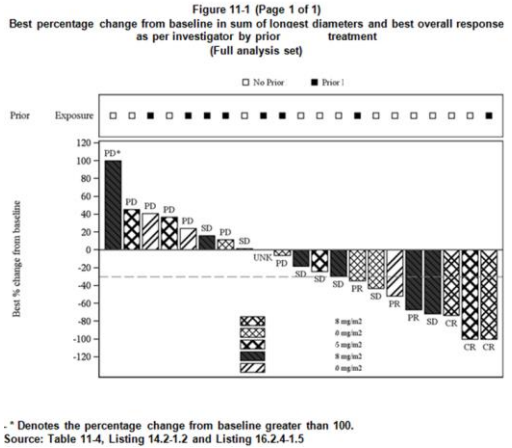


Lessons from a company wide data visualization initiative

Mark Baillie, AMDS Novartis

EFSPI/PSDM data visualization workshop, Utrecht 19th April 2023

https://graphicsprinciples.github.io/

How can we make better graphs?

During 2014, Novartis formed a cross-functional Graphics Workstream to:

- Enhance understanding and use of **good graphical principles**
- Promote **graphical thinking**
- Facilitate **easy access** to high quality graphics
- Provide **state-of-the-art** ideas on graphical presentation of data for exploratory analyses
- Outline a **view of graphics at Novartis tomorrow**

MAIN PAPER | Full Access

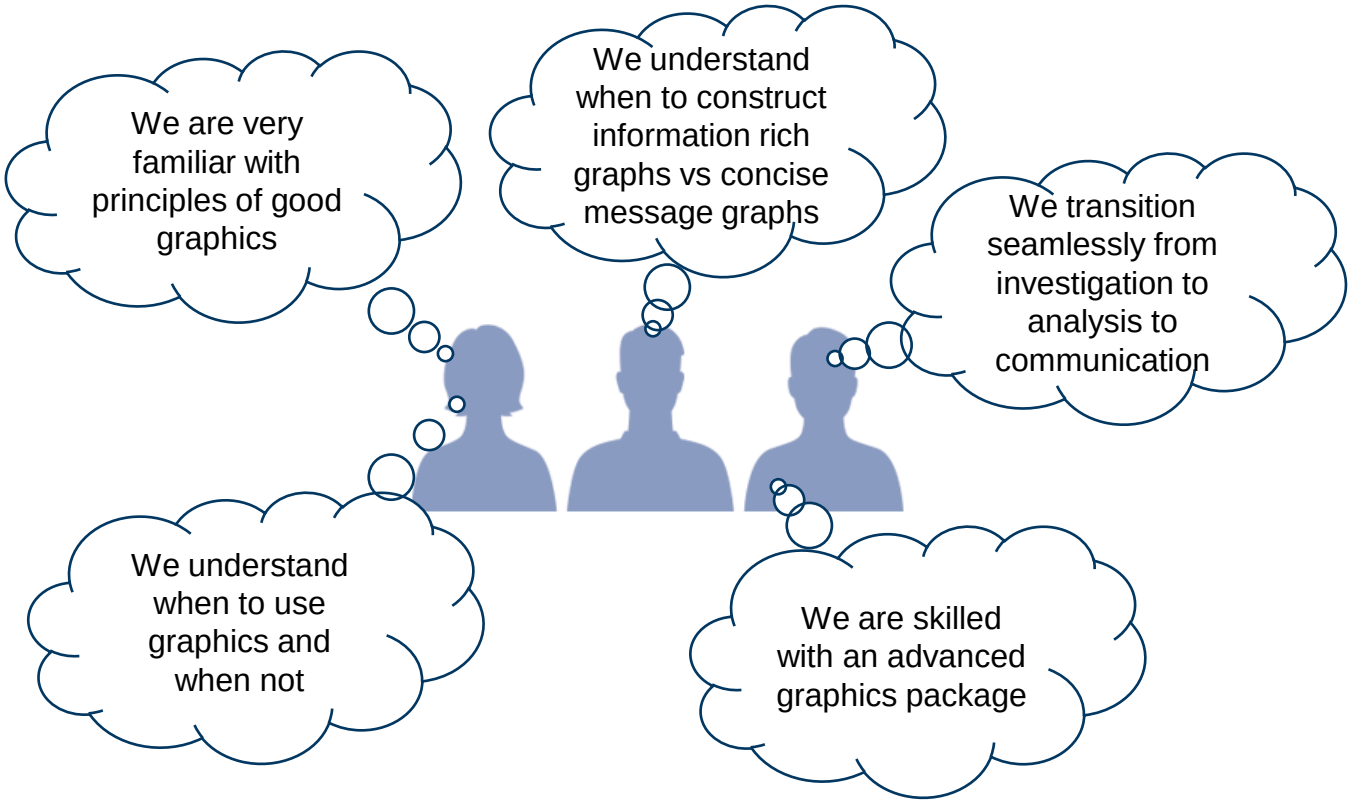
How can we make better graphs? An initiative to increase the graphical expertise and productivity of quantitative scientists

Marc Vandemeulebroecke, Mark Baillie, David Carr, Linda Kanitra, Alison Margolskee, Andrew Wright, Baldur Magnusson

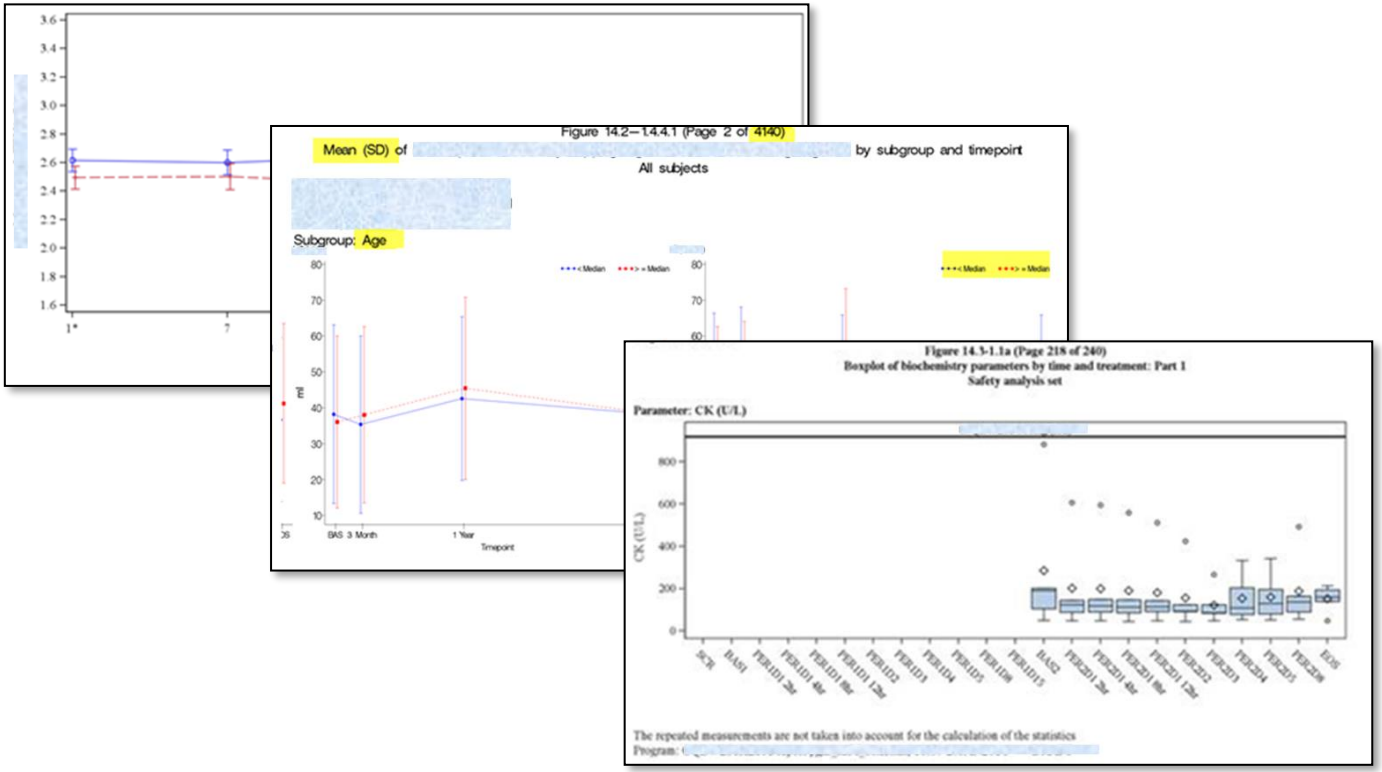
https://onlinelibrary.wiley.com/doi/full/10.1002/pst.1912

