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THE IMPACT OF DATA VISUALIZATION IN A STUDY OF CHRONIC DISEASE

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ABSTRACT

A recent study of chronic disease patients was sponsored by the University of Texas Health Science Center at San Antonio. Participants in the study wore a wrist monitor for 2 weeks. Information gathered by these devices included time and the patient's daily activity per minute.

Before analysis began various hypotheses were established regarding patients in the study. Researchers planned to summarize the activity data and analyze possible connections to health care utilization, hypothesizing that certain patterns of activity could be identified which would predict future hospitalization. In a real world setting, clinicians with access to activity data would then have the ability to foresee, provide early treatment, and possibly prevent an expensive hospitalization.

Research into these hypotheses began by taking the large amounts of activity data downloaded from the wrist monitors and converting them into a SAS data warehouse. Various steps were taken to clean and define valid data. Further steps were taken to establish criteria for computing analysis measures.

This poster presentation will outline the steps taken in this pilot research study to organize the data for analysis, data visualization and the eventual impact of visualization.

Keywords: SAS/GRAPH[®], GPLOT, ANNOTATE

INTRODUCTION - BACKGROUND AND MOTIVATION

Recently, there has been a vested interest in the study of chronic diseases. The rise in the cost of care has led to a push to better manage the nature of a patient's chronic disease. One way this can be done is to better predict patient hospitalizations and thereby avoid preventable hospitalizations. New technologies have been brought into the mainstream of such studies allowing for the continuous measure of a patient's level of activity. Among these strategies are a variety of medical devices which have been employed to this end, including wrist-based monitors.

In 2000 The University of Texas Health Science Center at San Antonio sponsored a study of chronic disease to track patients with various types of dispositions. As part of a clinical trial of educational and clinical intervention for chronic disease, researchers asked more than 300 trial participants to wear wristwatch-type activity monitors for as many successive 2 week periods as possible over the 18 months in which they participated in the trial. Information gathered by these devices included time of day and daily activity per minute. With some patients completing more than a dozen such cycles, the resulting dataset totaled more than 2GB for all patients. Data were then downloaded from the watches into ASCII files.

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MOVING FROM ASCII DATA TO MEASURE READY-DATA: DATA CLEANING AND VALIDATION

Much work was done to agree on our definition of a "valid dataset." This included detecting patient compliance with wearing the monitoring device, valid watch data, choosing a period where data was uniformly available and measurable for all patients, and others.

It took many iterations of computing summary measures to recognize problems with the data and the general methodology. This is a general flow of the computing cycle:

- ◆ Move ASCII data to a SAS dataset
- ◆ Clean/Edit dataset
- ◆ Validate the cleaned/edited data
- ◆ Compute summary measures
- ◆ Render visualization of measures

Most major problems encountered during the study originated with the ASCII data. Such problems included missing data, data format inconsistencies, faulty devices, and others. These problems were not detected until the computation or visualization steps of processing. This caused processing to begin again with new preprocessing utilities to correct these problems. Clearly, this was a tedious and time consuming process.

DOWNLOADING ACTIVITY DATA

In this study, there were slightly more than 300 patients who participated in wearing wrist bands. Each patient could have as many as 12 two week period data sets within the 18 month study. In total, there were approximately 3000 data files from wristwatch activity.

