

# FactorAnalysis.R

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```
diabetes = read.csv("F:/Courses/MVA/diabetes.csv")
str(diabetes)
```

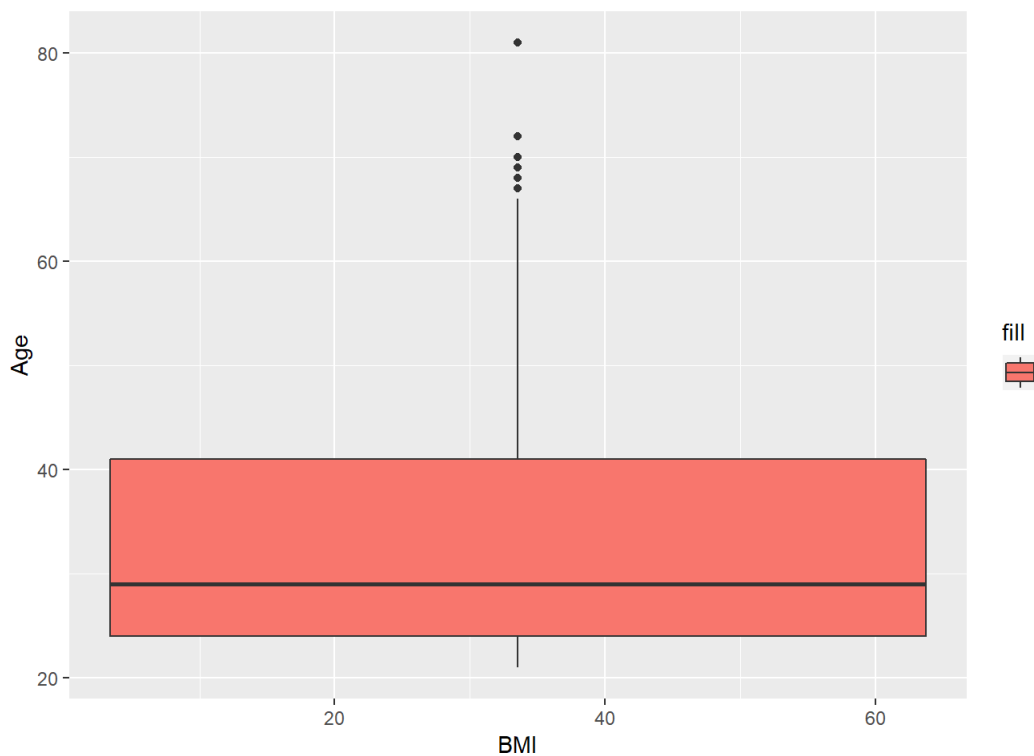
```
## 'data.frame': 768 obs. of 9 variables:
## $ Pregnancies : int 6 1 8 1 0 5 3 10 2 8 ...
## $ Glucose : int 148 85 183 89 137 116 78 115 197 125 ...
## $ BloodPressure : int 72 66 64 66 40 74 50 0 70 96 ...
## $ SkinThickness : int 35 29 0 23 35 0 32 0 45 0 ...
## $ Insulin : int 0 0 0 94 168 0 88 0 543 0 ...
## $ BMI : num 33.6 26.6 23.3 28.1 43.1 25.6 31 35.3 30.5 0 ...
## $ DiabetesPedigreeFunction: num 0.627 0.351 0.672 0.167 2.288 ...
## $ Age : int 50 31 32 21 33 30 26 29 53 54 ...
## $ Outcome : int 1 0 1 0 1 0 1 0 1 1 ...
```

