

Divergent Nested Bar Plot and SAS® Implementation

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ABSTRACT

Bar plots are commonly used in visualizing categorical outcomes. However, multiple nested categorical outcomes in two directions (ex: improvement vs worsening) pose unique challenges in interpretation and implementation. One example in ophthalmology is the proportions of improving or worsening of at least 5, 10, or 15 ETDRS letters. In this scenario, outcomes are nested, for example patients with ≥ 10 -letter gain inherently have ≥ 5 -letter gain.

Existing solutions include: 1) multiple independent bars or accumulative bars, 2) stacked bars. The most significant downside of these solutions is the loss of inherited nested relationship between outcomes, making interpretations difficult.

We propose a novel figure, the divergent nested bar plot, to solve this problem: placing two sets of nested bar plot on the opposing sides of the y-axis (positive: improvement; negative: worsening). This figure is intuitive to interpretate. It provides comparisons of percentages while maintaining both the nested nature and the improvement/worsening directionality.

Drawing divergent nested bar plot in SAS® involves multiple specific steps and settings. This publication aims to provide a roadmap for implementation. The divergent nested bar plot is a marked improvement over existing solutions in visualizing multiple nested binary outcomes with two directions of responses.

INTRODUCTION

How can we draw a graph for categories that shows all following characteristics: 1. Bi-directional polarities (positive Vs negative), 2. Accumulative aspect of combined categories. For example, Category ' ≥ 10 ' combines Category '10-15', and Category ' >15 '. 3. Nested relationship: Positive Category ≥ 5 is nested under Positive Category ≥ 0 while Negative Category ≥ 5 is nested under Negative Category ≥ 0 . Those two ' ≥ 5 ' categories look similar but are opposite. The graph should display a clear distinction.

Through simulated examples from existing clinical study data, specifically the proportion of patients with improving or worsening at least 0, 5, 10, or 15 ETDRS letters in patients experiencing macular edema following central retinal vein occlusion, we employed the divergent nested bar plot for displaying outcomes which include all three types of characteristics mentioned. The same data is used for all 4 figures in this paper.

EXISTING SOLUTIONS

Solution #1 – Stacked Bar Plot

Stacked bar plot displays categories and their percentages, but not the nested relationship. Accumulative categories require a mental calculation by the viewer.

Noted all category percentages add to 100%.

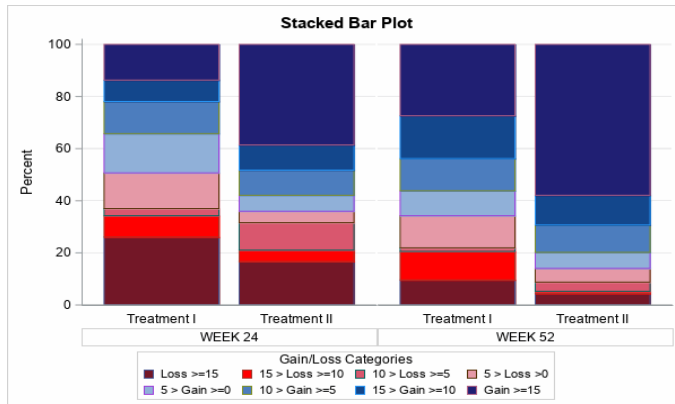


Figure 1. Stacked Bar Plot

Solution #2 –Bar Plot with Accumulated Percentages

Bar Plot with accumulative outcomes shows the additive nature of combined categories but loses the inherit bi-directional and nested relationship between outcomes. The adjacent accumulative bars can be easily misinterpreted as separate buckets of data.

