

What's Your Favorite Color? Controlling the Appearance of a Graph

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ABSTRACT

The appearance of a graph produced by the Graph Template Language (GTL) is controlled by Output Delivery System (ODS) style elements. These elements include fonts and line and marker properties as well as colors. A number of procedures, including the Statistical Graphics (SG) procedures, produce graphics using a specific ODS style template. This paper provides a very basic background of the different style templates and the elements associated with the style templates. However, sometimes the default style associated with a particular destination does not produce the desired appearance. Instead of using the default style, you can control which style is used by indicating the desired style on the ODS destination statement. However, sometimes not a single one of the 50-plus styles provided by SAS® achieves the desired look. Luckily, you can modify an ODS style template to meet your own needs. One such style modification is to control which colors are used in the graph. Different approaches to modifying a style template to specify colors used are discussed in depth in this paper.

INTRODUCTION

The appearance of many SAS-generated visualizations is controlled by ODS style elements. There are over 50 different ODS styles that can be used for ODS statistical graphics. These styles determine things such as the font, background color, the wall color, grouping color, and contrasting color, just to name a few. Each ODS destination has a default style associated with it. However, sometimes the default styles do not meet our needs. We may have a client that wants things in black and white but with a specific font, so using the standard colors associated with a style that utilizes that font may not be feasible. Or we may need to have a consistent set of colors for specific values, thus allowing SAS to set the colors may not be ideal. Because companies or individuals have different views on what they deem as an ideal look for a graph, SAS allows for customization of styles. You can write your own style, or you can start with a style that has most of the components you like and modify that style to fit your needs. This paper will focus on taking existing styles and modifying specific elements to create the desired look within GTL. However, these concepts can be applied to other types of visualizations.

UNDERSTANDING ODS STYLES AND ELEMENTS

Before you can write your own style, it is advisable to have a basic understanding of the different styles and some of the elements associated with styles. In this paper, we will touch briefly on some of the different style elements, with the primary focus being adjusting the colors.

DEFAULT STYLES AND COMMON ODS STYLES

For each device and ODS destination, SAS has default styles. For example, the default style for the PDF destination is the "Pearl" style template, and the default style for the RTF destination is the "RTF" style template (Figures 1 and 2).

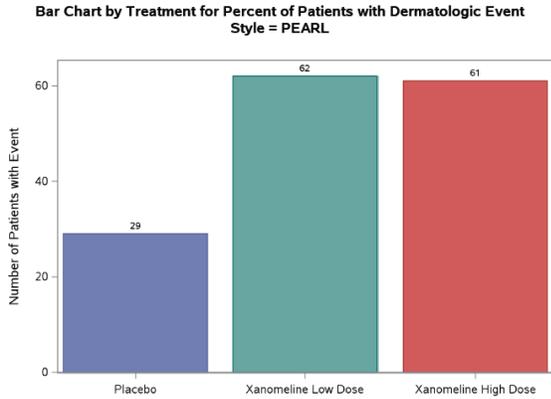


Figure 1: Sample Figure with STYLE = Pearl

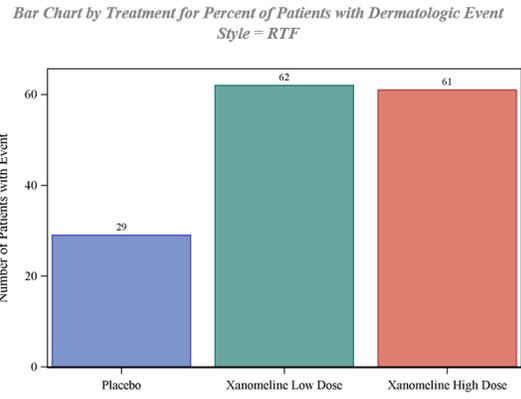


Figure 2: Sample Figure with STYLE = RTF

A list of default styles for each ODS destination and device combination can be found at [Default Devices and Styles for Commonly Used ODS Destinations](#). If you are curious as to how each of these styles would look in HTML, PDF and RTF, you can run the SAS code that is found at [Program for Viewing Multiple Styles](#).

However, you are not limited to using the default style for the indicated destination and device. There are over 50 styles that are part of SAS that you can choose from. Refer to the [ODS Styles Gallery](#) for a list of the various styles available in SAS.

Below are some recommended SAS-supplied style templates:

- DEFAULT
- HTMLBLUE
- ANALYSIS
- DAISY
- JOURNAL
- JOURNAL2
- JOURNAL3
- STATISTICAL

A complete list of recommended style templates can be found at [Recommended Styles for ODS Destinations](#).

What makes these styles different? They can vary based on font style, font size, and font color. They can also vary based on fill color, background color and a variety of other style elements as demonstrated in Figures 3 – 6 and Appendix 1.

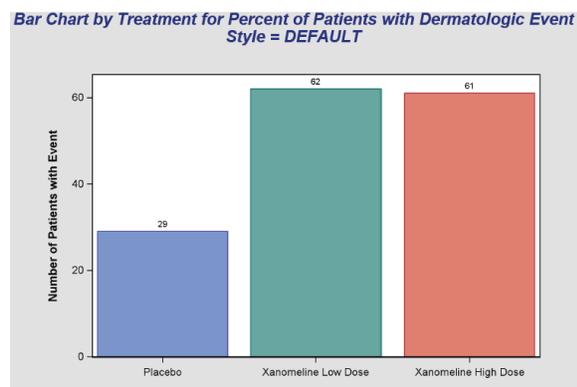


Figure 3: Sample Figure for Style = DEFAULT

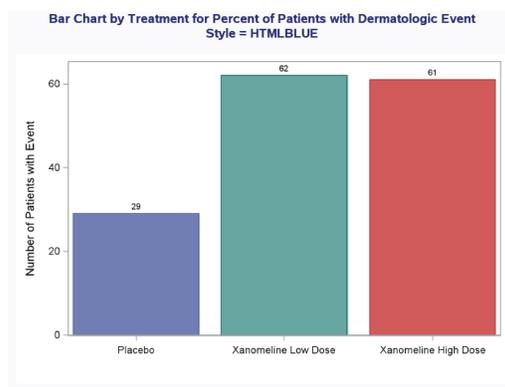


Figure 4: Sample Figure for Style = HTMLBLUE

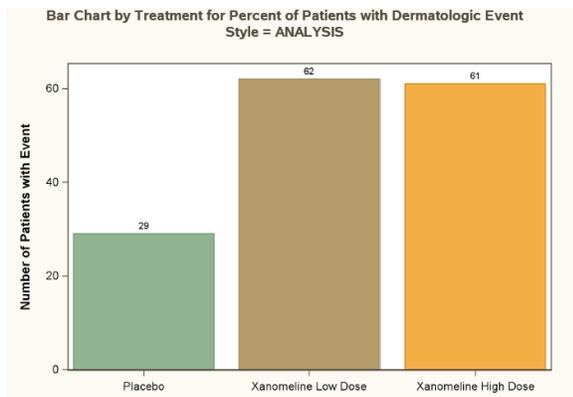


Figure 5: Sample Figure for Style = ANALYSIS

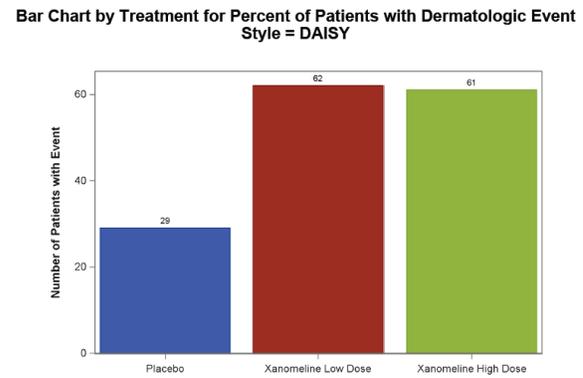


Figure 6: Sample Figure for Style = DAISY

To see more samples of the various styles visit [Statistical Graphics Using ODS: ODS Styles Comparisons](#).

COMMON ODS STYLE ELEMENTS

SAS has a set of common ODS style elements that are used to produce most graphs. For example, GraphDataDefault, GraphData1 – GraphData n , GraphConfidence as well as others. These common ODS style elements have pre-set values for various attributes, such as the marker size and symbol, line style and thickness, and color that are dependent on the style specified.

With most of the SAS defined styles, there is an inheritance from a parent style. For example, ANALYSIS style inherits most of its style elements from the DEFAULT style. In addition, DAISY inherits from the HTMLBLUE style which inherits from the STATISTICAL style and the STATISTICAL style inherits from the DEFAULT style. When one style inherits from another style only the elements that are different are specified.

GraphData1 – GraphData n are attributes that are specifically related to the grouped data item associated with the indicated number. For example, GraphData1 are the attributes associated with the first grouped data item, while GraphData4 are attributes associated with the fourth grouped data item.

How these various pre-defined ODS style elements are displayed is dependent on the ODS style used, as shown in Figures 7 – 10 and Appendix 2. Notice that for the Figures 7 – 10 that regardless of the type of graph that is displayed that if the colors are not specified for each grouped data that SAS will use the pre-defined elements associated with GraphData n for each n th group.

For example, if you view the differences between the styles for Figures 7 and 9 you will notice that the primary difference is the colors. For DEFAULT and ANALYSIS styles, GraphData1 uses the circle as the marker with a line pattern of 1 (solid line); GraphData2 uses the plus sign as the marker with a line pattern of 4 (medium dash); and GraphData3 uses an 'X' as the marker with a line pattern of 8 (MediumDashShortDash). However, as noted in Output 1 the colors are different. In Figures 8 and 10, you will notice that for all three groups the same marker and line pattern are used but as illustrated in Output 1 they have different colors.

DEFAULT and ANALYSIS use the default rotation pattern which means that it will use the markers, line patterns, and colors associated with the corresponding GraphData n . However, HTMLBLUE and DAISY (prior to SAS 9.4M6) used the color-priority as the default rotation. Note that starting with SAS 9.4M6 DAISY style will use the default rotation pattern instead of the color-priority rotation.