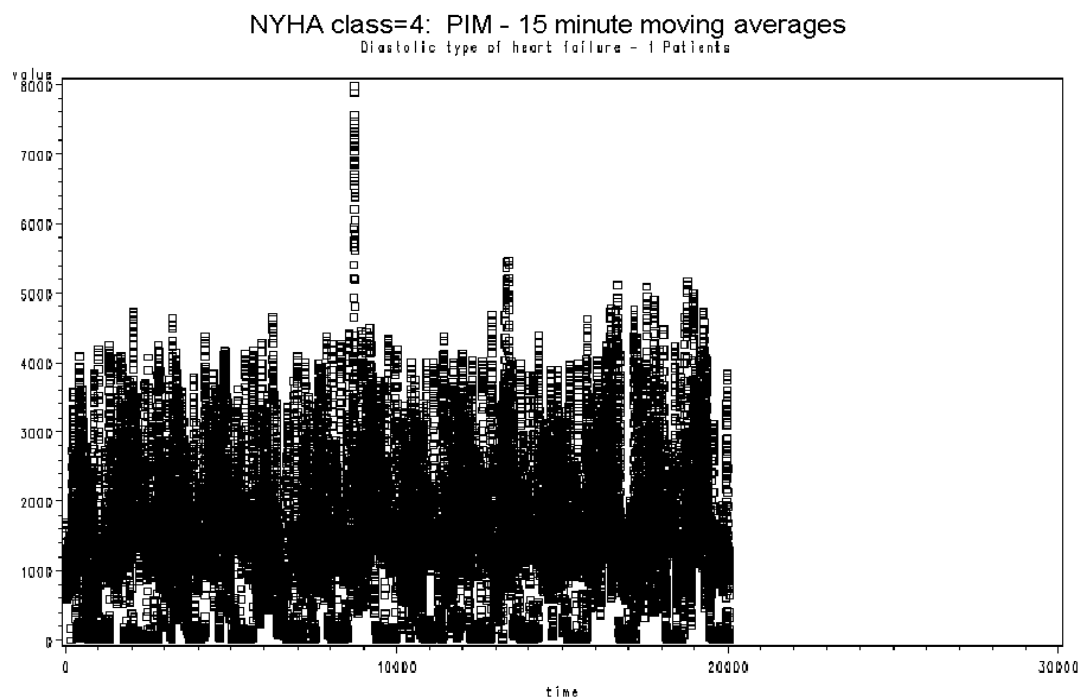
Downloading the data began with reading in the raw activity data. Data were organized as shown in Figure 1.

Figure 1. File for Patient 001

Date	Time	Activity_1	Activity_2	Activity_3
7/15/2000	9:00:00	3166	174	156
7/15/2000	9:01:00	2978	254	240
7/15/2000	9:02:00	3931	258	248
7/15/2000	9:03:00	2596	226	228
7/15/2000	9:04:00	1250	214	178
7/15/2000	9:05:00	2984	200	262
7/15/2000	9:06:00	2711	228	254

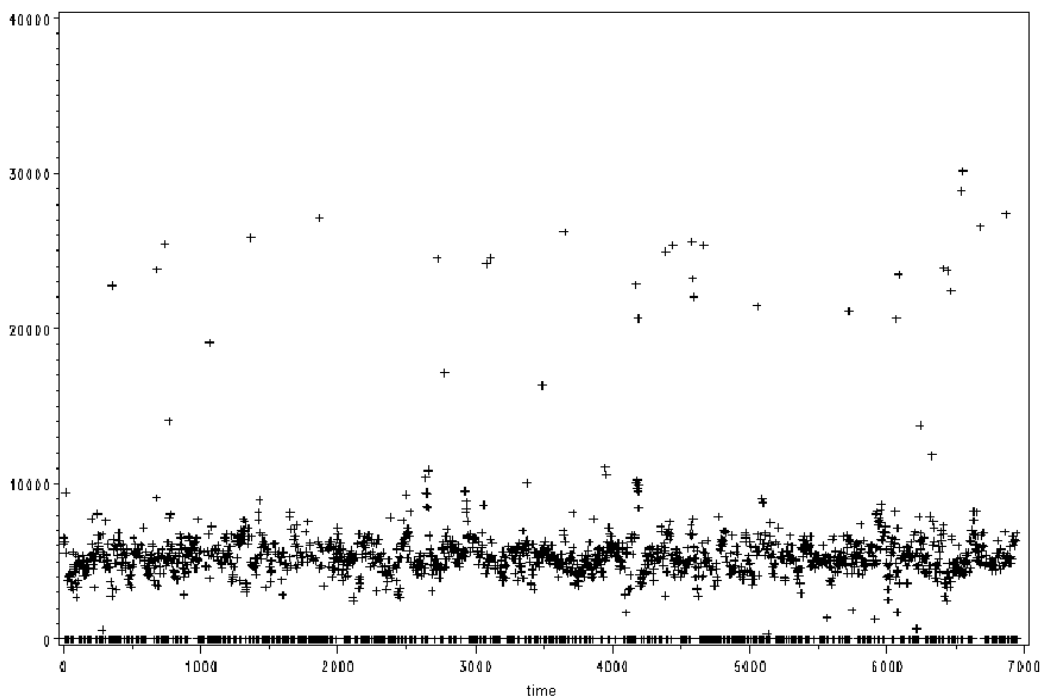
Figure 1 represents a sample of wristwatch activity data for a single patient for a single round in the study. In general, this activity data exists for a two week period. This means that each set of raw data would contain more than 20,000 rows of data. As shown, date and time are followed by three activity measures in comma separated files read via an Excel spreadsheet. Downloading the data was not a trivial task.

