TRUVEN HEALTH ANALYTICS
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100 TOP HOSPITALS

50 Top Cardiovascular Hospitals Study, 2017

18th Edition | Published November 7, 2016

Truven Health Analytics,™ an IBM® Company
100 Phoenix Drive
Ann Arbor, MI 48108 USA
800.525.9083
truvenhealth.com

Truven Health 50 Top Cardiovascular Hospitals Study, 2017; 18th Edition

ISBN: 978-57372-470-8

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Introduction

Each year, Truven Health Analytics,™ an IBM® Company, conducts objective, quantitative research to identify the nation's highest-performing hospitals, health systems, and cardiovascular service lines through the Truven Health 100 Top Hospitals® program. The ultimate goal of the program is to produce critical information that can help all healthcare organizations target balanced, improved performance. Organizations do not apply for our selection process, and award winners do not pay to market their honor.

Now, as we have for 18 years, Truven Health has again analyzed public data — with our proprietary methodologies — to provide the industry with the 2017 Truven Health 50 Top Cardiovascular Hospitals study.

Like all 100 Top Hospitals research, this study is based on a national scorecard of metrics, which is then used to identify and recognize the best cardiovascular service lines in the United States.

The study is far more than a list, though. It provides unbiased, action-driving, and achievable benchmarks for hospital and clinical leaders to use as they work to raise their own organizations' standards of performance.

Inspirational Leadership for a Value-Based World

Each year, winners of our 50 Top Cardiovascular Hospitals award are identifying opportunities to deliver healthcare value to their communities. They do this by finding ways to take clinical, operational, and financial performance to the next level.

Over and over again, we see that these hospitals lead the cardiovascular healthcare industry — often inspiring the clinicians and staff within their own walls and systems, as well as their peers and competitors, to better understand data and benchmarks, and close performance gaps.

It is a kind of leadership that is perhaps becoming even more important as the industry moves swiftly to a value-based payment environment.

The Truven Health 50 Top Cardiovascular Hospitals study focuses on one of healthcare's most important service lines — one that affects hundreds of thousands of patient lives annually and adds billions of dollars to our nation's overall healthcare costs.

That's why publishing new and achievable benchmarks for cardiovascular service line performance is substantially important — and has the potential to make a large and lasting impact on the quality and cost of care for heart patients across the U.S.

Why Cardiovascular Hospitals?

According to a 2016 report from the American Heart Association, one in three American adults has one or more types of cardiovascular disease.[1] Cardiovascular diseases have a large impact on mortality and cost — accounting for approximately one in four deaths[2] and about 17 percent of national health expenditures.[3] In addition, prevalence of cardiovascular disease is expected to increase to a point where approximately 40 percent of the U.S. population will have the disease by 2030.[3]

It's no wonder, then, that cardiovascular services are one of the highest-profile service lines in healthcare. With the stakes so high, it is important that hospitals provide high-quality, highly efficient cardiac care — and that they look closely for ways to improve. The Truven Health 50 Top Cardiovascular Hospitals study answers that need each year.

The 50 Top Cardiovascular Hospitals study is also unique for the 100 Top Hospitals program. The program's research series publishes only this one clinical service line study because of the limitations of inpatient public administrative data. Only the cardiovascular service line has consistently had both the inpatient volume and supplemental clinical process metrics from the Centers for Medicare & Medicaid Services (CMS) Hospital Compare initiative to support the publication of scorecard-based benchmarks for a service line. And with each annual 50 Top Cardiovascular Hospitals study, the results improve — as the transparency and depth of inpatient and continuum-of-care data grow and evolve.

Objective, Real-World Assessment

For many years, the vast majority of the 50 Top Cardiovascular Hospitals winners have used a dyad management model, and while the study scorecard is more heavily weighted on clinical metrics, our research reflects diverse, real-world organizational needs.

In addition, to maintain the study's high level of integrity, only public data sources are used for calculating study metrics. This eliminates bias, ensures inclusion of as many hospitals as possible, and facilitates consistency of definitions and data. All of this serves to make our benchmarks decidedly useful for assessing both service line management and clinical outcomes in an objective, independent, and meaningful way.

A Unique Measure of Leadership Excellence and Its Effect on Service Line Performance

For more than 20 years, Truven Health has collaborated with academics on a wide range of topics to dig deeper into the leadership practices of the nation's top healthcare organizations. Those studies have found that leadership excellence is essential for superior organizational and service line performance.

As such, the 100 Top Hospitals studies not only provide a distinctive approach to measuring the performance of hospitals, health systems, and cardiovascular service lines, but also deliver impartial insights into the effectiveness of hospital leadership. Higher composite scores on our national balanced scorecard reflect more effective leadership, as well as a management team's degree of success in executing short- and long-term goals across multiple key managerial and clinical domains.

The leadership of today's hospitals — including the board, executive team, and medical staff leadership — is responsible for ensuring all facets of a hospital and its cardiovascular service line are performing at the same high level. Only the 50 Top Cardiovascular Hospitals study and analytics provide that view of enterprise performance alignment. And that information is fundamental to assessing the strategic intersection among cost, quality, efficiency, and community value.

The Performance of the 2017 50 Top Cardiovascular Hospitals

The 50 Top Cardiovascular Hospitals study for 2017 identified U.S. hospitals that have achieved the best performance on a balanced scorecard of performance measures.

This year, based on comparisons between the study winners and a peer group of similar hospitals that were not winners, we found that our study winners delivered better outcomes while operating more efficiently and at a lower cost.

Compared to nonwinning cardiovascular hospitals, the 2017 winners had:

- Significantly higher inpatient survival (25 to 55 percent higher)
- Fewer patients with complications (20 to 22 percent fewer)
- Higher 30-day survival rates for acute myocardial infarction (AMI), heart failure (HF), and coronary artery bypass grafting (CABG) patients (0.5 to 1.1 percentage points higher)*
- Lower readmission rates for AMI, HF, and CABG patients (0.5 to 1.2 percentage points lower)
- Average lengths of stay for CABG patients that were one day lower (0.3 to 0.5 days lower than the other patient groups)
- $1,200 to $6,100 less in total costs per patient case; the median benchmark hospital spent approximately $6,100 less per bypass surgery patient and approximately $1,200 less per admitted HF patient

Further, our study indicated that if all cardiovascular hospitals performed at the same level of this year's winners:

- More than 9,100 additional lives could be saved
- Over 6,100 more heart patients could be complication-free
- Approximately $1.4 billion could be saved

We based this analysis on the Medicare patients included in this study. If the same standards were applied to all inpatients, the impact would be even greater.

* An AMI is a heart attack, which happens when the arteries leading to the heart become blocked and blood supply is slowed or stopped. Heart failure is a weakening of the heart's pumping power, leading to the body not receiving enough oxygen and nutrients to work properly. A CABG is a type of surgery that improves blood flow to the heart by moving or redirecting a blood vessel to bypass blockages.

There is evidence that hospitals with higher 30-day survival rates for AMI patients also have better long-term survival rates.[4]

An Oct. 6, 2016, article published in the *New England Journal of Medicine* concluded that AMI patients treated at hospitals with higher 30-day survival rates live, on average, about a year longer than those treated at hospitals with the lowest rates.

These findings suggest that better initial care for AMI patients is related to long-term benefits.

New This Year: Trends in Cardiovascular Care

For this year's 50 Top Cardiovascular Hospitals study, we added an analysis of trends in cardiovascular care. Our intent is to provide healthcare leaders with new insights by showing the direction and magnitude of change over a five-year period, from 2011 to 2015.

Our findings include:

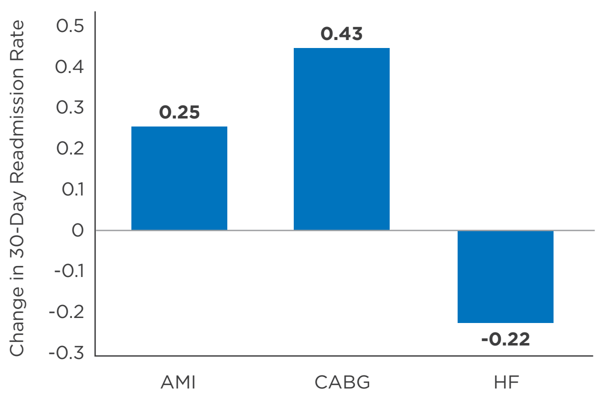
- Readmission rates for AMI and HF patients showed statistically significant improvement in a large percentage of hospitals (50.5 percent and 39.5 percent improvement, respectively).
- However, for HF patients, more than 16 percent of hospitals had statistically significant increases in 30-day mortality rates.
- A strong majority of hospitals (from 74.3 percent to 87.2 percent) held the cost of delivering care to AMI, HF, CABG, and percutaneous coronary intervention (PCI)* patients stable from 2011 to 2015, with no statistically significant change at 95-percent confidence.

In this year's study, we examined the correlation between 30-day readmission rates and 30-day mortality rates for the most current data point,** for AMI, HF, and CABG patients. The results were adjusted for the three cardiovascular hospital comparison groups in the study (teaching hospitals with cardiovascular residency programs, teaching hospitals without cardiovascular residency programs, and community hospitals).

AMI and CABG patients showed a positive correlation between improvements in readmissions and improvements in 30-day mortality. However, HF patients had a statistically significant negative correlation — as readmissions decreased, 30-day mortality increased.

Further research is needed to determine whether continuum-of-care issues, community characteristics, or sociodemographics — or all three — were factors behind this phenomenon.

Figure 1: 30-Day Readmission Rate Changes for Each Unit Increase in 30-Day Mortality Rate**



** CMS Hospital Compare July 1, 2012–June 30, 2015.
Adjusted for hospital comparison group. All results statistically significant.

* A PCI is a procedure that uses a small stent to open up blood vessels in the heart that have narrowed from a buildup of plaque.

Additional Findings

For more details about the 50 Top Cardiovascular Hospitals study findings, including complete hospital reporting data on this year's winning cardiovascular hospitals, please see the Findings section of this document.

We Welcome Your Input

For more than two decades, the 100 Top Hospitals program has worked to ensure that the measures and methodologies used are fair, consistent, and meaningful. We continually test the validity of our performance measures and data sources. In addition, as part of our own internal performance improvement process, we welcome comments about our study from health systems, hospitals, and physicians. To submit comments, visit the Contact Us section of **100tophospitals.com**.

More About the Multifaceted 100 Top Hospitals Program

The 50 Top Cardiovascular Hospitals research is just one of the studies of the Truven Health 100 Top Hospitals program. To increase understanding of trends in specific areas of the healthcare industry, the program includes a range of studies and reports, including:

- **100 Top Hospitals and Everest Award studies:** Highly anticipated research that annually recognizes the best hospitals in the nation based on overall organizational performance, as well as long-term rates of improvement
- **50 Top Cardiovascular Hospitals study:** An annual study identifying hospitals that demonstrate the highest performance in hospital cardiovascular services
- **15 Top Health Systems study:** A groundbreaking study introduced in 2009 that provides an objective measure of health system performance as a sum of its parts
- **100 Top Hospitals Performance Matrix reports:** A two-dimensional analysis — available for nearly all U.S. hospitals and health systems — that provides a clear view of how long-term improvement and current performance overlap and compare with national peers
- **Custom benchmark reports:** A variety of reports designed to help executives understand how their performance compares with peers within health systems, states, and markets

You can read more about these studies and see lists of all winners by visiting **100tophospitals.com**.

