EVC initiative team
Clinical Development & Analytics
Global Drug Development

Effective Visual Communication (EVC) for Quantitative Scientists

Marc Vandemeulebroecke, Baldur Magnusson, Mark Baillie & Alison Margolskee

ASCPT Pharmacometrics & Pharmacokinetics Webinar (part 1)
Friday, January 15, 2021
https://graphicsprinciples.github.io/

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Welcome to the ASCPT Webinar!

The presentation will start momentarily

Housekeeping Notes

- All attendees are auto-muted
- Please use the chat function to address ASCPT staff
- Please forward ideas for future webinar topics and/or questions on today's webinar to members@ASCPT.org
- We will be recording today's presentation. This presentation and all previously recorded webinars are available to members via the Online Learning page on ASCPT.org

ASCPT American Society for Clinical Pharmacology & Therapeutics

Please direct your questions through the Q&A function at any time throughout the presentation; if viewing in full screen, you may need to hover over the bottom of your screen to see this option

Effective Visual Communication (EVC) for Quantitative Scientists

Global Group Head for Biostatistics

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Methodologist supporting clinical development and analytics

Mark Baillie

Global Group Head in Early Development Analytics

Baldur Magnusson

Senior Principal Pharmacometrician supporting Cardiovascular and Metabolism projects

Alison Margolskee

ASCPT American Society for Clinical Pharmacology & Therapeutics

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Introduction and Agenda

Marc Vandemeulebroecke

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Agenda for Webinar: Part 1

Timing	Agenda Item	Presenter
3 min	Introduction and learning outcomes	Marc
15 min	Importance of EVC and overview of principles	Baldur
10 min	Structured approach to EVC	Mark
12 min	Your turn: homework assignment 1) Graph + purpose 2) Dataset + purpose 3) Bring your own example	Alison
3 min	Recap and resources	Marc
10 min	Q&A and close	Neeraj

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Learning outcomes

- Appreciate why effective visual communication 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 principles of effective visual communication in your daily work.

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Motivation

Baldur Magnusson

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Plotting data is fun, but…

- A bad plot can be worse than no plot
- Producing a lot of graphs ≠ effective visual communication

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Great graphs are not trivial

 https://github.com/GraphicsPrinciples/webinar

Effective visualizations are all around us

http://www.fivethirtyeight.com

http://www.ft.com/coronavirusfree

http://vis-sig.github.io/blog

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Is exposure different? How?

What are we supposed to conclude?

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It is not hard to find more examples of ineffective visualizations

 https://github.com/GraphicsPrinciples/webinar

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What if we could do better?

Producing visualizations that…

- Are crafted for a specific purpose
- Adhere to good graphical principles
- Are designed for a particular audience
- Answer the question clearly

Could lead to…

- More impactful communication
- Elevated influence
- Informed decision-making

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https://youtu.be/pfxulpF9XOw

3 principles for improving visual communications

- 1st principle: 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

- 2nd principle: 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)

- 3rd principle: 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://github.com/GraphicsPrinciples/webinar

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Principles with examples

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

Principles for EVC

Graphics Principles Cheat Sheet v1.1

Communication

Effective visualizations communicate complex statistical and quantitative information facilitating insight, understanding, and decision making.

But what is an effective graph?

This cheat sheet provides general guidance and points to consider.

Planning

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)

Principles of Effective Graphic Design

Proximity – group related elements together

Alignment – elements on the same vertical or horizontal plane are perceived as having similar properties

Simplicity – cut anything superfluous, only include elements that add value, limit to 2-3 colors or fonts

White space (empty space) – use white space to minimize distraction & provide clarity

Legibility – sans serif fonts are easier to read, use color for emphasis instead of a new typeface

Color – select colors that present enough contrast to make the graph legible. Choose monochromatic color schemes to prevent clashing. Use dark colors and accent colors to emphasize important information

Visual Hierarchy – use color, font, image size, typeface, alignment & placement to create a viewing order

Focal Points – primary area of interest that immediately attracts the eye, emphasize the most important concept and make it your focal point. Use contrasting colors to draw attention

Repetition – repeating elements can be visually appealing, repeated shapes, labels, colors

