General Visualization Principles
Concepts and Examples

F. Bancken on behalf of Industry-FDA-Academia Safety Graphics Working Group - General Principles Subteam

2nd International Symposium on Biophamaceutical Statistics

Berlin, Germany

NOVARTIS

Agenda

- Motivation
- Framework
- Catalog of clinical questions and associated graphs
- General Principles
  - Graph Navigator, Glossary, Do's and Don'ts
- References

Motivation

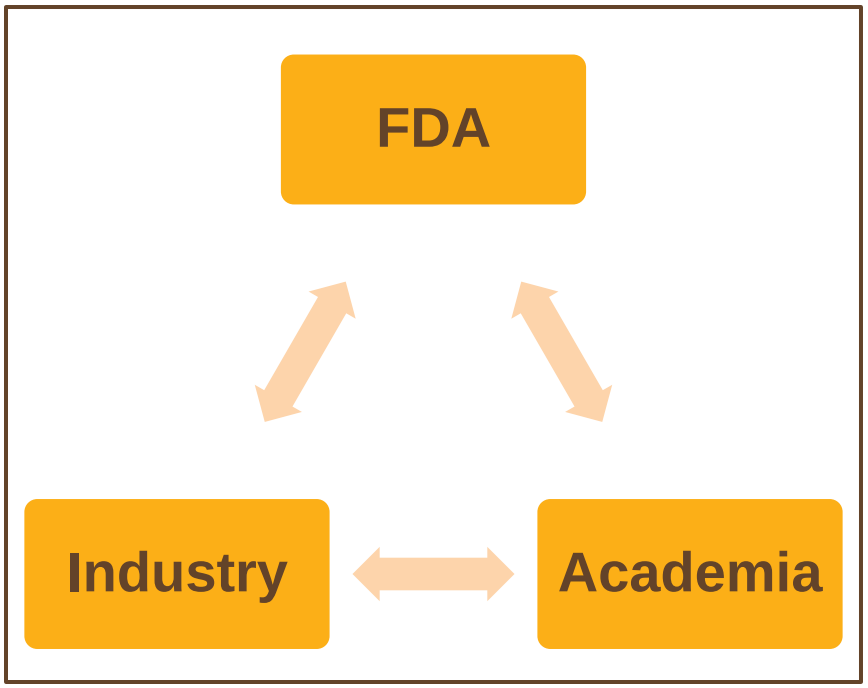
- Graphical vizualisation of a product‘s safety and efficacy data should be
  - More used (internal review, reports for submission)
  - When used,

    The choice of graph and its detailed design should allow a quick decode of the information

⇒ foster use of graphics (enablers, guidance)

Framework

Joint Collaboration



Themes / Subteams

- General Principles
- ECG / Vital Signs
- Labs / Liver
- Adverse Events

http://www.ctspedia.org

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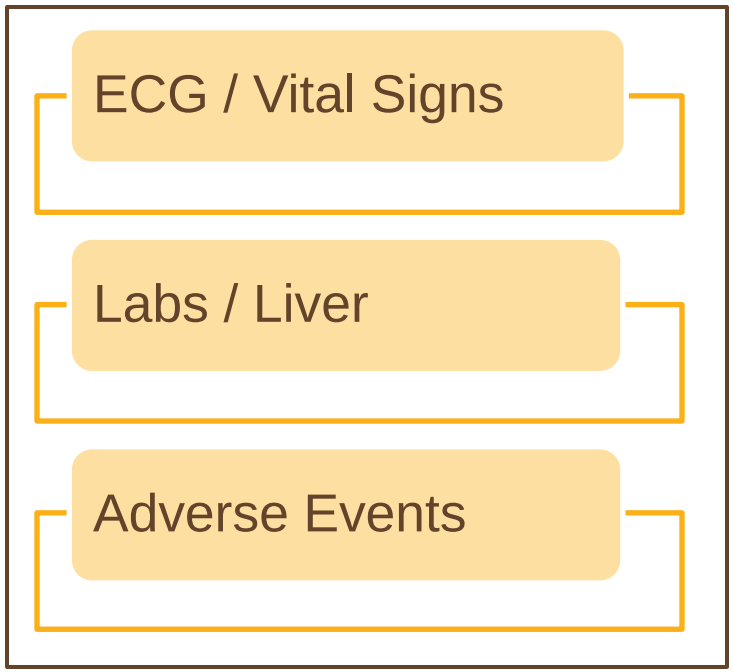
Catalog of clinical questions and associated graphs

Themes



Catalog Entries

- Required Fields
  - **Illustration**,
  - Title, Description,
  - Background [**clin.question**],
  - Use (reporting / exploratory),
  - Keywords
  - Author,
  - Software used, **Code,**
- Optional Fields
  - References, Data
- Categorization
  - **Graph Type** (bar, box plot, dot plot ...)