About Truven Health Analytics

Truven Health Analytics, an IBM Company, delivers the answers that clients need to help them improve healthcare quality and access while reducing costs. We provide market-leading performance improvement solutions built on data integrity, advanced analytics, and domain expertise. For more than 40 years, our insights and solutions have been providing hospitals and clinicians, employers and health plans, state and federal government agencies, life sciences companies, and policymakers the facts they need to help them make confident decisions that directly affect the health and well-being of people and organizations in the U.S. and around the world.

Truven Health Analytics owns some of the most trusted brands in healthcare, such as MarketScan,® 100 Top Hospitals,® Advantage Suite,® Micromedex,® Simpler,® ActionOI,® and JWA. Truven Health has its principal offices in Ann Arbor, Mich.; Chicago, Ill.; and Denver, Colo. For more information, please visit **truvenhealth.com**.

The Value of 100 Top Hospitals Benchmarks

To improve performance, cardiovascular hospital leaders need objective information about what is achievable — relevant benchmarks that allow them to compare their performance to peers and top-performing organizations.

By naming the Truven Health 50 Top Cardiovascular Hospitals in the nation, the Truven Health 100 Top Hospitals program provides hospital executives, physicians, and cardiovascular service line managers with practical targets for raising performance.

Information in this study, and in separate hospital-specific reports, provides performance levels to reach for, with detailed analysis of how the winners and their nonwinning peers performed on the study's balanced scorecard of measures.

2017 Award Winners

Truven Health Analytics,™ an IBM® Company, and its 100 Top Hospitals® program are pleased to present the 2017 Truven Health 50 Top Cardiovascular Hospitals.

We stratified winners by three separate peer groups: teaching hospitals with cardiovascular residency programs, teaching hospitals without cardiovascular residency programs, and community hospitals.

Please note that the order of hospitals in the following tables does not reflect performance rating. Hospitals are ordered alphabetically.

For full details on these peer groups and the process we used to select the winning benchmark hospitals, please see the Methodology section of this document.

Teaching Hospitals With Cardiovascular Residency Programs*		
Hospitals	**Location**	**Medicare ID**
Aultman Hospital	Canton, OH	360084
Baystate Medical Center	Springfield, MA	220077
Carilion Roanoke Memorial Hospital	Roanoke, VA	490024
Deborah Heart and Lung Center	Browns Mills, NJ	310031
Duke University Hospital	Durham, NC	340030
Henry Ford Hospital	Detroit, MI	230053
Lankenau Medical Center	Wynnewood, PA	390195
Mayo Clinic	Jacksonville, FL	100151
Park Nicollet Methodist Hospital	St. Louis Park, MN	240053
Riverside Medical Center	Kankakee, IL	140186
Steward St. Elizabeth's Medical Center	Brighton, MA	220036
The Christ Hospital Health Network	Cincinnati, OH	360163
The Mount Sinai Hospital	New York, NY	330024
UMass Memorial Medical Center	Worcester, MA	220163
University of Wisconsin Hospital and Clinics	Madison, WI	520098

* Order of hospitals does not reflect performance rating. Hospitals are ordered alphabetically.

Teaching Hospitals Without Cardiovascular Residency Programs*		
Hospitals	**Location**	**Medicare ID**
Aspirus Wausau Hospital	Wausau, WI	520030
Banner Boswell Medical Center	Sun City, AZ	030061
Billings Clinic Hospital	Billings, MT	270004
Bon Secours St. Mary's Hospital	Richmond, VA	490059
Eisenhower Medical Center	Rancho Mirage, CA	050573
Henry Ford Macomb Hospitals	Clinton Township, MI	230047
Kootenai Health	Coeur d'Alene, ID	130049
Memorial Hermann Hospital System	Houston, TX	450184
Memorial Regional Hospital	Hollywood, FL	100038
Mercy Hospital St. Louis	St. Louis, MO	260020
MidMichigan Medical Center-Midland	Midland, MI	230222
Mission Hospital	Asheville, NC	340002
Morton Plant Hospital	Clearwater, FL	100127
North Shore Medical Center	Salem, MA	220035
OSF Saint Anthony Medical Center	Rockford, IL	140233
ProMedica Toledo Hospital	Toledo, OH	360068
Saint Thomas West Hospital	Nashville, TN	440082
St. Luke's Boise Medical Center	Boise, ID	130006
Sutter Medical Center, Sacramento	Sacramento, CA	050108
Utah Valley Hospital	Provo, UT	460001

Community Hospitals*		
Hospitals	**Location**	**Medicare ID**
Banner Heart Hospital	Mesa, AZ	030105
Bellin Hospital	Green Bay, WI	520049
Cookeville Regional Medical Center	Cookeville, TN	440059
Hoag Hospital Newport Beach	Newport Beach, CA	050224
Longview Regional Medical Center	Longview, TX	450702
Mercy Hospital Jefferson	Festus, MO	260023
NCH Healthcare System	Naples, FL	100018
Nebraska Heart Institute & Heart Hospital	Lincoln, NE	280128
Ochsner Medical Center - Baton Rouge	Baton Rouge, LA	190202
Oklahoma Heart Hospital	Oklahoma City, OK	370215
Providence St. Patrick Hospital	Missoula, MT	270014
Sarasota Memorial Hospital	Sarasota, FL	100087
St. David's Medical Center	Austin, TX	450431
St. Vincent Heart Center of Indiana	Indianapolis, IN	150153
University Hospitals Parma Medical Center	Parma, OH	360041

* Order of hospitals does not reflect performance rating. Hospitals are ordered alphabetically.

Findings

This year's Truven Health 50 Top Cardiovascular Hospitals provided better care and were more efficient than their peers. If all cardiovascular hospitals performed at the level of our 2017 study winners, approximately 9,100 additional lives and $1.4 billion could be saved, and more than 6,100 additional bypass and angioplasty patients could be complication-free.

We based these findings on the Medicare patients included in this study and by analyzing study winners versus nonwinners. If the same standards were applied to all inpatients, the impact would be even greater.

One of the goals of the Truven Health 100 Top Hospitals® program is to provide action-driving benchmarks that can help all hospitals improve their performance. This section highlights winner (benchmark) versus nonwinner differences in all study hospitals as a group and by hospital type (residency program and teaching status).

Benchmark Hospitals Outperformed Peer Hospitals Across All Measures

Comparisons between this year's 50 Top Cardiovascular Hospitals and their peers showed that room for improvement still exists among the hospitals providing cardiovascular care in the U.S. (See Table 1.)

- Survival rates were markedly better at benchmark (winning) hospitals, particularly for patients receiving coronary artery bypass graft surgeries (CABGs) and percutaneous coronary interventions (PCIs). The median benchmark hospital had a risk-adjusted CABG mortality index of 0.44, meaning there were 56 percent fewer deaths than would be expected, given patient severity. With an index of 0.98, peer (nonwinning) hospitals had only 2 percent fewer CABG mortalities than expected. Winner versus nonwinner differences were similar for PCI survival rates.
- The 2017 cardiovascular study winners had 22.3 percent and 19.8 percent lower complications indexes for PCI and CABG, respectively, when compared to their peers.
- Longer-term outcomes were better at winning hospitals. The winning hospitals' 30-day heart failure (HF), heart attack (AMI), and CABG mortality rates were lower than their peers, meaning a smaller percentage of patients died, of any cause, 30 days after admission. The difference was particularly dramatic among AMI patients, with a 30-day mortality rate of 12.8 percent for winners versus 13.9 percent for nonwinners.

- The winning hospitals also had lower readmission rates, with a smaller percentage of patients returning to the hospital, for any cause, within 30 days of discharge. HF patient readmissions showed the biggest difference, with a 30-day readmission rate of 20.5 percent for winners versus 21.7 percent for nonwinners.
- Winning hospitals were more efficient, releasing patients sooner than their peers. The typical winning hospital released CABG patients nearly a full day sooner, and their AMI patients were released a half day sooner than at nonwinning peers.
- The 50 Top Cardiovascular Hospitals managed all of these clinical gains while still keeping costs lower. The typical winning hospital spent more than $6,100 less per CABG patient and more than $1,200 less per admitted HF patient.

Table 1: National Performance Comparisons (All Hospitals in Study)

	Performance Measure		Benchmark Median	Peer Median	Benchmark Compared With Peer Group		
					Difference	Percent Difference	How Winning Benchmark Hospitals Outperform Nonwinning Peer Hospitals
Clinical Outcome Measures[a]	Risk-Adjusted Mortality Index	AMI Mortality	0.76	1.02	-0.26	-25.5	Lower Mortality
		HF Mortality	0.67	1.00	-0.33	-33.0	Lower Mortality
		CABG Mortality	0.44	0.98	-0.54	-55.1	Lower Mortality
		PCI Mortality	0.59	1.00	-0.41	-41.0	Lower Mortality
	Risk-Adjusted Complications Index	CABG Complications	0.73	0.91	-0.18	-19.8	Fewer Complications
		PCI Complications	0.73	0.94	-0.21	-22.3	Fewer Complications
Clinical Process Measures	CABG Patients With Internal Mammary Artery (IMA) Use[a,c]		96.9	94.74	2.16	n/a	Higher IMA Use
Extended Outcome Measures	AMI 30-Day Mortality (%)[b,c]		12.8	13.9	-1.1	n/a	Lower 30-Day Mortality
	HF 30-Day Mortality (%)[b,c]		11.4	11.9	-0.5	n/a	Lower 30-Day Mortality
	CABG 30-Day Mortality (%)[b,c]		2.7	3.2	-0.6	n/a	Lower 30-Day Mortality
	AMI 30-Day Readmission (%)[b,c]		16.0	16.8	-0.9	n/a	Fewer 30-Day Readmissions
	HF 30-Day Readmission (%)[b,c]		20.5	21.7	-1.2	n/a	Fewer 30-Day Readmissions
	CABG 30-Day Readmission (%)[b,c]		13.9	14.4	-0.5	n/a	Fewer 30-Day Readmissions
Process Efficiency	AMI Severity-Adjusted Average Length of Stay (ALOS)		3.8	4.3	-0.5	-12.0	Shorter ALOS
	HF Severity-Adjusted ALOS		4.7	4.9	-0.3	-5.5	Shorter ALOS
	CABG Severity-Adjusted ALOS		8.4	9.3	-0.9	-9.5	Shorter ALOS
	PCI Severity-Adjusted ALOS		3.2	3.7	-0.4	-12.0	Shorter ALOS
Cost Efficiency	AMI Wage- and Severity-Adjusted Average Cost per Case		$7,994	$9,841	-$1,847	-18.8	Lower Cost per Case
	HF Wage- and Severity-Adjusted Average Cost per Case		$7,638	$8,884	-$1,246	-14.0	Lower Cost per Case
	CABG Wage- and Severity-Adjusted Average Cost per Case		$33,107	$39,271	-$6,163	-15.7	Lower Cost per Case
	PCI Wage- and Severity-Adjusted Average Cost per Case		$14,410	$17,512	-$3,102	-17.7	Lower Cost per Case

a. Medicare Provider Analysis and Review (MEDPAR) 2014 and 2015, combined.
b. Centers for Medicare & Medicaid Services (CMS) Hospital Compare July 1, 2012–June 30, 2015.
c. We do not calculate percentage difference for measures already expressed as a percent.

