QBS177_FINAL PROJECT

Data Exploration and Visualization-Parinitha Kompala, PCA-Xing Cheng,Kmenas- Avani Kuthe,Heirac

2/25/2022

This data set contains 31 clinical attributes, m-RNA levels z-score for 331 genes, and mutation in 175 genes for 1904 breast cancer patients. Here, we just used the clinical variables of the data set. Clinical attributes in the dataset have 31 variables.

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.1.1     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
RNA_Mutation<-read.csv("/Users/parinithakompala/Desktop/QBS177/METABRIC_RNA_Mutation.csv")#reading the
```

```
RNA_Mutation_updated<- RNA_Mutation[ -c(0,521:693) ] #removing all the mutation columns for better anal
```

```
#(is.na(RNA_Mutation_updated))#checking for NA
str(RNA_Mutation_updated)
```

```
## 'data.frame':    1904 obs. of  520 variables:
##  $ patient_id                    : int  0 2 5 6 8 10 14 22 28 35 ...
##  $ age_at_diagnosis              : num  75.7 43.2 48.9 47.7 77 ...
##  $ type_of_breast_surgery        : chr  "MASTECTOMY" "BREAST CONSERVING" "MASTECTOMY" "MASTECTOMY" .
##  $ cancer_type                   : chr  "Breast Cancer" "Breast Cancer" "Breast Cancer" "Breast Canc
##  $ cancer_type_detailed          : chr  "Breast Invasive Ductal Carcinoma" "Breast Invasive Ductal Ca
##  $ cellularity                   : chr  "" "High" "High" "Moderate" ...
##  $ chemotherapy                  : int  0 0 1 1 1 0 1 0 0 0 ...
##  $ pam50_._claudin.low_subtype   : chr  "claudin-low" "LumA" "LumB" "LumB" ...
##  $ cohort                        : num  1 1 1 1 1 1 1 1 1 1 ...
##  $ er_status_measured_by_ihc     : chr  "Positve" "Positve" "Positve" "Positve" ...
##  $ er_status                     : chr  "Positive" "Positive" "Positive" "Positive" ...
##  $ neoplasm_histologic_grade     : num  3 3 2 2 3 3 2 2 3 2 ...
##  $ her2_status_measured_by_snp6  : chr  "NEUTRAL" "NEUTRAL" "NEUTRAL" "NEUTRAL" ...
##  $ her2_status                   : chr  "Negative" "Negative" "Negative" "Negative" ...
##  $ tumor_other_histologic_subtype: chr  "Ductal/NST" "Ductal/NST" "Ductal/NST" "Mixed" ...
##  $ hormone_therapy               : int  1 1 1 1 1 1 1 1 1 0 ...
##  $ inferred_menopausal_state     : chr  "Post" "Pre" "Pre" "Pre" ...
##  $ integrative_cluster           : chr  "4ER+" "4ER+" "3" "9" ...
##  $ primary_tumor_laterality      : chr  "Right" "Right" "Right" "Right" ...
##  $ lymph_nodes_examined_positive : num  10 0 1 3 8 0 1 1 1 0 ...
```

```
##  $ mutation_count                : num  NA 2 2 1 2 4 4 1 4 5 ...
##  $ nottingham_prognostic_index   : num  6.04 4.02 4.03 4.05 6.08 ...
##  $ oncotree_code                 : chr  "IDC" "IDC" "IDC" "MDLC" ...
##  $ overall_survival_months       : num  140.5 84.6 163.7 164.9 41.4 ...
##  $ overall_survival              : int  1 1 0 1 0 0 1 0 0 0 ...
##  $ pr_status                     : chr  "Negative" "Positive" "Positive" "Positive" ...
##  $ radio_therapy                 : int  1 1 0 1 1 1 1 1 1 0 ...
##  $ X3.gene_classifier_subtype    : chr  "ER-/HER2-" "ER+/HER2- High Prolif" "" "" ...
##  $ tumor_size                    : num  22 10 15 25 40 31 10 29 16 28 ...
##  $ tumor_stage                   : num  2 1 2 2 2 4 2 2 2 2 ...
##  $ death_from_cancer             : chr  "Living" "Living" "Died of Disease" "Living" ...
##  $ brca1                         : num  -1.399 -1.38 0.067 0.674 1.293 ...
##  $ brca2                         : num  -0.574 0.278 -0.843 -0.543 -0.904 ...
##  $ palb2                         : num  -1.622 -1.215 0.211 -1.659 -0.722 ...
##  $ pten                          : num  1.452 0.53 -0.333 0.637 0.217 ...
##  $ tp53                          : num  0.3504 -0.0136 0.5141 1.6708 0.3484 ...
##  $ atm                           : num  1.1517 -0.2659 -0.0803 -0.888 0.3897 ...
##  $ cdh1                          : num  0.0348 1.3594 1.1398 1.2491 0.9131 ...
##  $ chek2                         : num  0.127 0.796 0.419 -1.189 0.936 ...
##  $ nbn                           : num  -0.836 0.542 -0.403 -0.417 0.767 ...
##  $ nf1                           : num  -0.858 -2.606 -1.131 -0.617 -0.294 ...
##  $ stk11                         : num  -0.429 0.512 0.236 1.008 -0.296 ...
##  $ bard1                         : num  -1.12 0.439 -0.172 -0.401 0.632 ...
##  $ mlh1                          : num  -0.484 1.227 -1.791 -1.391 -0.358 ...
##  $ msh2                          : num  -0.748 0.761 3.095 4.88 0.303 ...
##  $ msh6                          : num  -1.666 0.1821 0.6608 0.0615 0.8747 ...
##  $ pms2                          : num  -0.125 1.01 2.613 2.941 0.632 ...
##  $ epcam                         : num  -0.372 0.56 2.555 4.116 0.335 ...
##  $ rad51c                        : num  -0.6508 -0.4018 -0.0391 -0.3098 -0.2652 ...
##  $ rad51d                        : num  -0.128 -0.291 -0.442 -1.347 -0.154 ...
##  $ rad50                         : num  1.733 0.744 1.453 1.21 -0.763 ...
##  $ rb1                           : num  -0.277 -1.749 1.414 1.534 1.016 ...
##  $ rbl1                          : num  -1.067 0.46 0.314 -0.635 1.9 ...
##  $ rbl2                          : num  0.0615 0.7835 -0.0662 0.7279 0.6618 ...
##  $ ccna1                         : num  0.1034 -0.269 -0.5558 0.0219 -0.7454 ...
##  $ ccnb1                         : num  -1.663 -0.272 0.697 1.88 0.286 ...
##  $ cdk1                          : num  -2.0649 0.3895 1.2949 0.0476 1.1035 ...
##  $ ccne1                         : num  -1.339 -0.627 -0.124 -0.665 -1.051 ...
##  $ cdk2                          : num  -0.621 0.181 -0.111 -1.446 1.542 ...
##  $ cdc25a                        : num  -1.731 -1.264 -0.392 -0.383 1.217 ...
##  $ ccnd1                         : num  -0.806 1.106 -1.275 -0.454 0.117 ...
##  $ cdk4                          : num  -1.104 0.411 -0.531 -1.525 1.765 ...
##  $ cdk6                          : num  0.0744 -0.604 0.2585 0.3689 0.8892 ...
##  $ ccnd2                         : num  1.4313 0.0546 0.8958 1.1455 -1.0195 ...
##  $ cdkn2a                        : num  -0.5785 0.2754 -0.227 0.0432 0.3664 ...
##  $ cdkn2b                        : num  1.218 -0.0952 1.1899 1.0868 0.7145 ...
##  $ myc                           : num  2.56 0.725 -0.721 -0.524 0.522 ...
##  $ cdkn1a                        : num  2.315 0.439 1.483 0.212 1.564 ...
##  $ cdkn1b                        : num  -0.249 1.876 3.07 3.462 0.156 ...
##  $ e2f1                          : num  0.16 -1.898 2.225 0.461 -0.267 ...
##  $ e2f2                          : num  -1.88 -0.333 -1.486 -1.54 0.451 ...
##  $ e2f3                          : num  -1.363 -1.456 -0.413 -0.212 -0.445 ...
##  $ e2f4                          : num  0.199 1.001 -0.833 -0.833 -0.318 ...
##  $ e2f5                          : num  -0.0907 0.0519 0.2885 1.8323 2.2129 ...
```

```
##  $ e2f6                          : num  -0.117 -0.379 -0.35 0.387 1.106 ...
##  $ e2f7                          : num  -1.392 -0.491 -0.355 1.343 -0.065 ...
##  $ e2f8                          : num  -0.8178 -1.3693 0.0908 0.0409 1.4216 ...
##  $ src                           : num  -1.074 -0.33 -0.718 -0.38 0.972 ...
##  $ jak1                          : num  1.1097 0.9804 1.5835 0.6194 0.0461 ...
##  $ jak2                          : num  1.6186 -0.0104 0.7379 0.8552 0.1645 ...
##  $ stat1                         : num  0.0413 -1.194 -0.8346 0.3317 0.2677 ...
##  $ stat2                         : num  -0.756 -0.799 -1.349 -0.551 0.331 ...
##  $ stat3                         : num  0.977 -0.843 -0.224 -1.24 -0.505 ...
##  $ stat5a                        : num  3.9189 -0.4983 0.0434 -0.8535 -0.3295 ...
##  $ stat5b                        : num  2.5773 -1.3251 -1.0832 -0.0195 -0.4278 ...
##  $ mdm2                          : num  0.3126 0.8803 -0.8822 0.2551 -0.0063 ...
##  $ tp53bp1                       : num  -0.627 -1.592 0.759 -1.006 0.106 ...
##  $ adam10                        : num  -0.532 -1.267 2.036 1.466 0.938 ...
##  $ adam17                        : num  0.872 -0.201 -1.123 -1.049 -0.238 ...
##  $ aph1a                         : num  0.002 1.313 3.133 2.365 0.123 ...
##  $ aph1b                         : num  -0.0098 0.688 -0.4959 -1.2458 0.369 ...
##  $ arrdc1                        : num  -1.465 1.337 -1.06 1.492 0.922 ...
##  $ cir1                          : num  -0.275 1.591 1.674 2.644 0.202 ...
##  $ ctbp1                         : num  -1.102 1.193 -2.269 -0.727 -0.877 ...
##  $ ctbp2                         : num  0.841 0.301 0.24 -0.462 1.85 ...
##  $ cul1                          : num  0.447 -0.411 0.162 0.193 -0.684 ...
##  $ dll1                          : num  0.631 -1.548 -1.044 0.448 -1.216 ...
##  $ dll3                          : num  -0.507 -0.158 0.949 1.611 -0.821 ...
##  $ dll4                          : num  1.693 -0.101 -1.746 -0.592 0.276 ...
##   [list output truncated]
```

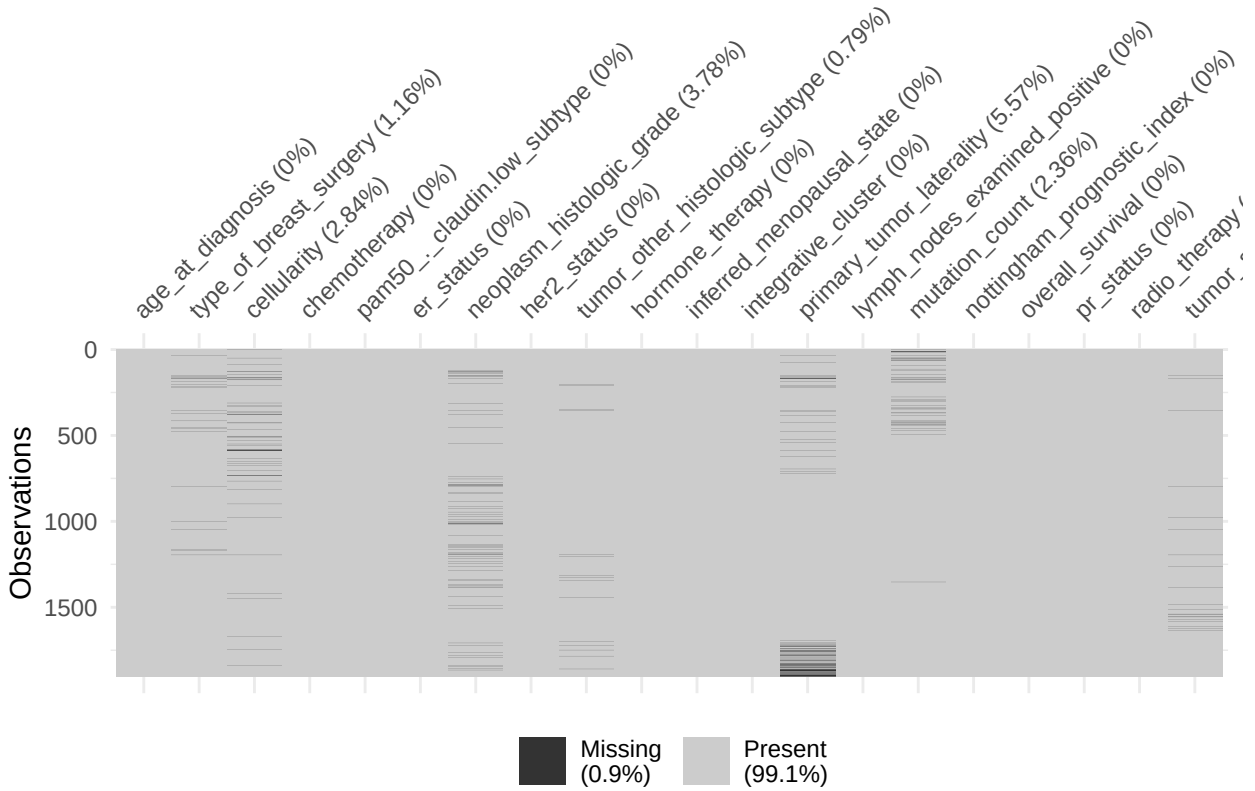
```
#To replace " " with  NA
RNA_Mutation_updated[RNA_Mutation_updated == ""] <- NA
```

