Plane Crash Analysis: There exist such a thing as a safest seat?

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Contents

1 Introduction

The Aviation industry is one of the safest in the world. The systems that it has in place to learn lessons from accidents and make sure they never happen again is well-established and highly regarded. This has made travelling by plane the safest way to travel. https://flyfright.com/plane-crash-statistics/#:~:text=Based%20on%20statistics%20from%202015,unharmed%2C%20injured%2C%20or%20killed

But perhaps due to these high safety standards, when an aircraft accident happens it makes headlines all over the world. Anxious passengers fear it's going to happen to them as well and they can't help but ask themselves if there is something they could do to have a safer flight.

One of the most frequent question that gets asked is : is there a part of the plane that is "safer" than other parts? Can the seating location make a difference in an accident? There are many articles where experts in the field give their opinions, and most answer that "yes, there are areas that give a higher chance of survival in case of an aircraft accident". But there are also studies that suggest that there is no safest seats on an airplane.

So, who is right? We are going to try to answer this question using statistics.

```
data <- read.csv("Aerei_Final.csv")

str(data)
```

```
## 'data.frame':    47 obs. of  21 variables:
##  $ NumVolo       : int  6 28 92 120 123 129 140 148 191 204 ...
```

```
##  $ X1.terzo.lievi: int  17 36 0 0 0 4 0 0 0 3 ...
##  $ X1.terzo.gravi: int  2 0 11 0 0 0 0 0 0 0 ...
##  $ X1.terzo.morti: int  15 0 22 0 136 14 18 16 55 33 ...
##  $ X2.terzo.lievi: int  1 30 4 5 0 5 7 1 0 25 ...
##  $ X2.terzo.gravi: int  15 0 30 0 0 0 0 0 8 0 ...
##  $ X2.terzo.morti: int  64 16 13 8 214 60 139 34 51 1 ...
##  $ X3.terzo.lievi: int  26 10 0 5 36 24 0 8 10 29 ...
##  $ X3.terzo.gravi: int  17 0 27 0 0 0 0 0 7 0 ...
##  $ X3.terzo.morti: int  0 36 11 21 109 43 91 30 16 0 ...
##  $ X1.meta.lievi : int  17 56 32 3 0 7 7 1 0 7 ...
##  $ X1.meta.gravi : int  3 0 0 0 0 0 0 0 1 0 ...
##  $ X1.meta.morti : int  41 8 34 6 226 23 95 36 79 35 ...
##  $ X2.meta.lievi : int  26 20 39 7 4 26 0 7 10 46 ...
##  $ X2.meta.gravi : int  31 0 0 0 0 0 0 0 14 0 ...
##  $ X2.meta.morti : int  34 44 13 23 225 90 145 46 48 0 ...
##  $ fonte         : chr  "W" "W" "W" "W" ...
##  $ PhaseOfFlight : chr  "Takeoff" "Takeoff" "Landing" "Landing" ...
##  $ Time          : chr  "Night" "Day" "Night" "Day" ...
##  $ Place         : chr  "Airport " "Outside" "Outside" "Airport " ...
##  $ HasFire       : chr  "Fire" "Fire" "Fire" "Fire" ...
```

```
summary(data)
```

```
##     NumVolo     X1.terzo.lievi   X1.terzo.gravi   X1.terzo.morti
##  Min.   :   6   Min.   :  0.00   Min.   : 0.000   Min.   :  0.00
##  1st Qu.: 227   1st Qu.:  0.00   1st Qu.: 0.000   1st Qu.:  1.50
##  Median : 812   Median :  4.00   Median : 0.000   Median : 11.00
##  Mean   :1591   Mean   : 12.87   Mean   : 2.553   Mean   : 16.15
##  3rd Qu.:1603   3rd Qu.: 17.00   3rd Qu.: 4.000   3rd Qu.: 19.00
##  Max.   :9642   Max.   :141.00   Max.   :16.000   Max.   :136.00
##  X2.terzo.lievi   X2.terzo.gravi   X2.terzo.morti   X3.terzo.lievi
##  Min.   :  0.00   Min.   : 0.000   Min.   :  0.00   Min.   :  0.0
##  1st Qu.:  1.00   1st Qu.: 0.000   1st Qu.:  2.00   1st Qu.:  3.0
##  Median :  7.00   Median : 2.000   Median : 12.00   Median : 10.0
##  Mean   : 22.11   Mean   : 4.638   Mean   : 28.62   Mean   : 20.4
##  3rd Qu.: 26.50   3rd Qu.: 8.000   3rd Qu.: 31.00   3rd Qu.: 27.0
##  Max.   :174.00   Max.   :30.000   Max.   :214.00   Max.   :142.0
##  X3.terzo.gravi   X3.terzo.morti   X1.meta.lievi    X1.meta.gravi
##  Min.   : 0.000   Min.   :  0.00   Min.   :  0.00   Min.   : 0.00
##  1st Qu.: 0.000   1st Qu.:  1.50   1st Qu.:  1.50   1st Qu.: 0.00
##  Median : 0.000   Median :  8.00   Median : 11.00   Median : 0.00
##  Mean   : 3.872   Mean   : 19.83   Mean   : 29.23   Mean   : 4.34
##  3rd Qu.: 4.500   3rd Qu.: 24.50   3rd Qu.: 40.50   3rd Qu.: 7.00
##  Max.   :27.000   Max.   :113.00   Max.   :221.00   Max.   :34.00
##  X1.meta.morti    X2.meta.lievi    X2.meta.gravi    X2.meta.morti
##  Min.   :  0.00   Min.   :  0.00   Min.   : 0.000   Min.   :  0.00
##  1st Qu.:  5.00   1st Qu.:  6.50   1st Qu.: 0.000   1st Qu.:  3.50
##  Median : 20.00   Median : 14.00   Median : 0.000   Median : 15.00
##  Mean   : 28.57   Mean   : 28.98   Mean   : 5.234   Mean   : 36.53
##  3rd Qu.: 35.00   3rd Qu.: 37.50   3rd Qu.: 7.500   3rd Qu.: 45.00
##  Max.   :226.00   Max.   :184.00   Max.   :31.000   Max.   :225.00
##     fonte           PhaseOfFlight          Time              Place
##  Length:47          Length:47          Length:47          Length:47
##  Class :character   Class :character   Class :character   Class :character
```

```
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##    HasFire
##  Length:47
##  Class :character
##  Mode  :character
##
##
##
```

```
#> data <- read.csv("Aerei_Final.csv")
#>
#> str(data)
#'data.frame':   47 obs. of  21 variables:
# $ NumVolo         : int  6 28 92 120 123 129 140 148 191 204 ...
# $ X1.terzo.lievi  : int  17 36 0 0 0 4 0 0 0 3 ...
# $ X1.terzo.gravi  : int  2 0 11 0 0 0 0 0 0 0 ...
# $ X1.terzo.morti  : int  15 0 22 0 136 14 18 16 55 33 ...
# $ X2.terzo.lievi  : int  1 30 4 5 0 5 7 1 0 25 ...
# $ X2.terzo.gravi  : int  15 0 30 0 0 0 0 0 8 0 ...
# $ X2.terzo.morti  : int  64 16 13 8 214 60 139 34 51 1 ...
# $ X3.terzo.lievi  : int  26 10 0 5 36 24 0 8 10 29 ...
# $ X3.terzo.gravi  : int  17 0 27 0 0 0 0 0 7 0 ...
# $ X2.terzo.morti.1: int  0 36 11 21 109 43 91 30 16 0 ...
# $ X1.meta.lievi   : int  17 56 32 3 0 7 7 1 0 7 ...
# $ X1.meta.gravi   : int  3 0 0 0 0 0 0 0 1 0 ...
# $ X1.meta.morti   : int  41 8 34 6 226 23 95 36 79 35 ...
# $ X2.meta.lievi   : int  26 20 39 7 4 26 0 7 10 46 ...
# $ X2.meta.gravi   : int  31 0 0 0 0 0 0 0 14 0 ...
# $ X2.meta.morti   : int  34 44 13 23 225 90 145 46 48 0 ...
# $ fonte           : chr  "W" "W" "W" "W" ...
# $ PhaseOfFlight   : chr  "Takeoff" "Takeoff" "Landing" "Landing" ...
# $ Time            : chr  "Night" "Day" "Night" "Day" ...
# $ Place           : chr  "Airport " "Outside" "Outside" "Airport " ...
# $ HasFire         : chr  "Fire" "Fire" "Fire" "Fire" ...
#> summary(data)
#    NumVolo     X1.terzo.lievi   X1.terzo.gravi   X1.terzo.morti
# Min.   :   6   Min.   :  0.00   Min.   : 0.000   Min.   :  0.00
# 1st Qu.: 227   1st Qu.:  0.00   1st Qu.: 0.000   1st Qu.:  1.50
# Median : 812   Median :  4.00   Median : 0.000   Median : 11.00
# Mean   :1591   Mean   : 12.87   Mean   : 2.553   Mean   : 16.15
# 3rd Qu.:1603   3rd Qu.: 17.00   3rd Qu.: 4.000   3rd Qu.: 19.00
# Max.   :9642   Max.   :141.00   Max.   :16.000   Max.   :136.00
# X2.terzo.lievi   X2.terzo.gravi   X2.terzo.morti   X3.terzo.lievi
# Min.   :  0.00   Min.   : 0.000   Min.   :  0.00   Min.   :  0.0
# 1st Qu.:  1.00   1st Qu.: 0.000   1st Qu.:  2.00   1st Qu.:  3.0
# Median :  7.00   Median : 2.000   Median : 12.00   Median : 10.0
# Mean   : 22.11   Mean   : 4.638   Mean   : 28.62   Mean   : 20.4
# 3rd Qu.: 26.50   3rd Qu.: 8.000   3rd Qu.: 31.00   3rd Qu.: 27.0
# Max.   :174.00   Max.   :30.000   Max.   :214.00   Max.   :142.0
# X3.terzo.gravi   X2.terzo.morti.1 X1.meta.lievi    X1.meta.gravi
# Min.   : 0.000   Min.   :  0.00   Min.   :  0.00   Min.   : 0.00
```

```
