How To Report Statistical Analysis Results

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For TIPPS

Outline: Session Objectives

- To highlight Common Errors
- To learn how to report results of descriptive analyses of baseline/demographic variables
- To learn how to report results of comparative analyses based on p-values and confidence intervals
- To learn how use graphics to summarize results

Common Errors

- Incomplete reporting of design issues
  - Type of design
  - Methods of recruitment
  - Sample size calculation and justification
    - Software/formula/reference for SS calculation
- Incomplete/inappropriate reporting of Methods
  - Inappropriate use summary measures. eg. mean (SD or SEM)
  - Methods for model assumptions/goodness-of-fit
  - Methods for handling missing data/outliers
  - Software for analysis
- Incomplete/inappropriate reporting of results
  - Use of p-values vs confidence interval
  - Inappropriate use of statistical terms
    - Proportion, risk, percentage, ratio
  - Decimal places for summary statistics

How to report Methods

- Describe the study design
- Describe how and when allocation sequence was generated
- Describe how the sequence was concealed
- Describe how the patients were enrolled (sampling strategy)
- Describe the technique used for blinding
- Describe how the patients were actually randomized
- Describe sources of missing data including losses to follow-up, withdrawals, etc
- Provide a schematic diagram of the study flow
- Describe methods used for data collection or measurements

How to report Methods of Analysis

- Descriptive analyses of demographics, baseline characteristics or Outcomes
  - Mean (SD) or median (min-max) for continuous variables
  - Use number (percent) for categorical variables
- Group Comparisons: for both primary and secondary outcomes
  - Specify the expected difference between groups apriori and state clearly whether
    - It is the MCID
    - It is the difference that investigators think is worth detecting
    - It is the difference that investigators think is likely to be detected
  - State the criterion for statistical significance (eg alpha=0.05)
  - Report details of sample size calculation
  - Report tests used for each comparison
    - State method for adjust of alpha for multiple comparisons (where applicable)
    - State a reference for uncommon or complex methods
    - State whether test(s) is(are) one-sided or two-sided
  - State methods
    - Assumptions of the tests/models (eg Normality, multicolinearity, etc)
    - Handling outliers/missing data (eg LOCF, mean/multiple imputation)
  - Specify planned sensitivity analyses
  - State software used for all analyses

How to report Descriptive Analyses

- **Report descriptive results of descriptive analyses first**
- Always provide a measure of location (dispersion/spread)
  - Use mean (SD) or median (min-max) for continuous variables
  - Use meaningful measures of centre and dispersion
    - Mean (SD) good for data with symmetric distributions
    - Use SD instead of SEM: SD has the same scale as raw data
    - Remember that Range = Max-Min
    - Do NOT use Mean ± SD
  - Report
    - Mean to at most one decimal place more than the original data
    - SD to at most two decimal places more than the original data
- Use number (percent) for categorical variables
  - N>100, report % to more than one decimal place
  - 20<N≤100, report % in whole numbers
  - N≤20, report actual data
  - Always give both numerator and denominator
- Beware of the use of
  - Ratio (usually expressed as 1:2)
  - Proportion (scale = [0,1])
  - Probability (scale = [0,1])
  - Percentage (scale = [0,100])

How to Report Results of Group Comparisons

- **Report the results of primary comparisons or analyses second**
- Report Summary measures by group (where appropriate)
- Report Effect estimate and corresponding SE (where appropriate)
- Provide 95% CIs for primary comparisons (whether significant or not)
  - 95% CI: xx ± xx
  - 95% CI: (xx, xx)
  - 95% CI: xx to xx
- Do not use SEM to express precision in an interval form
  - Mean ± SEM
  - Don't use errors bars to display judge comparisons between groups
- Report actual p-value and value of test statistic
  - Report p-values to two significant digits
  - P-value<0.001 should be reported as p<0.001
  - Remember to report the degrees of freedom for the t- and chi-squared tests
- Report results of goodness-of-fit and assessment of model assumptions

How to Report Results of Group Comparisons (Cont.)