```
# To change character variables to factor
RNA_Mutation_updated$type_of_breast_surgery <- as.factor(RNA_Mutation_updated$type_of_breast_surgery)
RNA_Mutation_updated$cellularity <- as.factor(RNA_Mutation_updated$cellularity);
RNA_Mutation_updated$chemotherapy <- as.factor(RNA_Mutation_updated$chemotherapy)
RNA_Mutation_updated$pam50_._claudin.low_subtype <- as.factor(RNA_Mutation_updated$pam50_._claudin.low_s
RNA_Mutation_updated$er_status <- as.factor(RNA_Mutation_updated$er_status);
RNA_Mutation_updated$neoplasm_histologic_grade <- as.factor(RNA_Mutation_updated$neoplasm_histologic_gra
RNA_Mutation_updated$her2_status <- as.factor(RNA_Mutation_updated$her2_status);
RNA_Mutation_updated$tumor_other_histologic_subtype <- as.factor(RNA_Mutation_updated$tumor_other_histol
RNA_Mutation_updated$hormone_therapy <- as.factor(RNA_Mutation_updated$hormone_therapy);
RNA_Mutation_updated$inferred_menopausal_state<- as.factor(RNA_Mutation_updated$inferred_menopausal_sta
RNA_Mutation_updated$integrative_cluster<- as.factor(RNA_Mutation_updated$integrative_cluster );
RNA_Mutation_updated$primary_tumor_laterality<- as.factor(RNA_Mutation_updated$primary_tumor_laterality
RNA_Mutation_updated$pr_status<- as.factor(RNA_Mutation_updated$pr_status);
RNA_Mutation_updated$radio_therapy <- as.factor(RNA_Mutation_updated$radio_therapy)
RNA_Mutation_updated$overall_survival<- as.factor(RNA_Mutation_updated$overall_survival);
```

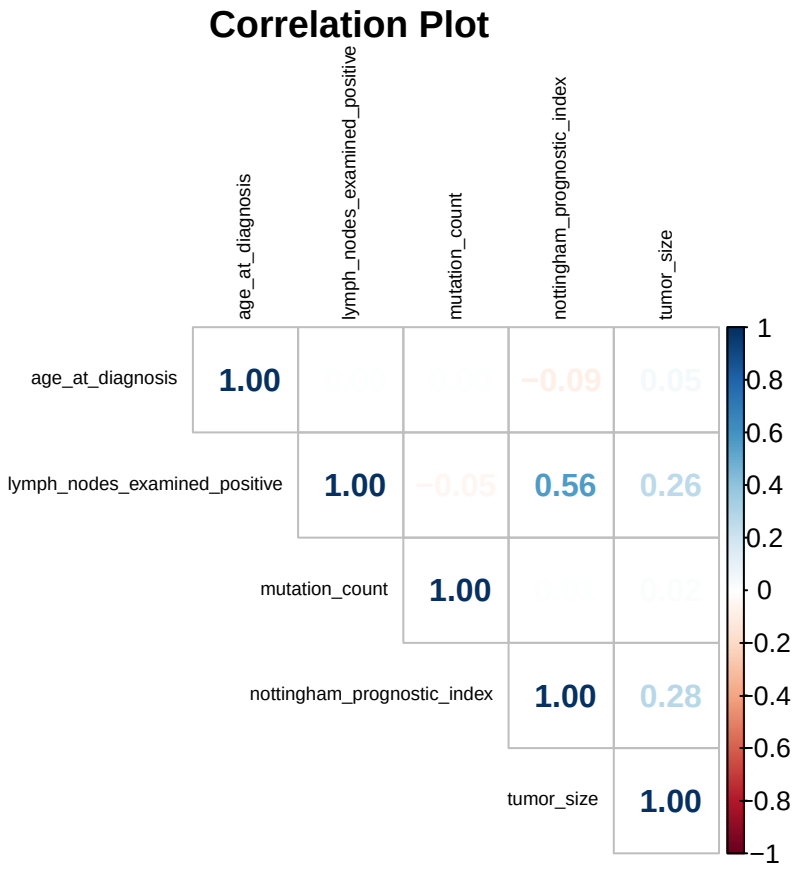
```
# exploring numeric data
# To remove Redundant  column
RNA_Mutation_updated$patient_id <- NULL
RNA_Mutation_updated$cancer_type <- NULL
RNA_Mutation_updated$death_from_cancer <- NULL
RNA_Mutation_updated$cancer_type_detailed <- NULL
RNA_Mutation_updated$oncotree_code <- NULL
RNA_Mutation_updated$cohort <- NULL
```

```
RNA_Mutation_updated$tumor_stage <- NULL
RNA_Mutation_updated$overall_survival_months  <- NULL
RNA_Mutation_updated$X3.gene_classifier_subtype  <- NULL
RNA_Mutation_updated$er_status_measured_by_ihc  <- NULL
RNA_Mutation_updated$her2_status_measured_by_snp6  <- NULL


clinical<-RNA_Mutation_updated[, c(1:20)]    # To make clinical data set
```

```
library(visdat)

clinical %>%
  visdat::vis_miss()
```




```
clinical_n <- select_if(clinical, is.numeric)
corrmatrix <- cor(clinical_n)



clinical_n<-clinical_n[complete.cases(clinical_n),]

corrmatrix <- cor(clinical_n)

corrplot::corrplot(corrmatrix, method="number", type = "upper",tl.cex=.6
, tl.col="black", title="Correlation Plot",number.font = 2, mar=c(0,0,1,0), )
```




```
library(ggformula)
```

```
## Loading required package: ggstance
```

```
##
## Attaching package: 'ggstance'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     geom_errorbarh, GeomErrorbarh
```

```
## Loading required package: scales
```

```
##
## Attaching package: 'scales'
```

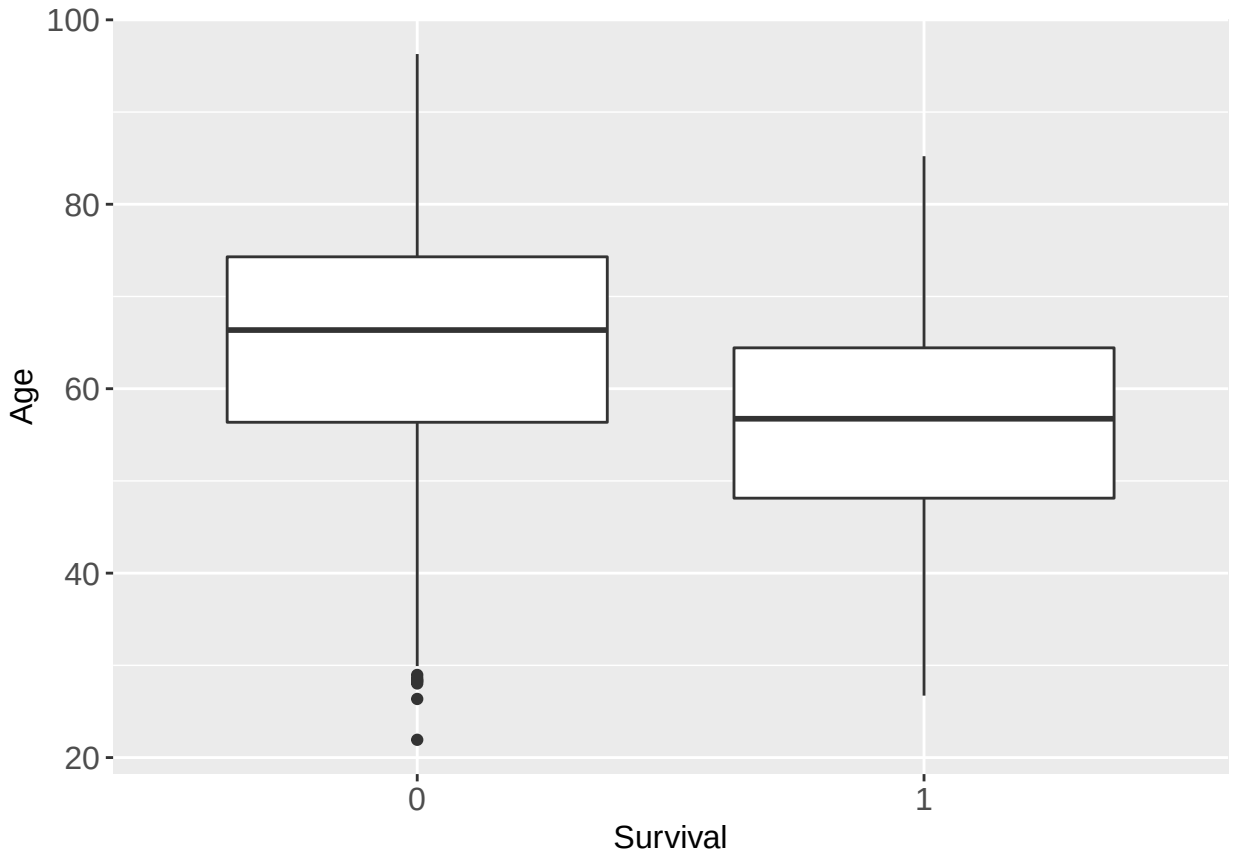
```
## The following object is masked from 'package:purrr':
##
##     discard
```

```
## The following object is masked from 'package:readr':
##
##     col_factor
```

```
## Loading required package: ggridges
```

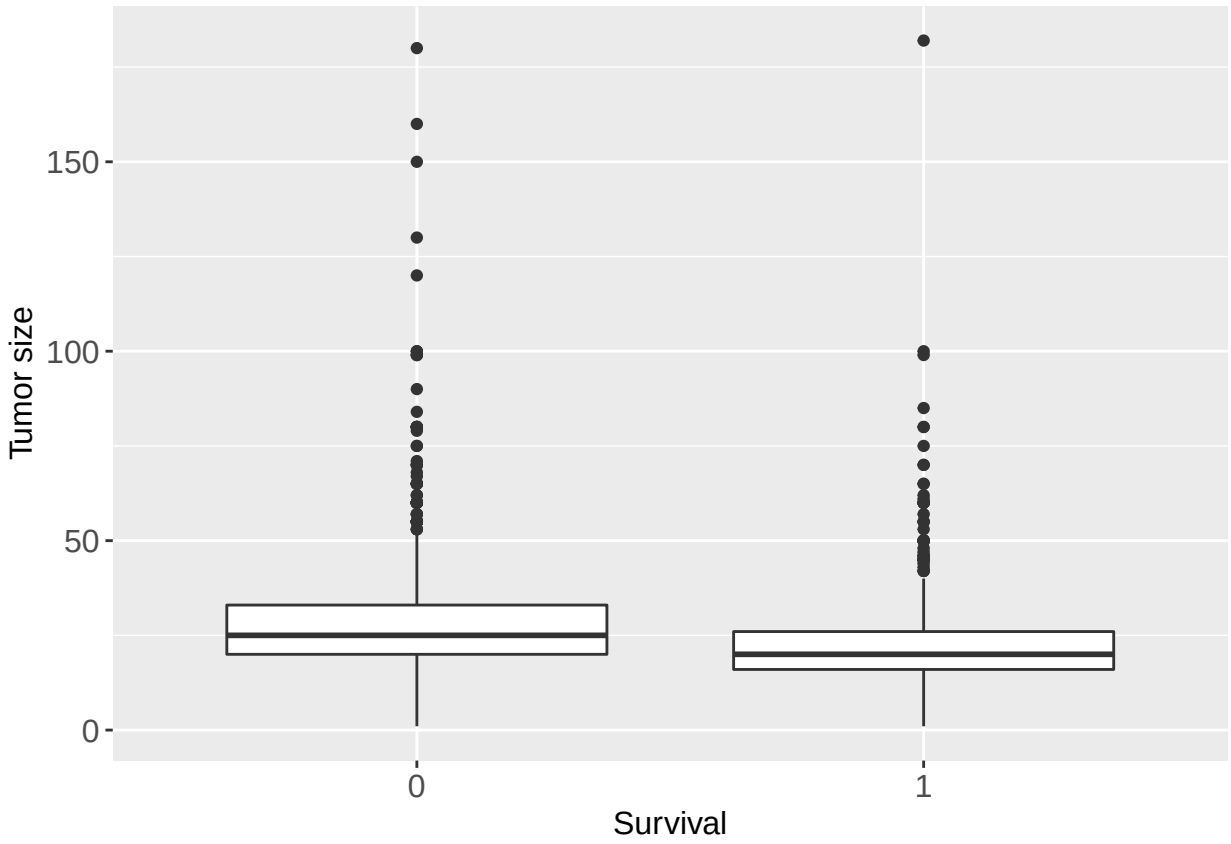
```
##
## New to ggformula?  Try the tutorials:
##  learnr::run_tutorial("introduction", package = "ggformula")
##  learnr::run_tutorial("refining", package = "ggformula")
```

```
clinical %>% gf_boxplot(age_at_diagnosis~overall_survival) %>%
  gf_labs(x = "Survival",
    y = "Age") %>%
  gf_theme(axis.text = element_text(size = 12),
           axis.title = element_text(size = 12),
         legend.title=element_text(size=14),
    legend.text=element_text(size=9))
```




```
clinical %>% gf_boxplot(tumor_size~overall_survival) %>%
  gf_labs(x = "Survival",
    y = "Tumor size") %>%
  gf_theme(axis.text = element_text(size = 12),
           axis.title = element_text(size = 12),
         legend.title=element_text(size=14),
    legend.text=element_text(size=9))
```

