Watson Health™
50 TOP
CARDIOVASCULAR

Watson Health 50 Top Cardiovascular Hospitals Study, 2018

19th edition | November 6, 2017

IBM®

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Printed and bound in the United States of America.

ISBN: 978-1-57372-473-9

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Introduction

Each year, IBM Watson Health™ conducts objective, quantitative research to shine a light on the nation's highest-performing hospitals, health systems, and cardiovascular service lines, through the Watson Health 100 Top Hospitals® program. The goal of the program is to deliver unbiased, guiding insights that can help all healthcare organizations focus their improvement initiatives and move toward consistent, sustainable top performance. Organizations do not apply for our selection process, and award winners do not pay to market their honor.

Now, as we have for 19 years, we have analyzed public data with our proprietary methodologies to provide the industry with the 2018 Watson Health 50 Top Cardiovascular Hospitals study.

Like all 100 Top Hospitals program research, this study is based on a scorecard of metrics that is used to identify top-performing cardiovascular providers in the United States.

But the study is far more than a list. Since our cardiovascular award winners have achieved an outstanding balance of clinical and operational excellence in a complex and changing landscape, we believe their success can help provide a clear and bright path for others to follow.

The information contained in our 50 Top Cardiovascular Hospitals study is designed to put impartial, action-driving, and attainable benchmarks in the spotlight for hospital and clinical leaders across the country to leverage as they work to raise their own organizations' standards of performance.

The Watson Health 50 Top Cardiovascular Hospitals study focuses on one of healthcare's most important service lines 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 important, and has the potential to make a large and lasting impact on the quality and cost of care for heart patients across the US.

Illuminating achievement for a value-based world

By finding ways to take clinical and operational performance to the next level, the winners of our 50 Top Cardiovascular Hospitals award are identifying opportunities to deliver healthcare value to patients, communities, and payers.

Repeatedly, 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 continues to transition to a value-based payment environment.

Why cardiovascular hospitals?

A 2016 report from the American Heart Association states that one in three American adults has one or more types of cardiovascular disease[1]. Cardiovascular diseases have a significant 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 US population will have the disease by 2030[3].

It is no wonder, then, that cardiovascular services are among 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 for ways to improve. The 50 Top Cardiovascular Hospitals study attempts to answer 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. 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, more is learned, as the transparency and depth of inpatient and continuum-of-care data grows and evolves.

Objective, real-world assessment

To maintain the study's level of integrity, only public data sources are used for calculating study metrics. This helps eliminate bias while including as many hospitals as possible, and facilitates consistency of definitions and data. In turn, this allows us to produce national norms and benchmarks that are useful for assessing clinical outcomes and operational efficiency in an objective, independent, and meaningful way. In addition, we report rate of improvement compared to peers, which enables clinical leadership and service line management to determine their real-world progress toward consistent top performance within and across the cardiovascular patient groups profiled.

A measure of leadership excellence and its effect on service line performance

For more than 20 years, the 100 Top Hospitals program has collaborated with academics on a wide range of topics to dig deeper into the leadership practices of the nation's top healthcare organizations.

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 potential insights into the effectiveness of hospital leadership. Higher composite scores on our national balanced scorecard may 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. The 50 Top Cardiovascular Hospitals study and analytics provide a view of that enterprise performance alignment. And that information can be helpful in assessing the strategic intersection among cost, quality, efficiency, and community value.

The performance of the 2018 50 Top Cardiovascular Hospitals

The 50 Top Cardiovascular Hospitals study for 2018 identified US hospitals that have achieved the highest 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 2018 winners had:

- Significantly higher inpatient survival (21% to 47.4% higher)
- Fewer patients with complications (17.9% to 20.4% fewer)
- Higher 30-day survival rates for acute myocardial infarction (AMI), heart failure (HF), and coronary artery bypass grafting (CABG) patients (0.3 to 0.9 percentage points higher)*
- Lower readmission rates for AMI, HF, and CABG patients (0.6 to 0.9 percentage points lower)
- Average lengths of stay (ALOS) for CABG patients that were nearly one day lower than nonwinners and 0.3 to 0.5 days lower for AMI, HF, and percutaneous coronary intervention (PCI)**
- $1,333 to $5,745 less in total costs per patient case (the smallest difference was for HF, and the largest was for CABG)
- Lower average 30-day episode of care payments for AMI and HF ($1,127 and $909 less per episode, respectively)

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

- More than 8,900 additional lives could be saved
- Nearly 3,700 heart patients could be complication-free
- Over $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.

Trends in cardiovascular care

An analysis of trends in cardiovascular care over the five-year period 2012 - 2016, revealed:

- Readmission rates for AMI and HF patients showed statistically significant improvement in a large percentage of hospitals (44.7% and 27.3% improvement, respectively)
- AMI 30-day mortality rates also showed statistically significant improvement for a large percentage of hospitals (34.8%)
- As with last year, a strong majority of hospitals (from 80% to 88.7%) continue to hold the cost of delivering care to AMI, HF, CABG, and PCI patients stable from 2012 to 2016, with no statistically significant change, at 95% confidence

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 25 years, the 100 Top Hospitals program has worked to ensure that the measures and methodologies use are fair, consistent, and meaningful. We continually test the validity of our performance measures and data sources.

In addition, as part of our 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.

* 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.

** 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.

More about the multifaceted 100 Top Hospitals program

The 50 Top Cardiovascular Hospitals research is just one of the studies of the Watson 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:

- 100 Top Hospitals and Everest Award studies: Research that annually recognizes the 100 top-rated hospitals in the nation based on a proprietary, balanced scorecard of overall organizational performance, and also identifies those hospitals that excel at long-term rates of improvement in addition to performance
- 50 Top Cardiovascular Hospitals study: An annual study identifying hospitals that demonstrate the highest performance in hospital cardiovascular services
- 15 Top Health Systems study: An annual study introduced in 2009 that provides an objective measure of health system performance overall and offers insight into the ability of a system's member hospitals to deliver consistent top performance across the communities they serve, all based on our national health system scorecard
- 100 Top Hospitals Performance Matrix: A two-dimensional analysis, available for nearly all US hospitals, that provides a view of how long-term improvement and resultant current performance compare with national peers
- Custom benchmark reports: A variety of reports designed to help healthcare executives understand how their organizational performance compares to peers within health systems, states, and markets

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

The value of 50 Top Cardiovascular Hospitals benchmarks

- To improve performance, cardiovascular hospital leaders need objective information about what is achievable. They need relevant benchmarks that allow them to compare their performance to peers and top-performing organizations.
- By naming the 50 Top Cardiovascular Hospitals in the nation, the 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.

About IBM Watson Health

Watson Health aspires to improve lives and give hope by delivering innovation to address the world's most pressing health challenges through data and cognitive insights.

Each day, professionals make powerful progress toward a healthier future. But in an industry that is fragmented and complex, there are many opportunities to support professionals as they work toward their goals to simplify, solve, care or cure, so they can transform health for the people they serve.

At Watson Health, we see and work across the health landscape, from payers and providers to government and life sciences. With an unrivaled vantage point across the industry, deep health expertise, and the power of cognitive computing, we create intelligent connections that shape new ways of working, drive value, and accelerate breakthroughs.

With Watson Health at work in their organizations, our clients can uncover, connect, and act on the insights that advance their work, and change the world.

IBM acquired Truven Health Analytics® in 2016 to help form the business of Watson Health. For more information, visit ibm.com/watson/health.