Better Performance at Benchmark Teaching Hospitals With Cardiovascular Residency Programs

Teaching hospitals with cardiovascular residency programs generally treat more complex patients, have a more complex staffing mix, and incur higher input costs than community hospitals and those without cardiovascular residency programs. Evaluating performance among these hospitals as a unique group produces valid comparisons. (See Table 2.)

- One example of the wide margin of performance difference was the benchmark group's markedly higher survival rates: Winners' inpatient mortality rates were 44 and 43 percent lower than their peers for CABG and PCI patients, respectively. Also, for AMI patients, the difference between winners and nonwinners was the greatest of all the three comparison groups (37.6 percent difference).
- This performance lead was not found for PCI complications; winning hospitals had a 2 percent higher complications index.
- Cardiovascular teaching benchmark hospitals were also much more efficient than their peers, with the greatest difference found for CABG patients — almost $5,400 less spent on each bypass surgery patient. In addition, winners had nearly 20 percent lower cost for PCI patients and over 17 percent lower cost for HF patients.
- It should also be noted that cardiovascular teaching winners had the highest rate of internal mammary artery (IMA) use for CABG patients, across all comparison groups, at 97.3 percent.

Table 2: Performance Comparisons for Teaching Hospitals With Cardiovascular Residency Programs

	Performance Measure		Benchmark Median	Peer Median	Benchmark Compared With Peer Group		
					Difference	Percent Difference	How Winning Benchmark Hospitals Outperform Nonwinning Peer Hospitals
Clinical Outcome Measures[a]	Risk-Adjusted Mortality Index	AMI Mortality	0.63	1.01	-0.38	-37.6	Lower Mortality
		HF Mortality	0.75	1.02	-0.27	-26.5	Lower Mortality
		CABG Mortality	0.52	0.93	-0.41	-44.1	Lower Mortality
		PCI Mortality	0.58	1.02	-0.44	-43.1	Lower Mortality
	Risk-Adjusted Complications Index	CABG Complications	0.70	0.89	-0.19	-21.3	Fewer Complications
		PCI Complications	0.95	0.93	0.02	2.2	More Complications
Clinical Process Measures	CABG Patients With IMA Use[a,c]		97.31	95.66	1.65	n/a	Higher IMA Use
Extended Outcome Measures	AMI 30-Day Mortality (%)[b,c]		12.8	13.5	-0.7	n/a	Lower 30-Day Mortality
	HF 30-Day Mortality (%)[b,c]		10.6	11.0	-0.4	n/a	Lower 30-Day Mortality
	CABG 30-Day Mortality (%)[b,c]		2.6	2.9	-0.3	n/a	Lower 30-Day Mortality
	AMI 30-Day Readmission (%)[b,c]		16.4	17.0	-0.6	n/a	Fewer 30-Day Readmissions
	HF 30-Day Readmission (%)[b,c]		21.0	21.9	-0.9	n/a	Fewer 30-Day Readmissions
	CABG 30-Day Readmission (%)[b,c]		14.6	14.2	0.4	n/a	More 30-Day Readmissions
Process Efficiency	AMI Severity-Adjusted ALOS		4.2	4.3	-0.1	-2.6	Shorter ALOS
	HF Severity-Adjusted ALOS		4.7	4.9	-0.2	-3.5	Shorter ALOS
	CABG Severity-Adjusted ALOS		8.7	9.2	-0.5	-5.4	Shorter ALOS
	PCI Severity-Adjusted ALOS		3.4	3.7	-0.3	-7.8	Shorter ALOS
Cost Efficiency	AMI Wage- and Severity-Adjusted Average Cost per Case		$8,565	$9,615	-$1,049	-10.9	Lower Cost per Case
	HF Wage- and Severity-Adjusted Average Cost per Case		$7,388	$8,923	-$1,535	-17.2	Lower Cost per Case
	CABG Wage- and Severity-Adjusted Average Cost per Case		$34,068	$39,445	-$5,378	-13.6	Lower Cost per Case
	PCI Wage- and Severity-Adjusted Average Cost per Case		$14,736	$18,356	-$3,620	-19.7	Lower Cost per Case

a. MEDPAR 2014 and 2015, combined.
b. CMS Hospital Compare July 1, 2012–June 30, 2015.
c. We do not calculate percentage difference for measures already expressed as a percent.

Better Performance at Benchmark Teaching Hospitals Without Cardiovascular Residency Programs

- Winning teaching hospitals without cardiovascular residency programs were much more efficient than their peers. (See Table 3.) This difference was most notable with CABG patients and length of stay: Winning hospitals kept patients nearly a day and a half less than nonwinning hospitals. These benchmark hospitals also treated their average CABG and PCI cases at a lower cost, 13.9 percent and 15.2 percent less, respectively, saving over $5,400 per CABG case and $2,600 per PCI case.
- Benchmark teaching hospitals without cardiovascular residency programs had the best outcomes for CABG patients and outperformed their peers on the CABG mortality measure with a wider margin than the two other hospital groups we studied. With a CABG mortality rate of 0.44, the winning teaching hospitals without cardiovascular residency programs had 56 percent fewer CABG patient deaths than expected.

Table 3: Performance Comparisons for Teaching Hospitals Without Cardiovascular Residency Programs

	Performance Measure		Benchmark Median	Peer Median	Benchmark Compared With Peer Group		
					Difference	Percent Difference	How Winning Benchmark Hospitals Outperform Nonwinning Peer Hospitals
Clinical Outcome Measures[a]	Risk-Adjusted Mortality Index	AMI Mortality	0.79	1.05	-0.26	-24.8	Lower Mortality
		HF Mortality	0.74	0.99	-0.25	-25.3	Lower Mortality
		CABG Mortality	0.44	1.00	-0.56	-56.0	Lower Mortality
		PCI Mortality	0.66	0.97	-0.31	-32.0	Lower Mortality
	Risk-Adjusted Complications Index	CABG Complications	0.68	0.89	-0.21	-23.6	Fewer Complications
		PCI Complications	0.74	0.96	-0.22	-22.9	Fewer Complications
Clinical Process Measures	CABG Patients With IMA Use[a,c]		96.79	94.38	2.41	n/a	Higher IMA Use
Extended Outcome Measures	AMI 30-Day Mortality (%)[b,c]		12.8	14.0	-1.3	n/a	Lower 30-Day Mortality
	HF 30-Day Mortality (%)[b,c]		11.7	12.2	-0.5	n/a	Lower 30-Day Mortality
	CABG 30-Day Mortality (%)[b,c]		2.8	3.3	-0.5	n/a	Lower 30-Day Mortality
	AMI 30-Day Readmission (%)[b,c]		15.9	16.7	-0.8	n/a	Fewer 30-Day Readmissions
	HF 30-Day Readmission (%)[b,c]		20.5	21.6	-1.1	n/a	Fewer 30-Day Readmissions
	CABG 30-Day Readmission (%)[b,c]		13.8	14.4	-0.6	n/a	Fewer 30-Day Readmissions
Process Efficiency	AMI Severity-Adjusted ALOS		4.0	4.4	-0.4	-9.1	Shorter ALOS
	HF Severity-Adjusted ALOS		4.8	5.0	-0.2	-3.8	Shorter ALOS
	CABG Severity-Adjusted ALOS		7.9	9.3	-1.4	-15.5	Shorter ALOS
	PCI Severity-Adjusted ALOS		3.3	3.6	-0.3	-7.8	Shorter ALOS
Cost Efficiency	AMI Wage- and Severity-Adjusted Average Cost per Case		$8,999	$9,981	-$983	-9.8	Lower Cost per Case
	HF Wage- and Severity-Adjusted Average Cost per Case		$8,028	$9,087	-$1,059	-11.7	Lower Cost per Case
	CABG Wage- and Severity-Adjusted Average Cost per Case		$33,567	$39,004	-$5,436	-13.9	Lower Cost per Case
	PCI Wage- and Severity-Adjusted Average Cost per Case		$14,599	$17,209	-$2,610	-15.2	Lower Cost per Case

a. MEDPAR 2014 and 2015, combined.
b. CMS Hospital Compare July 1, 2012–June 30, 2015.
c. We do not calculate percentage difference for measures already expressed as a percent.

Better Performance at Benchmark Community Hospitals

- Benchmark community hospitals outperformed their peers on the HF mortality measure. With an HF mortality rate of 0.52, the winning community hospitals had 48 percent fewer HF patient deaths than expected. (See Table 4.)
- The winning community hospitals were also much more efficient than their peers. They discharged AMI, CABG, and PCI patients nearly a day sooner, and HF patients nearly a half a day sooner. Cost-per-case medians in all patient groups were also much lower for benchmark community hospitals, with the most notable difference for CABG patients, at almost $7,500 less per case than peer hospitals in the group. This margin of difference is much wider than found with the other two comparison groups.
- Across most measures, the difference in performance between benchmark and peer hospitals was greatest in the community hospitals comparison group versus the other two groups.