```
attach(diabetes)
```

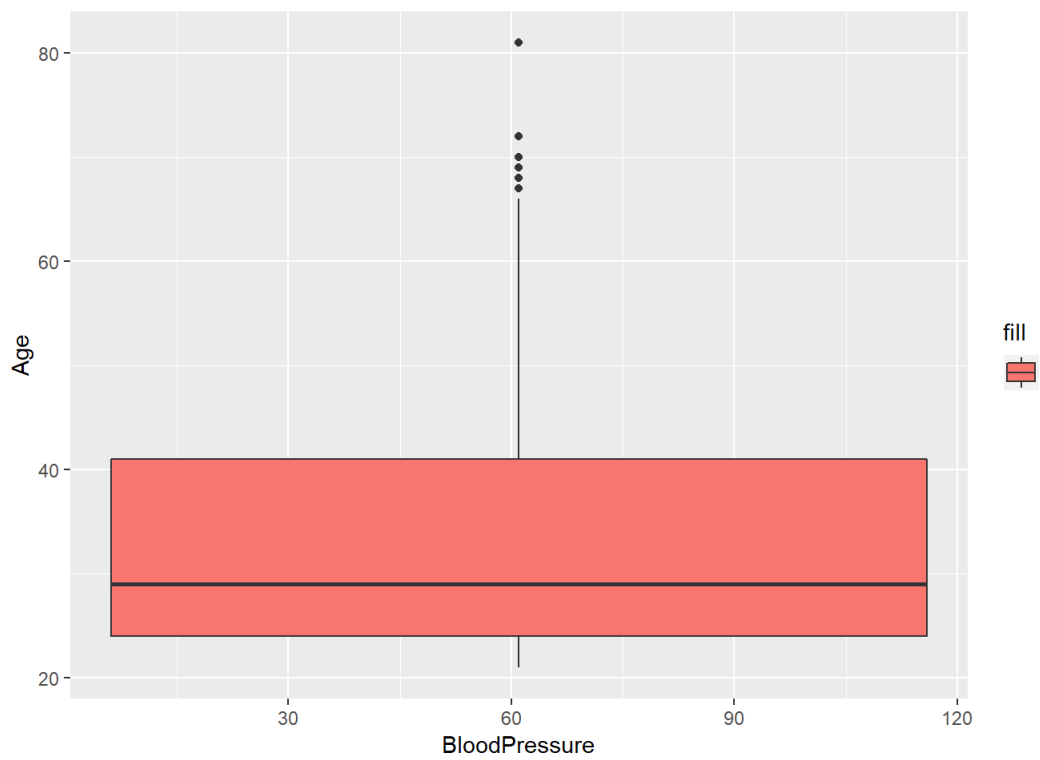
```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.5.3
```

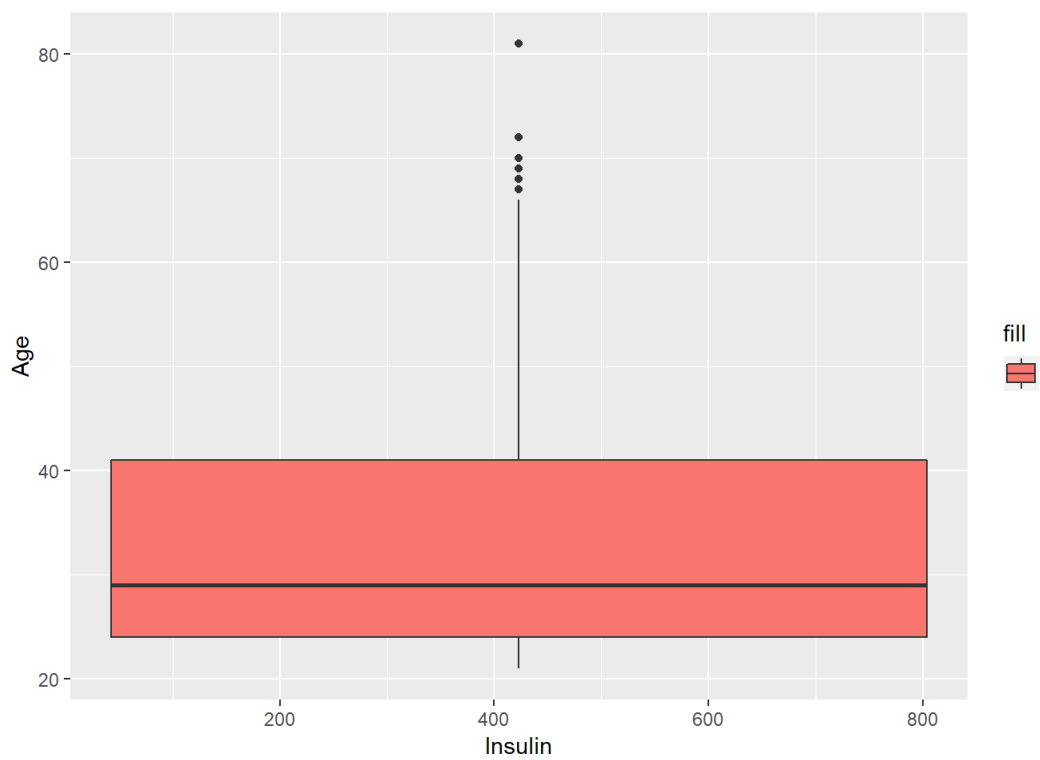
```
ggplot(diabetes, aes(y= Age ,x=BMI, fill='')) + geom_boxplot()
