Statistics: Tables, Graphs and Figures Explained

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1. Introduction

A basic knowledge of what data is being provided and how to interpret the visual information provided through tables, graphs and figures is a key element to understanding medical literature and conducting your own research. Herein we will discuss the key and common tables, graphs and figures seen in the Urologic literature.

2. Tables

2.1 Table 1

Biomedical research papers often include a “Table 1” which summarizes the characteristics of the subjects in the study. In studies comparing two or more treatments or groups, the table may divide subjects into separate columns by group. Rows of this table typically include important characteristics of the subjects. These can include a variety of clinical, demographic, socioeconomic, or pathologic information, as needed based on the nature of the study. Table 1 is important for the reader to understand the type of patients in a study and can be essential for understanding the external validity of the study. Similarly, if two groups are being compared, table 1 can demonstrate the ways in which the two groups were similar or different – an important element to assess the internal validity of the study.

Example figure:

Table 1. *Clinical features of patients discharged with extended-duration VTE prophylaxis during the baseline period and implementation period (per-protocol)*

	Baseline Period—Enoxaparin	Implementation Period—Apixaban	p Value
No. pts	161	154	
Median yrs age (IQR)	66 (58, 71)	66 (59, 73)	0.35
No. male (%)	127 (79)	130 (84.4)	0.21
Median kg/m^2 BMI (IQR)	29.4 (26.2, 33.8)	29.9 (26.8, 35)	0.22
Median postop mg/dl serum creatinine (IQR)	1.08 (0.87, 1.33)	1.02 (0.88, 1.24)	0.64
No. ASA® class (%):			0.02
2	21 (13.0)	8 (5.2)	
3	130 (81)	141 (91.6)	
4	10 (6.2)	5 (3.3)	
No. procedure (%):			
Pelvic/inguinal (any):	86 (53.4)	92 (59.7)	0.26
Radical cystectomy	49 (30.4)	62 (40.3)	0.07
Radical prostatectomy	27 (16.7)	20 (13)	0.36
Other pelvic	6 (3.7)	9 (5.8)	0.38
Penile/inguinal	4 (2.5)	1 (0.65)	0.19
Retroperitoneal:	75 (46.3)	62 (40.3)	0.28
Partial nephrectomy	24 (14.9)	23 (15)	0.98
Radical nephrectomy	42 (26.1)	28 (18.2)	0.09
RPLND	9 (5.6)	10 (6.5)	0.74
Open surgical procedure	77 (47.8)	74 (48.1)	0.96
Lymph node dissection (any)	112 (69.6)	106 (68.8)	0.88
Median days length of stay (IQR)	3 (2, 5)	3 (1, 5)	0.75
Median mins operative time (IQR)	263 (180, 370)	276 (198, 386)	0.40
Median ml operative blood loss (IQR)	200 (100, 400)	200 (50, 350)	0.49

ASA, American Society of Anesthesiologists®. *BMI*, body mass index. *RPLND*, retroperitoneal lymph node dissection.

Example figure from: Westerman et al., 2022[1]

Further reading: Hayes-Larson, Kezios, Mooney, & Lovasi, 2019[2]

2.2 Other tables

Tables are a way to concisely and clearly depict numerical information for the reader to reference. These allow readers to read the narrative of a manuscript without an excess of numbers. Tables can be effective ways to display group characteristics, trends, and patterns. In comparison studies, tables can allow for comparisons between groups (usually depicted on separate columns). Important elements of a table include:

- Clear title
- The first row typically includes headers with variable names or group descriptions
- The first column usually describes the data depicted in each row, with its units
- Footnotes can be included for clarification about specific elements of the table and can be used to expand abbreviations used within the table
- The data itself should be rounded to a reasonable (and easily readable) number of significant digits.

