

Data Processing

Team 2

2025-11-03

Data reading

```
data <- read.csv("00_ProstateCancer_Data.csv", header=T)
head(data)

##   Hasta_ID Yas Tani_Tarihi PSA_Tani Klinik_Evre Biyopsi_Gleason Risk_Grubu
## 1          0  59 2022-12-09    41.3      cT3a        3+5            3
## 2          1  69 2023-08-26    12.9      cT2b        4+3            2
## 3          2  66 2021-11-17    32.0      cT3b        3+5            3
## 4          3  59 2022-01-15   142.7      cT3b        4+4            3
## 5          4  70 2021-07-07    16.2      cT2b        3+4            2
## 6          5  73 2023-06-17    55.7      cT3b        5+4            3
##   Albumin Lenfosit CRP NLR CALLY_Index Komorbidite_Skor Tedavi_Tipi
## 1     4.1    2227 0.58 1.7       1.6           2            1
## 2     4.6    1168 0.12 1.7       4.5           0            1
## 3     4.1    1125 0.16 3.5       2.9           1            4
## 4     3.5    1623 1.76 1.7       0.3           0            2
## 5     4.3    1399 0.53 2.3       1.1           2            2
## 6     4.2    2103 0.10 2.2       8.8           4            2
##   Tedavi_Tarihi RT_Dozu ADT_Tipi ADT_Suresi Patolojik_Evre Cerrahi_Sinir
## 1 2023-02-14      NA      NA      NA      pT2c            0
## 2 2023-10-08      NA      NA      NA      pT2a            1
## 3 2022-01-19      70      1      12             NA
## 4 2022-03-30      74      NA      NA             NA
## 5 2021-07-28      70      NA      NA             NA
## 6 2023-07-28      70      NA      NA             NA
##   Final_Gleason PSA_Nadir PSA_Takip_3ay PSA_Takip_6ay PSA_Takip_12ay BCR_Durum
## 1         3+5    0.14      0.14      0.17      0.21      True
## 2         4+5    0.04      0.04      0.04      0.06     False
## 3         0.30    0.30      1.03      0.33      0.38     False
## 4         0.20    0.20      0.61      0.63      0.71     False
## 5         0.28    0.28      0.90      0.38      0.46     False
## 6         0.81    0.81      2.38      1.57      4.47      True
##   BCR_Tarihi Metastaz_Durum Metastaz_Tarihi Son_Durum Son_Takip_Tarihi
## 1 2028-01-11          0        NA        1 2029-05-22
## 2                      0        NA        1 2029-06-12
## 3                      0        NA        0 2022-03-05
## 4                      0        NA        1 2023-11-06
## 5                      0        NA        1 2027-11-16
## 6 2025-04-06          0        NA        1 2029-04-19
```

```
str(data)
```

```
## 'data.frame': 600 obs. of 31 variables:
## $ Hasta_ID      : int 0 1 2 3 4 5 6 7 8 9 ...
## $ Yas           : int 59 69 66 59 70 73 72 72 63 57 ...
## $ Tani_Tarihi   : chr "2022-12-09" "2023-08-26" "2021-11-17" "2022-01-15" ...
## $ PSA_Tani       : num 41.3 12.9 32 142.7 16.2 ...
## $ Klinik_Evre    : chr "cT3a" "cT2b" "cT3b" "cT3b" ...
## $ Biyopsi_Gleason: chr "3+5" "4+3" "3+5" "4+4" ...
## $ Risk_Grubu     : int 3 2 3 3 2 3 3 3 3 3 ...
## $ Albumin        : num 4.1 4.6 4.1 3.5 4.3 4.2 4.8 4.2 4 4.5 ...
## $ Lenfosit       : int 2227 1168 1125 1623 1399 2103 2038 1418 1936 1348 ...
## $ CRP            : num 0.58 0.12 0.16 1.76 0.53 0.1 0.46 0.27 0.11 0.62 ...
## $ NLR            : num 1.7 1.7 3.5 1.7 2.3 2.2 4 2.8 2.3 1.8 ...
## $ CALLY_Index    : num 1.6 4.5 2.9 0.3 1.1 8.8 2.1 2.2 7 1 ...
## $ Komorbidite_Skor: int 2 0 1 0 2 4 0 2 3 5 ...
## $ Tedavi_Tipi    : int 1 1 4 2 2 2 2 1 1 3 ...
## $ Tedavi_Tarihi  : chr "2023-02-14" "2023-10-08" "2022-01-19" "2022-03-30" ...
## $ RT_Dozu         : num NA NA 70 74 70 70 76 NA NA NA ...
## $ ADT_Tipi        : num NA NA 1 NA NA NA NA NA NA 2 ...
## $ ADT_Suresi      : num NA NA 12 NA NA NA NA NA NA 12 ...
## $ Patolojik_Evre  : chr "pT2c" "pT2a" "" "" ...
## $ Cerrahi_Sinir   : num 0 1 NA NA NA NA NA 1 1 NA ...
## $ Final_Gleason   : chr "3+5" "4+5" "" "" ...
## $ PSA_Nadir        : num 0.14 0.04 0.3 0.2 0.28 0.81 0.36 0.04 0.04 0.39 ...
## $ PSA_Takip_3ay    : num 0.14 0.04 1.03 0.61 0.9 2.38 1.28 0.04 0.05 1.5 ...
## $ PSA_Takip_6ay    : num 0.17 0.04 0.33 0.63 0.38 1.57 0.94 0.04 0.04 0.82 ...
## $ PSA_Takip_12ay   : num 0.21 0.06 0.38 0.71 0.46 4.47 0.56 0.08 0.04 0.39 ...
## $ BCR_Durum        : chr "True" "False" "False" "False" ...
## $ BCR_Tarihi       : chr "2028-01-11" "" "" ...
## $ Metastaz_Durum   : int 0 0 0 0 0 0 0 0 0 0 ...
## $ Metastaz_Tarihi  : logi NA NA NA NA NA NA ...
## $ Son_Durum         : int 1 1 0 1 1 1 1 1 1 1 ...
## $ Son_Takip_Tarihi : chr "2029-05-22" "2029-06-12" "2022-03-05" "2023-11-06" ...
```