2018 award winners

The Watson Health™ 100 Top Hospitals® program is pleased to present the 2018 Watson 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
Duke University Hospital	Durham, NC	340030
Henry Ford Hospital	Detroit, MI	230053
Lahey Hospital & Medical Center	Burlington, MA	220171
Mayo Clinic Hospital	Jacksonville, FL	100151
Providence-Providence Park Hospital	Southfield, MI	230019
Regions Hospital	Saint Paul, MN	240106
Rhode Island Hospital	Providence, RI	410007
St. Vincent Indianapolis Hospital	Indianapolis, IN	150084
The Christ Hospital Health Network	Cincinnati, OH	360163
The Mount Sinai Hospital	New York, NY	330024
University of Wisconsin Hospital and Clinics	Madison, WI	520098
Wake Forest Baptist Medical Center	Winston-Salem, NC	340047

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

** Throughout this document where we refer to 'cardiovascular residency programs,' we are including cardiovascular fellowship programs as well. Please refer to the Methodology section of this document for a complete list of cardiovascular residency and fellowship programs that are used to classify hospitals.

Teaching hospitals without cardiovascular residency programs*		
Hospitals	Location	Medicare ID
Aspirus Wausau Hospital	Wausau, WI	520030
Bon Secours Maryview Medical Center	Portsmouth, VA	490017
Bon Secours St. Mary's Hospital	Richmond, VA	490059
Cape Fear Valley Medical Center	Fayetteville, NC	340028
Carolinas Medical Center	Charlotte, NC	340113
Centra Health	Lynchburg, VA	490021
Decatur Memorial Hospital	Decatur, IL	140135
Eisenhower Medical Center	Rancho Mirage, CA	050573
Grand Strand Medical Center	Myrtle Beach, SC	420085
IU Health Ball Memorial Hospital	Muncie, IN	150089
Lee Memorial Hospital and HealthPark Medical Center (LMH/HPMC)	Fort Myers, FL	100012
Memorial Hospital	South Bend, IN	150058
Mission Hospital	Asheville, NC	340002
PIH Health Hospital - Whittier	Whittier, CA	050169
Providence Sacred Heart Medical Center	Spokane, WA	500054
Saint Thomas Midtown Hospital	Nashville, TN	440133
Saint Thomas West Hospital	Nashville, TN	440082
St. Joseph's Hospital Health Center	Syracuse, NY	330140
St. Luke's Boise Medical Center	Boise, ID	130006
The Moses H. Cone Memorial Hospital	Greensboro, NC	340091

Community hospitals*		
Hospitals	Location	Medicare ID
Adena Regional Medical Center	Chillicothe, OH	360159
Banner Heart Hospital	Mesa, AZ	030105
Bellin Health	Green Bay, WI	520049
Fort Sanders Regional Medical Center	Knoxville, TN	440125
Hoag Hospital Newport Beach	Newport Beach, CA	050224
Longview Regional Medical Center	Longview, TX	450702
McLaren Northern Michigan Hospital	Petoskey, MI	230105
Mercy Hospital	Iowa City, IA	160029
Nebraska Heart Institute & Heart Hospital	Lincoln, NE	280128
Oklahoma Heart Hospital	Oklahoma City, OK	370215
Presbyterian Hospital	Albuquerque, NM	320021
Salem Hospital	Salem, OR	380051
Southwest General Health Center	Middleburg Heights, OH	360155
St. Vincent Heart Center of Indiana	Indianapolis, IN	150153
University of Maryland St. Joseph Medical Center	Towson, MD	210063

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

Findings

This year's Watson 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 2018 study winners, more than 8,900 additional lives and over $1.4 billion could be saved, and nearly 3,700 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 Watson 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 US. (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 inpatient mortality index of 0.5, meaning there were 50% fewer deaths than would be expected, given patient severity. With an index of 0.95, peer (nonwinning) hospitals had only 5% fewer CABG deaths than expected. Winner versus nonwinner differences were similar for PCI survival rates.
- The 2018 cardiovascular study winners had 17.9% and 20.4% 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 inpatient 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 12.6% for winners versus 13.4% 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% for winners versus 21.4% for nonwinners.
- Winning hospitals were more efficient, releasing patients sooner than their peers. The typical winning hospital released CABG patients nearly a full day (0.9) sooner, and their AMI patients were released a half day sooner than at nonwinning peers.
- The 50 Top Cardiovascular Hospitals managed these clinical quality gains while keeping inpatient costs lower. The typical winning hospital spent about $5,700 less per CABG patient and about $1,300 less per admitted HF patient.
- Benchmark hospitals also showed stronger performance on measures of total Medicare payment across 30-day episodes of care for both AMI and HF patients ($1,127 less per AMI episode and $909 less per HF episode than their nonwinning peers).

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	0.79	1.00	-0.21	-21.0	Lower mortality
		HF mortality	0.72	1.00	-0.28	-28.0	Lower mortality
		CABG mortality	0.50	0.95	-0.45	-47.4	Lower mortality
		PCI mortality	0.72	1.02	-0.30	-29.4	Lower mortality
	Risk-adjusted complications index	CABG complications	0.74	0.93	-0.19	-20.4	Fewer complications
		PCI complications	0.78	0.95	-0.17	-17.9	Fewer complications
Clinical process measures[a,c]	CABG patients with internal mammary artery (IMA) use		96.8	95.0	1.8	n/a	Higher IMA use
Extended outcome measures[b,c]	AMI 30-day mortality (%)		12.6	13.4	-0.9	n/a	Lower 30-day mortality
	HF 30-day mortality (%)		11.2	11.5	-0.3	n/a	Lower 30-day mortality
	CABG 30-day mortality (%)		2.7	3.1	-0.4	n/a	Lower 30-day mortality
	AMI 30-day readmission (%)		15.7	16.3	-0.6	n/a	Fewer 30-day readmissions
	HF 30-day readmission (%)		20.5	21.4	-0.9	n/a	Fewer 30-day readmissions
	CABG 30-day readmission (%)		13.1	13.7	-0.6	n/a	Fewer 30-day readmissions
Process efficiency	AMI severity-adjusted average length of stay (ALOS)		3.8	4.2	-0.5	-11.1	Shorter ALOS
	HF severity-adjusted ALOS		4.5	4.8	-0.3	-6.4	Shorter ALOS
	CABG severity-adjusted ALOS		8.3	9.2	-0.9	-10.2	Shorter ALOS
	PCI severity-adjusted ALOS		3.2	3.6	-0.4	-12.1	Shorter ALOS
Cost efficiency	AMI wage- and severity-adjusted average cost per case		$7,942	$9,905	-$1,963	-19.8	Lower cost per case
	HF wage- and severity-adjusted average cost per case		$7,733	$9,066	-$1,333	-14.7	Lower cost per case
	CABG wage- and severity-adjusted average cost per case		$34,738	$40,484	-$5,745	-14.2	Lower cost per case
	PCI wage- and severity-adjusted average cost per case		$15,268	$18,540	-$3,272	-17.6	Lower cost per case
Extended efficiency measures[b]	AMI 30-day episode payment		$22,112	$23,239	-$1,127	-4.8	Lower 30-day payment
	HF 30-day episode payment		$15,797	$16,706	-$909	-5.4	Lower 30-day payment

a. Medicare Provider Analysis and Review (MEDPAR) 2015 and 2016, combined.

b. Centers for Medicare & Medicaid Services (CMS) Hospital Compare July 1, 2013 - June 30, 2016.

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.)