# 1st Qu.: 0.000   1st Qu.:  1.50   1st Qu.:  1.50   1st Qu.: 0.00
# Median : 0.000   Median :  8.00   Median : 11.00   Median : 0.00
# Mean   : 3.872   Mean   : 19.83   Mean   : 29.23   Mean   : 4.34
# 3rd Qu.: 4.500   3rd Qu.: 24.50   3rd Qu.: 40.50   3rd Qu.: 7.00
# Max.   :27.000   Max.   :113.00   Max.   :221.00   Max.   :34.00
# X1.meta.morti    X2.meta.lievi    X2.meta.gravi    X2.meta.morti
# Min.   :  0.00   Min.   :  0.00   Min.   : 0.000   Min.   :  0.00
# 1st Qu.:  5.00   1st Qu.:  6.50   1st Qu.: 0.000   1st Qu.:  3.50
# Median : 20.00   Median : 14.00   Median : 0.000   Median : 15.00
# Mean   : 28.57   Mean   : 28.98   Mean   : 5.234   Mean   : 36.53
# 3rd Qu.: 35.00   3rd Qu.: 37.50   3rd Qu.: 7.500   3rd Qu.: 45.00
# Max.   :226.00   Max.   :184.00   Max.   :31.000   Max.   :225.00
#    fonte           PhaseOfFlight          Time             Place
# Length:47          Length:47          Length:47          Length:47
# Class :character   Class :character   Class :character   Class :character
# Mode  :character   Mode  :character   Mode  :character   Mode  :character
```

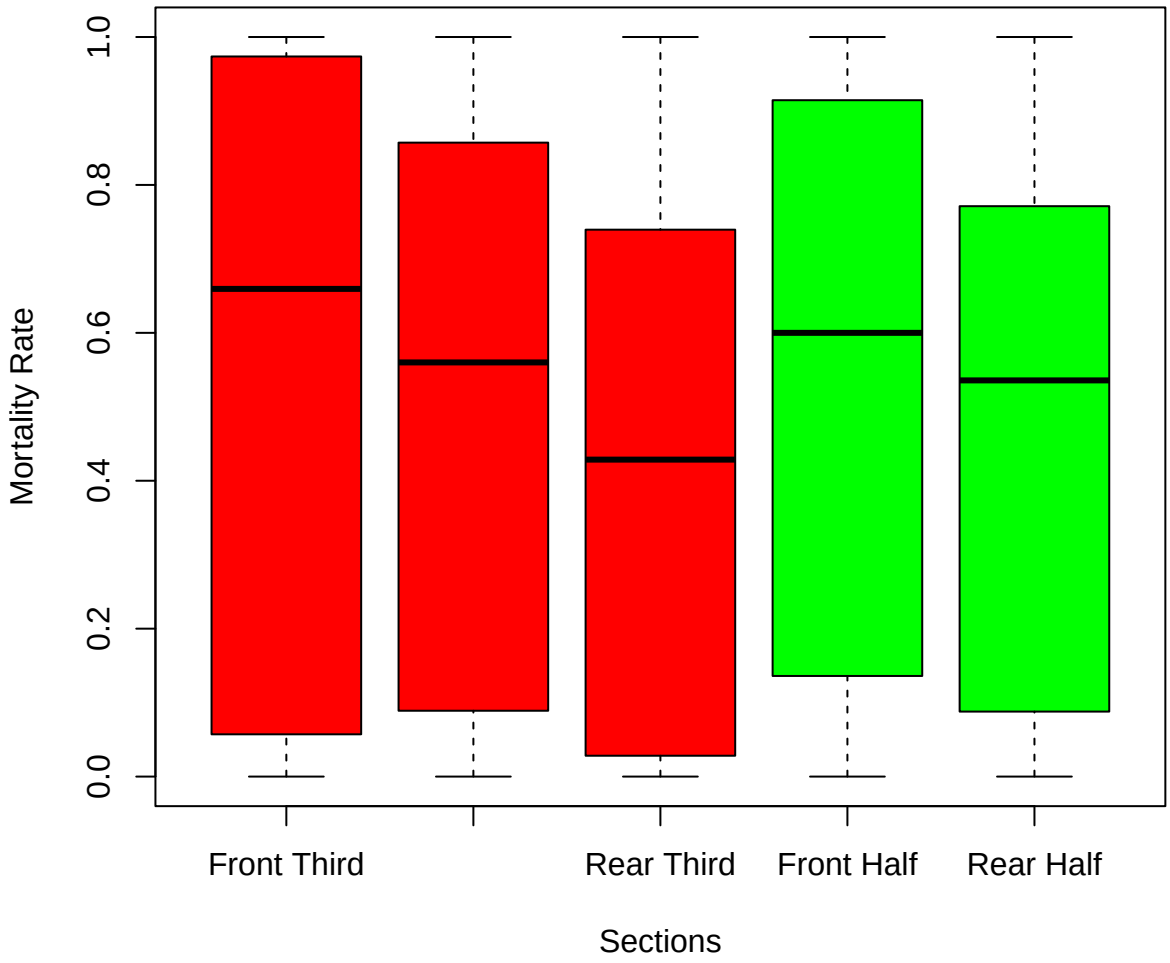
Some random text....

```
# add a colum of # of seat for each airplain section

data$X1.third.total <- data$X1.terzo.lievi + data$X1.terzo.gravi + data$X1.terzo.morti
data$X2.third.total <- data$X2.terzo.lievi + data$X2.terzo.gravi + data$X2.terzo.morti
data$X3.third.total <- data$X3.terzo.lievi + data$X3.terzo.gravi + data$X3.terzo.morti
data$X1.half.total <- data$X1.meta.lievi + data$X1.meta.gravi + data$X1.meta.morti
data$X2.half.total <- data$X2.meta.lievi + data$X2.meta.gravi + data$X2.meta.morti

# now make a colum of mortality rate for each section

data$X1.third.mortality.rate <- data$X1.terzo.morti / data$X1.third.total
data$X2.third.mortality.rate <- data$X2.terzo.morti / data$X2.third.total
data$X3.third.mortality.rate <- data$X3.terzo.morti / data$X3.third.total
data$X1.half.mortality.rate <- data$X1.meta.morti / data$X1.half.total
data$X2.half.mortality.rate <- data$X2.meta.morti / data$X2.half.total



head(data)
```

```
##   NumVolo X1.terzo.lievi X1.terzo.gravi X1.terzo.morti X2.terzo.lievi
## 1       6             17              2             15              1
## 2      28             36              0              0             30
## 3      92              0             11             22              4
## 4     120              0              0              0              5
## 5     123              0              0            136              0
## 6     129              4              0             14              5
##   X2.terzo.gravi X2.terzo.morti X3.terzo.lievi X3.terzo.gravi X3.terzo.morti
## 1             15             