```
summary(data)
```

```
##      Hasta_ID          Yas        Tani_Tarihi          PSA_Tani
## Min.   : 0.0   Min.   :50.00   Length:600   Min.   : 2.50
## 1st Qu.:149.8 1st Qu.:62.00   Class  :character 1st Qu.: 18.10
## Median :299.5  Median :67.00   Mode   :character Median : 59.35
## Mean   :299.5  Mean   :67.09   NA's    :100      Mean   : 64.70
## 3rd Qu.:449.2  3rd Qu.:72.00          NA's    :100      3rd Qu.:108.42
## Max.   :599.0   Max.   :85.00          NA's    :100      Max.   :150.00
##
##      Klinik_Evre        Biyopsi_Gleason      Risk_Grubu        Albumin
## Length:600          Length:600          Min.   :1.00   Min.   :3.500
## Class  :character    Class  :character    1st Qu.:2.00   1st Qu.:4.000
## Mode   :character    Mode   :character    Median :3.00   Median :4.200
##                  NA's    :100          Mean   :2.62   Mean   :4.219
##                  NA's    :100          3rd Qu.:3.00   3rd Qu.:4.500
##                  NA's    :100          Max.   :3.00   Max.   :5.000
##
```

```

##      Lenfosit          CRP          NLR          CALLY_Index
##  Min.   :1000   Min.   :0.100   Min.   :1.000   Min.   : 0.200
##  1st Qu.:1561  1st Qu.:0.130  1st Qu.:2.000  1st Qu.: 1.100
##  Median :1834  Median :0.345  Median :2.500  Median : 2.100
##  Mean   :1827  Mean   :0.518  Mean   :2.503  Mean   : 3.346
##  3rd Qu.:2093 3rd Qu.:0.690  3rd Qu.:3.000  3rd Qu.: 5.425
##  Max.   :2936  Max.   :3.590  Max.   :5.000  Max.   :13.000
##
##      Komorbidite_Skor  Tedavi_Tipi  Tedavi_Tarihi        RT_Dozu
##  Min.   :0.000   Min.   :1.000  Length:600   Min.   :70.00
##  1st Qu.:1.000  1st Qu.:1.000  Class  :character  1st Qu.:74.00
##  Median :3.000  Median :2.000  Mode   :character  Median :76.00
##  Mean   :2.515  Mean   :2.005                Mean   :74.63
##  3rd Qu.:4.000  3rd Qu.:3.000                3rd Qu.:76.00
##  Max.   :5.000  Max.   :4.000                Max.   :78.00
##                                NA's   :325
##      ADT_Tipi        ADT_Suresi  Patolojik_Evre  Cerrahi_Sinir
##  Min.   :1.000   Min.   : 6    Length:600   Min.   :0.0000
##  1st Qu.:1.000  1st Qu.:12   Class  :character  1st Qu.:0.0000
##  Median :2.000  Median :24   Mode   :character  Median :0.0000
##  Mean   :2.012  Mean   :21                Mean   :0.4764
##  3rd Qu.:3.000  3rd Qu.:36                3rd Qu.:1.0000
##  Max.   :3.000  Max.   :36                Max.   :1.0000
##  NA's   :436    NA's   :436               NA's   :346
##      Final_Gleason    PSA_Nadir    PSA_Takip_3ay    PSA_Takip_6ay
##  Length:600     Min.   :0.0100  Min.   :0.0100  Min.   :0.0100
##  Class  :character  1st Qu.:0.0400  1st Qu.:0.0500  1st Qu.:0.0700
##  Mode   :character  Median :0.1900  Median :0.7300  Median :0.4700
##                                Mean   :0.2847  Mean   :0.7633  Mean   :0.7016
##                                3rd Qu.:0.4400  3rd Qu.:1.2800  3rd Qu.:0.8925
##                                Max.   :1.0000  Max.   :2.4900  Max.   :2.9900
##
##      PSA_Takip_12ay    BCR_Durum    BCR_Tarihi        Metastaz_Durum
##  Min.   :0.0100  Length:600     Length:600   Min.   :0
##  1st Qu.:0.0800  Class  :character  Class  :character  1st Qu.:0
##  Median :0.4100  Mode   :character  Mode   :character  Median :0
##                                Mean   :0.9256  Mean   :0
##                                3rd Qu.:0.6700  3rd Qu.:0
##                                Max.   :4.9700  Max.   :0
##
##      Metastaz_Tarihi    Son_Durum    Son_Takip_Tarihi
##  Mode:logical   Min.   :0.0000  Length:600
##  NA's:600       1st Qu.:1.0000  Class  :character
##                                Median :1.0000  Mode   :character
##                                Mean   :0.8817
##                                3rd Qu.:1.0000
##                                Max.   :1.0000
##
```