- Cardiovascular teaching winners' inpatient mortality rates were 55% and 45% lower than peers for CABG and PCI patients, respectively, which was the greatest difference seen among the three comparison groups.
- These benchmark hospitals were also leaders for CABG patients (38% fewer complications than peers). This performance lead did not extend to PCI complications; winning hospitals had a 16% higher complications index than nonwinning peers.
- Cardiovascular teaching benchmark hospitals were also much more efficient than their peers, with severity-adjusted costs among all patient groups being on average about 15% lower than costs calculated for peer facilities. The greatest absolute difference in cost was found for CABG patients at $5,072 less per bypass surgery patient. In addition, winners had nearly 15% lower cost for PCI patients and about 18% lower cost for AMI patients.
- Winners slightly underperformed compared to nonwinners on two 30-day extended outcome measures: HF 30-day mortality rate (0.6 percentage points higher, at 11.4%) and CABG 30-day readmission rate (0.1 percentage points higher, at 13.6%).
- For the newly ranked 30-day episode Medicare payment measures, HF cases associated with winning cardiovascular teaching hospitals had 30-day payments that were on average 6.3% less than those at nonwinner hospitals ($15,878 versus $16,939), the greatest difference between winner and nonwinner performance on this among the three comparison groups.

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	0.80	1.01	-0.21	-20.8	Lower mortality
		HF mortality	0.75	1.03	-0.28	-27.2	Lower mortality
		CABG mortality	0.41	0.91	-0.50	-54.9	Lower mortality
		PCI mortality	0.56	1.02	-0.46	-45.1	Lower mortality
	Risk-adjusted complications index	CABG complications	0.59	0.96	-0.37	-38.5	Fewer complications
		PCI complications	1.09	0.94	0.15	16.0	More complications
Clinical process measures[a,c]	CABG patients with IMA use		97.4	95.9	1.5	n/a	Higher IMA use
Extended outcome measures[b,c]	AMI 30-day mortality (%)		12.4	13.1	-0.7	n/a	Lower 30-day mortality
	HF 30-day mortality (%)		11.4	10.8	0.6	n/a	Higher 30-day mortality
	CABG 30-day mortality (%)		2.4	2.8	-0.4	n/a	Lower 30-day mortality
	AMI 30-day readmission (%)		16.3	16.4	-0.1	n/a	Fewer 30-day readmissions
	HF 30-day readmission (%)		20.9	21.8	-0.9	n/a	Fewer 30-day readmissions
	CABG 30-day readmission (%)		13.6	13.5	0.1	n/a	More 30-day readmissions
Process efficiency	AMI severity-adjusted ALOS		4.0	4.3	-0.3	-6.4	Shorter ALOS
	HF severity-adjusted ALOS		4.6	4.9	-0.3	-5.1	Shorter ALOS
	CABG severity-adjusted ALOS		8.9	9.2	-0.2	-2.6	Shorter ALOS
	PCI severity-adjusted ALOS		3.3	3.7	-0.4	-9.8	Shorter ALOS
Cost efficiency	AMI wage- and severity-adjusted average cost per case		$8,070	$9,833	-$1,763	-17.9	Lower cost per case
	HF wage- and severity-adjusted average cost per case		$7,771	$8,986	-$1,216	-13.5	Lower cost per case
	CABG wage- and severity-adjusted average cost per case		$35,493	$40,565	-$5,072	-12.5	Lower cost per case
	PCI wage- and severity-adjusted average cost per case		$16,033	$18,838	-$2,805	-14.9	Lower cost per case
Extended efficiency measures[b]	AMI 30-day episode payment		$22,104	$23,273	-$1,169	-5.0	Lower 30-day payment
	HF 30-day episdoe payment		$15,878	$16,939	-$1,061	-6.3	Lower 30-day payment

a. MEDPAR 2015 and 2016, combined.

b. CMS Hospital Compare July 1, 2013 - June 30, 2016.

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 (1.3) less than nonwinning hospitals.
- These benchmark hospitals also treated their average CABG and PCI cases at a lower cost, 13.8% and 20.5% less, respectively, saving $5,481 per CABG case and $3,764 per PCI case.
- Winners had the strongest performance on risk-adjusted complications for PCI patients among the three comparison groups in the study data, with 27.6% fewer complications occurring in cases at their facilities, compared to nonwinners.
- AMI and CABG readmission rates were lowest for benchmark teaching hospitals without cardiovascular residency programs among the three comparison groups. (Winning community hospitals shared the same low rate for AMI.)
- For the newly ranked 30-day episode payment measures, winning teaching hospitals without cardiovascular residency programs outperformed the two other comparison groups, having the lowest median payment per AMI episode at $21,734. In addition, this was 6% less than peers, the greatest difference seen between benchmark and peer hospitals on this measure.

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	0.87	1.02	-0.15	-14.7	Lower mortality
		HF mortality	0.72	1.05	-0.33	-31.4	Lower mortality
		CABG mortality	0.47	0.99	-0.52	-52.5	Lower mortality
		PCI mortality	0.71	1.00	-0.29	-29.0	Lower mortality
	Risk-adjusted complications index	CABG complications	0.76	0.90	-0.14	-15.6	Fewer complications
		PCI complications	0.71	0.98	-0.27	-27.6	Fewer complications
Clinical process measures[a,c]	CABG patients with IMA use		96.4	94.8	1.7	n/a	Higher IMA use
Extended outcome measures[b,c]	AMI 30-day mortality (%)		12.7	13.5	-0.9	n/a	Lower 30-day mortality
	HF 30-day mortality (%)		11.1	11.9	-0.9	n/a	Lower 30-day mortality
	CABG 30-day mortality (%)		2.8	3.3	-0.5	n/a	Lower 30-day mortality
	AMI 30-day readmission (%)		15.5	16.2	-0.7	n/a	Fewer 30-day readmissions
	HF 30-day readmission (%)		20.6	21.2	-0.6	n/a	Fewer 30-day readmissions
	CABG 30-day readmission (%)		12.8	13.7	-0.9	n/a	Fewer 30-day readmissions
Process efficiency	AMI severity-adjusted ALOS		3.9	4.2	-0.4	-8.5	Shorter ALOS
	HF severity-adjusted ALOS		4.6	4.9	-0.3	-6.3	Shorter ALOS
	CABG severity-adjusted ALOS		8.0	9.3	-1.3	-14.4	Shorter ALOS
	PCI severity-adjusted ALOS		3.3	3.6	-0.3	-9.4	Shorter ALOS
Cost efficiency	AMI wage- and severity-adjusted average cost per case		$8,011	$10,186	-$2,175	-21.4	Lower cost per case
	HF wage- and severity-adjusted average cost per case		$7,379	$9,358	-$1,979	-21.1	Lower cost per case
	CABG wage- and severity-adjusted average cost per case		$34,255	$39,737	-$5,481	-13.8	Lower cost per case
	PCI wage- and severity-adjusted average cost per case		$14,621	$18,385	-$3,764	-20.5	Lower cost per case
Extended efficiency measures[b]	AMI 30-day episode payment		$21,734	$23,113	-$1,380	-6.0	Lower 30-day payment
	HF 30-day episdoe payment		$15,683	$16,473	-$791	-4.8	Lower 30-day payment

a. MEDPAR 2015 and 2016, combined.
b. CMS Hospital Compare July 1, 2013 - June 30, 2016.
c. We do not calculate percentage difference for measures already expressed as a percent.

