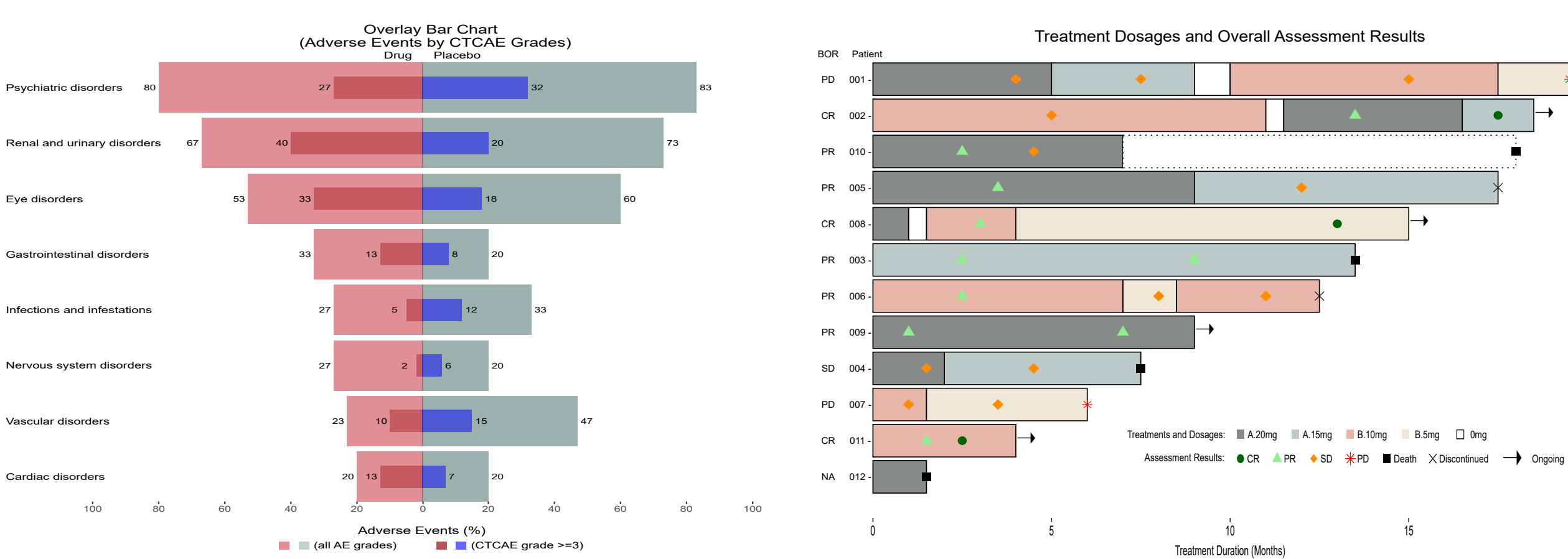