64             26             17              0
## 2              0             16             10              0             36
## 3             30             13              0             27             11
## 4              0              8              5              0             21
## 5              0            214             36              0            109
## 6              0             60             24              0             43
```

```
##   X1.meta.lievi X1.meta.gravi X1.meta.morti X2.meta.lievi X2.meta.gravi
## 1            17             3            41            26            31
## 2            56             0             8            20             0
## 3            32             0            34            39             0
## 4             3             0             6             7             0
## 5             0             0           226             4             0
## 6             7             0            23            26             0
##   X2.meta.morti fonte PhaseOfFlight  Time    Place HasFire X1.third.total
## 1            34     W       Takeoff Night Airport     Fire             34
## 2            44     W       Takeoff   Day  Outside    Fire             36
## 3            13     W       Landing Night  Outside    Fire             33
## 4            23     W       Landing   Day Airport     Fire              0
## 5           225     W       Takeoff Night  Outside    Fire            136
## 6            90     W       Landing   Day  Outside    Fire             18
##   X2.third.total X3.third.total X1.half.total X2.half.total
## 1             80             43            61            91
## 2             46             46            64            64
## 3             47             38            66            52
## 4             13             26             9            30
## 5            214            145           226           229
## 6             65             67            30           116
##   X1.third.mortality.rate X2.third.mortality.rate X3.third.mortality.rate
## 1               0.4411765               0.8000000               0.0000000
## 2               0.0000000               0.3478261               0.7826087
## 3               0.6666667               0.2765957               0.2894737
## 4                     NaN               0.6153846               0.8076923
## 5               1.0000000               1.0000000               0.7517241
## 6               0.7777778               0.9230769               0.6417910
##   X1.half.mortality.rate X2.half.mortality.rate
## 1              0.6721311              0.3736264
## 2              0.1250000              0.6875000
## 3              0.5151515              0.2500000
## 4              0.6666667              0.7666667
## 5              1.0000000              0.9825328
## 6              0.7666667              0.7758621
```