```



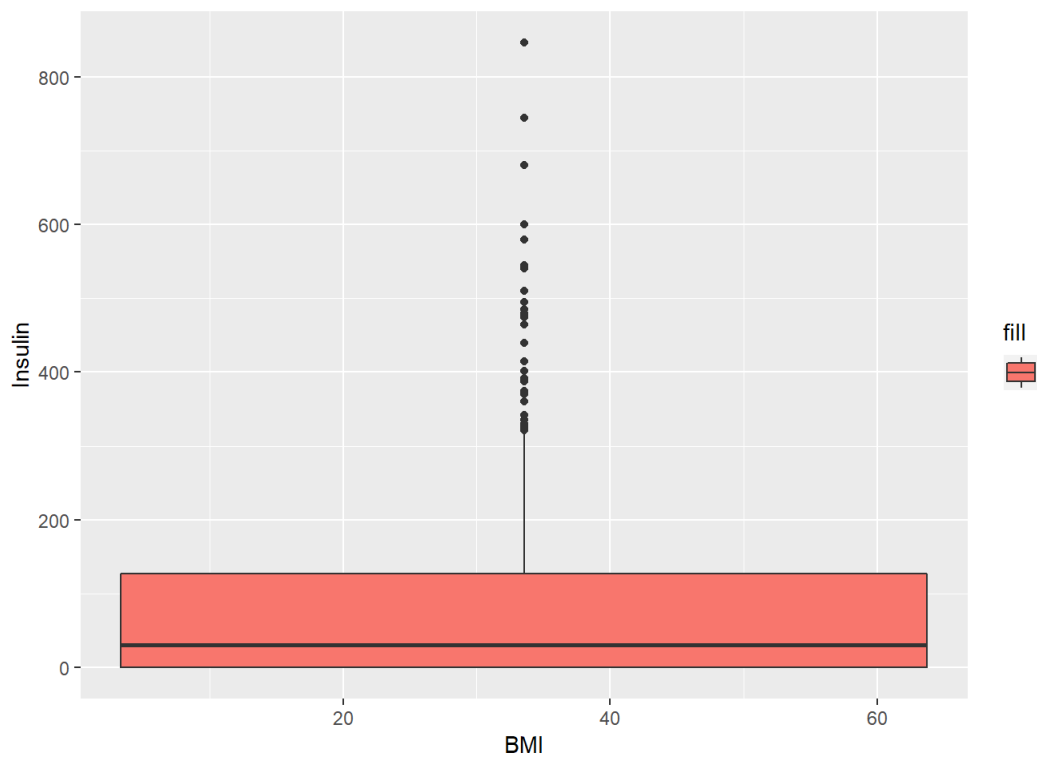
```
ggplot(diabetes, aes(y=Age,x=BloodPressure, fill='')) + geom_boxplot()
```



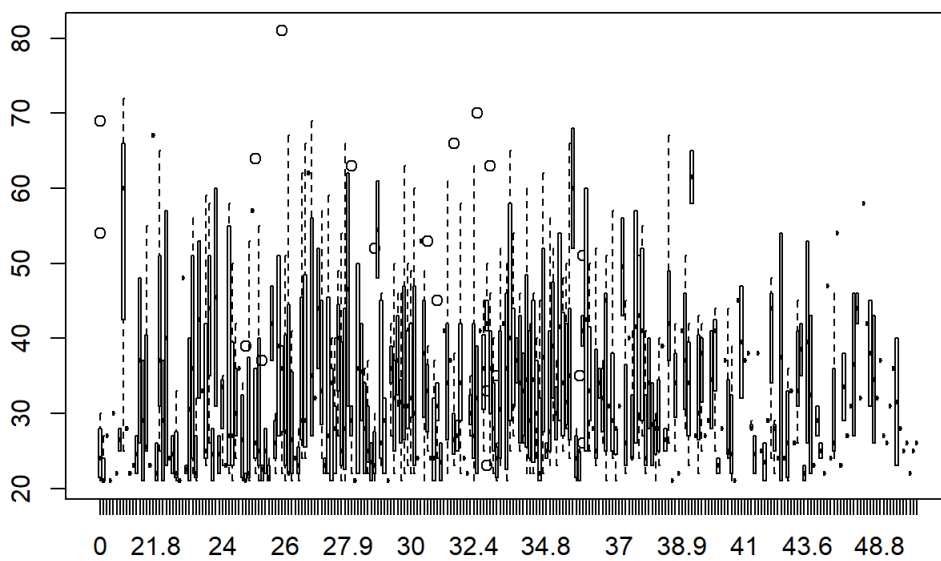
```
ggplot(diabetes, aes(y=Age, x=Insulin, fill='')) + geom_boxplot()
```