STEPS TO VISUALIZATION - COMPUTING MOVING AVERAGES



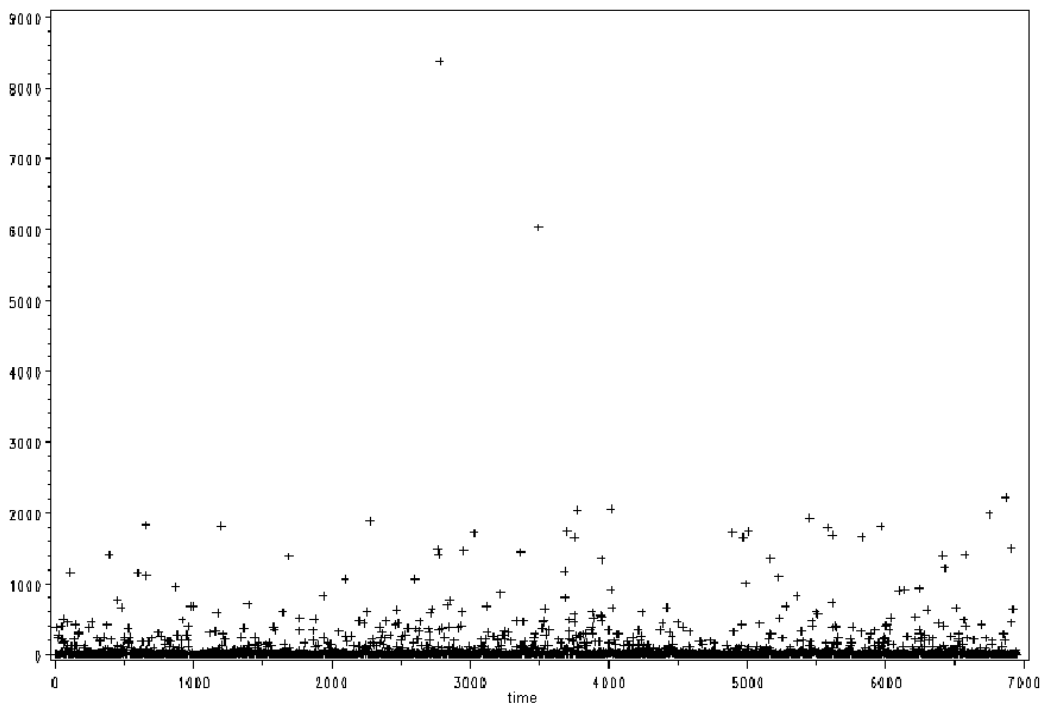
STEPS TO VISUALIZATION - COMPUTING A HIGH ACTIVITY MEASURE

Daytime Activity - PIM