 https://graphicsprinciples.github.io/

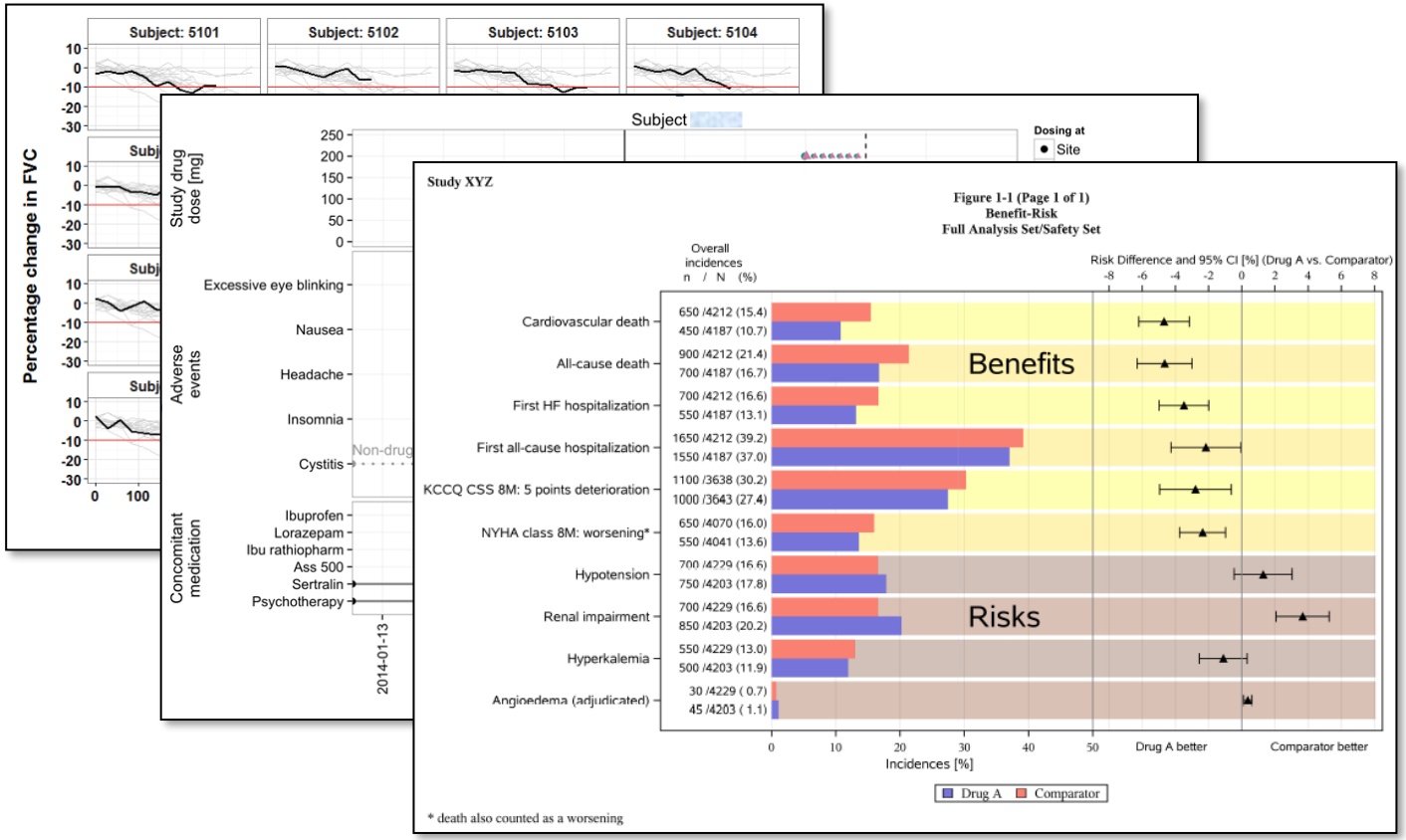
Vision: Tomorrow's ideal applied statistician



Goal: see less of these...



...and more of these



How do we get there?

- How do we tell a good graph from a bad one?
- How do we ensure we design a graph that is fit for purpose?
- Recall workstream goal: enhance understanding and use of **good graphical principles**

Elements of the initiative

Graphical principles and thinking

1. Graphics Principles Cheat Sheet
2. Newsletter

Easing the implementation

3. Graph Gallery
4. Analysis Results Datasets
5. Standardization of most common/important graphs

Graphics tomorrow ... or today?

6. Question-based visualizations and interactive graphics

...plus overarching stakeholder management and communication

MAIN PAPER | Full Access

How can we make better graphs? An initiative to increase the graphical expertise and productivity of quantitative scientists

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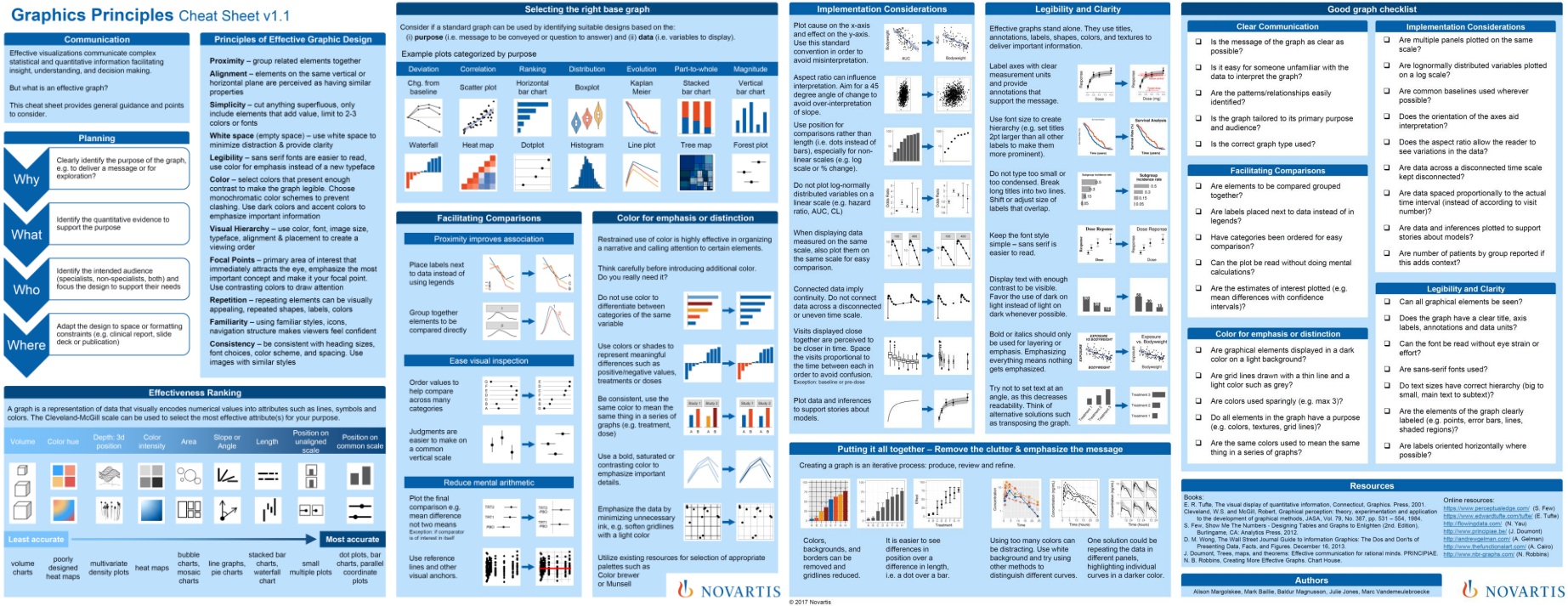
Graphics Principles Cheat Sheet

Graphics Principles Cheat Sheet



https://graphicsprinciples.github.io/

https://graphicsprinciples.github.io/cheatsheet.html

Planning questions

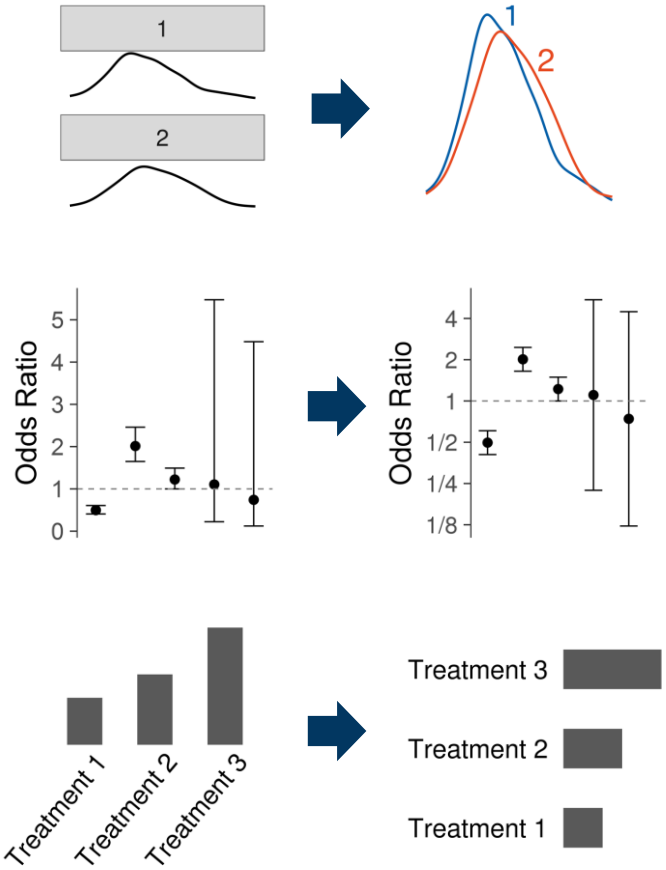
Why
Clearly identify the purpose of the graph, e.g. to deliver a message or for exploration?