DEFAULT		
CX7C95CA	CXDE7E6F	CX66A5A0
RGB(124, 149, 202)	RGB(222, 126, 111)	RGB(102, 165, 160)
ANALYSIS		
CX8FB38F	CXF2AE49	CXB49C6A
RGB(143, 179, 143)	RGB(242, 174, 73)	RGB(180, 156, 106)

HTMLBLUE		
CX6F7EB3	CXD05B5B	CX66A5A0
RGB(111, 126, 179)	RGB(208, 91, 91)	RGB(102, 165, 160)
DAISY		
CX3D5AAE	CX90B328	CX9D2E14
RGB(61, 90, 174)	RGB(144, 179, 40)	RGB(157, 46, 20)

Output 1: Color Codes GraphData1 – GraphData3 for DEFAULT, HTMLBLUE, ANALYSIS and DAISY styles

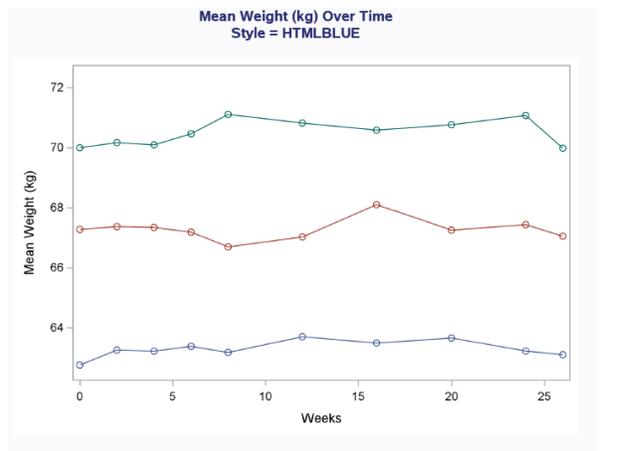
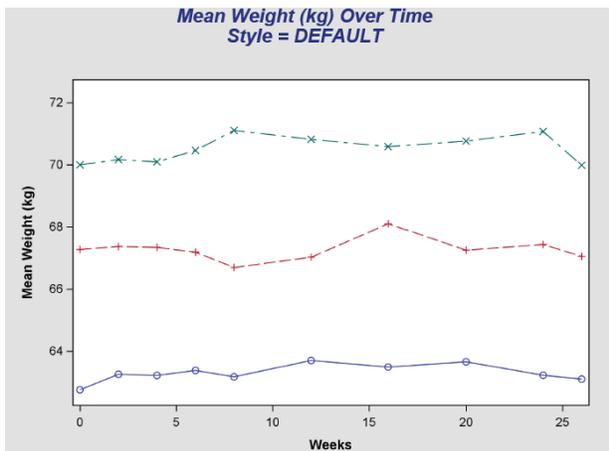
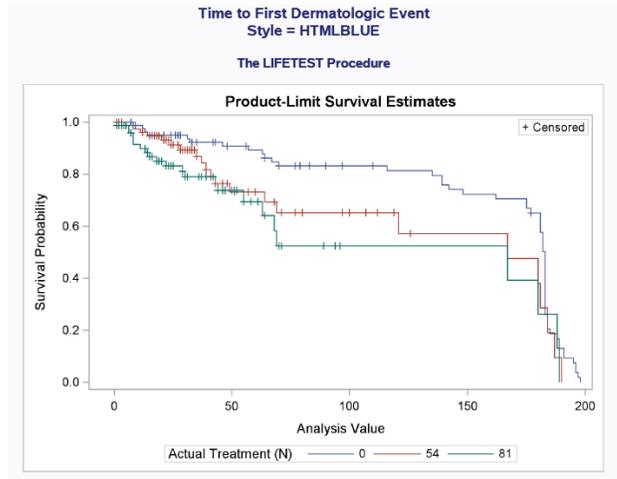
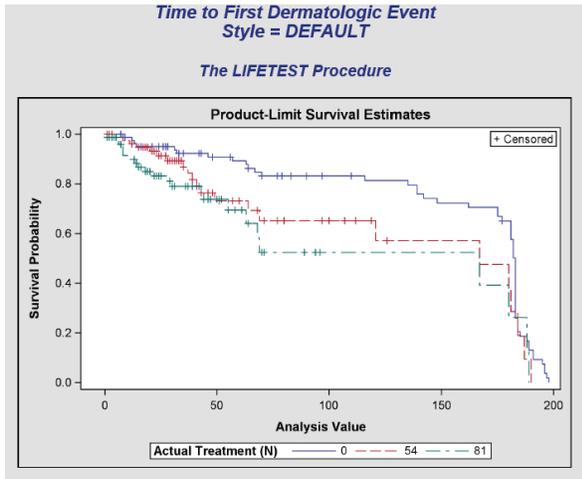


Figure 7: Sample Figures for Some Common ODS Style Elements for Style = DEFAULT

Figure 8: Samples Figure for Some Common ODS Style Elements for STYLE = HTMLBLUE

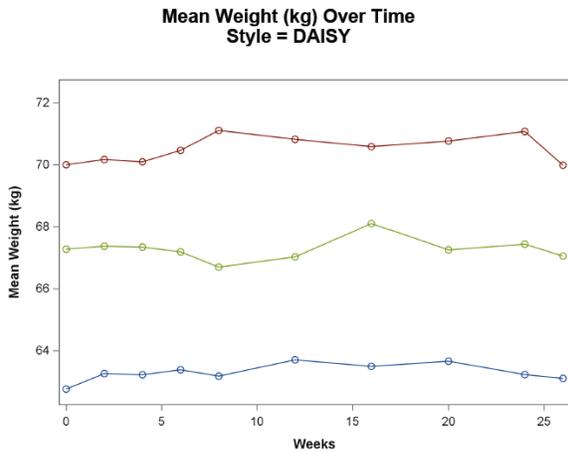
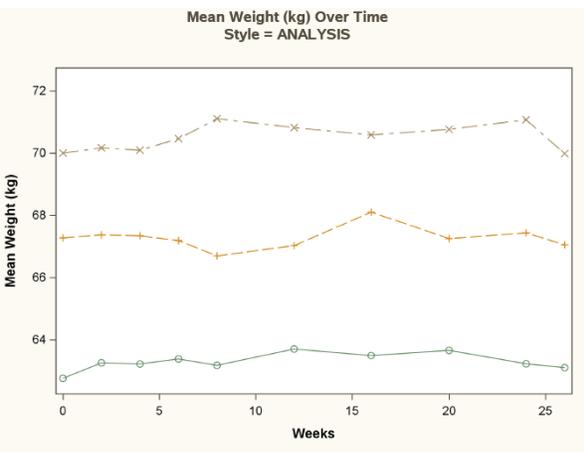
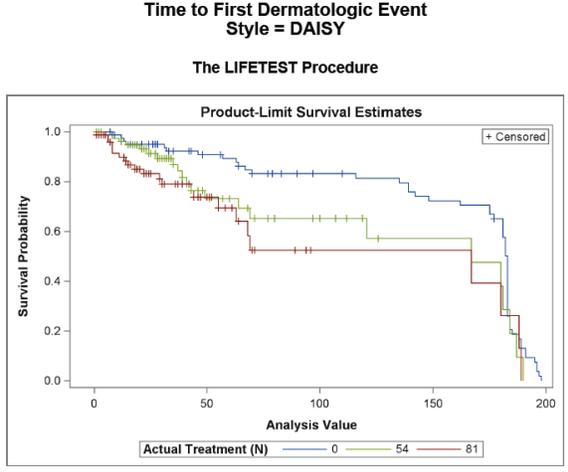
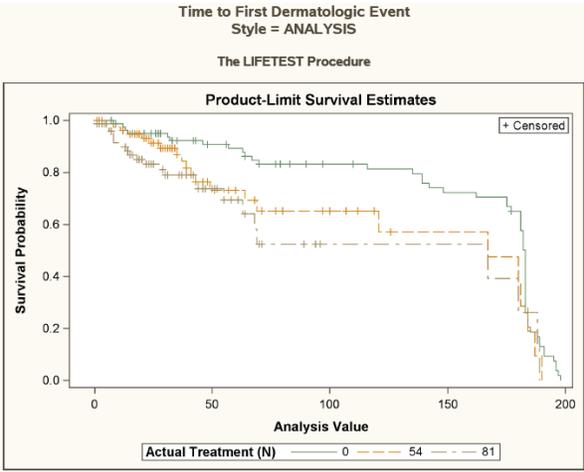


Figure 9: Sample Figures for Some Common ODS Style Elements for Style = ANALYSIS

Figure 10: Sample Figures for Some Common ODS Style Elements for Style = DAISY

Most of the styles use DEFAULT as the parent style. Each style definition inherits attributes from the parent style (e.g., DEFAULT) and specifies the attributes for the element(s) that are different from the parent.

For more common ODS Style Elements visit [Statistical Graphics Using ODS: Some Common ODS Style Elements](#).

IDENTIFYING COLORS

Millions of colors are available for use when creating the necessary output. These colors can be specified within SAS using one of the seven valid color-naming schemes.

- RGB (red green blue)
- CMYK (cyan magenta yellow black)
- HLS (hue lightness saturation)
- HSV (hue saturation brightness), also called HSB
- Gray scale
- SAS color names (from the SAS Registry)
- SAS Color Naming System (CNS)

Although there are millions of colors theoretically at our disposal, it does not mean that all the colors are available. There are limitations to the number of colors that can be displayed for given devices and/or

media types. The device you are using will determine the number of colors that can be processed and viewed, as not all devices have the capability to display all the possible colors specified for an output. If a specific color is not available, then SAS and the device use an existing color that is a close approximation of the desired color. Refer to the RGB and HLS values needed for SAS in Table 1.

Table 1 illustrates a couple of examples of what the color scheme value is for the specific color as well as the value in SAS that corresponds to the indicated color scheme value.

Color-Naming Scheme	Example for Pink	Value Specified in SAS	Example for Turquoise	Value Specified in SAS
RGB (red green blue)	255, 192, 203	CXFFC0CB CXFFBFCC #	64, 225, 208	CX40E0D0 CX40E0D1 #
CMYK (cyan magenta yellow black) †	0, 25, 20, 0	CMYK00403300	71, 0, 7, 12	B500121F
HLS (hue lightness saturation)	349, 87, 99	H06DE0FF H06EDFFF ‡	123, 144, 184	H12690B8 H12590B8 ‡
HSV (hue saturation brightness), also called HSB	348, 24, 100	V15C3DFF	173, 71, 87	V0ADB5DE
Gray scale	(255+192+203)/3	GRAYD8	(64+224+208)/3	GRAYA5
SAS color names (from the SAS Registry)	Pink	Pink	Turquoise	Turquoise
SAS Color Naming System (CNS) ††	Very light vivid purplish red	Verylightvividpurplishred	Light moderate blue green	Light_moderate_blue_green
<p># HEX code returned when %RGB macro is used. Although this is slightly different than the one in the SAS registry it yields a color that is nearly identical to the one provided by the HEX code in the list of predefined colors in the SAS registry.</p> <p>† If the value returned from %CMYK macro starts with a number, then the CMYK number used when specifying the color must start with 'CMYK'. Otherwise, the 'CMYK' prefix is not required.</p> <p>‡ HLS code returned when %RGB2HLS macro is used. Although this is slightly different than the one in the SAS registry, it yields a color that is nearly identical to the one provided in the list of predefined colors in the SAS registry.</p> <p>†† Although the colors do not match exactly with the RGB color, it is pretty close. When specifying a color using CNS, you can either remove spaces between each component or separate each component with an underscore.</p>				

Table 1: Color-Naming Schemes and Example Values

Assume you have the RGB decimal code (i.e., the values for R, G, and B), how do you convert that to a value that can be used by SAS? If you know the RGB values, you can easily retrieve the HEX code for each corresponding color element by using the HEX2 format, as illustrated in SAS Program 1. Data Display 1 shows the output from the program and provides the corresponding HEX code for pink and turquoise.