```
## Warning: Removed 20 rows containing non-finite values (stat_boxplot).
```



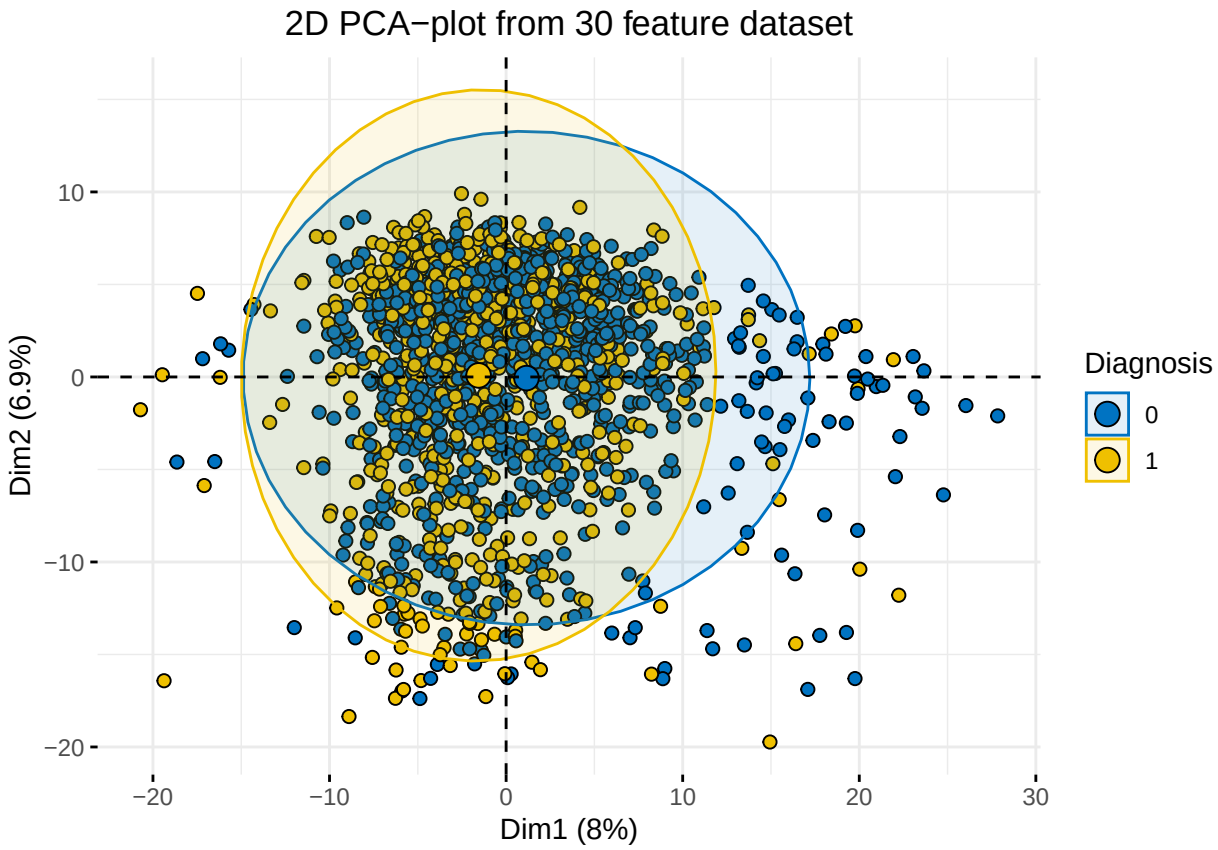

```
data.nona=RNA_Mutation_updated[complete.cases(RNA_Mutation_updated),] #delete all rows with any NA
genes=data.nona[,21:509] #subset gene columns
```

```
#PCA analysis
pca=prcomp(genes,scale=TRUE)
#summary(pca)
```

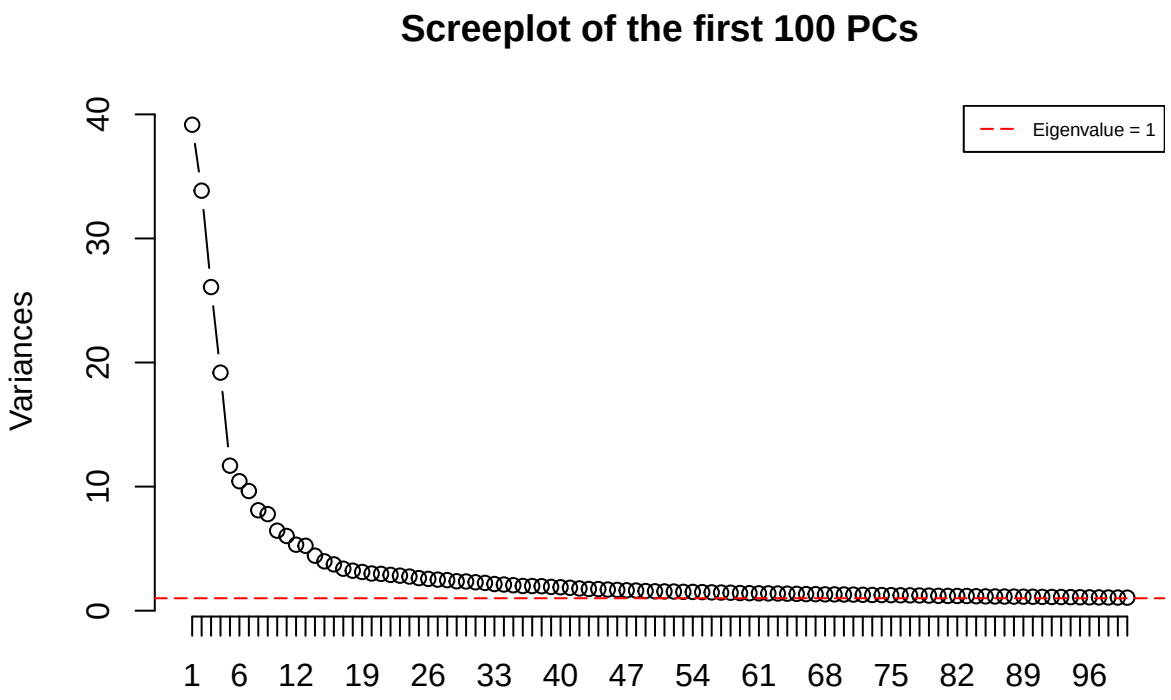
```
#install.packages("factoextra")
library(factoextra)
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

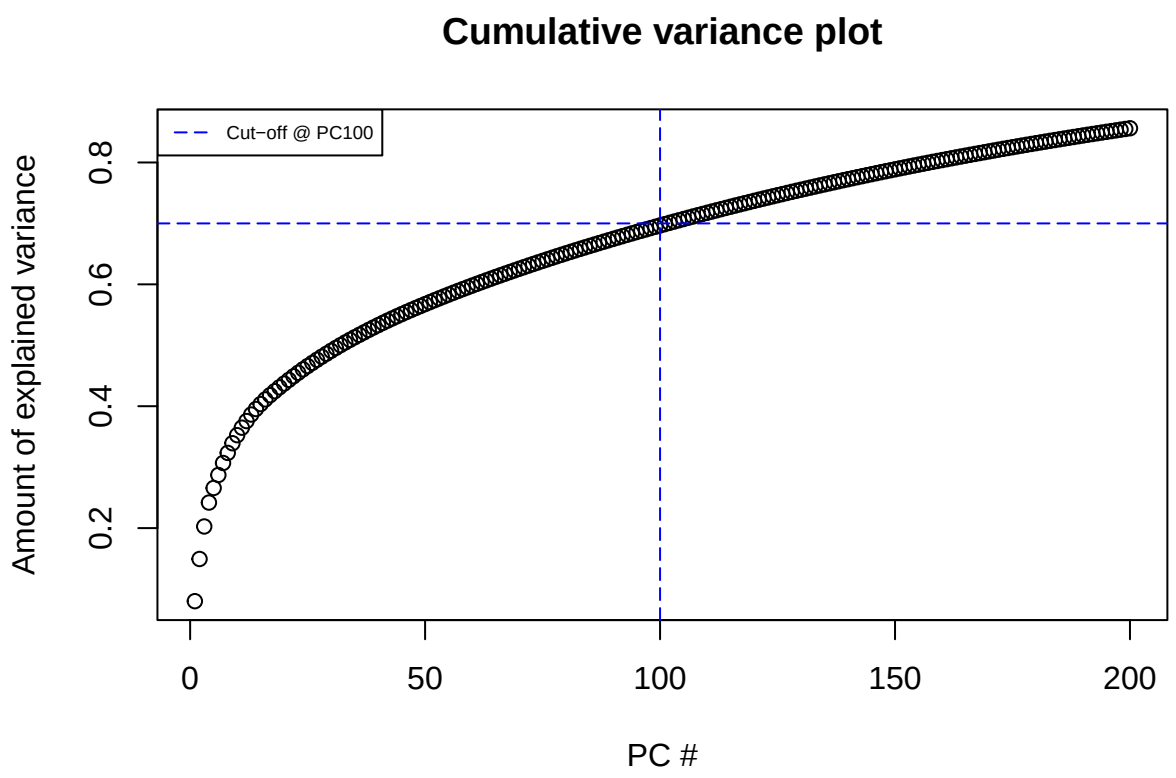
```
fviz_pca_ind(pca, geom.ind = "point", pointshape = 21,
             pointsize = 2,
             fill.ind = data.nona$overall_survival,
             col.ind = "black",
             palette = "jco",
             addEllipses = TRUE,
             label = "var",
             col.var = "black",
             repel = TRUE,
             legend.title = "Diagnosis") +
  ggtitle("2D PCA-plot from 30 feature dataset") +
  theme(plot.title = element_text(hjust = 0.5))
```




```
library(ggplot2)
screeplot(pca, type = "l", npcs = 100, main = "Screeplot of the first 100 PCs")
abline(h = 1, col="red", lty=5)
legend("topright", legend=c("Eigenvalue = 1"),
       col=c("red"), lty=5, cex=0.6)
```



```
cumpro <- cumsum(pca$sdev^2/sum(pca$sdev^2))
plot(cumpro[0:200], xlab = "PC #", ylab = "Amount of explained variance", main = "Cumulative variance pl
abline(v = 100, col="blue", lty=5)
abline(h = 0.7, col="blue", lty=5)
legend("topleft", legend=c("Cut-off @ PC100"),
       col=c("blue"), lty=5, cex=0.6)
```




```
comp=data.frame(pca$x[,1:100]) #retain the first 100 principal components
cluster.data=cbind(data.nona[,1:20],comp) #dataset for cluster analysis
```

K-Means Cluster Analysis

```
#looking purely at gene expression subset of the data - numeric values for kmeans clustering
kvars <- paste("PC", 1:100, sep = "")
k.df <- cluster.data[kvars]
#head(k.df)
```

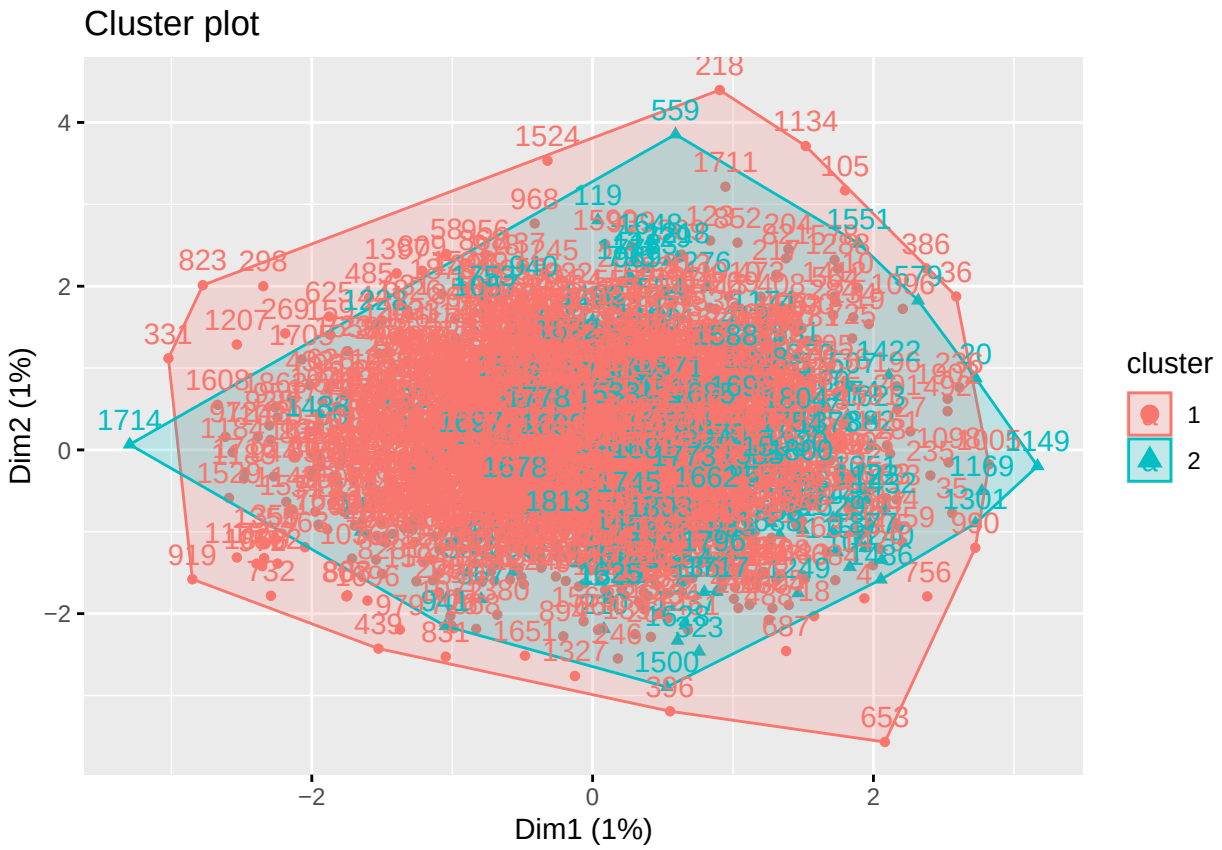
```
#scale the data - no dependency to arbitrary variable unit
k.df <- scale(k.df)
#head(k.df)
```

```
#euclidean distance
k.dist <- get_dist(k.df)
#k.dist
```

```
k.check <- kmeans(k.df, centers = 2, nstart = 25)
#k.check
```

Two clusters gives clusters with sizes 205 and 1403

```
fviz_cluster(k.check, data = k.df)
```