- Report results of missing-data analysis or any other sensitivity analyses
- Distinguish between results of
  - Secondary analyses (often relates to secondary outcomes)
  - Subgroup analyses (may also be stated as secondary)
  - Sensitivity analyses
- Sensitivity analyses
  - Methods of handling missing data
  - Different methods of analysis (different assumptions)
  - Outliers (analysis with and without outliers)
  - Different definitions of outcomes (ie different cut-off points for binary outcomes)
  - Any twists based on variations in assumptions

Interpretation of results: Cautions

- Emphasize CIs more than p-values, especially for results that are not statistically significant
  - Remember the difference between statistical significance and clinical significance (importance)
  - It's often better to use "clinical importance" than "clinical significance"
- Avoid the use of
  - Results "approach significance"
  - Results "trend toward significance"
- Remember that underpowered studies (with no statistically significant results) are inconclusive, not negative

Using Graphics to Display Data

- “Excellence in statistical graphics consists of ideas communicated with clarity, precision, and efficiency” (Tufte: The Visual Display of Quantitative Information. Graphcs Press, 1983)
- Basic Principles (From Tufte, 1983): Graphical Displays should
  - Serve a clear purpose: description, exploration, tabulation, decoration
  - Reveal different levels of detail in data
  - Show/reveal the data
  - Present many numbers in small space
  - Avoid distorting the data
  - Provoke the viewer to think about key messages
  - Encourage the eye to compare different pieces of data
  - Show coherence of large datasets
  - Be closely integrated with the statistical and verbal descriptions of data