Table 4: Performance Comparisons for Community Hospitals

	Performance Measure		Benchmark Median	Peer Median	Benchmark Compared With Peer Group		
					Difference	Percent Difference	How Winning Benchmark Hospitals Outperform Nonwinning Peer Hospitals
Clinical Outcome Measures[a]	Risk-Adjusted Mortality Index	AMI Mortality	0.77	1.01	-0.24	-23.8	Lower Mortality
		HF Mortality	0.52	1.00	-0.48	-48.0	Lower Mortality
		CABG Mortality	0.56	0.91	-0.35	-38.5	Lower Mortality
		PCI Mortality	0.58	1.00	-0.42	-42.0	Lower Mortality
	Risk-Adjusted Complications Index	CABG Complications	0.79	0.96	-0.17	-17.7	Fewer Complications
		PCI Complications	0.64	0.97	-0.33	-34.0	Fewer Complications
Clinical Process Measures	CABG Patients With IMA Use[a,c]		96.79	94.29	2.5	n/a	Higher IMA Use
Extended Outcome Measures	AMI 30-Day Mortality (%)[b,c]		12.8	14.0	-1.2	n/a	Lower 30-Day Mortality
	HF 30-Day Mortality (%)[b,c]		11.8	12.0	-0.2	n/a	Lower 30-Day Mortality
	CABG 30-Day Mortality (%)[b,c]		2.6	3.3	-0.7	n/a	Lower 30-Day Mortality
	AMI 30-Day Readmission (%)[b,c]		15.4	16.8	-1.4	n/a	Fewer 30-Day Readmissions
	HF 30-Day Readmission (%)[b,c]		20.1	21.7	-1.6	n/a	Fewer 30-Day Readmissions
	CABG 30-Day Readmission (%)[b,c]		13.5	14.5	-1.0	n/a	Fewer 30-Day Readmissions
Process Efficiency	AMI Severity-Adjusted ALOS		3.7	4.3	-0.7	-15.5	Shorter ALOS
	HF Severity-Adjusted ALOS		4.5	4.9	-0.4	-8.7	Shorter ALOS
	CABG Severity-Adjusted ALOS		8.6	9.3	-0.7	-7.4	Shorter ALOS
	PCI Severity-Adjusted ALOS		2.9	3.7	-0.8	-20.5	Shorter ALOS
Cost Efficiency	AMI Wage- and Severity-Adjusted Average Cost per Case		$7,637	$9,806	-$2,169	-22.1	Lower Cost per Case
	HF Wage- and Severity-Adjusted Average Cost per Case		$7,614	$8,915	-$1,302	-14.6	Lower Cost per Case
	CABG Wage- and Severity-Adjusted Average Cost per Case		$31,749	$39,236	-$7,487	-19.1	Lower Cost per Case
	PCI Wage- and Severity-Adjusted Average Cost per Case		$13,022	$17,227	-$4,205	-24.4	Lower Cost per Case

a. MEDPAR 2014 and 2015, combined.
b. CMS Hospital Compare July 1, 2012–June 30, 2015.
c. We do not calculate percentage difference for measures already expressed as a percent.

Potential New Measures for Future Studies

Every year, we evaluate the 50 Top Cardiovascular Hospitals study and explore whether new measures would enhance the value of the analysis we provide. For the 2017 study, we continue to test the following new performance measures to update basic standards of inpatient care and expand the balanced scorecard across the continuum of care. If you would like to provide feedback on these proposed measures, please email **100tophospitals@truvenhealth.com**.

30-Day Episode-of-Care Payment Measures for AMI and Heart Failure

Recently, CMS introduced new payment-of-care measures. The risk-standardized, 30-day episode-of-care payment measures for AMI and HF are included here for information only again, for the second time. These values represent the payments made for the care and supplies for AMI and HF patients, beginning with the day of hospital admission through the next 30 days. The data time period for these measures is the same as with the other 30-day measures, a rolling three years, July 1, 2012–June 30, 2015.

Comparing benchmark hospitals and peers on episode payment measures produces mixed results, as shown in Table 5.

- The benchmark median payment for AMI patients was $227 less than the peer median payment.
- Conversely, the peer median payment for HF patients was slightly lower than the benchmark group ($33 less).

Table 5: National Performance Comparisons for Episode Revenue Payments (All Hospitals in Study)

	Performance Measure	Benchmark Median	Peer Median	Benchmark Compared With Peer Group		
				Difference	Percent Difference	How Benchmark Hospitals Outperform Peer Hospitals
Efficiency Measures	Episode Payment for AMI Patients[a]	$22,935	$23,161	-$227	-0.98	Lower Payment per Case
	Episode Payment for HF Patients[a]	$16,505	$16,472	$33	0.20	Higher Payment per Case

a. CMS Hospital Compare July 1, 2012–June 30, 2015.

Trends in Cardiovascular Care

For the first time in our 50 Top Cardiovascular Hospitals study, we are presenting new findings on trends in cardiovascular care delivered in the nation's cardiovascular hospitals. Our intent is to provide healthcare leaders with new insights by showing the direction and magnitude of change in key cardiovascular care performance indicators, between 2011 and 2015.

Performance Improvement Over Time: All Hospitals

By studying the direction of performance change of all hospitals in our study (winners and nonwinners), we can see that in recent years, U.S. hospitals have not been able to significantly improve performance across the entire balanced scorecard. (See Table 6.) However, over the years we studied (2011 through 2015), there were a few noteworthy performance improvements for specific measures (see the green column in Table 6).

- A strong majority of hospitals significantly improved their 30-day readmission rates for AMI and HF (50.5 percent and 39.5 percent, respectively). This is likely a result of the attention these measures are getting in payment systems.
- However, for HF patients, the significant reduction in readmission rates is tempered by a statistically significant increase in 30-day mortality (in 16.2 percent of hospitals), which is currently unexplained (see the red column in Table 6).
- For AMI patient 30-day mortality, the trend shows a statistical improvement in nearly 30 percent of hospitals.
- More than 16 percent (16.5) of hospitals in the study demonstrated a significant improvement in the percentage of CABG patients with IMA graft usage.
- On the operating efficiency front, the vast majority of hospitals had no significant change in severity-adjusted cost per case over the five-year period (74 to 87 percent) for AMI, HF, CABG, and PCI patients.
- For the remainder of the measures, the majority of hospitals in the study had no statistically significant change in performance. (See the yellow column in Table 6.)

Table 6: Direction of Performance Change for All Cardiovascular Hospitals in Study, 2011–2015

Performance Measure		Significantly Improving Performance		No Statistically Significant Change in Performance		Significantly Declining Performance	
		Count of Hospitals[a]	Percentage of Hospitals[b]	Count of Hospitals[a]	Percentage of Hospitals[b]	Count of Hospitals[a]	Percentage of Hospitals[b]
Risk-Adjusted Mortality Index[a]	AMI Mortality	63	6.5%	896	93.1%	3	0.3%
	HF Mortality	75	7.8%	880	91.5%	7	0.7%
	CABG Mortality	24	2.5%	935	97.2%	3	0.3%
	PCI Mortality	26	2.7%	929	96.6%	7	0.7%
Risk-Adjusted Complications Index	CABG Complications	61	6.3%	885	92.0%	16	1.7%
	PCI Complications	51	5.3%	895	93.0%	16	1.7%
CABG Patients With IMA Use		158	16.5%	756	78.8%	46	4.8%
AMI 30-Day Mortality (%)		283	29.4%	644	66.9%	35	3.6%
HF 30-Day Mortality (%)		61	6.3%	745	77.4%	156	16.2%
AMI 30-Day Readmission (%)		486	50.5%	472	49.1%	4	0.4%
HF 30-Day Readmission (%)		380	39.5%	577	60.0%	5	0.5%
AMI Severity-Adjusted ALOS		65	6.8%	874	90.9%	23	2.4%
HF Severity-Adjusted ALOS		55	5.7%	834	86.7%	73	7.6%
CABG Severity-Adjusted ALOS		65	6.8%	865	89.9%	32	3.3%
PCI Severity-Adjusted ALOS		77	8.0%	823	85.6%	62	6.4%
AMI Wage- and Severity-Adjusted Average Cost per Case		54	5.6%	838	87.2%	69	7.2%
HF Wage- and Severity-Adjusted Average Cost per Case		31	3.2%	755	78.7%	173	18.0%
CABG Wage- and Severity-Adjusted Average Cost per Case		39	4.1%	791	82.6%	128	13.4%
PCI Wage- and Severity-Adjusted Average Cost per Case		45	4.7%	706	74.3%	199	20.9%

a. "Count" refers to the number of in-study hospitals whose performance fell into the highlighted category for the measure.
b. "Percentage" is calculated by dividing the count by the total in-study hospitals across all comparison groups.
Note: The total number of hospitals included in the analysis can vary by measure due to exclusion of interquartile range outlier data points, causing some in-study hospitals to have too few remaining data points to calculate a trend.

Methodology

The Truven Health 50 Top Cardiovascular Hospitals study is based on quantitative research that uses a balanced scorecard approach, based on publicly available data, to identify the top cardiovascular hospitals in the U.S. This study focuses on short-term, acute care, nonfederal U.S. hospitals that treat a broad spectrum of cardiology patients. It includes patients requiring medical management, as well as those who receive invasive or surgical procedures. Because multiple measures are used, a hospital must provide all forms of cardiovascular care, including open heart surgery, to be included in the study.

Overview

The main steps used in the selection of the 50 Top Cardiovascular Hospitals study winners are:

1. Building the database of hospitals, including special selection and exclusion criteria
2. Classifying hospitals into comparison groups
3. Scoring hospitals on a set of weighted performance measures
4. Determining the 50 hospitals with the best performance by rankings relative to comparison group

The following section is intended to be an overview of these steps. To request more detailed information on any of the study concepts outlined here, please email us at **100tophospitals@truvenhealth.com** or call **800.525.9083**.

Building the Database of Hospitals

Primary Data Sources

Like all Truven Health 100 Top Hospitals® studies, the 50 Top Cardiovascular Hospitals study uses only publicly available data. The data come from:

- Medicare Provider Analysis and Review (MEDPAR) dataset
- Centers for Medicare & Medicaid Services (CMS) Hospital Compare dataset
- Medicare Cost Reports

We use MEDPAR patient-level record information to calculate mortality, complications, and length of stay (LOS). MEDPAR is also used for patient-level charge data in estimating average cost per case. This dataset contains information on approximately 15 million Medicare patients who are discharged from the nation's acute care hospitals annually. Six years of MEDPAR data are used to develop the study trend database (2010–2015). In this 2017 study, we used the two most recent years of MEDPAR data available — 2014 and 2015 — to identify current performance and to select the winning hospitals. To be included in the study, a hospital must have both years of data available, with valid present-on-admission (POA) coding.

We use Medicare Cost Reports to create our proprietary database, which contains hospital-specific demographic information and hospital-specific, all-payer cost and charge data. The hospital cost-to-charge ratios are applied to MEDPAR patient-level claims data to estimate cost for the study's cost measures. This is done at the cost-center and charge-code levels for each patient record. For this study, we used 2015 (2014 when 2015 was not available) cost report data to determine the cost-to-charge ratios.

The Medicare Cost Report is filed annually by every U.S. hospital that participates in the Medicare program. Hospitals are required to submit cost reports to receive reimbursement from Medicare. It should be noted, however, that cost report data include services for all patients, not just Medicare beneficiaries.

Truven Health and many others in the healthcare industry have used the MEDPAR and Medicare Cost Report databases for many years. We believe they are accurate and reliable sources for the types of analyses performed in this study. Medicare data are highly representative of the cardiovascular patients included in this study. In fact, Medicare inpatients usually represent about two-thirds of all patients undergoing medical treatment for acute myocardial infarction (AMI) or experiencing heart failure (HF), and about half of all patients undergoing percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG).

Furthermore, many previous academic and economic studies of healthcare in the U.S. have been based on the assumption that Medicare data are representative of the all-payer activity at hospitals.