What
Identify the quantitative evidence to support the purpose

Who
Identify the intended audience (specialists, non-specialists, both) and focus the design to support their needs

Where
Adapt the design to space or formatting constraints (e.g. clinical report, slide deck or publication)

Tips & tricks



 https://graphicsprinciples.github.io/

Good graph checklist

Good graph checklist

Clear Communication

- ❑ Is the message of the graph as clear as possible?
- ❑ Is it easy for someone unfamiliar with the data to interpret the graph?
- ❑ Are the patterns/relationships easily identified?
- ❑ Is the graph tailored to its primary purpose and audience?
- ❑ Is the correct graph type used?

Facilitating Comparisons

- ❑ Are elements to be compared grouped together?
- ❑ Are labels placed next to data instead of in legends?
- ❑ Have categories been ordered for easy comparison?
- ❑ Can the plot be read without doing mental calculations?
- ❑ Are the estimates of interest plotted (e.g. mean differences with confidence intervals)?

Color for emphasis or distinction

- ❑ Are graphical elements displayed in a dark color on a light background?
- ❑ Are grid lines drawn with a thin line and a light color such as grey?
- ❑ Are colors used sparingly (e.g. max 3)?
- ❑ Do all elements in the graph have a purpose (e.g. colors, textures, grid lines)?
- ❑ Are the same colors used to mean the same thing in a series of graphs?

Implementation Considerations

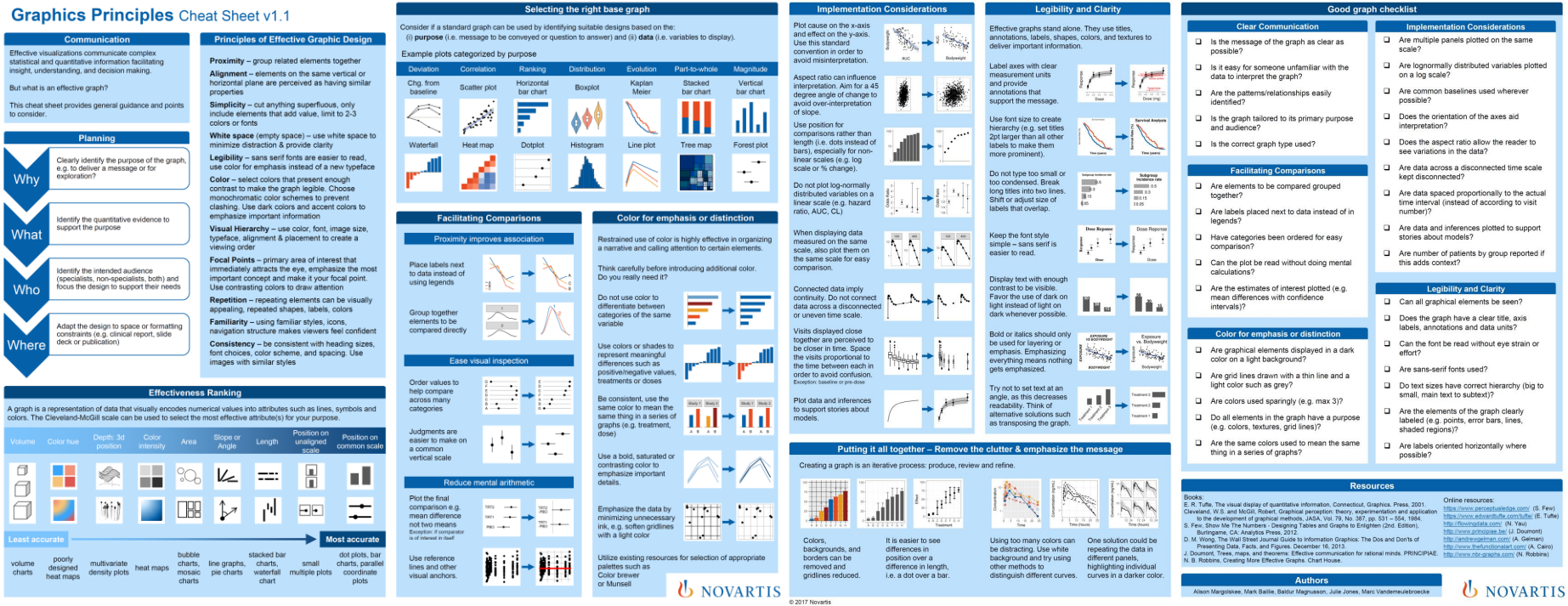
- ❑ Are multiple panels plotted on the same scale?
- ❑ Are lognormally distributed variables plotted on a log scale?
- ❑ Are common baselines used wherever possible?
- ❑ Does the orientation of the axes aid interpretation?
- ❑ Does the aspect ratio allow the reader to see variations in the data?
- ❑ Are data across a disconnected time scale kept disconnected?
- ❑ Are data spaced proportionally to the actual time interval (instead of according to visit number)?
- ❑ Are data and inferences plotted to support stories about models?
- ❑ Are number of patients by group reported if this adds context?

Legibility and Clarity

- ❑ Can all graphical elements be seen?
- ❑ Does the graph have a clear title, axis labels, annotations and data units?
- ❑ Can the font be read without eye strain or effort?
- ❑ Are sans-serif fonts used?
- ❑ Do text sizes have correct hierarchy (big to small, main text to subtext)?
- ❑ Are the elements of the graph clearly labeled (e.g. points, error bars, lines, shaded regions)?
- ❑ Are labels oriented horizontally where possible?

 https://graphicsprinciples.github.io/

Graphics Principles Cheat Sheet

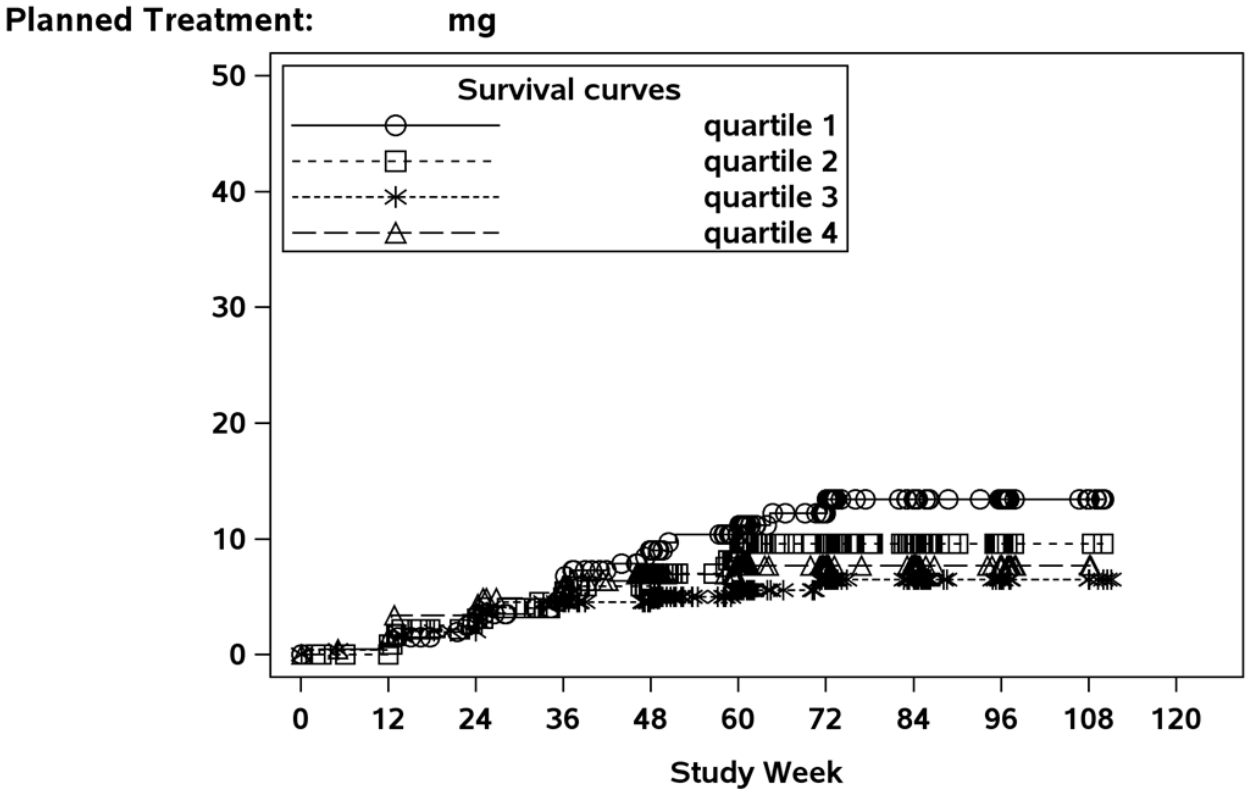


https://graphicsprinciples.github.io/

https://graphicsprinciples.github.io/cheatsheet.html

Principles of effective visual communication

This is a continual process



How do we get there?