The selection of colors is beyond the scope of the paper, but it is worth mentioning that there are a number of things to take under consideration when choosing colors: including the number of colors or shades needed for a color ramp; and whether the foreground and background are different enough so that someone who is color blind can distinguish between the different components. Sites such [ADA Compliance Site](#) which can help with determining colors for color blind, while you can use the [ColorBrewer2](#) to help choose colors, gray scale equivalents, and color ramps.

```

data color_convert;
  set color;
  rgbhex = cats("CX", put(r, hex2.), put(g, hex2.), put(b, hex2.));
  gray = (r + g + b) / 3;
  grayhex = put(gray, hex2.);
  rper = round(r/255*100);
  gper = round(g/255*100);
  bper = round(b/255*100);
run;

```

SAS Program 1: Determining HEX code

COLOR	R	G	B	RGBHEX	GRAY	GRAYHEX	RPER	GPER	BPER
pink	255	192	203	CXFFC0CB	216.6667	D8	100	75	80
turquoise	64	224	208	CX40E0D0	165.3333	A5	25	88	82

Data Display 1: RGB and Gray HEX Codes

In addition, there are several color SAS-defined utility macros that can help determine the code that should be used when specifying a color in SAS. %COLORMAC can be executed in order to compile all the SAS color utility macros. SAS Program 2 demonstrates some of the color utility macros.

Note that for %RGB macro, the individual color 255-based values need to be converted to a percentage. SAS Program 1 shows how R, G, and B are converted to percentages of 255. The last three columns in Data Display 1 show the converted values, which are used in the %RGB macro in SAS Program 2. For more information on these utility macros visit [Using Color Utility Macros](#).

```

data _null_;
  put "PINK RGB: %RGB(100, 75, 80)";
  put "PINK RGBtoHLS: %RGB2HLS(CXFFC0CB)";
  put "PINK HSV: %HSV(348, 24, 100)";
  put "PINK CMYK: " %CMYK(0, 25, 20, 0);
  put "TURQ RGB: %RGB(25, 88, 82)";
  put "TURQ RGBtoHLS: %RGB2HLS(CX40E0D0)";
  put "TURQ HSV: %HSV(174, 71, 87)";
  put "TURQ CMYK: " %CMYK(71, 0, 7, 12);
run;

```

SAS Program 2: Determining SAS Value for Different Color-Schemes

If you are unsure of the what the hue, saturation, light or brightness are for a specific HEX code, you can use a color converter tool such as the one found at this website <https://www.rapidtables.com/convert/color/>.

For more information on specifying colors visit [Color-Naming Schemes](#).

MODIFYING THE COLORS

As mentioned earlier the primary focus is going to be on changing the colors, but similar concepts illustrated for changing the colors can be applied for changing the font size, font style, marker size, line size and pattern. There are several ways to change the colors.

UNDERSTANDING ROTATION PATTERN

For each style there are attributes that are rotated through for grouped data. The attributes which are rotated through are determined based on the *GraphData**n* style element for the indicated style that is being used. Understanding the attribute rotation pattern is important to ensuring that the any grouped data is represented by the correct set of attributes. *ATTRPRIORITY* option on the *ODS GRAPHICS* statement or in *BEGINGRAPH* statement can be used to override the default rotation pattern. By default, *ATTRPRIORITY* is set to "AUTO" which allows the specific style used to determine the rotation pattern. *ATTRPRIORITY* = "COLOR" is known as a color-priority style or all-color style which indicates that the colors should be rotated through prior to rotating through the other attributes such as marker symbols and line patterns. When the attributes are rotated through it is based on the order of the data. Therefore, if you need to have colors appear in a specific order then either the colors need to be specified in the order in which they would appear in the data or the data needs to be sorted so that the data order is in alignment with the order in which the colors are specified.

SPECIFYING COLOR ON BEGINGRAPH STATEMENT

One of the easiest ways to change a color for all graphs within a template and have it applied to all plot statements within the template is to specify the fill color and/or contrast color on the *BEGINGRAPH* statement.

SAS Program 3 demonstrates the use of two options that allow you to specify the colors.

```
proc template;
  define statgraph bplot1;
    begingraph / border = false
      datacolors = (pink plum paleturquoise 1)
      datacontrastcolors = (black);

      layout overlay / xaxisopts = (label = " "
        type = discrete)
        yaxisopts = (label = "Number of Patients with Event");

      barchart x = trtan y = event / orient = vertical group = trtan
        barlabel = true;

    endlayout;
  endgraph;
end;
run;
```

SAS Program 3: Modifying Color within Graph Template Using *BEGINGRAPH* Options

- 1 On the *BEGINGRAPH* statement, there are several options available that will allow you to control the attributes. You can specify the fill colors to replace the colors associated with the *GraphData**n* style elements by using *DATACOLORS*. A color for each group should be specified. *DATACONTRASTCOLORS* is used to specify the contrast colors that are to be used. Colors are used for fill areas while the contrast colors are used for the markers and outlines. In Figure 11, you can see that each bar corresponds to one of the colors in the *DATACOLORS* option and the lines for each bar is black which corresponds to the color indicated in *DATACONTRASTCOLORS*. However, notice that the order in which the colors are listed: pink, plum, paleturquoise; but Figure 11 has pink, paleturquoise and plum. This is due to the fact that in the data, Xanomeline High Dose appears prior to Xanomeline Low Dose. If Xanomeline Low Dose should be plum, then the data should be sorted appropriately or the list on the *DATACOLORS* option should be reordered. If we sort the data by so that Placebo records come first, followed by Xanomeline Low Dose with Xanomeline High Dose last and re-render the template, then the colors would be as expected (Figure 12).

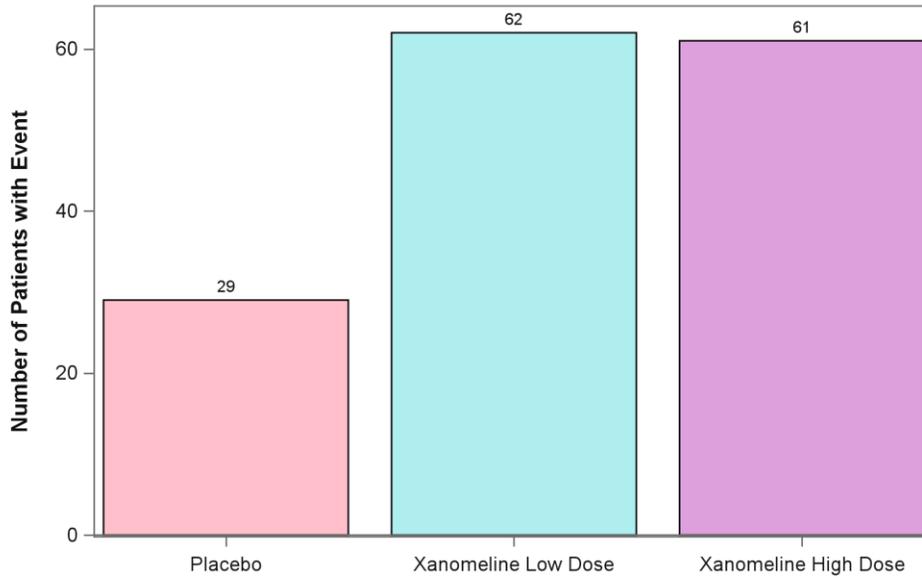


Figure 11: Modifying Color within Graph Template Using BEGINGRAPH Options – Rendering Graph without Sorting

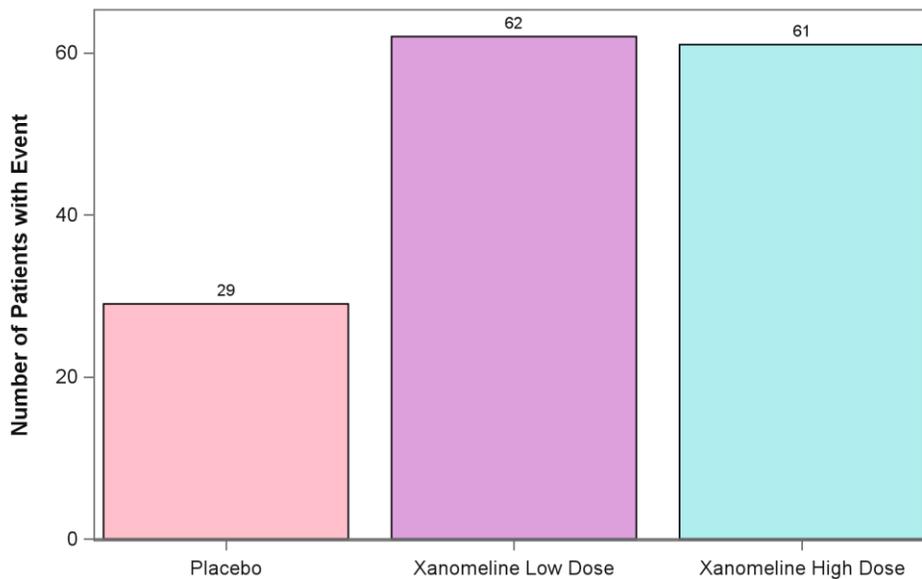


Figure 12: Modifying Color within Graph Template Using BEGINGRAPH Options – Sorting Data Prior to Rendering Graph

If there are not enough colors specified on the DATACOLORS option (SAS Program 4) to account for all the unique groups, then two additional sets of colors will be automatically created. The two additional sets of colors are generated based on the original colors specified. The first set is a shade lighter and the second set is a shade darker as illustrated by Figure 13.

```

proc template;
  define statgraph bplot4;
    begingraph / border = false
      datacolors=(pink)
      datacontrastcolors=(black);
    layout overlay / xaxisopts = (label = " "
      type = discrete
      yaxisopts = (label = "Number of Patients with Event");
    barchart x = trtan y = event / orient = vertical group = trtan
      barlabel = true;
    endlayout;
  endgraph;
end;
run;

```

SAS Program 4: Modifying Color within Graph Template Using BEGINGRAPH Options – Specifying Only One Color

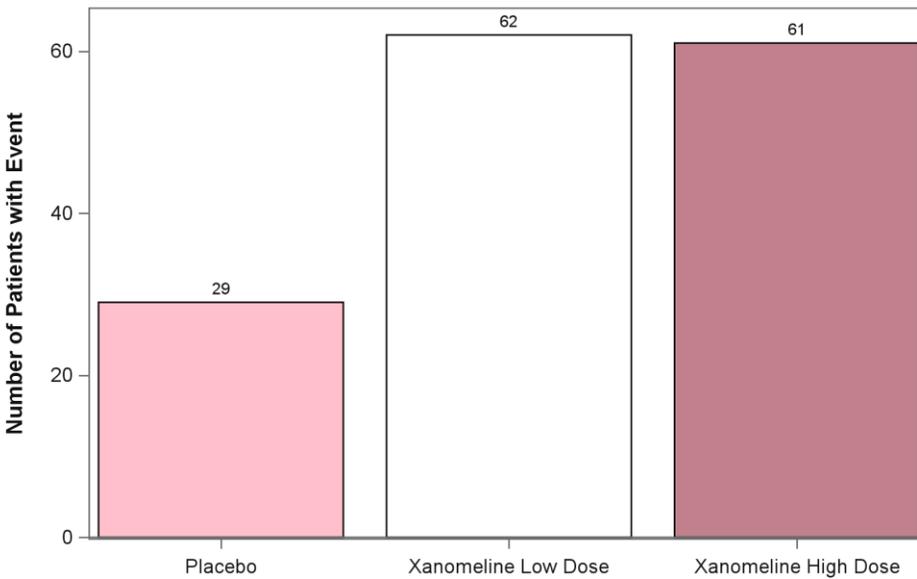


Figure 13: Modifying Color within Graph Template Using BEGINGRAPH Options – Specifying Only One Color

MANUALLY ASSIGNING ON PLOT STATEMENT

Another quick way to change a color is to assign the color directly on the corresponding plot statement. The options to modify the colors will vary based on the type of graph and whether or not the data is grouped (i.e., GROUP option is used).

