective visualization tool for comparing hospitals. This graphical representation displays the median, 25th percentile, 75th percentile, minimum, and maximum values, as well as any outliers, as illustrated in the graphic at right.



For illustration purposes, Figure 4 shows side-by-side box plots of hospitals in the lowest volume quintile, based on clustering attributes. Cluster 1 hospitals have higher newborn services and middle emergency services; Cluster 2 hospitals have lower emergency services and higher elective services; and Cluster 3 hospitals have high emergency services and low elective services.

Figure 4. *Clustering Criteria for Hospital Clusters in Lowest Quintile Inpatient Volume*

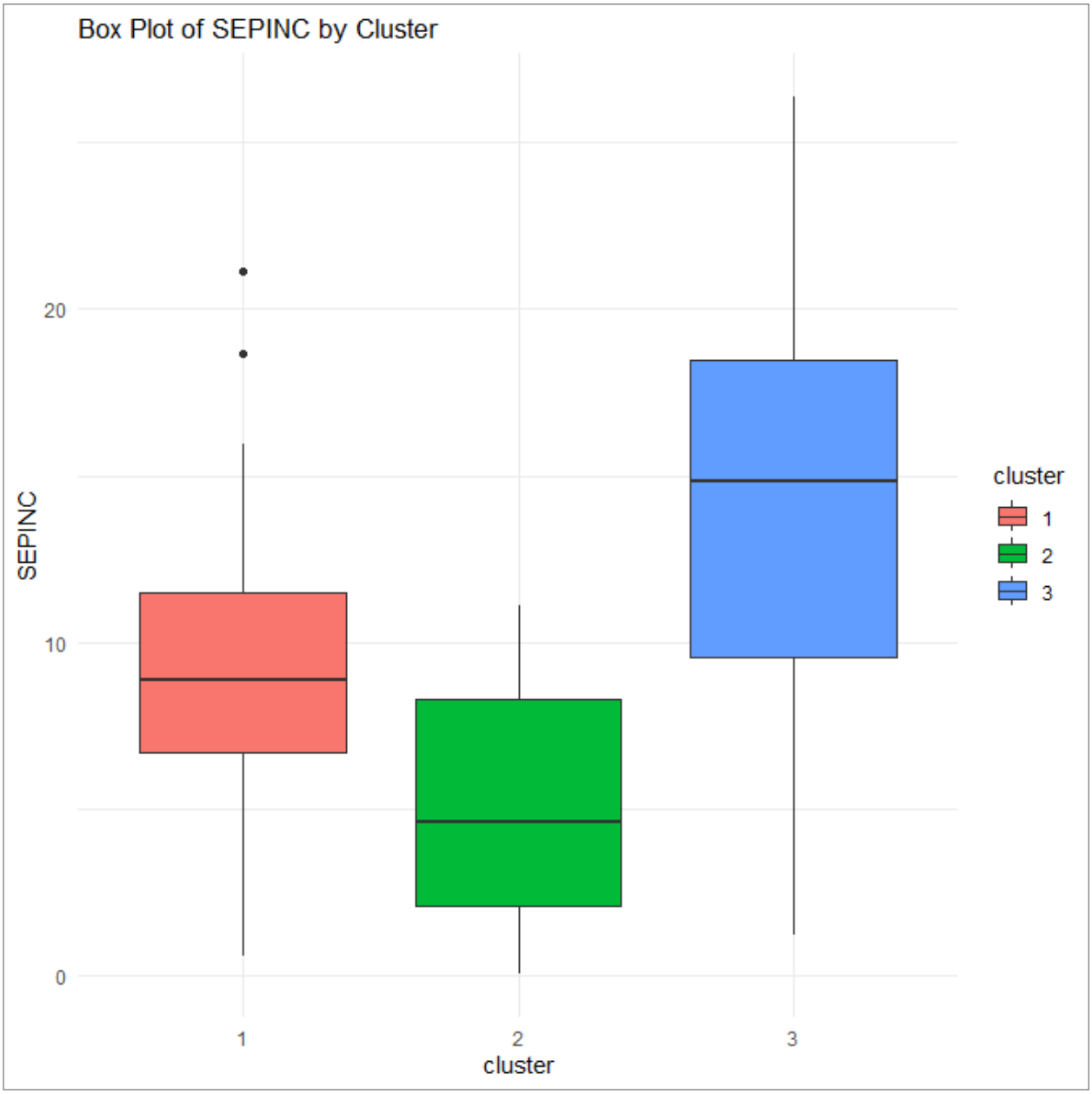


Validation of Clustering Results

It is reasonable to question whether these clusters exhibit different outcomes according to various statistics. The short answer is yes, grouping hospitals into peer groups may result in clusters with differing average patient outcomes according to certain metrics — but this is not guaranteed, as the attributes used for clustering may not always relate to the considered metric. Nonetheless, such differences do help provide some validation of the clustering results.

With this context, Figure 5 illustrates the incidence of sepsis among the inpatient population of hospitals in the *lowest* volume quintile. It is observed that Cluster 3, characterized by a lower incidence of "no complications/comorbidities" and "no serious complications/comorbidities," has a higher median incidence of sepsis. Conversely, the "higher elective admit type/lower emergency admit type" Cluster 2 has a much lower median incidence of sepsis. However, the distribution "tails" of the hospitals overlap significantly, indicating that such hospital cluster assignments do not provide complete separation for sepsis incidence, which may not be realistic.