```r
## Plot mortality rates as scatter plots for each section
## they must be separated on the x axis by group

boxplot(data$X1.third.mortality.rate,
  data$X2.third.mortality.rate,
  data$X3.third.mortality.rate,
  data$X1.half.mortality.rate,
  data$X2.half.mortality.rate,
  names = c("Front Third", "Middle Third", "Rear Third", "Front Half", "Rear Half"),
  main = "Mortality Rates by Section",
  ylab = "Mortality Rate",
  xlab = "Sections",
  col = c("red", "red", "red", "green", "green"))
```




```
# Perform ANOVA to test if there are significant differences in mortality rates between sections (only
mortality_data <- data.frame(
  Section = rep(c("Front Third", "Middle Third", "Rear Third"), each = nrow(data)),
  MortalityRate = c(data$X1.third.mortality.rate, data$X2.third.mortality.rate, data$X3.third.mortality
)
anova_result <- aov(MortalityRate ~ Section, data = mortality_data)
summary(anova_result)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## Section       2  0.364  0.1818   1.251  0.289
## Residuals   137 19.906  0.1453
## 1 observation deleted due to missingness
```

```
#half sections
mortality_data_half <- data.frame(
  Section = rep(c("Front Half", "Rear Half"), each = nrow(data)),
```

```
  MortalityRate = c(data$X1.half.mortality.rate, data$X2.half.mortality.rate)
)
anova_result_half <- aov(MortalityRate ~ Section, data = mortality_data_half)
summary(anova_result_half)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Section      1  0.056 0.05591   0.409  0.524
## Residuals   92 12.581 0.13675
```

```
#try using non-parametric test if ANOVA assumptions are not met
kruskal_result <- kruskal.test(MortalityRate ~ Section, data = mortality_data)
kruskal_result_half <- kruskal.test(MortalityRate ~ Section, data = mortality_data_half)
kruskal_result
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  MortalityRate by Section
## Kruskal-Wallis chi-squared = 2.9755, df = 2, p-value = 0.2259
```

```
kruskal_result_half
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  MortalityRate by Section
## Kruskal-Wallis chi-squared = 0.65567, df = 1, p-value = 0.4181
```