Applying One Color

SAS Program 5 illustrates the syntax needed to change all the bar charts to one color. Notice that in this example the bar chart is one color and the line around the bar chart is another color (Figure 14).

```
proc template;
  define statgraph bplot1;
    begingraph / border = false;
      entrytitle textattrs = (color = pink) "All Barcharts One Color";
      layout overlay / xaxisopts = (label = " " type = discrete)
        yaxisopts = (label = "Number of Patients with Event");

      barchart x = trtan y = event / orient = vertical group = trtan
        fillattrs = (color = pink)
        outlineattrs = (color = deeppink)
        barlabel = true;

    endlayout;
  endgraph;
end;
run;
```

SAS Program 5: Modifying Color within Graph Template to One Color – BARCHART

- 1 FILLATTRS controls the color of the filled area of the bars while OUTLINEATTRS controls the color of the line around the bars. The default color for non-grouped data is based on GraphDataDefault for the filled area and based on GraphOutlines for the bar outlines. For grouped data the color is based on the GraphData1 – GraphData n for both the filled bars and bar outlines.

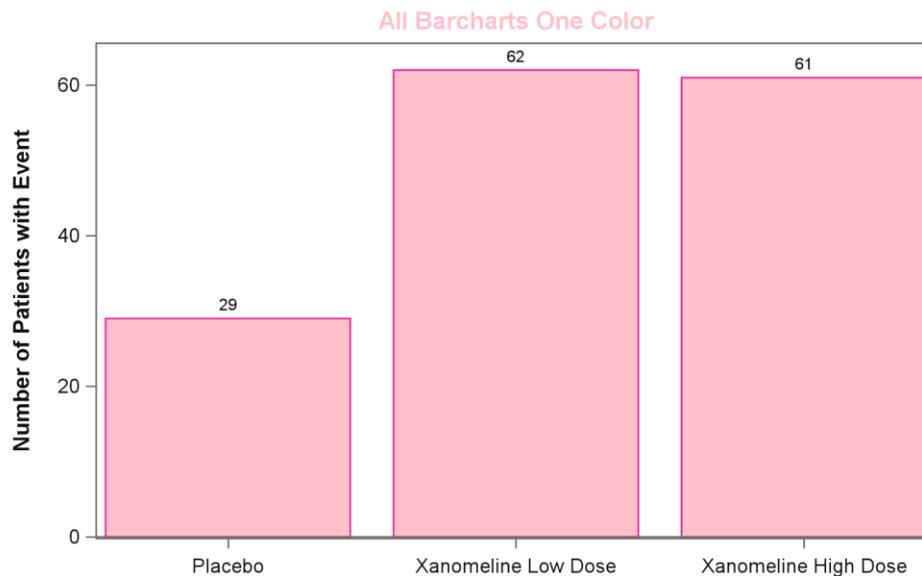


Figure 14: Modifying Color within Graph Template to One Color - BARCHART

SAS Program 6 shows the syntax needed to change the colors for all the series plots to one color. In this example, we demonstrate that the markers and the line can be two different colors. The color of the

marker is controlled by the MARKERATTRS statement and the color for the line is controlled by LINEATTRS statement. We can also control the color of the labels for the x and y axes.

Note that this is for illustration purposes only. Typically, this method is used when there is only one series to be plotted (i.e., GROUP option is not used).

```
proc template;
  define statgraph wtseries1;
    begingraph / border = false;
      layout overlay / xaxisopts = (label = 'Weeks'
        labelattrs = (color = black weight = bold)
        linearopts = (viewmin = 0 viewmax = 26))
        yaxisopts = (label = 'Mean Weight (kg)'
        offsetmin = 0.07
        offsetmax = 0.07
        labelattrs = (color = deeppink weight = bold)
        linearopts = (viewmin = 63 viewmax = 72));

      seriesplot x = avisitn y = mean / display = all group = trtan
        markerattrs = (symbol = circlefilled 1
          color = pink
          size = 6)
        lineattrs = (color = deeppink 2
          pattern = 34
          thickness = 3);

    endlayout;
  endgraph;
end;
run;
```

SAS Program 6: Modifying Color within Graph Template to One Color - SERIESPLOT

- 1 The marker is the symbol that is used to represent each point on the series plot. Within the MARKERATTRS option there are various other options that can be defined to meet the desired output needs. One such element is the color. As shown in Figure 15 the markers are filled pink circles.
- 2 Similar to markers, the line that connects the markers can have attributes that can be customized. In this example, we are using a deep pink dotted line to connect the pink filled circles that have a size of 6.

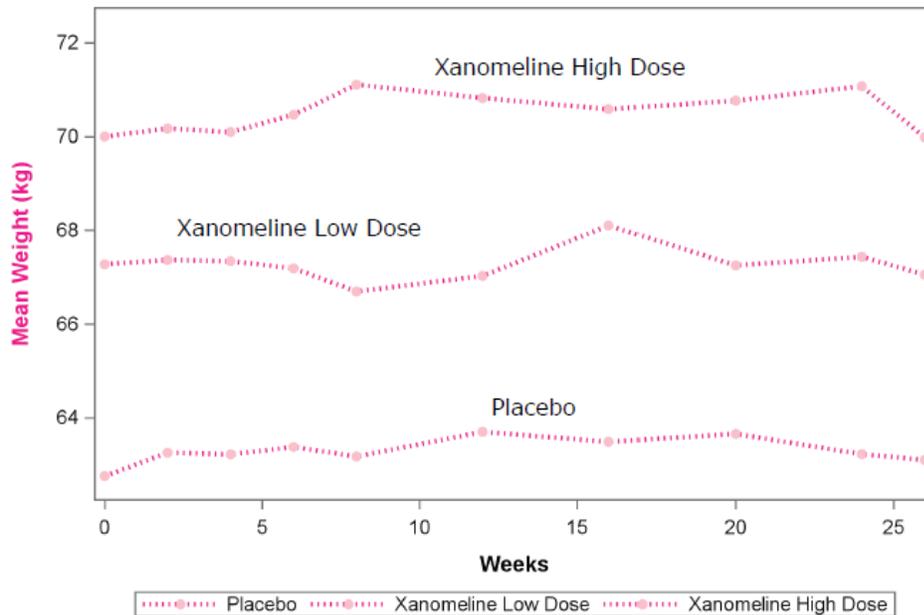


Figure 15: Modifying Color within Graph Template to One Color - SERIESPLOT

Notice that in Figure 15 that the legend does not provide any additional information since the markers and colors are the same for all three groups. Typically, when displaying grouped data, you need some attribute that distinguishes the data, such as color. It is possible to use an all-color style but have other attributes to help differentiate; however, the focus of this paper is illustrating the different ways to color. Note that the treatment values were manually inserted to help discern between the treatments.

Applying a Color Gradient or Color List

But what if we do not want everything to be one color? How do we assign the colors when the GROUP option is used?

SAS Program 7 uses the COLORMODEL and COLORRESPONSE options to control the colors for the graphs.

```

proc template;
  define statgraph bplot2;
    begingraph / border = false;
      entrytitle textattrs = (size = 11 pt color = pink) "Placebo";
      entrytitle textattrs = (size = 11 pt color = hotpink) "Low Dose";
      entrytitle textattrs = (size = 11 pt color = deeppink) "High Dose";
      layout overlay / xaxisopts = (label = " " type = discrete)
        yaxisopts = (label = "Number of Patients with Event");
      barchart x = trtan y = event / orient = vertical group = trtan
        colorresponse = trtan
        colormodel = (pink hotpink deeppink)
        barlabel = true;
    endlayout;
  endgraph;
end;
run;

```

SAS Program 7: Modifying Color within Graph Template to Different Colors – BARCHART

1 Attributes for entry titles can also be controlled using TEXTATTRS option. Figure 16 demonstrates that the colors for the ENTRYTITLE can be modified by using the TEXTATTRS = (COLOR = color) option.

2 The COLORMODEL specifies a color ramp. The COLORMODEL can use either a color-ramp style element or a color list. A color-ramp style element consists of a STARTCOLOR, NEUTRALCOLOR and ENDCOLOR. This color-ramp style element is used to create a continuous color gradient. SAS Program 7 shows the use of a color list for the COLORMODEL.

If COLORMODEL is used, then either COLORRESPONSE or COLORBYFREQ option needs to be used. For this example, the COLORRESPONSE option is used and it is tied to the GROUP option. The COLORRESPONSE represents which variable will be used to map the fill area of the bar chart based on the color model.

Figure 16 illustrates the results of using the COLORMODEL and COLORRESPONSE options in the template.

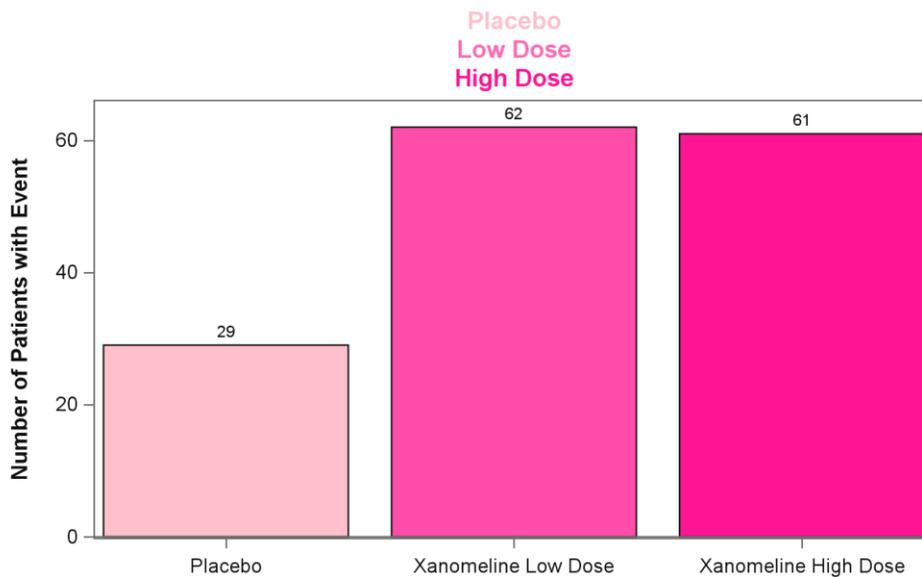


Figure 16: Modifying Color within Graph Template to Different Colors - BARCHART

USING A DISCRETE ATTRIBUTE MAP

An attribute map can be created that will help control various style elements, such as text attributes, line attributes and marker attributes, which includes the colors. The use of an attribute map can be created within the template or as an external data set. In addition, the referencing of the attribute map can also be done within the template or when the template is rendered.