Familiarity – using familiar styles, icons, navigation structure makes viewers feel confident

Consistency – be consistent with heading sizes, font choices, color scheme, and spacing. Use images with similar styles

Effectiveness Ranking

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Volume	Color hue	Depth: 3d position	Color intensity	Area	Slope or Angle	Length	Position on unaligned scale	Position on common scale

Least accurate → Most accurate

volume charts	poorly designed heat maps	multivariate density plots	heat maps	bubble charts, mosaic charts	line graphs, pie charts	stacked bar charts, waterfall chart	small multiple plots	dot plots, bar charts, parallel coordinate plots

Selecting the right base graph

Consider if a standard graph can be used by identifying suitable designs based on the:
(i) **purpose** (i.e. message to be conveyed or question to answer) and (ii) **data** (i.e. variables to display).

Example plots categorized by purpose

Deviation	Correlation	Ranking	Distribution	Evolution	Part-to-whole	Magnitude
Chg. from baseline	Scatter plot	Horizontal bar chart	Boxplot	Kaplan Meier	Stacked bar chart	Vertical bar chart
Waterfall	Heat map	Dotplot	Histogram	Line plot	Tree map	Forest plot

Facilitating Comparisons

Proximity improves association

Place labels next to data instead of using legends

Group together elements to be compared directly

Ease visual inspection

Order values to help compare across many categories

Judgments are easier to make on a common vertical scale

Reduce mental arithmetic

Plot the final comparison e.g. mean difference not two means
Exception: if comparator is of interest in itself

Use reference lines and other visual anchors.

Color for emphasis or distinction

Restrained use of color is highly effective in organizing a narrative and calling attention to certain elements.

Think carefully before introducing additional color. Do you really need it?

Do not use color to differentiate between categories of the same variable

Use colors or shades to represent meaningful differences such as positive/negative values, treatments or doses

Be consistent, use the same color to mean the same thing in a series of graphs (e.g. treatment, dose)

Use a bold, saturated or contrasting color to emphasize important details.

Emphasize the data by minimizing unnecessary ink, e.g. soften gridlines with a light color

Utilize existing resources for selection of appropriate palettes such as Color brewer or Munsell

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Implementation Considerations

Plot cause on the x-axis and effect on the y-axis. Use this standard convention in order to avoid misinterpretation.

Aspect ratio can influence interpretation. Aim for a 45 degree angle of change to avoid over-interpretation of slope.

Use position for comparisons rather than length (i.e. dots instead of bars), especially for non-linear scales (e.g. log scale or % change).

Do not plot log-normally distributed variables on a linear scale (e.g. hazard ratio, AUC, CL)

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Connected data imply continuity. Do not connect data across a disconnected or uneven time scale.

Visits displayed close together are perceived to be closer in time. Space the visits proportional to the time between each in order to avoid confusion.
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Plot data and inferences to support stories about models.

Legibility and Clarity

Effective graphs stand alone. They use titles, annotations, labels, shapes, colors, and textures to deliver important information.

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Use font size to create hierarchy (e.g. set titles 2pt larger than all other labels to make them more prominent).

Do not type too small or too condensed. Break long titles into two lines. Shift or adjust size of labels that overlap.

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Display text with enough contrast to be visible. Favor the use of dark on light instead of light on dark whenever possible.

Bold or italics should only be used for layering or emphasis. Emphasizing everything means nothing gets emphasized.

Try not to set text at an angle, as this decreases readability. Think of alternative solutions such as transposing the graph.

Putting it all together – Remove the clutter & emphasize the message

Creating a graph is an iterative process: produce, review and refine.

Colors, backgrounds, and borders can be removed and gridlines reduced.

It is easier to see differences in position over a difference in length, i.e. a dot over a bar.

Using too many colors can be distracting. Use white background and try using other methods to distinguish different curves.

One solution could be repeating the data in different panels, highlighting individual curves in a darker color.

