Technical Notes for HCAHPS Star Ratings

(Revised for January 2027 Public Reporting)

Overview of HCAHPS Star Ratings

As part of the initiative to add five-star quality ratings to its Care Compare websites, the Centers for Medicare & Medicaid Services (CMS) publish HCAHPS Star Ratings on its Hospital Compare website. Star Ratings make it easier for consumers to use the information on the Care Compare websites and spotlight excellence in healthcare quality. Twelve HCAHPS Star Ratings appear on Hospital Compare: one for each of the eleven publicly reported HCAHPS measures, plus an HCAHPS Summary Star Rating. CMS updates the HCAHPS Star Ratings each quarter. HCAHPS Star Ratings are based on the same data that are used to create the HCAHPS measures reported on the Hospital Compare website.

In this document we explain, through a series of steps, how the HCAHPS Star Ratings are created and provide an extended example to illustrate each step of the process. A set of Appendices (A, B and C) contain the current measure values for the adjustment and assignment of HCAHPS Star Ratings. Appendix D briefly describes the clustering algorithm.

The public reporting of the HCAHPS Star Ratings in January 2027 will be based on patients discharged between April 1, 2025 and March 31, 2026.

HCAHPS Measures Receiving HCAHPS Stars

HCAHPS Star Ratings are applied to each of the 11 publicly reported HCAHPS measures. Starting October 2026 public reporting, measures such as Responsiveness of Hospital Staff, Restfulness of Hospital Environment, Care Coordination, and Information about Symptoms are added to star ratings. Measures are created from specific questions (also referred to as items) on the Updated HCAHPS Survey, as follows:

- **HCAHPS Composite Measures**
  1. Communication with Nurses (comprised of three HCAHPS Survey items) - Q1, Q2, Q3
  2. Communication with Doctors (comprised of three HCAHPS Survey items) - Q4, Q5, Q6
  3. Restfulness of Hospital Environment (comprised of three HCAHPS Survey items) - Q8, Q9, Q18
  4. Care Coordination (comprised of three HCAHPS Survey items) - Q10, Q11, Q19
  5. Responsiveness of Hospital Staff (comprised of two HCAHPS Survey items) - Q13, Q14
  6. Communication About Medicines (comprised of two HCAHPS Survey items) - Q16, Q17
  7. Discharge Information (comprised of two HCAHPS Survey items) - Q22, Q23
- **HCAHPS Individual Items**
  8. Cleanliness of Hospital Environment - Q7
  9. Information About Symptoms - Q20
- **HCAHPS Global Items**
  10. Hospital Rating - Q24
  11. Recommend the Hospital - Q25

100 Survey Minimum for HCAHPS Star Ratings

Hospitals must have at least 100 completed HCAHPS surveys over a given four-quarter period in order to receive HCAHPS Star Ratings. In addition, hospitals must be eligible for public reporting of HCAHPS measures. Hospitals with fewer than 100 completed surveys do not receive Star Ratings; however, their HCAHPS measure scores are still publicly reported on Hospital Compare.

Construction and Adjustment of HCAHPS Linear Scores

CMS employs all survey responses in the construction of HCAHPS Star Ratings. The responses to the survey items used in each HCAHPS measure (shown below) are scored linearly, adjusted, rescaled, averaged across quarters, and rounded to produce a 0-100 linear-scaled score ("Linear Score"). The five steps occur as follows:

Linear scoring

The Linear Score used in HCAHPS Star Ratings is closely related to the "top-box," "middle-box" and "bottom-box" scores publicly reported on the Hospital Care Compare Web site.

Individual responses to the HCAHPS Survey are scored as follows:

For items 1-11, 13-14 and 16-17:

- "Never" = 1; "Sometimes" = 2; "Usually" = 3; and "Always" = 4

For items 18-20:

- "No" = 2; "Yes, somewhat" = 3; and "Yes, definitely" = 4

For items 22 and 23:

- "No" = 0; and "Yes" = 1

For item 24:

- Hospital Rating "0" = 0; Hospital Rating "1" = 1; Hospital Rating "2" = 2 … Hospital Rating "10" = 10

For item 25:

- "Definitely No" = 1; "Probably No" = 2; "Probably Yes" = 3; and "Definitely Yes" = 4

The item responses are averaged at the hospital level to form the hospital-level mean for each measure.