We used the CMS Hospital Compare dataset published in the second quarter of 2016 for 30-day mortality and 30-day readmission rate performance measures. CMS publishes these rates as three-year combined data values. Five data points are used to develop the study trend database. We label these data points based on the end date of each dataset. For example, July 1, 2012–June 30, 2015 is named "2015." We used the 2015 data to identify current performance and to select the winning hospitals.

We reference residency and fellowship program information from both the Accreditation Council for Graduate Medical Education (ACGME) and the American Osteopathic Association (AOA) to classify teaching hospitals. Participation in a cardiovascular fellowship program is identified and confirmed using the sources listed below.

- Electronic Residency Application Services (ERAS) — a program of the Association of American Medical Colleges (AAMC)
- ACGME website

- AOA Graduate Medical Education (OGME) website
- Medical college websites
- Hospital websites

Present-on-Admission Data

The Truven Health risk-adjustment models for mortality and complications, and severity-adjustment models for LOS and cost per case include POA data reported in the MEDPAR datasets. Under the Deficit Reduction Act of 2005, as of federal fiscal year 2008, hospitals receive a reduced payment for cases with certain conditions — such as falls, surgical-site infections, and pressure ulcers — that were not present on the patient's admission but occurred during hospitalization. As a result, CMS now requires all Inpatient Prospective Payment System hospitals to document whether a patient has these conditions when admitted.[5]

POA Coding Adjustments

From 2010 through 2015, we have observed a significant rise in the number of principal diagnosis (PDX) and secondary diagnosis (SDX) codes that do not have a valid POA indicator code in the MEDPAR data files. Since 2011, an invalid code of "0" is appearing. This phenomenon has led to an artificial rise in the number of conditions that appear to be occurring during the hospital stay. See the Appendix for details.

To correct for this bias, we adjusted MEDPAR record processing through our mortality and complications risk models, and LOS and cost-per-case severity-adjustment models, as follows:

- We treated all diagnosis codes on the CMS exempt list as "exempt," regardless of POA coding.
- We treated all principal diagnoses as present on admission.
- We treated secondary diagnoses where POA indicator codes "Y" or "W" appeared more than 50 percent of the time in the Truven Health all-payer database as present on admission.

Hospitals and Patient Groups Included

The focus of the study is on hospitals that offer both medical and surgical treatment options for patients with two of the most common cardiovascular conditions — AMI and HF. To build such a database, we included all hospitals that had, in the 2014 and 2015 data years combined, at least 30 unique cases[6] in each of the groups described below.

1. AMI patients in MS-DRGs 280–285 with the following ICD-9-CM codes as primary diagnosis only:
   410.01 Acute myocardial infarction of anterolateral wall, initial episode of care
   410.11 Acute myocardial infarction of other anterior wall, initial episode of care
   410.21 Acute myocardial infarction of inferolateral wall, initial episode of care
   410.31 Acute myocardial infarction of inferoposterior wall, initial episode of care
   410.41 Acute myocardial infarction of other inferior wall, initial episode of care
   410.51 Acute myocardial infarction of other lateral wall, initial episode of care
   410.61 Acute myocardial infarction, true posterior wall infarction, initial episode of care
   410.71 Acute myocardial infarction, subendocardial infarction, initial episode of care
   410.81 Acute myocardial infarction of other specified sites initial episode of care
   410.91 Acute myocardial infarction, unspecified site, initial episode of care
   The AMI group was restricted to nonsurgical patients.

The Effect of POA Data on Risk- and Severity-Adjustment

Since 2008, CMS regulations have required all Inpatient Prospective Payment System hospitals to document whether a patient has certain conditions when admitted; these are coded as Present on Admission (POA). Our complication rate methodology uses this POA data. Consequently, the complication rates exclude "false-positive" complications and are more accurate. In addition, our mortality, complications, LOS, and cost-per-case risk- and severity-adjustment models develop expected values based only on conditions that were present on admission.

2. HF patients in MS-DRGs 291–293 with the following ICD-9-CM code as primary diagnosis only:
   398.91 Rheumatic heart failure
   402.01 Malignant hypertensive heart disease
   402.11 Benign hypertensive heart disease
   402.91 Unspecified hypertensive heart disease
   404.01 Malignant hypertensive heart and renal disease
   404.03 Malignant hypertensive heart and renal disease with renal failure
   404.11 Benign hypertensive heart and renal disease
   404.13 Benign hypertensive heart and renal disease with renal failure
   404.91 Unspecified hypertensive heart and renal disease
   404.93 Unspecified hypertensive heart and renal disease with renal failure
   428.0 Unspecified congestive heart failure
   428.1 Left heart failure
   428.20 Unspecified systolic heart failure
   428.21 Acute systolic heart failure
   428.22 Chronic systolic heart failure
   428.23 Acute on chronic systolic heart failure
   428.30 Unspecified diastolic heart failure
   428.31 Acute diastolic heart failure
   428.32 Chronic diastolic heart failure
   428.33 Acute on chronic diastolic heart failure
   428.40 Unspecified combined systolic and diastolic heart failure
   428.41 Acute combined systolic and diastolic heart failure
   428.42 Chronic combined systolic and diastolic heart failure
   428.43 Acute on chronic combined
   428.9 Unspecified heart failure
   The HF category was restricted to nonsurgical patients.

3. PCI patients in MS-DRGs 246−251 with any of the following ICD-9-CM procedure codes:
   00.66 PTCA (percutaneous transluminal coronary angioplasty)
   36.06 Insertion of coronary artery stent(s)
   36.07 Insertion of drug-eluting coronary artery stent(s)
   17.55 Transluminal coronary athrectomy
   Patients with the 36.06 or 36.07 codes were excluded if they also had the procedure code 36.03 (open chest coronary artery angioplasty).

4. CABG patients in MS-DRGs 231–236 with any (primary or secondary) of the following ICD-9-CM procedure codes:
   36.10 Aortocoronary bypass, unspecified number of arteries
   36.11 Aortocoronary bypass, one coronary artery
   36.12 Aortocoronary bypass, two coronary arteries
   36.13 Aortocoronary bypass, three coronary arteries

36.14 Aortocoronary bypass, four or more coronary arteries
36.15 Single internal mammary-coronary artery bypass
36.16 Double internal mammary-coronary artery bypass
36.17 Abdominal-coronary artery bypass
36.19 Other bypass anastomosis for heart revascularization

When a patient record had both PCI and CABG procedures, we placed them in the CABG group for all performance measures.

Patient Records Excluded

The AMI and HF groups explicitly excluded patients who also had a PCI and/or CABG procedure. This ensures we have exclusively medical patients in these groups.

Also excluded are:

- Patients who were discharged to another short-term facility (to avoid double-counting)
- Patients who were not at least 65 years old

Hospitals Excluded

After building the database of cardiovascular hospitals, we excluded a number of hospitals that would have skewed the study results. Excluded from the study were:

- Hospitals with fewer than 30 unique patient records in each patient group (AMI, HF, CABG, and PCI) for the two most current MEDPAR years combined
- Specialty hospitals, other than cardiac hospitals (e.g., critical access hospitals, children's, women's, psychiatric, substance abuse, rehabilitation, and long-term acute care hospitals)
- Hospitals with fewer than 25 acute care beds
- Federally owned hospitals
- Non-continental U.S. hospitals (such as those in Puerto Rico, Guam, and the Virgin Islands)
- Hospitals with Medicare average LOS (ALOS) longer than 30 days
- Hospitals with no reported deaths
- Hospitals that do not have both 2014 and 2015 Medicare claims
- Hospitals missing data for calculation of one or more performance measures
- Hospitals for which a Medicare Cost Report was not available for 2015 or 2014
- Hospitals that did not code POA information on their 2014 and 2015 MEDPAR data

Classifying Hospitals Into Comparison Groups

Bed size, teaching status, and residency/fellowship program involvement have a profound effect on the types of patients a hospital treats and the scope of services it provides. When analyzing the performance of an individual hospital, it is crucial to evaluate it against other similar hospitals. To address this, we assigned each hospital to one of three comparison groups according to its teaching and residency program status.

Our formula for defining the cardiovascular hospital comparison groups includes each hospital's bed size, residents-to-beds ratio, and involvement in graduate medical education (GME) programs accredited by either the ACGME[7] or the AOA.[8] We define the groups as follows.

Teaching Hospitals With Cardiovascular Residency Programs

Hospitals in this category must be involved in a cardiovascular residency program accredited by the ACGME or the AOA. Cardiovascular residency programs include any of the following:

- Cardiology
- Cardiovascular disease
- Cardiovascular medicine
- Cardiothoracic surgery
- Interventional cardiology
- Clinical cardiac electrophysiology
- Thoracic surgery
- Thoracic surgery — integrated
- Advanced heart failure and transplant cardiology

Cardiovascular radiology residency programs are not included.

Participation in a fellowship program is identified and confirmed using the following sources:

- ERAS (AAMC program)
- ACGME website
- OGME website
- Medical college websites
- Hospital websites

Teaching Hospitals Without Cardiovascular Residency Programs

Hospitals in this category have no involvement in a cardiovascular residency program. These hospitals must meet any two of the following three criteria:

1. 200 or more acute care beds in service
2. An intern/resident-per-bed ratio of at least 0.03
3. Involvement in at least three accredited GME programs overall*

Community Hospitals

These hospitals must meet both of the following criteria:

1. 25 or more acute care beds in service
2. Not classified as a teaching hospital per definitions above

Bed size and number of interns/residents (full-time equivalents) were taken from each hospital's Medicare Cost Report for 2015 or 2014 (the most current year available).

Cardiovascular Study Groups

The final study group counts, after exclusions, are listed below.

Comparison Group	Total
Teaching Hospitals With Cardiovascular Residency Programs	229
Teaching Hospitals Without Cardiovascular Residency Programs	306
Community Hospitals	477
Total In-Study Hospitals	1,012

* As of 2015, detailed residency program files are no longer available for purchase from the American Medical Association. We used the residency counts from 2014 in this study. We are researching alternative ways to classify teaching hospitals for future studies.

Scoring Hospitals on Weighted Performance Measures

Evolution of Performance Measures

We use a balanced scorecard approach, based on public data, to select the measures most useful for hospital boards and CEOs in the current operating environment. We gather feedback from industry leaders, hospital executives, academic leaders, and internal experts; review trends in the healthcare market; and survey hospitals in demanding marketplaces to learn what measures are valid and reflective of top performance. As the market has changed, our methods have evolved.

Note: The AMI, HF, and Surgical Care Improvement Project (SCIP) cardiac core measures included in the 50 Top Cardiovascular Hospitals study in the past have been retired by CMS and are no longer are included in the study.

The measures used in this year's study, along with their data sources, are outlined below.