Starting with two clusters, we can see there is serious overlap in clusters. There is no clear division. We can find optimal cluster number with log-elbow method

```
#compute total within cluster sum of squares
set.seed(429)
wss <- function(k) {
  kmeans(k.df, k, nstart = 10 )$tot.withinss
}

#consider 1 to 100 clusters
kc.vals <- 1:100

#extract within cluster sum of squares for all number of clusters
wss.vals <- map_dbl(kc.vals, wss)
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

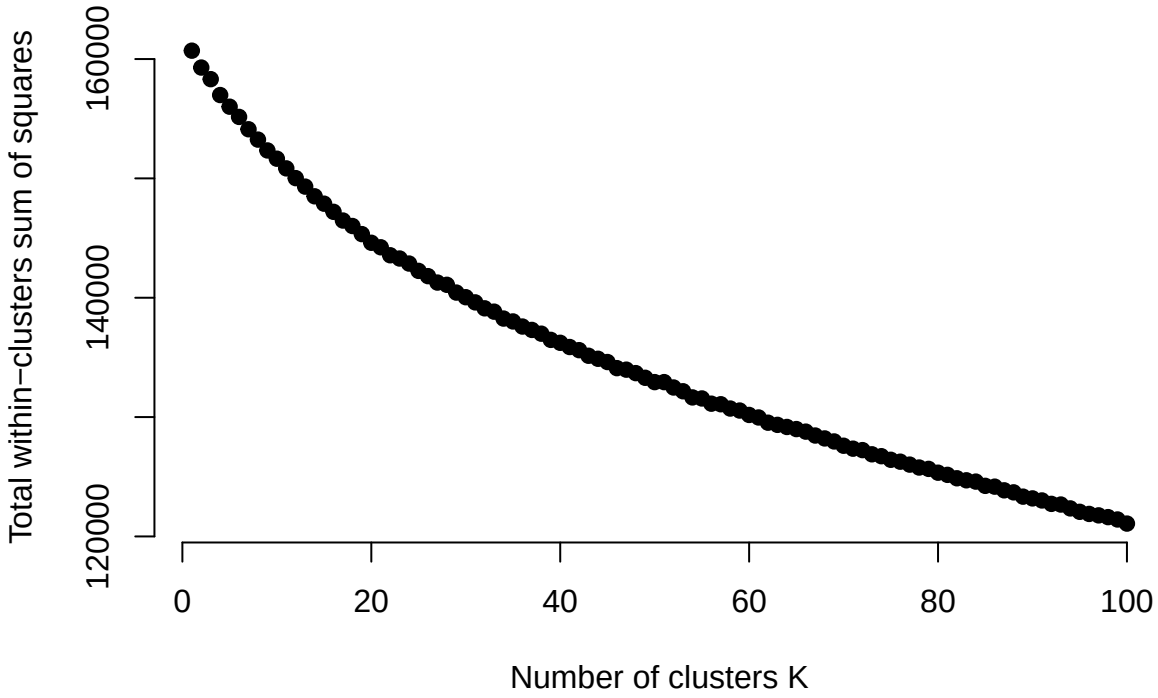
```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

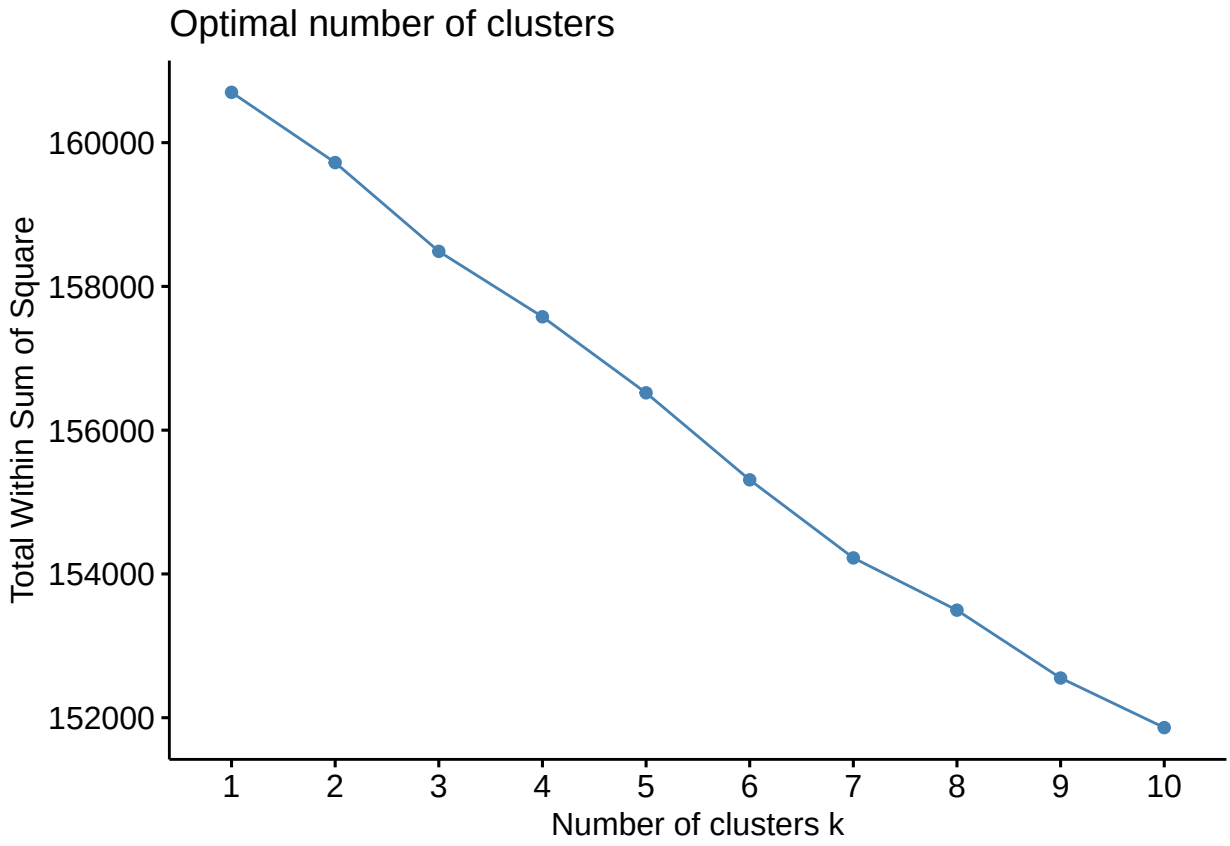
```
#plot log-elbow method
plot(kc.vals, wss.vals,
       type="b", pch = 19, frame = FALSE,
       xlab="Number of clusters K",
       ylab="Total within-clusters sum of squares")
```



We can say about 20 clusters looking at this. We can double check as well. From here we can move onto the optimal model

```
set.seed(429)

fviz_nbclust(k.df, kmeans, method = "wss")
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```




```
set.seed(429)
k.fin <- kmeans(k.df, 20, nstart = 25)
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations

## Warning: did not converge in 10 iterations
```

```
k.fin
```

```
## K-means clustering with 20 clusters of sizes 113, 168, 125, 17, 51, 105, 131, 100, 33, 45, 67, 15, 2
##
## Cluster means:
##             PC1         PC2          PC3          PC4          PC5         PC6
## 1  -0.159401375 -0.72905351 -0.253570661  0.146945197  0.947674847 -0.14752010
## 2   0.354612381  0.48801472  0.022993690 -0.016902101  0.134391082 -0.45336079
## 3   0.191558559  0.20376114  1.238933064  0.380364971  0.123937075  0.29040407
## 4   0.369109652 -0.79539113  0.169420104  0.073704508  0.477225609  0.38035709
## 5   2.896263114 -0.69961899 -0.605362405 -1.637788696  0.396646018  1.32339356
## 6  -0.352133739  0.81691058 -0.691615860  0.027552778 -0.498156454  0.61289062
## 7   0.230950217  0.85100763  0.301324573  0.228028729 -0.129233754  0.02985072
## 8  -0.218291964 -0.46480429 -0.715422030  0.185807742 -0.714860062  0.93352915
## 9  -0.493612950 -2.01773658 -0.004662949  0.467100944 -1.128835021 -0.23486334
## 10  0.284511533  0.75561382  0.761936986  0.078108297 -0.772627022  0.75375178
## 11 -0.595918862 -0.05201161 -0.144294640 -1.516215288  0.346093694  0.01279563
## 12 -2.581412763 -0.30332740  1.700174762 -4.403566400 -0.771131132  0.49666368
## 13 -0.501686566 -1.92703817  0.032809649  0.178781255 -1.448368657 -0.68389461
## 14 -0.520059974  0.56716363 -0.979970695 -0.023862414 -1.050502390  0.03133982
## 15  0.008019155 -0.11754706  0.340285069 -0.009063371  0.824302419 -0.48657113
## 16 -0.275213074 -2.05875070 -0.119534070  0.605585887 -0.805972970 -0.46770617
## 17 -0.415634210  0.44632193 -0.321654245  0.158492129  0.554894507 -0.36854485
## 18  0.301561871  0.64932976  0.239725265  0.176375484 -0.221269464 -0.46212133
## 19  0.350810414  0.06761348  0.716950680  0.302907388 -0.004488924 -0.32926488
## 20 -0.349407823 -0.57045675 -0.562719124  0.241366236  1.246163286  0.54927079
##             PC7         PC8           PC9         PC10        PC11         PC12
## 1   0.07881138  0.90901349  0.7228768176  0.44317898  0.4467268  0.57229703
## 2  -0.49583375  0.46857468  0.1412710397 -0.20804430  0.0291441  0.00940605
## 3   0.34543227 -0.63815262  0.3051796150 -0.10294468 -0.2994196 -0.06655065
## 4   0.86217023 -0.02510473  0.5944332951  0.45847934  0.4973931 -0.50718078
## 5   0.07299396 -0.28232149 -0.6853011580  0.20990402 -0.8115455 -0.97349250
## 6   0.04216167 -0.25765144 -0.0973682249  0.38462485 -0.3730947  0.15246398
## 7  -0.17422103  0.55325388 -0.5351263306 -0.49107728  0.8853158 -0.49271627
## 8   0.54544260  0.06850670  1.3938593637 -0.86658580  0.2748795 -0.20516491
```

```
## 9  -0.62897852 -0.13518380 -1.1517392915 -0.53853442 -0.1292969 -0.48739608
## 10 -0.42488566 -0.51288247 -1.0333333665 -0.24312531  1.6970553  0.41034193
## 11  0.22358310 -0.59735454 -0.7869754247 -0.18719917  0.3813121  1.32128106
## 12  0.47777297 -0.23323910  0.3172465517 -0.31821585 -0.2333481  0.42532896
## 13 -0.67950865 -0.11432644 -0.9204601307  0.63854330 -0.4819928 -0.14516959
## 14 -0.07041441  0.13435228  0.0979367594  1.19672096 -0.3719588  0.01804877
## 15  0.44534076 -0.41003334  0.3051763986 -0.08623085 -0.1714673 -0.05840051
## 16 -0.33055401  0.14350998 -0.7650548402  0.09558910 -0.1334638 -0.16012341
## 17 -0.12627334 -0.22847666  0.0001128549 -0.11343117 -0.5894351 -0.52534710
## 18 -0.10843286  0.79835145 -0.5718441860 -0.43615746 -0.7213417  0.06743697
## 19  0.14845293 -1.58209246  0.5843444989  0.76168194  0.2503491  0.36788879
## 20  0.35740272  1.57520231  0.0617544758  1.12568406  0.7739261  1.84423195
##           PC13        PC14        PC15        PC16         PC17         PC18
## 1  -0.20076937  0.03760660 -0.35346553  0.05228020  0.091389824  0.005344044
## 2   0.17668264  0.30514698  0.28412557 -0.30511946 -0.305259168 -0.287734868
## 3  -0.10459960  0.12245287  0.68509225  0.27474603  0.341976519 -0.083759232
## 4  -0.21034731  0.23247893  0.48538397 -0.17587228  0.647215547  0.024532303
## 5  -0.18623529 -0.40305702 -0.12888594 -0.33569531  0.151060580  0.209888239
## 6   0.26138576  0.30258124  0.66957993 -0.10556795  0.013477025  0.012784369
## 7  -0.10967534 -0.39026040  0.22564169 -0.25921872  0.107448675  0.522721758
## 8   0.34958326 -0.42713152 -0.26757784  0.08866775 -0.161252326 -0.043215770
## 9   0.14906241  0.10475440 -0.21661232 -0.41843170 -0.162547415 -0.448826412
## 10 -1.53514783 -0.16701581 -1.24579419  0.05153295 -1.019045065 -0.400751880
## 11  1.15020992 -0.09615291 -0.05056124  0.42754455 -0.732597426  0.299832547
## 12 -1.97377138 -0.43312747  1.51326044 -1.53987055  1.247569720 -0.487668722
## 13 -0.30722402  0.04948656 -0.21426336 -0.51554324  0.454210076  0.398248897
## 14 -0.04125328  0.33275833 -0.24798585 -0.08178679  0.176282451  0.432921107
## 15 -0.12274446  0.14834194  0.19238921 -0.24902164  0.199773543  0.256587534
## 16  0.11143775  0.07602646  0.29884766  0.01252252 -0.084694296 -0.124327372
## 17  0.17896222 -0.28334330 -0.15670772  0.23883581 -0.133757361  0.029845076
## 18  0.23159233  0.10999041 -0.58931062  0.70099386  0.317715315 -0.691710268
## 19 -0.19201529 -0.20067698 -1.37496211  0.13436429  0.294917412 -0.302768354
## 20 -1.01746228  0.91129953  0.32027504  0.79319555 -0.006955924  0.095165957
##          PC19         PC20         PC21        PC22        PC23        PC24
## 1   0.3502125 -0.350005451  0.000346309 -0.01738007 -0.12070171  0.55449482
## 2  -0.3889281  0.086788046  0.108803997 -0.34652025 -0.07683111  0.06289767
## 3  -0.2333183  0.235676520  0.255242514 -0.25668068  0.07776220  0.07568046
## 4  -0.0920786 -0.687756657 -0.014123771  0.04944049 -0.53003844 -0.18011655
## 5   0.2423945 -0.153246761  0.135772116 -0.38888986 -0.06886257 -0.21639889
## 6   0.3903801  0.512731992 -0.019398344  0.22273250  0.06679988  0.37447932
## 7   0.3828259  0.004642981  0.131961664  0.39514070  0.07001439 -0.03599291
## 8  -0.1354404  0.248820435  0.061938895 -0.11717396  0.28909647  0.04579135
## 9  -0.3015770  0.363614143  0.610010112  0.38278694  0.57223054 -1.04225242
## 10  0.7444000 -0.191070798 -0.246406649 -0.20930276  0.06165109  0.66613005
## 11 -0.5317299 -0.932944077 -0.683381360 -0.03279526  0.41309002 -0.16160892
## 12 -0.2904499 -0.424155149  0.308106030 -0.13283180 -2.02273646 -0.51015260
## 13 -0.1595156 -0.201163743  0.372421179  0.93845225  0.96800466  0.87007003
## 14 -0.3062581 -0.451007769 -0.004571833 -0.08749829  0.16646386 -0.28744512
## 15  0.1224769 -0.212370217 -0.440282194  0.21607333  0.37421799  0.20376402
## 16 -0.1055137  0.270177877 -0.500950210 -0.31832279 -0.65158661  0.27938244
## 17 -0.1617563  0.090166296  0.043367220  0.08223813 -0.31306273 -0.18389137
## 18  0.3885305 -0.343008052  0.238897083 -0.14708277 -0.14293682 -0.21214695
## 19 -0.4178647  0.181499539 -0.156078656  0.33353914  0.01452609 -0.54297758
## 20  1.0404585  1.418919752  0.880364021  0.23503567 -0.05601606 -1.82638633
```