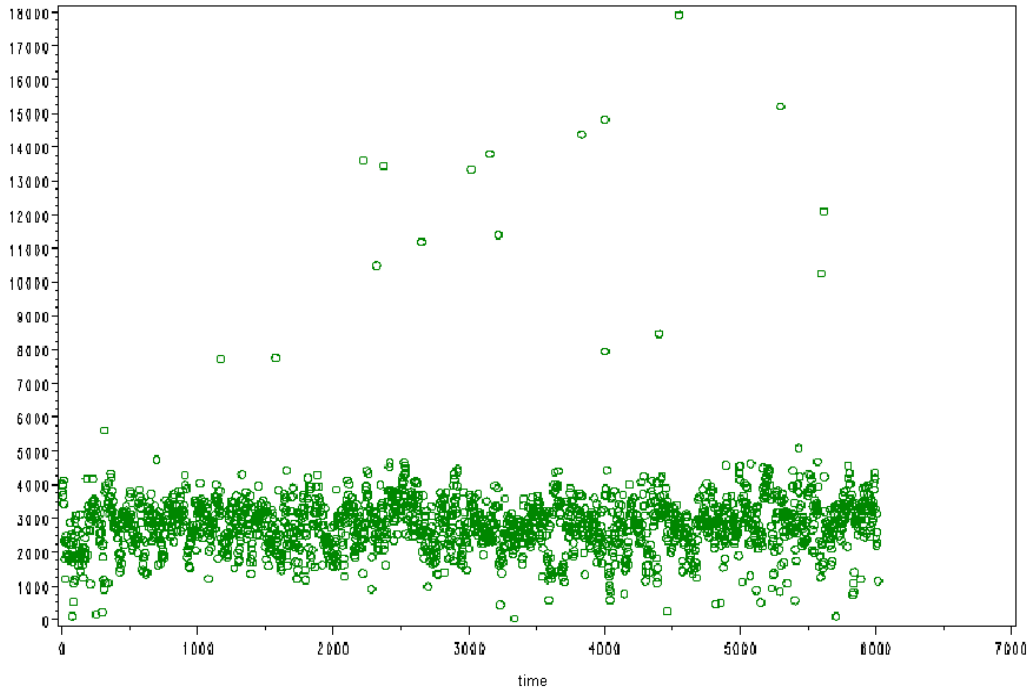
STEPS TO VISUALIZATION - COMPUTING A LOW ACTIVITY MEASURE

Nighttime Activity - PIM



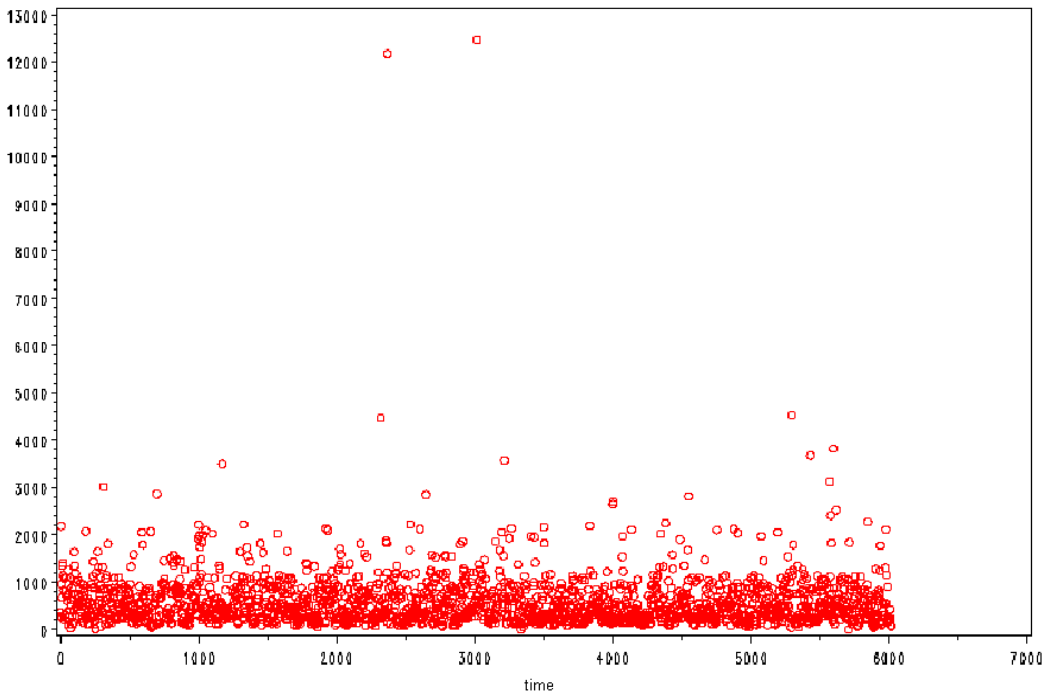
REFINING VISUALIZATION OF A HIGH ACTIVITY MEASURE