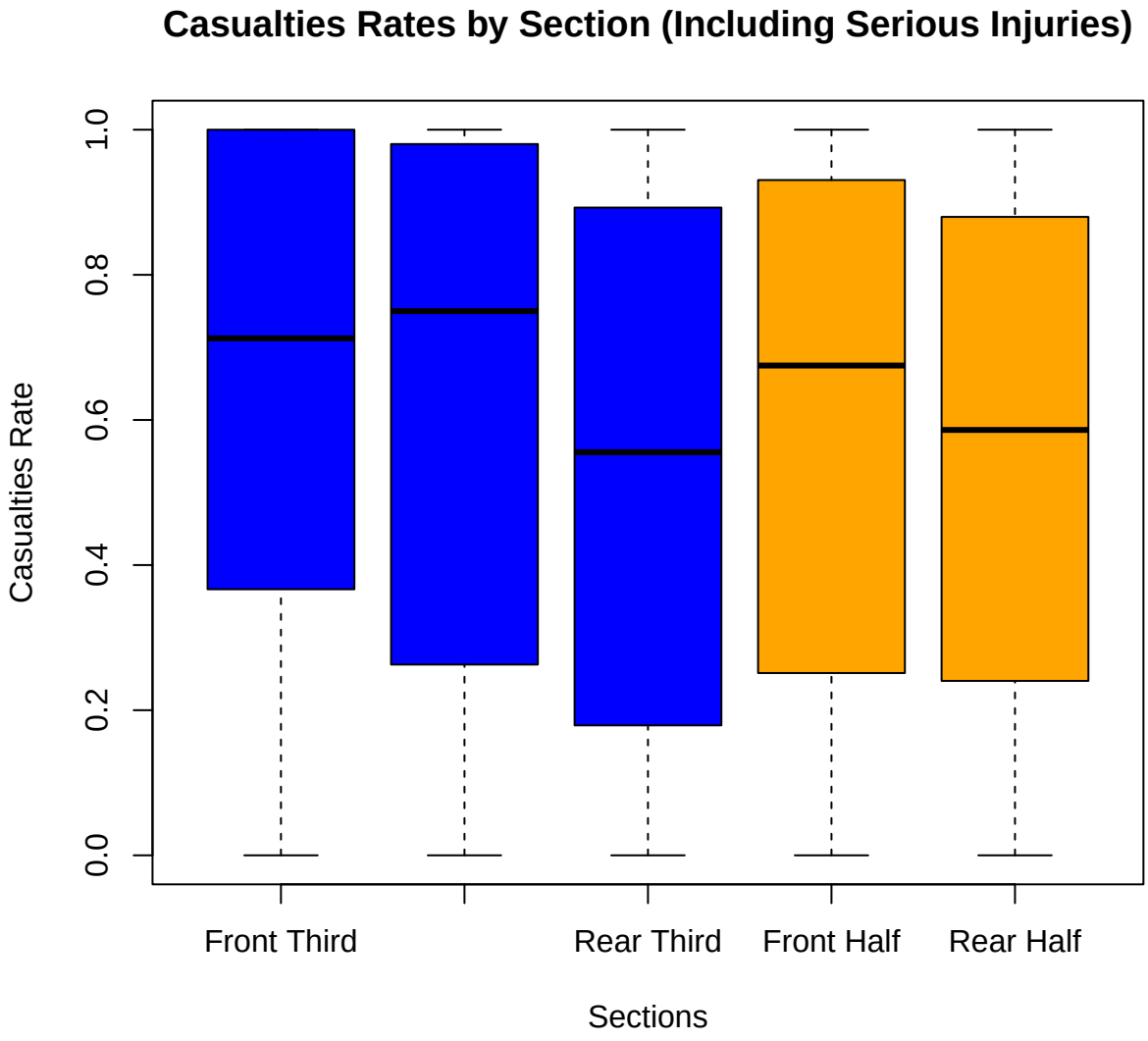
```
# now we do the same thing but considering the "gravi" as casualties too

data$X1.casualties_rate_new <- (data$X1.terzo.morti + data$X1.terzo.gravi) / data$X1.third.total
data$X2.casualties_rate_new <- (data$X2.terzo.morti + data$X2.terzo.gravi) / data$X2.third.total
data$X3.casualties_rate_new <- (data$X3.terzo.morti + data$X3.terzo.gravi) / data$X3.third.total
data$X1.half.casualties_rate_new <- (data$X1.meta.morti + data$X1.meta.gravi) / data$X1.half.total
data$X2.half.casualties_rate_new <- (data$X2.meta.morti + data$X2.meta.gravi) / data$X2.half.total

head(data)
```

```
##   NumVolo X1.terzo.lievi X1.terzo.gravi X1.terzo.morti X2.terzo.lievi
## 1       6             17              2             15              1
## 2      28             36              0              0             30
## 3      92              0             11             22              4
## 4     120              0              0              0              5
## 5     123              0              0            136              0
## 6     129              4              0             14              5
##   X2.terzo.gravi X2.terzo.morti X3.terzo.lievi X3.terzo.gravi X3.terzo.morti
## 1             15             64             26             17              0
## 2              0             16             10              0             36
## 3             30             13              0             27             11
## 4              0              8              5              0             21
## 5              0            214             36              0            109
```

```
## 6              0             60             24              0             43
##   X1.meta.lievi X1.meta.gravi X1.meta.morti X2.meta.lievi X2.meta.gravi
## 1            17             3            41            26            31
## 2            56             0             8            20             0
## 3            32             0            34            39             0
## 4             3             0             6             7             0
## 5             0             0           226             4             0
## 6             7             0            23            26             0
##   X2.meta.morti fonte PhaseOfFlight  Time    Place HasFire X1.third.total
## 1            34     W       Takeoff Night Airport     Fire             34
## 2            44     W       Takeoff   Day  Outside    Fire             36
## 3            13     W       Landing Night  Outside    