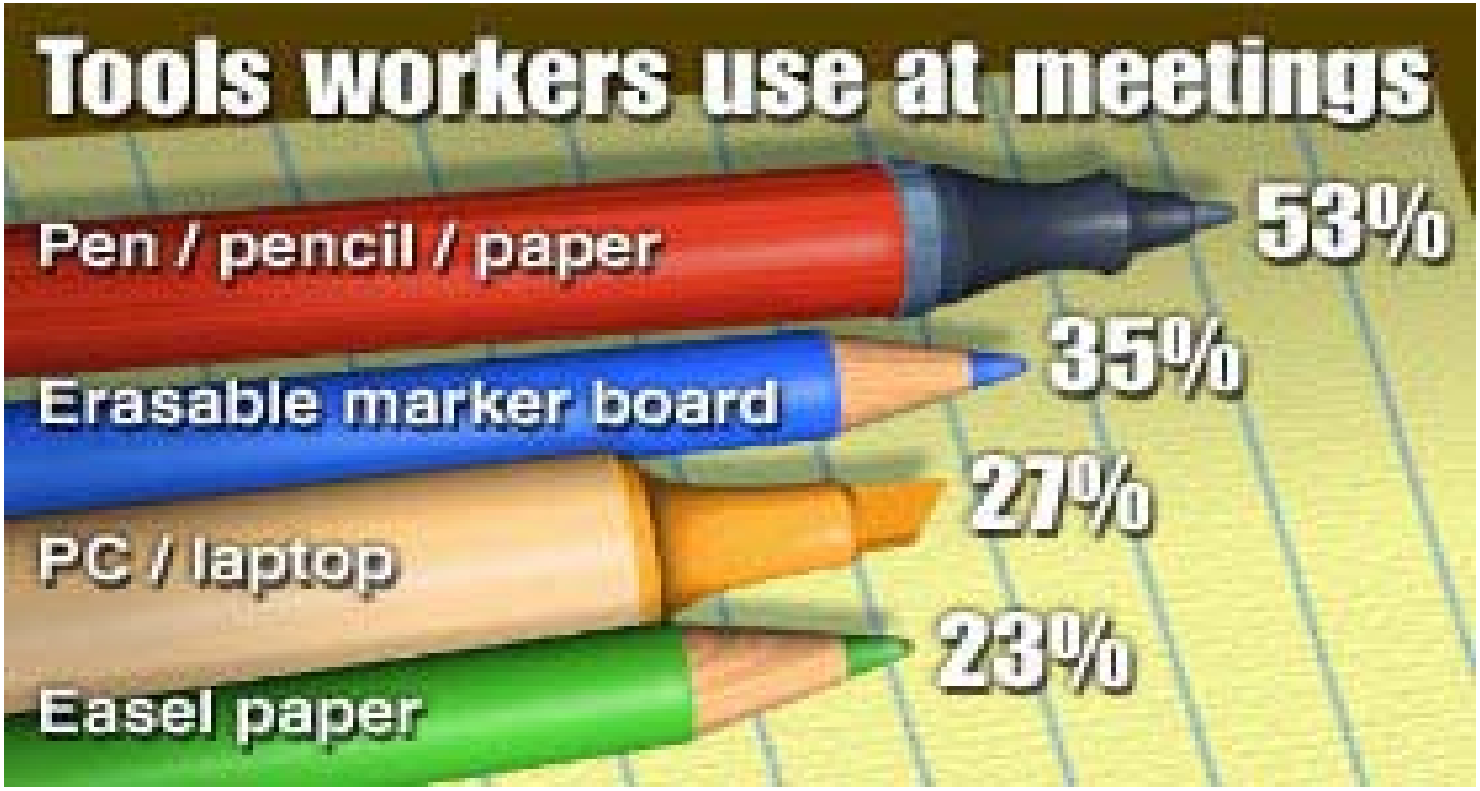
Common Graphical Errors

- Missing labels (units) or titles
- Wrong use of scale
  - Comparative graphs must be plotted on the same axes to facilitate comparisons
- Misplaced zero point
  - Most people assume that the zero point is at the bottom of the graph
  - This can give a very misleading impression of the amount of change present in a data series
- Wrong choice of chart type:
  - Pie chart vs bar chart
  - Bar charts vs line chart
  - Bar chart vs table
- Grid lines too dark, missing or not relevant to the graph
- Shading, 3-D effects
  - They distort the data
  - They add little new information
- Area vs length
  - If you make a picture twice as large, it looks as if it has four times the area!
- Dollar amounts must be adjusted for inflation
  - To avoid misleading comparisons

Bad Graphics: Example 1

http://www.usatoday.com/snapshot/news/nsnap194.htm

Message: The majority of the workforce does not use laptops and PCs in meetings.



Example 2: Comparative Graphs

Source: http://www.rdg.ac.uk/ssc/publications/guides/toptgs.html

- It is easier to make comparisons between adjacent bars than between distant bars

Fig. 1a

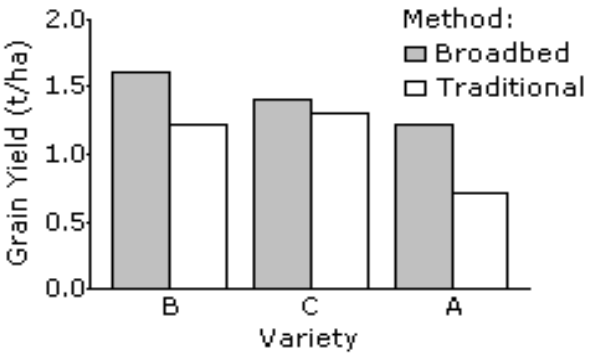


Fig. 1b

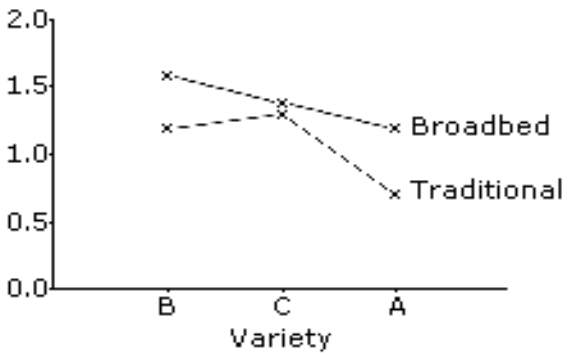


Fig. 1c

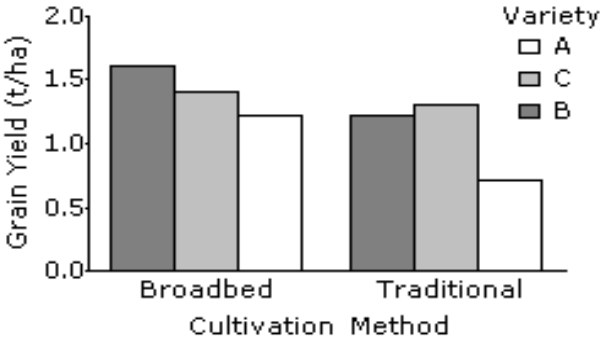
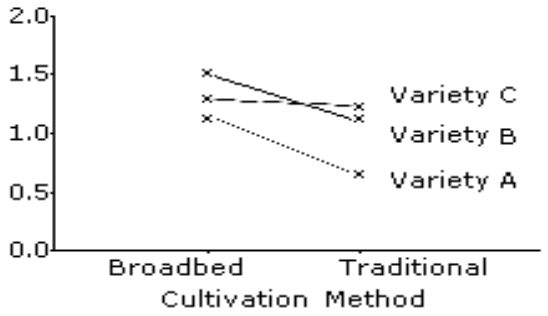