Figure 5. *Sepsis Incidence for Hospital Clusters in Lowest Quintile Inpatient Volume*



The California hospitals in each HQI Hospital Similarity Cluster resulting from these procedures are shown in Table 4 on the following pages. Note that the groupings reflect an underlying expectation in many instances (e.g. Kaiser facilities serving similar communities tend to be grouped together, as do rural hospitals, etc.).

Table 4. *California Hospitals in Each HQI Hospital Similarity Cluster*

LOWEST VOLUME (0 – 20th Percentile)		
Cluster 1	**Cluster 2**	**Cluster 3**
Adventist Health Clear Lake	Chapman Global Medical Center	Adventist Health Bakersfield Heart Hospital
Adventist Health Tulare	Colorado River Medical Center	Adventist Health Tehachapi Valley
Banner Lassen Medical Center	Goleta Valley Cottage Hospital	AHMC Greater El Monte Community Hospital
Barton Memorial Hospital	Good Samaritan Hospital - Bakersfield	Barstow Community Hospital
East Los Angeles Doctors Hospital	LAC-Rancho Los Amigos National Rehabilitation Center	Chinese Hospital
Fairchild Medical Center	Sutter Maternity and Surgery Center of Santa Cruz	Coast Plaza Hospital
Mad River Community Hospital		Encino Hospital Medical Center
Memorial Hospital - Los Banos		Mammoth Hospital
Mercy Medical Center - Mount Shasta		Mark Twain Medical Center
Northern Inyo Hospital		San Gorgonio Memorial Hospital
Novato Community Hospital		Santa Ynez Valley Cottage Hospital
Palo Verde Hospital		
Plumas District Hospital		
South Coast Global Medical Center		
Sutter Amador Hospital		
Sutter Coast Hospital		
Sutter Lakeside Hospital		
Tahoe Forest Hospital District		
LOW VOLUME (20 – 40th Percentile)		