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General Principles

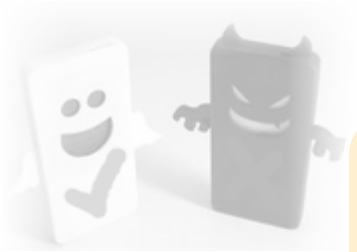
Graphics Navigator

Glossary

Do's and Don'ts

General Principles

Graphics Navigator

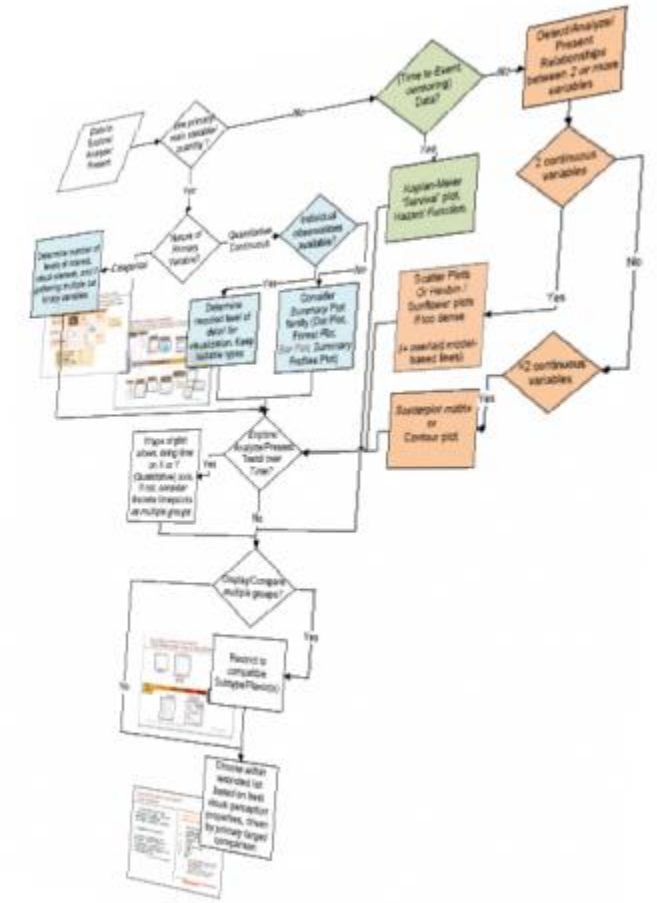


Do's and Don'ts

Glossary

Graphics Navigator - Main Flow Diagram

- Main drivers
  - Type (categ., quant.) of variables
  - Number of Variables
  - Number of levels of categorical variables
  - Level of detail needed for the distribution (quant.),
  - Visual Perception Criteria



Graphics Navigator - Main Flow Diagram

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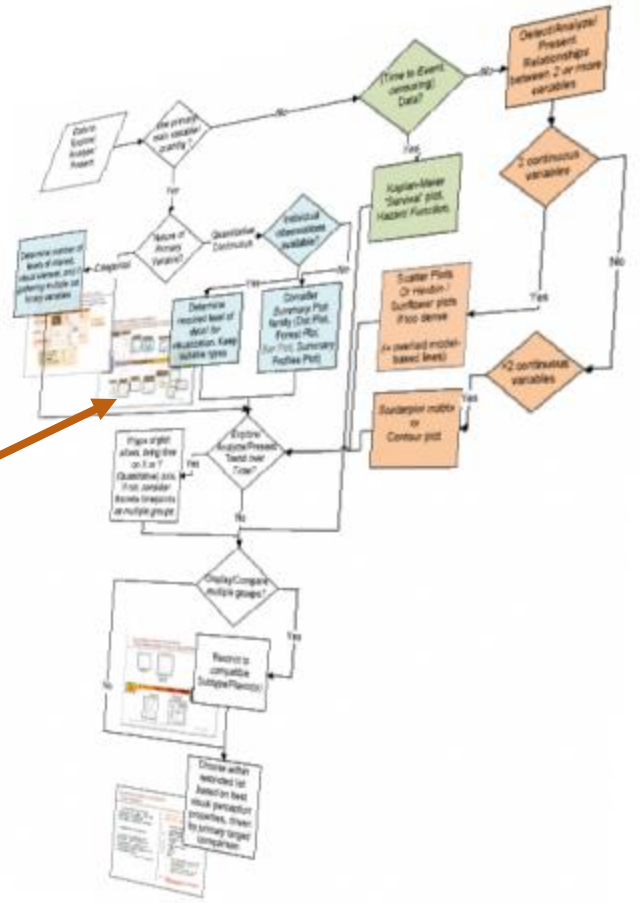
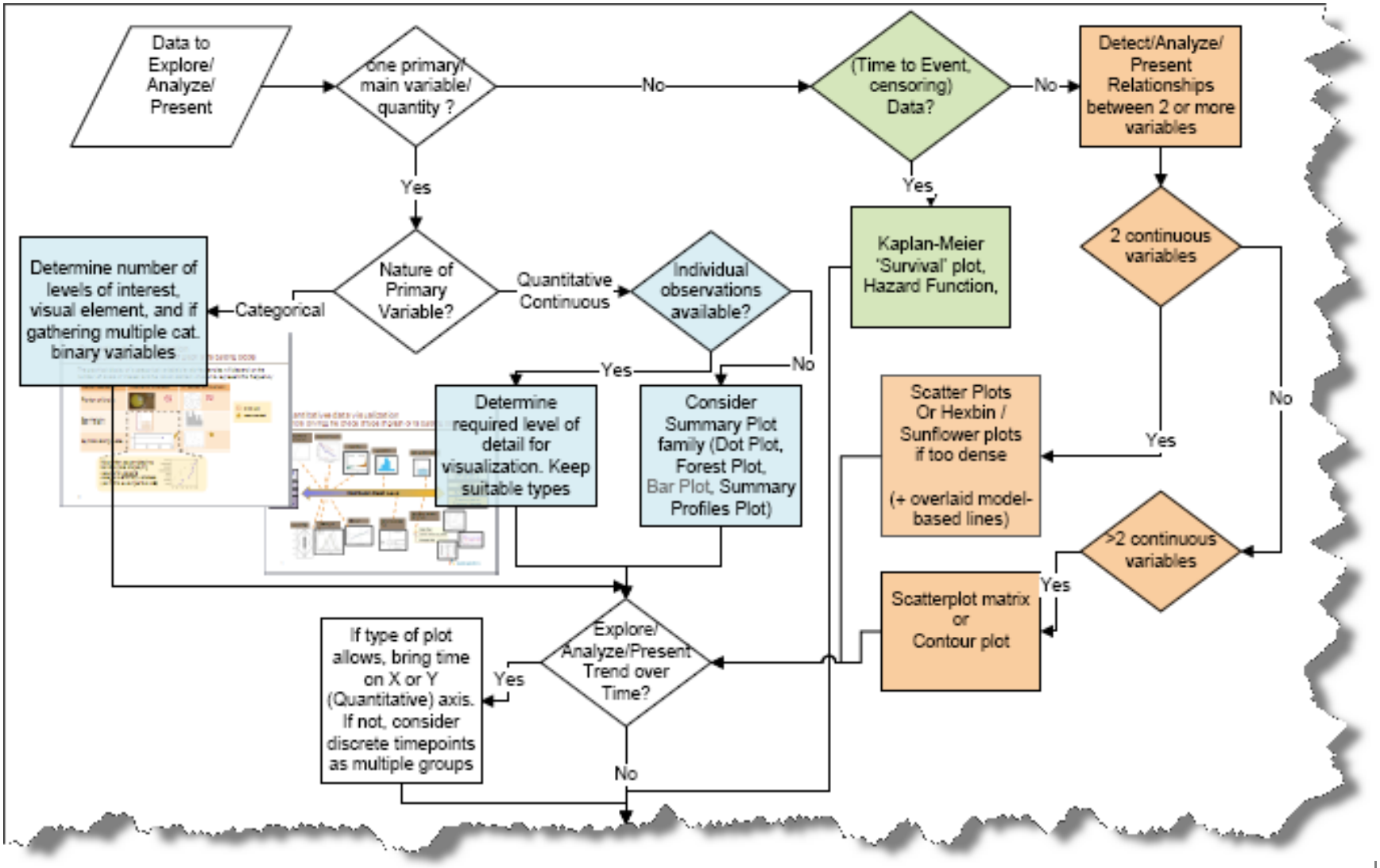


