

COMPARING PATIENT QUALITY OF CARE SCORING METHODS WITH SAS-PRODUCED PAIRED BOXPLOTS

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Abstract

A program using both SAS Macro Language and SAS/GRAPH was developed to communicate 2 types of patient quality of care (i.e., adherence to process of care) scores to 12 hospitals. The object of the program was to present each hospital the spread of their unweighted and weighted adherence scores compared to the other 11 hospitals (via boxplots). These scores were calculated for every combination of 3 different diseases (i.e., congestive heart failure, chronic obstructive lung disease, and diabetes mellitus) and 3 separate portions of the patient stay at the hospital (i.e., admission workup, treatment regimen, preparation for discharge) thereby creating 9 graphs. The convenience of keeping all the boxplots (for a given graph) on a single page was important. To accomplish this goal, SAS code was created to place the 2 distinct boxplots for any hospital side-by-side. The boxplots demonstrate that, in general, the weighted adherence scores were greater than unweighted scores (although not by a large margin). Implications of these results are discussed. In addition, the general usefulness of side-by-side boxplots in quality of care studies and other fields of study is also discussed.

Introduction

The quality of hospital care is an important health care issue. Several studies have shown that poor quality of care, measured in a variety of ways, was predictive of unfavorable post-discharge outcomes.¹⁻³ Ashton et al devised a method of developing quality of care criteria that includes a computation of an adherence score.⁴ The score reflects whether the hospital staff followed the procedures necessary to properly admit, treat, and discharge a patient. *Adherence scores* can be either unweighted or weighted depending on whether the criteria are unit (i.e., equally) weighted or differentially weighted.

The aim of this study was to develop a graphical tool to compare hospital-level weighted and unweighted adherence scores. To obtain this objective, the creation of a program was necessary (using SAS) to produce paired (i.e., side-by-side) boxplots which would allow a hospital to compare its own distribution of unweighted and weighted scores with those of other participating hospitals. This quality assessment method was used in another study looking at early unplanned readmission.⁵

Methods

Subjects

The patients in this study were selected from a random sample of patients discharged alive for treatment of congestive heart failure (CHF), chronic obstructive lung disease (COPD), or diabetes mellitus (DM) from 12 acute care hospitals in the southern United States between October 1, 1987, and September 30, 1989. The hospitals can be characterized into 1 of 3 broad categories. Three were large, urban, referral centers closely affiliated with medical schools. Five were medium-sized hospitals in less urban areas and more distantly related to medical schools. The final four were small hospitals in relatively small towns with limited or no affiliation to medical schools.

The sampling was performed using a computerized hospital discharge database which contains records of all hospital stays for the study hospitals. The index stay was defined as the first hospital stay during the 24-month period. Patients discharged alive from an index stay with 1 of the 3 conditions of interest were considered potentially eligible. The lists of potentially eligible patients were sent to each hospital where personnel in their records departments pulled charts. Study personnel traveled to each hospital to perform chart reviews.

Data Collection and Analysis

Process of care was measured for 3 distinct *stages* of the index stay via a review using *explicit criteria* (i.e., verification of functions performed on the patient by the medical staff) listed on patient charts. These stages include the admission workup, the treatment regimen, and preparation for discharge. The development of the explicit criteria, the method of scoring, the weighting of the criteria, and the training of the chart reviewers are discussed in another report.⁴ To give an example of what the criteria were like, the explicit criteria for preparation for discharge for CHF patients are listed in Appendix I.

Two reviewers traveled as a team to each hospital. One served as the administrative reviewer and the other as the process reviewer. They alternated functions at times by day or by site. The first goal of the chart review was to verify that the patient met 2 final inclusion criteria: (1) that the patient arrived at the hospital with symptoms and signs indicative of an exacerbation of the condition in question (CHF, COPD, or DM), and (2) that the dictated hospitalization summary indicated that the condition in question was the primary reason for the index admission. Once the reviewers deemed the patient eligible, the administrative reviewer extracted severity of illness data. The chart was then given to the process reviewer who determined whether or not each of the explicit criteria was met, recording the answers into an on-line data management program on a laptop computer. Criteria weights were not shown to the process reviewer in order to eliminate a potential source of bias. The unweighted and weighted

adherence scores for each patient were computed by the study data analysts at the conclusion of the data collection phase.

The weighted scores emphasize varied clinical importance placed on the explicit criteria while the unweighted scores represent equal importance. The importance of each criteria was determined by an expert panel of physicians. Weights from 1 (lowest clinical importance) to 7 (greatest clinical importance) were established. Actual criteria weights implemented for this study may be requested from the authors.