Adjustment of HCAHPS linear scores

CMS applies adjustments for the effects of survey mode, patient mix, and quarterly weighting through a series of steps, as follows.

First, HCAHPS quarterly scores are adjusted by CMS for the effect of survey mode administration (Mail-Only, Phone-Only, Mail-Phone, Web-Mail, Web-Phone, or Web-Mail-Phone, beginning with January 2025 discharges). CMS derived the survey mode adjustments from a large-scale, randomized mode experiment. The mode adjustments are included in Appendix A. These adjustments are applied to HCAHPS scores on the scale shown above. These values are shown for each answer option on the survey instrument. With the new web-first survey modes, adjustment for survey mode may differ within a hospital. For detailed information about the mode experiment and survey mode adjustment, please see www.hcahpsonline.org.

Second, CMS applies patient-mix adjustment (PMA) to quarterly HCAHPS scores to account for the tendency of certain patient sub-groups to respond more positively or negatively to the HCAHPS Survey. PMA enables fair comparisons across hospitals by adjusting hospital scores as if all hospitals had an identical mix of patient characteristics. The patient-mix adjustment table can be found in Appendix B (Table 1). Appendix B also contains the national means (Table 2) for patient-mix variables. Similar to the survey mode adjustments, these PMA adjustments are applied on the original scale shown on the HCAHPS survey instrument for each measure. information about the application of the HCAHPS patient-mix adjustments, including the definition of the PMA factors, can be found in the documents on the HCAHPS On-Line Web site, www.hcahpsonline.org, under the *"Mode & Patient-Mix Adj"* tab.

Note: In calculation of official HCAHPS scores, CMS applies survey mode adjustment prior to using the CAHPS SAS macro to apply PMA for each hospital and establish the national adjustments for patient mix. However, hospitals or survey vendors trying to estimate their scores can apply PMA and mode adjustment in any order.

The example shown later adds PMA first, and then survey mode adjustment, to account for the scale of adjustments in Appendices A and B.

Rescaling of HCAHPS linear adjusted scores
Each adjusted HCAHPS linear measure score on the original scale (shown above) is then transformed into a 0-100 linear-scaled score using the following conversion:

The adjusted hospital-level measure mean, **M**, minus the lowest possible response to the measure, **R**, divided by the highest possible response to the measure, **K**, minus the lowest response, R. An example follows:

$$100 * \frac{M - R}{K - R}$$

Weighted Average of Quarters of HCAHPS linear scores
The four-quarter averages of HCAHPS linear scores are weighted proportionately to the number of eligible patients seen by the hospital in each quarter of the reporting period. Specifically, each quarter's score has a quarterly weight equal to that quarter's eligible discharge size divided by the total eligible discharge size for the four quarters that make up the reporting period.

Rounding of HCAHPS linear scores
The four-quarter averages of HCAHPS linear scores are rounded to integer values (whole numbers) using standard rounding rules, as follows:

> If the unrounded four-quarter average is less than [X.5], then round down to nearest whole integer. If the unrounded four-quarter average is equal to or greater than [X.5], then round up to nearest whole integer.

An example of the calculation of an HCAHPS Linear Score
The following is an example of the construction and adjustment of an HCAHPS linear score.

Note: for hospitals attempting to estimate their linear mean scores, these steps have been updated to apply PMA first, then survey mode adjustment, given the scales used in the adjustment tables of Appendices A and B.

Step 1: Linear scoring
For a single quarter from Hospital A, 5 patients responded to the HCAHPS Survey Cleanliness item (item 7) as follows: 4, 4, 3, 2, and 4. The mean of these responses is **3.4**.

