



VISUALIZING HOSPITAL READMISSION RATES: HOW WELL DOES YOUR HOSPITAL PERFORM?

Andrea Barbo, Craig S. Parzynski, Jacqueline Grady

Yale New Haven Health Services Corporation/Center for Outcomes Research and Evaluation (CORE)

Abstract

Introduction
Radar Plot in SAS
Results
Discussion
References
SAS Code

Please use the headings above to navigate through the different sections of the poster

Abstract:

Hospital readmission is an adverse but often preventable event that has been shown to be related to a hospital's quality of care (Frankl et al., 1991). To reduce unplanned 30-day readmission rates among Medicare beneficiaries, the Centers for Medicare & Medicaid Services introduced measures of risk-standardized readmission rates (RSRRs) in both its quality reporting and pay for performance programs. RSRRs are calculated for five medical conditions, two procedures, and one hospital-wide measure for participating hospitals. These results are publicly reported on *Hospital Compare*, an online tool that patients can use to guide their decisions about where to seek care. Radar plots provide a tool that can illuminate differences and similarities of rates within and across hospitals. This can be useful for patients seeking the best possible care, or for hospital quality departments trying to understand their hospital's performance compared to their peers. This technique can be implemented using the POLYGON statement in the SG PANEL procedure (Hebbar, 2013). The code can be modified to add grids, tick marks, and labels, which provide more information on the estimates. Plotting the hospitals' RSRRs against the observed national rate enables one to quickly see which hospitals perform worse or better than the national average and which perform similarly in certain measures. In summary, radar plots are an effective way to display multiple hospital RSRRs at once and make quick comparisons.



Andrea Barbo



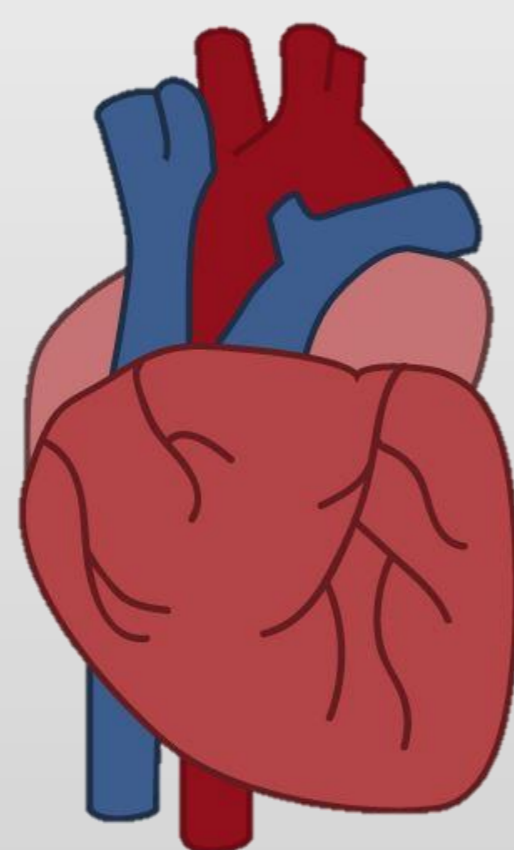
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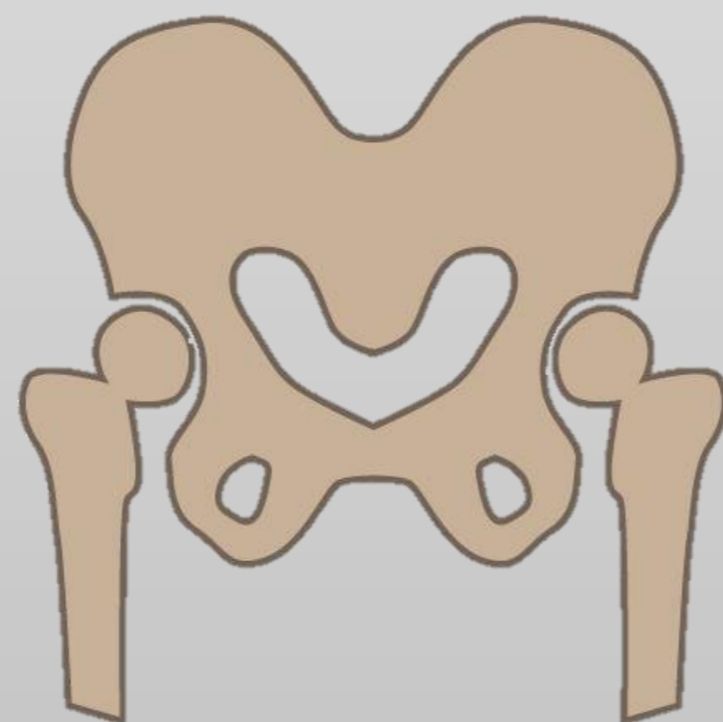
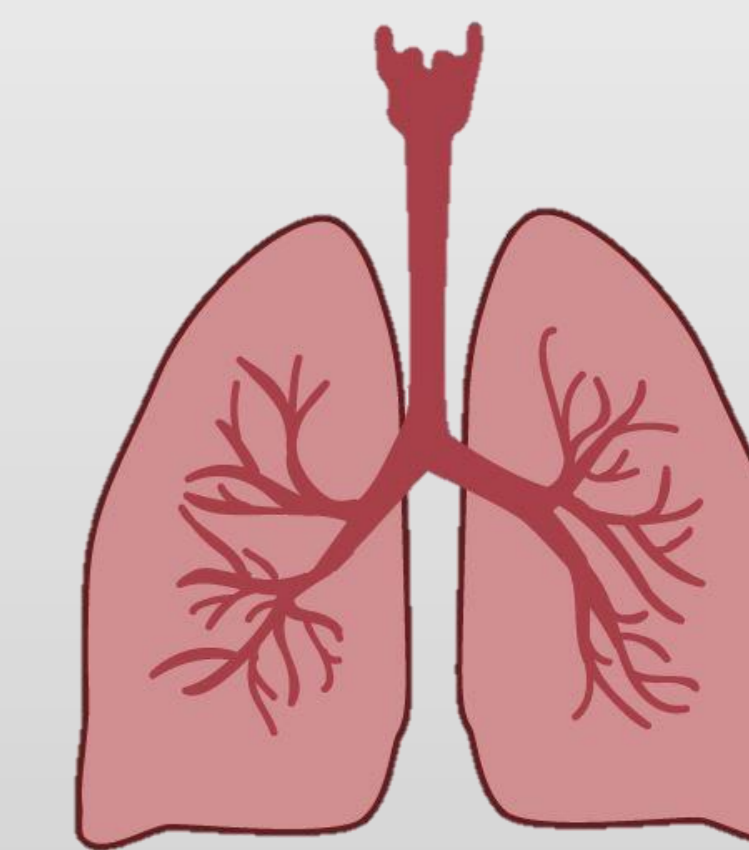
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Introduction:

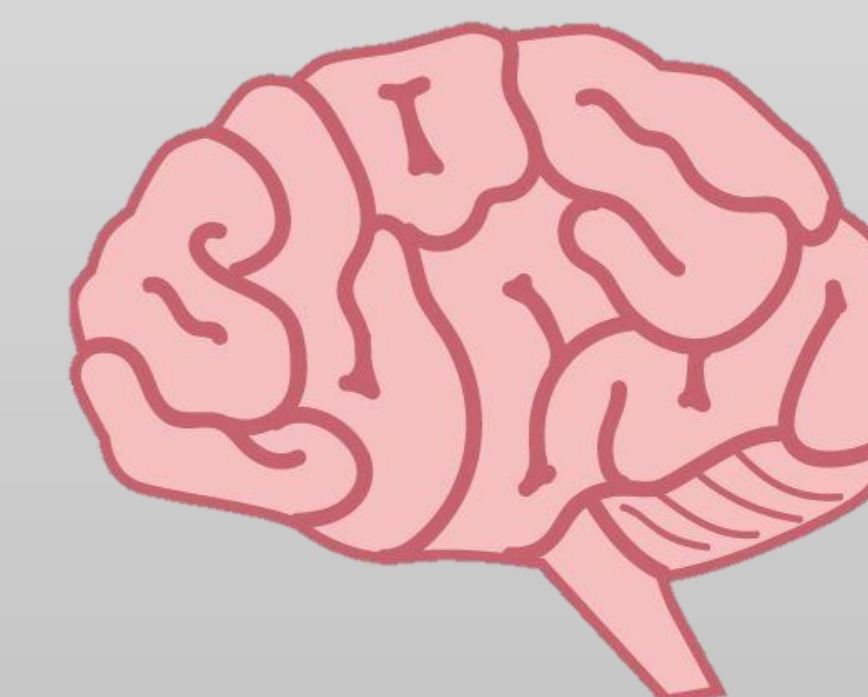
- ❑ Readmission of patients who were recently hospitalized is an important health outcome that can be prevented with high quality coordinated care by hospitals.
- ❑ The Centers for Medicare & Medicaid Services (CMS) developed unplanned 30-day risk-standardized readmission rates (RSRRs) to evaluate and compare hospitals' quality of care among Medicare beneficiaries.
- ❑ RSRRs are calculated for the following medical conditions and procedures:



- ❖ Acute myocardial infarction (AMI)
- ❖ Chronic obstructive pulmonary disease (COPD)
 - ❖ Heart failure
 - ❖ Pneumonia
 - ❖ Stroke



- ❖ Coronary artery bypass graft (CABG) surgery
 - ❖ Hip/knee arthroplasty
 - ❖ Hospital-wide all-cause



- ❑ Hospitals can receive payment incentives for reporting their readmission rates and are subject to penalties if they don't reduce readmissions.
- ❑ Hospitals participating in the Hospital Inpatient Quality Reporting (IQR) program, specifically, have their RSRRs and other quality data publicly reported on *Hospital Compare*.
- ❑ There are many ways to present hospital readmission rates that are helpful for consumers, and radar plots provide an effective way to visualize such data.
- ❑ In this E-Poster, we describe the features of a radar plot, why it is a suitable display tool, and how it can be implemented in SAS using PROC SG PANEL.

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Radar Plot in SAS

Results

Discussion

References

SAS Code

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Radar Plot in SAS:

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❑ Graphically displays multivariate data along spokes, each originating from the center of the plot.

❑ Plotted along a polar coordinate system.

❑ Also sometimes referred to as spider plot.

❑ *Key features:*

➤ Gives out a unique shape, which can highlight patterns and differences across groups of interest.

➤ In a set of radar plots, observations with similar characteristics share a similar shape.

➤ Easy to spot outliers and to determine observations that are consistently better or worse than others.

❑ *Limitations:*

➤ Not ideal for making exact comparisons of magnitude of the measurements.

➤ Can be overwhelming as the number of variables increase.

❑ Prashant Hebbar, on the SAS blog *Graphically Speaking*, discussed how radar plots can be created using PROC SGPANEL.

❑ *Steps:*

1. Transform numeric variables to [0, 1]

2. Calculate the polar coordinates for each variable, ensuring equidistant angles

3. Map the polar coordinates to Cartesian coordinates, and

4. Draw the outline of the polygon using the coordinates.

❑ The SERIES statement can be used instead of POLYGON to generate the radar outlines using series plots.

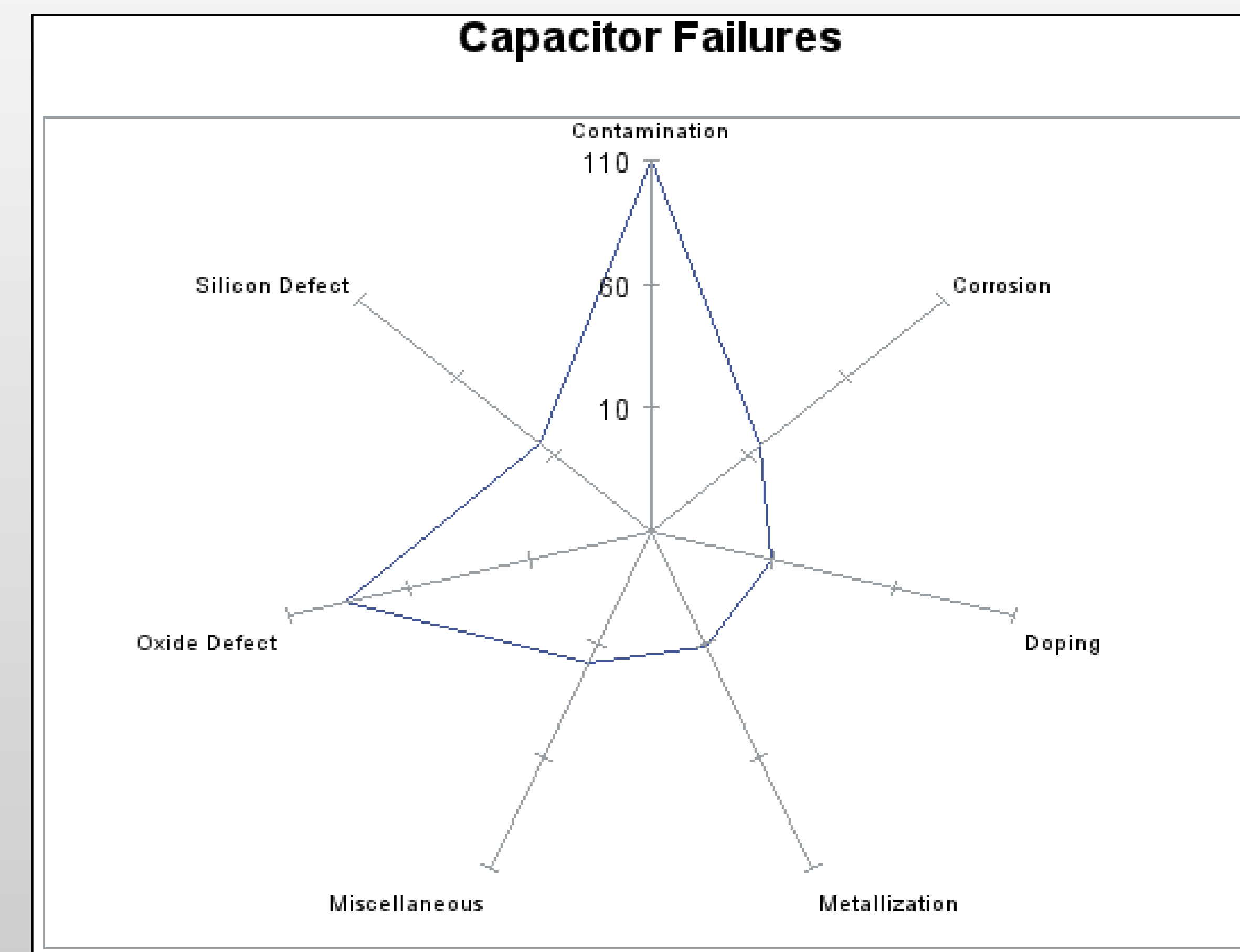


Figure obtained from SAS/GRAPH 9.4: Reference, Fifth Edition



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Results:

- The dataset of hospital-level RSRRs was downloaded freely from *Hospital Compare* and has the following data structure:

Hospital ID:	RSRR for Hospital-Wide:	National Rate for Hospital-Wide:	RSRR for AMI:	National Rate for AMI:	RSRR for CABG:	National Rate for CABG:	
Hospital A	0.180	0.153	0.190	0.160	0.140	0.132	...
Hospital B	0.160	0.153	0.200	0.160	0.110	0.132	
Hospital C	0.160	0.153	0.160	0.160	0.150	0.132	
Hospital D	0.170	0.153	0.160	0.160	0.130	0.132	
Hospital E	0.170	0.153	0.140	0.160	0.110	0.132	
Hospital F	0.170	0.153	0.170	0.160	0.130	0.132	

- We modified Prashant's code to accommodate the plotting of two radars: for hospital-specific and observed national rates, and applied the steps to generate the radar panel plot on the top right.