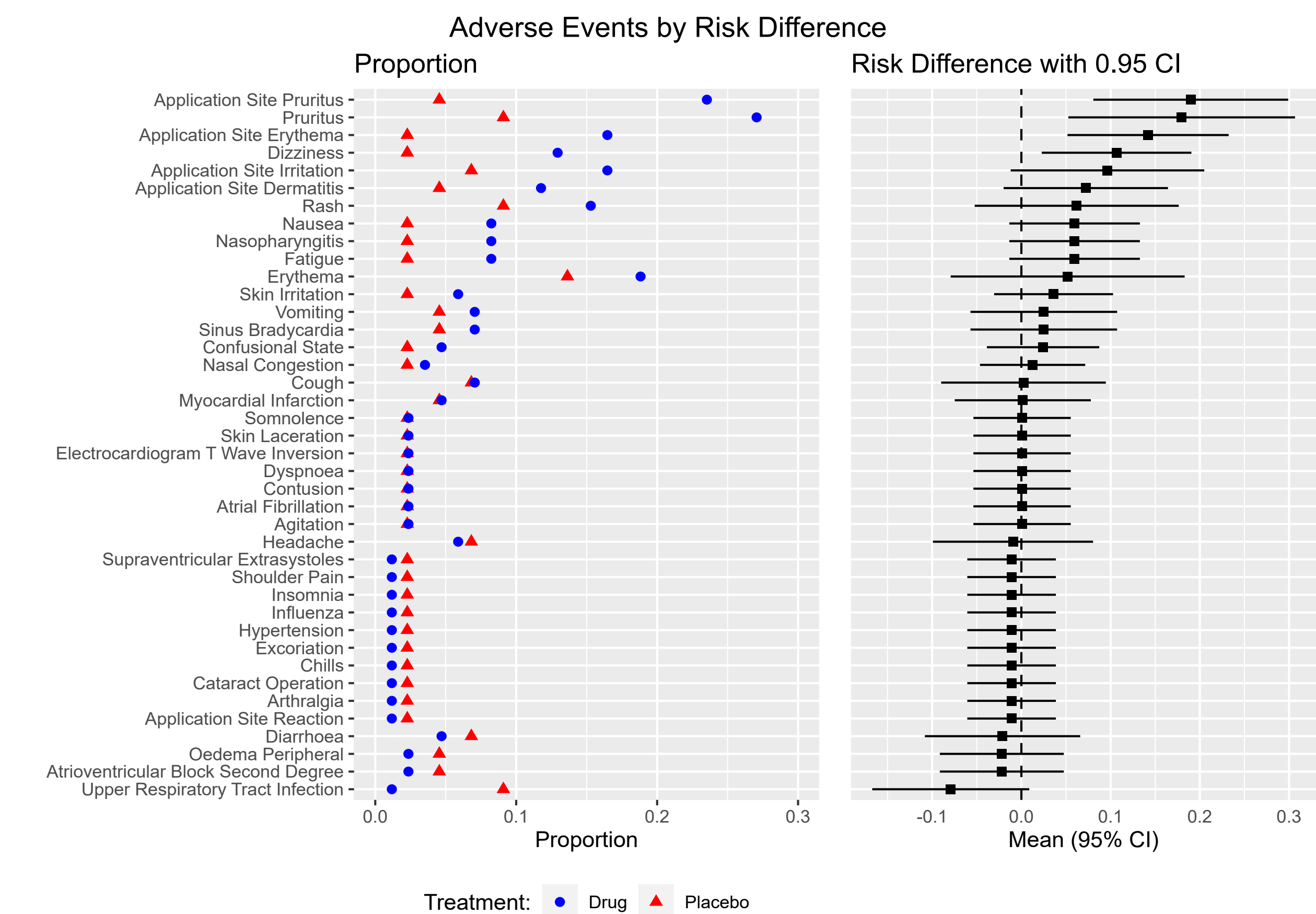