Within a Graph Template

With the use of an attribute map, you can ensure that specific values will have a consistent color across various outputs that use that specific template regardless of what ODS style is used and regardless if the data source has all the data available. For example, if we want 'Placebo' to always be pink and 'Xanomeline Low Dose' to always be hot pink and 'Xanomeline High Dose' to always be deep pink when this particular graph is produced, then if the data source is missing a treatment it will still maintain the color scheme which is defined in the attribute map. SAS Program 8 and Figure 17 illustrates the use of a discrete attribute map within the graph template.

```

proc template;
  define statgraph bplot3;
    begingraph / border = false;
      entrytitle textattrs = (size = 11 pt color = black)
        "DISCRETEATTRMAP Defined in Template";

      discreteattrmap name = "TRTCOLOR";
        value "Placebo" / fillattrs = (color = pink)
          lineattrs = (color = black);
        value "Xanomeline Low Dose" / fillattrs = (color = hotpink)
          lineattrs = (color = black);
        value "Xanomeline High Dose" / fillattrs = (color = deeppink)
          lineattrs = (color = black);

      enddiscreteattrmap;

      discreteattrvar attrvar = colorvar var = trtan attrmap = "TRTCOLOR";

      layout overlay / xaxisopts = (label = " "
        type = discrete)
        yaxisopts = (label = "Number of Patients with Event");

        barchart x = trtan y = event / orient = vertical
          group = colorvar
          barlabel = true;

      endlayout;
    endgraph;
  end;
run;

```

SAS Program 8: Modifying Color using Discrete Attribute Map Defined Within Graph Template

- 1 The DISCRETEATTRMAP statement is used to create an attribute map within the graph template. It allows the user to specify various attributes, such as color, for each formatted data value. If a data value is formatted, then the formatted value must be used in the attribute map. DISCRETEATTRMAP **must** be placed inside the template between the BEGINGRAPH statement and the first LAYOUT statement. There are three main components of the attribute map.
 - The first is the initialization of the map. This is where the attribute map is provided a name. In SAS Program 8 the attribute map is referred to as "TRTCOLOR". When naming the attribute map, several options can also be specified, such as IGNORECASE, TRIMLEADING and DISCRETELEGENDENTRYPOLICY.
 - The second part is defining the attributes for one or more **formatted** data value using the VALUE statement. With the VALUE statement things like color and line options can be defined for each formatted data value that is to have a specific set of attributes. If two or more values have the same set of attributes, rather than defining the attributes for each value, all the values sharing the same attributes can be on the same VALUE line with each individual value enclosed in its own set of quotation marks and separated by a blank space. Refer to SAS Program 9 for how the DISCRETEATTRMAP would be set up when multiple values share the same attribute (Figure 18). The value statement can have OTHER (not in quotes) to create a category of all other values that are not specified. If OTHER is not specified, then those data values that do not have a VALUE statement will have attributes assigned as if there were no attribute map.
 - The last component is to signal the end of the attribute map definition, which is done with ENDDISCRETEATTRMAP.
- 2 Once the attribute map is defined, then the attributes need to be associated with the corresponding variable. In addition, the association must be provided a name for reference within the template. DISCRETEATTRVAR statement is used in order to make this association. In SAS Program 8, "TRTCOLOR" attribute map is associated with the variable TRTAN and the association is named COLORVAR.

- 3 The association name assigned on the DISCRETEATTRVAR statement is then specified in the appropriate plot statement.

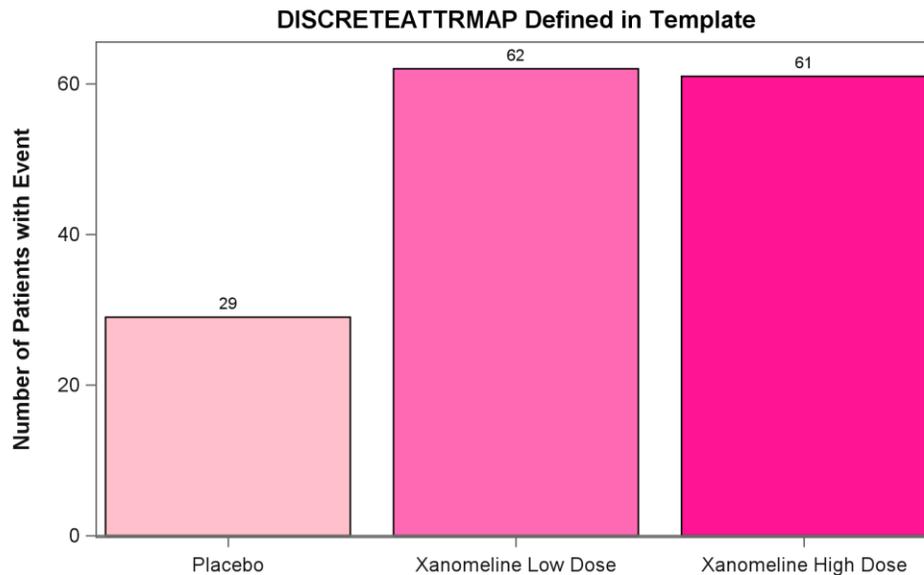


Figure 17: Modifying Color using Discrete Attribute Map Defined Within Graph Template

```
discreteattrmap name = "TRTCOLOR";  
  value "Placebo" /  
    fillattrs = (color = pink)      lineattrs = (color = black);  
  value "Xanomeline Low Dose" "Xanomeline High Dose" /  
    fillattrs = (color = deeppink) lineattrs = (color = black);  
enddiscreteattrmap;
```

SAS Program 9: Modifying Color using Discrete Attribute Map Defined Within Graph Template with Multiple Values Having Same Attributes

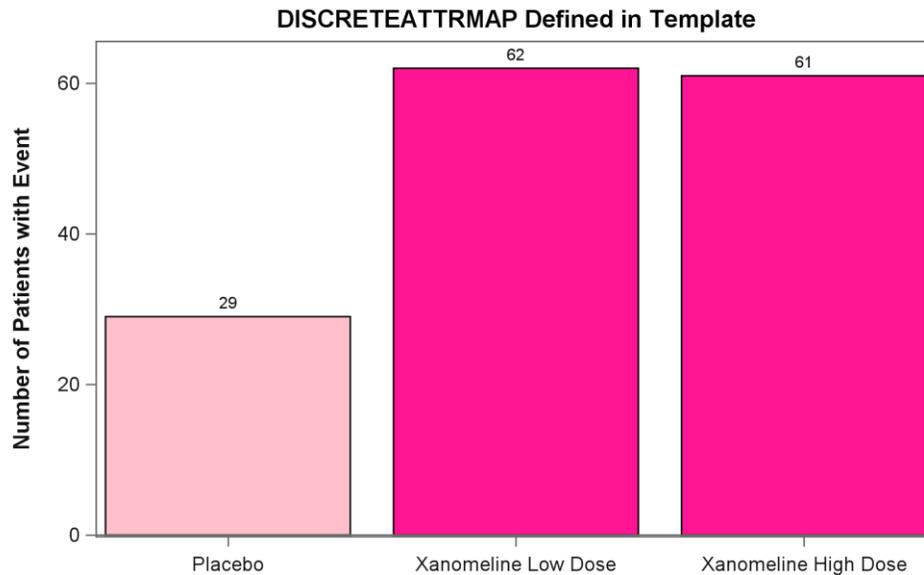


Figure 18: Modifying Color using Discrete Attribute Map Defined Within Graph Template with Multiple Values Having Same Attributes

Within a Data Set

There may be situations where a particular color scheme may need to be used across various types of graphs. In these cases, defining the attribute map within the template is not ideal because it would need to be defined in each graph template that is created. In order to reuse an attribute map, it can be stored in a data set that can be referenced when the graph template is rendered.

When creating a data set for the attribute mapping, it needs to contain an ID which has a value that is equivalent to the name that the attribute map would be assigned if using DISCRETEATTRMAP within the graph template. In addition, the data set needs to have a record for each possible formatted value that has specific attributes. The data set only needs to contain the necessary fields that are needed for the specific attributes that are to be associated with the value. For example, if you only need the color scheme to create bar charts then only FILLCOLOR and LINECOLOR are needed. However, if the color scheme will be used for other types of graphs such as a series plot, then other fields, such as MARKERCOLOR, need to be included. SAS Program 10 demonstrates how an attribute map can be created as a permanent data set. With this permanent data set, the color scheme can be reused. Notice that more than one color scheme can be stored within an attribute map data set. They are distinguishable by the ID (Table 2).

```

data ADAM.ATTRMAP (drop = i j);
  array idvr(2) $9 _TEMPORARY_ ('TRTCOLOR' 'TRTCOLOR2');
  array vals(3) $25 _TEMPORARY_ ('Placebo' 'Xanomeline Low Dose'
                                'Xanomeline High Dose');
  array clr(2, 3) $20 _TEMPORARY_ ('Pink' 'HotPink' 'DeepPink'
                                   'Turquoise' 'MediumTurquoise' 'DarkTurquoise');

  do i = 1 to 2;
    ID = idvr(i);
    do j = 1 to 3;
      VALUE = vals(j);
      FILLCOLOR = clr(i, j);
      LINECOLOR = clr(i, j);
      MARKERCOLOR = clr(i, j);
      output;
    end;
  end;
run;

```

SAS Program 10: Creating an Attribute Map as a Permanent Data Set

ID	VALUE	FILLCOLOR	LINECOLOR	MARKERCOLOR
TRTCOLOR	Placebo	Pink	Pink	Pink
TRTCOLOR	Xanomeline Low Dose	HotPink	HotPink	HotPink
TRTCOLOR	Xanomeline High Dose	DeepPink	DeepPink	DeepPink
TRTCOLOR2	Placebo	Turquoise	Turquoise	Turquoise
TRTCOLOR2	Xanomeline Low Dose	MediumTurquoise	MediumTurquoise	MediumTurquoise
TRTCOLOR2	Xanomeline High Dose	DarkTurquoise	DarkTurquoise	DarkTurquoise

Table 2: ATTRMAP Data Set

When the attribute map is stored in a data set, there is no need to use the DISCRETEATTRMAP statement as illustrated in SAS Program 8. However, the DISCRETEATTRVAR statement is still needed in order to associate the attributes with the corresponding variable. After the attribute map data set is created it needs to be associated with the graph template and the data. This is done using the DATTRMAP option on SGRENDER procedure (SAS Program 11).

```

proc sgrender data = adtte template = bplot4
  dattrmap = ADAM.ATTRMAP;
  format trtan trt.;
run;