PIM: Daytime Activity

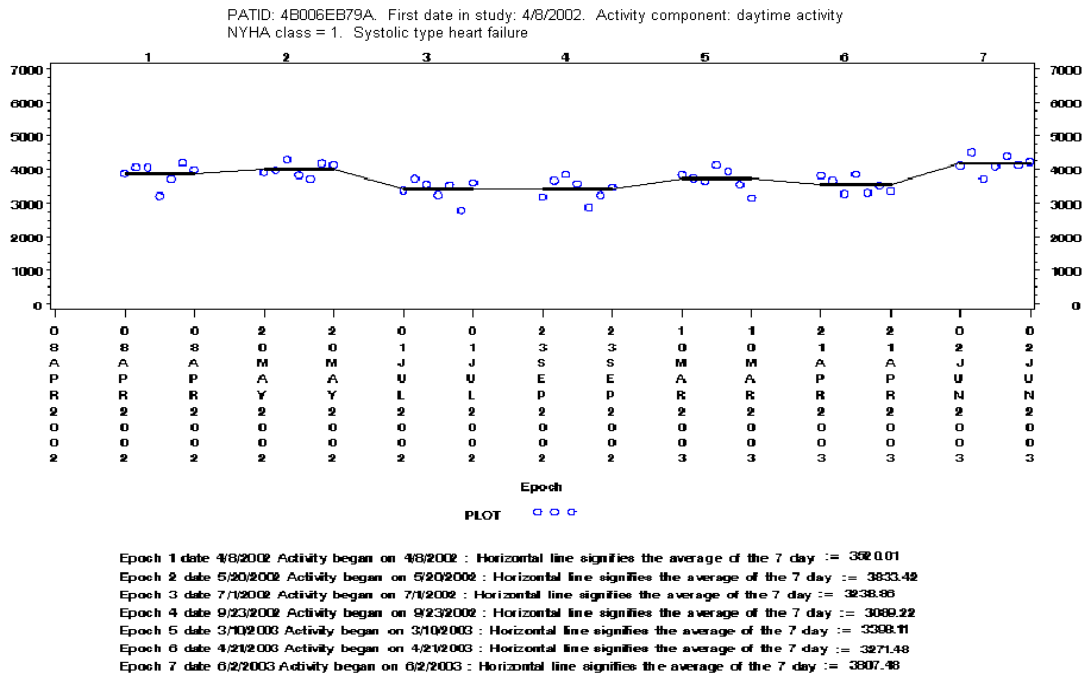


REFINING VISUALIZATION OF A LOW ACTIVITY MEASURE

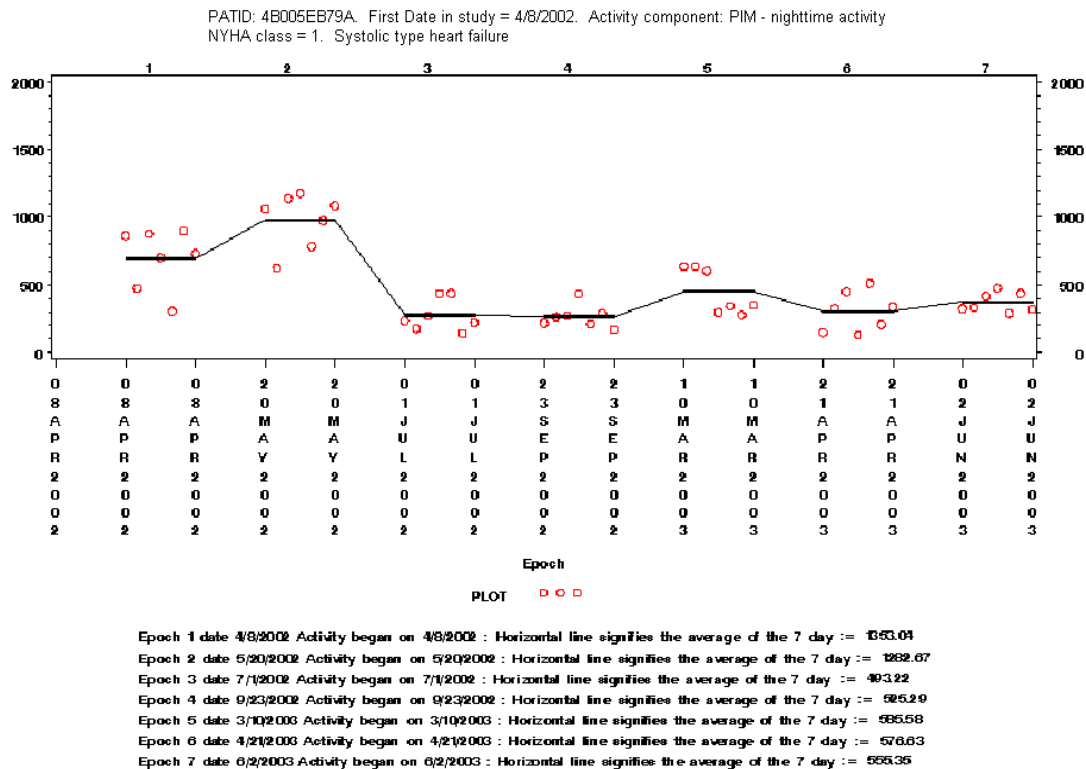
PIM: Nighttime activity



VISUALIZATION - A COMPLETE HIGH ACTIVITY EPOCH

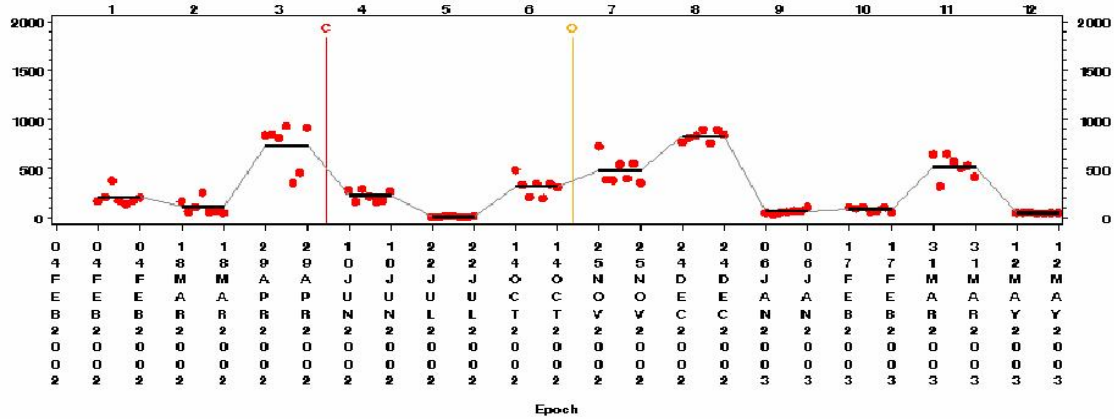