Further reading: Liu, 2018[3]

3. Graphs and Figures

3.1 Histogram

Histograms are used to visualize data, usually during the early stages of data analysis. Histograms are simple figures often plotting the distribution of a single quantitative variable in the data. This **allows the researcher to identify outliers in the data and view the distribution of the data to identify skew or uni-/bi-modality**. Additionally, plotting two or more groups in a histogram can allow for the comparison of groups or subgroups within a data set. **Histograms are invaluable early**

analysis tools for research. First, researchers may use histograms to **identify outliers which might represent errors in data collection** or cleaning. True outliers may also provide important signals regarding the data generating process. Second, **viewing the distribution of the data is important prior to selecting statistical tests**. For example, data with a positive skew (e.g. length of hospital stay) are not normally distributed and have a lower limit (i.e. 0 days). Thus, after seeing the distribution of the data, researchers may choose to summarize the data using median and interquartile range, rather than mean and standard deviation. Additionally, the histogram may reveal the need for nonparametric statistical tests instead of parametric tests.

Interpreting the figure: The y-axis of a histogram is typically a count. The variable of interest is usually grouped into "bins" along the x-axis. The size and number of bins to include along the x-axis is an important consideration when plotting a histogram and impacts the "resolution" of the data being visualized.

Example figure:

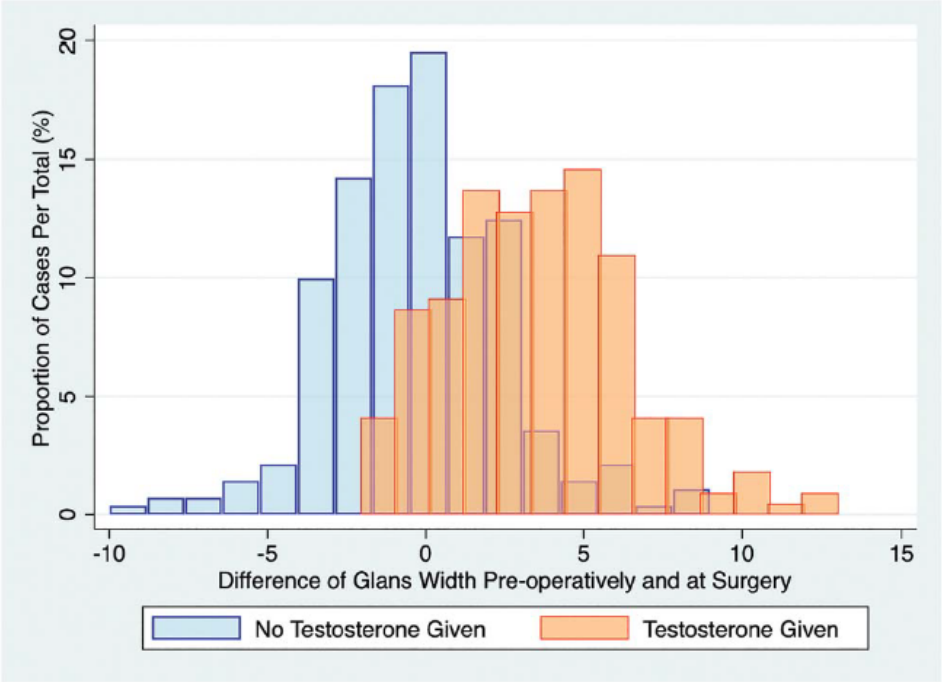


Figure 2. Changes in GW from preoperative visit to surgery based on status of preoperative T administration.

Example figure from: Mittal et al., 2022[4]

Further reading: Nuzzo, 2019[5]

3.2 Box plot

Box plots are another method to visualize the distribution of data and, like histograms, can be used to compare groups. While histograms typically require larger sample size, box plots can be used with even smaller samples. Box plots can also have additional features (e.g. 'whiskers') which can provide

even more information.

The **basic box of the box plot identifies the the 25th, 50th (median), and 75th percentile of a distribution**. The boundaries of the box are typically the 25th and 75th percentiles and thus the **size of the box represents the interquartile range**. A line in the box typically identifies the median value of the data. Whiskers attached to the box can extend to maximum and minimum outliers or outliers to a specific limit. Optionally, outliers even more extreme than the whiskers can be identified by individual points.