- How do we tell a good graph from a bad one?
- How do we ensure we design a graph that is fit for purpose?
- Recall workstream goal: enhance understanding and use of **good graphical principles**

Effective Visual Communication (EVC)!

CPT: Pharmacometrics & Systems Pharmacology

Tutorial | Open Access

Effective Visual Communication for the Quantitative Scientist

Marc Vandemeulebroecke, Mark Baillie, Alison Margolskee, Baldur Magnusson

First published: 22 July 2019 | https://doi.org/10.1002/psp4.12455 | Citations: 7

 https://graphicsprinciples.github.io/

https://youtu.be/pfxulpF9XOw

3 principles for better visual communication

1. **Have a clear purpose**
   - Understand the question you are trying to answer
   - Identify the quantitative evidence to answer that question
   - Know your audience and focus the design to support their needs

2. **Show the data clearly**
   - Choose the appropriate graph type to display your data
   - Avoid misrepresentation (use appropriate scales)
   - Maximize data to ink ratio (reduce distraction, less is more)

3. **Make the message obvious**
   - Minimize mental arithmetic (e.g. plot the difference)
   - Use proximity and alignment to aid in comparisons
   - Use colors and annotations to highlight important details

https://graphicsprinciples.github.io/

https://youtu.be/pfxulpF9XOw

Learning outcomes for today's workshop

- Appreciate why Effective Visual Communication (EVC) is a key competency for the quantitative scientist.
- Explain the three principles of EVC (purpose, clarity and message).
- Design a visualization based on a specific purpose.
- Redesign a visualization to show data clearly.
- Enhance the message of a visualization.
- Recognize where to apply the three EVC principles in your daily work.

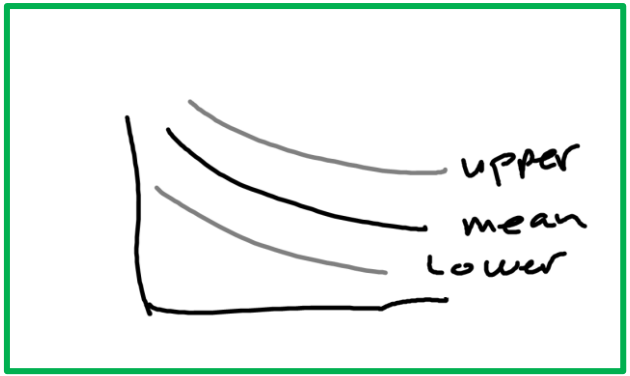
https://graphicsprinciples.github.io/

Purpose

What is the purpose of the visualization?
What is the main objective of the visualization? *The visualization is to display supporting evidence that LNP023 has demonstrated proof of concept and is a good candidate to take into phase 3 development.* List the (scientific) question(s) the visualization is trying to answer. Try to be specific. - *Is there a decrease in LDH to "normal levels" post LNP023 dose as a mono and combo therapy?* - *Does LNP023 increase hemoglobin levels?* What is the key evidence that is available to answer the question? *Two studies.* *Two different dose cohorts in one study. Mono and combo.* *LDH is a surrogate measure of efficacy for PNH.* *Consistency across gender for Hemoglobin improvement.*

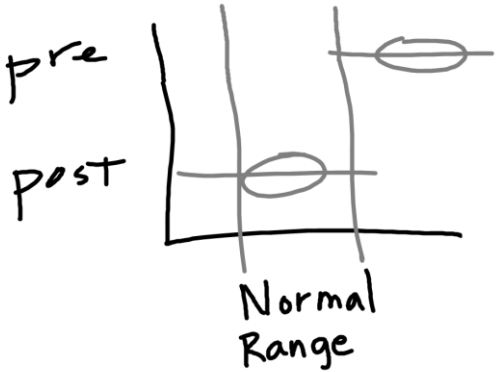
2nd principle – select the appropriate graph

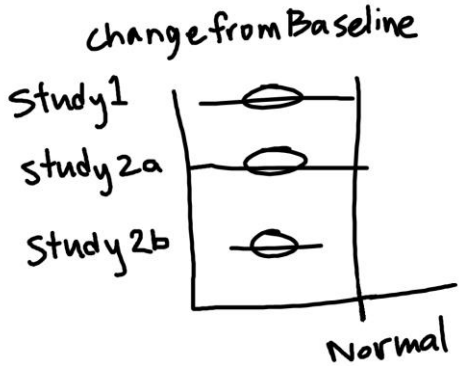
- Brainstorm different ways to display the data
- The more ideas the better!
- Select the display that supports the key message



Continuing with LNP example

- What is the key message:
  - LNP023 reduces LDH levels to normal
- The key evidence to support this:
  - Two studies with different dose cohorts
  - LDH as a surrogate for efficacy