Fig. 1d



Example 2: Ineffective use of bar charts

source: http://www.rdg.ac.uk/ssc/publications/guides/toptgs.html

- Bar charts are not the most appropriate way to display data

Fig. 2a

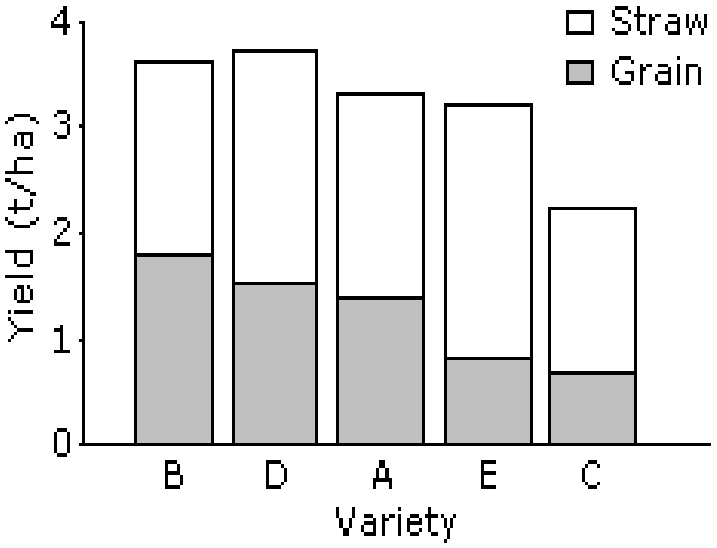
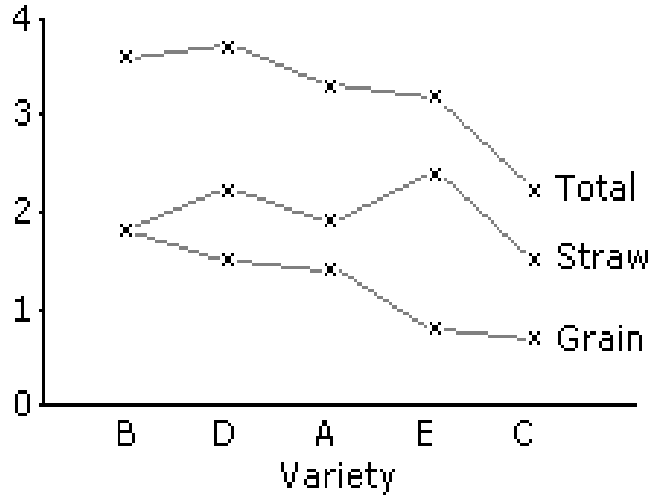