- In the figure, one can quickly compare hospitals in terms of:

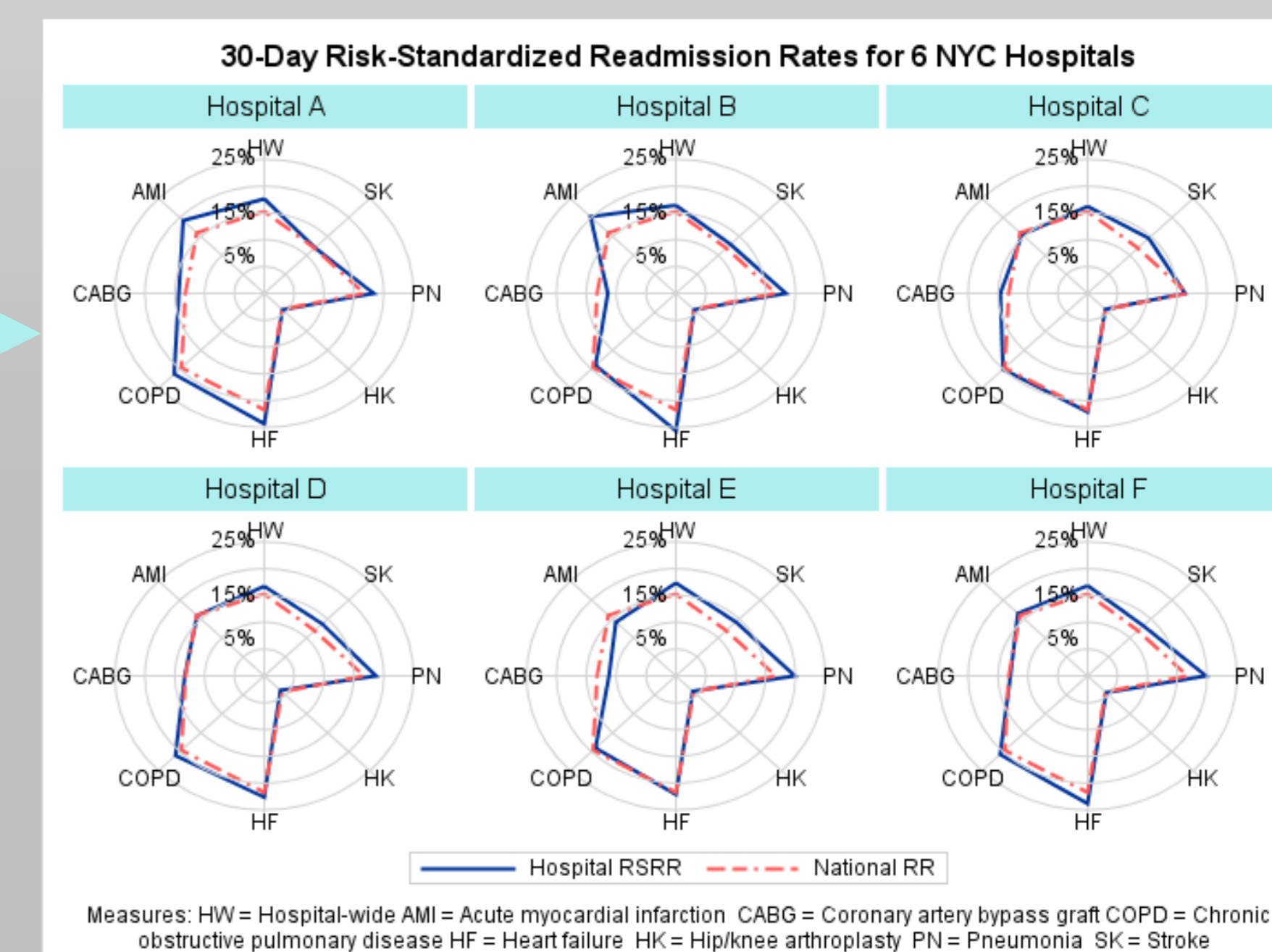
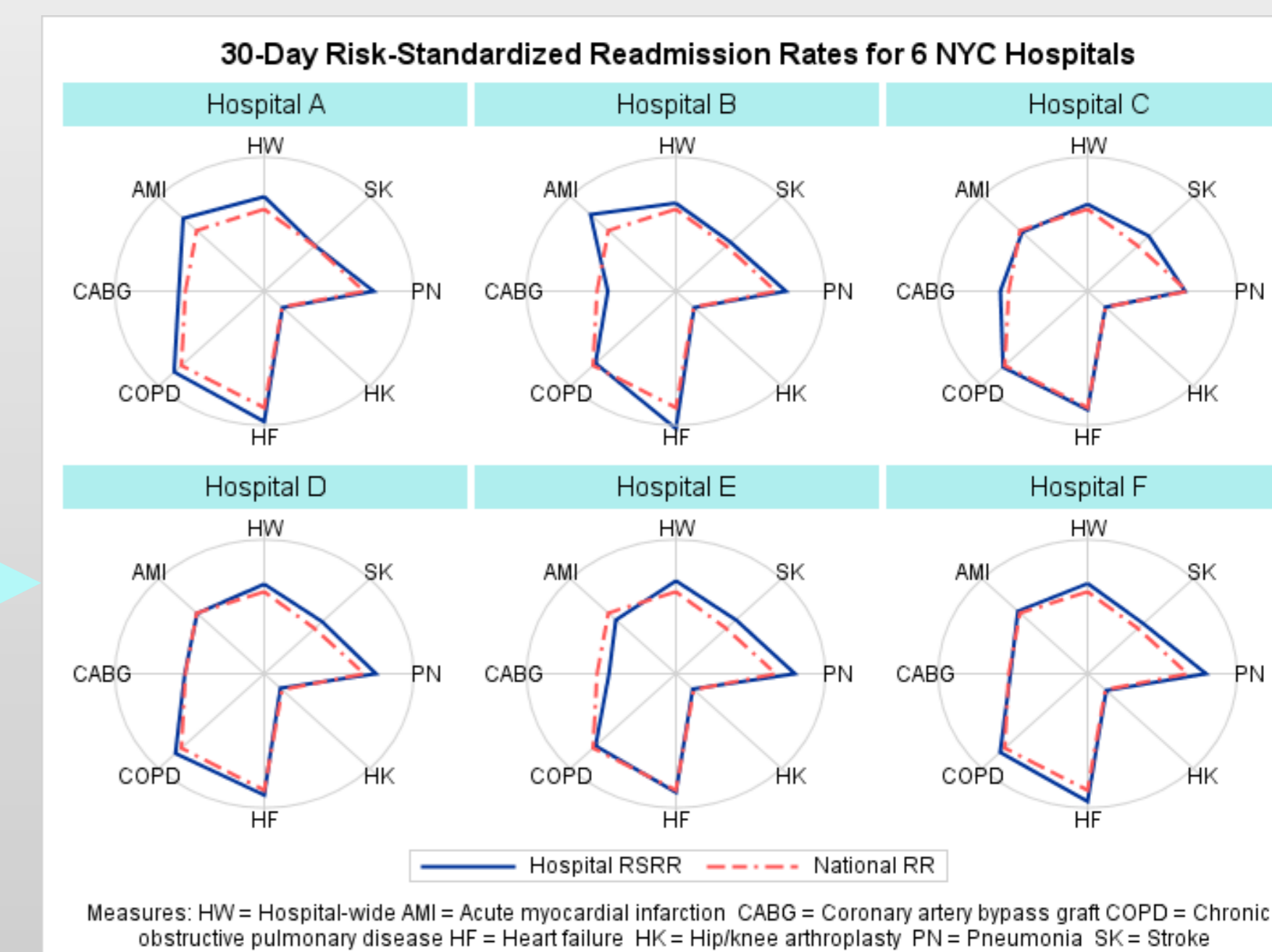
- Their "shape" – gives a high-level view of their performance on the eight readmission measures. Note that values closer to the center represent lower rates, i.e. good performance for the hospital.
 - Hospitals **D** and **F** seem to have similar readmission rates for most of the measures.
 - Hospital **B** appears to have a unique shape compared to the rest.
- How close their performance was to the national average.
 - AMI** and **heart failure** patients admitted to either Hospital **A** or **B** were readmitted at a higher rate than average.

- One may be interested in seeing the actual rates or want to be able to judge whether the differences between hospitals are substantial or not. To address this, we added circular grids and tick labels to the plot on the bottom right.

- The readmission rates ranged anywhere from **less than 5% to more than 20%** across all measures.
- Hospital **B** had about **5%** higher rate than average for their **AMI** patients, but it, along with Hospital **E**, did fairly well for their patients who underwent **CABG surgery**.

- For the step-by-step PROC SGPANEL code [CLICK HERE](#).