Fire             33
## 4            23     W       Landing   Day Airport     Fire              0
## 5           225     W       Takeoff Night  Outside    Fire            136
## 6            90     W       Landing   Day  Outside    Fire             18
##   X2.third.total X3.third.total X1.half.total X2.half.total
## 1             80             43            61            91
## 2             46             46            64            64
## 3             47             38            66            52
## 4             13             26             9            30
## 5            214            145           226           229
## 6             65             67            30           116
##   X1.third.mortality.rate X2.third.mortality.rate X3.third.mortality.rate
## 1               0.4411765               0.8000000               0.0000000
## 2               0.0000000               0.3478261               0.7826087
## 3               0.6666667               0.2765957               0.2894737
## 4                     NaN               0.6153846               0.8076923
## 5               1.0000000               1.0000000               0.7517241
## 6               0.7777778               0.9230769               0.6417910
##   X1.half.mortality.rate X2.half.mortality.rate X1.casualties_rate_new
## 1              0.6721311              0.3736264              0.5000000
## 2              0.1250000              0.6875000              0.0000000
## 3              0.5151515              0.2500000              1.0000000
## 4              0.6666667              0.7666667                    NaN
## 5              1.0000000              0.9825328              1.0000000
## 6              0.7666667              0.7758621              0.7777778
##   X2.casualties_rate_new X3.casualties_rate_new X1.half.casualties_rate_new
## 1              0.9875000              0.3953488                   0.7213115
## 2              0.3478261              0.7826087                   0.1250000
## 3              0.9148936              1.0000000                   0.5151515
## 4              0.6153846              0.8076923                   0.6666667
## 5              1.0000000              0.7517241                   1.0000000
## 6              0.9230769              0.6417910                   0.7666667
##   X2.half.casualties_rate_new
## 1                   0.7142857
## 2                   0.6875000
## 3                   0.2500000
## 4                   0.7666667
## 5                   0.9825328
## 6                   0.7758621
```

