There is quite a difference between simply looking at a chart and seeing it. —Mary Eleanor Spear

**INTRODUCTION**

“Don’t fear, the Internet is here” used to be the go-to lines for the researchers at the beginning of the current century. The Internet was hailed as “the solution” instead of “a solution” to most of the problems. Thus, the Internet and related applications developed at breakneck speed in the last two decades. The current COVID-19 pandemic has further intensified the innovation and integration of digital infrastructure. True to its potential and forecast, the Internet has penetrated almost every domain of life. The meteoric rise of the Internet gave immense power to individuals. Many new people are joining and utilizing the Internet regularly to communicate. As anyone and everyone can write and communicate, it is becoming increasingly difficult to find reliable and accurate information on the Internet. Paradoxically, the Internet that was declared as “the miracle” is gradually turning into “the misery” itself. There is an avalanche of information on the Internet but rarely does one come across credible information. Therefore, it is the collective responsibility of all to communicate effectively and efficiently.

The communication is a two-way process between the source and recipient. The hallmark of efficient communication is clear and concise delivery of the intended message to the receiver with ease. Therefore, it is important to know and focus on the requirements of the targeted audience. In the current age of infodemic, there is a continuous struggle between various modes of the digital ecosystem to get attention. The graphical display plays an important role in communication as they exploit human perception and cognition. The graphs reduce information processing time and cognitive load by lowering dependence on working and long-term memory.1 Anyone can create colorful charts with the help of computers but very few know the essentials of making effective graphs. An effective graph displays the data, trends, and interrelationship with ease, efficiency, and minimum use of color and symbols.

In a data-driven world, the ability to create effective charts is akin to good writing.2 Good graphs supplement good writing and vice versa. The graphs can display large and complex information with ease as compared to tables. Therefore, there is an increasing thrust by research and nonresearch community to communicate graphically. In response to this, various commercial (such as Tableau, Power BI, and QlikView) and noncommercial (such as inzight, Google Charts, and datawrapper) graphical tools were either developed or updated in the last two decades. The graphical display is associated with the visual system that is responsible for acting. However, the default graphical output is inefficient to communicate effectively. Therefore, graphs need refinement for final production.

The science of visual display was scattered, rudimentary before William Playfair.3 The Playfair developed various statistical charts such as pie chart, bar chart, and line chart. Till today, pie chart, bar chart, and line chart remained the mainstay of visual display. However, many researchers still struggle to achieve graphical excellence. Therefore, this article is an attempt to attain graphical excellence for effective communication. In continuation with previous articles in “Biostatistics Series,” the graphs were generated using Microsoft Excel due to its flexibility and popularity. Since, pie chart, bar chart, and line chart are the most frequently used charts. Therefore, these charts were used to plot and convey the idea of graphical excellence to readers in the current article.
**General Graphical Rules**

Charts are remarkably effective for communication as the same are easy and quick for displaying data, trends, and comparisons. Typically, most academic institutions and publication houses have standard guidelines for publication of graphs. The guidelines discussed here are not exclusive and exhaustive. Researchers may consult excellent textbooks written by Tufte, Few, and Wong for more details.²⁻⁴ The default graphical options may vary as per variation in operating systems (such as Windows vs. macOS), different softwares (such as Tableau vs inzight), and even alternative versions of the same software (such as Microsoft Excel vs Google Charts). By default, Excel produces a graphical chart with Calibri black font and font size of 9 to display axes labeling. The two new menus named as “chart design” and “format” pops-up in the ribbon along with the graph. The same can be used to customize the graph. The general guidelines while making final graphs are summarized below for readers’ perusal.

- Select an appropriate chart for the data, e.g., a line for a trend.
- Select the appropriate axis baseline and increments. The axis title should contain the units of measurement such as ₹, $ & %.
- Select an appropriate title, description, and legends.
- Select colors and symbols strategically to depict the content.

Since one size does not fit all, every chart also has specific requirements.

- Use **bold** and *italics* to highlight important points but do not use both (**bold & italics**) at the same time.
- Avoid ALL CAPS as it is difficult to read.
- Do not use stylized (**Stylized font**) fonts.
- Avoid writing at an angle.
- Refrain from hammering white out of black or colors.
- 3D charts are complex, difficult to read and challenging to present on 2D paper. Therefore, avoid 3D charts at all cost.
- A footnote may be provided to give methodological information and data source.