Pinch-to-zoom



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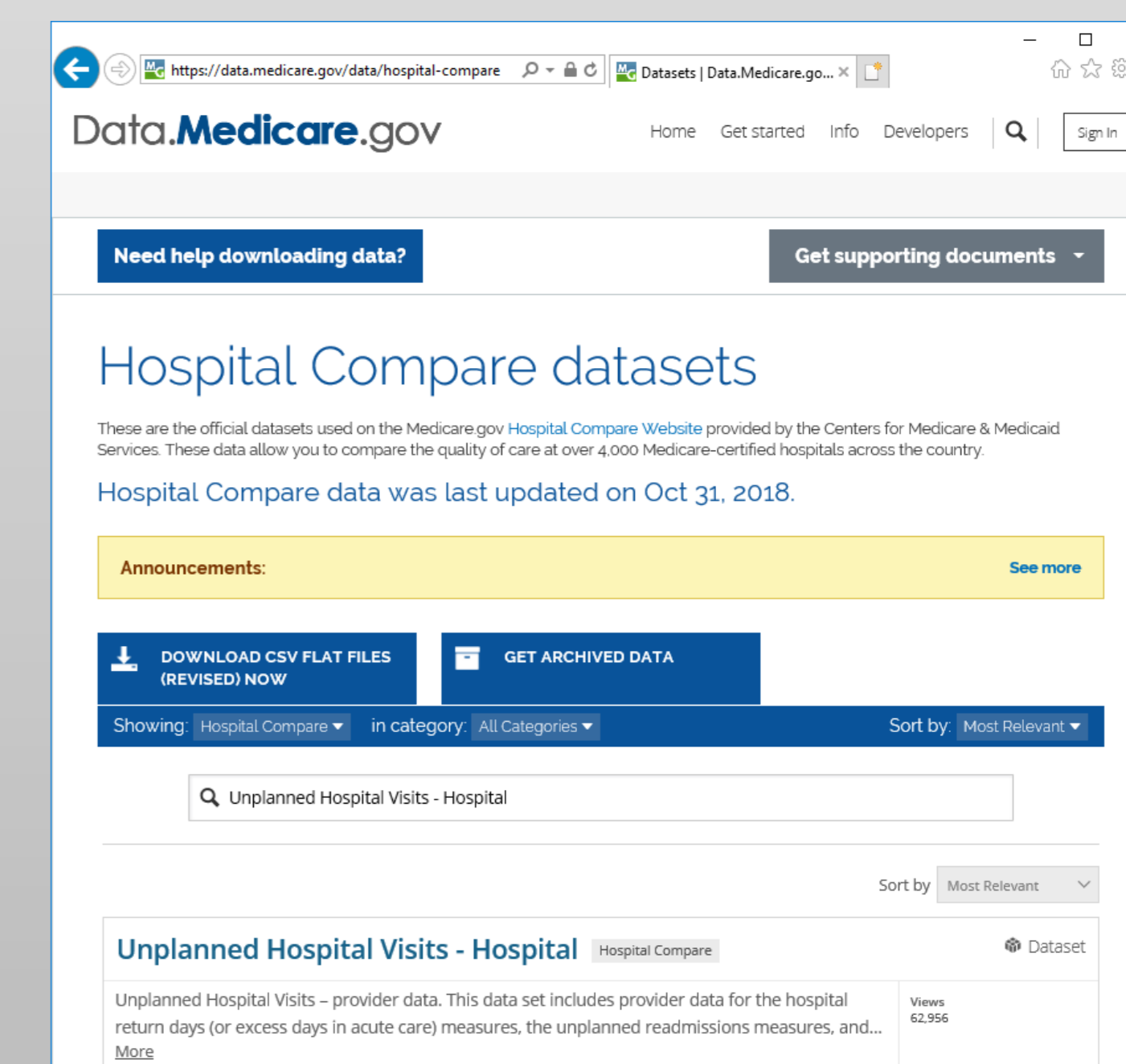
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Discussion:

- ❑ Radar plots:
 - An effective way to display multivariate data.
 - Can be implemented in SAS using PROC SGPANEL.
 - A valuable visualization tool for looking at quality of care provided by a subset of hospitals, e.g. hospitals within a hospital system, hospitals within a certain mile radius, or hospitals sharing a certain set of characteristics.
- ❑ **For patients and caregivers:** the plots can help identify the hospital that is best for their condition.
- ❑ **For hospitals:** useful to track and understand their performance in relation to their peers.
- ❑ Healthcare data analysts can adapt the SAS code and apply it to other measures on *Hospital Compare* as a means to visualize hospital results.



Other measures include:
Survey of patient experiences
Measures of timely and effective care
Complications and death rates
Unplanned hospital visit rates
Use of medical imaging
Payment and value of care
Overall hospital rating



- ❑ Ultimately, using radar plots to summarize these findings can simplify and enhance the consumers' ability to quickly assess hospital quality.
- ❑ Future work should continue to identify visualizations that simplify the interpretation of CMS quality data.

Download *Hospital Compare* data from <https://data.medicare.gov/data/hospital-compare>

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References:

Frankl SE, Breeling JL, Goldman L. Preventability of emergent hospital readmission. *American Journal of Medicine*. Jun 1991;90(6):667-674.

Centers for Medicare & Medicaid Services (U.S.). 2000. "Hospital compare: A quality tool for adults, including people with Medicare." Accessed October 22, 2018. <https://www.medicare.gov/hospitalcompare/search.html>.

Centers for Medicare & Medicaid Services (U.S.). 2000. "QualityNet: Measure Methodology Reports Readmission Measures." Accessed October 22, 2018. <https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1219069855841>.

Wikipedia. 2019. "Radar chart." Accessed October 22, 2018. https://en.wikipedia.org/wiki/Radar_chart.

Hebbar, P. (2013, November 27). Is there a car on your radar? [Blog post]. Retrieved from <https://blogs.sas.com/content/graphicallyspeaking/2013/11/27/is-there-a-car-on-your-radar/>.

SAS Institute Inc. SAS/GRAPH®9.4: Reference. (Cary, NC: SAS Institute Inc., 2018).

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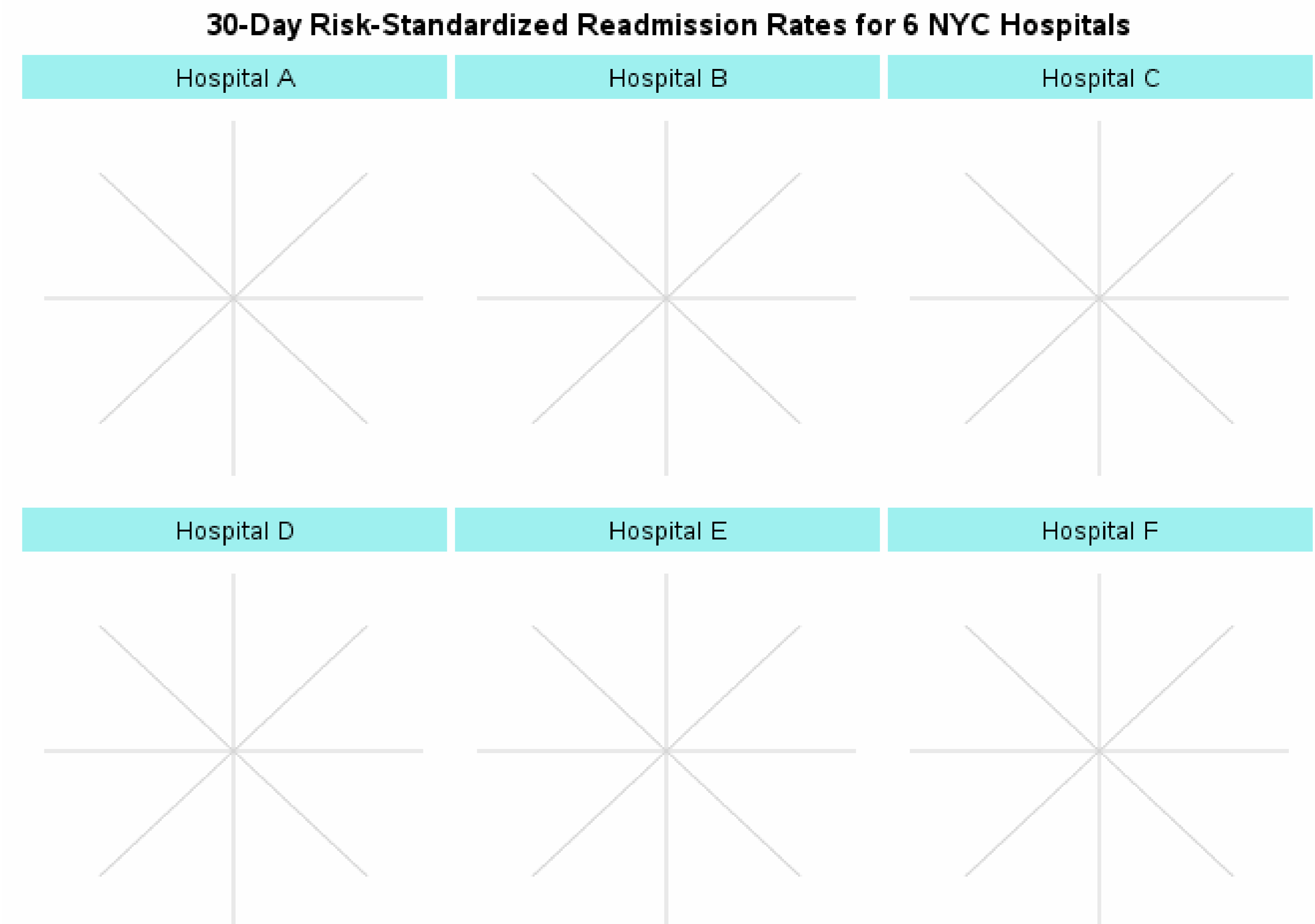
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Step-by-step PROC SGPANEL