The distribution of unweighted and weighted scores at each of the 12 hospitals have been displayed using boxplots. A SAS program utilizing SAS/GRAPH and SAS Macro Language was created so that the boxplots for any hospital were placed side-by-side. This enabled all the boxplots for a given combination of disease and portion of the hospital stay (e.g., CHF discharge) to be displayed on a single graph. The program in its entirety is shown in Appendix II. The paired boxplots have been produced in the following way:

1. Create macro variables for each type of score (i.e., %let u = 1 for unweighted scores, %let w = 2 for weighted scores).
2. Set up appropriate goptions for host system.
3. Set up global SAS/GRAPH statements:
 - a. symbol statement (use i = boxt option).
 - b. axis1 and axis2 statements (to customize axis labels).
4. For each disease (denoted by the macro variable i), create 2 datasets from original master dataset. The first dataset will contain an assigned hospital code variable (or point) and the 3 unweighted scores (for the separate portions of the hospital stay: admission, treatment, and discharge), while the second dataset contains the point variable and the 3 weighted scores. Scores exist for patients at 12 study hospitals.
5. Set the *unweighted* dataset and define dummy = 1. Set the *weighted* dataset and define dummy = 2. Also, rename the weighted scores to appear like the unweighted scores (i.e., rename wtscore1 = score1, etc.).
6. Create a single dataset by setting the *unweighted* and *weighted* datasets together. Implement a macro which creates a variable called pointx which concatenates the point variable (1 - 12) and the score macro variable (1 - 2; see step 1 above). Therefore, 24 values of pointx will exist (e.g., the weighted scores for point, or hospital, 12 will be referred to as pointx = 122; the unweighted scores for point 3 will become pointx = 31).
7. Finally, for each portion of the hospital stay (denoted by the macro variable k) within each disease, run proc gplot. Use the following plot statement:
plot score&k * pointx / haxis = axis vaxis = axis2. Nine sets of boxplots will be created if all combinations of 3 diseases and 3 portions of the hospital stay are run through the program.

Results and Discussion

Although not all 9 graphs are presented, the results of Figure 1 are typical of the other graphs. That is, in general, for a given hospital, the weighted scores were greater than the unweighted scores. That weighted scores were higher reflects the fact that hospitals were more likely to adhere to the criteria with higher weights (i.e., the criteria likely to have more influence on patient outcomes).

The weights applied to the criteria did not have an extended distribution. In theory, the weights could range from 1 (lowest) to 7 (of highest clinical importance). However, because of the way the criteria were derived,⁴ the weights generally ranged from 5 to 7. Therefore, there was not much discrimination between the weights which resulted in only a small difference between the weighted and unweighted adherence scores. Future studies should try to determine if a larger weight range (e.g., 1 to 20) would result in a greater discrimination between weights. If there still exist only small differences in the weights, then the cost of obtaining the weights may outweigh the benefits of their utilization.

The comparison among hospitals was a secondary goal of this paper. Review of the boxplots shows that hospital differences did exist. Having all the hospital comparisons on a single page eases the ability to detect these differences. For example, Figure 1 shows that Hospital 6 should be relatively pleased with their distribution of adherence to process of care scores (although they likely will be interested in an explanation for their low outliers); Hospitals 4, 5, and 7 may conclude they have to raise their standards.