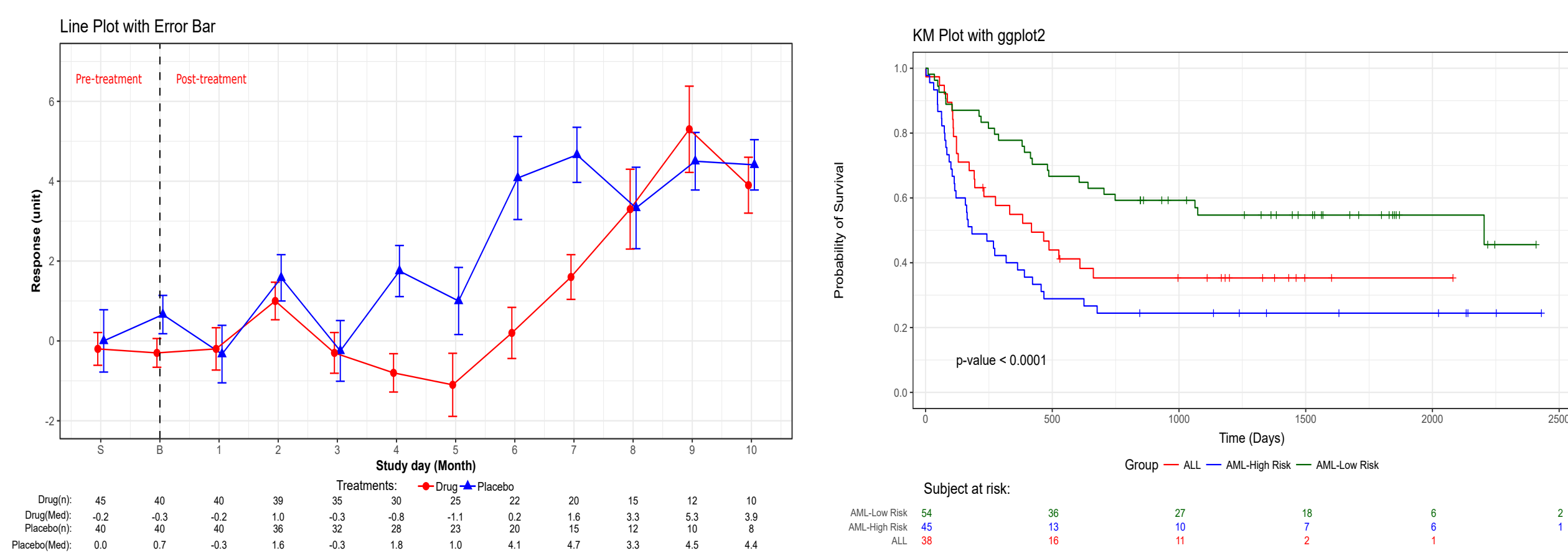