Dataset Variables

Initial Diagnosis

Hasta_ID (Categorical): Patient ID

Yas (Discrete): Age

Tani_Tarihi (Date): Diagnosis Date

PSA_Tani (Continuous): Serum Prostate-Specific Antigen (PSA) level at diagnosis (ng/mL)

Klinik_Evre (Ordinal/Categorical): Clinical cT-Stage determined by pre-treatment examinations (cT1c < cT2a < cT2b < cT2c < cT3a < cT3b for increasing extent of tumor invasion)

Biyopsi_Gleason (Ordinal/Categorical): Biopsy Gleason Score (3+3 < 3+4 < 4+3 < 3+5 < 4+4 < 4+5 < 5+4 < 5+5, higher score indicates higher aggressiveness)

Risk_Grubu (Ordinal/Categorical): Risk Group Classification (1 for Low, 2 for Intermediate, 3 for High)

Risk Factors

Albumin (Continuous): Serum albumin level (g/dL). Indicator of nutritional status and systemic health

Lenfosit (Discrete): Lymphocyte (Immune system component) Count

CRP (Continuous): C-Reactive Protein (mg/L). Indicator of inflammation

NLR (Continuous): Neutrophil-to-Lymphocyte Ratio. A prognostic indicator for systemic inflammation and cancer aggressiveness.

CALLY_Index (Continuous): CALLY Index. A composite index, likely related to inflammation or blood components.

Komorbidite_Skor (Ordinal/Categorical): Comorbidity Score indicating the severity of other co-existing chronic diseases (0 (No comorbidities) < ... < 5 (Severe comorbidities))

Treatment Information

Tedavi_Tipi (Categorical): Main Treatment Type received (1 for Radical Prostatectomy, 2 for Radiotherapy/RT, 3 for Hormone Therapy, 4 for Combination of Radiotherapy and Hormone Therapy)

Tedavi_Tarihi (Date): Treatment Date

RT_Dozu (Continuous): Total Radiation Dose (in Gy), if radiotherapy was performed

ADT_Tipi (Categorical): Androgen Deprivation Therapy (ADT, hormone therapy) Type used

ADT_Suresi (Continuous): ADT(hormone therapy) Duration

Pathological Markers

Patolojik_Evre (Ordinal/Categorical): Final Tumor Pathological Stage determined after surgery on the removed tissue (pT2a < pT2b < pT2c < pT3a < pT3b < pT4, NaN indicates patient did not undergo surgery)

Cerrahi_Sinir (Binary/Categorical): Surgical Margin Status indicating if cancer cells were present at the edge of the removed tissue. Crucial for recurrence prediction (0: Negative, 1: Positive, NaN indicates patient did not undergo surgery).