VISUALIZATION - A COMPLETE LOW ACTIVITY EPOCH



VISUALIZATION IMPACT - SYSTOLIC TYPE HEART FAILURE WITH EVENTS AND SPIKE

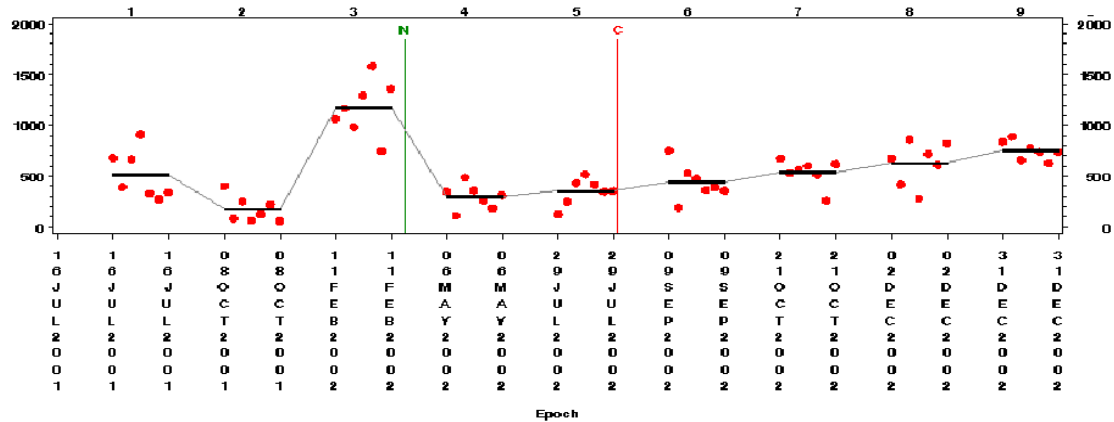
PATID: 12006BF525. First Date in study: 2/4/2002. Activity component: PIM - nighttime activity
 NYHA class= 2. Systolic type heart failure