Example figure:

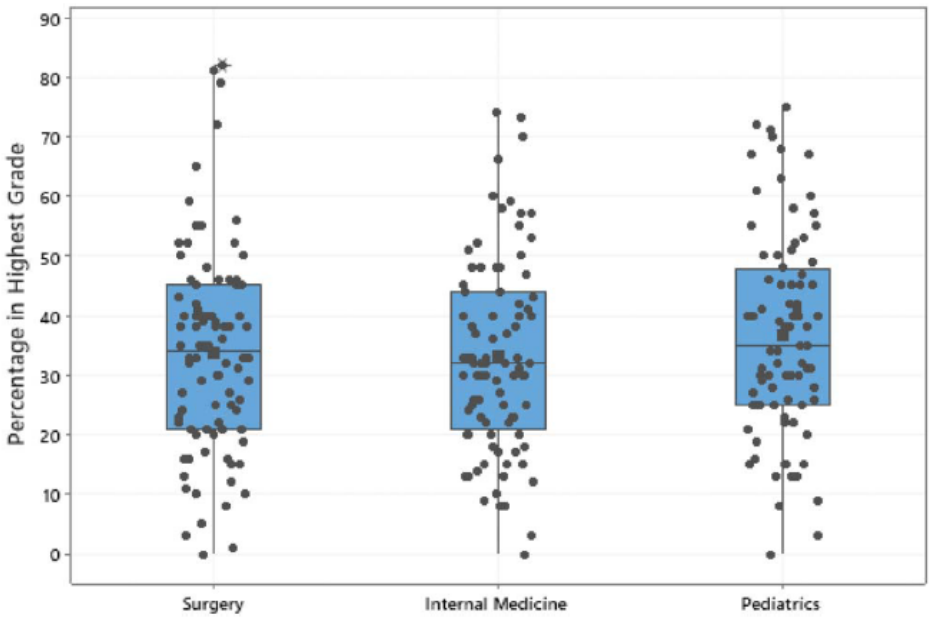


Figure. Plot of the percentage of highest grade by clerkship for the entire 2022 graduating class. Dots are medical schools (n = 90). Box is the interquartile range (IQR), 25th to 75th percentile. Asterisks are outliers defined by being >1.5 × IQRs from the box. Whiskers are the nonoutlier range.

Example figure from: Visingardi, Inouye, Feustel, & Kogan, 2022[6]

Further reading: Krzywinski & Altman, 2014[7]

3.3 Bar chart and line graph

Bar charts and line graphs are among the most common figures used in the biomedical literature. Key elements of these figures include:

- **Figure number and title**. These should be sequentially numbered and have a short, descriptive title or caption.
- **Vertical (Y) and horizontal (X) axes with labels and scales**. Each axis should have a label identifying the variable being plotted. Tick marks along the axes should identify logical intervals

of these variables.

- **Conventionally, the y-axis represents the outcome or dependent variable**. This is usually a continuous variable and the y-axis should start at zero. If a non-zero starting value for the Y-axis is selected, this should be clearly marked and its implications considered – it can make small differences appear much larger.
- **The horizontal axis typically represents different levels of an independent variable**, which can be continuous or categorical.
- **Data is presented as points on a line(s) or bar(s)**. Points on different lines often use different symbols for ease of distinguishing these, especially in black and white publications.
- **Example figure:**