Final_Gleason (Ordinal/Categorical): Final Gleason Score confirmed from the final excised tissue (3+3 < 3+4 < 4+3 < 3+5 < 4+4 < 4+5 < 5+4 < 5+5, higher score indicates higher aggressiveness)

Follow-up & Outcomes

PSA_Nadir (Continuous): The lowest PSA level reached after treatment (ng/mL). A lower nadir generally indicates better treatment success

PSA_Takip_3ay / 6ay / 12ay (Continuous): Follow-up PSA levels (ng/mL) measured at 3/6/12 Months

BCR_Durum (Binary/Categorical): Biochemical Recurrence (BCR) Status whether the PSA level rise above a recurrence threshold? (True for Recurrence occurred, False for no Recurrence occurred)

BCR_Tarihi (Date): Date when biochemical recurrence was confirmed

Metastaz_Durum (Binary/Categorical): Metastasis Status whether distant metastasis occur during follow-up? (0 for No, 1 for Yes)

Metastaz_Tarihi (Date): Date when metastasis was confirmed

Son_Durum (Binary/Categorical): Patient's Survival Status at the last follow-up (0 for Alive, 1 for Deceased)

Son_Takip_Tarihi (Date): Date of the last recorded patient information.

Data handling 1: Remove variables that we will not use for analysis

```
cols1 <- c("Tani_Tarihi", "Tedavi_Tarihi", "PSA_Takip_3ay", "PSA_Takip_6ay", "PSA_Takip_12ay", "BCR_Tar...  
data <- data[, !names(data) %in% cols1]
```

Data handling 2: Turning all categorical variables to factors

```
cols2 <- c("Klinik_Evre", "Biyopsi_Gleason", "Risk_Grubu", "Komorbidite_Skor", "Tedavi_Tipi", "ADT_Tipi...  
data[cols2] <- lapply(data[cols2], as.factor)  
  
str(data)
```

```
## 'data.frame': 600 obs. of 23 variables:  
## $ Hasta_ID      : int 0 1 2 3 4 5 6 7 8 9 ...  
## $ Yas           : int 59 69 66 59 70 73 72 72 63 57 ...  
## $ PSA_Tani       : num 41.3 12.9 32 142.7 16.2 ...  
## $ Klinik_Evre    : Factor w/ 6 levels "cT1c","cT2a",...: 5 3 6 6 3 6 6 6 5 6 ...  
## $ Biyopsi_Gleason: Factor w/ 9 levels "3+3","3+4","3+5",...: 3 4 3 5 2 8 7 5 6 5 ...  
## $ Risk_Grubu     : Factor w/ 3 levels "1","2","3": 3 2 3 3 2 3 3 3 3 3 ...  
## $ Albumin        : num 4.1 4.6 4.1 3.5 4.3 4.2 4.8 4.2 4 4.5 ...  
## $ Lenfosit       : int 2227 1168 1125 1623 1399 2103 2038 1418 1936 1348 ...  
## $ CRP            : num 0.58 0.12 0.16 1.76 0.53 0.1 0.46 0.27 0.11 0.62 ...  
## $ NLR            : num 1.7 1.7 3.5 1.7 2.3 2.2 4 2.8 2.3 1.8 ...  
## $ CALLY_Index    : num 1.6 4.5 2.9 0.3 1.1 8.8 2.1 2.2 7 1 ...  
## $ Komorbidite_Skor: Factor w/ 6 levels "0","1","2","3",...: 3 1 2 1 3 5 1 3 4 6 ...  
## $ Tedavi_Tipi    : Factor w/ 4 levels "1","2","3","4": 1 1 4 2 2 2 2 1 1 3 ...  
## $ RT_Dozu         : num NA NA 70 74 70 70 76 NA NA NA ...  
## $ ADT_Tipi        : Factor w/ 3 levels "1","2","3": NA NA 1 NA NA NA NA NA 2 ...
```

```

## $ ADT_Suresi      : num  NA NA 12 NA NA NA NA NA NA 12 ...
## $ Patolojik_Evre   : Factor w/ 7 levels "", "pT2a", "pT2b", ... : 4 2 1 1 1 1 1 2 6 1 ...
## $ Cerrahi_Sinir    : Factor w/ 2 levels "0", "1": 1 2 NA NA NA NA 2 2 NA ...
## $ Final_Gleason    : Factor w/ 10 levels "", "3+3", "3+4", ... : 4 7 1 1 1 1 1 7 2 1 ...
## $ PSA_Nadir        : num  0.14 0.04 0.3 0.2 0.28 0.81 0.36 0.04 0.04 0.39 ...
## $ BCR_Durum        : Factor w/ 2 levels "False", "True": 2 1 1 1 1 2 1 1 1 1 ...
## $ Metastaz_Durum   : Factor w/ 1 level "0": 1 1 1 1 1 1 1 1 1 1 ...
## $ Son_Durum        : Factor w/ 2 levels "0", "1": 2 2 1 2 2 2 2 2 2 2 ...