Step 2: Patient-mix adjustment of HCAHPS linear scores
Calculate Hospital A's PMA using the national patient-mix adjustments and national means found in Appendix B of this document. The instructions for calculating a hospital's PMA can be found in the "Mode & Patient-Mix Adj" tab on www.hcahpsonline.org. For this example, assume Hospital A has a total PMA of **-0.038** for the Cleanliness item. This adjustment is on the original linear scale of 1 to 4.

The linear score after PMA is 3.4 – 0.038 = **3.362.**

Step 3: Rescaling of HCAHPS linear scores and mode adjustment
Cleanliness has a maximum response of 4 (K) and a minimum response of 1 (R).
To put this score into the 0-100 scale:

> 100*((3.362 – 1) / (4 - 1)) = **78.73**

Thus, **78.73** is the linear mean score, with PMA included, for Cleanliness for Hospital A.

Note: For measures that include questions Q18, Q19, Q20, rescaling is performed using the formula: 100 × (M − 4/3) / (4 − 4/3).

After rescaling, apply survey mode adjustment. Hospital A uses the Web-Phone survey mode. For a single quarter, this hospital had an email address (EMA) for 20% of their patients and did not have an email address (NEMA) for 80% of their patients. Note, these mode adjustments may alternatively be applied at the patient level and then aggregated accordingly.

Using Appendix A, the linear mean mode adjustment on the 0-100 scale at the hospital-level for Cleanliness: 20%*(2.26 WP EMA) + 80%*(0.02 Phone/WP NEMA) = 0.468

This hospital has a total Web-Phone mode adjustment of **0.468**

Next, add the Web-Phone mode adjustment to the previously calculated score with PMA:

Final quarterly adjusted (PMA and mode) score: 78.73 + 0.468 = **79.20**

Step 4: Weighted Average of Quarters of HCAHPS linear scores
The four-quarter averages of HCAHPS linear scores are weighted proportionately to the number of eligible patients seen by the hospital in each quarter of the reporting period. For instance, a hospital has the following scores and numbers of eligibles for the four quarters in a reporting period:

Q1: 72.35, 4 eligibles; Q2: 67.26, 7 eligibles; Q3: 75.94, 8 eligibles; Q4: 79.20, 5 eligibles.

$$4 + 7 + 8 + 5 = 24\ total\ eligibles$$
$$\left(72.35 * \left(\frac{4}{24}\right)\right) + \left(67.26 * \left(\frac{7}{24}\right)\right) + \left(75.94 * \left(\frac{8}{24}\right)\right) + \left(79.20 * \left(\frac{5}{24}\right)\right) = 73.49\ four\ quarter\ average$$

Step 5: Rounding of HCAHPS linear scores
Four-quarter average HCAHPS linear scores are rounded to the nearest integer using standard rounding rules. In this case, 73.49 is rounded to 73 because 0.49 is less than 0.5.

Conversion of Linear Scores into HCAHPS Star Ratings for the 8 HCAHPS Measures
Next, CMS assigns 1, 2, 3, 4, or 5 whole stars (only whole stars are assigned; partial stars are not used) for each HCAHPS measure by applying statistical methods that utilize relative distribution and clustering.

The Star Rating for each of the 11 HCAHPS measures is determined by applying a clustering algorithm to the individual measure scores. Conceptually, the clustering algorithm identifies the 'gaps' in the data and creates five categories (one for each star rating) such that scores of hospitals in the same score category (star rating) are as similar as possible, and scores of hospitals in different categories are as different as possible. This clustering algorithm is the same one employed by CMS to determine Medicare Part C and Part D Star Ratings.

The variance in measure scores is separated into within-cluster and between-cluster sum of squares components. The algorithm develops clusters that minimize the variance of measure scores within the clusters. More specifically, the clustering algorithm minimizes the within-cluster sum of squares for each of the Star Ratings levels. The cut points (boundaries) for star assignments are derived from the range of individual measure Star Ratings per cluster. The star levels associated with each cluster are determined by ordering the means of

each cluster. The cut points for the current HCAHPS Star Ratings are shown in Appendix C. Additional information about the clustering method can be found in Appendix D.