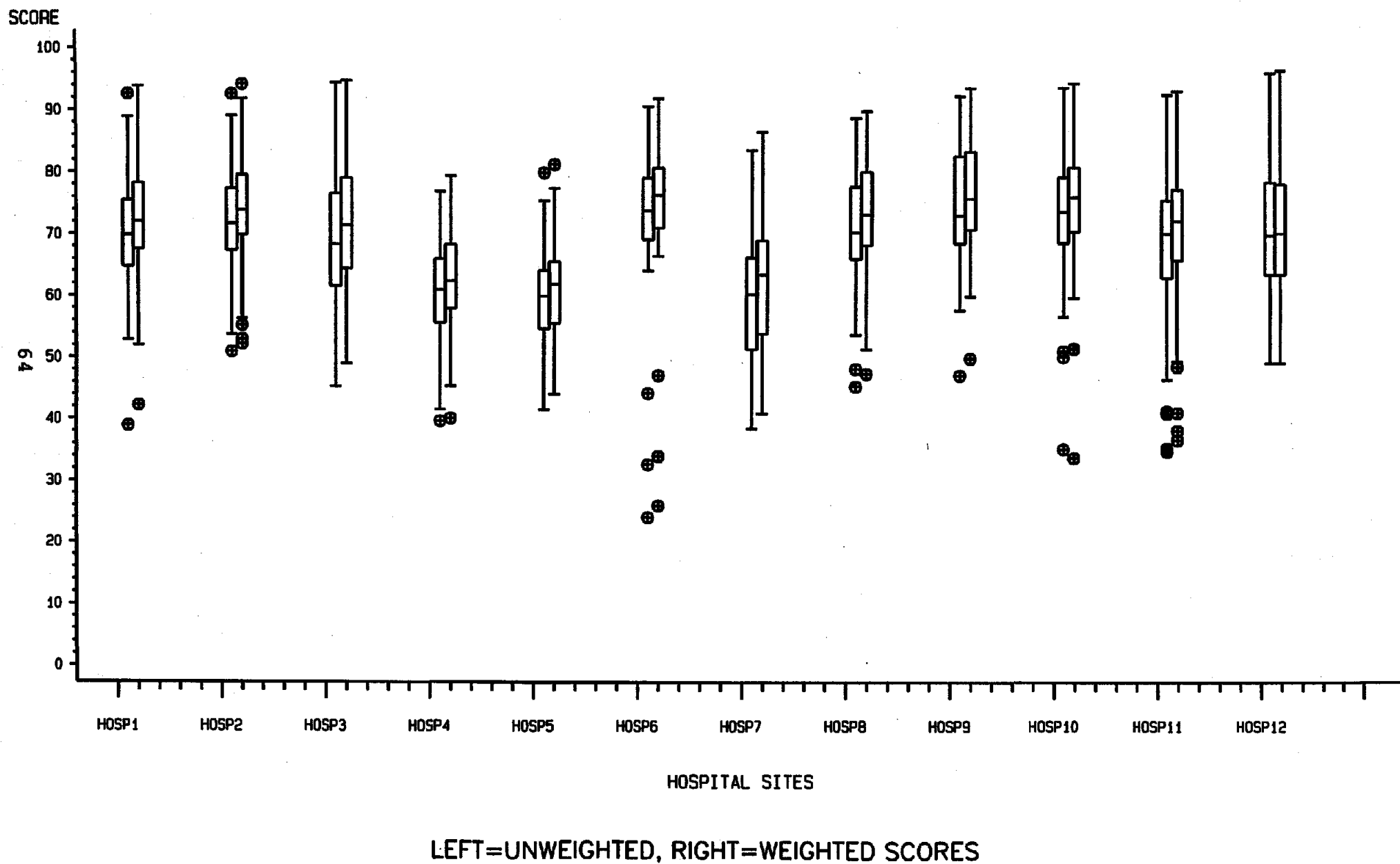
Combining SAS/GRAPH and SAS Macro Language proved to be a valuable tool in presenting the 2 types of hospital quality of care measures in a easy to interpret yet comprehensive manner. These plots can ease the communication of fairly complex data to busy hospital administrators and clinicians, who can use the graphs to compare their performance against a benchmark or against other organizations in their peer group. There has been a great increase in the number of multi-hospital chains seen in the United States over the past decade. The paired boxplots provide the people in charge of these chains a visual method to compare the performance of their constituent hospitals.

Paired boxplots (or similarly created tripled or quadrupled boxplots) could be extended to numerous fields of study. For example, a multicenter clinical trial study analysis could look at the distribution of responses of treatment A versus treatment B across the different sites. Another potential application could be a marketing information firm comparing 2 related companies on distribution of produced revenue from the individual sales forces across the last eight quarters. Not much effort would be necessary to think of other examples where paired boxplots could be a useful measure in comparing distributions of data across such things as people, places, or time.

References

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Figure 1. COMPARISON OF COPD ADMISSION ADHERENCE SCORES BY HOSPITAL
unweighted vs. weighted scores



Appendix I

Preparation for Discharge Explicit Criteria Measured for Patients Hospitalized for Congestive Heart Failure

The patient admitted for heart failure is ready for discharge when ...

1. significant improvement in symptoms (dyspnea, orthopnea) and signs (neck vein distention, S3, rales, edema, body weight) has occurred.
2. body weight has been stable or falling, not increasing.
3. temperature has been $<100^{\circ}$ F for over 24 hours.
4. urea nitrogen and creatinine are stable or falling, not rising.
5. no change in cardiac medications has been made for at least 24 hours.
6. serum digoxin level is in the therapeutic range (<2 micrograms/ml).
7. there is documentation in the chart that the patient or family understands the medication regimen.
8. if the patient is receiving warfarin, the prothrombin time has reached a plateau and is not increasing.
9. there is documentation in the chart that the patient or family understands the dietary regimen.
10. plans for postdischarge medical care are stated in the chart.