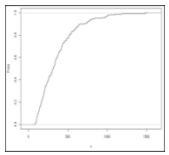
Graphics Navigator - Main Flow Diagram



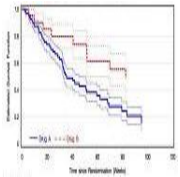
Graphics Navigator– Navigator Slide 1

Factors driving the choice of type of graph/building blocks (1 quant. var)

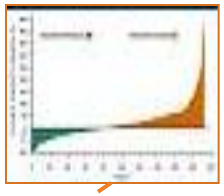
Cumulative Distribution



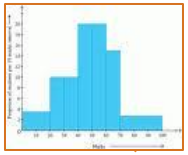
Kaplan-Meier



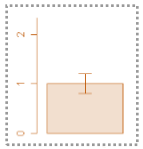
Waterfall



Histogram



Bars & Error Bars



Fine-Grained Distribution

High Detail

Raw data

Analysis/ Exploration

Distribution Detail Level

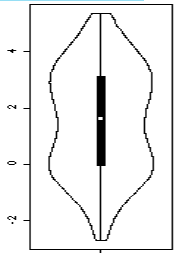
Mean/Median & IQR/SE/95%CI

Low Detail

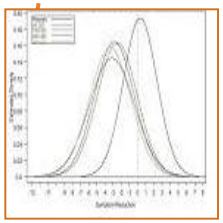
Summarized data

Communication/ Concise Message

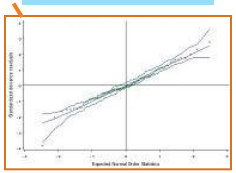
Violin Plot



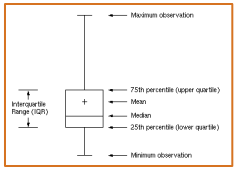
PDF plot



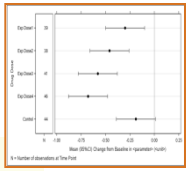
QQ plot



[Extended] Box Plot



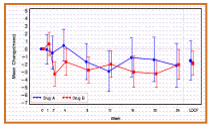
"Symbols & Error Bar"

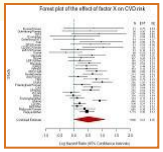


Dot Plot

Over-Time CI plots

Forest Plot





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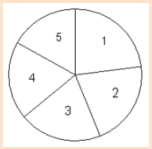
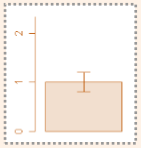
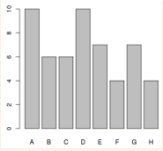
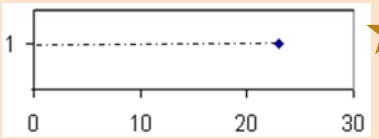
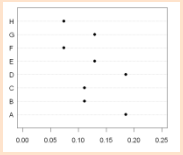
Graphics Navigator – Navigator Slide 2

Factors driving the choice of type of /building blocks (1 main categ. var)

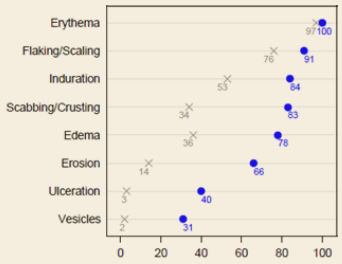
The graphical display of a categorical variable's levels frequencies will depend on the **number of levels** of interest and the **visual element** chosen to represent this frequency

Visual Element	1 Level of interest	>1 Level of interest
Portion of circle		
Bar Height		
Symbol along scale		

: avoid use

: recommended

Most often assembled into bar/dot plots displaying results for **several** categorical binary variables (as in this example for 8 AEs)



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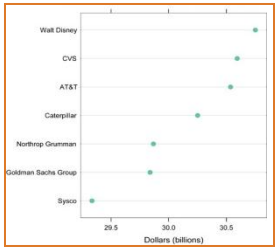
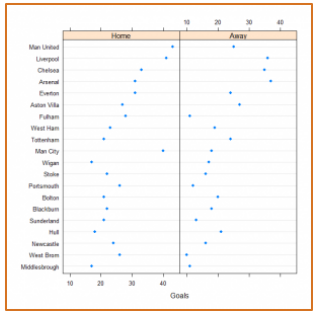
Graphics Navigator – Navigator slide 3
Factor influencing the choice of Subtype