	Ranked Performance Metric	Current Profile Data Sources	Trend Profile Data Sources
Clinical Outcomes	1. Risk-Adjusted Mortality (AMI, HF, CABG, PCI)	MEDPAR Federal Fiscal Year (FFY) 2014 and 2015	MEDPAR FFY 2010–2015*
	2. Risk-Adjusted Complications (CABG, PCI)	MEDPAR FFY 2014 and 2015	Same data periods as inpatient mortality
Clinical Process	3. Percentage of CABG Patients With Internal Mammary Artery (IMA) Use	MEDPAR FFY 2014 and 2015	MEDPAR FFY 2010–2015
Extended Outcomes	4. 30-Day Mortality Rates (AMI, HF, CABG**)	CMS Hospital Compare July 1, 2012–June 30, 2015	CMS Hospital Compare three-year datasets ending June 30 of the following years: 2011, 2012, 2013, 2014, 2015
	5. 30-Day Readmission Rates (AMI, HF, CABG**)	CMS Hospital Compare July 1, 2012–June 30, 2015	Same data periods as 30-day mortality
Process Efficiency	6. Severity-Adjusted ALOS (AMI, HF, CABG, PCI)	MEDPAR FFY 2015	MEDPAR FFY 2011–2015
Cost Efficiency	7. Wage- and Severity-Adjusted Average Cost per Case (AMI, HF, CABG, PCI)	MEDPAR FFY 2015	MEDPAR FFY 2011–2015

* Two years of MEDPAR data are combined for each study year, as follows: 2010–2011, 2011–2012, 2012–2013, 2013–2014, 2014–2015.
** CABG 30-day rates are not yet available for trending; insufficient data points.

Below, we provide rationale for the selection of our balanced scorecard domains and the measures used for each.

Clinical Excellence

Clinical excellence can be measured by looking at several key domains: outcomes, process, and extended outcomes.

Our clinical outcome measures are the risk-adjusted mortality indexes for all included cardiovascular patient groups (AMI, HF, CABG, and PCI) and risk-adjusted complications indexes for CABG and PCI patient groups. These mortality and complications measures show us how the provider is performing on the most basic and essential care standards — patient survival and error-free care — while treating patients in the facility. Our study incorporates a comprehensive, risk-adjusted complications model that includes 47 possible patient complications with expected probabilities calculated from the Truven Health national inpatient database. For more information, see the measures details in the table on the following page and read about our mortality and complications models in the Appendix.

The cardiovascular core measures have been retired by CMS, so the remaining clinical process measure included in this study is the percentage of CABG patients with internal mammary artery (IMA) use. The clinical advantages of using an internal mammary graft are many and have been spelled out in numerous studies over several decades.[9–18]

The study's extended outcomes domain includes 30-day mortality rates and 30-day readmission rates for AMI, HF, and CABG patients. These measures help us understand how the hospital's patients are faring over a longer period of time and help flag issues with discharge appropriateness, effectiveness of follow-up care coordination, and availability of appropriate post-acute care. Hospitals with lower values appear to be providing care with better medium-term results for these conditions.

Service Delivery Efficiency

We use severity-adjusted ALOS and wage- and severity-adjusted cost per case as our measures of service delivery efficiency. For the life of the study, severity-adjusted ALOS has served as a proxy for clinical efficiency, and cost per case has served as a measure of both clinical and operating efficiency. Cost per case provides insight into how cost-effectively a hospital is caring for its patients. Wage and severity adjustments consider patient acuity and labor market cost differences, and help ensure that we are making fair comparisons among hospitals.

Risk-Adjusted Mortality Index (Inpatient)

Why We Include This Element	Calculation	Comments	Favorable Values Are
Patient survival is a universally accepted measure of hospital quality. The lower the mortality index, the greater the survival of the patients in the hospital, considering what would be expected based on patient characteristics. While all hospitals have patient deaths, this measure can show where deaths occurred but were not expected, or the reverse, given the patient's condition.	The Risk-Adjusted Inpatient Mortality Index is the number of actual deaths occurring in the hospital divided by the number of normalized expected deaths, given the risk of death for each patient. Expected deaths are based on our statistical model for predicting the likelihood of a patient's death based on age, sex, presence of complicating diagnoses (POA only), and other characteristics. Palliative care patients (v66.7) are included in the risk model. "Do not resuscitate" (DNR) patients (v49.86) are excluded at this time. Separate index values are calculated for each patient group: AMI, HF, CABG, and PCI. We normalize each index based on the ratio of observed to expected deaths for each patient group, by comparison group (cardio teaching, teaching, community hospital). The reference value for this index is 1.00; a value of 1.15 indicates 15 percent more events than predicted, and a value of 0.85 indicates 15 percent fewer.	We base the scoring for each patient group (AMI, HF, CABG, and PCI) on the difference between observed and expected deaths, expressed in normalized standard deviation units (z-score). Hospitals with the fewest deaths, relative to the number expected, after accounting for standard binomial variability, receive the most favorable scores. We use two years of MEDPAR data (2014 and 2015) to reduce the influence of chance variation. The MEDPAR dataset includes both Medicare Fee-for-Service claims and Medicare Advantage (HMO) encounter records. Hospitals with observed values statistically worse than expected (99-percent confidence), and whose values are above the high trim point, are not eligible to be named benchmark hospitals.	Lower

Risk-Adjusted Complications Index			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
Keeping patients free from potentially avoidable complications is an important goal for all healthcare providers. A lower complications index indicates fewer patients with complications, considering what would be expected based on patient characteristics. Like the mortality index, this measure can show where complications occurred but were not expected, or the reverse, given the patient's condition.	The Risk-Adjusted Complications Index is the number of actual complications occurring in the hospital divided by the number of normalized expected complications, given the risk of complications for each patient. Observed complications are those that are coded as not present on admission. Expected complications are based on our statistical model for predicting the likelihood of a patient experiencing a complication while in the hospital, based on age, sex, presence of complicating diagnoses (POA only), and other characteristics. Separate index values are calculated for each pateint group: AMI, HF, CABG, and PCI. We normalize each index based on the ratio of observed to expected complications for each patient group, by comparison group (cardio teaching, teaching, community hospital). The reference value for this index is 1.00; a value of 1.15 indicates 15 percent more events than predicted, and a value of 0.85 indicates 15 percent fewer.	We base the scoring for each patient group (AMI, HF, CABG, and PCI) on the difference between observed and expected complications, expressed in normalized standard deviation units (z-score). Hospitals with the fewest complications, relative to the number expected, after accounting for standard binomial variability, receive the most favorable scores. We use two years of MEDPAR data (2014 and 2015) to reduce the influence of chance variation. The MEDPAR dataset includes both Medicare Fee-for-Service claims and Medicare Advantage (HMO) encounter records. Hospitals with observed values statistically worse than expected (99-percent confidence), and whose values are above the high trim point, are not eligible to be named benchmark hospitals.	Lower

Percentage of CABG Patients With Internal Mammary Artery (IMA) Use			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
The clinical advantages of using an IMA graft are many. Studies over decades have confirmed the benefits of IMA grafts over saphenous (leg) vein grafts, with a higher patency rate being the most significant clinical benefit.[9–18] On a patient-specific basis, certain factors may promote or prohibit the use of an internal mammary graft. However, it is reasonable to use the overall rate at which these grafts are performed as a measure of hospital quality.	We calculate the percentage of CABG patients with IMA use by dividing the number of CABG surgeries using IMAs by the total number of CABG surgeries and multiplying by 100. Patients with prior CABG surgeries are excluded from the denominator.	We use two years of MEDPAR data (2014 and 2015) to reduce the influence of chance fluctuation.	Higher

30-Day Mortality Rates for AMI, HF, and CABG Patients			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
30-day mortality rates are an accepted measure of the effectiveness of overall hospital care. They allow us to look beyond immediate patient outcomes and understand how the care the hospital provided to inpatients with these particular conditions may have contributed to their longer-term survival. Because these measures are part of the CMS value-based purchasing program, they are being watched closely in the industry. In addition, tracking these measures may help hospitals identify patients at risk for post-discharge problems and target improvements in discharge planning and after-care processes. Hospitals that score well may be better prepared for risk-based population health payment systems.	CMS calculates a 30-day mortality rate for each patient condition using three years of MEDPAR data combined. CMS does not calculate rates for hospitals where the number of cases is too small (less than 25). The rates are presented as percentages. We use the rates as reported by CMS, without alteration. A 10-percent 30-day mortality rate indicates that 10 percent of patients died, of any cause, within 30 days of the original admission date.	Data are from the CMS Hospital Compare dataset for the second quarter of 2016. This contains data from July 1, 2012, through June 30, 2015.[19] The CMS Hospital Compare data for 30-day mortality is based on Medicare Fee-for-Service claims only.	Lower

30-Day Readmission Rates for AMI, HF, and CABG Patients			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
30-day readmissions are an accepted measure of the effectiveness of overall hospital care. They allow us to understand how the care the hospital provided to inpatients with these particular conditions may have contributed to issues with their post-discharge medical stability and recovery. These measures are now being watched closely in the industry. Tracking these measures may help hospitals identify patients at risk for post-discharge problems if discharged too soon, as well as target improvements in discharge planning and after-care processes. Hospitals that score well may be better prepared for a pay-for-performance structure.	CMS calculates a 30-day readmission rate for each patient condition using three years of MEDPAR data combined. CMS does not calculate rates for hospitals where the number of cases is too small (less than 25). The rates are presented as percentages. We use the rates as reported by CMS, without alteration. A 20-percent 30-day readmission rate would indicate that 20 percent of patients were readmitted to an acute care hospital within 30 days of discharge.	Data are from the CMS Hospital Compare dataset for the second quarter of 2016. This contains data from July 1, 2012, through June 30, 2015.[19] The CMS Hospital Compare data for 30-day mortality is based on Medicare Fee-for-Service claims only.	Lower

Severity-Adjusted Average Length of Stay (ALOS)			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
A lower severity-adjusted ALOS (average number of days spent by a patient in a hospital) generally indicates a more efficient consumption of hospital resources and reduced risk to patients.	We calculate an LOS index value for each patient group (AMI, HF, CABG, and PCI) based on the sum of the observed patient LOS divided by the sum of the normalized expected LOS. Expected LOS adjusts for differences in severity of illness among patients using a linear regression model. Conditions that are present on admission (POA) are taken into account when determining expected LOS. We normalize the expected values based on the ratio of observed to expected LOS for each patient group (AMI, HF, CABG, and PCI) by hospital comparison group. Each patient group LOS index is converted into an average LOS in days by multiplying it by the grand mean LOS of the group's in-study patient population, without regard to hospital comparison group.	Data for this measure are from 2015 MEDPAR only. The MEDPAR dataset includes both Medicare Fee-for-Service claims and Medicare Advantage (HMO) encounter records.	Lower

Wage- and Severity-Adjusted Cost per Case			
Why We Include This Element	**Calculation**	**Comments**	**Favorable Values Are**
The cost-per-case measure helps to determine how cost-effectively a hospital is caring for its patients. Ideally, best value is achieved when patients receive high-quality care, with good outcomes, at the lowest cost. Hospitals that score well may be better prepared for risk-based population health payment systems.	We calculate a cost index value for each patient group (AMI, HF, CABG, and PCI) based on the sum of the patient-level observed cost divided by the sum of the normalized expected cost. We estimate the observed cost by applying the hospital cost-to-charge ratios for each cost center, as reported in the hospital cost report (most current available), to the MEDPAR patient-level charges by revenue code. Expected cost adjusts for differences in severity of illness using a linear regression model. Conditions that are present on admission are taken into account when determining expected cost. Expected cost is area wage index-adjusted. We normalize the expected values based on the ratio of observed to expected cost per case for each patient group, by hospital comparison group. Each patient group cost index is converted into an average cost per case expressed in dollars by multiplying it by the grand mean cost per case of the group's in-study patient population, without regard to hospital comparison group.	Charge data for this measure are from 2015 MEDPAR claims only. Cost-to-charge ratios are from the hospital's 2015 Medicare Cost Report (2014 cost reports are used when 2015 are not available). The MEDPAR dataset includes both Medicare Fee-for-Service claims and Medicare Advantage (HMO) encounter records.	Lower

For more information on methodologies, see the Appendix.