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Good graph checklist

Clear Communication

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Facilitating Comparisons

- ❑ Are elements to be compared grouped together?
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Resources

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Cleveland, W.S. and McGill, Robert, Graphical perception: theory, experimentation and application to the development of graphical methods, JASA, Vol. 79, No. 387, pp. 531 – 554, 1984.
S. Few, Show Me The Numbers - Designing Tables and Graphs to Enlighten (2nd. Edition), Burlingame, CA: Analytics Press, 2012.
D. M. Wong, The Wall Street Journal Guide to Information Graphics: The Dos and Don'ts of Presenting Data, Facts, and Figures. December 16, 2013.
J. Doumont, Trees, maps, and theorems: Effective communication for rational minds. PRINCIPIAE.
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Online resources:
https://www.perceptualedge.com/ (S. Few)
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http://flowingdata.com/ (N. Yau)
http://www.principiae.be/ (J. Doumont)
http://andrewgelman.com/ (A. Gelman)
http://www.thefunctionalart.com/ (A. Cairo)
http://www.nbr-graphs.com/ (N. Robbins)

Authors

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Law 1
Have a clear purpose

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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)

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Law 2
Show the data clearly

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Choosing the correct graph type aids interpretation

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Space measurements proportional to the time between each

Measurements displayed close together are perceived to be closer in time

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Law 3
Make the message obvious

Show the answer!

If the question is about a treatment effect, plot that directly

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Group elements to aid direct comparison

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Use informative labels and annotations to support the message

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Putting it all together – is exposure different?

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Principles for EVC

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Authors

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Structured EVC approach

Mark Baillie

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Early Phase 2 data support advancing LNP023 as a front-line treatment for PNH

https://www.novartis.com/sites/www.novartis.com/files/2019-12-05-novartis-r-d-day-investor-presentation.pdf

In a Phase 2 PNH trial, LNP023 add-on to eculizumab in patients with hemolysis delivered consistent LDH normalization and transfusion-free hemoglobin increase in all patients

The ongoing LNP023 monotherapy trial in eculizumab-naive PNH patients shows early efficacy (LDH↓)

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1st principle
Have a clear purpose

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Have a Clear Purpose Worksheet

- Having a clear purpose for a visualization encompasses having clarity around 4 areas:
  - What is the **purpose**?
  - Who is your **audience**?
  - What is the **importance** of this visualization?
  - What is the key **message** of this visualization?
- A worksheet was created to be used as a guide to help defining the clear purpose a graph is supposed to achieve

Have a clear purpose (worksheet)

Identify a project you are working on where you need to communicate in a data-driven way. Reflect upon and fill out the following.

What is the purpose of the visualization?

What is the main objective of the visualization?

List the (scientific) question(s) the visualization is trying to answer. Try to be specific.

What is the key evidence that is available to answer the question?

Who is your audience?

List the primary groups or individuals you will be communicating to.

If you had to narrow that to a single person, who would that be?

What does your audience care about?

What action does your audience need to take?

What is the importance of this project?

What are the benefits if your audience acts in the way that you want them to?

What are the risks if they do not?

What is the key message (the so what?)

Write out in a single sentence the key message

The purpose worksheet is inspired by the big idea worksheet from the excellent book: Knaflic, Cole. Storytelling With Data: Let's Practice! Wiley, © 2019.

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The 4 areas for a clear purpose

What is the purpose of the visualization?

- What is the main objective of the visualization?
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1st principle – have a clear purpose

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The ongoing LNP023 monotherapy trial in eculizumab-naive PNH patients shows early efficacy (LDH↓)

LNP023 included from the public 2019 R&D day deck
https://www.novartis.com/sites/www.novartis.com/files/2019-12-05-novartis-r-d-day-investor-presentation.pdf

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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.*

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Audience

Who is your audience?
List the primary groups or individuals you will be communicating to. *NVS senior management* *Investors* *Scientific community* If you had to narrow that to a single person, who would that be? *Development Unit Head.* What does your audience care about? *Clear demonstrable evidence that LNP023 has activity on markers related to PNH.* What action does your audience need to take? *A decision on whether to provide resources to take LNP023 to late stage development.*

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Importance and message

What is the importance of this project?
What are the benefits if your audience acts in the way that you want them to? *This could improve lives of patients with an unmet need.* *This could lead to a new scientific breakthrough and understanding of the disease.* *This could be an asset to the company.* What are the risks if they do not? *Cancellation of an important compound.* *Patients untreated.*