Back

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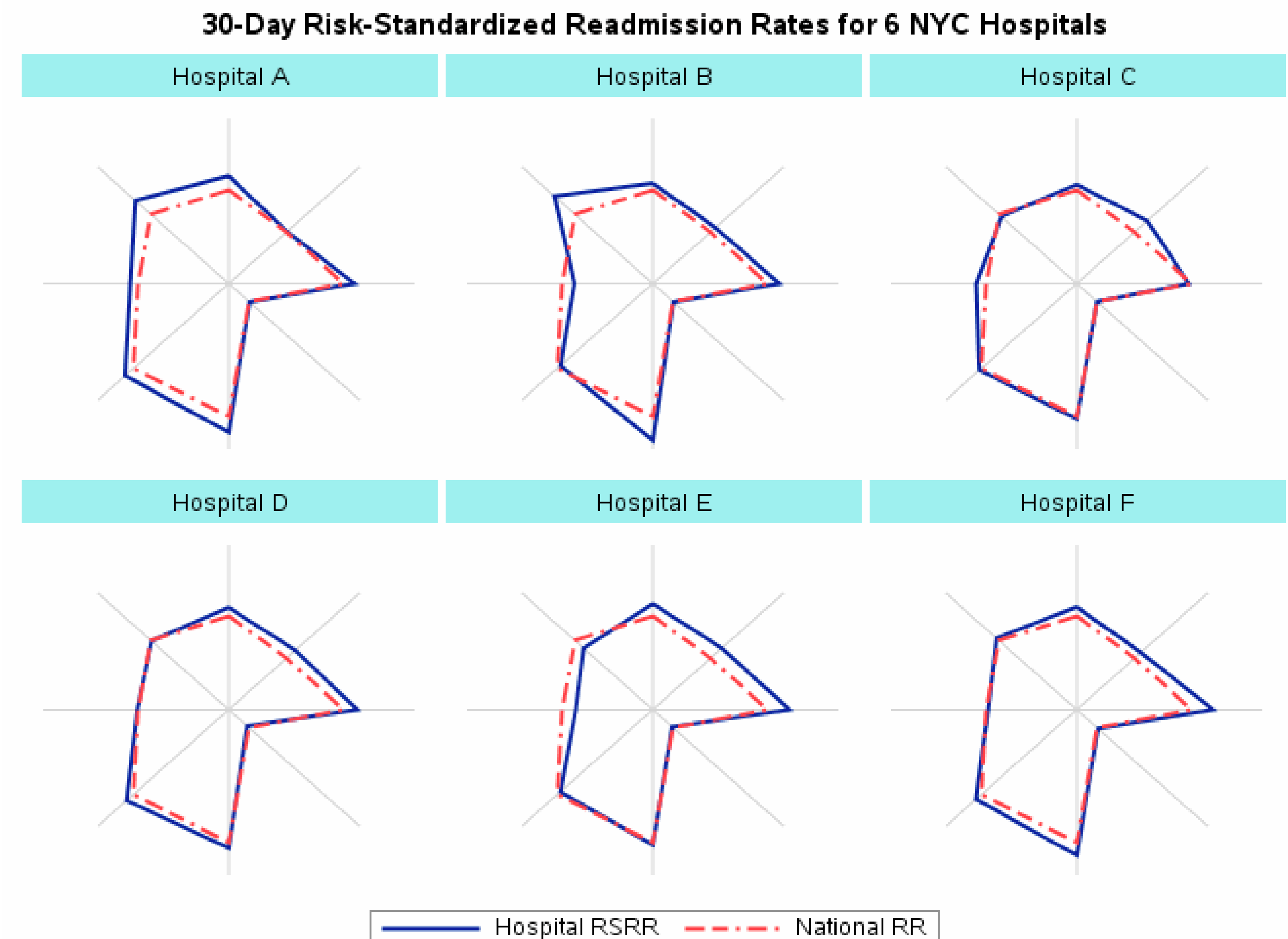
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Step-by-step PROC SG PANEL



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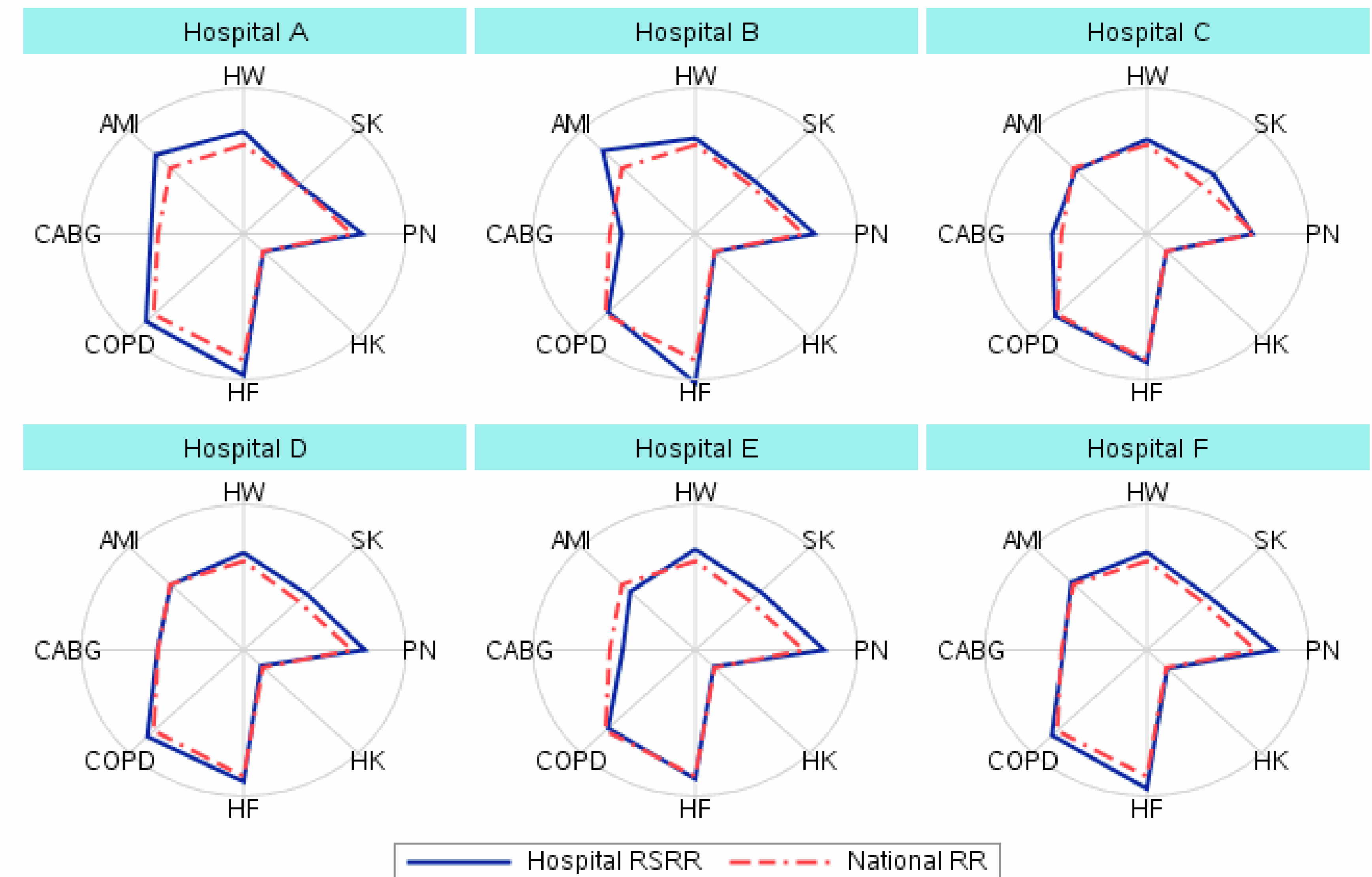
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Step-by-step PROC SGPANEL