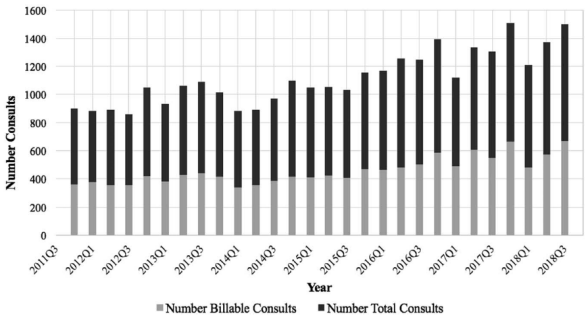
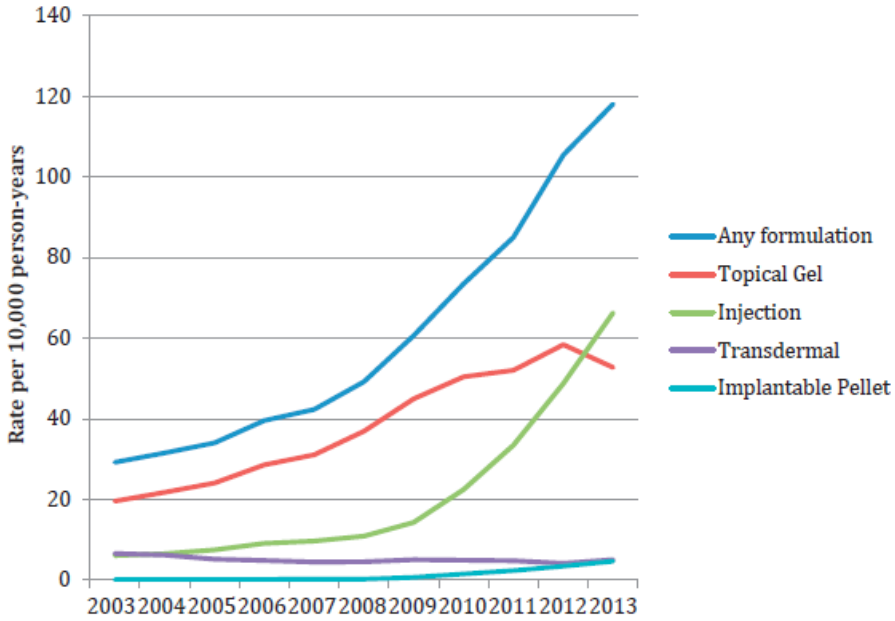


Figure 1. Numbers of consults and billable consults per 3-month quarters (*Qs*) from July 2011 to December 2018. Total number of consults is indicated with dark and light gray bars. Number of billable consults is indicated with light gray bar. Q1—January to March; Q2—April to June; Q3—July to September; Q4—October to December.

Example figure from: Marchetti et al., 2020[8]

Example figure:



Overall and formulation specific rates of TRT use in American men 18 to 45 years old in 2003 to 2013.

Example figure from: Rao et al., 2017[9]

Further reading: King, 2018[10]

3.4 Waterfall plot

Waterfall plots have become common in oncology and can be used to represent, at the individual patient level, responses to therapy or survival outcomes. These **figures are a specialized bar graph, with individual patients each represented by a single bar**. The y-axis represents a continuous outcome variable (e.g. change in tumor size) and extends above and below the x-axis. In addition to providing a depiction of one outcome per individual, color coding the individual patient bars can provide information about groupings within the data (e.g. randomization to treatment vs control, presence of a certain predictor, or degree of response)

Recent research suggests that while the use of waterfall plots in cancer research is increasing, there are **significant limitations to this plot** that should be understood by authors and readers of the medical literature. First, there is the possibility of **measurement error and inter-observer variability** in determining changes in tumor size, which is a common data point to represent using waterfall plots. Second, the **data inputs for waterfall plot do not always match up well with what is reported in oncology clinical trials**. For example, a common variable plotting on the y-axis of a waterfall plot is “Maximum change” in tumor size from a single scan. However, most trials use criteria which require confirmation of objective response in tumor size. Finally, clinical trial results often select intention-to-treat analysis for the primary end point to minimize bias. However, to depict results

on the figure, subjects would have to have an evaluable scan – thus excluding those who dropped out, died, or otherwise were unavailable for a post-baseline scan. For these reasons, **waterfall plots may overestimate the response rate to treatment** and should be interpreted cautiously.

Example figure:

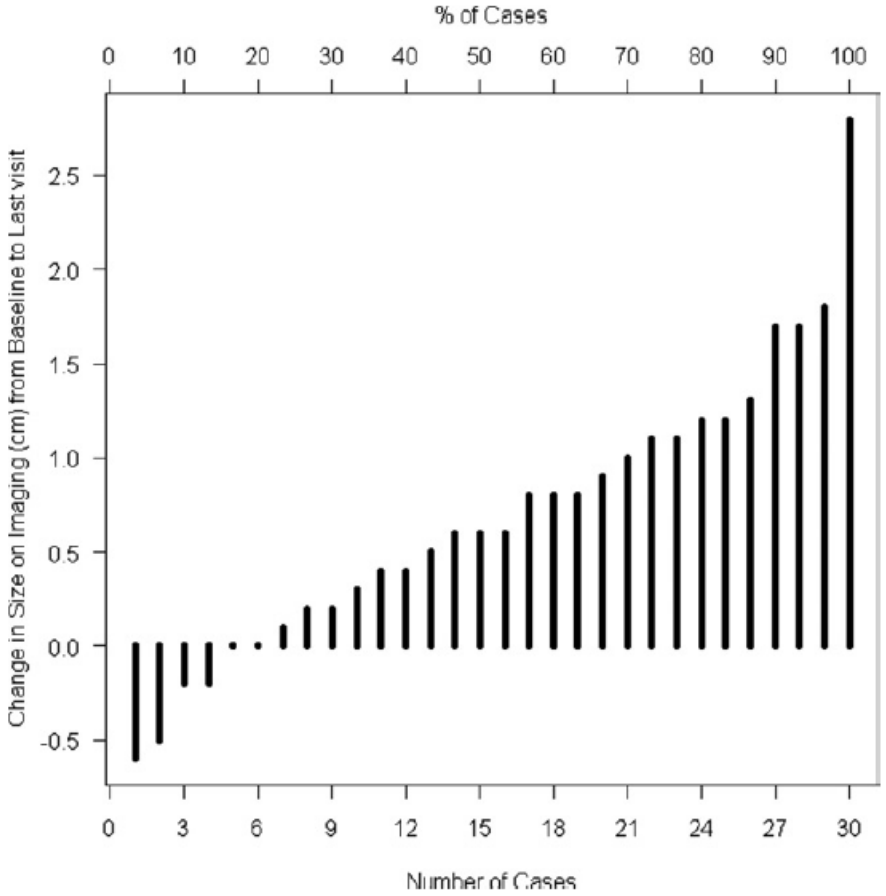


Figure 1. Waterfall plot shows overall change in size from baseline visit to last visit for all 30 lesions.

Example figure from: Kawaguchi et al., 2011[11]

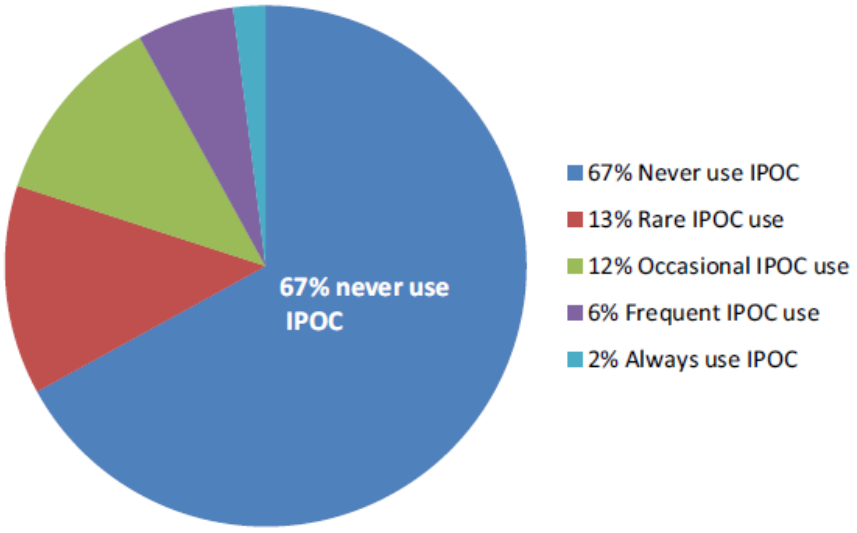
Further reading: Shao et al., 2014[12]

3.5 Pie Chart

Pie charts are commonly used in popular culture to **represent categories as segments of a whole**. Typically a circle or a short cylinder, the “pie” is divided into “slices” each representing a category or group. The size of the slice represents the size of the group relative to the whole and may be accompanied by a percentage. While pie charts are common in popular culture, they are **rarely used in biomedical research because of several issues that make their interpretation challenging**. First, it typically works best with a small number of slices. Using many can make the figure appear muddled and it can be difficult to label. Second, comparing groups in a pie chart is

often less intuitive than, for example, a bar chart portraying the same information. Finally, the pie chart should include all possible outcomes in order to reliably depict the proportions of each. **In general, data that could be presented in a pie chart may be better suited to a table, text, or a bar graph.**

Example figure:



Overall immediate postoperative instillation use. Pie chart indicates percentage of patients who received immediate postoperative instillation of chemotherapy for NMIBC by physician practice pattern. For example, 67% of urologists never used IPOC and 2% of urologists always used IPOC (245, with 14 urologists supplying fewer than 4 cases and, therefore, excluded from analysis).