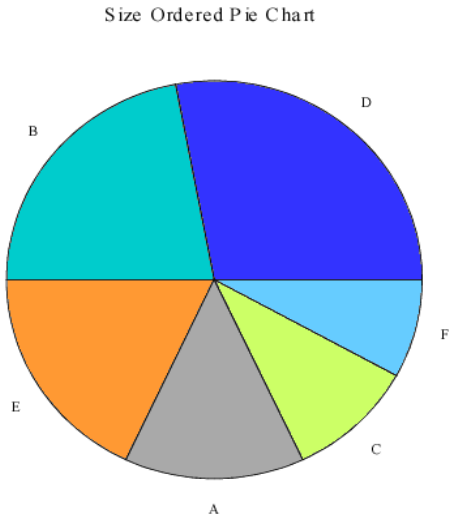
Fig. 2b

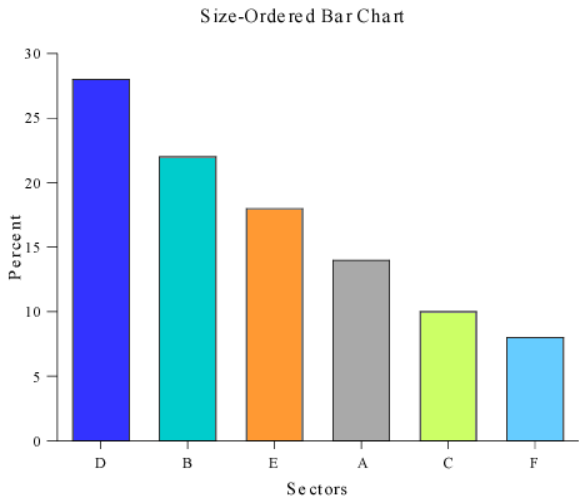


Example 4: Pie charts vs Bar Charts

Source:http://www.eia.doe.gov/neic/graphs/bars.htm

- Pie charts have limited utility
- They are good for simple messages
- Bar or dot charts are effective for displaying complex messages more clearly than pie charts

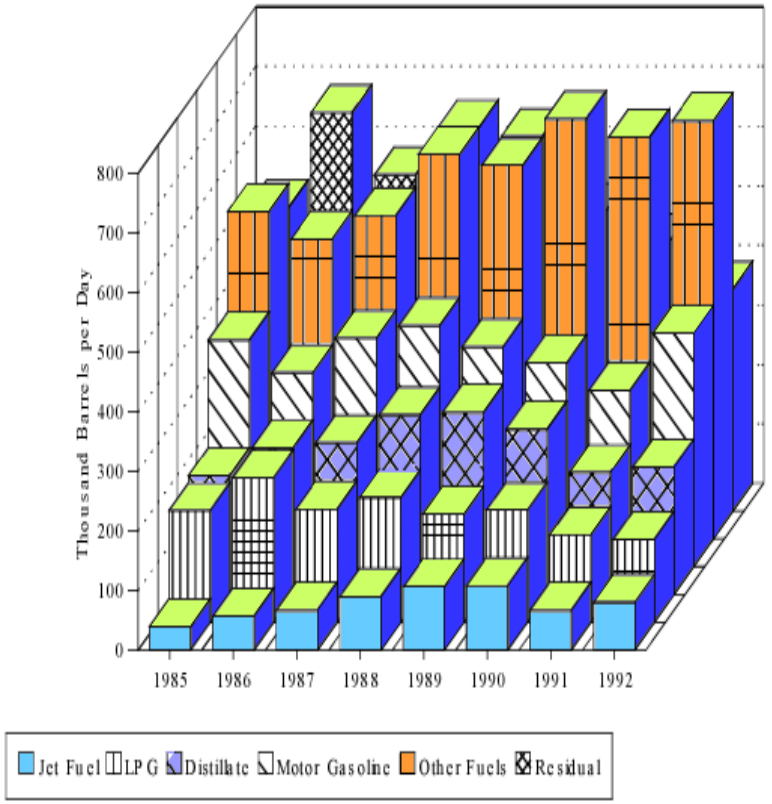




Example: 3-D graphics

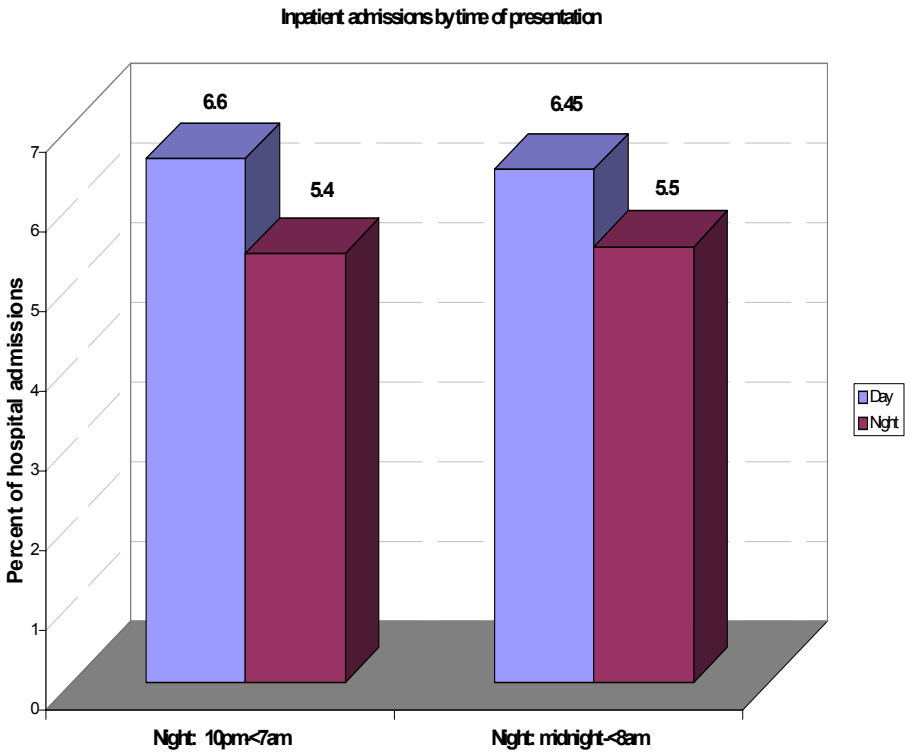
Source:http://www.eia.doe.gov/neic/graphs/bars.htm