Better performance at benchmark community hospitals

- Benchmark community hospitals again outperformed their peers on the inpatient HF mortality measure, as in last year's study. With a median risk-adjusted mortality index value of 0.54 for HF patients, the winning community hospitals had 46% fewer HF patient deaths than expected. (See Table 4.)
- The winning community hospitals were also much more efficient than their peers. They discharged CABG patients one day sooner, and AMI and PCI patients over a half a day sooner (0.65 and 0.53, respectively).
- Cost-per-case medians in all patient groups were also much lower for benchmark community hospitals, with the largest difference for CABG patients, at $4,179 less per case than peer hospitals.
- Notably, benchmark community hospitals had the strongest performance across the 50 Top Cardiovascular Hospitals study groups on HF 30-day readmissions (19.9%), and on internal mammary artery (IMA) use for CABG patients (97.9%).

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	0.66	0.99	-0.33	-33.3	Lower mortality
		HF mortality	0.54	0.96	-0.42	-43.8	Lower mortality
		CABG mortality	0.48	0.89	-0.41	-46.1	Lower mortality
		PCI mortality	0.83	1.00	-0.17	-17.0	Lower mortality
	Risk-adjusted complications index	CABG complications	0.80	0.97	-0.17	-17.5	Fewer complications
		PCI complications	0.79	0.94	-0.15	-16.0	Fewer complications
Clinical process measures[a,c]	CABG patients with IMA use		97.9	94.5	3.4	n/a	Higher IMA use
Extended outcome measures[b,c]	AMI 30-day mortality (%)		12.4	13.4	-1.0	n/a	Lower 30-day mortality
	HF 30-day mortality (%)		11.1	11.6	-0.5	n/a	Lower 30-day mortality
	CABG 30-day mortality (%)		3.0	3.2	-0.2	n/a	Lower 30-day mortality
	AMI 30-day readmission (%)		15.5	16.3	-0.8	n/a	Fewer 30-day readmissions
	HF 30-day readmission (%)		19.9	21.4	-1.5	n/a	Fewer 30-day readmissions
	CABG 30-day readmission (%)		13.1	13.8	-0.7	n/a	Fewer 30-day readmissions
Process efficiency	AMI severity-adjusted ALOS		3.6	4.3	-0.7	-15.2	Shorter ALOS
	HF severity-adjusted ALOS		4.5	4.9	-0.4	-9.0	Shorter ALOS
	CABG severity-adjusted ALOS		8.3	9.3	-1.0	-10.9	Shorter ALOS
	PCI severity-adjusted ALOS		3.1	3.6	-0.5	-14.6	Shorter ALOS
Cost efficiency	AMI wage- and severity-adjusted average cost per case		$8,251	$9,919	-$1,668	-16.8	Lower cost per case
	HF wage- and severity-adjusted average cost per case		$7,961	$9,067	-$1,106	-12.2	Lower cost per case
	CABG wage- and severity-adjusted average cost per case		$36,408	$40,587	-$4,179	-10.3	Lower cost per case
	PCI wage- and severity-adjusted average cost per case		$15,952	$18,293	-$2,341	-12.8	Lower cost per case
Extended efficiency measures[b]	AMI 30-day episode payment		$22,123	$23,342	-$1,219	-5.2	Lower 30-day payment
	HF 30-day episdoe payment		$15,882	$16,671	-$789	-4.7	Lower 30-day payment

a. MEDPAR 2015 and 2016, combined.

b. CMS Hospital Compare July 1, 2013 - June 30, 2016.

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 this 2018 study, we continued 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@us.ibm.com.

30-day excess days in acute care (heart attack and heart failure)

In this study, we have profiled performance, for information only, on the new Centers for Medicare & Medicaid Services (CMS) excess days in acute care (EDAC) measures:

- 30-day EDAC for AMI patients
- 30-day EDAC for HF patients

As defined by CMS[4], the EDAC measures capture excess days that a hospital's patients spent in acute care within 30 days after discharge. The outcomes of these measures are the number of risk-adjusted days a hospital's patients spend in an emergency department (ED), a hospital observation unit, or a hospital inpatient unit during 30 days following a hospitalization for AMI or HF.

The measures report the difference ("excess") between each hospital's average days in acute care ("predicted days") and the number of days in acute care that each hospital's patients would have been expected to spend if discharged from an average-performing hospital ("expected days"). The measure is reported as excess days per 100 discharges[1].

Comparing benchmark hospitals and peers on this measure yields interesting results, as shown in Table 5 on the following page.

- The benchmark median EDAC score for AMI patients was 11.8 days less than the peer EDAC score, at -5.2 versus 6.6 for nonwinning hospitals
- The benchmark median EDAC score for HF patients was 13.6 days less than the peer EDAC score, at -5.4 versus 8.2 for nonwinning hospitals

Further research is needed on the relationship between hospital performance on "excess days" and on other measures, such as inpatient mortality, 30-day readmissions, and average length of stay (ALOS).

Table 5. National performance comparisons for excess days in acute care (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
Extended efficiency measures[a,b]	AMI 30-day excess days in acute care[c]	-5.2	6.6	-11.8	n/a	Fewer days in acute care
	HF 30-day excess days in acute care[c]	-5.4	8.2	-13.6	n/a	Fewer days in acute care

a. CMS Hospital Compare July 1, 2013 - June 30, 2016.
b. We do not calculate percentage difference for measures already expressed as a percent.
c. Reported as excess days per 100 discharges.

Trends in cardiovascular care

Again in our 2018 50 Top Cardiovascular Hospitals study, we are presenting new findings on trends in cardiovascular care delivered in the nation's teaching and community 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 2012 and 2016.

Performance improvement over time: All hospitals

By studying the direction of performance change of all hospitals eligible for our study (winners and nonwinners), we can see that US hospitals have not been able to significantly improve performance across the entire 50 Top Cardiovascular Hospitals balanced scorecard. (See Table 6.) However, over the years we studied (2012 through 2016), there were a few notable performance improvements for specific measures, especially those extending beyond the acute inpatient stay timeframe. (See the green left column in Table 6.)

- A plurality of hospitals significantly improved their 30-day readmission rates for AMI and HF (44.7% and 27.3%, respectively). This is likely a result of the attention these measures are getting due to both public and private payer readmission penalty/incentive programs.
- However, for HF patients, the significant reduction in risk-standardized readmission rate was tempered slightly by a statistically significant increase in 30-day mortality in 10.4% of hospitals, which is currently unexplained (see the red right column in Table 6). On the positive side, a greater proportion of hospitals improved HF 30-day mortality between 2012 - 2016 (11.4%).
- For AMI patient 30-day mortality, the five-year trend results showed a statistical improvement in 34.8% of hospitals.
- More than 13% of hospitals (13.3%) in the study demonstrated a significant improvement in the percentage of CABG patients with IMA graft usage.
- A strong majority of hospitals had no significant change in severity-adjusted ALOS over the five-year period (87% to 91%) for AMI, HF, CABG, and PCI patients.
- Noteworthy improvement in AMI and HF severity-adjusted cost per case was observed (11.9% and 17.3%, respectively).