```
##           PC25        PC26         PC27        PC28        PC29        PC30
## 1   0.06233861 -0.20177277  0.005494171  0.45547268  0.10314016 -0.19540730
## 2   0.02979452  0.16670702  0.179505248 -0.06757032  0.01224886 -0.31568723
## 3  -0.10908442  0.06067247  0.089484460 -0.30125447  0.20378650  0.04465585
## 4  -0.25719899  0.25985784 -0.371897268  0.65366278  0.74644652  0.45105976
## 5  -0.32682721 -0.31929748 -0.163211265  0.20693966 -0.19569921  0.06614594
## 6   0.12655607 -0.10461236  0.621060631  0.48382208 -0.24888299 -0.02862691
## 7  -0.04819016 -0.23341117 -0.352880311 -0.16275235 -0.36657823  0.35861017
## 8   0.29351737  0.03156494 -0.240276615  0.05870004  0.11925260 -0.17133947
## 9  -0.51722780 -0.04115477 -0.594055427  0.04976032 -0.66857266 -0.70276932
## 10 -0.47451643  0.19617828  0.710837287 -0.70811530  0.41955566 -0.28122876
## 11  1.05566525 -0.03965200  0.188459465 -0.16761773  0.11475690  0.44021508
## 12 -0.64974184 -0.58064414 -1.309413765  0.84025478 -0.00861170 -1.25829967
## 13  1.22008248  1.01610588 -1.279819799 -0.14814541  0.25910416  1.69711407
## 14 -0.66212477 -0.25034449 -0.249037083 -0.29915633  0.95859929  0.11538854
## 15  0.00362014  0.24031898 -0.176424917 -0.18393526 -0.10672241 -0.04028091
## 16 -0.16229441 -0.16018121  0.642134809 -0.18552660 -0.31552850  0.01544319
## 17 -0.16214460  0.12236603  0.015337967 -0.02532875 -0.01045095 -0.10963329
## 18  0.50664265  0.07981441 -0.309843117  0.67698385  0.29733851  0.19186782
## 19 -0.15176570 -0.23629843  0.300463346  0.08786877 -0.57952267 -0.27537479
## 20 -0.16648650  0.25554759 -0.277565228 -0.57751407 -0.18140424  1.03321745
##            PC31         PC32        PC33         PC34        PC35          PC36
## 1  -0.028993985  0.137620612 -0.46071229  0.01089805 -0.24235240  0.049070338
## 2  -0.040583781 -0.009123084  0.08296171  0.16953235  0.47309462  0.145598756
## 3   0.399419823  0.360683748  0.16997084  0.20851075 -0.08750926  0.003773005
## 4   0.073598510 -1.157435377  0.54216520  0.98671411  0.42258258 -0.027017430
## 5   0.228411086 -0.052421439 -0.01994763  0.33353605 -0.67143707  0.112373733
## 6  -0.200004576  0.113890448 -0.49037143 -0.21382366  0.26177997  0.184105057
## 7   0.158804747  0.023752637  0.27276555 -0.03513693 -0.08854412 -0.085787010
## 8  -0.167107348 -0.141779691  0.26420437  0.08181813  0.04934581  0.133092903
## 9  -0.572820510  1.816163272 -0.27360754  0.13311068  0.73377692 -0.655920494
## 10 -1.087235843 -0.343957897 -0.21394438 -0.17902074  0.14610377 -0.253696369
## 11  0.459566464  0.477315317  0.55056890 -0.46465507 -0.17764857 -0.369186727
## 12  0.198839942  0.530431068 -0.30024389  0.52719602  0.73995644  1.099924073
## 13  0.002992077 -0.687469777 -0.68789837  0.83543506  0.42357883  1.048413835
## 14  0.225390949 -0.174767128  0.21239828  0.21701936 -0.20967177 -0.481307299
## 15 -0.492138405 -0.072103001 -0.02617451 -0.09850989  0.06180526 -0.324173367
## 16  0.214807430 -0.477089155  0.40391799 -0.21496873 -0.51086883  0.031791902
## 17  0.131459543 -0.061731727 -0.21868780  0.03205905 -0.14242196  0.074977937
## 18 -0.007329232 -0.446388499 -0.11632133 -0.08043030 -0.19543649 -0.231286830
## 19  0.009237010 -0.447577590 -0.28164299 -0.51787553  0.49260255  0.333264825
## 20  0.029570039  1.007712409  0.63665681 -0.61003453 -0.65735317  0.416726083
##           PC37         PC38         PC39        PC40        PC41         PC42
## 1  -0.24247360  0.035002170  0.380241940  0.09871508  0.22130910 -0.16938626
## 2   0.31531700  0.035241799 -0.153793050 -0.11037325 -0.21500081  0.01994678
## 3  -0.43981200 -0.315993243  0.515098448 -0.09403113 -0.07767025 -0.11603224
## 4  -1.30990865  0.149869020 -0.326774162 -0.86523005 -0.04362145  0.88403094
## 5   0.03340093  0.598156977  0.121482830 -0.36389339 -0.24798193 -0.11110087
## 6  -0.20334573  0.292655091 -0.172768977  0.15824375  0.08156266 -0.11204409
## 7   0.12312388 -0.262273437 -0.123679961  0.28109900  0.16763681  0.13013356
## 8  -0.00131631  0.142357102 -0.003348719 -0.01674138  0.21650304 -0.03139636
## 9   0.05670320  0.192347016  0.086045958 -0.16815685  1.14111040 -0.04609971
## 10 -0.44051098  0.240602158  0.546232648  0.08298641 -0.31663113  0.16827657
## 11 -0.20014801 -0.166798207 -0.164119443  0.10350535  0.26624800  0.29601482
```

```
## 12  0.81790386  0.474518034 -0.036783075  0.55879417  0.17805920 -0.80283802
## 13 -0.65919425  0.434714116  0.300207354 -0.49566202 -1.32204165 -0.89052259
## 14  0.09457966 -0.453586334  0.177218172 -0.45733171  0.27988758  0.24626118
## 15  0.23690168 -0.004374513 -0.324136978 -0.22215066  0.10852419 -0.10157154
## 16  0.18940041 -0.391275879 -0.108402234  0.51704135 -0.17812735  0.27651038
## 17 -0.20584996  0.044577363 -0.059676474  0.59564744 -0.36362359 -0.00256442
## 18  0.51096475 -0.215714590  0.063520746 -0.63802375  0.21338852 -0.42103948
## 19  0.36991151  0.342221229 -0.395531521 -0.46393149  0.35420542  0.20880016
## 20  0.45595978  0.511935219 -0.175188491 -0.17263835 -0.85158435  0.54697366
##            PC43        PC44         PC45         PC46         PC47        PC48
## 1  -0.247734518  0.29260136  0.107728043 -0.027983995  0.132973265  0.17141923
## 2   0.094779459 -0.05682700 -0.001800546 -0.292341141  0.001750859 -0.12077866
## 3  -0.146612801  0.23522336  0.032451026 -0.298176779  0.011803245 -0.06499841
## 4   0.169537895 -0.68149124 -0.752117237 -0.838273131  0.705594242  0.51154322
## 5  -0.039953901 -0.30463232  0.206449039  0.096282104 -0.235948575 -0.14222084
## 6   0.246473934  0.03136304  0.030242660  0.211973348  0.194398447 -0.15171089
## 7   0.301006609  0.38822045 -0.167634488  0.005862347 -0.026060072  0.11884088
## 8   0.121765949  0.10184179  0.328499682  0.074703593 -0.123666606 -0.04961027
## 9  -0.169602022  0.17387258  1.073392843  0.230783669  0.210137981 -0.18871751
## 10 -0.533105756 -0.39667673 -0.052497073 -0.248760917  0.307695655 -0.22616022
## 11  0.191610055  0.20509058  0.016321408 -0.367028212  0.147436839  0.19759552
## 12 -0.614853745 -0.60677701 -0.717494217 -0.071896297 -0.646762481  0.90530759
## 13  0.446334239  0.02054519 -0.084200616 -0.643691895  0.005720572 -0.09626481
## 14 -0.143589484  0.04114168 -0.298041734 -0.022884605 -0.061691547  0.04969395
## 15  0.163351156 -0.20269723 -0.413183004  0.072637785  0.002073078 -0.13953800
## 16 -0.053805530  0.16204642 -0.149909551  0.277945083 -0.087080841 -0.16593338
## 17 -0.269634692 -0.32011307  0.176382038  0.072703900  0.003632899  0.18095827
## 18  0.002151941 -0.04670276 -0.176877128  0.555941000 -0.289354657 -0.10160526
## 19  0.165057330  0.06279197  0.221204288  0.210870436 -0.118666691  0.13492807
## 20 -0.143762783 -0.79119716  0.175215122  0.625953132 -0.098633141  0.02123048
##            PC49         PC50          PC51         PC52         PC53        PC54
## 1   0.05722440 -0.086416091  0.3511298804 -0.022319126 -0.013601105  0.20651466
## 2  -0.04028942 -0.046033022 -0.0176961847 -0.128090068  0.135981516  0.08063513
## 3  -0.02451363 -0.452213543  0.0512581584 -0.004460399  0.063896986 -0.08647734
## 4  -0.81360537  0.988582659 -1.4021773789  0.235866627 -1.407180049 -1.06763105
## 5   0.34990076  0.028183385 -0.0015759500  0.194721119  0.038078128 -0.04907482
## 6  -0.05961773  0.385299621 -0.2494012000  0.364632199  0.037155067  0.10913782
## 7   0.17353380  0.166920223  0.1402869098  0.022092870 -0.161649151  0.31964613
## 8  -0.07270022  0.005911615  0.0007872413 -0.308328903  0.093038981 -0.01820721
## 9   0.67034434 -0.486572912 -0.7633814854  0.218133885 -0.080931865 -0.83947797
## 10 -0.21997096 -0.145142066  0.0031441992  0.135621683  0.105758668 -0.05863838
## 11  0.08531866  0.315486738  0.0597100748 -0.324356425 -0.045556900 -0.10922780
## 12 -0.78387942  0.271054645  0.4370210714 -0.222305890  0.564166632  0.03838014
## 13 -0.02609487  0.745764966  0.8221383786 -0.599414757  0.320587723 -0.28865553
## 14  0.28578708 -0.395263527  0.0742488124  0.190857424  0.163696410 -0.08774758
## 15  0.12410609  0.296503440 -0.3480378157  0.221840473 -0.041666111 -0.02095335
## 16 -0.28527673 -0.234969869 -0.2923875677  0.347939669 -0.079977274  0.64774565
## 17 -0.21133941 -0.032225448 -0.1220434909 -0.206392492  0.007617446 -0.23219937
## 18  0.04873288 -0.137355303  0.4057766415 -0.015213962 -0.094704531 -0.28764575
## 19 -0.11988951  0.057160511  0.3823348780 -0.012629141 -0.194043048  0.40897352
## 20  0.39745466 -0.141665551  0.3086494536 -0.225725802  0.085223223 -0.86089086
##            PC55        PC56        PC57          PC58       PC59        PC60
## 1  -0.005920011 -0.21406599 -0.22718084 -0.3572740418 -0.1649682 -0.15847168
## 2  -0.194942005 -0.09773960 -0.21617669 -0.1364930207  0.1078194 -0.20980029
```