Determining the 50 Top Cardiovascular Hospitals

Ranking

Within each of the three hospital comparison groups, we ranked hospitals based on their performance on each of the measures independently, relative to other hospitals in their groups. Each performance measure is assigned a weight for use in overall ranking. The weights for each measure are indicated in the table below.

Each hospital's measure ranks were summed to arrive at a total score for the hospital. The hospitals were then ranked based on their total scores, and the hospitals with the best overall ranks in each comparison group were selected as the benchmark hospitals (winning hospitals).

Only current profile rank performance is used for the selection of benchmark award-winning hospitals. Trend performance is ranked for information only.

Ranked Performance Metric	Patient Group	Current Profile Weight (50 Top Award Selection)	Trend Profile Weight
Risk-Adjusted Inpatient Mortality (Normalized Z-Score)	AMI	1/2	1/2
	HF	1/2	1/2
	CABG	1/2	1/2
	PCI	1/2	1/2
Risk-Adjusted Complications (Normalized Z-Score)	CABG	1/4	1/4
	PCI	1/4	1/4
CABG Patient With IMA Use (%)		1/2	1/2
30-Day Mortality Rates (%)	AMI	1/6	1/4
	HF	1/6	1/4
	CABG	1/6	*
30-Day Readmission Rates (%)	AMI	1/6	1/4
	HF	1/6	1/4
	CABG	1/6	*
Severity-Adjusted ALOS (days)	AMI	1/4	1/4
	HF	1/4	1/4
	CABG	1/4	1/4
	PCI	1/4	1/4
Wage- and Severity-Adjusted Cost per Case ($)	AMI	1/4	1/4
	HF	1/4	1/4
	CABG	1/4	1/4
	PCI	1/4	1/4

* CABG does not have sufficient data to trend.
Note: Mortality and complications normalized z-scores are converted to indexes for reporting. We convert LOS and cost-per-case indexes to ALOS and average cost per case, respectively, for reporting. For more details, see the performance measures tables on the preceding pages.

Screening for Outliers

To reduce the impact of unsustainable performance anomalies, and reporting anomalies or errors, hospitals with one or more mortality or complications index values that were high statistical outliers (99-percent confidence) were not eligible to be winners.

Also, hospitals with costs per case for any patient group that were high or low statistical outliers (using interquartile range [IQR]-trimming methodology) were not eligible to be winners. In addition, any hospital that had less than 11 cases in any one of the four patient groups (AMI, HF, PCI, and CABG) in the most current data year (2015) was not eligible to be a winner.

The number of hospitals selected to receive the 50 Top Cardiovascular Hospitals award in each hospital comparison group was as follows:

Comparison Group	Total
Teaching Hospitals With Cardiovascular Residency Program	15
Teaching Hospitals Without Cardiovascular Residency Program	20
Community Hospitals	15
Total	50

Appendix: Methodology Details

Normative Database Development

For the 50 Top Cardiovascular Hospitals study, Truven Health constructed a normative database of case-level data from its Projected Inpatient Database (PIDB). The PIDB is one of the largest U.S. inpatient, all-payer databases of its kind, containing more than 23 million all-payer discharges annually. These data are obtained from approximately 5,000 hospitals, representing over 65 percent of all discharges from short-term, general, nonfederal hospitals in the U.S. (PIDB discharges are statistically weighted to represent the universe of all short-term, general, nonfederal hospitals in the U.S.) Demographic and clinical data are also included: age, sex, and length of stay (LOS); clinical groupings (MS-DRGs), ICD-9-CM principal and secondary diagnoses and procedures; present-on-admission (POA) coding; admission source and type; and discharge status. ICD-10-CM data are now being integrated into the database, as well.

The Truven Health proprietary risk-adjustment models for inpatient mortality and complications, and the severity-adjustment models for LOS and cost per case, have been recalibrated for this release using federal fiscal year (FFY) 2013 data available in the Truven Health PIDB.

PCI Group Definition

While most patients undergoing an inpatient percutaneous coronary intervention (PCI) are grouped into one of the PCI-related MS-DRGs, a few are grouped into other MS-DRGs. Patients may be grouped into another MS-DRG if they have a cardiac procedure considered to be higher in the DRG surgical hierarchy than PCI, or if they have a principal diagnosis that is not cardiac in nature.

The approximately 12 percent of Medicare 2015 PCI patients grouped to other MS-DRGs tend to have longer LOS, higher costs, and more complications than those in PCI MS-DRGs, likely because many of them have more complex surgeries during the same hospitalization. We have confined PCI patients to those patients in a PCI-related MS-DRG for this study.

Present-on-Admission Data

Under the Deficit Reduction Act of 2005, as of FFY 2008, hospitals receive reduced payments for cases with certain conditions — such as falls, surgical site infections, and pressure ulcers — that were not present on the patient's admission, but occurred during hospitalization. As a result, the Centers for Medicare & Medicaid Services (CMS) now requires all Inpatient Prospective Payment System hospitals to document whether a patient has these conditions when they are admitted. The Truven Health proprietary risk-adjustment models and severity-adjustment models take into account POA data reported in the Medicare Provider Analysis and Review (MEDPAR) datasets. Our mortality, complications, LOS, and cost-per-case models develop expected values based only on conditions that are present on admission.

From 2010 through 2015, there have been a growing number of records with an invalid POA indicator code of "0" in the MEDPAR data files. (See table below.) In addition, coding of exempt diagnoses with the POA code of "1" has apparently been dropped by hospitals. For this reason, we used the CMS exempt code tables to identify and flag all exempt diagnoses. We also developed a methodology to determine whether a diagnosis was usually coded as present (Y, W) for all records with valid POA coding in the PIDB. Based on this analysis, we treated codes that were found to be present greater than 50 percent of the time as "present" in the MEDPAR file where "0" was coded. In addition, we treated all principal diagnoses as "present."

Percentage of Diagnosis Codes With POA Indicator Code of "0" by MEDPAR Year

	2010	2011	2012	2013	2014	2015
Principal Diagnosis	0.00%	4.26%	4.68%	4.37%	3.40%	4.99%
Secondary Diagnosis	0.00%	15.05%	19.74%	22.10%	21.58%	23.36%

Methods for Identifying Patient Severity

Without adjusting for differences in patient severity, comparing outcomes among hospitals does not present an accurate picture of performance. To make valid normative comparisons of hospital outcomes, we must adjust raw data to accommodate differences that result from the variety and severity of admitted cases.

Truven Health is able to make valid normative comparisons of mortality and complications rates by using patient-level data to control effectively for case-mix and severity differences. Conceptually, we group patients with similar characteristics (e.g., age, sex, principal diagnosis, procedures performed, admission type, and comorbid conditions that are present on admission) to produce expected, or normative, comparisons. Through extensive testing, we have found that this methodology produces valid normative comparisons using readily available administrative data, eliminating the need for additional data collection.[20]

To support the transition from ICD-9-CM to ICD-10-CM, our risk- and severity-adjustment models have been modified to leverage the Agency for Healthcare Research and Quality (AHRQ) Clinical Classifications System (CCS)[21] categories for risk assignment. CCS categories are defined in both coding languages with the intent of being able to accurately compare ICD-9 categories with ICD-10 categories. Calibrating the models using CCS categories provides the flexibility to accept and score records from either ICD-9 or ICD-10 coded data and allows for consistent results in risk and severity adjustment. The CCS-based approach applies to all Truven Health proprietary models that use code-based rate tables, which include the risk-adjusted mortality index model, expected complication risk index, and patient financial data/expected resource demand LOS and cost models.

Risk-Adjusted Mortality Index Models

Truven Health has developed an overall mortality risk model, which is used for patients in the cardiovascular study. The mortality risk model used in this study is calibrated for patients age 65 and older. Additionally, in response to the upcoming transition to ICD-10-CM, diagnosis and procedure codes (and the interactions among them) have been mapped to the AHRQ CCS for assignment of risk instead of using the individual diagnosis, procedure, and interaction effects.

We exclude patients who were transferred to another short-term, acute care facility. We also exclude all records that have Do Not Resuscitate (DNR) (v49.86) coded as POA from the mortality risk models. Excluding records that are DNR status at admission removes these high-probability-of-death patients from the analysis and allows hospitals to concentrate more fully on events that could lead to deaths during the hospitalization. Palliative Care (v66.7) patients are included in the mortality risk models, which are calibrated to determine probability of death for these patients.

A standard logistic regression model is used to estimate the risk of mortality for each eligible discharge. This is done by weighting the patient records of the profiled hospital by the logistic regression coefficients associated with the corresponding terms in the model and the intercept term. This produces the expected probability of an outcome for each eligible patient (numerator) based on the experience of the norm for patients with similar characteristics (age, clinical grouping, severity of illness, and so forth).[22–26]

After assigning the predicted probability of the outcome for each patient, the patient-level data can then be aggregated across a variety of groupings, including system, hospital, clinical service line, or the MS-DRG classification systems, which were originally developed at Yale University in the 1980s.

This model takes into account only patient conditions that are present on admission when calculating risk.

Expected Complications Rate Index Models

Risk-adjusted complications refer to outcomes that may be of concern when they occur at a greater-than-expected rate among groups of patients, possibly reflecting systemic quality-of-care issues. The Truven Health complications model uses clinical qualifiers to identify complications that have probably occurred in the inpatient setting. Only conditions that are not coded as POA are counted as observed complications. Additionally, in response to the upcoming transition to ICD-10-CM, diagnosis and procedure codes (and the interactions among them) have been mapped to the AHRQ CCS for assignment of risk instead of using the individual diagnosis, procedure, and interaction effects.

Hospice Versus Palliative Care Patients

Separately licensed hospice unit patient records are not included in MEDPAR data. They have a separate billing type and separate provider numbers. In addition, patients receiving hospice treatment in acute care beds are billed under hospice, not hospital, and would not be in the MEDPAR data file.

Inpatients coded as Palliative Care (v66.7) are included in the study. Over the past few years, the number of patients coded as Palliative Care has increased significantly, and our risk models have been calibrated to produce valid expected values for these patients.