The HCAHPS Summary Star Rating

In addition to Star Ratings for the 11 HCAHPS measures, CMS introduced a new metric, the HCAHPS Summary Star Rating, which is the average of all the Star Ratings of the HCAHPS measures. The HCAHPS Summary Star Rating is constructed from the following components:

- **Star Ratings from each of the 7 HCAHPS Composite Measures**
  - Communication with Nurses, Communication with Doctors, Restfulness of Hospital Environment, Care Coordination, Responsiveness of Hospital Staff, Communication About Medicines, and Discharge Information.
- **A single Star Rating for 2 HCAHPS Individual Items**
  - The average of the Star Ratings assigned to Cleanliness of Hospital Environment and Information About Symptoms.
- **A single Star Rating for 2 HCAHPS Global Items**
  - The average of the Star Ratings assigned to Hospital Rating and Recommend the Hospital.

The 9 Star Ratings (7 Star Ratings for Composite Measure + 1 Star Rating for Individual Items + 1 Star Rating for Global Items) are combined as a simple average to form the HCAHPS Summary Star Rating. In the final step, normal rounding rules are applied to the average of HCAHPS Summary Star Rating (1, 2, 3, 4, or 5 stars).

An example of the calculation of the HCAHPS Summary Star Rating.

The following is an example of how to calculate the HCAHPS Summary Star Rating. Suppose a hospital has Star Ratings for each of the 11 HCAHPS measures as shown in following table.

	11 HCAHPS Measure Star Ratings	**9 Star Ratings Used in HCAHPS Summary Star Rating**	**HCAHPS Summary Star Rating Average *(unrounded)***	**HCAHPS Summary Star Rating *(rounded)***
HCAHPS Composite Measures			(4+3+5+3+4+4+4+4.5+3.5)/9 = 3.8889	**4**
Communication with Nurses	4	4		
Communication with Doctors	3	3		
Restfulness of Hospital Environment	5	5		
Care Coordination	3	3		
Responsiveness of Hospital Staff	4	4		
Communication About Medicines	4	4		
Discharge Information	4	4		
HCAHPS Individual Items				
Cleanliness of Hospital Environment	5	(5+4)/2 = 4.5		
Information About Symptoms	4			
HCAHPS Global Items				
Hospital Rating	4	(4+3)/2 = 3.5		
Recommend the Hospital	3			

Step 1: Calculate a Star Rating for HCAHPS Individual Items by averaging the Star Ratings for Cleanliness of Hospital Environment and Information about Symptoms.

In this example, the Star Rating for HCAHPS Individual Items = (5+4)/2 = 4.5.

Step 2: Calculate a Star Rating for HCAHPS Global Items by averaging the Star Ratings for Hospital Rating and Recommend the Hospital.

In this example, the Star Rating for HCAHPS Global Items = (4+3)/2 = 3.5. ***Note: Do not round this average.***

Step 3: Calculate the HCAHPS Summary Star Rating as the average of the 7 composite measure Star Ratings, the Star Rating for HCAHPS Individual Items, and the Star Rating for HCAHPS Global Items.

In this example, the HCAHPS Summary Star Rating = (4+3+4+4+4+5+3+4.5+3.5)/9 = 3.8889.

Step 4: Lastly, round the HCAHPS Summary Star Rating Average using the rounding table below.

In this example, the hospital's HCAHPS Summary Star Rating rounds to 4 stars.

CMS uses standard rounding rules for the assignment of HCAHPS Summary Stars, as follows:

HCAHPS Summary Star Rating Average	HCAHPS Summary Star Rating Assignment
≥1.00 and <1.50	1 Star
≥1.50 and <2.50	2 Stars
≥2.50 and <3.50	3 Stars
≥3.50 and <4.50	4 Stars
≥4.50 and ≤5.00	5 Stars

Appendix A: Survey Mode Adjustments of HCAHPS Linear Scores to Adjust to a Reference of Mail Mode (for HCAHPS score adjustments beginning with January 1, 2025 discharges)