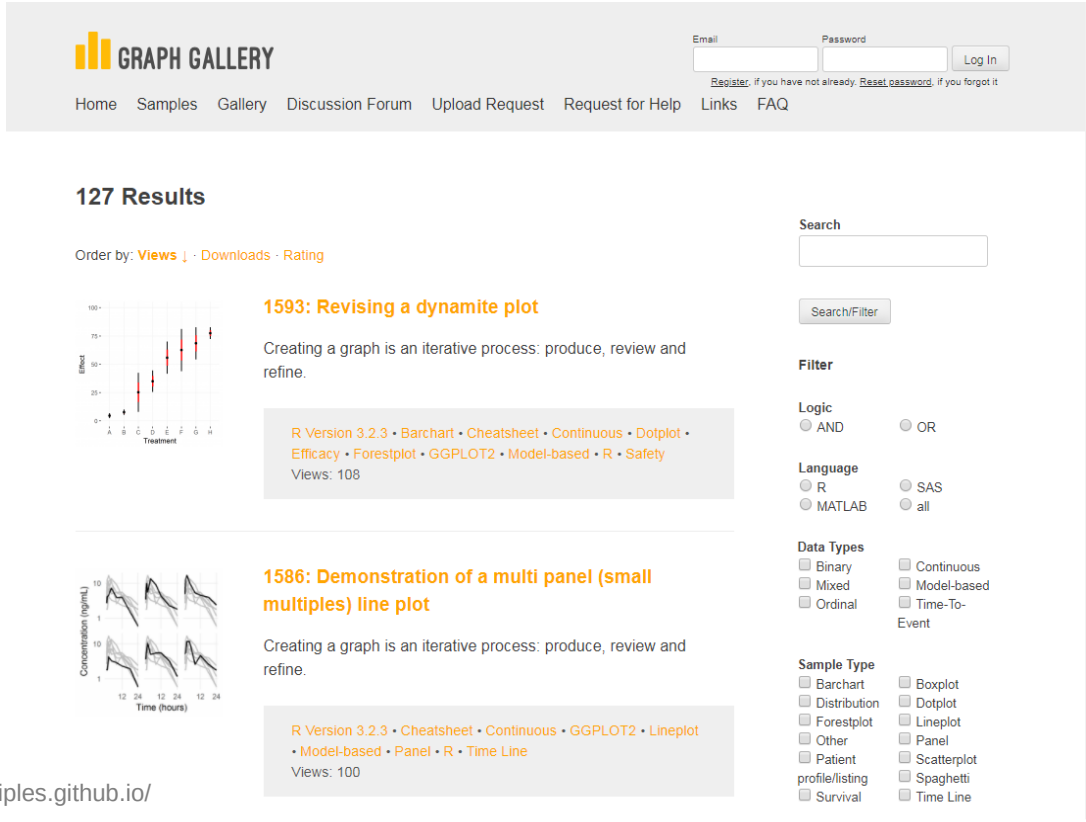




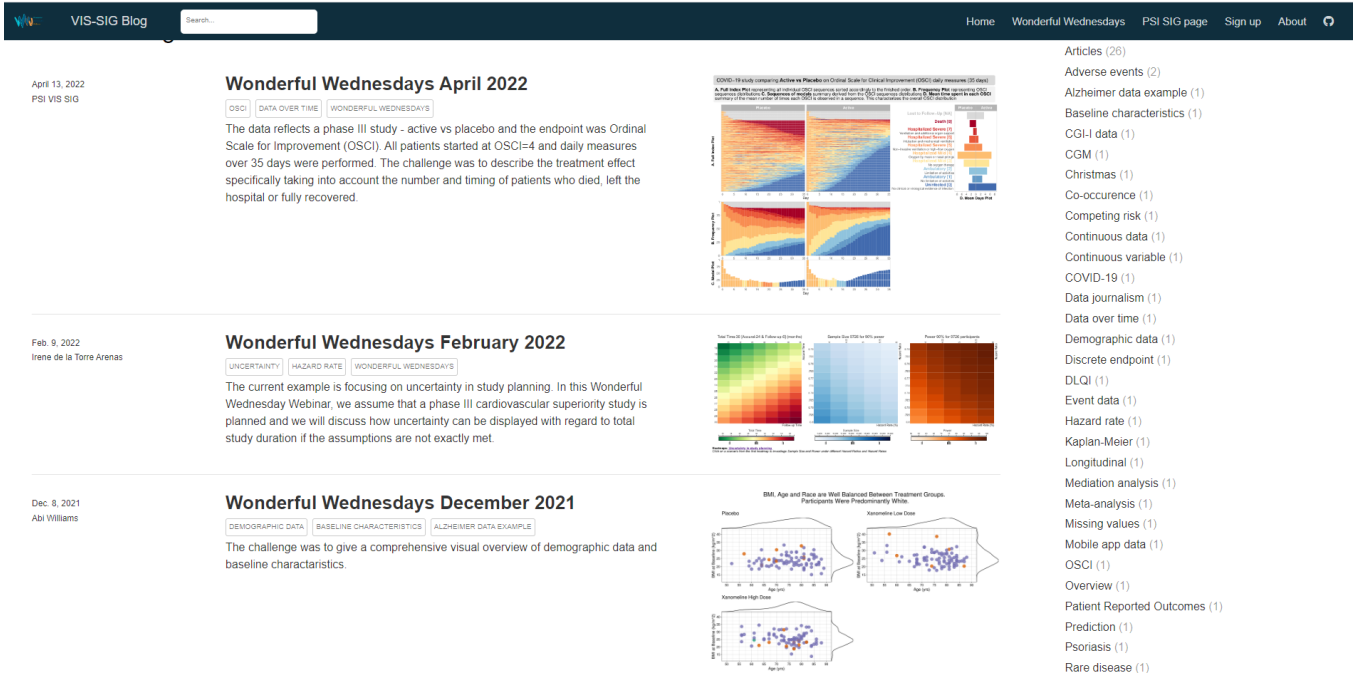
 https://graphicsprinciples.github.io/

3. Graph Gallery

3. Graph Gallery: Providing access to example code and data



Resources for practice



Blog, code and data @ https://vis-sig.github.io/blog/

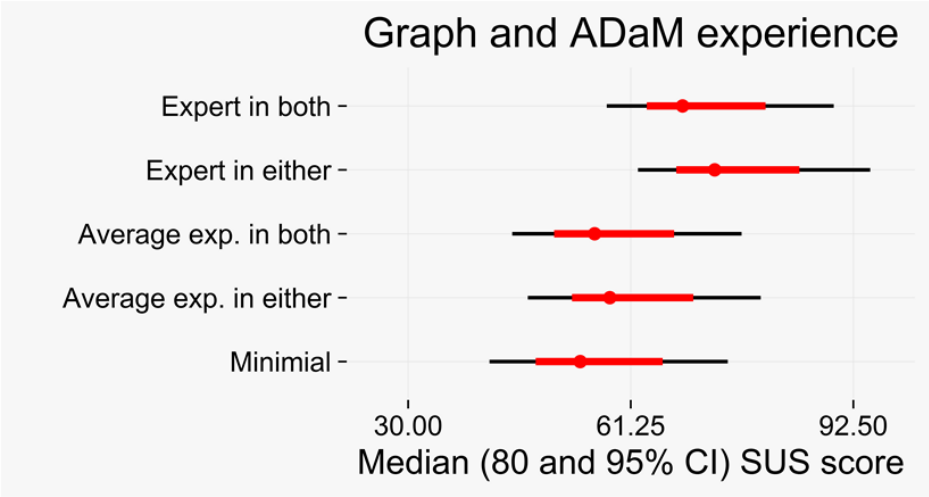
4. Analysis results data sets

How can we help with implementation across varying skill levels?

A survey was sent to associates working with clinical data

The purpose to:

- evaluate ADaM as a data standard for graph production
- Identify key issues associates currently experience
- Explore issues related to role and experience level
- 85 respondents

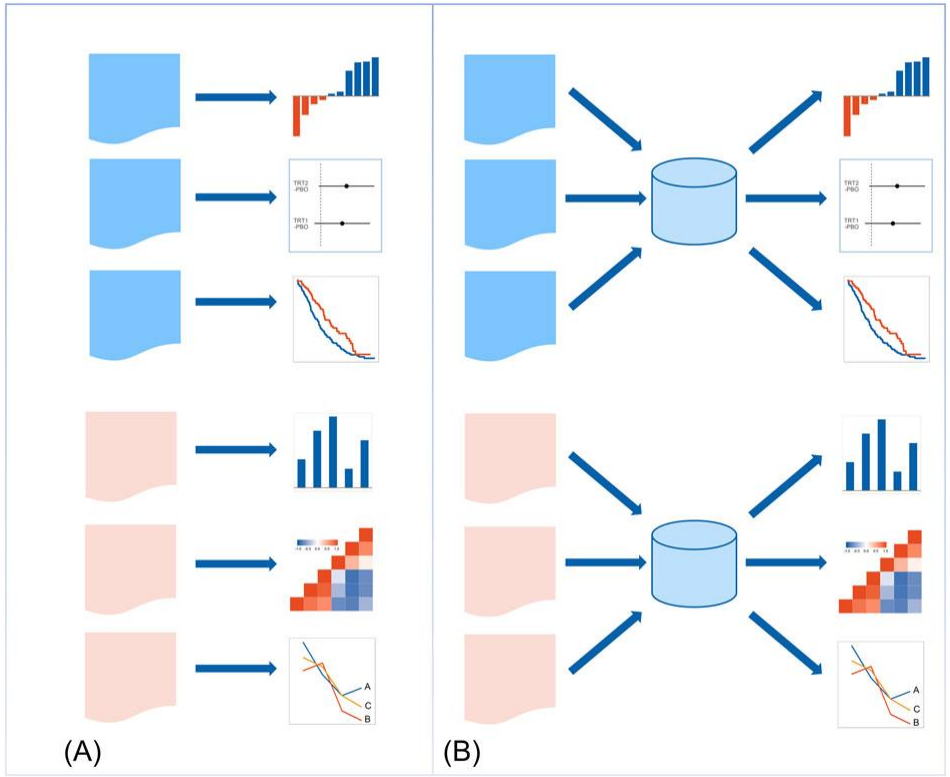


How can we help with implementation across varying skill levels?