```
## 3  -0.017671848 -0.05233993  0.18939876 -0.2418146706  0.2005643 -0.09133525
## 4   1.136023894 -1.46452269 -1.35729023 -0.6348191488  0.4298157  0.09362802
## 5  -0.281089225  0.12812854  0.06988066  0.0523797740  0.1021370 -0.08888706
## 6   0.043270543 -0.11098689 -0.35027766  0.0009583132  0.2662183  0.07609362
## 7   0.312928866 -0.12715691  0.08820419  0.0836724320 -0.2140266 -0.04524788
## 8  -0.204655181 -0.04831680  0.09916894  0.2006651198  0.2424532  0.11953979
## 9  -0.163348597 -0.40326105 -0.18065946  0.0044835465 -0.4015098  0.04031055
## 10 -0.198152984  0.16069256 -0.03021853  0.2254643801  0.1710806  0.16799197
## 11 -0.009726881 -0.26840339 -0.06591404  0.0612804193 -0.2940315 -0.11606063
## 12  0.737587590 -0.03548595  0.12885481  0.3660945645 -0.4222118  0.30251056
## 13  0.189030191  0.76611268  0.17639524  0.1072326183 -0.1956913 -0.12342774
## 14 -0.126256846  0.16927167 -0.06221278 -0.1751704573 -0.3680249 -0.07358071
## 15  0.008396370  0.14371715  0.16340344  0.0449692291  0.2167154  0.25327021
## 16  0.166880974  0.01743415  0.11018011  0.2654778947 -0.0900634 -0.27541657
## 17 -0.091264380  0.14025822  0.31126653  0.2594453369 -0.1091478  0.09215514
## 18  0.099284375  0.10841453  0.05923637  0.0552108911  0.1912126  0.48535964
## 19  0.092359613  0.33318281 -0.20390077 -0.3460232030 -0.3717305 -0.12033196
## 20  0.034262101  0.65637977  0.38992562  0.2995729438  0.4452204  0.22894140
##            PC61         PC62         PC63        PC64         PC65         PC66
## 1   0.270192437 -0.109451769 -0.096191498 -0.19912310  0.156296091 -0.151349537
## 2   0.016210022 -0.132119403  0.072126075 -0.04036042  0.226980060  0.048840336
## 3  -0.002486045  0.312071708  0.064870497  0.29071437  0.006550897  0.345444292
## 4  -0.886426259 -0.496706773  0.078169643  0.88413021 -0.092971912 -0.643755323
## 5  -0.227527159 -0.193227975  0.096025781 -0.18453291  0.070144479 -0.113920314
## 6  -0.049018307  0.338114135 -0.052437955 -0.08646847 -0.070075286 -0.130082229
## 7  -0.178729559 -0.178747397 -0.060065202  0.13291740  0.002321961 -0.200369048
## 8   0.105896881 -0.036074935  0.015117596 -0.02311756 -0.045442946  0.150450579
## 9   0.264736677 -0.599074249 -0.004432551  0.04932368 -0.640639943 -0.379174890
## 10 -0.023440603 -0.232565585 -0.043790446 -0.12708127 -0.093120777 -0.009757199
## 11 -0.095273305  0.265209518  0.205795750  0.18598381  0.150194398 -0.022965514
## 12  0.213682169  0.253643950 -0.746435660 -0.18184599 -0.053151041 -0.465134566
## 13 -0.066495445 -0.056043839 -0.354588099  0.24352769  0.270589755 -0.072144296
## 14 -0.088724889  0.003410295  0.009191240 -0.02649207  0.050904579  0.185532657
## 15  0.077520422 -0.170862209 -0.041799768 -0.25748801 -0.189848206  0.171220613
## 16  0.166087409  0.274274108  0.094181800  0.05154063 -0.046637009  0.376517908
## 17 -0.042031194 -0.092845763 -0.016663498 -0.10334688  0.021830785 -0.258403298
## 18  0.193170006  0.569836723  0.101053838 -0.02395701 -0.518114637  0.057045900
## 19 -0.008286518 -0.054213263 -0.063645821  0.09396875  0.063888233 -0.028720067
## 20 -0.487732535 -0.317893258  0.038240346  0.37634438  0.504054257  0.174830586
##            PC67        PC68        PC69        PC70        PC71         PC72
## 1  -0.082618470 -0.03825689 -0.10950024 -0.09941520 -0.20404180 -0.071739068
## 2  -0.003248534  0.24018000 -0.04466465  0.17075553 -0.02184463 -0.027411547
## 3  -0.049206429 -0.15605813 -0.13417871  0.17098152 -0.04041255 -0.204347148
## 4  -1.431186173 -0.41141914 -0.67039436 -1.33182904 -0.05258386 -0.036259799
## 5   0.205715908  0.09966576  0.00448427  0.08529577 -0.12439676  0.188910781
## 6   0.005134019 -0.18056179  0.05269502  0.26600571 -0.01857745  0.224939419
## 7  -0.034595064  0.05729019 -0.03728532  0.05196501  0.13190475 -0.036902110
## 8   0.082487553 -0.07305080  0.20949259 -0.18633474  0.15625627 -0.230466449
## 9   0.341693631 -0.64513637 -0.11319872  0.29259475  0.10106536 -0.471375831
## 10 -0.019590119 -0.29452811 -0.39874686 -0.25027057 -0.38240603  0.219800343
## 11  0.184619584 -0.25474104 -0.18837246  0.13404281 -0.06536437  0.009445049
## 12  0.043196223 -0.57842427 -0.08800106  0.20997466 -0.47958141  0.447229799
## 13  0.483885666  0.80248934  0.26674252  0.13933153 -0.15285096 -0.306562284
## 14 -0.235598046  0.21220835  0.11490653 -0.31469181 -0.14938449 -0.242030981
```

```
## 15 -0.100924156  0.06085871  0.62905753 -0.18150782  0.08457021  0.211888910
## 16 -0.225832163 -0.05407595  0.06287011  0.02542395  0.03566844  0.314634706
## 17  0.307538533 -0.07945281 -0.09678909 -0.19039455  0.07530983  0.011685729
## 18 -0.213134532 -0.07654916 -0.23926754 -0.07693673  0.25671789  0.219513037
## 19 -0.038829298  0.67469182 -0.10569664  0.31318999  0.21355745 -0.237047287
## 20  0.182488932 -0.01098533  0.17427580  0.32519031 -0.32446396  0.122092840
##            PC73        PC74        PC75        PC76         PC77        PC78
## 1   0.038620110  0.29274526  0.02003190 -0.15113494 -0.040412833  0.03836551
## 2  -0.184827297  0.01130965 -0.01594649 -0.13652263  0.084465726 -0.19346027
## 3   0.082084038  0.12471358  0.27068855  0.05393216  0.006491563  0.07918455
## 4   0.608603855 -0.69503888 -0.26197225 -0.25325279  0.106599701 -0.28177692
## 5  -0.073771174  0.08585380  0.23973034 -0.09720508 -0.126020519 -0.08828502
## 6   0.231476055 -0.01092920  0.20044881  0.12395499  0.108126121  0.06946130
## 7  -0.268338760 -0.03805971 -0.05239980 -0.09424299  0.009253262  0.02933898
## 8  -0.109117259 -0.08093855 -0.09494659  0.18034438  0.067124338  0.05766615
## 9   0.151620788 -0.03559521 -0.09313591 -0.08617705 -0.287412430  0.31445083
## 10 -0.132708453  0.31738250 -0.10158200  0.04852316 -0.309410744  0.35532051
## 11  0.077291646  0.04433344  0.11103021  0.06427415 -0.094414428 -0.20814552
## 12 -0.905350468 -0.19554872 -0.06347173  0.20814232  0.528217617 -0.25477966
## 13  0.408415081  0.60193217  0.21517249 -0.11621345 -0.361856208 -0.37942369
## 14  0.243685089  0.07017651 -0.06630162 -0.03156895  0.019478528  0.05072331
## 15  0.367971399 -0.07840729 -0.07941739  0.26870369  0.250147720  0.04057611
## 16 -0.108906834 -0.13450782 -0.10114578  0.07674907  0.337019497 -0.14523595
## 17 -0.005350701 -0.02486047 -0.26176437 -0.13167427 -0.188565658  0.13382081
## 18 -0.002050934 -0.20733301  0.25133393 -0.14242698 -0.110723905 -0.03043135
## 19 -0.385967086 -0.44287684  0.01332453  0.30138468 -0.220628052 -0.10987222
## 20  0.097376106  0.19532833 -0.09479697 -0.13741296 -0.010439298  0.08716412
##            PC79        PC80         PC81        PC82         PC83         PC84
## 1  -0.22685772  0.09075127 -0.004598309 -0.13621050  0.078175827  0.096364900
## 2   0.14144652  0.07743947 -0.133889758  0.18652951  0.004957962 -0.066809733
## 3   0.19735394  0.11860348 -0.040986158  0.08514801  0.116263194 -0.042405745
## 4   0.75427939  0.86515700  1.393193764 -0.24362760 -1.504728070  1.003110242
## 5  -0.17640935 -0.04751415 -0.007171128  0.02571296  0.028944756 -0.107408855
## 6   0.19185330  0.09178366  0.282915297 -0.17075178 -0.007753887 -0.156951636
## 7  -0.19841940 -0.11106682  0.143035477 -0.14362552  0.069373273  0.025836553
## 8  -0.02968421  0.08089294 -0.043696116  0.25301802  0.112677265  0.145303279
## 9   0.16317232  0.32056732  0.189963733 -0.32401252 -0.164502736 -0.351773836
## 10  0.29753617  0.13474651 -0.453863577  0.07178983 -0.199961830 -0.110342621
## 11 -0.04407639  0.13466641 -0.007316956 -0.04497758  0.077823805  0.065211529
## 12 -0.63740230 -0.38377167 -0.002179590  0.29477644 -0.107231258 -0.145335714
## 13  0.18760392  0.41053161  0.051056162  0.03166888 -0.261981566  0.056333550
## 14 -0.16063811 -0.31863128 -0.289319934 -0.13579695  0.146748758  0.005865523
## 15  0.08491317 -0.06514681 -0.203170341 -0.05038623  0.267421218 -0.133919963
## 16 -0.06897697 -0.20671913 -0.048785787 -0.08383049  0.005270597  0.098261763
## 17 -0.05524793 -0.07355341 -0.014115031  0.18157271 -0.170166598  0.070247482
## 18 -0.06868973 -0.22208700  0.166225414 -0.16175315  0.067541136  0.215478429
## 19 -0.13544641  0.05342126  0.241451952 -0.12209427 -0.159470609 -0.140100907
## 20  0.05325715 -0.35384061 -0.029128356  0.19581369 -0.415892488 -0.172858924
##            PC85         PC86        PC87         PC88         PC89           PC90
## 1  -0.15957981  0.102167745 -0.46141990  0.128991420  0.144993020 -0.1005461372
## 2  -0.04485744 -0.027548842 -0.15589653  0.146229196 -0.006189139 -0.1358098438
## 3  -0.23598427  0.138887838 -0.16935354 -0.112417562 -0.149613037 -0.1190485965
## 4   0.22201490  0.420051161  0.46195802 -0.274882727 -0.384418223  0.1925665816
## 5  -0.26749506 -0.148334641 -0.46121676  0.106866205  0.242088643  0.0827239191
```

```
## 6   0.25098265  0.167659020 -0.05432925 -0.227533143  0.114046871 -0.1492637419
## 7   0.14506977 -0.292071778  0.03061599 -0.009229078  0.173812116 -0.2559554329
## 8   0.06275217 -0.003078407  0.13244994  0.024285792  0.035891948  0.0028709572
## 9  -0.28393787  0.205019460 -0.08844735  0.615317398 -0.203667266 -0.1014403353
## 10  0.08137172  0.352605720  0.04343468  0.046858321 -0.199903733  0.4280055365
## 11 -0.10814157 -0.085187444  0.17854346  0.166996131 -0.017285028 -0.1369813020
## 12  0.24648472  0.074332222  0.53971713  0.277597145 -0.186464822  0.0640942974
## 13  0.10218465 -0.071879538 -0.19345513  0.145983852  0.224598072 -0.1328566438
## 14 -0.18912190  0.194755716  0.17826757  0.259450160 -0.049169581  0.0002129585
## 15 -0.02086360 -0.037707371  0.29617492 -0.265485975 -0.186886436  0.1795576193
## 16  0.24517589  0.062196838  0.11063966 -0.246578351  0.128742221  0.1186052605
## 17 -0.01839237 -0.144492246 -0.09122441  0.053637917 -0.111915695  0.2300907337
## 18  0.05400981  0.089096921  0.41845835  0.021928865 -0.192582607  0.5273787871
## 19  0.13532079 -0.308088975  0.02896185 -0.103629718  0.342441558 -0.2620882554
## 20  0.22014265  0.112688080  0.48912216 -0.521644664 -0.044263138 -0.1584809374
##            PC91         PC92         PC93         PC94         PC95
## 1   0.098629279  0.054584225  0.198186949 -0.062944487  0.026213697
## 2  -0.031932085  0.060919102 -0.120494201  0.149225009 -0.135163532
## 3   0.103691915  0.011641910 -0.129707565  0.057679590  0.097832061
## 4  -0.061165558 -0.454211382  0.366424120  1.595409319 -0.568295637
## 5   0.078437817  0.034916877  0.135572927  0.169232002  0.164920377
## 6   0.002773903 -0.043538975  0.007674264 -0.080101578  0.031990680
## 7   0.339269870 -0.055597593 -0.250008384 -0.172583975  0.083638301
## 8   0.003606051 -0.047792055  0.064233976  0.046196136  0.101639494
## 9  -0.491774760 -0.108950218 -0.253446254  0.014678224 -0.397009665
## 10 -0.343150808  0.033754392 -0.074590211  0.081415453  0.291800670
## 11 -0.283789556 -0.053827720  0.320575991  0.127171360  0.042502743
## 12 -0.525956630  0.175656873  0.049799744 -0.349056199 -0.023381560
## 13  0.110582966  0.129107923 -0.123735065  0.110852502 -0.140645661
## 14  0.041407286  0.233432304 -0.103274407 -0.007110747 -0.059689190
## 15 -0.163716526  0.245955346  0.129123663 -0.445700511 -0.009678699
## 16  0.066303650 -0.006965843 -0.033870243 -0.121431485  0.003146941
## 17  0.048135180 -0.183335538  0.037821062  0.060399426 -0.098576222
## 18 -0.060904888 -0.089695858  0.192025775 -0.013801168  0.164404649
## 19  0.081413042 -0.097803005 -0.055357185  0.125031743  0.094684418
## 20 -0.305613190  0.033605699 -0.082330609  0.092016821 -0.373364427
##            PC96        PC97        PC98         PC99       PC100
## 1   0.033714728  0.09067162 -0.08900970 -0.095497035  0.14787360
## 2  -0.133547403  0.02591845 -0.16537038  0.194838784 -0.12472838
## 3  -0.159558978  0.03009275 -0.04940875 -0.211287783 -0.12921985
## 4   0.169927735 -0.78613832  0.44016858  1.325451193  0.53817387
## 5   0.050885319  0.33471957 -0.20392814 -0.103255433  0.01793765
## 6   0.132002247  0.04953905  0.03765414 -0.261206250  0.10318471
## 7   0.026693351 -0.03186351  0.01047551 -0.049098398  0.28731524
## 8   0.139173790  0.28486295 -0.06522351  0.089609426 -0.14201588
## 9  -0.130278747  0.02466301  0.42436987 -0.163981209  0.41033051
## 10 -0.044652657 -0.08808456 -0.19806257  0.072136041 -0.15350382
## 11  0.137697689 -0.03343006  0.15192486 -0.023919986  0.07398684
## 12 -0.196718248  0.26918442 -0.17697124 -0.163036549 -0.39309252
## 13 -0.068796081 -0.09161582 -0.06055979 -0.203894916 -0.24802354
## 14  0.016570116 -0.15022172  0.14118690  0.171077238  0.18082197
## 15 -0.164837646 -0.10983250  0.03056265  0.099310977 -0.09530717
## 16 -0.042015672 -0.08642359 -0.27632757  0.097048088 -0.36968658
## 17  0.037314702 -0.08697977  0.15297262 -0.034200326  0.30250995
```