Table 6. Direction of performance change for all cardiovascular hospitals in study, 2012 - 2016							
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 inpatient mortality index	AMI mortality	14	1.5%	918	95.4%	30	3.1%
	HF mortality	16	1.7%	910	94.6%	36	3.7%
	CABG mortality	13	1.4%	933	97.0%	16	1.7%
	PCI mortality	19	2.0%	920	95.6%	23	2.4%
Risk-adjusted complications index	CABG complications	27	2.8%	907	94.3%	28	2.9%
	PCI complications	10	1.0%	914	95.0%	38	4.0%
CABG patients with IMA use		128	13.3%	778	81.1%	53	5.5%
AMI 30-day mortality		335	34.8%	605	62.9%	22	2.3%
HF 30-day mortality		110	11.4%	752	78.2%	100	10.4%
AMI 30-day readmission		430	44.7%	525	54.6%	7	0.7%
HF 30-day readmission		263	27.3%	656	68.2%	43	4.5%
AMI severity-adjusted ALOS		52	5.4%	878	91.3%	32	3.3%
HF severity-adjusted ALOS		70	7.3%	837	87.0%	55	5.7%
CABG severity-adjusted ALOS		48	5.0%	870	90.4%	44	4.6%
PCI severity-adjusted ALOS		73	7.6%	857	89.1%	32	3.3%
AMI wage- and severity-adjusted average cost per case		114	11.9%	825	85.8%	22	2.3%
HF wage- and severity-adjusted average cost per case		166	17.3%	768	80.0%	26	2.7%
CABG wage- and severity-adjusted average cost per case		91	9.5%	828	86.3%	41	4.3%
PCI wage- and severity-adjusted average cost per case		5	0.5%	850	88.7%	103	10.8%

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. This affects the cost-per-case measures.

Methodology

The Watson 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 US. This study focuses on short-term, acute care, nonfederal US 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 overall performance by ranking relative to like comparison groups

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@us.ibm.com or call 800-525-9083.

Building the database of hospitals

Primary data sources

Like all Watson Health 100 Top Hospitals® studies, the 50 Top Cardiovascular Hospitals study used only publicly available data. The data came from:

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

We used MEDPAR patient-level record information to calculate inpatient mortality, complications, and length of stay (LOS). MEDPAR was also used for patient-level charge data in estimating average cost per case. This data set contains information on approximately 15 million Medicare patients who are discharged from the nation's acute care hospitals annually.

Six years of MEDPAR data were used to develop the study trend database (2011 - 2016). In this 2018 study, we used the two most recent years of MEDPAR data available (2015 and 2016) 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 used 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 were applied to MEDPAR patient-level claims data to estimate cost for the study's cost measures. This was done at the cost-center and charge-code levels for each patient record. For this study, we used 2016 (2015 when 2016 was not available) cost report data to determine the cost-to-charge ratios.

The Medicare Cost Report is filed annually by every US 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 includes services for all patients, not just Medicare beneficiaries.

The 100 Top Hospitals program and many others in the healthcare industry have used the MEDPAR and Medicare Cost Report databases for years. We believe they are accurate and reliable sources for the types of analyses performed in this study. Medicare data is 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), as found in the Watson Health Projected Inpatient Database (PIDB)*.

We used the CMS Hospital Compare data set published in the second quarter of 2017 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 data set. For example, July 1, 2013 - June 30, 2016 is named “2016.” We used the 2016 data to identify current performance and to select the winning hospitals.

We referenced 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 Office of Graduate Medical Education (OGME) website
- Medical college websites
- Hospital websites

Present-on-admission data

Our risk-adjustment models for inpatient mortality and complications, and severity- adjustment models for LOS and cost per case included POA data reported in the MEDPAR data sets. Under the Deficit Reduction Act of 2005, as of federal fiscal year (FFY) 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].

Present-on-admission coding adjustments

From 2010 through 2016, 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” has been appearing. This phenomenon has led to an artificial rise in the number of complications that appear to be occurring during the hospital stay. See the Appendix for details.

* The Watson Health Projected Inpatient Database (PIDB) is one of the largest US inpatient, all-payer databases of its kind, containing more than 23 million all-payer discharges annually. This data is obtained from approximately 5,000 hospitals, representing over 65% of all discharges from short-term, general, nonfederal hospitals in the US.

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

- We treated all principal diagnoses as present on admission
- We treated all diagnosis codes on the CMS exempt list as "exempt," regardless of POA coding
- We treated secondary diagnoses where POA indicator codes "Y" or "W" appeared more than 50% of the time in the 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 2015 and 2016 data years combined, at least 30 unique cases[6] in each of the four patient groups described below.

- AMI patients – restricted to nonsurgical patients
- HF patients – restricted to nonsurgical patients
- CABG patients – includes all ICD-9-CM and ICD-10-CM procedure codes, principal or secondary in MS-DRGs 231 - 236
- PCI patients – excludes patients with open chest coronary artery angioplasty

Each patient group is mutually exclusive, by design. To define patient diagnoses, the 2011 through 2015 MEDPAR data files utilize ICD-9-CM and the 2016 files utilize ICD-10-CM. See the Appendix – Patient Group Definitions for the code-level detail.

The effect of present-on-admission 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 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.

Patient records excluded

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

Also excluded:

- 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 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 (critical access hospitals, children's, women's, psychiatric, substance abuse, rehabilitation, and long-term acute care hospitals)
- Federally owned hospitals
- Noncontinental US 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 did not have both 2015 and 2016 Medicare claims
- Hospitals missing data for calculation of one or more performance measures
- Hospitals for which a Medicare Cost Report was not available for 2016 or 2015
- Hospitals that did not code POA indicators on their 2015 and 2016 MEDPAR data

Classifying hospitals into comparison groups

Bed size, teaching status, and residency/fellowship program involvement have a significant 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 included 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 meet the definition of teaching (see teaching hospitals without cardiovascular residency programs definition) and 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

Note: Cardiovascular radiology residency programs are not included.

Participation in a fellowship program was 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 2016 or 2015 (the most current year available).

Cardiovascular study groups

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

Table 7. Cardiovascular hospital comparison groups

Comparison group	Total
Teaching hospitals with cardiovascular residency programs	234
Teaching hospitals without cardiovascular residency programs	307
Community hospitals	475
Total in-study hospitals	1,016

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 chief executive officers 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.

The measures used in this year's study, along with their data sources, are outlined in Table 8.

* 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.

Table 8. Summary of measure data sources and data periods			
	Ranked performance metric	Current profile data sources	Trend profile data sources
Clinical outcomes	1. Risk-adjusted inpatient mortality (AMI, HF, CABG, PCI)	MEDPAR FFY 2015 and 2016	MEDPAR FFY 2011 - 2016[a]
	2. Risk-adjusted complications (CABG, PCI)	MEDPAR FFY 2015 and 2016	Same data periods as inpatient morality
Clinical process	3. Percentage of CABG patients with IMA use	MEDPAR FFY 2015 and 2016	MEDPAR FFY 2011 - 2016[a]
Extended outcomes	4. 30-day mortality rates (AMI, HF, CABG[b])	CMS Hospital Compare July 1, 2013 - June 30, 2016	CMS Hospital Compare three-year data sets ending June 30 of the following years: 2012, 2013, 2014, 2015, 2016
	5. 30-day readmission rates (AMI, HF, CABG[b])	CMS Hospital Compare July 1, 2013 - June 30, 2016	Same data periods as 30-day mortality
Process efficiency	6. Severity-adjusted ALOS (AMI, HF, CABG, PCI)	MEDPAR FFY 2016	MEDPAR FFY 2012 - 2016
Cost efficiency	7. Wage- and severity-adjusted average cost per case (AMI, HF, CABG, PCI)	MEDPAR FFY 2016	MEDPAR FFY 2012 - 2016
Extended efficiency	8. 30-day episode payment (AMI[b], HF[b])	CMS Hospital Compare July 1, 2013 - June 30, 2016	n/a

a. Two years of MEDPAR data are combined for each study year, as follows: 2011 - 2012, 2012 - 2013, 2013 - 2014, 2014 - 2015, 2015 - 2016.
b. These 30-day patient groups 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 inpatient 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 45 possible patient complications with expected probabilities calculated from our national inpatient database. For more information, see the measures details in the tables on the following pages 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 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.

Performance measures

For more information on methodologies, see the Appendix.