	Phone/NEMA, Web-Phone	Mail-Phone/NEMA, Web-Mail-Phone	EMA, Web-Mail	EMA, Web-Phone	EMA, Web-Mail-Phone
HCAHPS Composite Measures					
Communication with Nurses	-1.33	0.27	-0.54	-0.31	-0.35
Communication with Doctors	-0.17	0.17	-0.98	0.43	-0.29
Restfulness of Hospital Environment	-2.36	-0.35	0.99	0.47	1.19
Care Coordination	-1.35	0.75	-0.20	0.60	0.42
Responsiveness of Hospital Staff	-0.80	1.58	0.25	0.64	0.40
Communication About Medicines	-1.74	-0.35	-0.45	0.07	-2.09
Discharge Information	-1.34	0.39	0.28	-0.50	-0.38
HCAHPS Individual Items					
Cleanliness of Hospital Environment	0.02	0.42	0.83	2.26	0.70
Information About Symptoms	-2.10	0.53	-0.89	0.09	-0.19
HCAHPS Global Items					
Hospital Rating	-1.25	0.38	-0.28	0.39	0.56
Recommend the Hospital	-0.55	0.34	0.51	1.04	1.14

Note: Adjustments are shown on the 0-100 linear mean scale.

Appendix B, Table 1: HCAHPS Patient-Mix Adjustments of Linear Scores for Patients Discharged between Quarter 2, 2025 and Quarter 1, 2026 (April 1, 2025 to March 31, 2026)[1]

	Communication with Nurses	Communication with Doctors	Restfulness of Hospital Env.	Care Coordination	Responsiveness of Hospital Staff	Communication About Medicines	Discharge Information	Cleanliness of Hospital Env.	Information About Symptoms	Hospital Rating	Recommend the Hospital
Education (per level; 1=8th grade or less and 6=More than 4-year college degree)	0.0177	0.0249	0.0460	0.0329	0.0298	0.0546	0.0074	0.0143	0.0279	0.1219	0.0205
Self-Rated Health (per level; 1=Excellent and 5=Poor)	0.0525	0.0537	0.0725	0.0590	0.0801	0.0786	0.0103	0.0548	0.0578	0.2491	0.0771
Self-Rated Mental Health (per level; 1=Excellent and 5=Poor)	0.0520	0.0560	0.0509	0.0589	0.0655	0.0746	0.0169	0.0361	0.0577	0.1556	0.0493
Planned Stay	-0.0616	-0.0947	-0.1220	-0.1082	-0.1082	-0.1344	-0.0450	-0.0852	-0.1235	-0.2871	-0.0973
Response Percentile (per 1% of response percentile)	0.0024	0.0024	0.0001	0.0017	0.0040	0.0042	0.0008	0.0008	0.0007	0.0032	0.0018
Spanish	-0.0345	-0.0678	-0.1274	-0.0644	-0.0682	-0.0904	-0.0256	0.0098	-0.0860	-0.5296	-0.1596
Chinese	0.0531	0.0221	-0.1407	0.0166	0.0377	-0.0109	-0.0280	0.0348	-0.0843	-0.0652	-0.0193
Other (“Another Language”)	0.0009	-0.0297	-0.1759	-0.0349	-0.0052	-0.0576	-0.0029	0.0219	-0.0607	-0.1644	-0.0562
English (REFERENCE)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Age 18-24	0.0865	0.1374	0.1282	0.1495	0.1639	-0.0789	-0.0136	0.0436	0.0718	0.8594	0.2460
Age 25-34	0.0482	0.1024	0.0806	0.1134	0.0763	-0.1285	-0.0234	0.0392	0.0488	0.6993	0.1891
Age 35-44	0.0427	0.0889	0.0926	0.1035	0.0629	-0.1348	-0.0235	0.0506	0.0618	0.6140	0.1669
Age 45-54	0.0019	0.0339	0.0727	0.0468	0.0228	-0.1546	-0.0346	0.0515	0.0244	0.3915	0.0956
Age 55-64	-0.0262	-0.0064	0.0586	0.0105	-0.0077	-0.1543	-0.0384	0.0559	0.0029	0.1986	0.0395
Age 65-74	-0.0431	-0.0314	0.0497	-0.0150	-0.0226	-0.1329	-0.0391	0.0394	-0.0110	0.0554	0.0096
Age 75-84	-0.0406	-0.0317	0.0171	-0.0250	-0.0304	-0.0853	-0.0212	0.0191	-0.0085	-0.0404	-0.0120
Age 85+ (REFERENCE)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Male Medical	-0.0127	-0.0027	-0.0003	-0.0336	-0.0117	-0.1020	-0.0331	-0.1073	-0.0909	-0.0630	-0.0335
Male Surgical	-0.0138	-0.1283	-0.0112	-0.0868	-0.0172	-0.1169	-0.0724	-0.1117	-0.1510	-0.3058	-0.1132
Female Surgical	0.0070	-0.1306	-0.0303	-0.0500	0.0019	-0.0015	-0.0507	-0.0038	-0.0715	-0.2368	-0.0768
Female Maternity	-0.0638	-0.1456	-0.0977	-0.1350	-0.1659	-0.1867	-0.0491	-0.0068	-0.0950	-0.5032	-0.1752
Female Medical (REFERENCE)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Surgical Line * Age[2]	-0.0007	0.0119	0.0045	0.0038	-0.0039	0.0004	0.0019	-0.0022	0.0040	0.0230	0.0074
Maternity Line * Age[2]	-0.0020	0.0069	0.0262	0.0092	0.0029	0.0190	0.0048	0.0064	-0.0173	0.0586	0.0139