```
## 18  0.188872779 -0.11539175  0.15127840 -0.038780391 -0.49665892
## 19  0.096468384  0.14835222  0.18255974  0.001996086 -0.03334343
## 20 -0.006779751 -0.10096645 -0.07373939 -0.036029932 -0.22237215
##
## Clustering vector:
##    2    3    4    5    6    7    8    9   10   11   12   14   18   19   20   21
##   17   12   12    4   15   12   12    3   18   10   12    2   12   12   16   12
##   23   24   25   26   27   28   29   30   31   32   33   34   35   36   38   39
##   15   12   12   12   12   12   10    3   13    7    1   18   12   12    2    6
##   41   42   43   44   45   46   47   48   49   50   51   54   57   58   59   61
##   18   16   14    6    3   17   18   18   14    6    7    6   18   18   10   17
##   62   63   64   66   67   68   70   71   72   73   74   75   76   77   78   79
##   17   14   15   18    2    6    5    1   13    9    3   20    7    6   17   17
##   81   82   83   84   85   86   87   88   89   90   92   93   94   96   97   98
##   16   14   19   17   17    6   14   18    3    8   14   17    3   17    6   10
##   99  100  101  102  103  104  105  106  107  108  109  110  111  112  113  114
##    2   19    9    8    7   17    3   17   17    7   16    1    2    3   17    6
##  115  116  118  119  120  121  122  123  125  126  128  130  131  134  135  137
##   16   17   17   16   17   17    8   20   19   17   18   14   17   18    8    7
##  138  139  140  141  142  143  144  146  148  150  151  152  155  156  158  159
##    8   16   17   17   17    7   10   17   20   17   15   17    7   15    3   14
##  162  163  164  165  170  175  177  178  179  181  182  183  184  185  186  187
##    7    3    7    6   14   17   18   15    1    1   14    7    6   13    3    2
##  188  191  192  193  195  196  197  198  199  201  202  203  204  206  208  209
##   14    7    2   15   15    1   19   16    7    3    6    3    3   19    3   10
##  210  212  214  215  216  217  218  220  221  222  223  224  226  227  228  229
##    4    6   14    6   20    7   15    1    2    8    7   17    7    1    7    8
##  230  231  232  233  234  235  236  237  238  239  240  241  242  243  244  245
##    7    8   18    6    3    3    3   15    9   17   15   16   14    1   17    3
##  246  247  248  249  250  251  252  253  254  255  256  257  258  259  260  261
##    1    2   15   17   19    6    8   15    8   14    8   17    1    9   14   15
##  262  263  264  265  266  267  268  269  270  271  272  273  274  275  276  277
##   20   17   14   14    3   17    8   17   19   15   16    2   15    3   17   15
##  278  280  281  282  283  284  285  286  287  288  289  290  291  292  293  295
##    2    7   14    8    3    3    6   15    1   10    8    7    3    6    8   17
##  296  297  298  299  300  302  303  304  306  307  308  309  310  311  312  313
##   16   14   18   17    1    8   14   17    8   17    1   15   14    1   19   19
##  315  317  318  319  320  321  322  323  324  325  326  327  328  329  331  332
##    3   17   17    8    6    1    3   13    6    3   17    6    7    6    8   10
##  333  335  336  337  338  339  340  342  343  344  345  346  348  350  351  352
##   17   15   15    6    8   16    7   17   17   14    1    8    8   17   17   10
##  354  355  356  357  359  360  362  363  364  366  367  368  369  373  374  375
##   16   17    8   17   17   20    6   17    2    3   14   18    4    3    8    3
##  377  380  383  384  385  386  387  389  390  391  392  393  394  395  396  397
##   17    2   17    7   17    3   17    3   17   15    1   14   17   19   20   13
##  398  399  400  401  402  403  404  405  406  407  408  409  410  411  412  413
##    7    7   15   19   15   20    6    3    2    1    3    6   14   15   10   19
##  414  415  416  419  420  422  423  424  426  428  429  431  432  433  434  435
##   15   17   17    9    3   15    7   17    3    7    8   14    6    6    3    6
##  437  438  439  441  442  443  444  445  447  448  449  450  451  452  453  454
##   19    6   17   17    2    6    1   17    7    1    6    2   17    6   17   15
##  455  457  459  460  461  463  465  466  467  469  470  471  472  473  474  476
##    7    4   16   13   17   17   16    2   16    9   19    7   15   15    6    3
##  478  479  480  481  482  483  484  485  486  487  488  489  490  491  492  493
```

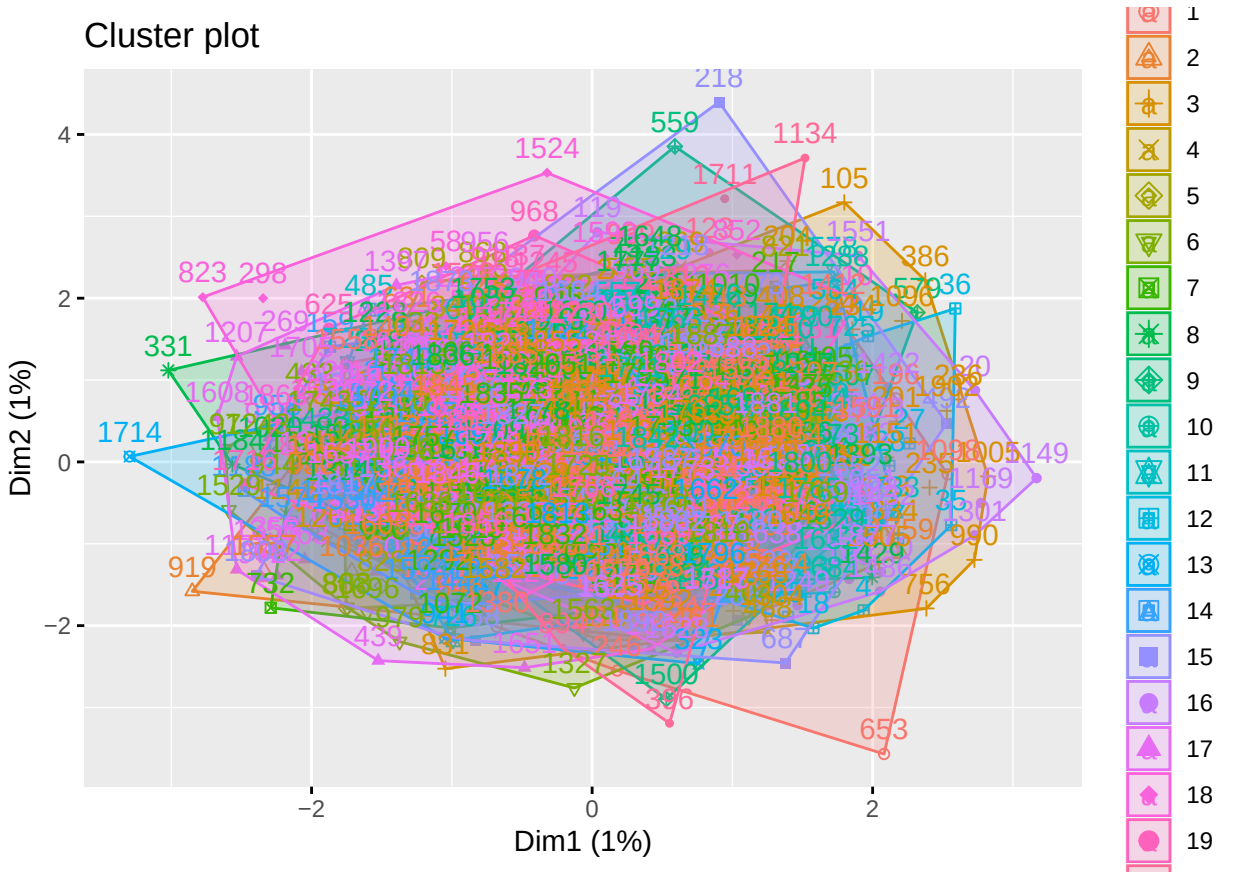
```
##   17   13    7    8   11   11   11   11   11   11    4   11   14   11   15   11
##  494  495  496  498  499  500  501  502  503  504  505  507  508  510  511  512
##   15    7   11   15    8    9   17   15    2   17   15    9    6   14    3    3
##  513  514  516  517  518  519  520  521  522  523  524  525  527  528  529  531
##   19    1   18    7    6    6    2   16    1    1    7    7    6   15   17    9
##  532  533  534  535  536  537  538  539  540  541  542  544  545  546  547  548
##   17   17   17    3    3   15   17    6   11    3    8   14   11    3    2   14
##  549  550  553  554  555  556  557  558  559  560  561  562  564  565  566  567
##   11   11   16    8   11   11   11   11    9   11   11    6   11   11   20   13
##  568  569  570  571  572  573  574  575  576  577  578  579  580  581  582  583
##   11   11   11   11   11   11   11   11   11   11   11    9   11   18   11   10
##  584  590  593  594  595  596  597  598  599  600  601  602  603  604  605  606
##   11   11   11   11   11   11   18   16   11   17    1   11   11   11   11   17
##  607  608  609  610  611  612  613  614  615  616  617  618  619  620  621  622
##   15    3   18   13    6    2    6   11   17   18    6   17    6    6   11   15
##  623  624  625  627  628  629  630  631  632  633  634  635  636  637  639  640
##    2    1   19    8   17    7   17    2   17    6   19   16   17   19   15   17
##  641  642  643  644  645  646  647  648  649  650  651  652  653  654  656  657
##   16   18    3   14    7    3    3   15   14    7    7    2    1   16   16    7
##  658  659  660  661  662  663  664  666  667  668  669  670  671  672  673  674
##    7   15   13   16   17   17    1   15   17   15    9    1   15    9    8   14
##  675  676  677  679  680  681  682  683  684  685  686  687  688  689  690  691
##   13    6    3    3   18    1   15   14   10    7    1   15   15   15    9   10
##  692  693  694  695  696  698  699  700  701  702  703  704  705  706  708  709
##    1   18    6    2    6   16    1    3   19   14   11   15   15    7   14   17
##  710  712  713  714  715  716  717  718  719  720  722  723  724  725  726  727
##   11   10   17    2   11   11   11   14    3    1    8   11   19   11   11    3
##  728  729  730  731  732  733  734  738  739  740  741  742  744  745  746  747
##   11   11   16   11    7   11   11   11   11    1    8   11    3   11   15   14
##  748  749  750  751  752  753  754  756  757  758  759  760  761  762  763  764
##   11    6   11   10    8   15    7    3   10   19    8   17    8   17    6    1
##  765  766  768  769  770  771  772  773  774  775  777  778  779  780  781  782
##    6   17   10    5    5    3    6   19    2   19    1   19    6   14    8    5
##  783  784  785  787  788  790  792  793  795  796  797  798  799  801  802  803
##    8    5    5    5    7   15    5    5    5    2    8    5    7    2   10    5
##  804  805  806  807  808  809  810  811  812  813  815  816  817  818  819  820
##    5   15    3    5    2    5    2    9    5   19   15    1    8   15   17    3
##  821  822  823  824  825  826  827  828  829  830  831  833  834  835  836  837
##    5    5   18    4    5    7    5    5    5    3    3   19    3    7    6    5
##  838  839  840  842  843  844  845  846  847  848  849  850  851  852  853  854
##   20   10    1    5   15    5    5    2    4    5    5    2    5   18    5    5
##  855  856  857  858  859  860  861  862  863  864  865  866  867  868  869  870
##    7    5    9    5    5    5    5   10    5    5   18   14    2    5    5   17
##  871  872  873  874  875  876  877  878  879  880  881  882  883  884  885  886
##    7    3   18    7   18    1    2    5    2    2   15   16    6    2    5    2
##  888  889  890  891  892  893  894  895  896  897  898  899  901  902  903  904
##    6    2   15   15    7   19   20    2    7   15   19   14   18    5   17    1
##  905  906  907  908  909  910  911  912  913  914  915  917  918  919  920  921
##    3   17    8   15    7    3    3   19    7   18    9    3   19    2    8   15
##  922  923  924  925  926  928  929  930  931  932  933  934  935  936  937  938
##   18    7   16    6   16   17   18   15   14   14    2   13    6    2    6    8
##  939  940  941  942  943  944  945  946  948  949  950  951  952  953  954  955
##   20   16   13    6   13    6    7    2   19   20   15   15   18    1    9    8
##  956  957  958  959  960  962  963  964  965  966  967  968  969  970  972  973
```