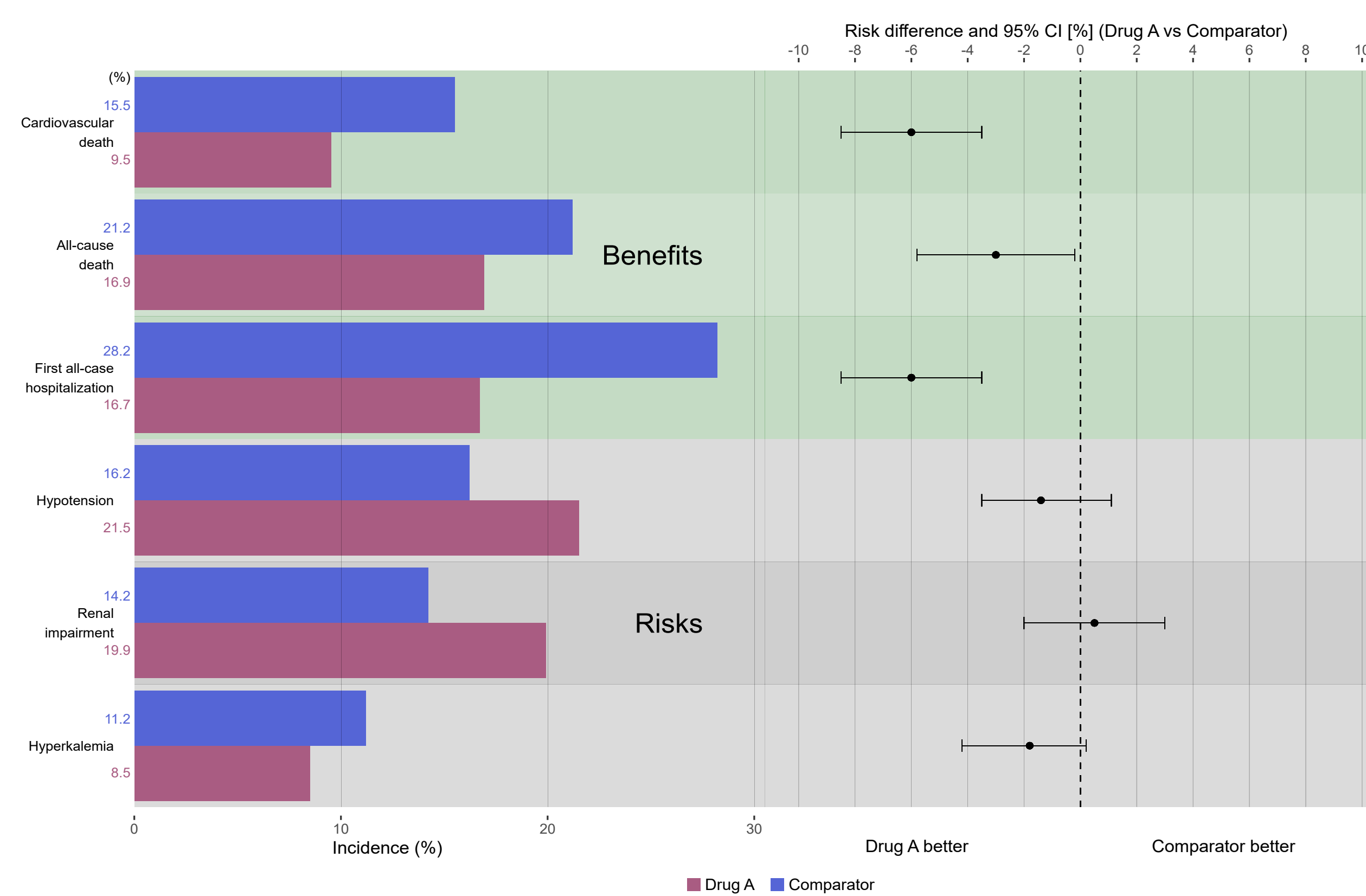