30-Day Risk-Standardized Readmission Rates for 6 NYC Hospitals



Measures: HW = Hospital-wide AMI = Acute myocardial infarction CABG = Coronary artery bypass graft COPD = Chronic obstructive pulmonary disease HF = Heart failure HK = Hip/knee arthroplasty PN = Pneumonia SK = Stroke

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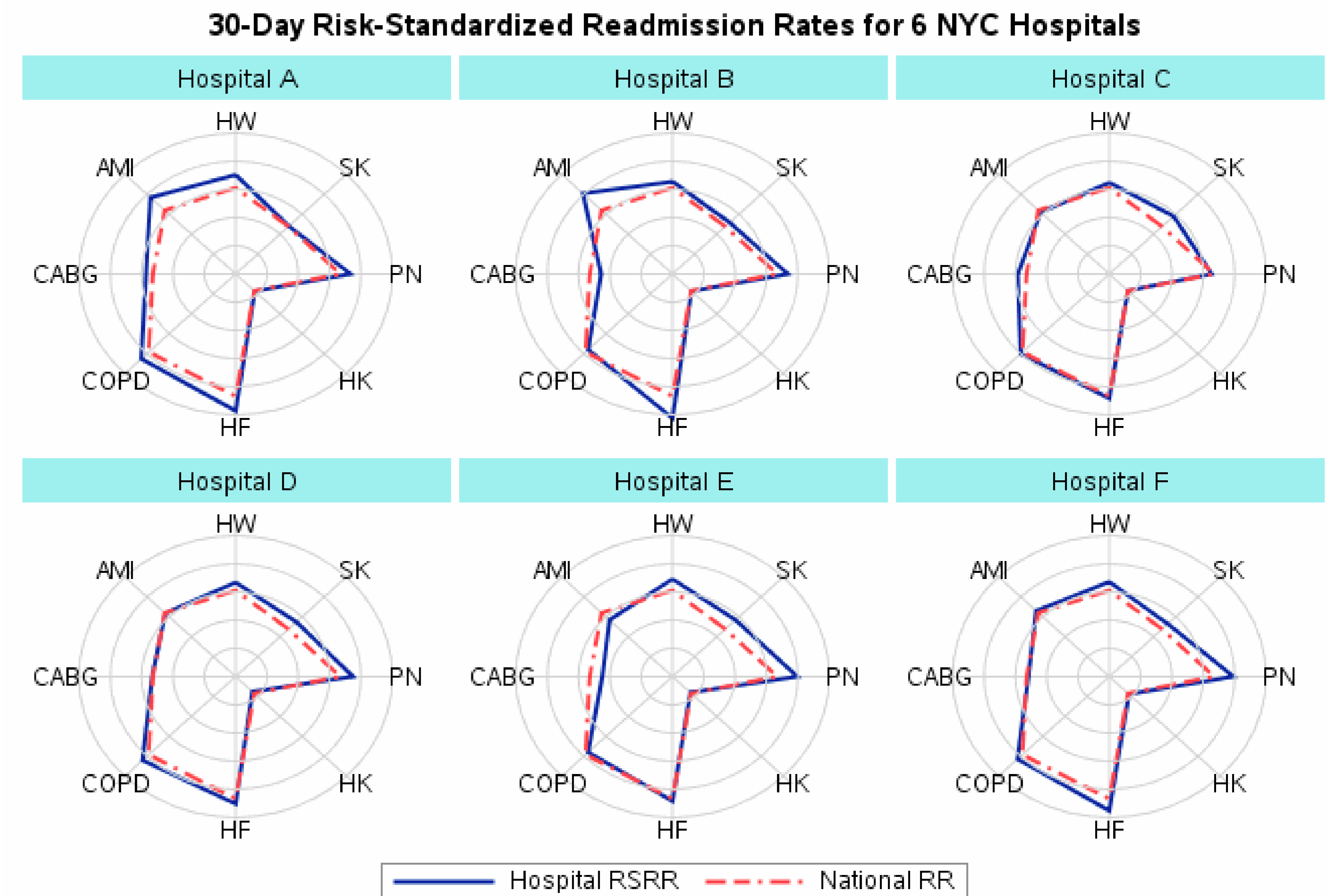
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Step-by-step PROC SG PANEL



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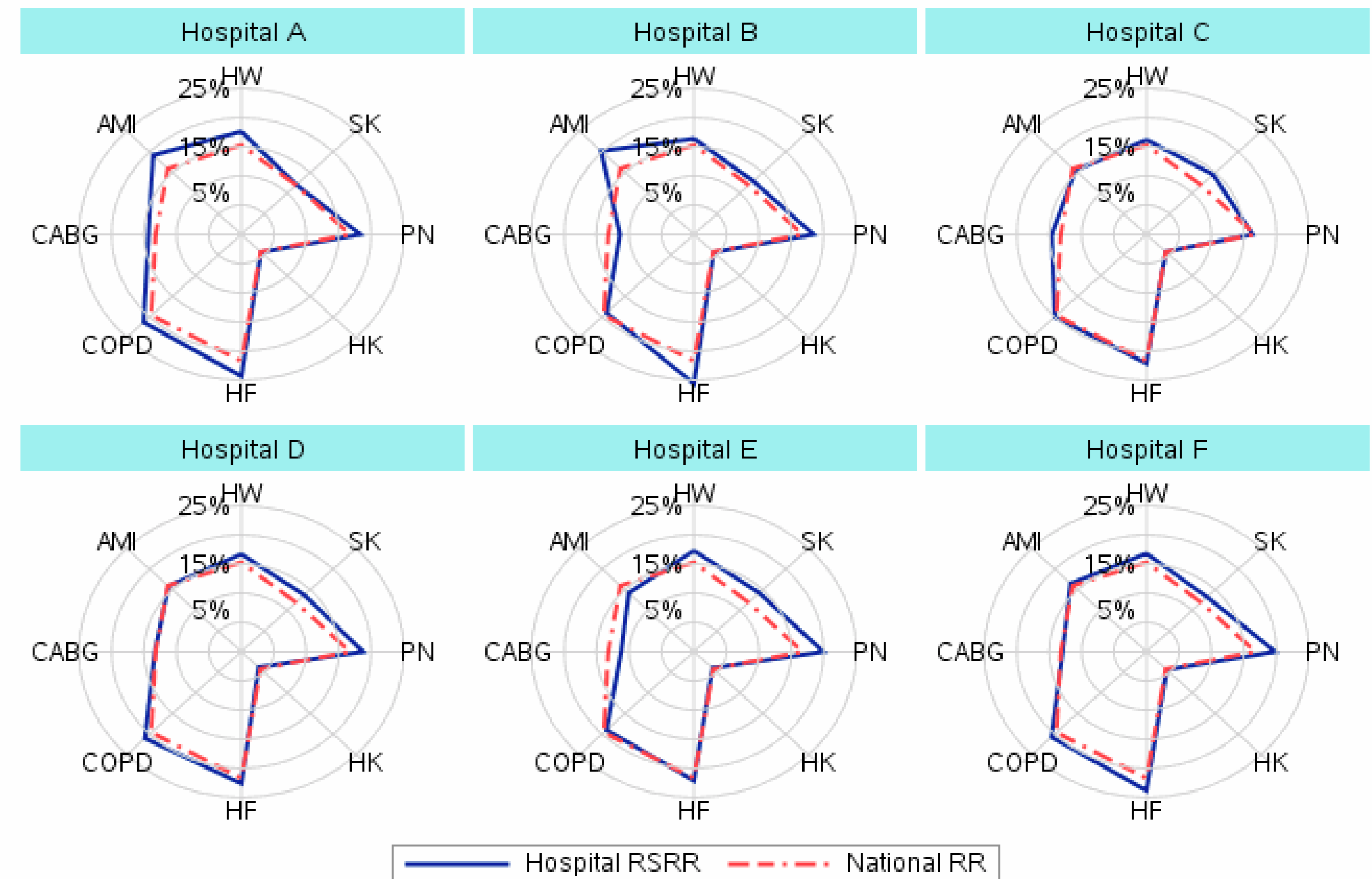
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Step-by-step PROC SG PANEL

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Back

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ABSTRACT

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INTRODUCTION

The readmission of patients who were recently hospitalized is an important health outcome that can be reduced with high quality coordinated care by hospitals. While some readmissions are a result of a worsening medical condition and are therefore unavoidable, it can also be a result of poor quality of care provided during the initial hospitalization, or lack of proper transitional care and monitoring post-discharge. In year 2004 alone, it was estimated that readmissions within 30 days of discharge cost Medicare more than \$17.4 billion (Jencks, 2009). It is costly to the healthcare system and adversely affects the day to day lives of patients and caregivers.