What is the key message (the so what?)
Write out in a single sentence the key message *LNP023 reduces LDH levels to normal; strong evidence the compound may improve the lives of patients with PNH.*

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2nd principle
Show the data clearly

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Show the data clearly, an iterative process

- The “purpose” worksheet is a guide to stay in line with the key evidence that supports your key message
- Try to display the same sets of data in different ways and select the one you consider the more adapted (often being the simplest)
- It is then time to iterate and eliminate clutter
  - Add what is missing to show your data clearly
  - Remove what is just adding noise

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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

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2nd principle – Iterate and eliminate clutter

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3rd principle
Make the message obvious

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Make your message obvious

- This 3rd principle applies particularly when communicating to others
- Draw the audience attention to the critical element(s)
- Each element of the slide fits in the story it is aiming to tell

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3rd principle – draw attention

- Draw the viewer's attention to points of interest
- Use arrows, labels, reference lines to drive home the message
- Make sure to have clear axis labels and informative titles

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3rd principle – tell a story

Practice telling the story of your graph, and make sure your graph captures the key points

Example story:

- LDH is a biomarker of hemolysis, released during destruction of RBC
- LNP023 reduces LDH to normal levels in PNH patients, indicating protection against hemolysis
- Recommend advancement of LNP023 to Phase 3

- Normal LDH levels indicate protection against hemolysis
- Recommend advancement of LNP to Phase 3

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Your turn! (Homework for Part 2)

Alison Margolskee

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Your turn! (Homework for Part 2)

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- Apply the 3 principles of Effective Visualization to an example on your own
- 3 options to choose from (more details on next slides)
  1. Graph + purpose – rework the graph to show the data & message more clearly
  2. Dataset + purpose – create a graph from the dataset
  3. Bring your own example
- Assignment:
  1. Complete the Purpose Worksheet for the example you choose
  2. Select what data to display, and how to display it, iterate through a few alternatives in quick sketches
  3. Choose a graph or two from the previous step, and refine to make the message obvious
  4. Submit your examples ahead of Part 2 for discussion/feedback via webform or email

Note: For steps 2 and 3, you may choose to use pen and paper, or a drawing, graphing, or coding software. It's up to you!

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Option 1) Efficacy of Capmatinib in NSCLC with MET mutations

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- Background:
  - Phase 2 study of Capmatinib (MET receptor inhibitor) in NSCLC patients with various MET mutations
  - Primary endpoint: overall response (complete or partial response)
  - Secondary endpoint: duration of response
- Key question:
  - Does Capmatinib show meaningful response in patients with various types of MET mutation?

See reference for additional background, purpose and key messages:

Wolf et al. NEJM 2020; 383:944-957
https://www.nejm.org/doi/full/10.1056/NEJMoa2002787

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Option 1) Efficacy of Capmatinib

Purpose worksheet, partially completed

Purpose Worksheet

See reference for additional background, purpose and key messages:

Wolf et al. NEJM 2020; 383:944-957
https://www.nejm.org/doi/full/10.1056/NEJMoa2002787

What is the purpose of the visualization?

What is the main objective of the visualization?
Summarize the efficacy results of the Capmatinib Phase 2 study in NSCLC patients with MET mutations

List the (scientific) question(s) the visualization is trying to answer. Try to be specific.
- Are the response rates clinically meaningful for patients with various types of MET mutation (exon 14 skipping, various degrees of amplification)?

What is the key evidence that is available to answer the question?
- Individual RECIST data, individual duration of response, overall response rates by cohort
- cohorts defined as MET exon 14 skipping mutation (with and without prior treatment), and MET amplification with various levels of gene copy number (GCN) (with and without prior treatment)
- clinically relevant response defined as >= 35% in previously treated patients (with 95% CI > 25%) and >= 55% in patients not previously treated (with 95% CI > 35%)

Who is your audience?