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 (Z515) (V66.7) are included in the risk model. Do not resuscitate (DNR) patients (Z66) (V49.86) are excluded at this time. Separate index values are calculated for each patient group: AMI, HF, CABG, PCI. We normalize each index based on the ratio of observed to normalized expected deaths for each patient group, by comparison group (cardiovascular 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 (2015 and 2016) to reduce the influence of chance variation. The MEDPAR data set includes both Medicare fee-for-service claims and Medicare Advantage (HMO) encounter records. Hospitals with observed values statistically worse than expected (99% 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 patient group: AMI, HF, CABG, PCI. We normalize each index based on the ratio of observed to normalized expected complications for each patient group, by comparison group (cardiovascular teaching, teaching, community hospital). The reference value for this index is 1.00; a value of 1.15 indicates 15% more events than predicted, and a value of 0.85 indicates 15% 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 (2015 and 2016) to reduce the influence of chance variation. The MEDPAR data set includes both Medicare fee-for-service claims and Medicare Advantage (HMO) encounter records. Hospitals with observed values statistically worse than expected (99% confidence), and whose values are above the high trim point, are not eligible to be named benchmark hospitals.	Lower

Percentage of CABG patients with IMA use			
Why we include this element	Calculation	Comments	Favorable values are
The clinical advantages of using an internal mammary 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 (2015 and 2016) 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% 30-day mortality rate indicates that 10% of patients died, of any cause, within 30 days of the original admission date.	Data is from the CMS Hospital Compare data set for the second quarter of 2017. This contains data from July 1, 2013, through June 30, 2016[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 value-based payment models.	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% 30-day readmission rate would indicate that 20% of patients were readmitted to an acute care hospital within 30 days of discharge.	Data is from the CMS Hospital Compare data set for the second quarter of 2017. This contains data from July 1, 2013, through June 30, 2016[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			
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, 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 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, 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 is from 2016 MEDPAR only. The MEDPAR data set 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, 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 POA 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 is from 2016 MEDPAR claims only. Cost-to-charge ratios are from the hospital's 2016 Medicare Cost Report. (2015 cost reports are used when 2016 are not available.) The MEDPAR data set includes both Medicare fee-for-service claims and Medicare Advantage (HMO) encounter records.	Lower

30-day episode-of-care payment for AMI and HF patients			
Why we include this element	Calculation	Comments	Favorable values are
Recently, CMS began publicly reporting hospital risk-standardized payments associated with a 30-day episode of care for AMI and HF. The values represent the payments made for the care and supplies for AMI and HF patients, beginning with the hospital admission through the next 30 days. They are meant to reflect differences in services and supplies provided to similar patients. The intent by CMS in creating these measures is to better understand differences in the patterns of post-discharge care and associated payments made for Medicare patients across the entire continuum of care. The measures are meant to be used along with the other 30-day measures (mortality and readmission) to fully assess a hospital's financial and quality-of-care performance.	CMS calculates the 30-day payment by using the ratio of predicted 30-day payment to expected 30-day payment, which is then multiplied by the national mean payment to get the risk-standardized payment for each hospital for AMI and HF patients. The payment measures include Medicare claims data 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 payment in dollars. We use the payments as reported by CMS, without alteration.	Data is from the CMS Hospital Compare data set for the second quarter of 2017. This contains data from July 1, 2013, through June 30, 2016[19].	Lower

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 was 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 was used for the selection of benchmark award-winning hospitals. Trend performance was ranked for information only.

Table 9. Ranked performance measures and weights

Ranked performance measure	Patient group	Current profile weight	Trend profile weight
Risk-adjusted inpatient mortality (normalized z-score)	AMI	½	½
	HF	½	½
	CABG	½	½
	PCI	½	½
Risk-adjusted complications (normalized z-score)	CABG	¼	¼
	PCI	¼	¼
Percentage of CABG patients with IMA use		½	½
30-day mortality rates (%)	AMI	⅙	¼
	HF	⅙	¼
	CABG	⅙	*
30-day readmission rates (%)	AMI	⅙	¼
	HF	⅙	¼
	CABG	⅙	*
Severity-adjusted ALOS (days)	AMI	¼	¼
	HF	¼	¼
	CABG	¼	¼
	PCI	¼	¼
Wage- and severity-adjusted cost per case ($)	AMI	¼	¼
	HF	¼	¼
	CABG	¼	¼
	PCI	¼	¼
30-day episode payment ($)	AMI	½	*
	HF	½	*

* CABG and 30-day episode payment do not have sufficient data to trend.

Note: Inpatient 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 information 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 inpatient mortality or complications index values that were high statistical outliers (99% 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 (2016) 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:

Table 10. Study populations by comparison group

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, Watson Health™ constructed a normative database of case-level data from its Projected Inpatient Database (PIDB). The PIDB is one of the largest US inpatient, all-payer databases of its kind, containing more than 23 million all-payer discharges annually. This data is obtained from approximately 5,000 hospitals, representing over 65% of all discharges from short-term, general, nonfederal hospitals in the US (PIDB discharges are statistically weighted to represent the universe of all short-term, general, nonfederal hospitals in the US). Demographic and clinical data is 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 is now being integrated into the database, as well.

The Watson 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) 2015 data available in the Watson Health PIDB.

Patient group definitions		
Acute myocardial infarction (AMI) patient group		
AMI patients in MS-DRGs 280 - 285 with these ICD-9-CM codes as primary diagnosis only:	410.01	Acute myocardial infarction, of anterolateral wall, initial episode
	410.11	Acute myocardial infarction, of other anterior wall, initial episode
	410.21	Acute myocardial infarction, of inferolateral wall, initial episode
	410.31	Acute myocardial infarction, of inferoposterior wall, initial episode
	410.41	Acute myocardial infarction, of other inferior wall, initial episode
	410.51	Acute myocardial infarction, of other lateral wall, initial episode
	410.61	Acute myocardial infarction, true posterior wall infarction, initial episode
	410.71	Acute myocardial infarction, subendocardial infarction, initial episode
	410.81	Acute myocardial infarction, of other specified sites, initial episode
	410.91	Acute myocardial infarction, unspecified site, initial episode

AMI patients in MS-DRGs 280 - 285 with these ICD-10-CM codes as primary diagnosis only:	I2101	ST elevation (STEMI) myocardial infarction involving left main coronary artery
	I2102	ST elevation (STEMI) myocardial infarction involving left anterior descending coronary artery
	I2109	ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall
	I2111	ST elevation (STEMI) myocardial infarction involving right coronary artery
	I2119	ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall
	I2121	ST elevation (STEMI) myocardial infarction involving left circumflex coronary artery
	I2129	ST elevation (STEMI) myocardial infarction involving other sites
	I213	ST elevation (STEMI) myocardial infarction of unspecified site
	I214	Non-ST elevation (NSTEMI) myocardial infarction
	I220	Subsequent ST elevation (STEMI) myocardial infarction of anterior wall
	I221	Subsequent ST elevation (STEMI) myocardial infarction of inferior wall
	I222	Subsequent non-ST elevation (NSTEMI) myocardial infarction
	I228	Subsequent ST elevation (STEMI) myocardial infarction of other sites
	I229	Subsequent ST elevation (STEMI) myocardial infarction of unspecified site
	The AMI group was restricted to nonsurgical patients.	