```r
# Plot new casualties rates as scatter plots for each section
boxplot(data$X1.casualties_rate_new,
  data$X2.casualties_rate_new,
```

```
  data$X3.casualties_rate_new,
  data$X1.half.casualties_rate_new,
  data$X2.half.casualties_rate_new,
  names = c("Front Third", "Middle Third", "Rear Third", "Front Half", "Rear Half"),
  main = "Casualties Rates by Section (Including Serious Injuries)",
  ylab = "Casualties Rate",
  xlab = "Sections",
  col = c("blue", "blue", "blue", "orange", "orange"))
```




```
# Perform ANOVA to test if there are significant differences in casualties rates between sections (only
casualties_data <- data.frame(
  Section = rep(c("Front Third", "Middle Third", "Rear Third"), each = nrow(data)),
  CasualtiesRate = c(data$X1.casualties_rate_new, data$X2.casualties_rate_new, data$X3.casualties_rate_r
)
anova_casualties_result <- aov(CasualtiesRate ~ Section, data = casualties_data)
summary(anova_casualties_result)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## Section       2   0.33  0.1648   1.228  0.296
## Residuals   137  18.38  0.1342
## 1 observation deleted due to missingness
```

```
#half sections
casualties_data_half <- data.frame(
  Section = rep(c("Front Half", "Rear Half"), each = nrow(data)),
  CasualtiesRate = c(data$X1.half.casualties_rate_new, data$X2.half.casualties_rate_new)
)
anova_casualties_result_half <- aov(CasualtiesRate ~ Section, data = casualties_data_half)
summary(anova_casualties_result_half)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Section      1  0.039 0.03904   0.318  0.574
## Residuals   92 11.283 0.12264
```

```
#try using non-parametric test if ANOVA assumptions are not met
kruskal_casualties_result <- kruskal.test(CasualtiesRate ~ Section, data = casualties_data)
kruskal_casualties_result_half <- kruskal.test(CasualtiesRate ~ Section, data = casualties_data_half)
kruskal_casualties_result
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  CasualtiesRate by Section
## Kruskal-Wallis chi-squared = 2.6064, df = 2, p-value = 0.2717
```

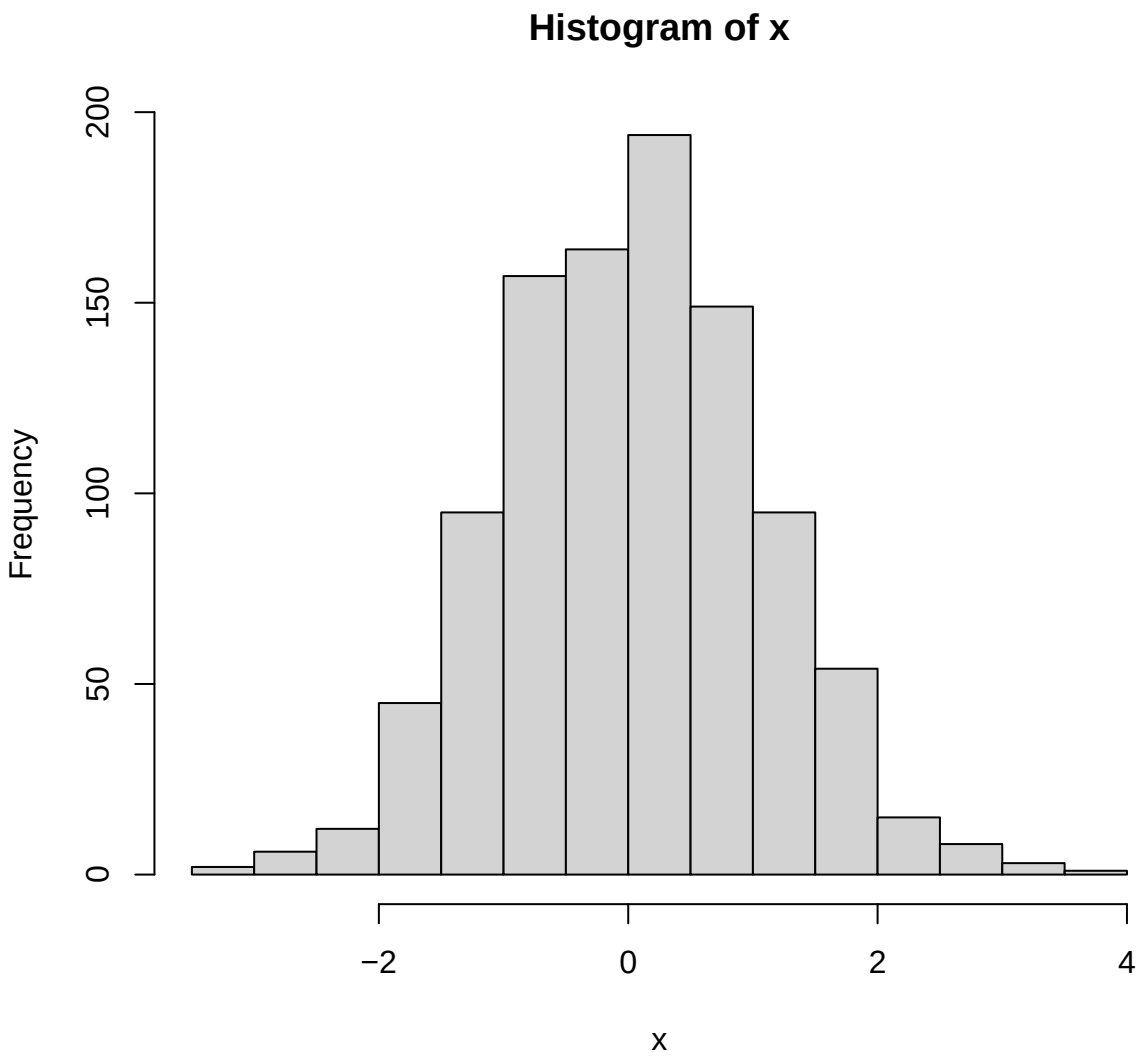
```
kruskal_casualties_result_half
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  CasualtiesRate by Section
## Kruskal-Wallis chi-squared = 0.4796, df = 1, p-value = 0.4886
```

2 Data Description

This is an example of r-chuch. You can instrt the R code, Knit-it and your report is compiled in pdf.

```
x <- rnorm(1000)
hist(x)
```



3 Analysis

4 Results

5 Conclusions