**Pie Chart**

A pie chart is a circular diagram in which data of each category are presented by different segments also known as pie. It is intuitive to read in the clockwise direction starting from 12'O clock in a circular display. Therefore, it is critical to place the segments of the pie in a proper order. The segment with the highest value comes at the right of 12'O clock. The segment with second-highest value come at the left of 12'O clock. Subsequently, follow an anti-clockwise decreasing pattern to arrange remaining data. There is an exception to the preceding rule for data of equivalent size. Each segment in the pie reflects the percentage of the area displayed by a category from the total area. Pie charts are broadly popular to a varying degrees among scientific and nonscientific audience despite advice against using them.³⁻⁵ Experts recommend only three to five categories in the pie chart; else the same become cluttered and confusing. Excel gives several options such as colors, font, axis, and gridlines to customize graphs. However, still many retain default colors and font in the pie chart. The colors should be used strategically to highlight a different aspect of data rather than esthetic appeal. The quick layout option is frequently used by researchers to produce the final graph and the same is displayed in Figure 1A. Depending on the objective of data to highlight maximum or minimum, color can be used strategically. The final graphical display with alternative font and strategic usage of color is given in Figure 1B for readers’ perusal.

**Bar Graph**

A bar graph is also known as a column graph. It is a two-dimensional display that is used to present discrete categories. The bar graph is recommended for three or more groups. The data in the bars are represented with the length of the bar as against area in the pie chart. The human eye is efficient in reading and understanding length than angles or area. Therefore, many experts recommend using a bar chart instead of a pie chart.⁴⁻⁵ Another, important advantage of the bar graph is the comparison of multiple categories (such as percentages of male vs. female in different consultation groups) in the bar chart as compared to a pie chart. Bar chart always starts at zero for an accurate comparison of data. To highlight the difference, some researchers and softwares truncate the data and start value other than zero baselines. Jagged bar chart without a zero baseline is a recipe for disaster. Bars are naturally selected based on increasing or decreasing order of data rather than alphabetic sequence to make sense. Normally, it is ideal to plot a column chart for five to seven categories. The x-axis becomes cramped when the frequency of categories increased. To adjust the axis,
Excel rotates the labels on the x-axis for readability. However, the rotated text needs extra efforts to read, which increases the cognitive load and physical discomfort. It is better to adopt a horizontal bar chart or use standard abbreviations to label the X-axis. The default bar chart is displayed in Figure 2A. It just displays the data without focusing on the intended message. In contrast, Figure 2B is delivering the message with ease to the audience with strategic usage of color. Eyes are naturally focusing on the top four bars to get the intended message.

**LINE CHART**

A line chart is used to depict the data collected over a period. The purpose of a line graph is to display a trend rather than the total value. Therefore, the line chart in contrast to bar chart can have a nonzero baseline. The time in line chart is plotted on the x-axis and value for categories/s are presented on the y-axis. The values on the y-axis of a series are connected to show the trend. Many a time, the line chart does not display expected trends. It is difficult to depict any trend using a zero baseline. The researcher or software by default truncates the y-axis. It is not wrong to do it, but care must be taken while doing so. A simple principle of presenting the data with two-third of the y-axis can be used in truncated or nonzero baseline. Remaining one-third of the axis is used for nondata or left blank to avoid depiction of drastic trends. Figure 2B applied the rule of two-third to obtain effective line chart. Another important aspect of a line chart is y-axis increment. The increment of 1, 2, 5, and multiple of 5 is easily understood. Therefore, researchers need to utilize the natural tendency of readers to interpret and act. Similarly, the same color legends are placed strategically for ease of interpreting the graph. The x-axis labeling is modified to avoid rotation of labels (Fig. 3).

**CONCLUSION**

Graphs are routinely used to communicate data. However, most of the researchers take an informal approach of “learning by doing” rather than formal training. A major reason for poor graphs can be attributed to limited training in making graphs during undergraduate and postgraduate courses. With routine usage
and advances in technology, anyone can make graphs. However, effective visualization requires strategic use of color, appropriate axis, font, and title. Therefore, the researcher can utilize general and specific principles discussed in this article for effective and efficient communication.

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