(Negative) qualitative comments

- ***Complex graphs such as Forest Plots will need a fair amount of data manipulation to get all needed for input to the graph***
- ***some variables*** *needed for graphs are not in ADaM datasets*
- *Trying to figure out what the different parameters mean and* ***extracting the information relevant to my task.***

Analysis results data sets



ORIGINAL ARTICLE

Aliskiren, Enalapril, or Aliskiren and Enalapril in Heart Failure

John J.V. McMurray, M.D., Henry Krum, M.B., B.S., Ph.D., William T. Abraham, M.D., Kenneth Dickstein, M.D., Ph.D., Lars V. Køber, M.D., D.M.Sc., Akshay S. Desai, M.D., M.P.H., Scott D. Solomon, M.D., Nicola Greenlaw, M.Sc., M. Atif Ali, B.A., Yanntong Chiang, Ph.D., Qing Shao, Ph.D., Georgia Tarnesby, M.B., B.Chir., et al., for the ATMOSPHERE Committees Investigators†

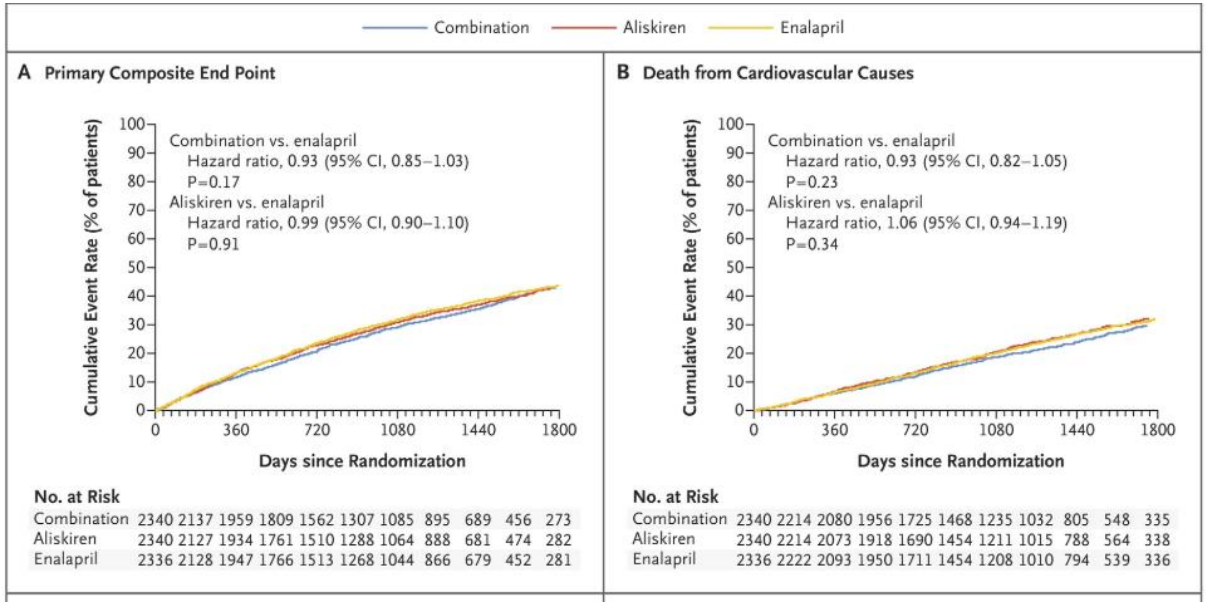
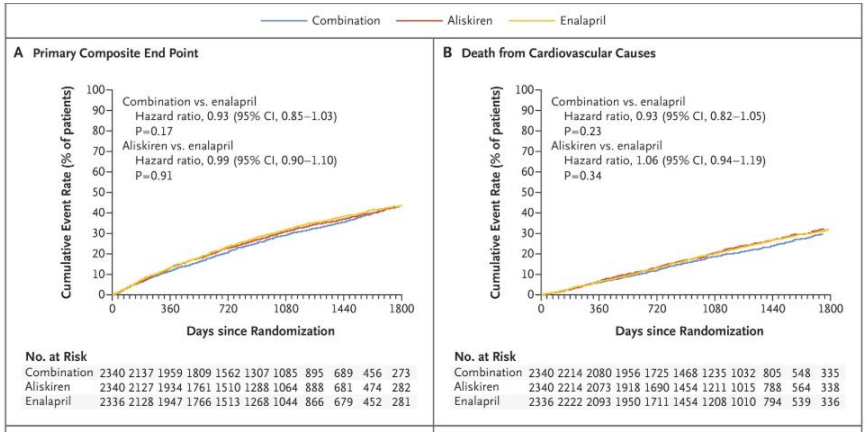


Table 2. Protocol-Specified Primary and Secondary Outcomes.*

Outcome	Combination Therapy (N=2340)	Aliskiren (N=2340)	Enalapril (N=2336)	Combination Therapy vs. Enalapril		Aliskiren vs. Enalapril	
				Hazard Ratio or Difference (95% CI)	P Value	Hazard Ratio or Difference (95% CI)	P Value
Primary composite outcome: death from cardiovascular causes or first hospitalization for worsening heart failure — no. (%)	770 (32.9)	791 (33.8)	808 (34.6)	0.93 (0.85 to 1.03)	0.17	0.99 (0.90 to 1.10)	0.91
Death from cardiovascular causes	512 (21.9)	562 (24.0)	547 (23.4)	0.93 (0.82 to 1.05)	0.23	1.06 (0.94 to 1.19)	0.34
First hospitalization for worsening heart failure	430 (18.4)	442 (18.9)	452 (19.3)	0.93 (0.82 to 1.06)	0.29	0.99 (0.87 to 1.13)	0.91
Secondary outcome: change in KCCQ clinical summary score at 12 mo†	−5.04±0.56	−6.03±0.57	−5.01±0.55	−0.03 (−1.56 to 1.50)	0.97	−1.02 (−2.56 to 0.52)	0.20
Other prespecified exploratory outcomes — no. (%)‡							
Death from cardiovascular causes, hospitalization for heart failure, nonfatal myocardial infarction, nonfatal stroke, or resuscitated cardiac arrest	841 (35.9)	874 (37.4)	877 (37.5)	0.94 (0.86 to 1.04)	0.23	1.01 (0.92 to 1.11)	0.80
Fatal or nonfatal myocardial infarction	88 (3.8)	84 (3.6)	100 (4.3)	0.87 (0.66 to 1.16)	0.36	0.85 (0.64 to 1.14)	0.28
Fatal or nonfatal stroke	87 (3.7)	103 (4.4)	93 (4.0)	0.93 (0.70 to 1.25)	0.65	1.12 (0.85 to 1.49)	0.42
First resuscitated cardiac arrest	31 (1.3)	35 (1.5)	32 (1.4)	0.96 (0.58 to 1.57)	0.86	1.10 (0.68 to 1.78)	0.69
Death from any cause	595 (25.4)	654 (27.9)	646 (27.7)	0.91 (0.82 to 1.02)	0.12	1.04 (0.93 to 1.16)	0.46
Composite renal outcome — no. (%)§	39 (1.7)	26 (1.1)	18 (0.8)	2.17 (1.24 to 3.79)	0.007	1.50 (0.82 to 2.74)	0.18



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Other prespecified exploratory outcomes — no. (%)‡							
Death from cardiovascular causes, hospitalization for heart failure, nonfatal myocardial infarction, nonfatal stroke, or resuscitated cardiac arrest	841 (35.9)	874 (37.4)	877 (37.5)	0.94 (0.86 to 1.04)	0.23	1.01 (0.92 to 1.11)	0.80
Fatal or nonfatal myocardial infarction	88 (3.8)	84 (3.6)	100 (4.3)	0.87 (0.66 to 1.16)	0.36	0.85 (0.64 to 1.14)	0.28
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UANALID	TRTVAR	TRTVAL	AVISITN	PARAMCD	ROWCAT1	ANLTYP1	ANLTYP2	STAT	STATVAL	ANLMETH
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Combination vs. Enalapril	RESPONSE	Experimental	SMALLN	770	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Combination vs. Enalapril	RESPONSE	Experimental	BIGN	2340	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Combination vs. Enalapril	RESPONSE	Experimental	PERCENT	32.9	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Enalapril		PCE	Combination vs. Enalapril	RESPONSE	Enalapril	SMALLN	808	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Enalapril		PCE	Combination vs. Enalapril	RESPONSE	Enalapril	BIGN	2336	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Enalapril		PCE	Combination vs. Enalapril	RESPONSE	Enalapril	PERCENT	34.6	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		Hazard	0.93	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		95CILOW	0.846	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		95CIHIGH	1.03	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		1sidedp	0.0862	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		2sidedp	0.1724	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P			PCE	Combination vs. Enalapril	COMPARISON		adj1sidep	0.3448	Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Non Diabetes: Combination vs Enalapril(1)	RESPONSE	Experimental	SMALLN		Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Non Diabetes: Combination vs Enalapril(1)	RESPONSE	Experimental	BIGN		Lifetest KM
<STUDYID>_<RA>_XXX1	TRT01P	Combination		PCE	Non Diabetes: Combination vs Enalapril(1)	RESPONSE	Experimental	PERCENT		Lifetest KM

scientific **data**

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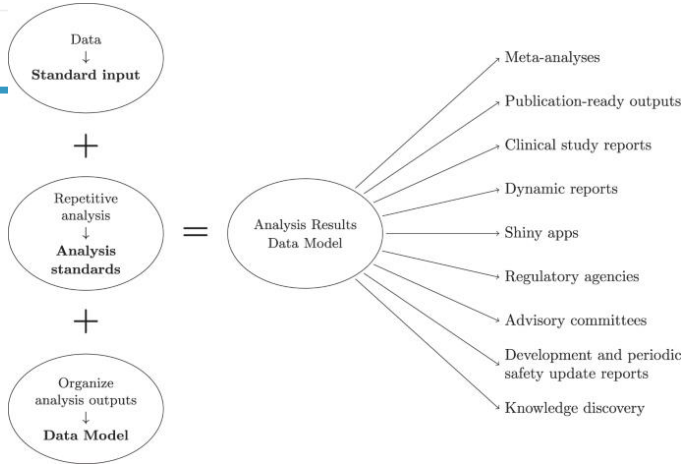
nature › scientific data › articles › article