Simple



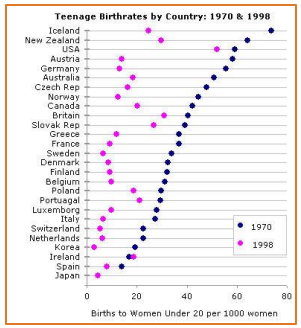
Multipanel of simple

0 or 1 grouping Variable

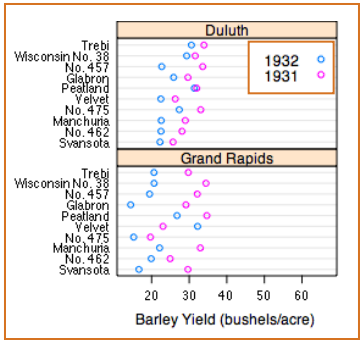
Graph Subtype/Flavor

Multiple grouping Variables (e.g., age category x gender x treatment group)

Grouped



Multipanel of grouped



General Principles

Graphics Navigator

Do's and Don'ts

Glossary

Glossary

- Graph Types
  - Histogram, Violin, Box plot ...

    ⇨ Description, typical use,

    Illustration(s), sample code, limitations
- Graph Subtypes
  - Simple, Grouped, Multipanel
- Graph Terms
  - Shift, Jitter, axis frame,
  - Major, minor tick marking, tick mark mirrorring ...

General Principles

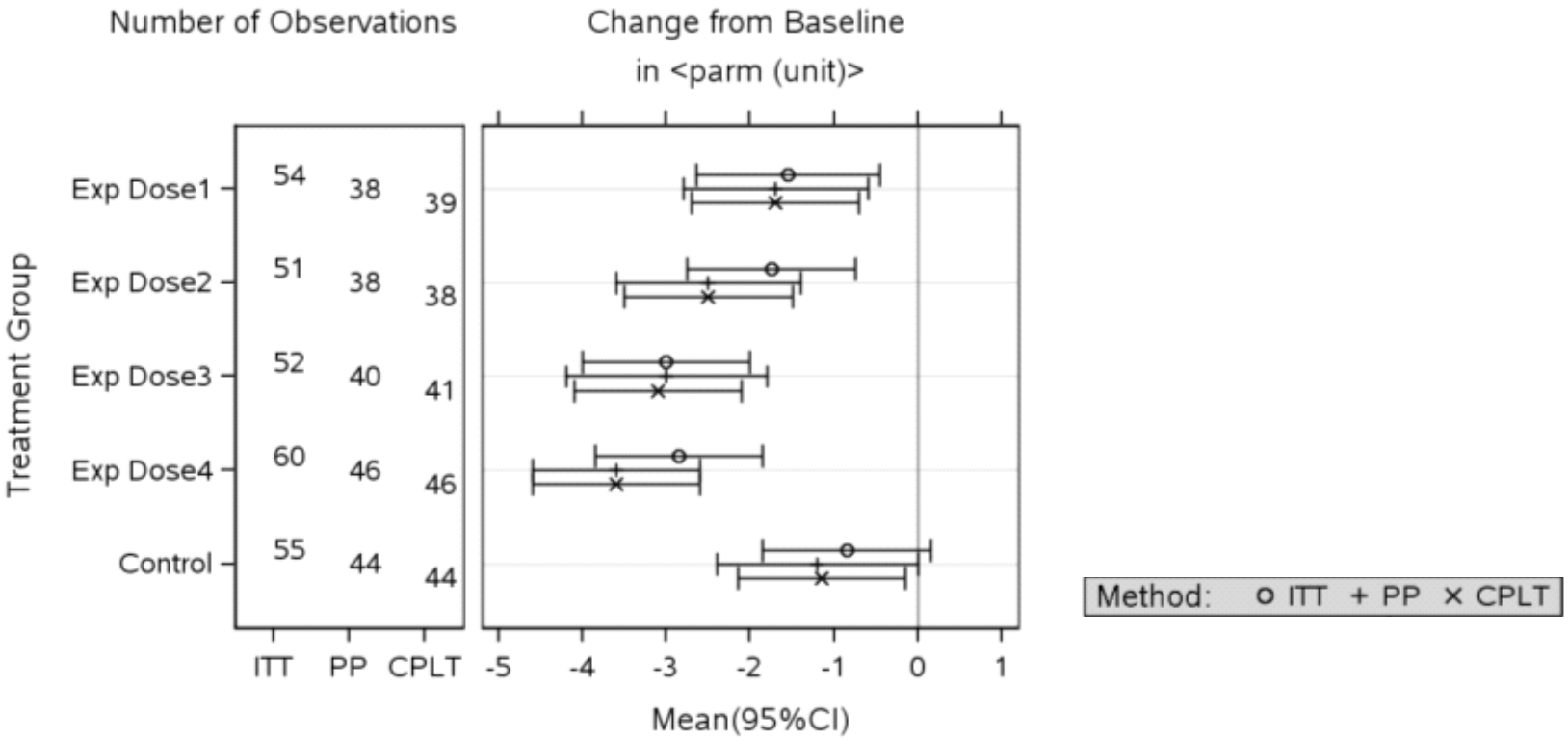
Graphics Navigator

Do's and Don'ts

Glossary

Do's and don'ts

- Display the quantity of interest
  - *Don't assume the reader can 'visually subtract' displayed quantities*