Clinical Graph - Risk Difference Plot

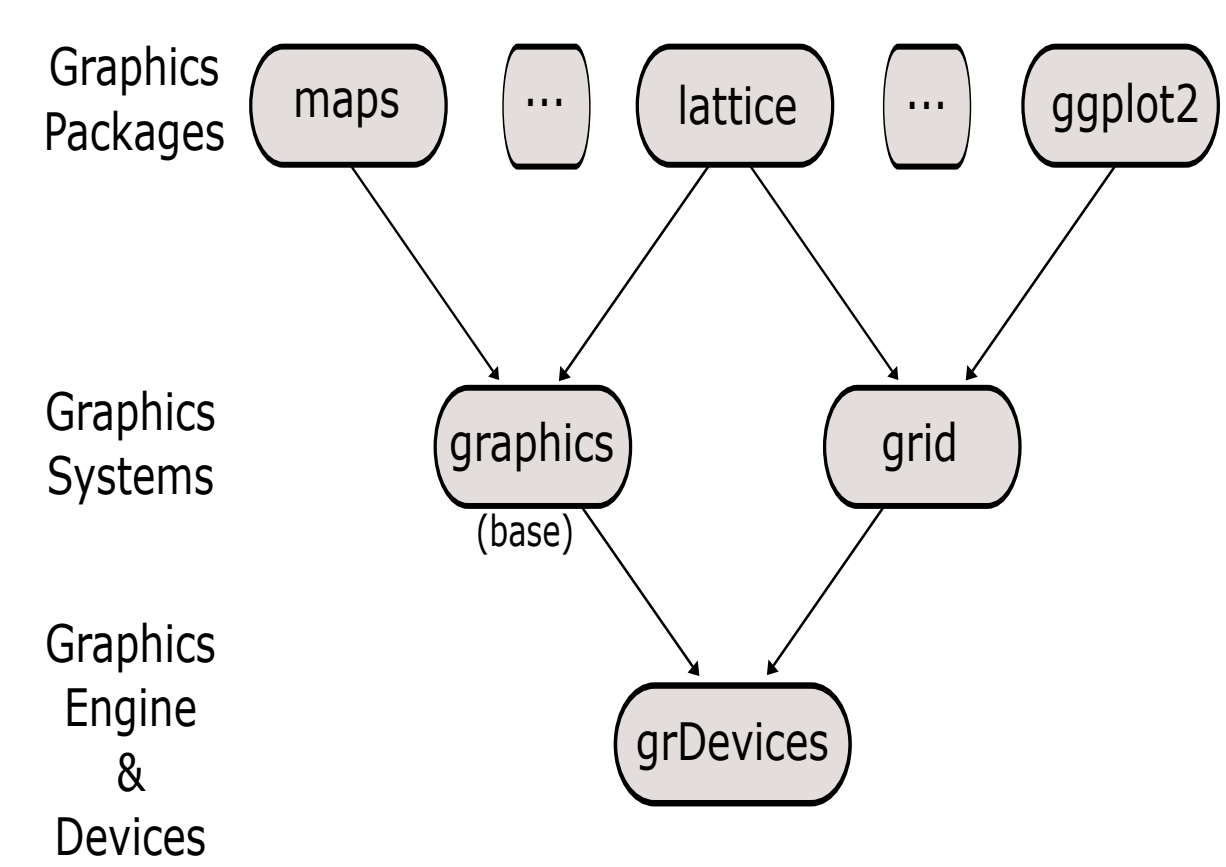


## Introduction

R is one of the best software applications for producing *static graphs*. It includes the fantastic '**Graphics Engine & Devices**' and a solid foundation of '**Graphics Systems**' (base and grid) for building graphical packages. Among the existing is the most popular **ggplot2** by H Wickham [1], built upon the **grid** package by P Murrell [2]. With its extendible capability via adopting '*The Grammar of Graphics*' by L Wilkinson [3], many supporting packages have and will continue to follow. Some of the more well-known are **patchwork**, **cowplot** and **ggtext** for arranging and annotating plots. As for the output formats both raster (png, jpeg, tiff) and vector based (svg, pdf, ps) are supported in all graphical systems.

The purpose of this presentation is to give a brief overview of the aforementioned R graphics and showcase a sample of typical publication-ready graphs seen in clinical reporting. Note - all numbers in these plots are arbitrary; the intention is to advocate the limitless possibilities of R graphics!

## R Graphics Structure



## base

base graphics offers tools to create primitives and entire plots in a piecemeal manner. However, once drawn it cannot be overwritten in contrast to ggplot2.

```
line1 <- c(2,3,7,4,12)
line2 <- c(3,5,4,9,10)
plot(line1, type="o", col="blue",
      xlab="Days", ylab="Total")
lines(line2, type="o", lty=2,
      col="red")
title(main="Base line Plot")
```

## lattice

The lattice, like base and ggplot2, is a high-level data visualisation system but with an emphasis on Trellis (panel) graphics. This is particularly useful for visualising plots by subgroups.