```

SAS Program 11: Specifying Attribute Map Data Set on PROC SGRENDER

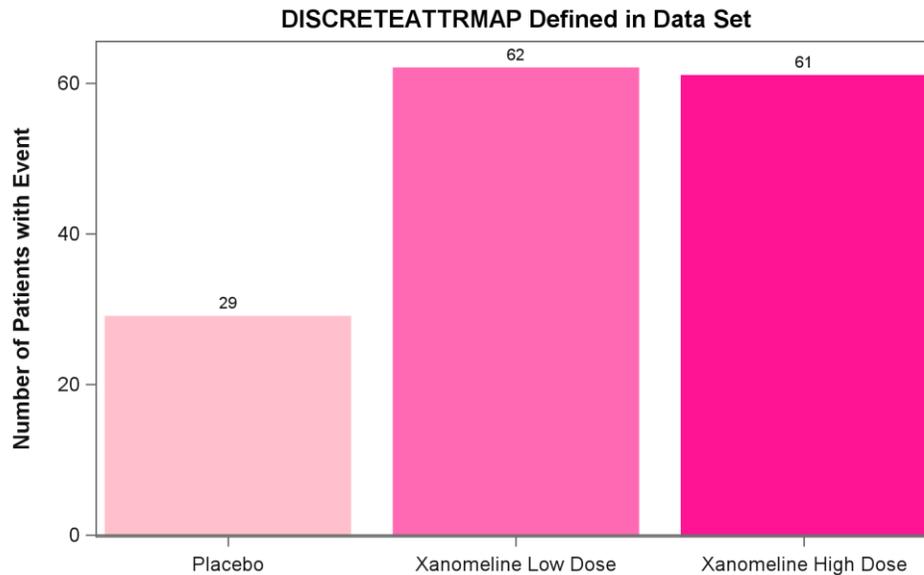


Figure 19: Creating an Attribute Map as a Permanent Data Set and Specifying Attribute Map on PROC SGRENDER

Notice that in Figure 19 it looks slightly different than the figure that is produced by SAS Program 8 (Figure 17). This is because in SAS Program 8 the outline of the bar charts was set to black, while the outline in the attribute map data set matches the color of the corresponding bar. By creating the data set we can update the attribute map without having to update the graph template(s). If you wish for the outlines to be black similar to what shown in Figure 17, then LINECOLOR in Table 2 would be changed to 'Black' instead of matching the value in FILLCOLOR.

Even though an attribute map data set was created, the use of DISCRETEATTRVAR was still needed. However, this can also be removed, and an association can be made at the time of rendering, which allows different color schemes to be implemented using the same template (SAS Program 12).

```

proc sgrender data = adtte template = bplot5
    dattrmap = ADAM.ATTRMAP;
    dattrvar trtan = 'TRTCOLOR';
    format trtan trt.;
run;

proc sgrender data = adtte template = bplot5
    dattrmap = ADAM.ATTRMAP;
    dattrvar trtan = 'TRTCOLOR2';
    format trtan trt.;
run;

```

SAS Program 12: Associating the Attribute Map with Corresponding Variable on PROC SGRENDER

¹ DATTRVAR is used to associate the variable with the corresponding attribute map name. The attribute map name must exist in the attribute map data set and must be enclosed in quotes when specified on the DATTRVAR statement. Note that if there is more than one plot defined in the template and each plot has attributes defined in the attribute map data set, then DATTRVAR statement would list all possible variable assignments (separated by a space) needed for rendering the graph with the specific template.

With the use of the DATTRVAR, it allows the attributes to be changed for the graph without changing the template (Figure 20).

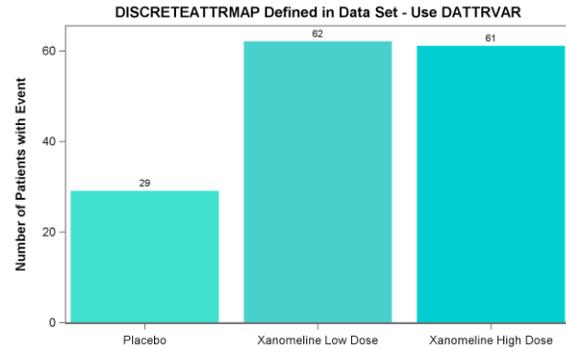
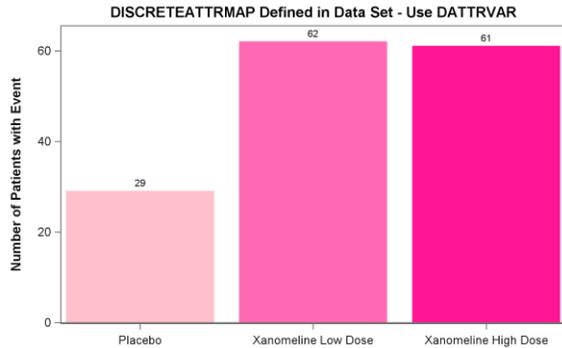


Figure 20: Illustration of use of DATTRVAR to Change Attributes

Thus, with the use of DATTRMAP and DATTRVAR, an attribute map data set can be used on any graph template that has the indicated values as demonstrated in SAS Program 13 and Figure 21.

```

proc sgrender data = meanwt template = wtseries3 dattrmap = ADAM.ATTRMAP;
  dattrvar trtan = 'TRTCOLOR';
  format trtan trt.;
run;

proc sgrender data = meanwt template = wtseries3 dattrmap = ADAM.ATTRMAP;
  dattrvar trtan = 'TRTCOLOR2';
  format trtan trt.;
run;

```

SAS Program 13: Reuse of Attribute Map Data Set and Different Attribute Maps

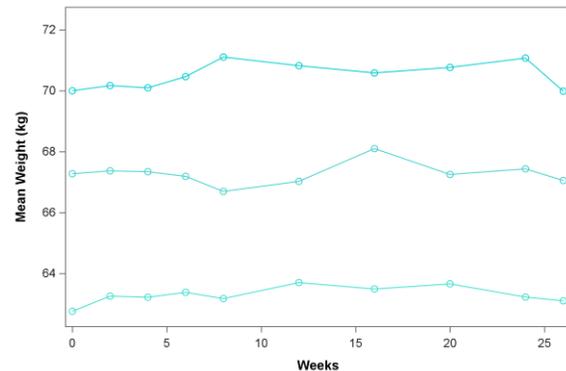
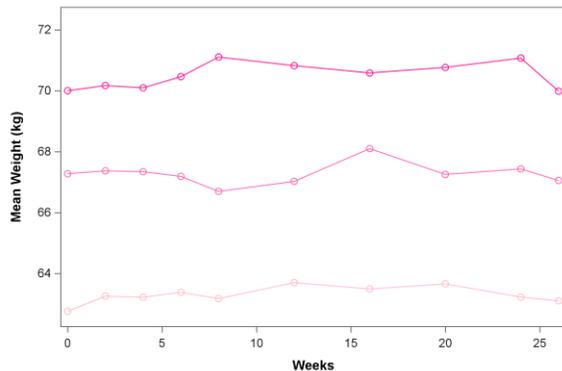


Figure 21: Reuse of Attribute Map Data Set and Different Attribute Maps

For more details on using attributes map refer to [Using Attribute Maps](#).

CREATING YOUR OWN STYLE

Typically, when dealing with styles, you start with an existing one rather than writing one from scratch due to the complexity. Thus, you can view the many styles that SAS offers and determine which one is close to what you want but may require the modification of a few of the elements. There are several ways to modify an existing style.

If you wish to view the source code that is associated with a particular style template, you can run the following code (SAS Program 14). This will write the code used to produce that style to the log.

```
proc template;
  source STYLES.DAISY;
run;
```

SAS Program 14: Viewing Source Code for Style Template

Using the Style Template Modification Macro

The easiest way to update an existing style is to use the style template modification macro, %MODSTYLE. It allows you to customize the style elements that govern the appearance of group observations. There are several parameters that can be specified, such as NAME, PARENT, COLORS, FILLCOLORS, and more. For parameters that are not specified when the macro is called the default values will be used. Refer to [Style Template Modification Macro](#) for full details. SAS Program 15 demonstrates how the macro can be specified.

```
%modstyle(name = mystyle1, 1
  parent = default, 2
  colors = black black black, 3
  fillcolors = pink plum paleturquoise) 4
...
ods pdf dpi = 300 file="%outdir.modified barchart mystyle1.pdf" style = mystyle1; 5
```

SAS Program 15: Modifying Style Using %MODSTYLE

- 1 NAME parameter allows you to specify the name for the new style that you are creating. If NAME is not provided, then the new style name will default to NEWSTYLE.
- 2 PARENT parameter indicates what style the newly created style should inherit the majority of its attributes from. If PARENT is not provided, then the parent style will default to DEFAULT. Since the default parent style is DEFAULT, then it is not necessary to specify PARENT = DEFAULT. It is only done in SAS Program 15 for illustration purposes.
- 3 COLORS parameter contains one or more colors that are space delimited. The colors specified are used for markers and lines. If the COLORS option is not used, then the colors from the parent style are used.
- 4 FILLCOLORS parameter is the color list that is used for bands and fill areas (e.g., bar charts). Note that the number of colors listed in FILLCOLORS needs to be same number of colors specified in COLORS. If there are more colors listed in FILLCOLORS, then any extra colors will be ignored. Notice that for FILLCOLORS there are three colors specified, therefore, three colors needed to be specified on the COLORS parameter, even if all the colors are the same there needs to be three colors in the color list. If FILLCOLORS is not provided, then the fill colors from the parent style are used.
- 5 On the ODS statement, the STYLE = option can be used to specify the name of the style that was created. Without the STYLE = option, SAS will use the default style for the indicated destination.

Figure 22 illustrates the results of using %MODSTYLE (SAS Program 15). The DEFAULT was the parent style thus we have the grey background. The fill area for the bar charts were changed from blue, red, and green to pink, plum, and pale turquoise. In addition, the bar outlines were changed from blue, red, and green to black for all three.

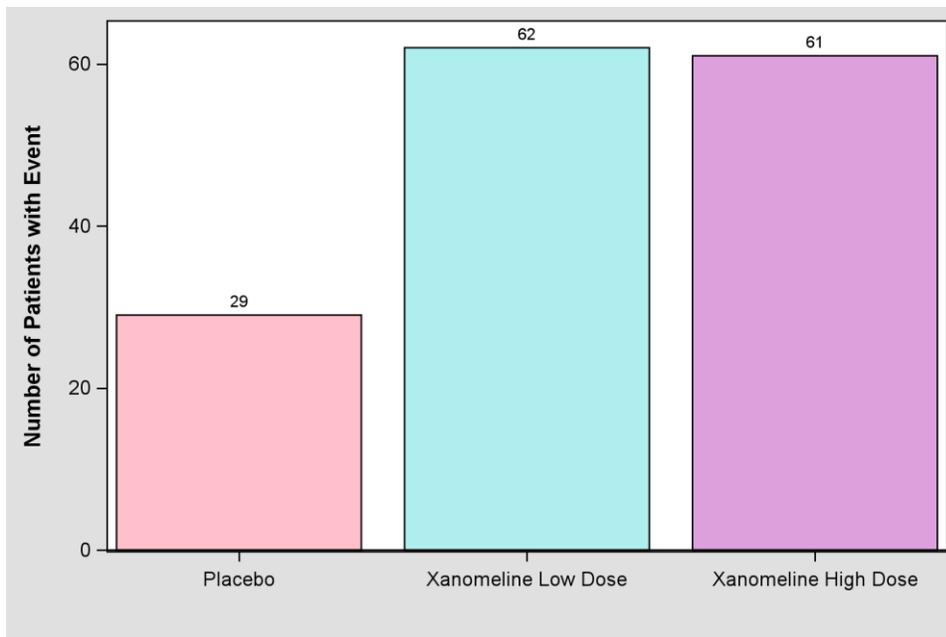


Figure 22: Modifying Style Using %MODSTYLE

Using STYLE Statement in TEMPLATE Procedure

There are other methods for modifying the elements of an existing style without having to use the macro. Recall that with the %MODSTYLE there are default values for some of the parameters if they are not specified. If you do not want to use the default values from the style template modification macro but do not want to specify all the parameters (or are not sure how to specify them), then you can use TEMPLATE procedure.