```

Data Visualization 1: Frequency of Treatment Type (Tedavi_Tipi)

```

sum(is.na(data$Tedavi_Tipi))

## [1] 0

table(data$Tedavi_Tipi)

##
##      1     2     3     4
## 254 182  71  93

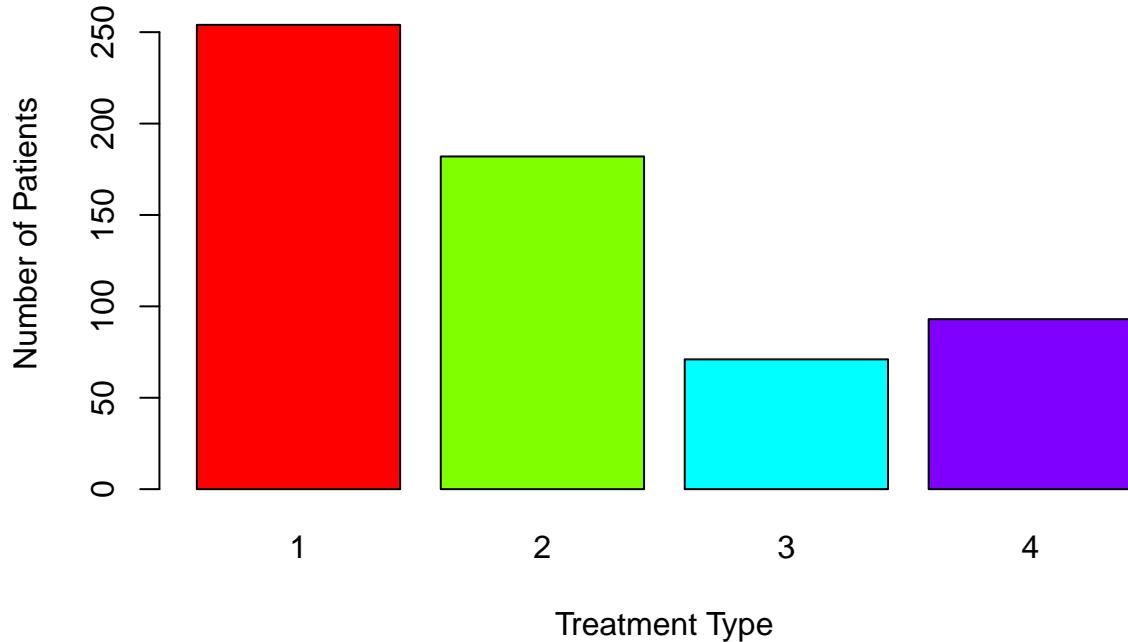
round(prop.table(table(data$Tedavi_Tipi)), 3)

##
##      1     2     3     4
## 0.423 0.303 0.118 0.155

frequencies <- table(data$Tedavi_Tipi)
barplot(
  frequencies,
  main = "Frequency of Treatment Type (Tedavi_Tipi)",
  xlab = "Treatment Type",
  ylab = "Number of Patients",
  col = rainbow(4),
  ylim = c(0, max(frequencies) * 1.1)
)

```

Frequency of Treatment Type (Tedavi_Tipi)