Cluster 1	**Cluster 2**	**Cluster 3**
Adventist Health Dameron Hospital	Adventist Health Delano	Adventist Health Sonora - Greenley
AHMC Alhambra Hospital Medical Center	Adventist Health Sierra Vista	Adventist Health St. Helena
AHMC Seton Medical Center	Adventist Health Twin Cities	California Pacific Medical Center - Mission Bernal Campus
Alameda Hospital	Adventist Health Ukiah Valley	Cedars-Sinai Marina Del Rey Hospital
Anaheim Global Medical Center	AHMC Monterey Park Hospital	Foothill Regional Medical Center
Chino Valley Medical Center	Doctors Hospital of Manteca	French Hospital Medical Center
Community Hospital of Huntington Park	El Centro Regional Medical Center	Los Angeles Community Hospital - Los Angeles
Emanate Health Foothill Presbyterian Hospital	Petaluma Valley Hospital	Menifee Global Medical Center
Garden Grove Hospital and Medical Center	Pioneers Memorial Healthcare District	Pacifica Hospital of the Valley
Kaiser Permanente Fremont Medical Center	Sequoia Hospital	Providence Little Company of Mary Medical Center - San Pedro
Kaiser Permanente San Rafael Medical Center	St. Elizabeth Community Hospital	San Ramon Regional Medical Center
Kaiser Permanente South San Francisco Medical Center	Sutter Davis Hospital	Shasta Regional Medical Center
La Palma Intercommunity Hospital	Sutter Tracy Community Hospital	St. Francis Memorial Hospital
Marshall	Watsonville Community Hospital	St. Mary's Medical Center - San Francisco
Memorial Hospital - Gardena	Woodland Healthcare	Sutter Solano Medical Center
Montclair Hospital Medical Center		
Paradise Valley Hospital		
San Dimas Community Hospital		
Sherman Oaks Hospital		
Sierra Nevada Memorial Hospital		
St. Rose Hospital		
Sutter Auburn Faith Hospital		
UC San Diego Health - East Campus		
UCI Health - Placentia Linda		