[1] Note: Adjustments shown on the original response scale; 1-4 for most items. See ‘Linear scoring’ on page 2.

[2] Age takes on the values of 1 to 8 as follows: (1: 18 to 24); (2: 25 to 34); (3: 35 to 44); (4: 45 to 54); (5: 55 to 64); (6: 65 to 74); (7: 75 to 84); and (8: 85+).

Appendix B, Table 2: National Means of Patient-Mix Adjustment Variables for Patients Discharged between Quarter 2, 2025 and Quarter 1, 2026 (April 1, 2025 to March 31, 2026)

	National Means
Education (per level; 1=8th grade or less and 6=More than 4-year college degree)	3.776
Self-Rated Health (per level; 1=Excellent and 5=Poor)	2.965
Self-Rated Mental Health (per level; 1=Excellent and 5=Poor)	2.345
Planned Stay	20.13%
Response Percentile	13.92%
LANGUAGE SPOKEN AT HOME	
Spanish	4.57%
Chinese	0.25%
Other ("Another Language")	1.73%
English (REFERENCE)	93.46%
AGE	
Age 18-24	1.66%
Age 25-34	5.68%
Age 35-44	4.35%
Age 45-54	5.03%
Age 55-64	12.36%
Age 65-74	26.62%
Age 75-84	29.56%
Age 85+ (REFERENCE)	14.74%
SERVICE LINE	
Male Medical	31.88%
Male Surgical	11.09%
Female Surgical	11.42%
Female Maternity	7.16%
Female Medical (REFERENCE)	38.44%
INTERACTIONS	
Surgical Line * Age[3]	1.319
Maternity Line * Age[3]	0.151

[3] Age takes on the values of 1 to 8 as follows: (1: 18 to 24); (2: 25 to 34); (3: 35 to 44); (4: 45 to 54); (5: 55 to 64); (6: 65 to 74); (7: 75 to 84); and (8: 85+).

Appendix C: HCAHPS Star Rating Cut Points for Patients Discharged Between Quarter 2, 2025 and Quarter 1, 2026 (April 1, 2025 to March 31, 2026)