Do's and don'ts

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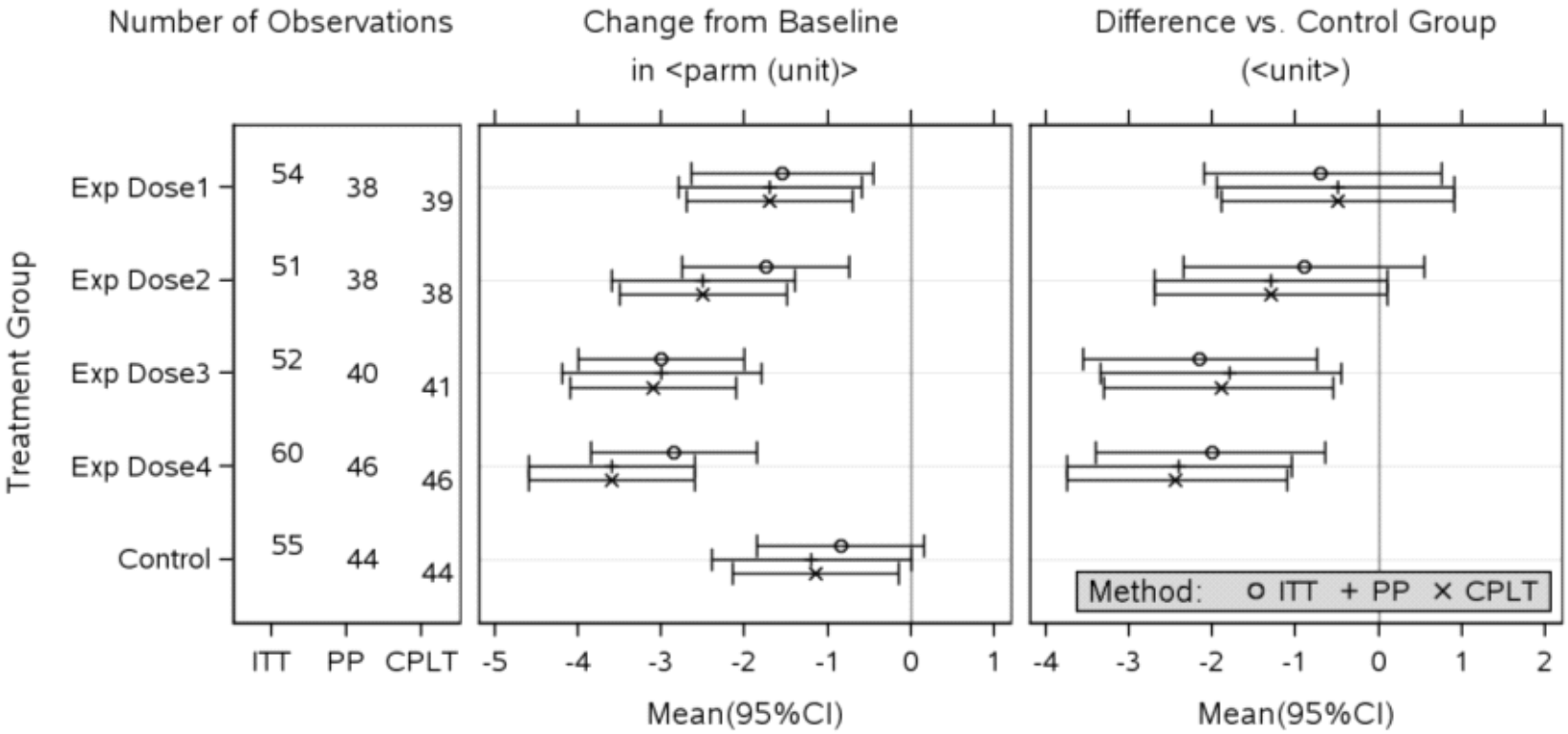
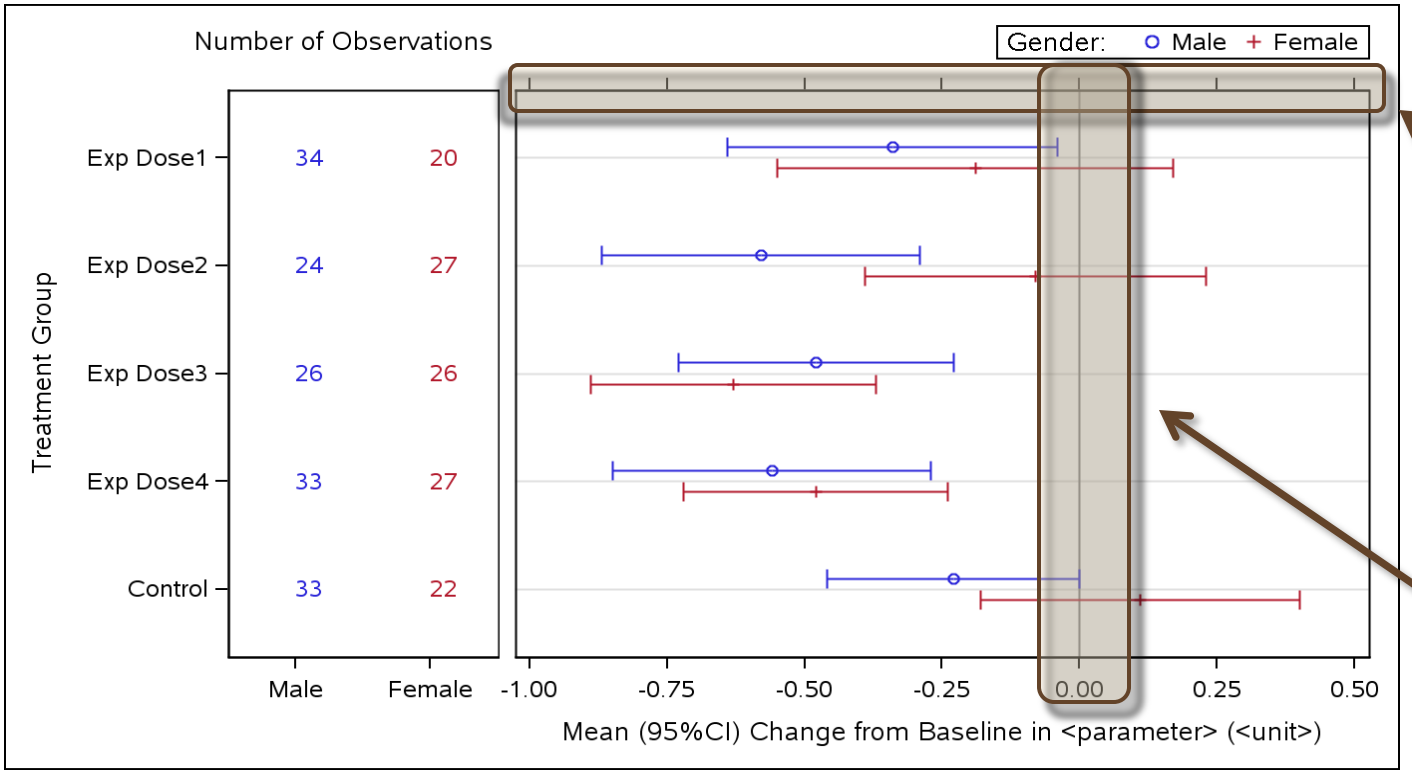