The complications used in the model are:

Complication	Patient Group
Postoperative complications relating to urinary tract	Surgical only
Postoperative complications relating to respiratory system except pneumonia	Surgical only
Gastrointestinal (GI) complications following procedure	Surgical only
Infection following injection/infusion	All patients
Decubitus ulcer	All patients
Postoperative septicemia, abscess, and wound infection	Surgical, including cardiac
Aspiration pneumonia	Surgical only
Tracheostomy complications	All patients
Complications of cardiac devices	Surgical, including cardiac
Complications of vascular and hemodialysis devices	Surgical only
Nervous system complications from devices/complications of nervous system devices	Surgical only
Complications of genitourinary devices	Surgical only
Complications of orthopedic devices	Surgical only
Complications of other and unspecified devices, implants, and grafts	Surgical only
Other surgical complications	Surgical, including cardiac
Miscellaneous complications	All patients
Cardio-respiratory arrest, shock, or failure	Surgical only
Postoperative complications relating to nervous system	Surgical only
Postoperative acute myocardial infarction (AMI)	Surgical only
Postoperative cardiac abnormalities except AMI	Surgical only
Procedure-related perforation or laceration	All patients
Postoperative physiologic and metabolic derangements	Surgical, including cardiac
Postoperative coma or stupor	Surgical, including cardiac
Postoperative pneumonia	Surgical, including cardiac
Pulmonary embolism	All patients
Venous thrombosis	All patients
Hemorrhage, hematoma, or seroma complicating a procedure	All patients
Postprocedure complications of other body systems	All patients
Complications of transplanted organ (excludes skin and cornea)	Surgical only
Disruption of operative wound	Surgical only
Complications relating to anesthetic agents and central nervous system (CNS) depressants	Surgical, including cardiac
Complications relating to antibiotics	All patients
Complications relating to other anti-infective drugs	All patients
Complications relating to antineoplastic and immunosuppressive drugs	All patients
Complications relating to anticoagulants and drugs affecting clotting factors	All patients
Complications relating to blood products	All patients
Complications relating to narcotics and related analgesics	All patients
Complications relating to non-narcotic analgesics	All patients
Complications relating to anticonvulsants and antiparkinsonism drugs	All patients
Complications relating to sedatives and hypnotics	All patients
Complications relating to psychotropic agents	All patients
Complications relating to CNS stimulants and drugs affecting the autonomic nervous system	All patients
Complications relating to drugs affecting cardiac rhythm regulation	All patients
Complications relating to cardiotonic glycosides (digoxin) and drugs of similar action	All patients
Complications relating to other drugs affecting the cardiovascular system	All patients
Complications relating to antiasthmatic drugs	All patients
Complications relating to other medications (includes hormones, insulin, iron, and oxytocic agents)	All patients

Complication rates are calculated from normative data for two patient risk groups: medical and surgical. A standard regression model is used to estimate the risk of experiencing a complication for each eligible discharge. This is done by weighting the patient records of the client hospital by the regression coefficients associated with the corresponding terms in the prediction models and intercept term. This method produces the expected probability of a complication for each patient based on the experience of the norm for patients with similar characteristics. After assigning the predicted probability of a complication for each patient in each risk group, it is then possible to aggregate the patient-level data across a variety of groupings.[27–30]

This model takes into account only patient conditions that are present on admission when calculating risk.

Index Interpretation

An outcome index is a ratio of an observed number of outcomes to an expected number of outcomes in a particular population. This index is used to make normative comparisons and is standardized in that the expected number of events is based on the occurrence of the event in a normative population. The normative population used to calculate expected numbers of events is selected to be similar to the comparison population with respect to relevant characteristics, including age, sex, region, and case mix.

The index is simply the number of observed events divided by the number of expected events and can be calculated for outcomes that involve counts of occurrences (e.g., deaths or complications). Interpretation of the index relates the experience of the comparison population relative to a specified event to the expected experience based on the normative population

Examples:

10 events observed ÷ 10 events expected = 1.0: The observed number of events is equal to the expected number of events based on the normative experience.

10 events observed ÷ 5 events expected = 2.0: The observed number of events is twice the expected number of events based on the normative experience.

10 events observed ÷ 25 events expected = 0.4: The observed number of events is 60 percent lower than the expected number of events based on the normative experience.

Therefore, an index value of 1.0 indicates no difference between observed and expected outcome occurrence. An index value greater than 1.0 indicates an excess in the observed number of events relative to the expected based on the normative experience. An index value less than 1.0 indicates fewer events observed than would be expected based on the normative experience. An additional interpretation is that the difference between 1.0 and the index is the percentage difference in the number of events relative to the norm. In other words, an index of 1.05 indicates 5 percent more outcomes than expected, and an index of 0.90 indicates 10 percent fewer outcomes than expected based on the experience of the norm. The index can be calculated across a variety of groupings (e.g., system, hospital, clinical service line, and MS-DRG).

Percentage of CABG Patients With Internal Mammary Artery Use

We include only patients with an isolated coronary artery bypass graft (CABG) procedure in the denominator. In addition, patients with a prior CABG procedure are excluded. The excluded cases are those coded with a DX of 41402, 41403, 41404, 41405, 99603, or V4581 (any mention).

Length-of-Stay and Cost-per-Case Methodologies

The study's LOS and cost-per-case performance measures use Truven Health severity-adjusted resource-demand methodologies. In response to the upcoming transition to ICD-10-CM, diagnosis, procedure, and interaction codes have been mapped to AHRQ CCS for severity assignment instead of using the individual diagnosis, procedure, and interaction effects.

Our severity-adjusted resource-demand model allows us to produce risk-adjusted performance comparisons on hospital LOS and costs between or across virtually any subgroup of inpatients. These patient groupings can be based on MS-DRGs, systems, hospitals, clinical service lines, geographic regions, physicians, etc. The methodology adjusts for differences in diagnosis type and illness severity, based on ICD-9-CM coding. It also adjusts for patient age, gender, and admission status. These models take into account only patient conditions that are present on admission when calculating risk. The associated LOS and cost weights allow group comparisons on a national level and within a specific market area. These weights are calculated separately for LOS and cost from the PIDB. PIDB discharges are statistically weighted to represent the universe of all short-term, general, nonfederal hospitals in the U.S.

This regression-based model has been demonstrated to provide accuracy in predicting results. The POA component allows us to determine appropriate adjustments based on pre-existing conditions versus complications of hospitalization. We calculate expected values from model coefficients that are normalized to the clinical group and transformed from log scale.

We estimate costs using the cost center-cost-to-charge ratios* applied to the specific charges reported for the study's cardiovascular patients (AMI, HF, CABG, and PCI) in the most recent MEDPAR file. To account for geographic cost-of-living differences, expected values are adjusted for each hospital using the CMS area wage index for the FFY that matches the MEDPAR file year.

Performance Measure Normalization

The mortality, complications, LOS, and cost measures are normalized, based on the in-study population, by hospital comparison group, to provide a more easily interpreted comparison among hospitals. To address the impact of bed size, teaching status, and residency program involvement, and compare hospitals to other like hospitals, we assign each hospital in the study to one of three comparison groups (teaching hospitals with cardiovascular residency programs, teaching hospitals without cardiovascular residency programs, and community hospitals). Detailed descriptions of the patient and hospital comparison groups can be found in the Methodology section of this document.

* In this study, the 2015 hospital cost reports were used unless they were unavailable; then 2014 reports were used instead.

For the mortality and complications measures, we base our scoring on the difference between observed and expected events, expressed in standard deviation units (z-scores). We normalize the individual hospital expected values for each patient group by multiplying them by the ratio of the observed-to-expected values for the comparison group, prior to calculating the z-score.

For LOS and cost measures, we base our scoring on the severity-adjusted LOS index and the wage- and severity-adjusted cost-per-case index. These indexes are the ratio of the observed and the normalized expected values for each hospital, where the expected values are the sum of the weights for the hospital cases included in the measure. We normalize the individual hospital expected values for each patient group by multiplying them by the ratio of the observed-to-expected values for the comparison group. The hospital's normalized index is then calculated by dividing the hospital's observed value by its normalized expected value to produce the normalized index for the hospital, for each patient group.

Each patient group LOS index is converted into an average LOS (ALOS) in days by multiplying it by the grand mean LOS of the group's in-study patient population, without regard to hospital comparison group. Each patient group cost index is converted into an average cost per case expressed in dollars by multiplying it by the grand mean cost per case of the group's in-study patient population, without regard to hospital comparison group. The ALOS and average cost-per-case values are the reported values.

IQR Range Methodology

For each individual cost-per-case measure, we calculate an IQR based on data for all in-study hospitals. Two outlier points (trim points) are set for each measure: one upper limit and one lower limit.

A value (X) is considered an outlier if either of the following is true:
X > = upper-limit outlier point
X < = lower-limit outlier point

The procedure for calculating the IQR and outlier points is as follows:

- Determine the first quartile (Q1). This is the 25th percentile value of all records in the population.
- Determine the third quartile (Q3). This is the 75th percentile value of all records in the population.
- Calculate the IQR by subtracting Q1 from Q3 (IQR = Q3 – Q1).
- Calculate the upper- and lower-limit trim points:
  - upper-limit = Q3 + (3.0 × IQR)
  - lower-limit = Q1 – (3.0 × IQR)

Data points outside the IQR limits are considered to be extreme outliers and are excluded.

Winner Exclusion Methodology — Binomial Measures

We do not include hospitals with statistically poor inpatient mortality or complications during the winner selection process. We use a two-step process to identify excluded hospitals.

1) By measure, we calculate the approximate binomial confidence interval (or exact mid-p binomial confidence interval for less than 30 observations). We divide the upper and lower limits by the expected value. The confidence interval upper and lower index values are used to determine whether a measure is statistically better than, worse than, or as expected, with 99-percent confidence.

2) By measure, we calculate the 75th percentile index value from the range measure values that are worse than expected. This becomes the measure high trim point.

A hospital is excluded if both of the following conditions apply for one or more inpatient mortality or complications measures:

- The measure is statistically worse than expected with 99-percent confidence.
- The measure value is above the high trim point.

Why We Have Not Calculated Percent Change in Specific Instances

We do not calculate winner (benchmark) versus peer percent differences when the performance measure value is already in units of percent. In this case, we report linear difference only. Percent change is a meaningless statistic when the underlying quantity can be positive, negative, or zero. The actual change may mean something, but dividing it by a number that may be zero or of the opposite sign does not convey any meaningful information because the amount of change is not proportional to its previous value.[31]

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5 For more information on the CMS Hospital-Acquired Conditions (POA Indicator) program, see cms.gov/HospitalAcqCond.

6 CMS has ruled that no data points based on fewer than 11 discharges may be displayed. To comply with this rule, we excluded any values based on fewer than 11 discharges.

7 We obtain GME program involvement data annually from the Accreditation Council for Graduate Medical Education (ACGME). This year's study is based on ACGME files from April 2014.

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