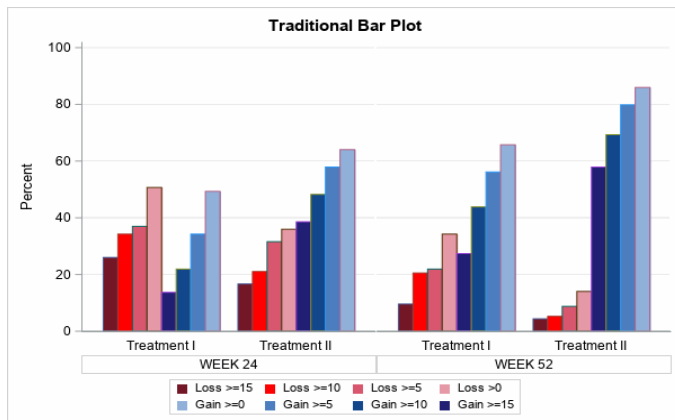


Figure 2. Bar Plot with Accumulated Percentages

Solution #3 – Nested Bar Plot

Nested Bar Plot show nested accumulative percentages within directional categories. The direction of gain/loss (positive Vs negative) can be perceived by using colors. It is still not ideal for a color-blind audience, and it is not clear what the positive or negative directions are.

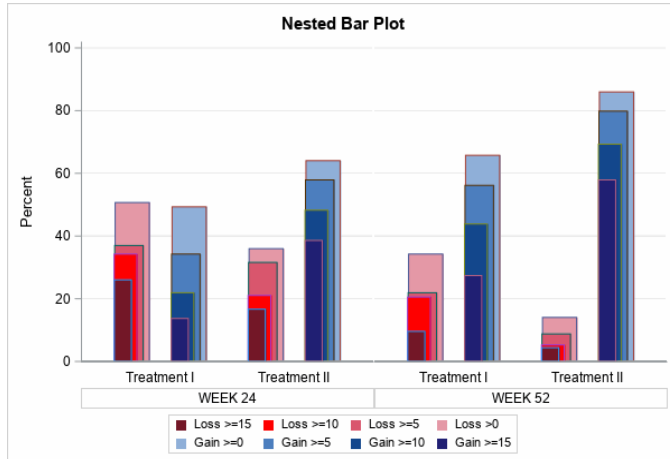


Figure 3. Nested Bar Plot

PROPOSED SOLUTION – DIVERGENT NESTED BAR PLOT

For each treatment group and timepoint, two sets of nested bar plot are placed on opposing sides of the y-axis (proportion of patients with gaining at least 0, 5, 10 or 15 letters on the positive side; proportion of patients with losing at least 0, 5, 10 or 15 letters on the negative side) with intuitive color conventions for different directions of response.

One can easily compare the outcomes between treatment groups over time while maintaining the nested nature of the outcomes as well as the improvement/worsening relationship.

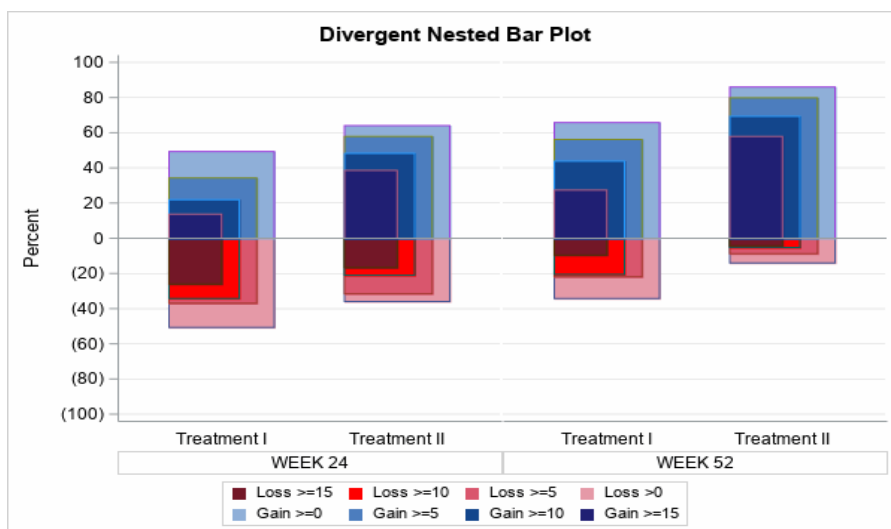


Figure 4. Divergent Nested Bar Plot

BENEFITS of Divergent Nested Bar Plot

- Easily compare multiple nested binary outcomes particularly when they represent different directions of response
- Maintain the nested nature of the outcomes
- Maintain the different directions of response (improvement/worsening) relationship
- Easily observe the change of the outcomes over time
- Requires little explanation thanks to the use of intuitive conventions