- 3-D graphics are good for displaying relationship among three continuous variables
- Introducing a third dimension in displaying relationships among two variables causes distortion and ambiguity



Another Example: 3-D Graphics

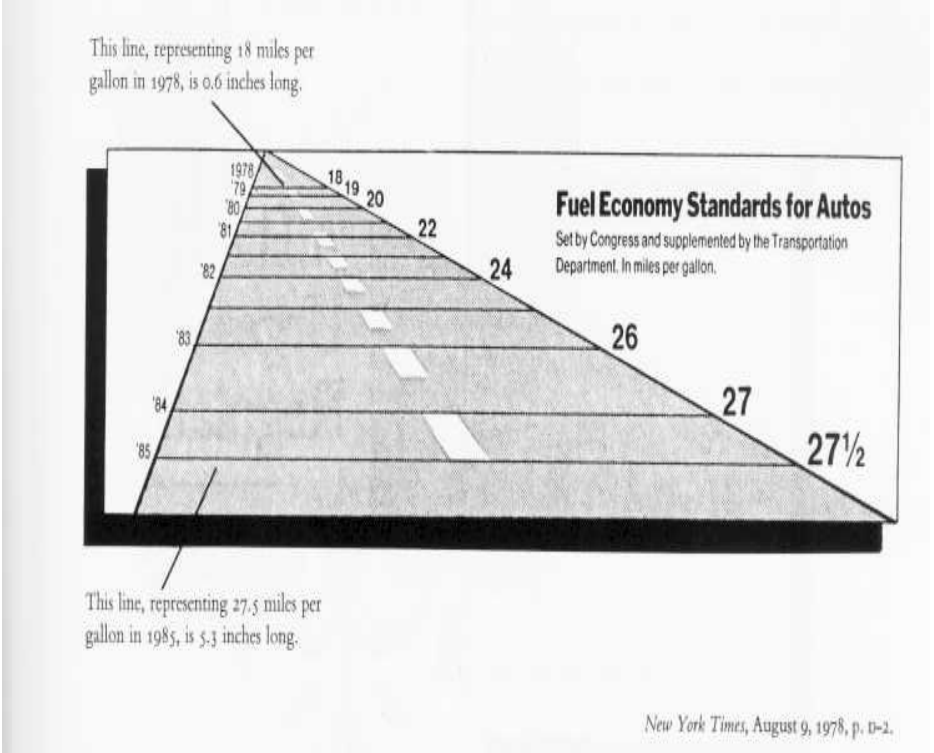
- Sometimes it's better to use numbers instead of graphics to reveal data
- Again, third dimension distorts data



The Lie factor

Source: **The Lie Factor.** (from Tufte, 1983, p.57); gif image by Clay Helberg, *Pitfalls of Data Analysis*

- **Basic Principle:** "The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the quantities represented."
- Lie Factor, defined as the ratio of the size of an effect shown in the graphic to the size of the effect in the data.
- This graph, from the NY Times, purports to show the mandated fuel economy standards set by the US Department of Transportation. The standard required an increase in mileage from 18 to 27.5, an increase of 53%. The magnitude of increase shown in the graph is 783%, for a whopping lie factor = (783/53) = 14.8!