Table 4. *California Hospitals in Each HQI Hospital Similarity Cluster (cont.)*

MEDIUM VOLUME (40 – 60th Percentile)		
Cluster 1	**Cluster 2**	**Cluster 3**
AHMC Anaheim Regional Medical Center	AHMC Doctors Hospital of Riverside	Adventist Health Lodi Memorial
AHMC Garfield Medical Center	AHMC San Gabriel Valley Medical Center	Adventist Health Simi Valley
Corona Regional Medical Center - Main	AHMC Whittier Hospital Medical Center	Alta Bates Summit Medical Center
Eden Medical Center	College Medical Center	Desert Valley Hospital
Emanate Health Inter-Community Hospital	Community Hospital of San Bernardino	Dominican Hospital
Emanuel Medical Center	Contra Costa Regional Medical Center	Hemet Global Medical Center
Glendale Memorial Hospital and Health Center	JFK Memorial Hospital	John Muir Health - Concord Medical Center
Kaiser Permanente Antioch Medical Center	Kaiser Permanente Moreno Valley Medical Center	Martin Luther King, Jr. Community Hospital
Kaiser Permanente Fresno Medical Center	Natividad	Mission Community Hospital - Panorama Campus
Kaiser Permanente Panorama City Medical Center	Victor Valley Global Medical Center	PIH Health Downey Hospital
Kaiser Permanente Redwood City Medical Center		Providence St. Joseph Hospital - Eureka
Kaiser Permanente Vacaville Medical Center		Scripps Green Hospital
Kaiser Permanente Vallejo Hospital and Rehabilitation Center		Southern California Hospital - Hollywood
Kaiser Permanente West Los Angeles Medical Center		Southwest Healthcare Temecula Valley Hospital
Kaiser Permanente Woodland Hills Medical Center		St. John's Regional Medical Center
MarinHealth Medical Center		Sutter Delta Medical Center
Mercy Hospital - Folsom		UCI Health - Lakewood
Orange County Global Medical Center		UCI Health - Los Alamitos
Palmdale Regional Medical Center		UCLA Health West Valley Medical Center
Providence Queen of the Valley Medical Center		USC Keck Hospital
Redlands Community Hospital		West Anaheim Medical Center
Sierra View Medical Center		
St. Mary Medical Center - Long Beach		
Stanford Health Care Tri-Valley - Pleasanton		
Sutter Santa Rosa Regional Hospital		
Tri-City Healthcare District		
USC Verdugo Hills Hospital		
HIGH VOLUME (60 – 80th Percentile)		
Cluster 1	**Cluster 2**	**Cluster 3**
Centinela Hospital Medical Center	Adventist Health Hanford	Adventist Health and Rideout
Kaiser Permanente Sacramento Medical Center	Alta Bates Summit Medical Center - Alta Bates Campus	Adventist Health Bakersfield
Long Beach Medical Center	California Pacific Medical Center - Van Ness Campus	California Hospital Medical Center - Los Angeles
Mercy General Hospital	CHA Hollywood Presbyterian Medical Center	Community Hospital of the Monterey Peninsula
Northridge Hospital Medical Center	Community Memorial Hospital - Ventura	Good Samaritan Hospital - San Jose
Oroville Hospital	Henry Mayo Newhall Hospital	Highland Hospital
Providence Mission Hospital	Kaiser Permanente Baldwin Park Medical Center	Kaiser Permanente South Bay Medical Center
Providence Santa Rosa Memorial Hospital	Kaiser Permanente Riverside Medical Center	Loma Linda University Medical Center - Murrieta
Providence St. Jude Medical Center	Kaiser Permanente San Francisco Medical Center	Los Robles Health System
Regional Medical Center of San Jose	Kaiser Permanente San Jose Medical Center	Mercy Medical Center - Redding
St. Bernardine Medical Center	Kaiser Permanente San Leandro Medical Center	Mills-Peninsula Medical Center
UCLA Health UCLA Medical Center - Santa Monica	Kaiser Permanente Santa Rosa Medical Center	NorthBay Health Medical Center
	Kaiser Permanente Walnut Creek Medical Center	Orange Coast Medical Center
	Kern Medical	PIH Health Good Samaritan Hospital
	LAC-Olive View - UCLA Medical Center	Providence Saint John's Health Center
	Marian Regional Medical Center	Providence Saint Joseph Medical Center
	Mercy Hospital - Bakersfield	Providence St. Mary Medical Center
	Mercy Medical Center - Merced	Saddleback Medical Center - Laguna Hills
	Providence Cedars-Sinai Tarzana Medical Center	Salinas Valley Health
	San Joaquin General Hospital	San Antonio Regional Hospital
	Valley Presbyterian Hospital	Scripps Memorial Hospital - Encinitas
	Ventura County Medical Center - Ventura	UCI Health - Fountain Valley - Euclid
		USC Arcadia Hospital
		Washington Hospital Healthcare System - Fremont
		Zuckerberg San Francisco General Hospital and Trauma Center