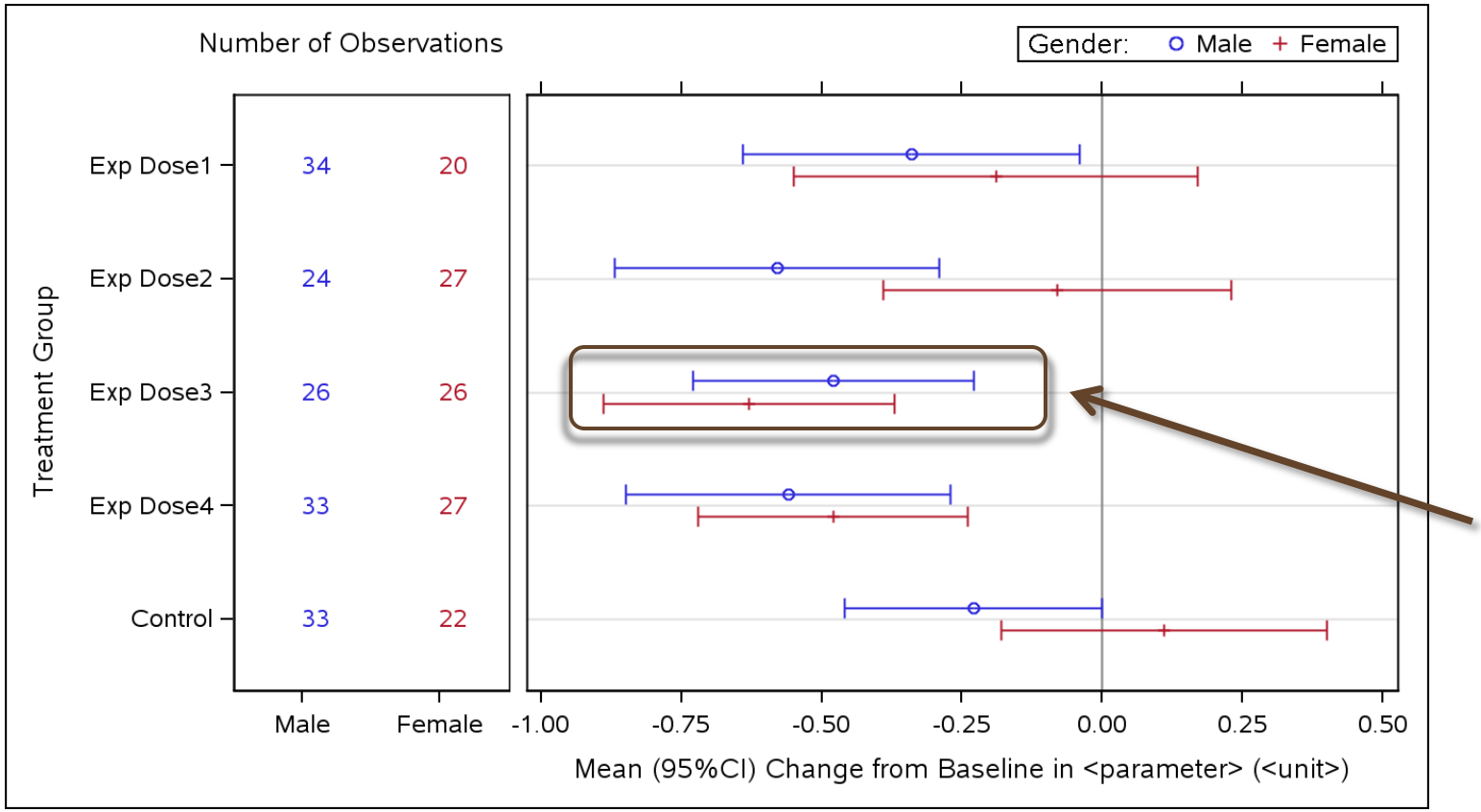
Do's and don'ts

- Provide visual anchors (but less prominent than data)
  - *Use meaningful reference lines, mirror tick mark onto right and upper axes, regression lines / curves, smoothed curves*