SAS Program 16 and SAS Program 17 provide two examples of how to modify an existing style.

```
proc template;
  define style mystyle2; 1
    parent = STYLES.DAISY;
    style GraphOutlines from GraphOutlines / linethickness = 3;
    style GraphData1 / color = pink;
    style GraphData2 / color = plum;
    style GraphData3 / color = paleturquoise; 2
  end;
run;
```

SAS Program 16: Modifying Style Using STYLE Statement in PROC TEMPLATE – Example 1

- 1 When customizing an existing style, you will need to provide it a style name. The style name cannot overwrite an existing SAS style. By default, any style created or modified will be saved to the SASUSER.TEMPLAT area. However, if you want to make the style available to others, you can save it to a permanent location by modifying the ODS PATH statement (refer to SAS Program 17).
- 2 For the data being used there are three groups and we want the colors for each group to be different than what is in the parent style, but everything else for each group to be consistent. This is known as an 'all-color' style (or 'color-priority' style). In other words, we want the attribute rotation to go through the colors first.

An 'all-color' style is when the other attributes are the same (e.g., line pattern, marker) and only the color is used to distinguish between the groups until all the colors for the style is exhausted then it recycles the colors with a different marker or line pattern. For example, in a bar chart, the line color and pattern remain the same until all the colors in a style is used. Once all the colors are used then the line color and/or

pattern changes and then goes through the cycle of colors again. This cycle repeats until all groups in the data have been accounted for.

In order to achieve an 'all-color' style, we use the STYLE statement to redefine GraphData1, GraphData2, GraphData3. With the STYLE statement specified as in SAS Program 16 only the attribute for color is defined. All other attributes that would be associated with GraphData1 – GraphData3 would default to non-grouped data attribute.

```
libname ADAM "C:\Users\gonza\Desktop\Conferences\What is Your Favorite Color\Data";  
  
ods path ADAM.TEMPLAT (update) SASUSER.TEMPLAT (read) SASHELP.TMPLMST (read); ①  
  
proc template;  
  define style mystyle3;  
    parent = STYLES.DAISY;  
    style GraphOutlines from GraphOutlines / linethickness = 3;  
    style GraphData1 from GraphData1 / color = pink;  
    style GraphData2 from GraphData2 / color = plum;  
    style GraphData3 from GraphData3 / color = paleturquoise; ②  
  end;  
run;
```

SAS Program 17: Modifying Style Using STYLE Statement in PROC TEMPLATE – Example 2

① In order to save the modified style to a permanent location so that others can use, the ODS PATH statement needs to be updated so that it lists the location of where the new style should reside. The order in which the template stores are specified is the order in which SAS will search. If no modification is made to the ODS PATH, then SAS will search in SASUSER.TEMPLAT first and then SASHELP.TMPLMST. The UPDATE option allows new templates to be written to that template store as well as allowing templates to be read from it. In SAS Program 17, the new style is written to a permanent location and this permanent location will be the first template store that is searched when looking for a specific template.

② Notice that the STYLE statements in SAS Program 17 are very similar to SAS Program 16. The difference is that for GraphData1, GraphData2, and GraphData3 the 'from GraphData' is used to indicate that the attributes are inherited from the parent style and only the attribute specified is modified.

The best way to understand the difference between SAS Program 16 and SAS Program 17 is to view the graphs. For purpose of illustration, the bar chart outlines were made to have a line thickness of 3 so that they are easier to see, thus making it easier to see the difference between the styles.

Figure 23 is generated from SAS Program 16 and Figure 24 is generated from SAS Program 17.

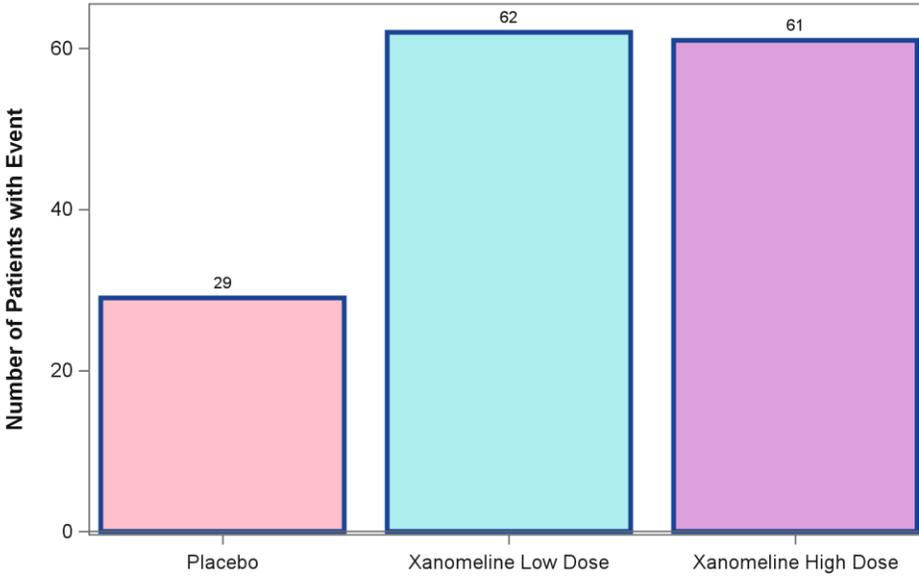


Figure 23: Modifying Style Using STYLE Statement in PROC TEMPLATE – Example 1

Notice in Figure 23 that the outline around each bar is blue. This is because MYSTYLE2 is an ‘all-color’ style; and GraphData1, GraphData2, and GraphData3 were redefined to only specify the color attribute. Therefore, the outlines for the bars defaulted to the first color in the parent style which is blue.

In Figure 24, the outlines for each bar correspond to the outlines of the original style element. This is because when creating MYSTYLE3 it inherited the attributes from the corresponding GraphData*n* element and only the fill area color was overwritten. Unlike in MYSTYLE2 where the entire style element was overwritten.

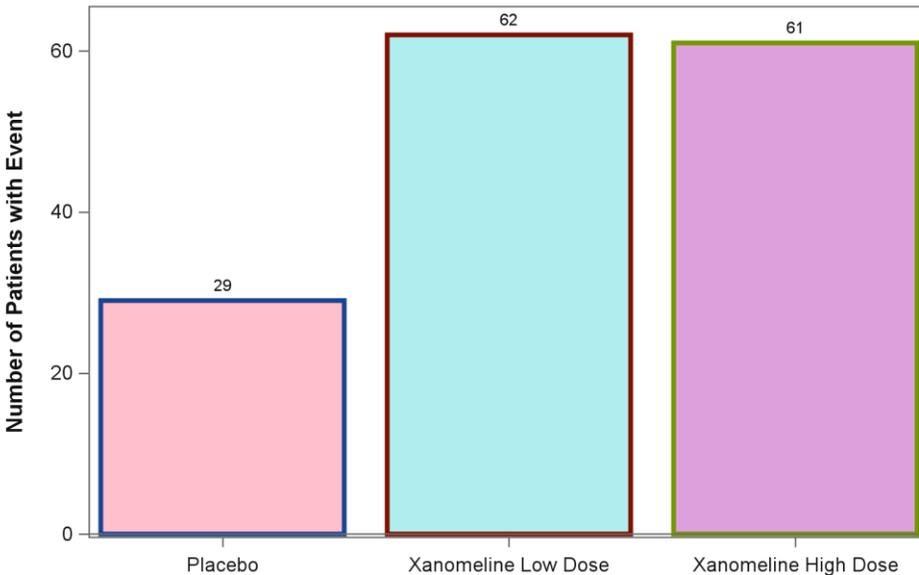


Figure 24: Modifying Style Using STYLE Statement in PROC TEMPLATE – Example 2

The use of the COLORRESPONSE and COLORMODEL options was previously introduced when we wanted to specify the list of colors. But the COLORMODEL can be more than just a list of colors, it can

be used to determine a color gradient. SAS Program 18 demonstrates how to create a color ramp using style template.

```
proc template;
  define style mygradient;
    parent=styles.daisy;
    class twocoloraltramp /
      startcolor = deeppink
      endcolor = darkturquoise;
  end;
run;

ods pdf style = mygradient;

proc sgplot data = hgt_wgt;
  scatter x = wgt y = hgt / colorresponse = hgt
    colormap = twocoloraltramp
    markerattrs = (symbol = circlefilled size = 8);
  xaxis label = 'Mean Weight (kg)';
  yaxis label = 'Mean Height (cm)';
run;
```

SAS Program 18: Modifying Color within Using a ColorRamp

- 1 To define a custom color gradient, you can overwrite the color ramp that is part of an existing style. There are four pre-defined color ramps: TWOCOLORRAMP, TWOCOLORALTRAMP, THREECOLORRAMP, THREECOLORALTRAMP. For the two-color ramp, you only need to specify STARTCOLOR and ENDCOLOR. But for the three-color ramp, you need to also specify NEUTRALCOLOR. With a color gradient, SAS will determine the colors between the smallest color (STARTCOLOR) and the largest color (ENDCOLOR). If NEUTRALCOLOR is provided, then this will be the mid-point color. The new color ramp is defined in a style template by using a parent style and just overwriting the necessary color ramp. The color ramps with 'ALT' in the name are used for markers and plot lines, while the ones without 'ALT' in the name are used for fill areas. Since the graph that is being produced with Figure 25 is a scatter plot, then only the TWOCOLORALTRAMP is used because there are only markers and plot lines; there are no fill areas.
- 2 In order to use the color ramp that is defined with the new style, you need to specify the name of the new style on the ODS statement with STYLE option.
- 3 When using COLORMODEL, you can specify a color gradient. Prior to defining the template for the graph, the DAISY template was modified to change the color ramp. This modified color ramp is specified on the COLORMODEL statement.