SAS® IMPLEMENTATION OF DIVERGENT NESTED BAR PLOT

The following steps are programmed in SAS® 9.4 to draw the plot:

- Accumulative percentages on each polarity were calculated from raw category percentages. Each new accumulative category is then transposed to a new variable prior to plotting the graph.
- Percentages, by nature, are all positive values regardless of directions. Values in the worsening categories are set with the negative sign and then formatted with Format negparenX.X.
- Drawn each category with a separate VBAR statement in SGPANEL, starting from the largest / tallest bars. shorter bars will then be drawn with off-set and narrower bandwidth to partially overlap existing bars. Stepwise VBAR statements will create the nested effect.
- Two sets of color palettes were selected to show the two polarities. 4 tones of blues for positive categories and 4 tones of red for negative categories starting from the tallest bars in the lightest color. It is better to keep nested categories to a similar hue for consistency and visual design.

The example graph (Fig 4) is drawn via Proc SGPANEL VBAR with bandwidths from 0.6 to 0.3 in 0.1 unit decrease and with 0 to -0.15 offset in -0.05 increase to accommodate 4 positive and 4 negative categories. The bars with the highest accumulative frequencies (Gain>=0, Loss>0) were produced first. The subsequent sets were then drawn with corresponding decreased bandwidths and increased offset to nest with existing bars. The SAS® codes for SGPANEL segment are as follows:

SGPANEL CODE

```
proc sgpanel data=work.data1 ;
  format percentm1-percentm4 negparen8.2 trtn trtf.;
  panelby avisit / layout=columnlattice onepanel noborder colheaderpos=bottom novarname;
  styleattrs datacolors=(lipk stpk red str vligb bigb vlgb stb ) ;
  vbar trtn / response=percentm4 barwidth=0.6 ;
  vbar trtn / response=percentm3 barwidth=0.5 discreteoffset=-0.05;
  vbar trtn / response=percentm2 barwidth=0.4 discreteoffset=-0.1 ;
  vbar trtn / response=percentm1 barwidth=0.3 discreteoffset=-0.15;
  vbar trtn / response=percent4 barwidth=0.6 ;
  vbar trtn / response=percent3 barwidth=0.5 discreteoffset=-0.05;
  vbar trtn / response=percent2 barwidth=0.4 discreteoffset=-0.1 ;
  vbar trtn / response=percent1 barwidth=0.3 discreteoffset=-0.15 ;
  colaxis display=(nolabel noticks);
  rowaxis label='Percent' values=(-100 to 100 by 20) grid offsetmax=0.025;
```

Output 1. Example SAS® SGPanel Codes for divergent nested bar plot

CONCLUSION

Divergent nested bar plot displays nested relationship of accumulative frequencies on bi-directional measurements such as improving & worsening categories, making interpretations easier. The display can also allow customization of treatment groups, timepoints, and multiple nested outcomes. The divergent nested bar plot can enhance the communication with non-statistical and non-technical colleagues and external audiences by presenting the information in a simple and clear format.

The future works include data labels and actual percentages displayed on the side of the plot. The authors are also working on combining divergent nested bar plot with stack bar plot to be able to show individual and nested categories side-by-side in single chart. Fine tuning color selections and establish color & shade patterns for more than 4 categories on each polarity is planned.

REFERENCES

Pan F., Wang W., Liu J. 2017. "Building a Nested Range Bar Chart with SAS® Graph Template Language." *Proceedings of SESUG 128-2017*

Website: SAS® Communities Library "Three Steps to Building a Nested Bar Chart, available at <https://communities.sas.com/t5/SAS-Communities-Library/Three-Steps-to-Building-a-Nested-Bar-Chart/ta-p/682769>

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RECOMMENDED READING

- *Base SAS® Procedures Guide*
- *Statistical Graphics Procedures by Example: Effective Graphs Using SAS®*
- *SAS® /GRAPH: Beyond the Basics*
- *The How-To Book for SAS® /GRAPH Software*

CONTACT INFORMATION

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