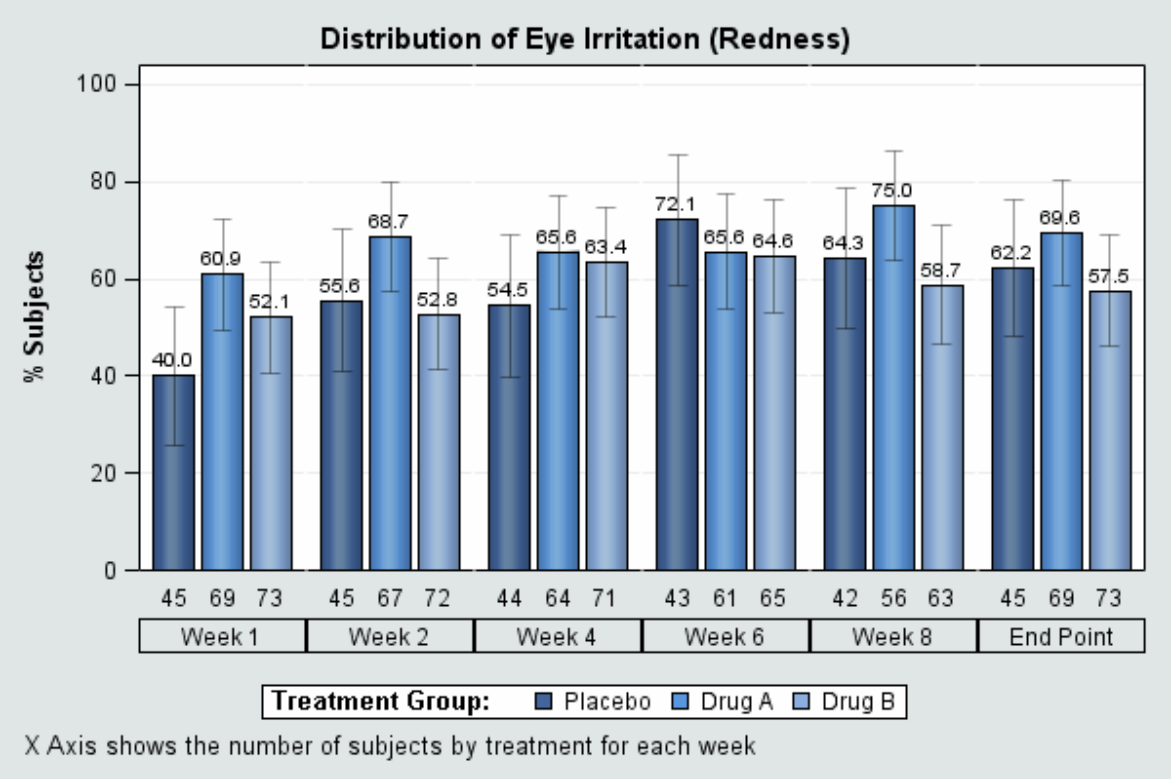
Do's and don'ts

- Bring closer items the reader needs to compare
  - Dose-Response relationship ? Consistent effects across subgroups?



Do's and don'ts

- Maximize the data-to-ink ratio
- Use quantitative scales ... for quantitative variables
  - 'Lot of ink' version ... with timepoint considered as categorical



Do’s and don’ts

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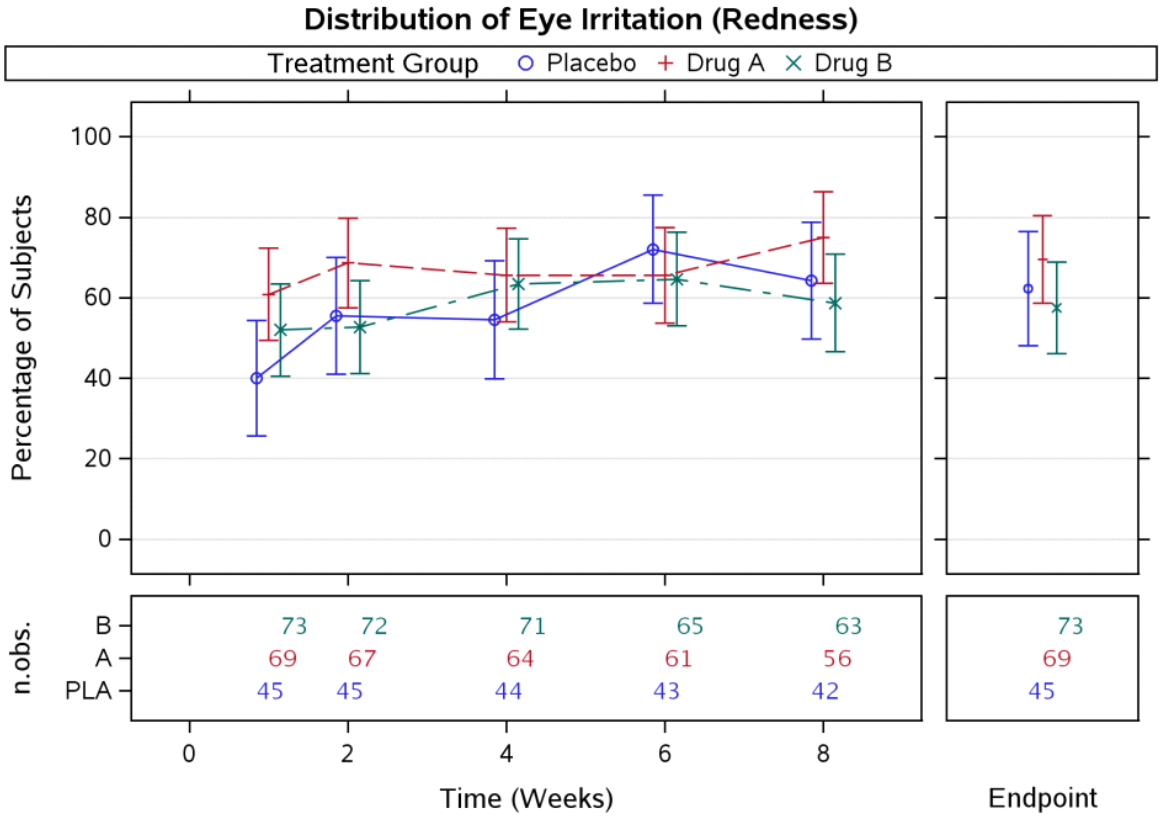
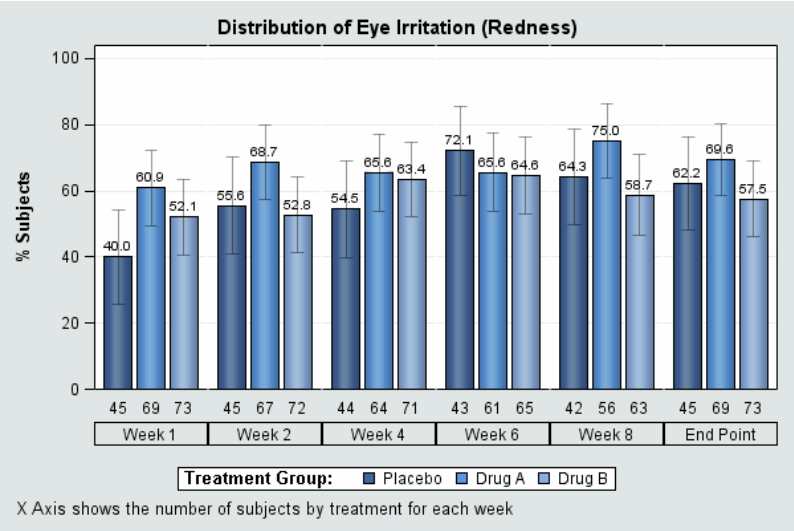
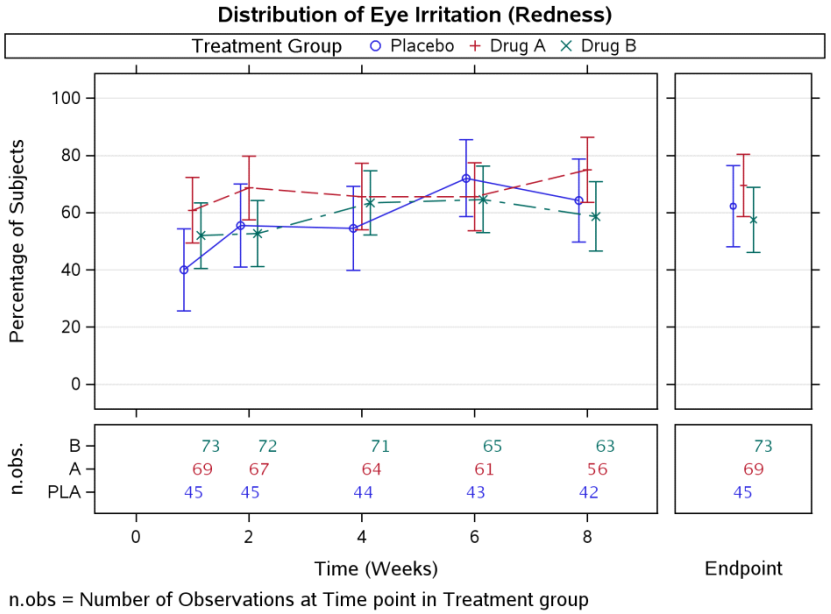