Heart failure (HF) patient group		
HF patients in MS-DRGs 291 - 293 with these ICD-9-CM codes as primary diagnosis only:	398.91	Rheumatic heart failure
	402.01	Malignant hypertensive heart disease with heart failure
	402.11	Benign hypertensive heart disease with heart failure
	402.91	Unspecified hypertensive heart disease with heart failure
	404.01	Malignant hypertensive heart and chronic kidney disease, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
	404.03	Malignant hypertensive heart and chronic kidney disease, with heart failure and with chronic kidney disease stage V or end stage renal disease
	404.11	Benign hypertensive heart and chronic kidney disease, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
	404.13	Benign hypertensive heart and chronic kidney disease, with heart failure and chronic kidney disease stage V or end stage renal disease
	404.91	Unspecified hypertensive heart and chronic kidney disease, with heart failure and with chronic kidney disease stage I through stage IV, or unspecified
	404.93	Unspecified hypertensive heart and chronic kidney disease, with heart failure and chronic kidney disease stage V or end stage renal disease
	428.0	Congestive heart failure, unspecified
	428.1	Left heart failure
	428.20	Systolic heart failure, unspecified
	428.21	Acute systolic heart failure
	428.22	Chronic systolic heart failure
	428.23	Systolic heart failure, acute on chronic
	428.30	Diastolic heart failure, unspecified
	428.31	Diastolic heart failure, acute
	428.32	Diastolic heart failure, chronic
	428.33	Diastolic heart failure, acute on chronic
	428.40	Combined systolic and diastolic heart failure, unspecified
	428.41	Combined systolic and diastolic heart failure, acute
	428.42	Combined systolic and diastolic heart failure, chronic
	428.43	Combined systolic and diastolic heart failure, acute on chronic
	428.9	Unspecified heart failure

HF patients in MS-DRGs 291 - 293 with these ICD-10-CM codes as primary diagnosis only:	I501	Left ventricular failure
	I5020	Unspecified systolic (congestive) heart failure
	I5021	Acute systolic (congestive) heart failure
	I5022	Chronic systolic (congestive) heart failure
	I5023	Acute on chronic systolic (congestive) heart failure
	I5030	Unspecified diastolic (congestive) heart failure
	I5031	Acute diastolic (congestive) heart failure
	I5032	Chronic diastolic (congestive) heart failure
	I5033	Acute on chronic diastolic (congestive) heart failure
	I5040	Unspecified combined systolic (congestive) and diastolic (congestive) heart failure
	I5041	Acute combined systolic (congestive) and diastolic (congestive) heart failure
	I5042	Chronic combined systolic (congestive) and diastolic (congestive) heart failure
	I5043	Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure
	I509	Heart failure, unspecified
	I0981	Rheumatic heart failure
	I110	Hypertensive heart disease with heart failure
	I130	Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease
	I132	Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease
	The HF category was restricted to nonsurgical patients.	

Coronary artery bypass graft (CABG) patient group

CABG patients in MS-DRGs 231 - 236 (includes all ICD-9-CM and ICD-10-CM procedure codes, principal or secondary, in these MS-DRGs).

Percutaneous coronary intervention (PCI) patient group

PCI patients in MS-DRGs 246 - 251 with any of these ICD-9-CM procedure codes:	00.66	Percutaneous transluminal coronary angioplasty (PTCA)
	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).	
PCI patients in MS-DRGs 246 - 251 with any of these ICD-10-CM procedure codes:	0270346	Dilation of coronary artery, one site, bifurcation, with drug-eluting intraluminal device, percutaneous approach
	027034Z	Dilation of coronary artery, one site with drug-eluting intraluminal device, percutaneous approach
	02703D6	Dilation of coronary artery, one site, bifurcation, with intraluminal device, percutaneous approach
	02703DZ	Dilation of coronary artery, one site with intraluminal device, percutaneous approach
	02703T6	Dilation of coronary artery, one site, bifurcation, with radioactive intraluminal device, percutaneous approach
	02703TZ	Dilation of coronary artery, one site with radioactive intraluminal device, percutaneous approach
	02703Z6	Dilation of coronary artery, one site, bifurcation, percutaneous approach
	02703ZZ	Dilation of coronary artery, one site, percutaneous approach
	0270446	Dilation of coronary artery, one site, bifurcation, with drug-eluting intraluminal device, percutaneous endoscopic approach
	027044Z	Dilation of coronary artery, one site with drug-eluting intraluminal device, percutaneous endoscopic approach
	02704D6	Dilation of coronary artery, one site, bifurcation, with intraluminal device, percutaneous endoscopic approach
	02704DZ	Dilation of coronary artery, one site with intraluminal device, percutaneous endoscopic approach

02704T6	Dilation of coronary artery, one site, bifurcation, with radioactive intraluminal device, percutaneous endoscopic approach
02704TZ	Dilation of coronary artery, one site with radioactive intraluminal device, percutaneous endoscopic approach
02704Z6	Dilation of coronary artery, one site, bifurcation, percutaneous endoscopic approach
02704ZZ	Dilation of coronary artery, one site, percutaneous endoscopic approach
0271346	Dilation of coronary artery, two sites, bifurcation, with drug-eluting intraluminal device, percutaneous approach
027134Z	Dilation of coronary artery, two sites with drug-eluting intraluminal device, percutaneous approach
02713D6	Dilation of coronary artery, two sites, bifurcation, with intraluminal device, percutaneous approach
02713DZ	Dilation of coronary artery, two sites with intraluminal device, percutaneous approach
02713T6	Dilation of coronary artery, two sites, bifurcation, with radioactive intraluminal device, percutaneous approach
02713TZ	Dilation of coronary artery, two sites with radioactive intraluminal device, percutaneous approach
02713Z6	Dilation of coronary artery, two sites, bifurcation, percutaneous approach
02713ZZ	Dilation of coronary artery, two sites, percutaneous approach
0271446	Dilation of coronary artery, two sites, bifurcation, with drug-eluting intraluminal device, percutaneous endoscopic approach
027144Z	Dilation of coronary artery, two sites with drug-eluting intraluminal device, percutaneous endoscopic approach
02714D6	Dilation of coronary artery, two sites, bifurcation, with intraluminal device, percutaneous endoscopic approach
02714Dz	Dilation of coronary artery, two sites with intraluminal device, percutaneous endoscopic approach
02714T6	Dilation of coronary artery, two sites, bifurcation, with radioactive intraluminal device, percutaneous endoscopic approach
02714TZ	Dilation of coronary artery, two sites with radioactive intraluminal device, percutaneous endoscopic approach
02714Z6	Dilation of coronary artery, two sites, bifurcation, percutaneous endoscopic approach
02714ZZ	Dilation of coronary artery, two sites, percutaneous endoscopic approach
0272346	Dilation of coronary artery, three sites, bifurcation, with drug-eluting intraluminal device, percutaneous approach
027234Z	Dilation of coronary artery, three sites with drug-eluting intraluminal device, percutaneous approach
02723D6	Dilation of coronary artery, three sites, bifurcation, with intraluminal device, percutaneous approach
02723DZ	Dilation of coronary artery, three sites with intraluminal device, percutaneous approach
02723T6	Dilation of coronary artery, three sites, bifurcation, with radioactive intraluminal device, percutaneous approach
02723TZ	Dilation of coronary artery, three sites with radioactive intraluminal device, percutaneous approach
02723Z6	Dilation of coronary artery, three sites, bifurcation, percutaneous approach
02723ZZ	Dilation of coronary artery, three sites, percutaneous approach
0272446	Dilation of coronary artery, three sites, bifurcation, with drug-eluting intraluminal device, percutaneous endoscopic approach
027244Z	Dilation of coronary artery, three sites with drug-eluting intraluminal device, percutaneous endoscopic approach
02724D6	Dilation of coronary artery, three sites, bifurcation, with intraluminal device, percutaneous endoscopic approach
02724DZ	Dilation of coronary artery, three sites with intraluminal device, percutaneous endoscopic approach
02724T6	Dilation of coronary artery, three sites, bifurcation, with radioactive intraluminal device, percutaneous endoscopic approach