	1 Star	2 Stars	3 Stars	4 Stars	5 Stars
HCAHPS Composite Measures					
Communication with Nurses	<87	≥87 to <90	≥90 to <92	≥92 to <94	≥94
Communication with Doctors	<86	≥86 to <89	≥89 to <92	≥92 to <94	≥94
Restfulness of Hospital Environment	<73	≥73 to <77	≥77 to <81	≥81 to <85	≥85
Care Coordination	<82	≥82 to <86	≥86 to <89	≥89 to <93	≥93
Responsiveness of Hospital Staff	<77	≥77 to <82	≥82 to <86	≥86 to <90	≥90
Communication About Medicines	<71	≥71 to <76	≥76 to <80	≥80 to <84	≥84
Discharge Information	<78	≥78 to <83	≥83 to <88	≥88 to <92	≥92
HCAHPS Individual Items					
Cleanliness of Hospital Environment	<78	≥78 to <82	≥82 to <86	≥86 to <91	≥91
Information About Symptoms	<82	≥82 to <85	≥85 to <88	≥88 to <92	≥92
HCAHPS Global Items					
Hospital Rating	<81	≥81 to <86	≥86 to <89	≥89 to <93	≥93
Recommend the Hospital	<76	≥76 to <83	≥83 to <87	≥87 to <91	≥91

Appendix D: Individual Measure Star Assignment Process

Below are detailed steps of the clustering method to develop individual measure stars. For each measure, the clustering method does the following:

1. Produce the individual measure distance matrix.
2. Group the measure scores into an initial set of clusters.
3. Select the final set of clusters.

1. Produce the individual measure distance matrix.
For each pair of hospital j and k (j>=k) among the n hospitals with measure score data, compute the Euclidian distance of their measure scores (e.g., the absolute value of the difference between the two measure scores). Enter this distance in row j and column k of a distance matrix with n rows and n columns. This matrix can be produced using the DISTANCE procedure in SAS as follows:

```
proc distance data=inclusterdat out=distancedat method=Euclid;
    var interval(measure_score);
    id CCN;
run;
```

In the above code, the input data set, *inclusterdat,* is the list of hospitals with scores for a particular measure. Each record has a unique identifier, CCN. The option *method=Euclid* specifies that distances between hospital measure scores should be based on Euclidean distance. The input data contain a variable called *measure_score.* In the *var* call, the parentheses around *measure_score* indicate that *measure_score* is considered to be an interval or numeric variable. The distances computed by this code are stored to an output data set called *distancedat.*

2. Create a tree of cluster assignments.
The distance matrix calculated in Step 1 is the input to the clustering procedure. The stored distance algorithm is implemented to compute cluster assignments. The following process is implemented by using the CLUSTER procedure in SAS:

a. The input measure score distances are squared.
b. The clusters are initialized by assigning each hospital to its own cluster.
c. In order to determine which pair of clusters to merge, Ward's minimum variance method is used to separate the variance of the measure scores into within-cluster and between-cluster sum of squares components.
d. From the existing clusters, two clusters will be selected for merging to minimize the within-cluster sum of squares over all possible sets of clusters that might result from a merge.
e. Steps b and c are repeated to reduce the number of clusters by one until a single cluster containing all hospitals results.

The result is a data set that contains a tree-like structure of cluster assignments, from which any number of clusters between 1 and the number of hospital measure scores could be computed. The SAS code for implementing these steps is:

```
proc cluster data=distancedat method=ward outtree=treedat noprint;
    id CCN;
run;
```

The *distancedat* data set containing the Euclidian distances was created in Step 1. The option *method=ward* indicates that Ward's minimum variance method should be used to group clusters. The output data set is denoted with the outtree option and is called *treedat*.

3. Select the final set of clusters from the tree of cluster assignments.
The process outlined in Step 2 will produce a tree of cluster assignments, from which the final number of clusters is selected using the TREE procedure in SAS as follows:

```
proc tree data=treedat ncl=NSTARS horizontal out=outclusterdat noprint;
    id CCN;
run;
```

The input data set, treedat, is created in Step 2 above. The syntax, ncl=NSTARS, denotes the desired final number of clusters (or star levels). NSTARS equals 5.

Final Threshold and Star Creation
The cluster assignments produced by the above approach have cluster labels that are unordered. The final step after applying the above steps to all hospital measure scores is to order the cluster labels so that the 5-star category reflects the cluster with the best performance and the 1-star category reflects the cluster with the worst performance. The measure thresholds are defined by examining the range of measure scores within each of the final clusters.