Data Visualization 2: Frequency of Biochemical Recurrence Status (BCR_Durum)

```
sum(is.na(data$BCR_Durum))

## [1] 0

table(data$BCR_Durum)

##
##  False  True 
##  416   184

round(prop.table(table(data$BCR_Durum)), 3)

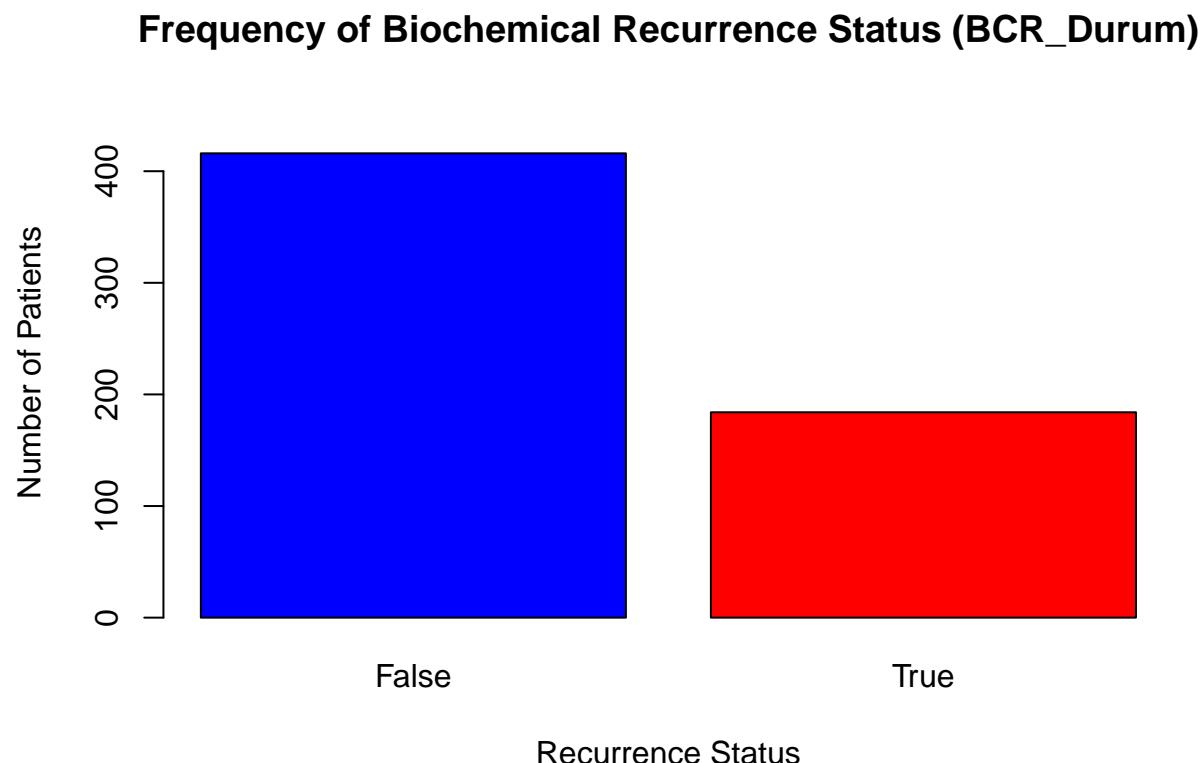
##
##  False  True 
##  0.693 0.307

frequencies <- table(data$BCR_Durum)
barplot(
  frequencies,
```

```

main = "Frequency of Biochemical Recurrence Status (BCR_Durum)",
xlab = "Recurrence Status",
ylab = "Number of Patients",
col = c("blue", "red"),
ylim = c(0, max(frequencies) * 1.1)
)