02724TZ	Dilation of coronary artery, three sites with radioactive intraluminal device, percutaneous endoscopic approach
02724Z6	Dilation of coronary artery, three sites, bifurcation, percutaneous endoscopic approach
02724ZZ	Dilation of coronary artery, three sites, percutaneous endoscopic approach
0273346	Dilation of coronary artery, four or more sites, bifurcation, with drug-eluting intraluminal device, percutaneous approach
027334Z	Dilation of coronary artery, four or more sites with drug-eluting intraluminal device, percutaneous approach
02733D6	Dilation of coronary artery, four or more sites, bifurcation, with intraluminal device, percutaneous approach
02733DZ	Dilation of coronary artery, four or more sites with intraluminal device, percutaneous approach
02733T6	Dilation of coronary artery, four or more sites, bifurcation, with radioactive intraluminal device, percutaneous approach
02733TZ	Dilation of coronary artery, four or more sites with radioactive intraluminal device, percutaneous approach
02733Z6	Dilation of coronary artery, four or more sites, bifurcation, percutaneous approach
02733ZZ	Dilation of coronary artery, four or more sites, percutaneous approach
0273446	Dilation of coronary artery, four or more sites, bifurcation, with drug-eluting intraluminal device, percutaneous endoscopic approach
027344Z	Dilation of coronary artery, four or more sites with drug-eluting intraluminal device, percutaneous endoscopic approach
02734D6	Dilation of coronary artery, four or more sites, bifurcation, with intraluminal device, percutaneous endoscopic approach
02734DZ	Dilation of coronary artery, four or more sites with intraluminal device, percutaneous endoscopic approach
02734T6	Dilation of coronary artery, four or more sites, bifurcation, with radioactive intraluminal device, percutaneous endoscopic approach
02734TZ	Dilation of coronary artery, four or more sites with radioactive intraluminal device, percutaneous endoscopic approach
02734Z6	Dilation of coronary artery, four or more sites, bifurcation, percutaneous endoscopic approach
02734ZZ	Dilation of coronary artery, four or more sites, percutaneous endoscopic approach
02C03ZZ	Extirpation of matter from coronary artery, one site, percutaneous approach
02C04ZZ	Extirpation of matter from coronary artery, one site, percutaneous endoscopic approach
02C13ZZ	Extirpation of matter from coronary artery, two sites, percutaneous approach
02C14ZZ	Extirpation of matter from coronary artery, two sites, percutaneous endoscopic approach
02C23ZZ	Extirpation of matter from coronary artery, three sites, percutaneous approach
02C24ZZ	Extirpation of matter from coronary artery, three sites, percutaneous endoscopic approach
02C33ZZ	Extirpation of matter from coronary artery, four or more sites, percutaneous approach
02Z34ZZ	Extirpation of matter from coronary artery, four or more sites, percutaneous endoscopic approach
X2C0361	Extirpation of matter from coronary artery, one site using orbital atherectomy technology, percutaneous approach, new technology group 1
X2C1361	Extirpation of matter from coronary artery, two sites using orbital atherectomy technology, percutaneous approach, new technology group 1
X2C2361	Extirpation of matter from coronary artery, three sites using orbital atherectomy technology, percutaneous approach, new technology group 1
X2C3361	Extirpation of matter from coronary artery, four or more sites using orbital atherectomy technology, percutaneous approach, new technology group 1

PCI group definition

While most patients undergoing an inpatient 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% 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 Watson Health proprietary risk-adjustment models and severity-adjustment models take into account POA data reported in the Medicare Provider Analysis and Review (MEDPAR) data sets. Our inpatient mortality, complications, LOS, and cost-per-case models develop expected values based only on conditions that are present on admission.

From 2010 through 2016, 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% 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	2016
Principal diagnosis	0.00%	4.26%	4.68%	4.37%	3.40%	4.99%	2.45%
Secondary diagnosis	0.00%	15.05%	19.74%	22.10%	21.58%	23.36%	21.64%

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.

Watson Health makes valid normative comparisons of inpatient 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 (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 Software (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 Watson 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.

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) (Z66) 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.

Risk-adjusted mortality index models

Watson Health has developed an overall inpatient 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 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) (Z515) 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) (Z66) 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 considers 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 Watson 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 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.

The complications used in the model are listed on the following page:

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, vascular, and hemodialysis devices	Surgical, including cardiac
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 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 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 considers 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 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 (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% 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% more outcomes than expected, and an index of 0.90 indicates 10% fewer outcomes than expected based on the experience of the norm. The index can be calculated across a variety of groupings (system, hospital, clinical service line, and MS-DRG).

Percentage of coronary artery bypass graft patients with internal mammary artery use

We include only patients with an isolated CABG procedure in the denominator. In addition, patients with a prior CABG procedure are excluded. The excluded cases are those coded with an ICD-9-CM DX of 41402, 41403, 41404, 41405, 99603, V4581 or ICD-10-CM DX of I25700, I25701, I25708, I25709, I25710, I25711, I25718, I25719, I25720, I25721, I25728, I25729, I25730, I25731, I25738, I25739, I25790, I25791, I25798, I25799, I25810, T82211A, T82211D, T82211S, T82212A, T82212D, T82212S, T82213A, T82213D, T82213S, T82218A, T82218D, T82218S, Z951 (any mention).

Length-of-stay and cost-per-case methodologies

The study's LOS and cost-per-case performance measures use Watson Health severity-adjusted resource demand methodologies. In response to the 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 factors such as MS-DRGs, systems, hospitals, clinical service lines, geographic regions, and physicians. The methodology adjusts for differences in diagnosis type and illness severity, based on ICD-9-CM and ICD-10-CM coding. It also adjusts for patient age, gender, and admission status. These models consider 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 US.

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.

Excess days in acute care after hospitalization for acute myocardial infarction and heart failure

In 2016, CMS first provided hospitals with their results on the 30-day AMI and HF excess days in acute care (EDAC) measures, and they appeared on the CMS Hospital Compare website publicly for the first time in July 2017. CMS intends to include them in the fiscal year 2018 payment determination for the Hospital Inpatient Quality Reporting Program. We are including them here in the 2018 edition of the 50 Top Cardiovascular Hospitals study, as information-only measures.

* In this study, the 2016 hospital cost reports were used unless they were unavailable; then 2015 reports were used instead.

These values represent the result of a risk-standardized algorithm applied to longitudinal Medicare beneficiary data combined across a three-year rolling data period. CMS defines days in acute care as days spent in an emergency department, admitted to observation status, or admitted as an unplanned readmission for any cause within 30 days from the date of discharge from the index AMI or HF hospitalization. From a patient perspective, days in acute care from any cause may represent an adverse event; hence, our decision to begin tracking and analyzing this measure for possible inclusion as a ranked measure in a future study.

Results are expressed as an integer that combines each of the three types of excess days, with a negative value indicating fewer excess days observed than expected, and a positive value indicating more excess days than expected.

Performance measure normalization

The inpatient 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.

For the inpatient 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 expected values 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.

Interquartile range methodology

For each individual cost-per-case measure, we calculate an an interquartile range (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 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% 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% 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. In addition we do not report percent change when the measure value can be positive, negative, or zero.

Footnotes

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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.

8. AOA residency information was collected from the AOA website (opportunities. osteopathic.org) in May 2014.

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Produced in the United States of America November 2017

TOP 18386 1117

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