n.obs = Number of Observations at Time point in Treatment group

Do’s and don’ts

- Maximize the data-to-ink ratio
- Use quantitative scales ... for quantitative variables





Special Thanks

The members of the FDA/Industry/Academia Working Group

- Regulatory: George Rochester, Bruce Weaver, Stephine Keeton, Janelle Charles, Chuck Cooper, Suzanne Demko, Robert Fiorentino, Richard Forshee, Eric Frimpong, Ted Guo, Pravin Jadjav, Leslie Kenna, Joyce Korvick, Antonio Paredes, Matt Soukup, Je Summers, Mark Walderhaug, Yaning Wang, Markus Yap, Hao Zhu, Catherine Njue
- Industry: Ken Koury, Rich Anziano, Susan Duke, Mac Gordon, Andreas Brueckner, Navdeep Boparai, Brenda Crowe, Sylvia Engelen, Larry Gould, Matthew Gribbin, Liping Huang, Qi Jiang, Andreas Krause
- Academia: Frank Harrell, Mary Banach

References and Useful Links

Amit, O., Heiberger, R. and Lane, P. (2007). Graphical approaches to the analysis of safety data in clinical trials. Pharmaceut. Stat. 7(1):20-35.

Cooper, A. J. P., Lettis, S., Chapman, C. L., Evans, S. J. W., Waller, P. C., Shakir, S., Payvandi, N. and Murray, A. B. (2008), Developing tools for the safety specification in risk management plans: lessons learned from a pilot project. Pharmacoepidemiology and Drug Safety, 17: 445–454.

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Michael Friendly's Gallery of Data Visualization - The Best and Worst of Statistical Graphics http://www.math.yorku.ca/SCS/Gallery/

Robert Allison's SAS/Graph Examples - http://robslink.com/SAS/Home.htm

http://stat-computing.org/events/2010-jsm - Use of Graphics in Clinical Trials

Frank Harell's Tutorial: Statistical Presentation Graphics

http://biostat.mc.vanderbilt.edu/twiki/pub/Main/StatGraphCourse/graphscourse.pdf

Backup Slides

NOVARTIS

Graphics Navigator – Navigator Slide 4
Visual Perception

"When a graph is constructed, information is *encoded*. The *visual decoding* of this encoded information is *graphical perception*.

The decoding is the vital link …

No matter how ingenious the encoding … and no matter how technologically impressive the production, a graph is a failure if the visual decoding fails."

William Cleveland, The Elements of Graphing Data

Hierarchy of human graphical perception abilities

1. Position along a common scale (most accurate)
2. Position along identical nonaligned scales
3. Length
4. Angle and slope
5. Area
6. Volume
7. Color
    1. Hue (red, green, blue, etc) can give good discrimination but poor ordering
    2. Saturation (pale/deep) can be useful if order is important

Source: W.S. Cleveland - Elements of Graphing Data