Appendix II

```
*** program to compare 12 participating hospital      ;
*** adherence scores (3 scores w/in 3 diseases)      ;
*** -does side by side plots of unweighted vs. weighted ;
*** -this setup produces graph for Figure 1          ;

filename g1 '/data/users/dubin/program/misc/scsug94/boxplot.scsug94.gph';
                                                    ** for hp graphics output;
filename macrolib '/data/users/dubin/data/macrolib'; ** for weight macro;

libname filein  '/data/sasdata/readml4d'; *** for disease files;

*** macro variables ***;
%let s=2;      *** represents 1st disease;
%let f=2;      *** represents last disease (1=chf, 2=copd, 3=dm);

%let y=1;      *** 1st adherence score;
%let z=1;      *** last adherence score (1=adm, 2=treat, 3=dis);

%let u=1;      *** represents unweighted scores;
%let w=2;      *** represents weighted scores;

%let file1=filein.chf725;      *** needed to read in chf perm sas dataset;
%let file2=filein.copd1104;    *** needed to read in copd perm sas dataset;
%let file3=filein.dm569;       *** needed to read in dm perm sas dataset;

%let dis1=CHF;                  *** disease macros for title statement;
%let dis2=COPD;
%let dis3=DM;

%let adh1=ADMISSION;           *** adherence score macros for title statement;
%let adh2=TREATMENT;
%let adh3=DISCHARGE;

%let d=device;
%let t=target;
%let dev=&d;                    *** use device (hp only) or target (hp and inter);
%let mode=append;              *** use append or replace;

*** program options (not goptions) ***;
options mprint mlogic nodate nonumber sasautos=macrolib;

*** below is sas-graph appearance code *** ;

goptions reset=all
      htext=2.0 pct
      vpos=30
      &dev=hpgl3si gaccess=sasgaedt
      gsfname=g1 gsfname=&mode display
      rotate=landscape;

symbol i=boxt mode=include v=+ color=black h=0.5;
axis1 value= ('HOSP1' 'HOSP2' 'HOSP3' 'HOSP4' 'HOSP5' 'HOSP6'
              'HOSP7' 'HOSP8' 'HOSP9' 'HOSP10' 'HOSP11' 'HOSP12' ' ')
           offset=(3,3) label=(height=2.5 pct 'HOSPITAL SITES');
axis2 label=(height=2.5 pct 'SCORE')
           order=(0 to 100 by 10);
```

```

%macro loop;
  %do i=%s %to %f;  *** do-loop for different diseases ***;

  data wfile&i (keep=point wtscore1-wtscore3)  ufile&i (keep=point score1-score3);
  set &&file&i;
  if acuthosp='a16' then point=1;
  else if acuthosp='a54' then point=2;
  else if acuthosp='a63' then point=3;
  else if acuthosp='a58' then point=4;
  else if acuthosp='a37' then point=5;
  else if acuthosp='a17' then point=6;
  else if acuthosp='a08' then point=7;
  else if acuthosp='a05' then point=8;
  else if acuthosp='a93' then point=9;
  else if acuthosp='a67' then point=10;
  else if acuthosp='a55' then point=11;
  else if acuthosp='a43' then point=12;
  %wtgt;  *** to include weighted criterion score creation *** ;
  score1=100*(cryes1/(cryes1+crnocal));
  wtscore1=100*(wtyes1/(wtyes1+wtnocal));
  score2=100*(cryes2/(cryes2+crnoca2));
  wtscore2=100*(wtyes2/(wtyes2+wtnoca2));
  score3=100*(cryes3/(cryes3+crnoca3));
  wtscore3=100*(wtyes3/(wtyes3+wtnoca3));

  data ufile&i;
  set ufile&i;
  dummy=1;

  data wfile&i;
  set wfile&i;
  dummy=2;
  rename wtscore1=score1 wtscore2=score2 wtscore3=score3;

  data file&i (drop=dummy point);
  set ufile&i wfile&i;
  %do a=1 %to 12;  *** do-loop to sort out weighted and unweighted scores;
    if (point=%a and dummy=1) then do;
      pointx=%a&u;
    end;
    else if (point=%a and dummy=2) then do;
      pointx=%a&w;
    end;
  %end;

  %do k=%y %to %z;  *** do-loop for different adherence scores ***;

  title1 height=2.75 pct font=simplex
    "COMPARISON OF &&DIS&I &&ADH&K ADHERENCE SCORES BY HOSPITAL";
  title3 height=2.25 pct font=simplex 'unweighted vs. weighted scores';
  footnotel height=2.5 pct font=simplex 'LEFT=UNWEIGHTED, RIGHT=WEIGHTED SCORES';

  proc gplot data=file&i;
    plot score&k * pointx /haxis=axis1 vaxis=axis2;

  run;
  %end;  *** adherence score do-loop;
  %end;  *** disease do-loop;
%mend loop;
%loop;

```