```
##   17   15   14   17    3   14   18    1    2    2    2   19   16    9   17    1
##  974  975  976  977  978  979  980  982  983  984  985  986  987  988  990  991
##   17   17   13    1    2    6    7    2    7    2   19    8   16   16    3    2
##  992  993  994  995  996  997  998  999 1000 1002 1003 1004 1005 1007 1008 1009
##   18    2    7    2   17   17   16   14   10   17    2    2    3    2    4   15
## 1010 1014 1015 1016 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029
##    7    1   18    7   18    1    8    2   15   16   17    2    7   10    1    6
## 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045
##    6    8    2    1    5   16    2   17    1    2   15    8    2    1   14   18
## 1046 1047 1049 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062
##   18   15   19    2   16    3    2   15    2   15    9   19    2    1   19   16
## 1063 1064 1065 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077 1078
##    2   16    3   16    2    2    1    3    5    7   17    2    2   17    2    8
## 1079 1080 1081 1082 1083 1085 1086 1087 1088 1089 1090 1091 1092 1093 1094 1095
##    3    2    8    7    7   17    1   19    6    3    1   20    7   14    3   18
## 1096 1097 1098 1099 1100 1101 1102 1103 1104 1105 1106 1107 1108 1109 1110 1111
##    3    5    1    7    7    7   18    8    7   20    7   18   19    2   18   19
## 1112 1113 1114 1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127
##    8    2    7    1   15   19    7    8    7    1   16   20   18    2    7    8
## 1128 1129 1130 1131 1132 1133 1134 1136 1137 1138 1139 1140 1142 1143 1144 1145
##    1   10    8    2   10    8   20   18    1    7    2   18    7    6   15    4
## 1147 1148 1149 1150 1151 1153 1154 1155 1156 1157 1158 1159 1160 1161 1163 1164
##   13    2   16    2    3   19    1   16    3   18    2    2    1    7    3   15
## 1166 1167 1168 1169 1171 1172 1173 1174 1175 1176 1177 1178 1179 1181 1182 1183
##    7   15   18   16    8   17   15    9    7   20   10    7   14    1    3   14
## 1184 1185 1186 1187 1189 1190 1191 1192 1197 1198 1199 1200 1201 1202 1204 1205
##    8    7    8    4    2   14    1   16    6    6    7    2    6    2   16    6
## 1207 1208 1209 1210 1211 1212 1213 1214 1216 1217 1218 1219 1220 1221 1222 1223
##   17    7    1   15   19    1    3    7   16   10   15    4    3    1   20   14
## 1224 1225 1226 1227 1228 1229 1230 1231 1232 1233 1234 1235 1237 1238 1239 1240
##   18    3   18    8    8   17   13   15    3   15    1   14    1   15   16   16
## 1241 1242 1243 1244 1245 1247 1248 1249 1250 1251 1252 1253 1254 1255 1256 1257
##   14    3    6    2   19    2    2   16    1    6    7   18    4   14    7   15
## 1258 1259 1260 1262 1264 1265 1266 1267 1268 1269 1270 1271 1272 1273 1274 1275
##    8    8   19    4   18   14   20    6   17    8    2   19    2   15   16   16
## 1276 1277 1278 1279 1280 1281 1282 1283 1284 1285 1287 1288 1289 1290 1291 1292
##    1   16   16   18   18   19   14    7   17    8    8   10   15    3    8    7
## 1293 1294 1295 1296 1297 1298 1299 1300 1301 1302 1303 1304 1305 1306 1307 1308
##    6    1   19    1   17    2   15    3   16   15    2    3    2   13    2    9
## 1309 1310 1311 1312 1313 1314 1315 1316 1318 1319 1320 1321 1322 1323 1324 1325
##   17   14    2    2    3    8    7    1   10   10    2    7   16    2   17    7
## 1327 1328 1329 1330 1331 1332 1333 1334 1335 1336 1338 1339 1340 1341 1344 1345
##    6   17    3   16    1   10   17    2    2    7   17    3   10    2   18    8
## 1346 1347 1348 1349 1350 1351 1352 1354 1355 1356 1357 1358 1359 1360 1361 1362
##    1   15    1   17    1    1   17    9   17    2    7   14   16   17   10   14
## 1363 1364 1365 1367 1368 1369 1370 1371 1373 1374 1375 1376 1377 1378 1379 1380
##    3   19    2    9   15   16   18   20    9   18    2   14    8    8   17    1
## 1381 1384 1385 1387 1388 1389 1390 1391 1392 1393 1394 1395 1396 1397 1398 1399
##    1   16   16   17    2    2    8    3    3    8   19   16    1   17   19   15
## 1400 1401 1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412 1413 1414 1415
##    2    2   18    6    2   14    3    1   17   15    7    2    1    2   10    2
## 1416 1417 1418 1419 1420 1422 1423 1424 1425 1426 1427 1428 1429 1430 1431 1432
##    2   17    8    7   16   16    6   17   15   15    8    1    8   14    2   16
## 1433 1434 1435 1436 1438 1439 1440 1441 1443 1444 1445 1446 1447 1448 1449 1451
```

```
##    9    1    7   16    6    1    3   14   16    7    7    8   16    2    7    3
## 1452 1453 1454 1455 1456 1457 1458 1459 1460 1461 1462 1463 1464 1465 1466 1467
##    2    8    2    7    2    2    2    8    2    2    2   18    1    7    2    2
## 1468 1469 1470 1471 1472 1473 1474 1475 1476 1477 1478 1479 1480 1481 1483 1484
##    3    1    2    3    7    2    2   13   10    7    2    2   13    2    2    3
## 1485 1486 1487 1489 1490 1491 1492 1493 1494 1495 1496 1497 1498 1499 1500 1501
##    8   16   19    7   10    3    2    3    2   19    2   20    2    2    9   14
## 1502 1503 1504 1505 1506 1508 1509 1510 1511 1512 1513 1515 1516 1517 1518 1519
##    6    2   15    3    8    5   14   10    7    2    5    3   15    2    2   17
## 1520 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531 1532 1533 1534 1535
##    2   17   15    8   18   17    8   15    7    6   14   15    8   16   17   15
## 1536 1537 1538 1540 1541 1542 1543 1545 1546 1547 1548 1549 1550 1551 1552 1553
##    9   20    7   17   15   19    5    8    6    2   20    6    5   16    1    4
## 1555 1557 1558 1559 1560 1561 1562 1563 1564 1565 1566 1567 1568 1570 1571 1572
##    7    2    1    1    1   17    4    6   17    1    2   17    2   14    8   19
## 1573 1574 1575 1576 1577 1578 1579 1580 1582 1583 1584 1585 1586 1587 1588 1589
##   17   14    5    1    1   17    1    8    4   17    6   17    1    2   16    7
## 1590 1591 1592 1593 1594 1595 1596 1597 1598 1599 1600 1601 1602 1603 1604 1605
##   18    1    7    3   14   14   16    7   19   17   17    6   17   17    2    2
## 1606 1607 1608 1609 1611 1612 1613 1614 1615 1616 1617 1618 1619 1620 1622 1623
##    8    2   17    2    8    4    1   17    3    8   17    2    7    7   17   17
## 1624 1625 1626 1627 1628 1629 1630 1631 1632 1633 1634 1635 1637 1638 1639 1640
##   18   16   16    1   16    9    7   10   10   17    6    7   17   16   19    6
## 1641 1642 1643 1644 1645 1646 1647 1648 1649 1650 1651 1652 1653 1654 1655 1656
##   17    7   17   19   18   10    3    8    3    2   17   15    3    1    6    2
## 1657 1658 1659 1660 1661 1662 1663 1664 1665 1666 1668 1669 1670 1671 1672 1673
##    3    3    3    8   15   13    1   15    2    1    1   19    2    6   18   17
## 1674 1675 1676 1677 1678 1679 1680 1681 1682 1683 1684 1685 1686 1687 1688 1689
##   18   18   16   20   13    7   15   16    7   15   15    9    6   15   20   15
## 1690 1691 1693 1694 1695 1696 1697 1698 1700 1701 1703 1704 1705 1706 1708 1709
##    1    3    7    1   15    6   13    9   10    1    7   14   17    6   15    8
## 1710 1711 1713 1714 1715 1716 1717 1721 1722 1725 1729 1730 1731 1732 1733 1734
##    6   20    2   13    1   19   16    2   14    6    3   20    1   15    1   17
## 1735 1736 1738 1739 1741 1743 1744 1745 1746 1749 1753 1754 1757 1759 1762 1763
##    8    3    6    3   17    6   18    8    1   14    8    2    7    2    3   10
## 1764 1765 1766 1767 1768 1769 1771 1772 1773 1776 1777 1778 1784 1785 1786 1787
##   14   10   19    6    3    6    3   17   16    2    8    8    3    7    7   15
## 1790 1791 1793 1794 1795 1796 1797 1799 1800 1802 1803 1804 1805 1808 1809 1810
##   10   10    7   20    2   13   19    2    9   18   16    9   18   15   19    2
## 1813 1814 1815 1816 1817 1818 1819 1820 1821 1822 1824 1826 1827 1831 1832 1835
##   13   18    6    6   15    6    6    8   17   19    3   18   15   19    7    7
## 1836 1842 1845 1846 1850 1851 1852 1854 1855 1856 1863 1872 1873 1874 1877 1880
##    8   10    2   17    6    7    2    7    3   19   18   15   15    3   16    1
## 1881 1882 1885 1887 1890 1892 1900 1902
##   16   15    2    6    3   15   17    3
##
## Within cluster sum of squares by cluster:
##  [1] 10476.893 12984.858 12231.229  1854.231  6737.223  7534.825 10218.593
##  [8]  7739.826  4903.815  4274.809  5091.740  1673.295  3656.989  5024.042
## [15] 11975.080 10699.877 12462.896  5463.272  6994.567  2667.258
##  (between_SS / total_SS =  10.0 %)
##
## Available components:
##
```

```
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
## Warning: did *not* converge in specified number of iterations
```

```
fviz_cluster(k.fin, data = k.df)
```



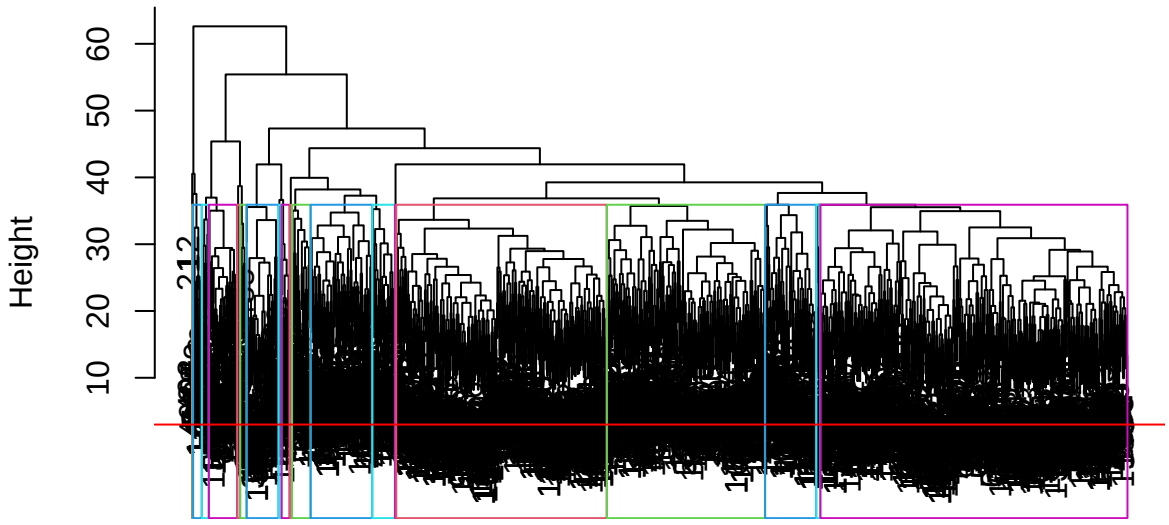
We can see that K-Means clustering did yield clusters of genes that have similar properties and while the plots do look chaotic, we can attribute this to the number of dimensions associated with the data. From the PCA, we yielded about 100 genes to consider, and we use them all in our clustering analysis.

#HCLUSTERING

```
any(is.na(comp))
```

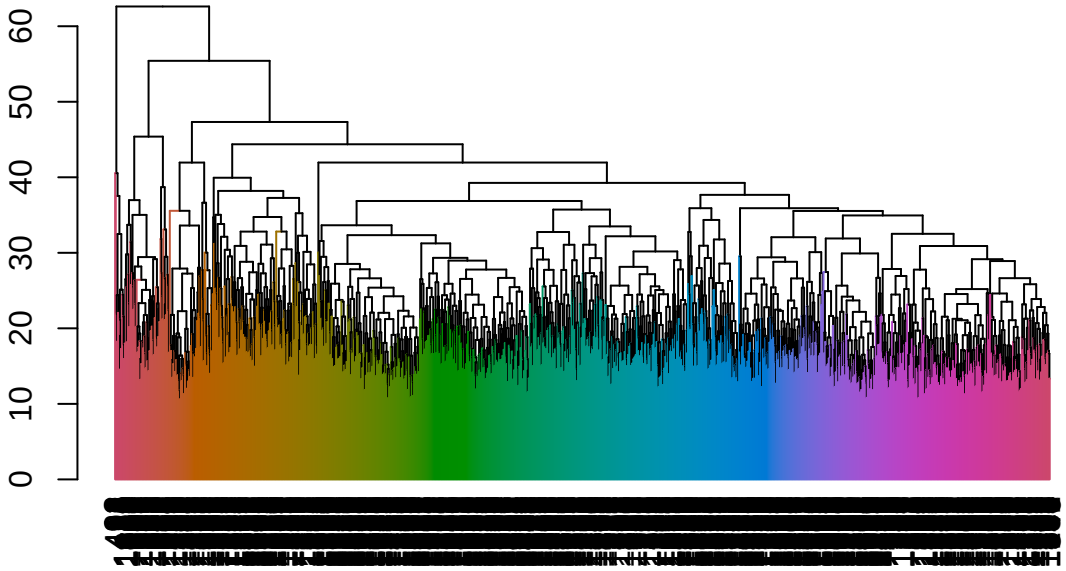
```
## [1] FALSE
```

```
dist_mat <- dist(comp, method = 'euclidean')
#clust.euclid.average<- hclust(dist(comp),method="complete")
#plot(clust.euclid.average)
hclust_avg <- hclust(dist_mat, method = 'complete')
plot(hclust_avg)

cut_avg <- cutree(hclust_avg, k = 20)

plot(hclust_avg)
rect.hclust(hclust_avg , k = 20, border = 2:6)
abline(h = 3, col = 'red')
```



dist_mat
hclust (*, "complete")

```
suppressPackageStartupMessages(library(dendextend))
avg_dend_obj <- as.dendrogram(hclust_avg)
avg_col_dend <- color_branches(avg_dend_obj, h = 3)
plot(avg_col_dend)
```




```
suppressPackageStartupMessages(library(dplyr))
seeds_df_cl <- mutate(cluster.data, cluster = cut_avg)
count(seeds_df_cl,cluster)
```

```
##    cluster   n
```

```
## 1         1 272
## 2         2  15
## 3         3  39
## 4         4 362
## 5         5   1
## 6         6  32
## 7         7   1
## 8         8 106
## 9         9 528
## 10       10  55
## 11       11  49
## 12       12  88
## 13       13   4
## 14       14   2
## 15       15   5
## 16       16   5
## 17       17  11
## 18       18  14
## 19       19  12
## 20       20   7
```

```
suppressPackageStartupMessages(library(ggplot2))
ggplot(seeds_df_cl, aes(x=cluster.data$mutation_count, y = cluster.data$tumor_size, color = factor(seeds
```

```
## Warning: Use of `seeds_df_cl$cluster` is discouraged. Use `cluster` instead.
```