List the primary groups or individuals you will be communicating to.
- Capmatinib project team, NSCLC investigators, scientific community, head of oncology

If you had to narrow that to a single person, who would that be?
Oncology development head

What does your audience care about?
- Whether Capmatinib appears to work in any of the cohorts

What action does your audience need to take?
- Decide whether to keep developing Capmatinib for NSCLC with MET mutations, and for which MET mutations specifically

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Option 1) Efficacy of Capmatinib in NSCLC with MET mutations

- Right: Primary visualization of Phase 2 study results from Wolf et al. NEJM 2020
- Can you improve this graph, or create your own to display the key message(s)?

Wolf et al. NEJM 2020; 383:944-957
https://www.nejm.org/doi/full/10.1056/NEJMoa2002787

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Option 2) Predicting Effect of Missed Doses due to COVID-19 on Efficacy

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- Situation:
  - A Phase 3 time to event trial is being conducted for Drug A
  - Drug A is administered in the clinic by a healthcare provider
- Complication:
  - Due to COVID pandemic, patients' access to clinic has been greatly impacted
- Question:
  - What effect would 1, 2, or 3 missed doses have on the efficacy of the current trial?
  - Should the trial be stopped, or should the trial management team make significant efforts to increase compliance, or is the predicted impact negligible?

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Option 2) Missed Doses due to COVID-19

Purpose worksheet, partially completed

Purpose Worksheet

What is the purpose of the visualization?

What is the main objective of the visualization?

Determine the effect of missed doses due to COVID pandemic on the efficacy of the drug

List the (scientific) question(s) the visualization is trying to answer. Try to be specific.

- Would efficacy (event-free survival, hazard ratio, decrease in PD marker) be greatly affected by 1, 2, or 3 missed doses due to COVID?

- What is the relationship between missed doses and predicted efficacy?

What is the key evidence that is available to answer the question?

Individual data for: Average drug exposure up to event of interest, treatment subgroup (# of missed doses), average decrease in PD marker up to event of interest, time to event of interest, model predicted relative change in hazard

Who is your audience?

List the primary groups or individuals you will be communicating to.

Project team / clinical trial team members

If you had to narrow that to a single person, who would that be?

Global project head

What does your audience care about?

The impact of missed doses on the hazard ratio

What action does your audience need to take?

Decide whether to continue or stop the trial, or make serious effort / do nothing to increase compliance

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Option 2) Predicting Effect of Missed Doses due to COVID-19 on Efficacy

Header of dataset

id	TRT	time	status	label	avgAUC	avgAUEC	HRR
1	Placebo	1.60	1	censored	0	-0.0526862995	-0.0263431498
2	Placebo	0.70	2	event	0	-0.2601473290	-0.1300736645
3	Placebo	2.90	1	censored	0	0.4552197065	0.2276098533
4	Placebo	1.95	2	event	0	0.3814016001	0.1907008000
5	Placebo	1.95	1	censored	0	0.2787141185	0.1393570592

Download dataset

Missed_Doses_Due_to_COVID.csv

Variable definitions

- id = unique subject identifier
- TRT = treatment group ("Continuous Treatment", "1 missing dose", "2 missing doses", "3 missing doses", "Placebo")
- time = time of event (years)
- status = event identifier (1 = right censored / lost to follow up, 2 = event of interest)
- label = description of event
- avgAUC = average drug exposure up to time of event (ng/mL)
- avgAUEC = average change from baseline in PD marker (mmol/L)
- HRR = model predicted relative change in hazard based on avgAUEC (relative to avgAUEC of 0)

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Option 3) Bring your own example

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Your example here!

Purpose worksheet, empty

Purpose Worksheet

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Recap and resources

Marc Vandemeulebroecke

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https://youtu.be/pfxulpF9XOw

3 principles for improving visual communications

- 1st principle: 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

- 2nd principle: 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)

- 3rd principle: 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

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Learning outcomes

- Appreciate why effective visual communication 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 principles of effective visual communication in your daily work.

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Resources, where to find out more?

http://www.storytellingwithdata.com/books

- Effective Visual Communication Tutorial
  https://graphicsprinciples.github.io/
- PKPD Exploratory graphics (xGx)
  https://opensource.nibr.com/xgx
- Paper 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

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Even more resources?

https://www.principiae.be/book/

https://socviz.co/

https://serialmentor.com/dataviz/

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And many more…

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ASCPT American Society for Clinical Pharmacology & Therapeutics

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