In an effort to lower unplanned 30-day readmission rates among Medicare beneficiaries, the Centers for Medicare & Medicaid Services (CMS) evaluates and compares hospitals' quality of care using risk-standardized readmission rates (RSRRs). RSRRs are calculated for five medical conditions, namely, acute myocardial infarction (AMI), chronic obstructive pulmonary disease (COPD), heart failure, pneumonia, and stroke. There are also two procedure-specific measures, coronary artery bypass graft (CABG) surgery and hip/knee arthroplasty, as well as a hospital-wide measure that evaluates readmissions for all admissions occurring at a hospital. These eight measures are included in the Hospital Inpatient Quality Reporting (IQR), and Hospital Readmissions Reduction Programs, CMS' pay for reporting and performance programs, respectively. This means that hospitals can receive payment incentives for reporting their readmission rates and are subject to penalties if they don't reduce their readmissions. For the methodology used to calculate the measures, please refer to the reports on [QualityNet](#).

Hospitals participating in the IQR program have their RSRRs and other quality data publicly reported on [Hospital Compare](https://www.medicare.gov/hospitalcompare). It is an online tool that promotes transparency among hospitals and encourages improvement. Patients can also use the tool to guide their health care decisions. There are many ways to present hospital readmission rates that are helpful for consumers, and radar plots provide an effective way to visualize such data. In this article, we describe the features of a radar plot, why it is a suitable display tool, and how it can be implemented in SAS® using PROC SGPANEL.



Display 1. Hospital Compare Website

RADAR PLOT IN SAS

A radar plot, also sometimes referred to as spider plot, graphically displays multivariate data along spokes, which correspond to the size of the numeric variables. The spokes are equiangular and originate from the same point in the center of the plot. A radar plot can also be thought of as a line plot with a closed loop, plotted along a polar coordinate system instead of cartesian.

One of the plot's key features is that it gives out a unique shape, which can highlight patterns and differences across groups of interest. In a set of radar plots, observations with similar characteristics share a similar shape. This makes it easy to spot outliers and to determine groups or observations that are consistently better or worse than others. On the other hand, a radar plot is not ideal if the goal of the visualization is to make exact comparisons of magnitude of the measurements, and it can get overwhelming as the number of variables grow large.

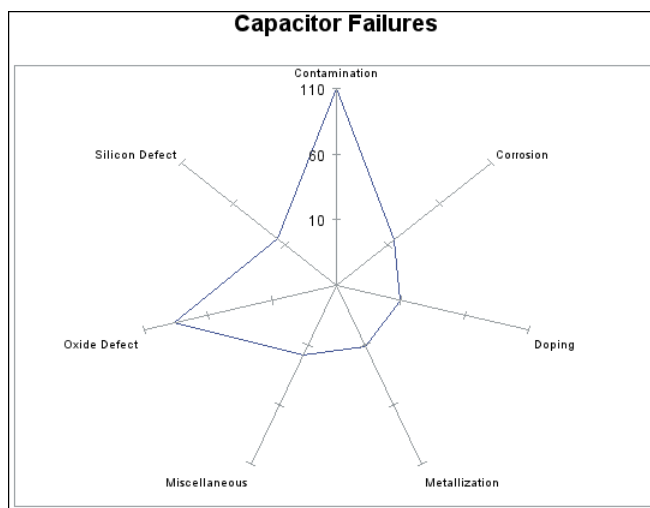


Figure 1. Radar Plot Example (obtained from SAS/GRAPH® 9.4: Reference, Fifth Edition)

As of this writing, there is no radar plot statement in ODS Graphics. However, Prashant Hebbar, on the SAS blog [Graphically Speaking](https://blogs.sas.com/content/graphicallyspeaking/), discussed how radar plots can be created in a few easy steps using SAS 9.4 ODS Graphics, specifically via PROC SGPANEL. These steps include 1) transforming the numeric variables to be within the range of 0 and 1, 2) calculating the polar coordinates for each variable ensuring equidistant angles, 3) mapping the polar coordinates to Cartesian coordinates, and 4) drawing the outline of the polygon using the coordinates. Prashant further showed that with a slight modification to the code, the SERIES statement can be used instead of POLYGON to generate the radar outlines using series plots.

RESULTS

We followed the above steps using our dataset of hospital-level RSRRs, named HOSPITAL_RSRR, which was downloaded freely from [Data.Medicare.gov](https://data.medicare.gov/), along with the [national readmission rates](#), and was processed to have the following data structure:

Hospital ID: PROV_ID	RSRR for Hospital-Wide: READM_30_HOSP_WIDE	National Rate for Hospital-Wide: USA_HOSP_WIDE	RSRR for AMI: READM_30_AMI	National Rate for AMI: USA_AMI	RSRR for CABG: READM_30_CABG	National Rate for CABG: USA_CABG	...
Hospital A	0.180	0.153	0.190	0.160	0.140	0.132	
Hospital B	0.160	0.153	0.200	0.160	0.110	0.132	
Hospital C	0.160	0.153	0.160	0.160	0.150	0.132	
Hospital D	0.170	0.153	0.160	0.160	0.130	0.132	
Hospital E	0.170	0.153	0.140	0.160	0.110	0.132	
Hospital F	0.170	0.153	0.170	0.160	0.130	0.132	

Table 1. A Section of the Hospital-Level Dataset of RSRRs

Our variables of interest, RSRRs, could technically be greater than 1. However, in our data, all hospitals across all measures had RSRRs below 1. As such, it wasn't necessary to perform Step 1. For those interested, however, Prashant's code included a way to normalize the variables to values from 0 to 1. We further modified Prashant's code to accommodate the plotting of two radars, one for the hospital-specific (Hospital RSRR) and another for the observed national rate (National RR), and applied the remaining steps to generate the radar panel plot below:

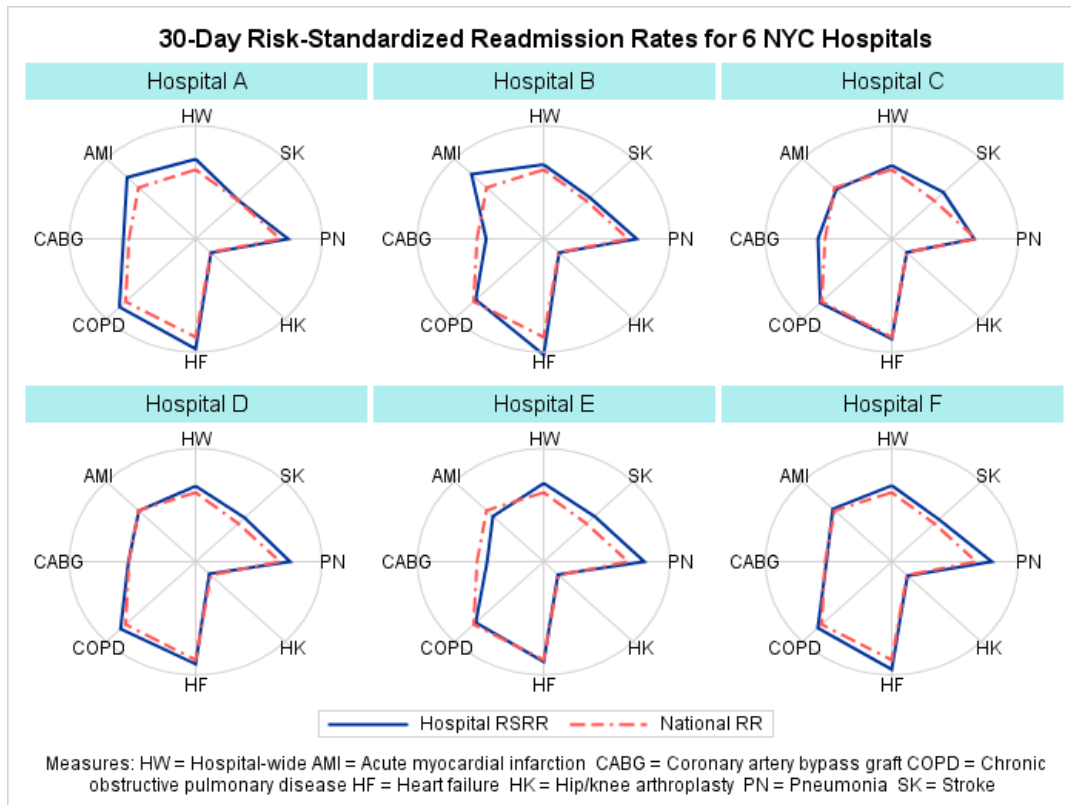


Figure 2. Radar Panel Plot of Hospital RSRRs

Note that values closer to the center represent lower rates, i.e. good performance for the hospital. In the figure above, one can quickly compare hospitals in terms of:

- Their “shape”, which gives a high-level view of their performance on the eight readmission measures. For example, Hospitals D and F seem to have similar readmission rates for all the measures, while Hospital B appears to have a unique shape compared to the rest. This information might be of interest to hospital quality departments that want to understand their hospital’s performance in relation to their peers.
- How close their performance is with the national average. A high readmission rate is undesirable, as such, we want our hospitals to have lower rates than average. In our example, the AMI and heart failure patients admitted to either Hospital A or B got readmitted at a higher rate than average. These specific groups of patients can then take this information into account when deciding where to seek follow-up care.

A reader might be interested in seeing the actual rates or may want more information to judge whether the differences in RSRRs between hospitals are substantial or not. To address this, we added circular grids and tick labels to the plot below:

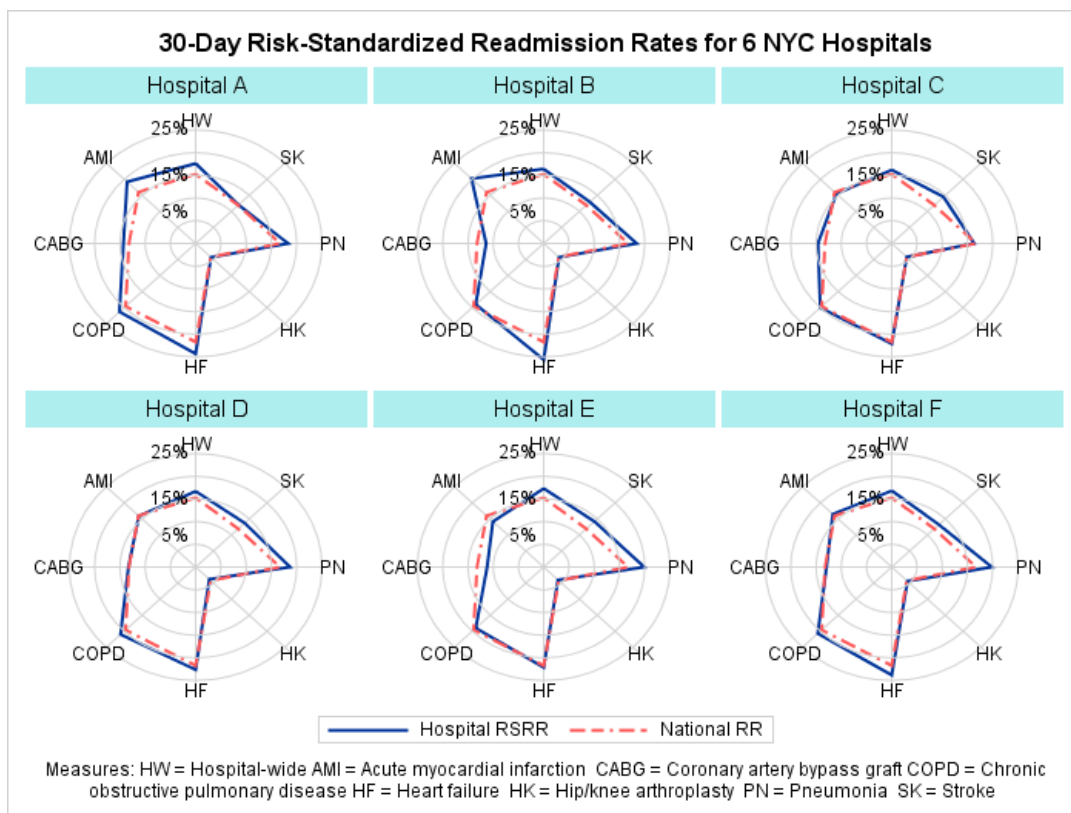


Figure 3. Modified Radar Panel Plot of Hospital RSRRs

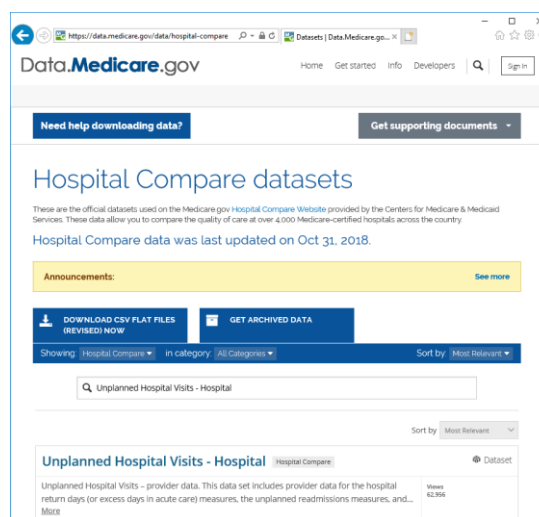
With the added features, the reader could tell that the readmission rates ranged from less than 5% to more than 20% across all measures. Hospital B had about 5% higher rate than average for their AMI patients, but it, along with Hospital E, did pretty well for their patients who underwent CABG surgery. For reference, the complete SAS code that performs all 4 steps is included in this paper.

CONCLUSION

Radar plots are an effective way to display multivariate data and they can be implemented in SAS using PROC SGPANEL with just a few steps. We provided a novel look at hospital

readmissions data that allowed us to make meaningful comparisons. We have shown that the plots can be a valuable visualization tool for looking at a subset of hospitals, e.g. hospitals within a hospital system, hospitals within a certain mile radius, or hospitals sharing a certain set of characteristics. Patients and caregivers can use the information presented in the plots to identify the hospital that can best serve their needs. On the other hand, hospitals can take this information to track and benchmark their performance against their peers.

Healthcare data analysts can adapt the SAS code and apply it to other measures to visualize hospital results. In fact, there is a wealth of hospital quality indicators available on *Hospital Compare* for over 4,000 Medicare-certified hospitals as well as over 130 Veterans Administration (VA) medical centers nationwide. These include a survey of patient experiences, measures of timely and effective care, complications and death rates, unplanned hospital visit rates, use of medical imaging, payment and value of care, and an overall hospital rating, which is a composite score derived from 57 quality measures. In addition, general information about the hospitals such as name, address, contact information, etc. are available. Consumers can utilize the website, in addition to external data sources, to compare hospitals with respect to indicators or factors that are important to them. Ultimately, summarizing the findings using radar plots can simplify and enhance the consumers' ability to quickly assess hospital quality. Future work should continue to identify novel ways to visualize and interpret CMS quality data.



Display 2. Hospital Compare Datasets on Data.Medicare.gov

REFERENCES

- Frankl SE, Breeling JL, Goldman L. Preventability of emergent hospital readmission. *American Journal of Medicine*. Jun 1991;90(6):667-674.
- Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. Apr 2 2009;360(14):1418-1428.
- Centers for Medicare & Medicaid Services (U.S.). 2000. "Hospital compare: A quality tool for adults, including people with Medicare." Accessed October 22, 2018. <https://www.medicare.gov/hospitalcompare/search.html>.
- Centers for Medicare & Medicaid Services (U.S.). 2000. "QualityNet: Measure Methodology Reports Readmission Measures." Accessed October 22, 2018. <https://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1219069855841>.
- The Data Visualisation Catalogue. 2017. "Radar Chart." Accessed October 22, 2018. https://datavizcatalogue.com/methods/radar_chart.html.
- Hebbar, P. (2013, November 27). Is there a car on your radar? [Blog post]. Retrieved from <https://blogs.sas.com/content/graphicallyspeaking/2013/11/27/is-there-a-car-on-your-radar/>.
- SAS Institute Inc. SAS/GRAPH®9.4: Reference. (Cary, NC: SAS Institute Inc., 2018).

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