Table 4. *California Hospitals in Each HQI Hospital Similarity Cluster (cont.)*

HIGHEST VOLUME (80 – 100th Percentile)		
Cluster 1	**Cluster 2**	**Cluster 3**
Adventist Health White Memorial	Adventist Health Glendale	Cedars-Sinai
Antelope Valley Hospital Medical Center	Arrowhead Regional Medical Center	Loma Linda University Medical Center
Bakersfield Memorial Hospital	Community Regional Medical Center - Fresno	Sharp Memorial Hospital
Clovis Community Medical Center	Desert Regional Medical Center	Stanford Hospital at 300 Pasteur Drive
El Camino Health - Mountain View	Doctors Medical Center - Modesto	UC Davis Health UC Davis Medical Center
Hoag Memorial Presbyterian Hospital	Eisenhower Health	UC San Diego Health - Hillcrest Medical Center
Kaiser Permanente Downey Medical Center	Enloe Health	UCI Health Medical Center
Kaiser Permanente Fontana Medical Center	Huntington Health	UCLA Health Ronald Reagan UCLA Medical Center
Kaiser Permanente Manteca Medical Center	John Muir Health - Walnut Creek Medical Center	UCSF Health UCSF Medical Center - San Francisco
Kaiser Permanente Orange County - Anaheim Medical Center	Kaiser Permanente Los Angeles Medical Center	
Kaiser Permanente Roseville Medical Center	Kaiser Permanente Oakland Medical Center	
Kaiser Permanente San Diego - Zion Medical Center	LAC-Harbor - UCLA Medical Center	
Kaiser Permanente Santa Clara Medical Center	Los Angeles General Medical Center	
Kaiser Permanente South Sacramento Medical Center	Memorial Medical Center - Modesto	
Kaweah Health Medical Center	Mercy Medical Center - San Juan	
Palomar Medical Center - Escondido	PIH Health Whittier Hospital	
Pomona Valley Hospital Medical Center	Providence Holy Cross Medical Center	
Providence St. Joseph Hospital - Orange	Riverside Community Hospital	
Riverside University Health System - Medical Center	Santa Barbara Cottage Hospital	
Sharp Chula Vista Medical Center	Santa Clara Valley Medical Center	
Sharp Grossmont Hospital	Scripps Memorial Hospital - La Jolla	
Southwest Healthcare Rancho Springs Hospital	Scripps Mercy Hospital	
St. Agnes Medical Center	St. Joseph's Medical Center - Stockton	
St. Francis Medical Center	Sutter Roseville Medical Center	
Sutter Medical Center - Sacramento	Torrance Memorial Health	
Strong SNF Cluster (> 5% Skilled Nursing)		
Cluster 1	**Cluster 2**	**Cluster 3**
Adventist Health Reedley	Orchard Hospital	Glenn Medical Center
Ridgecrest Regional Hospital	Colusa Medical Center	Providence Redwood Memorial Hospital
Providence Little Company of Mary Medical Center - Torrance	Coalinga Medical Center	Kern Valley Healthcare District
Methodist Hospital of Sacramento	John C. Fremont Healthcare District	Adventist Health Howard Memorial
Hazel Hawkins Memorial Hospital	Adventist Health Mendocino Coast	Modoc Medical Center
Hi-Desert Medical Center	Seneca Healthcare District	George L. Mee Memorial Hospital
Palomar Medical Center - Poway-Pomerado Hospital	San Bernardino Mountains Community Hospital	Eastern Plumas Health Care - Portola Campus
Lompoc Valley Medical Center	Mayers Memorial Hospital District	Bear Valley Community Hospital
	Oak Valley Hospital	San Mateo Medical Center
	Trinity Hospital	Healdsburg Hospital
	Community Memorial Hospital - Ojai	Sonoma Valley Hospital

CONCLUSION

Comparing hospital performance on quality metrics to peers can be helpful to achieve quality goals. While various existing peer comparison groups are already available in HQIP, the addition of HQI's Hospital Similarity Clusters provides for more comparable peers identified by grouping hospitals across multiple characteristics, such as inpatient admission volume and hospital type.

Although no comparison point is perfect due to the uniqueness of each hospital, this analysis paper demonstrated how hospitals can be grouped into clusters based on characteristics of the populations they serve. These characteristics can be used in combination to build clusters representing various data points, facilitating the creation of comparison groups designed to identify the most similar hospitals. These groupings enable high-quality comparisons of performance metrics, which is important for a variety of reasons, including that such comparisons allow for more meaningful evaluation of performance, help identify whether poor outcomes are possibly due to hospital performance vs. population factors, and help identify realistic benchmarks and achievable goals, to name a few.

Contact Aaron Koll, data scientist, at akoll@hqinstitute.org with any questions.

ABOUT US

The Hospital Quality Institute (HQI) is dedicated to advancing patient safety and quality of care for all Californians. Through strategic partnerships and innovative programs, HQI supports hospitals in achieving excellence by providing data analytics, educational resources, and statewide initiatives focused on performance improvement. HQI oversees and coordinates the Collaborative Health Care Patient Safety Organization (CHPSO).