Epoch 1 date 2/4/2002 — Activity began on 2/4/2002 :: Horizontal line signifies the average of the 7 day := 308.94
 Epoch 2 date 3/18/2002 — Activity began on 3/18/2002 :: Horizontal line signifies the average of the 7 day := 260.59
 Epoch 3 date 4/29/2002 — Activity began on 4/29/2002 :: Horizontal line signifies the average of the 7 day := 1097.9
 Epoch 4 date 6/10/2002 — Activity began on 6/10/2002 :: Horizontal line signifies the average of the 7 day := 394.53
 Epoch 5 date 7/22/2002 — Activity began on 7/22/2002 :: Horizontal line signifies the average of the 7 day := 29.37
 Epoch 6 date 10/14/2002 — Activity began on 10/14/2002 :: Horizontal line signifies the average of the 7 day := 516.93
 Epoch 7 date 11/25/2002 — Activity began on 11/25/2002 :: Horizontal line signifies the average of the 7 day := 602.27
 Epoch 8 date 12/24/2002 — Activity began on 12/24/2002 :: Horizontal line signifies the average of the 7 day := 885.17
 Epoch 9 date 1/6/2003 — Activity began on 1/6/2003 :: Horizontal line signifies the average of the 7 day := 102.41
 Epoch 10 date 2/17/2003 — Activity began on 2/17/2003 :: Horizontal line signifies the average of the 7 day := 280.85

VISUALIZATION IMPACT - SYSTOLIC TYPE HEART FAILURE WITH EVENTS AND NO SPIKE

PATID: 51004A4D40 - First Date in study: 7/16/2002. Activity component: PIM - nighttime activity
 NYHA class= 3. Systolic type heart failure



Epoch 1 date 7/16/2002 — Activity began on 7/16/2002 :: Horizontal line signifies the average of the 7 day := 836.49
 Epoch 2 date 10/8/2002 — Activity began on 10/8/2002 :: Horizontal line signifies the average of the 7 day := 618.06
 Epoch 3 date 2/11/2003 — Activity began on 2/11/2003 :: Horizontal line signifies the average of the 7 day := 1042.27
 Epoch 4 date 5/8/2002 — Activity began on 5/8/2002 :: Horizontal line signifies the average of the 7 day := 891.66
 Epoch 5 date 7/29/2002 — Activity began on 7/29/2002 :: Horizontal line signifies the average of the 7 day := 604.69
 Epoch 6 date 9/9/2002 — Activity began on 9/9/2002 :: Horizontal line signifies the average of the 7 day := 928.41
 Epoch 7 date 10/21/2002 — Activity began on 10/21/2002 :: Horizontal line signifies the average of the 7 day := 1014.42
 Epoch 8 date 12/2/2002 — Activity began on 12/2/2002 :: Horizontal line signifies the average of the 7 day := 1087.38
 Epoch 9 date 12/31/2002 — Activity began on 12/31/2002 :: Horizontal line signifies the average of the 7 day := 1216.99

Note that in the above visualization impact graphs contain event lines. These events indicate a patient's hospitalization due to the following: C – cardiology, O – other, and N – non-cardiological hospitalization.