```



Data Visualization 3: Frequency of Survival Status (Son_Durum)

```

sum(is.na(data$Son_Durum))

## [1] 0

table(data$Son_Durum)

##
##    0    1
##   71 529

round(prop.table(table(data$Son_Durum)), 3)

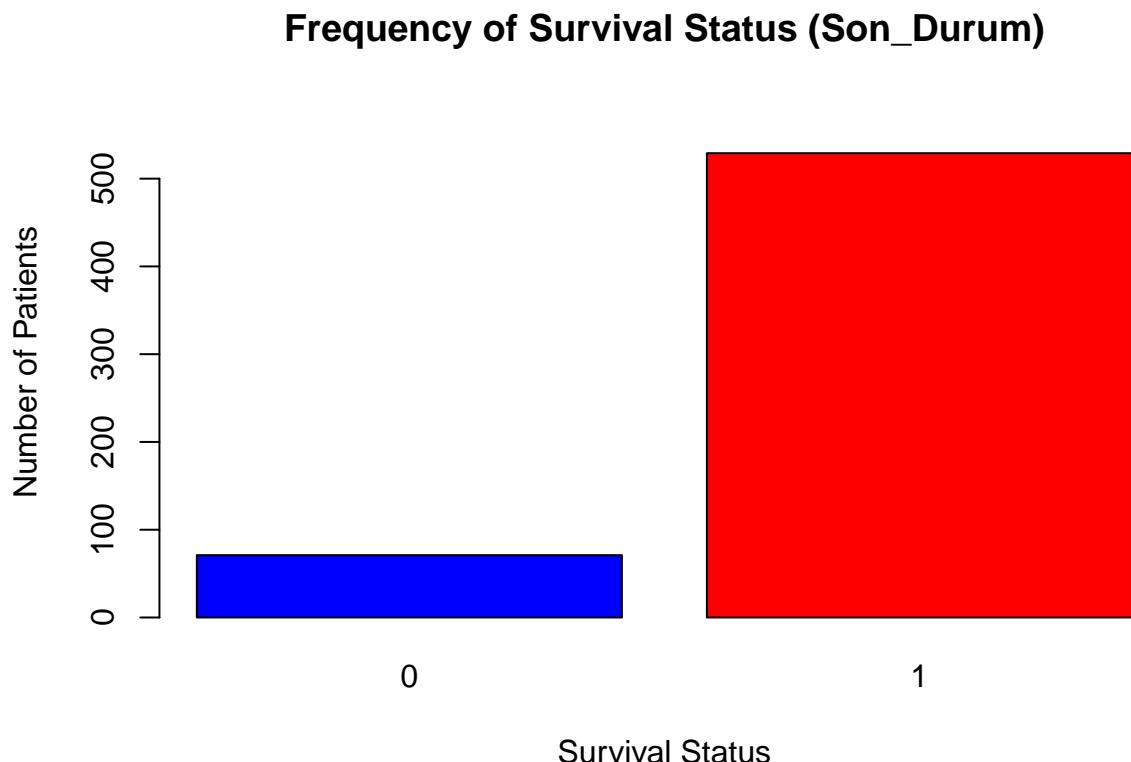
```

```

##          0          1
## 0.118 0.882

frequencies <- table(data$Son_Durum)
barplot(
  frequencies,
  main = "Frequency of Survival Status (Son_Durum)",
  xlab = "Survival Status",
  ylab = "Number of Patients",
  col = c("blue", "red"),
  ylim = c(0, max(frequencies) * 1.1)
)

```



Data Visualization 4: Serum Prostate-Specific Antigen (PSA) level at diagnosis & after treatment

```

PSA <- c("PSA_Tani", "PSA_Nadir")
sapply(data[, PSA], function(x) sum(is.na(x)))

```

```

##  PSA_Tani  PSA_Nadir
##          0          0

```

```

summary(data[, PSA])

##      PSA_Tani      PSA_Nadir
##  Min.   :  2.50   Min.   :0.0100
##  1st Qu.: 18.10   1st Qu.:0.0400
##  Median : 59.35   Median :0.1900
##  Mean   : 64.70   Mean   :0.2847
##  3rd Qu.:108.42   3rd Qu.:0.4400
##  Max.   :150.00   Max.   :1.0000

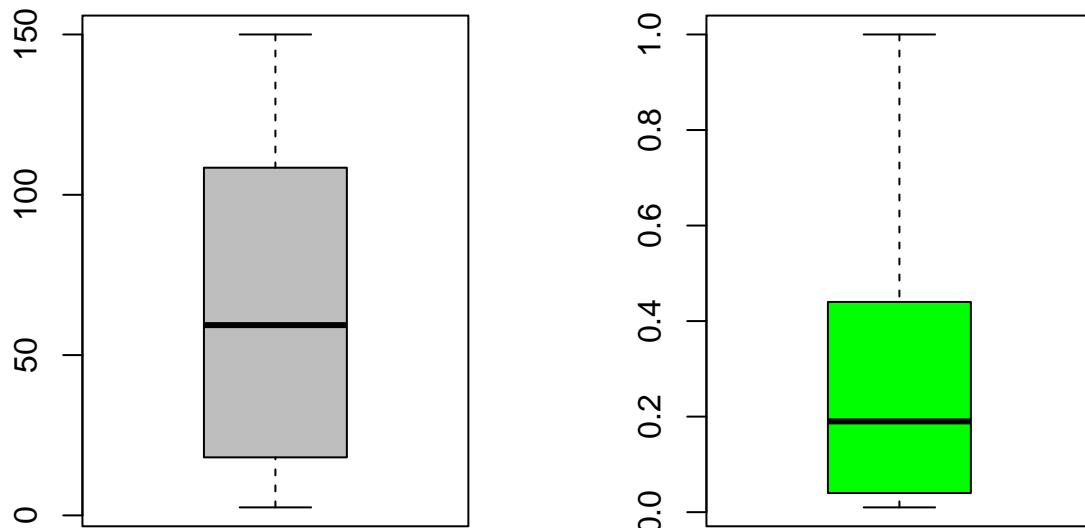
par(mfrow = c(1, 2))

boxplot(data[["PSA_Tani"]],
        main = "Box Plot of PSA level at diagnosis",
        col = "grey")

boxplot(data[["PSA_Nadir"]],
        main = "Box Plot of PSA level after treatment",
        col = "green")