Article | Open Access | Published: 10 November 2022

Rethinking clinical study data: why we should respect analysis results as data

Joana M. Barros, Lukas A. Widmer, Mark Baillie & Simon Wandel

Scientific Data **9**, Article number: 686 (2022) | Cite this article



https://www.nature.com/articles/s41597-022-01789-2

Pre-clinical	Clinical			
Organize	Plan	Collect	Organize	Analyze
SEND	PRM	CDASH	SDTM	ADaM
Tabulation for animal studies	Model for planning	Model for data collection	Model for tabulation of study data	Analysis data model

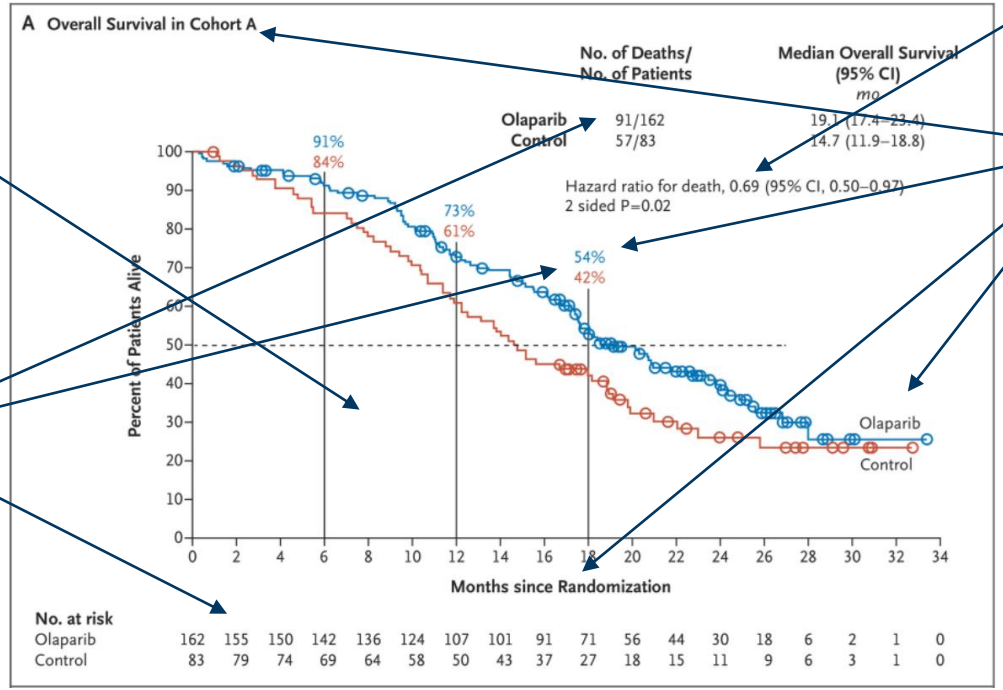
The anatomy of a KM plot

Additional inferential statistics

Data area

Titles, labels and annotations

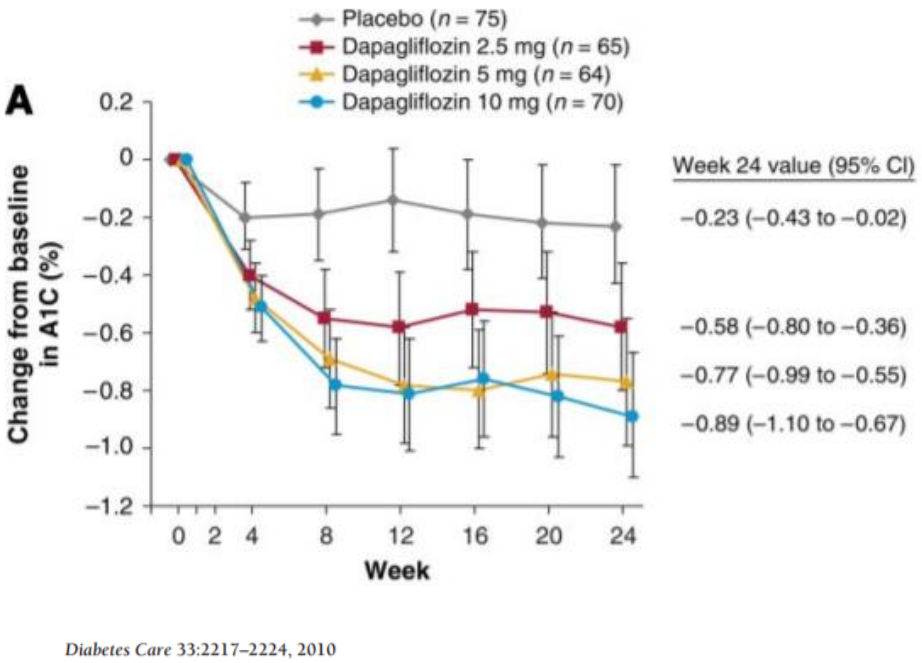
Additional summary information for context



https://graphicsprinciples.github.io/

Activity 1 | Results from Analysis of Primary Endpoint

Study 2013



Diabetes Care 33:2217–2224, 2010

Treatment	Treatment difference versus placebo*	P-value	% Patients with rescue medication
placebo			12% (9/75)
2.5 mg	-0.35	p < 0.05	11% (7/65)
5 mg	-0.54	p < 0.001	2% (1/64)
10 mg	-0.66	p < 0.001	0% (0/70)

* Difference between means in change from baseline HbA1c at Week 24

Remember: HbA1c values collected after rescue were **excluded** from the analysis.

Interesting point: % of patients with rescue were not presented in the primary manuscript!

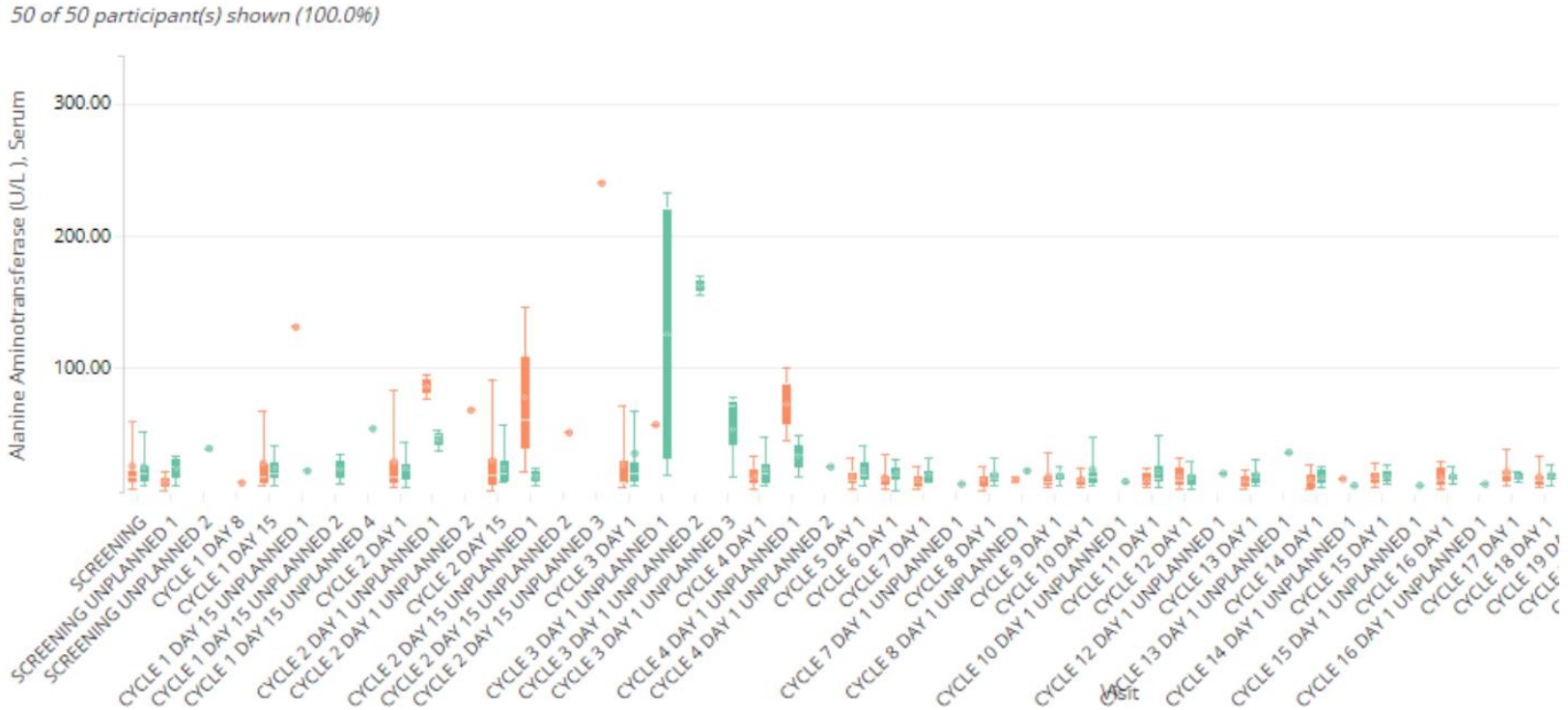
Lessons from a company wide data visualization initiative

Why does it matter?