Example figure from: Cookson et al., 2012[13]

Further reading: Annesley, 2010[14]

3.6 Scatter plots and correlation coefficients

A scatter plot is a **display of the relationship between two sets of data**. Scatter plots are composed of X- and Y- axes, each **usually representing a continuous variable**. Dots on the plot each represent a single observation or data point. By plotting several data points, one can use scatter plots to describe the relationship between the two data points (i.e. the correlation). **A positive correlation is one in which X- and Y- increase together whereas a negative correlation is one in which X increases as Y decreases and vice-versa** .

The Pearson correlation coefficient ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation), with 0 representing no linear association between the two variables. This correlation assumes that the two variables are normally distributed, that each point is independent of

the others, and that any relationship between the two variables is linear. Additionally, the correlation of two variables can be unduly influenced by outliers and this should be considered when deciding to use Pearson correlation. **For data with significant outliers or with a nonlinear relationship, Spearman correlation can be used instead**.

The **correlation coefficient, ranging from -1 to 1, provides information as to the strength of the relationship between two variables. This is represented by 'r'**. While there are some traditional approaches to labeling the strength of the correlation with cut off points between 0-1, these should be considered in the context of the clinical question being studied. **The closer to 1 the correlation coefficient is, the stronger the correlation**. Typically, researchers will use a statistical test to determine if the correlation is statistically significant (i.e. to test the null hypothesis that the correlation coefficient is zero). If sufficient data are available, even a weak correlation can be statistically significant. Thus, it is important to understand the distinction between the strength of the correlation and its statistical significance.

Example figure:

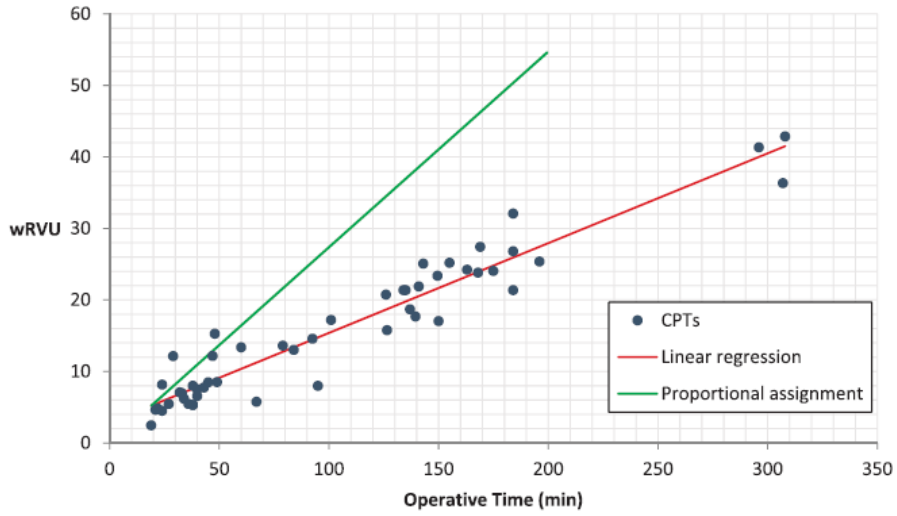


Figure 3. Linear regression (red line) ($y = 2.8 - 0.13x$, x variable 95% CI 0.11–0.14, $p < 0.001$; $R^2 = 0.91$), operative time and wRVU. Blue dots represent individual CPT. Green line is theoretical line representing proportional assignment of wRVU for increases in operative time.

Example figure from: Chakiryan et al., 2020[15]

Further reading: Schober, Boer, & Schwarte, 2018[16]

3.7 Kaplan-Meier Survival Curve

Kaplan-Meier curves are a commonly used figure to **depict time-to-event analysis**. The "event" in question is usually death, but can include other endpoints (e.g. progression, metastasis, initiation of

chemotherapy). This type of analysis is **necessary to compare the survival (or time-to-event) for people along their clinical course when the start and end point of that time differs for each individual in the study**.