```

Box Plot of PSA level at diagnosis **Box Plot of PSA level after treatment**



Data Visualization 5: Summary & Boxplots of Risk Factors

```

risk_factors <- c("Albumin", "Lenfosit", "CRP", "NLR", "CALLY_Index", "Komorbidite_Skor")
sapply(data[, risk_factors], function(x) sum(is.na(x)))

##          Albumin        Lenfosit         CRP         NLR
##            0              0            0            0
##    CALLY_Index Komorbidite_Skor
##            0              0

summary(data[, risk_factors])

##      Albumin        Lenfosit         CRP         NLR
##  Min.   :3.500  Min.   :1000  Min.   :0.100  Min.   :1.000
##  1st Qu.:4.000  1st Qu.:1561  1st Qu.:0.130  1st Qu.:2.000
##  Median  :4.200  Median  :1834  Median  :0.345  Median  :2.500
##  Mean    :4.219  Mean    :1827  Mean    :0.518  Mean    :2.503
##  3rd Qu.:4.500  3rd Qu.:2093  3rd Qu.:0.690  3rd Qu.:3.000
##  Max.    :5.000  Max.    :2936  Max.    :3.590  Max.    :5.000
##      CALLY_Index Komorbidite_Skor
##  Min.   : 0.200  0:100
##  1st Qu.: 1.100  1:101
##  Median  : 2.100  2: 87
##  Mean    : 3.346  3:102
##  3rd Qu.: 5.425  4:122
##  Max.    :13.000  5: 88

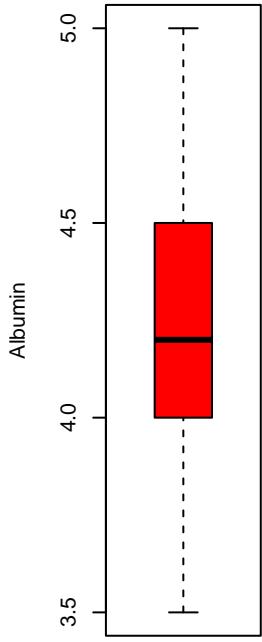
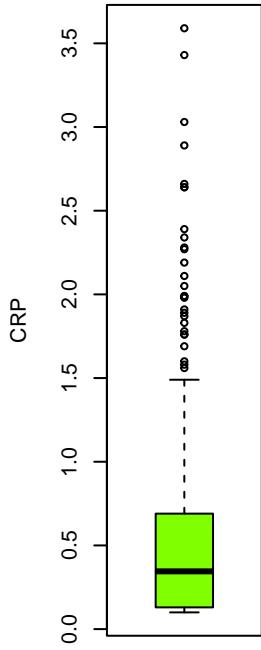
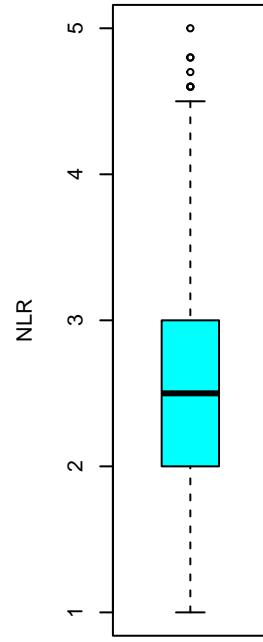
continuous_risks <- c("Albumin", "CRP", "NLR", "CALLY_Index")
plot_colors <- rainbow(4)

par(mfrow = c(1, 4))

for (i in 1:length(continuous_risks)) {
  var_name <- continuous_risks[i]
  var_data <- data[[var_name]]

  boxplot(var_data,
          main = paste("Box Plot of", var_name),
          ylab = var_name,
          col = plot_colors[i])
}

```

Box Plot of Albumin**Box Plot of CRP****Box Plot of NLR****Box Plot of CALLY_Index**