A GENERALIZED TEMPLATE OF THE MACRO USED FOR VISUALIZATION

```

/*****/
/* Create GRAPH_FILE from IN_FILE of patient study information. */
/* Number of times in the study, */
/* time points, */
/* disease classifications, */
/* patient events in the study, if any */
/* DAYTIME & NIGHTTIME activity measures, MAXs & MINs */
/* Summary measures for each time in the study */
/*****/

/*****/
/* Open ODS conduits */
/*****/
ods listing close;
ods html path="&path_data_plot.\&in_patid.\&in_var."
          gpath="&path_data_plot.\&in_patid.\&in_var."
          file="&plot_file." ;
options ftext=swissb rotate=landscape;

/*****/
/* Create annotate file */
/*****/
data anno_activity;
length color function $8 text $25;
retain xsys '2' ysys '2' when 'a';
%do z = 1 %to &total_time_in_study.;
  function='move';
  x=%sysfunc(round(&&first_act_t_&z..,1));
  y=%sysfunc(round(&&daily_avg_activity_&z..,1));
  output;
  function='draw';
  x=%sysfunc(round(&&last_act_t_&z..,1));
  y=%sysfunc(round(&&daily_avg_activity_&z..,1));
  color='black';
  size=2;
  output;
  function='label';
  x=%sysfunc(round(%eval(&&last_act_t_&z.. - %eval(4*1440)),1));
  y=2000;
  size=1;
  position='2';
  color='black';
  text="&z.";
  output;
%end;
run;

/*****/
/* Set up GPLOT X & Y axis definitions */
/* and references including patient events */
/* as reference lines, if they exist */
/*****/
/*****/
/* X axis */
/*****/
axis1 major=none minor=none value=none
%if &ref_count > 0 %then %do; rellabel=(h=1 &ref. ) %end; ;
/*****/
/* Y axis */

```

```

/*****/
axis4 order=(0 to 2000 by 500) ;
symbol1 v=dot color=red;

/*****/
/* Plot patient's study data */
/*****/
proc gplot data=GRAPH_FILE;
format Epoch datetime9.;
plot ACTIVITY*Epoch
/ overlay legend vaxis=axis4 anno=anno_activity haxis=axis1
  %if &ref_count > 0 %then %do; href=&ref_date. chref=(&href_colors.) %end; ;
plot2 ACTIVITY_*Epoch / vaxis=axis4;

/*****/
/* Titles set up */
/*****/
%let month=%sysfunc(month(%sysfunc(datepart(&date_1.))));
%let day  =%sysfunc(day(%sysfunc(datepart(&date_1.))));
%let year =%sysfunc(year(%sysfunc(datepart(&date_1.))));
title h=1 "PATID: &in_patid. - First Date in study: &month./&day./&year.
- Activity component: %upcase(&in_var.) - Nighttime activity";
%if "&in_thf."="D" %then
%do;
  title2 h=1 "NYHA class=%trim(%left(&in_class.)) - Diastolic type heart failure";
%end;
%else %if "&in_thf."="S" %then
%do;
  title2 h=1 "NYHA class=%trim(%left(&in_class.)) - Systolic type heart failure";
%end;
%else
%do;
  title2 h=1 "No heart failure information available";
%end;

/*****/
/* Footnotes created here */
/*****/
%do z = 1 %to &total_time_in_study.;
%let month1=%sysfunc(month(%sysfunc(datepart(&&date_&z.))));
%let day1  =%sysfunc(day(%sysfunc(datepart(&&date_&z.))));
%let year1 =%sysfunc(year(%sysfunc(datepart(&&date_&z.))));
%let month2=%sysfunc(month(%sysfunc(datepart(&&first_act_t_&z.))));
%let day2  =%sysfunc(day(%sysfunc(datepart(&&first_act_t_&z.))));
%let year2 =%sysfunc(year(%sysfunc(datepart(&&first_act_t_&z.))));
footnote&z. j=1
  "Epoch &z. date &month1/&day1/&year1
  - Activity began on &month2/&day2/&year2
  :: Horizontal line signifies the average of the 7 day
  := %sysfunc(round(&activity_&z. ,.01));" ;
%end;
run;
quit;

/*****/
/* Cleanup: clear out footnotes, titles */
/*****/
%do z = 1 %to &total_time_in_study.; footnote&z. '00'x; %end;
title ' ';
title2 ' ';

```

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