Each individual in the analysis will have a **set start point** (e.g. diagnosis, start of investigational therapy, surgery) **and a duration of follow up**. That **follow up will end in one of two ways. Either the subject will have the event of interest or they will be "censored"**. Censoring means that the individual is no longer at-risk for the event, either because they dropped out of the study, the study ended, they died from another cause, or are otherwise unavailable for assessment of their outcome.

Thus, **to construct a Kaplan-Meier survival curve, one must know the duration of follow up for each individual, their duration of follow up, and their status at the end of that follow up** (either the event occurred or they were censored). The Kaplan-Meier plot typically has the survival along the Y-axis, ranging from 0 to 1. The **X-axis represents time**. The curve itself represents the cumulative survival rate for subjects over time. The horizontal portions of that curve represent each interval of time without an event. The **vertical portion of the curve represent the decrement in survival probability when an event occurs**. Censoring, which is non-informative (i.e. we do not know if the subject suffered an event or not beyond the time of censoring), does not influence the shape of the curve immediately, but does reduce the denominator of subjects at risk for each subsequent interval.

Typically, numbers of patients at risk in each group/curve are presented below the X-axis to allow for better interpretation of the figure. The **Kaplan-Meier curve estimates survival for a group of subjects and is most accurate with larger cohorts of subjects at risk**. After a significant proportion of remaining patients are censored, the estimated survival becomes less reliable.

Kaplan-Meier curves are **analyzed statistically using the log-rank test**, a nonparametric test comparing two complete curves and testing the null hypothesis that there is no difference between the two. Similarly, calculating the hazard ratio compares the estimated event rates between two curves. It is important to note that these methods consider the entire curve and not the outcome at a single time point (e.g. 5-year overall survival or 3-year disease-specific survival).

Example figure:

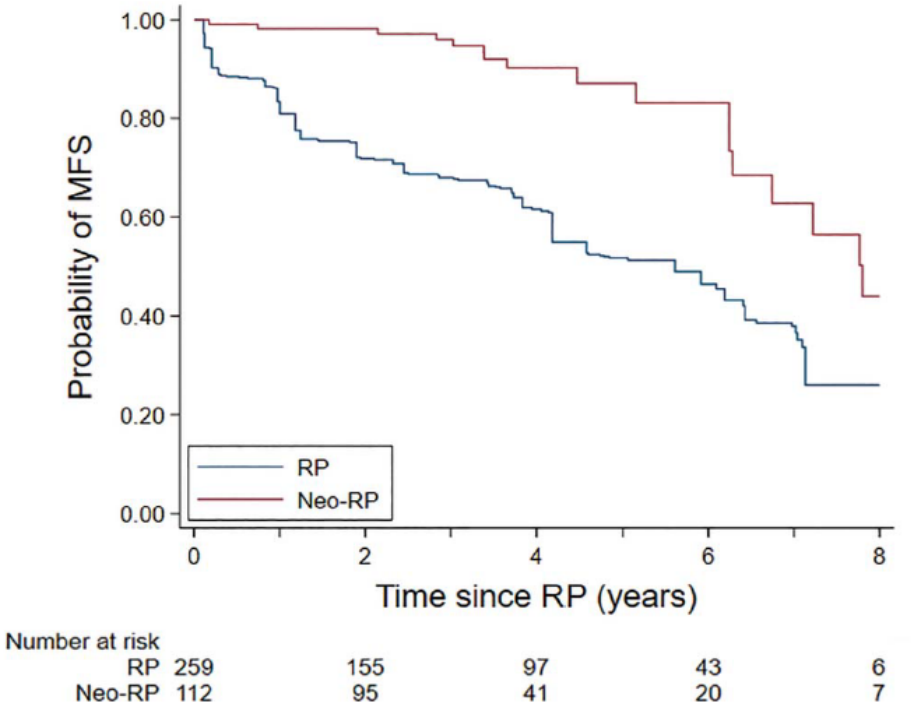


Figure. MFS in the neo-RP and RP cohorts after IPTW. The number of participants at risk is based on unweighted population.

Example figure from: Ravi et al., 2022[17]

Further reading: Rich et al., 2010[18]

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