Some Basic Hints

- Provide a title and label the axes
- Independent variables should be plotted on x-axis, and dependent variable on y-axis
- Choose carefully
  - Don’t use bar charts for plotting continuous variables, use line or dot plots
  - Don’t use SE for error plots, use CI
  - Don’t use overlapping CIs to assess statistical significance
  - Use bar charts in place of pie charts
- Graphs usually have axes intersecting at zero

Resources

- Textbooks on reporting statistical results
  - Lang TA, Secic M. How to report Statistics in Medicine. American College of Physician Medical Writing and Communication. Philadelphia, PA: 2003.
- Articles
  - Moher D, Schutz KF, Atman DG. The CONSORT Statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. Lancet 2001;357:1191-4.
  - Campbell MK, Elbourne DR, Altman DG. CONSORT Statement: Extension to Cluster Randomized Trials. BMJ 2004;328:702-8.
  - Bossuyt PM et al. Towards Complete Reporting of Studies of Diagnostic Accuracy: The STARD Statement. Ann Int Med 2003;138:40-5.
  - Des Jarlais DC, Lyles C, Crepaz N. Improving the Reporting of Nonrandomized Evaluations of Behavioral and Public Health Interventions: The TREND Statement. Amer J Pub Health 2004;94(3):361-6.
  - Stroup DF et al. Meta-analysis of observational studies: A proposal for reporting: The MOOSE Statement. JAMA 2000; 283: 2008-12
  - Moher D, Cook DJ et al. Improving the Quality of Reports of Meta-analysis of randomized controlled trials: The QUOROM Statement. Lancet 1999; 354:1998-1900.
  - Speigelhalter DJ, Myles JP, Jones DR, Abrams KR. Bayesian Methods in Health Technology: A Review. Health Techology Assessment 2000; 4(38): 133 pages (Chapter 8).
  - Hughes MD. Reporting Bayesian analyses of clinical trials. Statistics in Medicine 1993; 12: 1651-63.
  - Hughes MD. Practical reporting of Bayesian analyses of clinical trials. Drug Information Journal 1991; 25: 381-93.

Resources

- Textbooks on Graphics
  - **Wallgren, A., Wallgren, B., Persson, R., Jorner, U., & Haaland, J-A. (1996). *Graphing statistics & data: Creating better charts.* Newbury Park, CA: Sage.**
  - **Cleveland, W. S. (1994). *The elements of graphing data* (rev. ed.). Summit, NJ: Hobart Press**
  - **Schmid, C. F. (1983). *Statistical graphics.* Wiley-Interscience. Now in a reprint edition from Krieger Publishing Company, 1992**
  - **Harris, R. L. (1999). *Information graphics: A comprehensive illustrated reference*. Oxford University Press**
  - **Tufte, E. R. (2001). *The visual display of quantitative information* (rev. ed.). Cheshire: CN: Graphics Press**
  - **Tufte, E. R. (1990). *Envisioning Information*. Cheshire, CN: Graphics Press**
  - **Tufte, E. R. (1997). *Visual explanations: Images and quantities, evidence and narrative.* Cheshire, CN: Graphics Press**
  - **Wainer, H. (1997). *Visual revelations: Graphical tales of fate and deception from Napoleon Bonaparte to Ross Perot.* Copernicus (Springer-Verlag New York).**
  - **Henry, G. T. (ed.). (1997). *Creating effective graphs: Solutions for a variety of evaluation data*. *New Directions for Program Evaluation,* No. 73. Jossey-Bass**

More Resources

- Websites
  - Informative Presentation of Tables, Graphs and Statistics: http://www.rdg.ac.uk/ssc/publications/guides/toptgs.html
  - The guides for statistical graphics: http://www.eia.doe.gov/neic/graphs/preface.htm
  - For some interesting good and bad examples: http://www.math.yorku.ca/SCS/Gallery/
  - Bureau of Transportation Statistics Guide to Good Statistical Practice: http://www.bts.gov/products/guide_to_good_statistical_practice_in_the_transportation_field/index.html
  - For information on free statistics tools on the web: http://gsociology.icaap.org/methods/statontheweb.html
  - Review of some statistics websites by myself and colleagues: http://www.lehanathabane.com/personal/websitereviews.htm