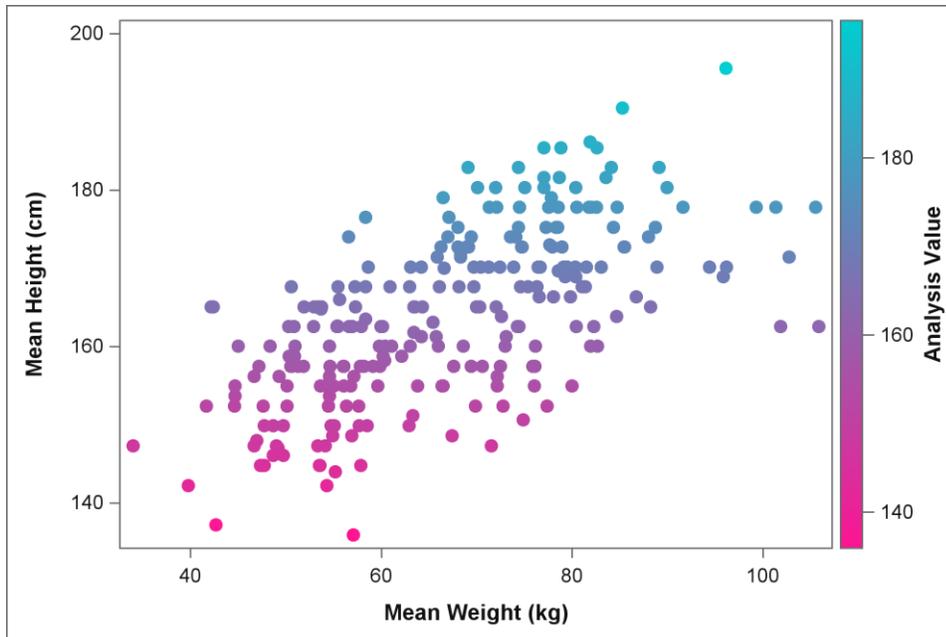


Figure 25: Modifying Color within Using a ColorRamp

Using CLASS Statement in TEMPLATE Procedure

In addition to using the style template modification macro and the STYLE statement within PROC TEMPLATE, you can modify the colors using the CLASS statement. Refer to SAS Program 19 and SAS Program 20.

```

proc template;
  define style mystyle4;
    parent = STYLES.DAISY;
    class GraphOutlines / linethickness = 3;
    class GraphData1 / color = pink;
    class GraphData2 / color = paleturquoise;
    class GraphData3 / color = plum;
  end;
run;

```

SAS Program 19: Modifying Style Using CLASS Statement in PROC TEMPLATE – Example 1

1 Like the examples that used the STYLE statement, the goal is to modify the colors for the three groups so that it is different than what was in the parent style. The code is very similar to SAS Program 16 with the difference being that SAS Program 19 uses CLASS instead of STYLE. So, what makes them different? Recall in SAS Program 16, it produced an 'all-color' style for all other attributes that were not modified in the PROC TEMPLATE. Thus, GraphData1 – GraphData3 were redefined. However, with the use of the CLASS statement it is only modifying the attribute specified and inheriting the rest of the attributes from the parent element. The CLASS statement works in the same manner as using the STYLE statement with the FROM clause. In other words, the CLASS statement implies the FROM, thus CLASS statement is the same as using the STYLE statement with the FROM clause. They both inherit from the parent element. Notice that Figure 26 looks the same as Figure 24.

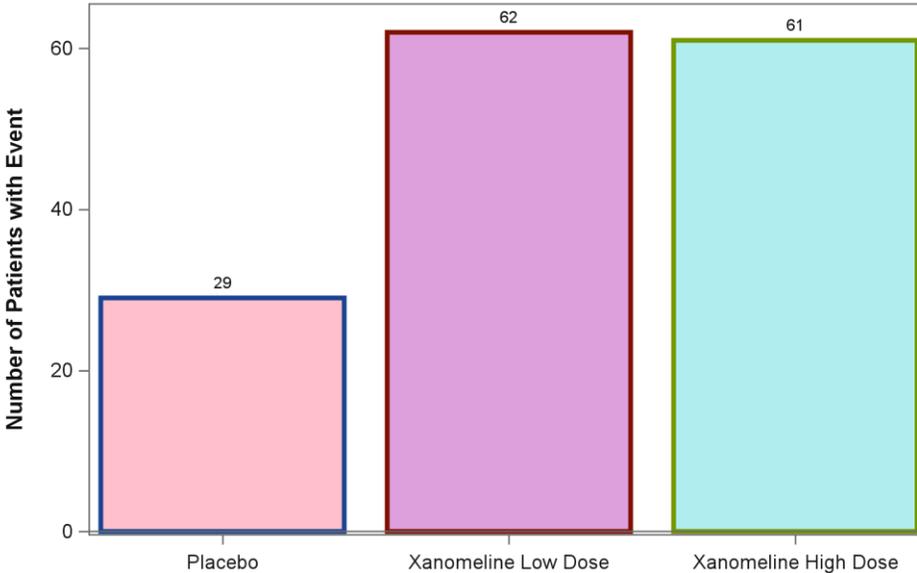


Figure 26: Modifying Style Using CLASS Statement in PROC TEMPLATE – Example 1

Since the filled area of the bar charts had a color change it only makes sense to have a color change for the outlines of the bars. This can also be achieved using the CLASS statement or the STYLE statement with the FROM clause.

```

proc template;
  define style mystyle4;
    parent = STYLES.DAISY;
    class GraphOutlines / linethickness = 3;
    class GraphData1 / color = pink
                      contrastcolor = deeppink;
    class GraphData2 / color = paleturquoise
                      contrastcolor = darkturquoise;
    class GraphData3 / color = plum
                      contrastcolor = purple;
  end;
run;

```

SAS Program 20: Modifying Style Using CLASS Statement in PROC TEMPLATE – Example 2

1 While the COLOR option on the CLASS statement controls the color for the filled area of the bar charts, the CONTRASTCOLOR option is used to indicate what colors are used for the outline of the bar. Refer to Figure 27.

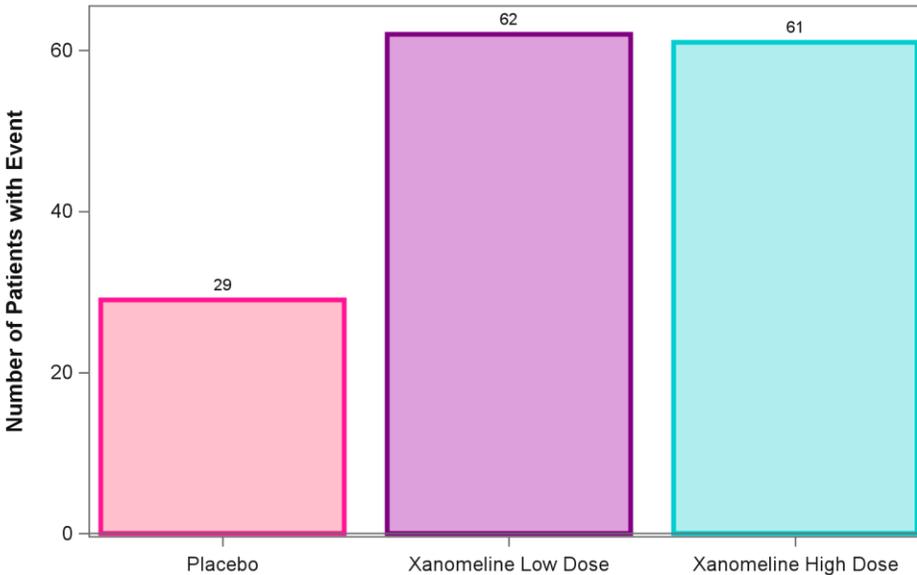


Figure 27: Modifying Style Using CLASS Statement in PROC TEMPLATE – Example 2

For more details on creating a style template visit [TEMPLATE Procedure: Creating a Style Template](#)

CONCLUSION

You are not limited to using the pre-defined styles and/or pre-defined color schemes associated with those styles. You can customize your graphs to meet your needs. There are several different ways in which the colors can be modified. The option you choose is dependent on whether you plan to reuse the color scheme for other graphs or if it is a one-time use. Have fun coloring!

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ACKNOWLEDGMENTS

Thank you to Louise Hadden for always helping me with coming up with that 'perfect' word or phrase that helps clarify a concept. Thanks to Dan Heath for patiently answering all my questions. I would also like to thank Kriss Harris for his thorough review of the content and providing valuable feedback.

RECOMMENDED READING

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Program for Viewing Multiple Styles

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Recommended Styles for ODS Destinations

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Statistical Graphics Using ODS: Some Common ODS Style Elements

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Predefined Colors

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CONTACT INFORMATION

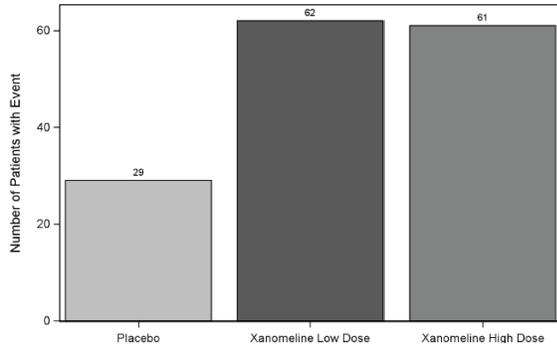
Your comments and questions are valued and encouraged. Contact the author at:

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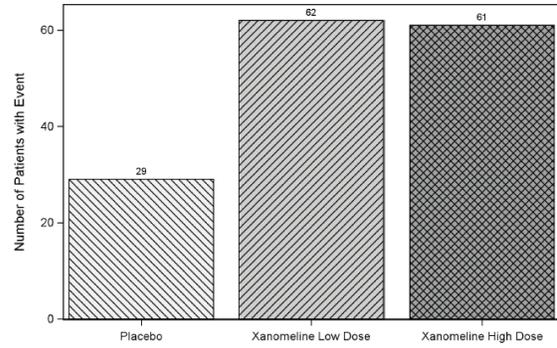
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APPENDIX 1: ADDITIONAL SAMPLES OF COMMON ODS STYLES

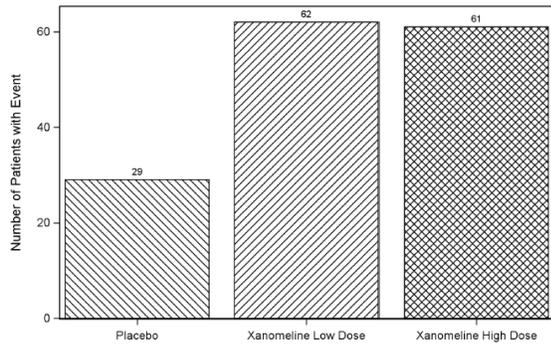
Bar Chart by Treatment for Percent of Patients with Dermatologic Event
Style = JOURNAL



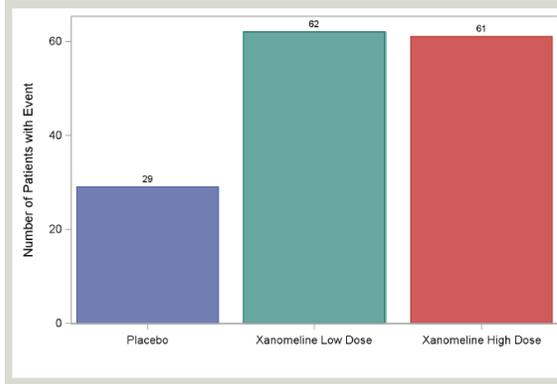
Bar Chart by Treatment for Percent of Patients with Dermatologic Event
Style = JOURNAL3



Bar Chart by Treatment for Percent of Patients with Dermatologic Event
Style = JOURNAL2



Bar Chart by Treatment for Percent of Patients with Dermatologic Event
Style = STATISTICAL



APPENDIX 2: ADDITIONAL SAMPLES OF COMMON ODS STYLE ELEMENTS