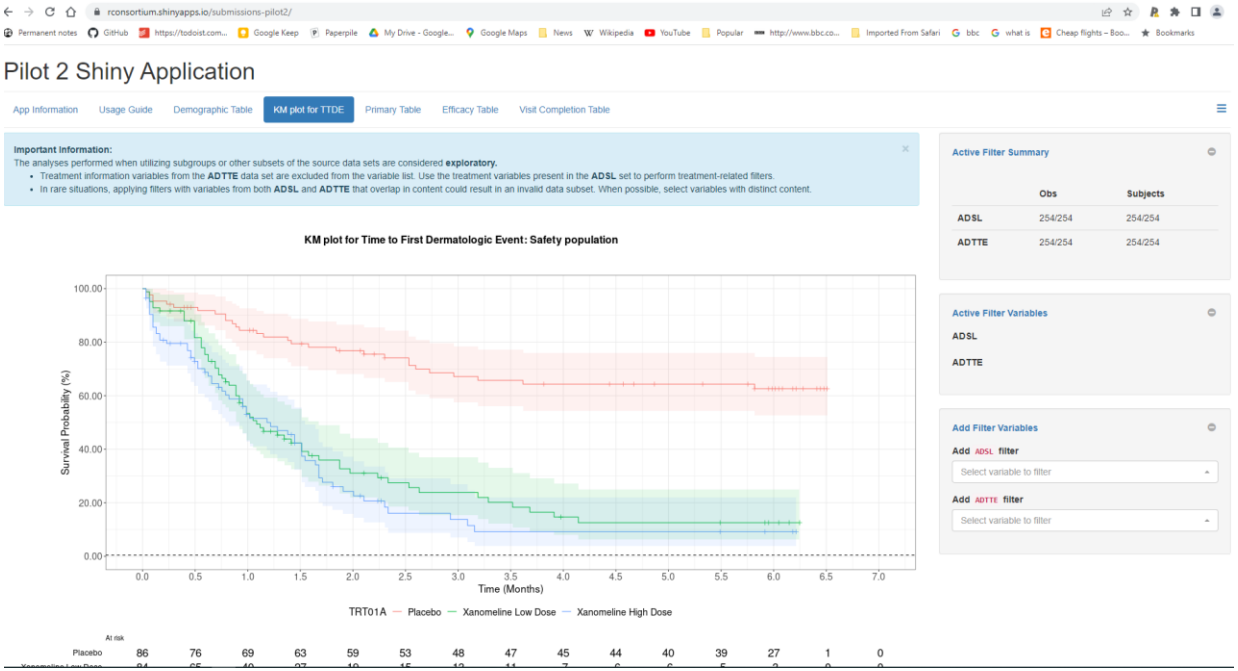
- Data visualization and more importantly Effective Visual Communication (EVC) is essential in every step of a quantitative workflow, from scoping to execution through to communicating results and conclusions
- Within the quantitative sciences, traditional university and professional training curricula have not focused on EVC
- One hears regularly “I don’t understand this graph”
- A visual representation can be very powerful if it is clear and aligned with the intended purpose

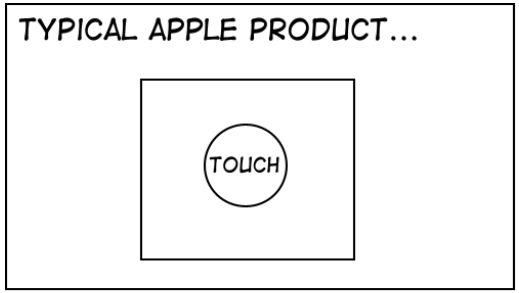
https://graphicsprinciples.github.io/

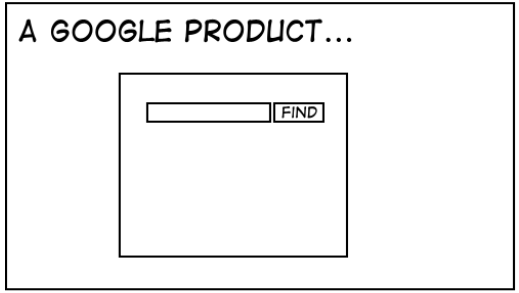
This is a continual process

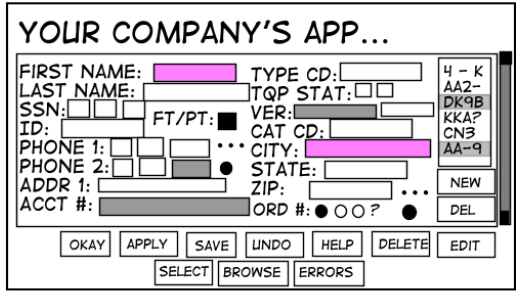


R for Pharma









STUFFTHATHAPPENS.COM BY ERIC BURKE

H/T Simon Wandel

Effective visualization is a practice!

- Tufte: “Graphical competence demands three quite different skills: the substantive, statistical, and artistic.”
- These skills cannot be learned by reading an article
- Adopt visualization in every part of your workflow; make it a habit
- Think graphically
- Use pencil and paper before coding in software
- Calculate and communicate
- Test and repeat

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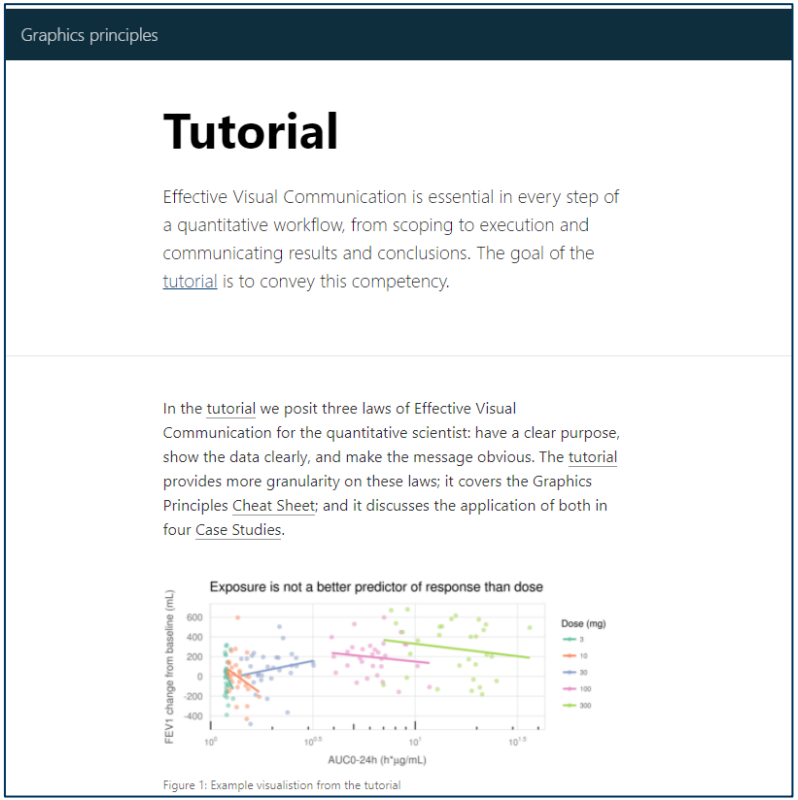
- Frank Bretz
- Bonnie Petrucka
- Malika Cremer

And many more…

https://graphicsprinciples.github.io/

Resources, where to find out more?



Additional resources:

- Effective Visual Communication Website
  https://graphicsprinciples.github.io/
- PKPD Exploratory graphics (xGx)
  https://opensource.nibr.com/xgx
- Tutorial on effective visual communication
  https://ascpt.onlinelibrary.wiley.com/doi/full/10.1002/psp4.12455
- Video on the three principles
  https://youtu.be/pfxulpF9XOw
- Presentation checklist
  https://opensource.nibr.com/xgx/Resources/Presentation_Checklist_v2.03.pdf
- Wonderful Wednesdays
  https://www.psiweb.org/sigs-special-interest-groups/visualisation/welcome-to-wonderful-wednesdays

Thank you

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