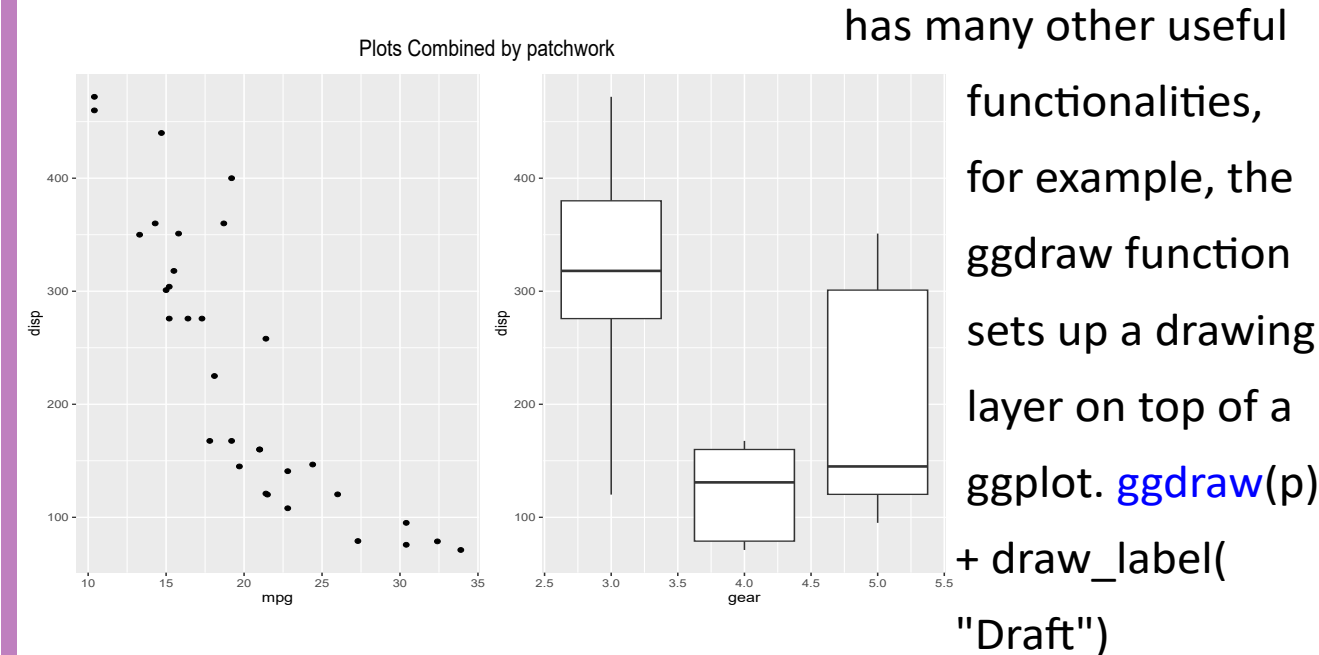
```
xplot(mpg~wt | cyl*gear, pch=19,
      main="Scatterplots by Cylinders and Gears",
      ylab="Miles per Gallon, xlab="Car Weight")
```

## patchwork and cowplot

patchwork and cowplot are two of the most commonly used packages in conjunction with ggplot2. Their main goal is to easily combine and arrange ggplot2 objects.

```
library(patchwork)
p1 <- ggplot(mtcars) + geom_point(aes(mpg, disp))
p2 <- ggplot(mtcars) + geom_boxplot(aes(gear, disp,
      group = gear))
```

p1 + p2 + plot\_annotation ("Plots Combined by patchwork")



## R Graphics Devices

Graphics devices allow a plot to be displayed on a screen or saved to a file. By default the plot is sent to the "screen device" but there are also multiple "file devices", in both raster and vector formats. To save a plot, simply turn a device on and off, capturing the plot in between.

```
#saving a plot to SVG format
svg(file="my_plot.svg") # save the plot to a file
plot(rnorm(30))         # codes for the plot
dev.off()               # close the graphics device
```

This can be used similarly for other file devices such as png, pdf and tiff. To see the full list just run the "?Devices" command.

## grid

grid graphics define a set of functions to create primitive graphical objects (grobs), for example, drawing a circle, square etc. The intention is that these grobs serve as building blocks for other graphical systems such as ggplot2 and lattice.

```
circle <- circleGrob(x=0.5, y=0.5, r=0.5,
                    gp=gpar(fill = "black", alpha=0.5))
grid.draw(circle)

rect <- rectGrob(x = 0.5, y = 0.5, width = 0.8,
                height = 0.3, gp=gpar(fill = "red", alpha=0.5))
grid.draw(rect)
```

## ggplot2

ggplot2 is by far the most popular system, and the key idea behind this system is the concept of an iterative process in laying and customising independent graphical components into graphics with an underlying grammar. This design makes extending ggplot2 easy - indeed there are many additional complementary packages and this makes ggplot2 powerful. On the contrary, systems like base are limited to a set of pre-defined (named) graphics and functions.

```
ggplot() +
layers(data=mtcars,
      mapping=aes(x=hp, y=mpg),
      geom="point", params=
list(size=2),
      stat="identity",
      position="identity") +
layers(..further layers..)
```

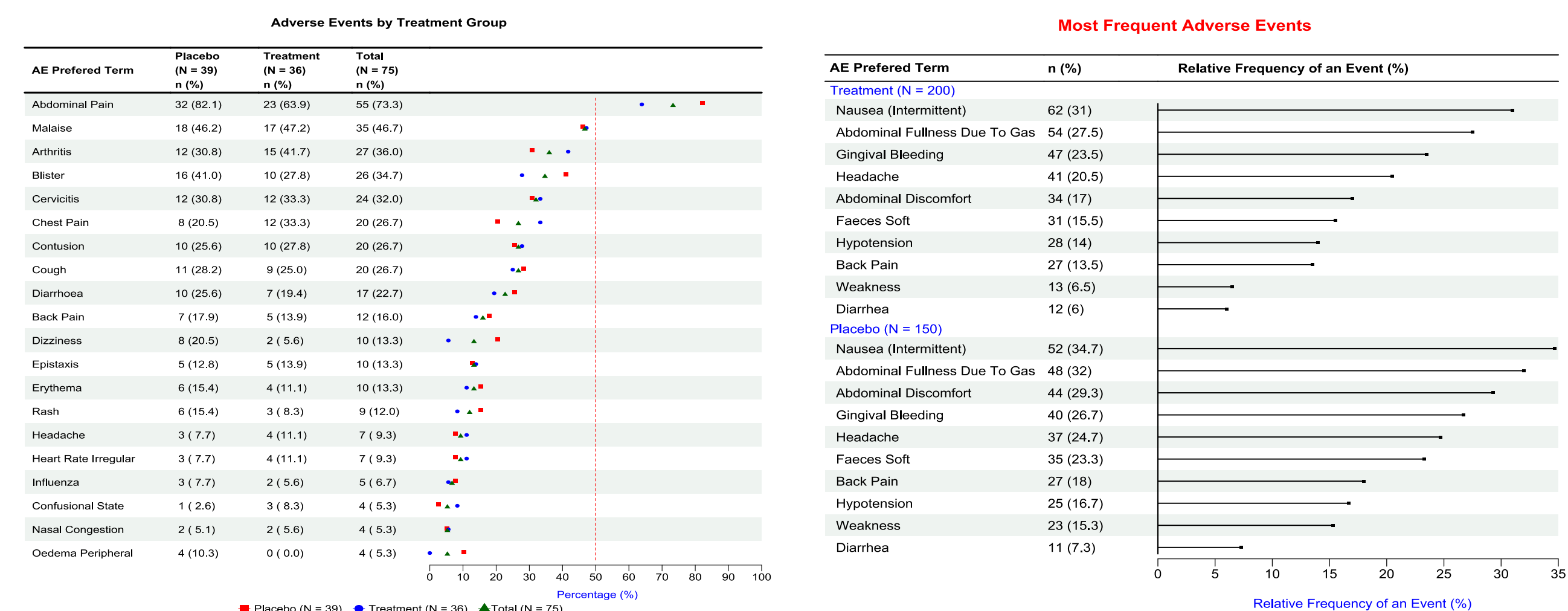
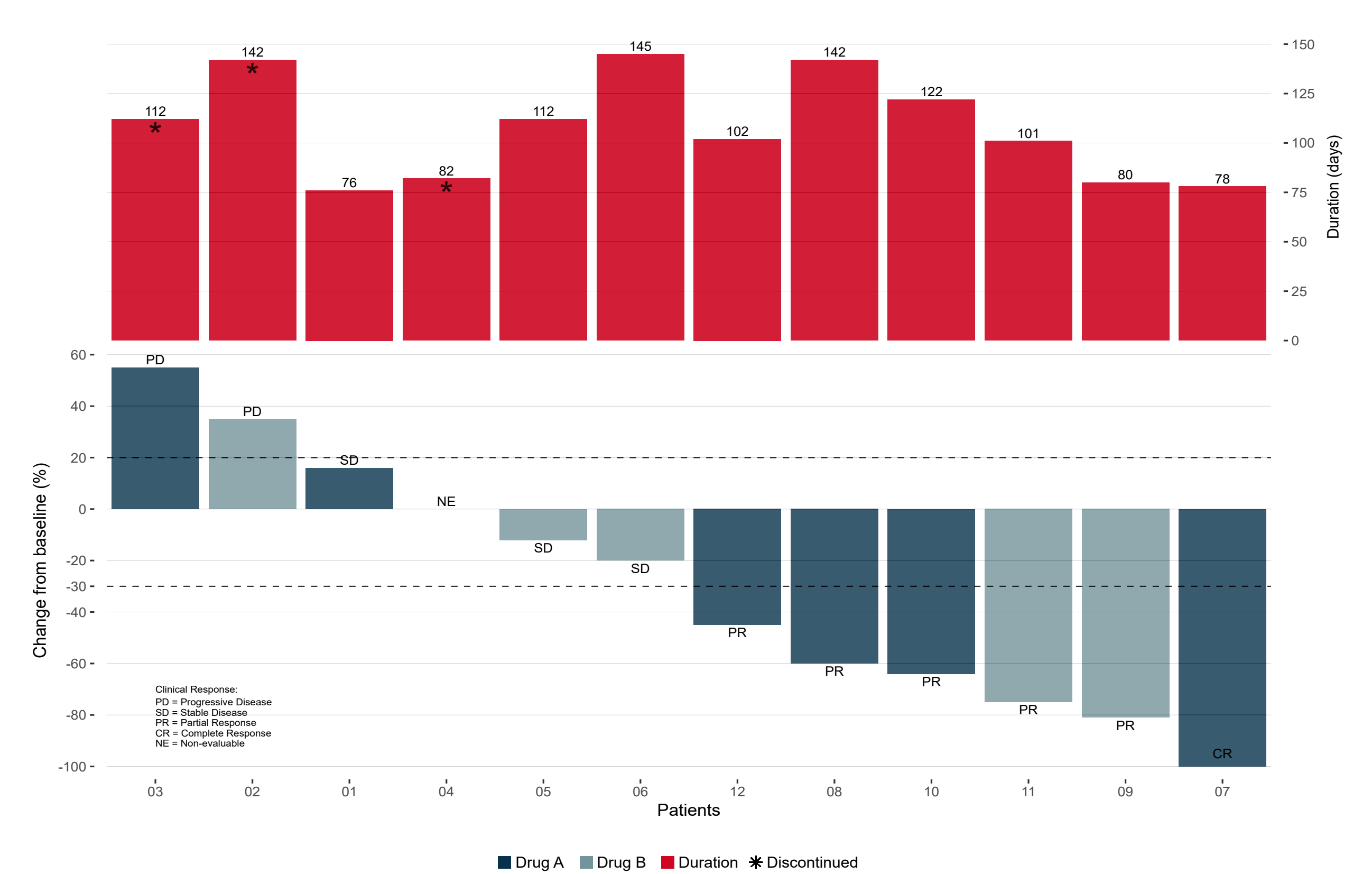
## Conclusions

R is a language and environment for a diverse range of applications in statistical computing, graphics, data science and data visualisations to name a few. In this presentation only a sample of clinical-related publication-ready plots are used to demonstrate a flavour of its powerful graphics capabilities. Beyond these examples there are many more fantastic R graphics, data visualisation and generative arts seen online.

## References

- Wickham, H., ggplot2 Elegant Graphics for Data Analysis (Second Edition)
- Murrell, P., R Graphics (Third Edition)
- Wilkinson, L., The Grammar of Graphics (Second Edition)

Change in Tumor Size and Clinical Response



## Forest Plot