```
ggplot(diabetes, aes(y=Insulin, x=BMI, fill='')) + geom_boxplot()
```



```
boxplot(Age ~ BMI)
```



```
unique(diabetes$default)
```

```
## NULL
```

```
default_dummy=ifelse(diabetes$default=='yes',1,0)
```

```
unique(diabetes$BMI)
```

```
## [1] 33.6 26.6 23.3 28.1 43.1 25.6 31.0 35.3 30.5 0.0 37.6 38.0 27.1 30.1
## [15] 25.8 30.0 45.8 29.6 43.3 34.6 39.3 35.4 39.8 29.0 36.6 31.1 39.4 23.2
## [29] 22.2 34.1 36.0 31.6 24.8 19.9 27.6 24.0 33.2 32.9 38.2 37.1 34.0 40.2
## [43] 22.7 45.4 27.4 42.0 29.7 28.0 39.1 19.4 24.2 24.4 33.7 34.7 23.0 37.7
## [57] 46.8 40.5 41.5 25.0 25.4 32.8 32.5 42.7 19.6 28.9 28.6 43.4 35.1 32.0
## [71] 24.7 32.6 43.2 22.4 29.3 24.6 48.8 32.4 38.5 26.5 19.1 46.7 23.8 33.9
## [85] 20.4 28.7 49.7 39.0 26.1 22.5 39.6 29.5 34.3 37.4 33.3 31.2 28.2 53.2
## [99] 34.2 26.8 55.0 42.9 34.5 27.9 38.3 21.1 33.8 30.8 36.9 39.5 27.3 21.9
## [113] 40.6 47.9 50.0 25.2 40.9 37.2 44.2 29.9 31.9 28.4 43.5 32.7 67.1 45.0
## [127] 34.9 27.7 35.9 22.6 33.1 30.4 52.3 24.3 22.9 34.8 30.9 40.1 23.9 37.5
## [141] 35.5 42.8 42.6 41.8 35.8 37.8 28.8 23.6 35.7 36.7 45.2 44.0 46.2 35.0
## [155] 43.6 44.1 18.4 29.2 25.9 32.1 36.3 40.0 25.1 27.5 45.6 27.8 24.9 25.3
## [169] 37.9 27.0 26.0 38.7 20.8 36.1 30.7 32.3 52.9 21.0 39.7 25.5 26.2 19.3
## [183] 38.1 23.5 45.5 23.1 39.9 36.8 21.8 41.0 42.2 34.4 27.2 36.5 29.8 39.2
## [197] 38.4 36.2 48.3 20.0 22.3 45.7 32.7 22.1 42.1 42.4 18.2 26.4 45.3 37.0
## [211] 24.5 32.2 59.4 21.2 26.7 30.2 46.1 41.3 38.8 35.2 42.3 40.7 46.5 33.5
## [225] 37.3 30.3 26.3 21.7 36.4 28.5 26.9 38.6 31.3 19.5 20.1 40.8 23.4 28.3
## [239] 38.9 57.3 35.6 49.6 44.6 24.1 44.5 41.2 49.3 46.3
```

```
BMI_dummy=ifelse(diabetes$BMI=='yes',1,0)
```

```
unique(diabetes$Outcome)
```

```
## [1] 1 0
```

```
Outcome_dummy=ifelse(diabetes$Outcome=='yes',1,0)
```

```
unique(diabetes$Insulin)
```

```
## [1] 0 94 168 88 543 846 175 230 83 96 235 146 115 140 110 245 54
## [18] 192 207 70 240 82 36 23 300 342 304 142 128 38 100 90 270 71
## [35] 125 176 48 64 228 76 220 40 152 18 135 495 37 51 99 145 225
## [52] 49 50 92 325 63 284 119 204 155 485 53 114 105 285 156 78 130
## [69] 55 58 160 210 318 44 190 280 87 271 129 120 478 56 32 744 370
## [86] 45 194 680 402 258 375 150 67 57 116 278 122 545 75 74 182 360
## [103] 215 184 42 132 148 180 205 85 231 29 68 52 255 171 73 108 43
## [120] 167 249 293 66 465 89 158 84 72 59 81 196 415 275 165 579 310
## [137] 61 474 170 277 60 14 95 237 191 328 250 480 265 193 79 86 326
## [154] 188 106 65 166 274 77 126 330 600 185 25 41 272 321 144 15 183
## [171] 91 46 440 159 540 200 335 387 22 291 392 178 127 510 16 112
```

```
Insulin_dummy=ifelse(diabetes$Insulin=='yes',1,0)
```

```
unique(diabetes$BloodPressure)
```

```
## [1] 72 66 64 40 74 50 0 70 96 92 80 60 84 30 88 90 94
## [18] 76 82 75 58 78 68 110 56 62 85 86 48 44 65 108 55 122
## [35] 54 52 98 104 95 46 102 100 61 24 38 106 114
```

```
BloodPressure_dummy=ifelse(diabetes$BloodPressure=='yes',1,0)
```

```
diabetes1 =data.frame(Age,BMI,Outcome,Insulin,BloodPressure)
```

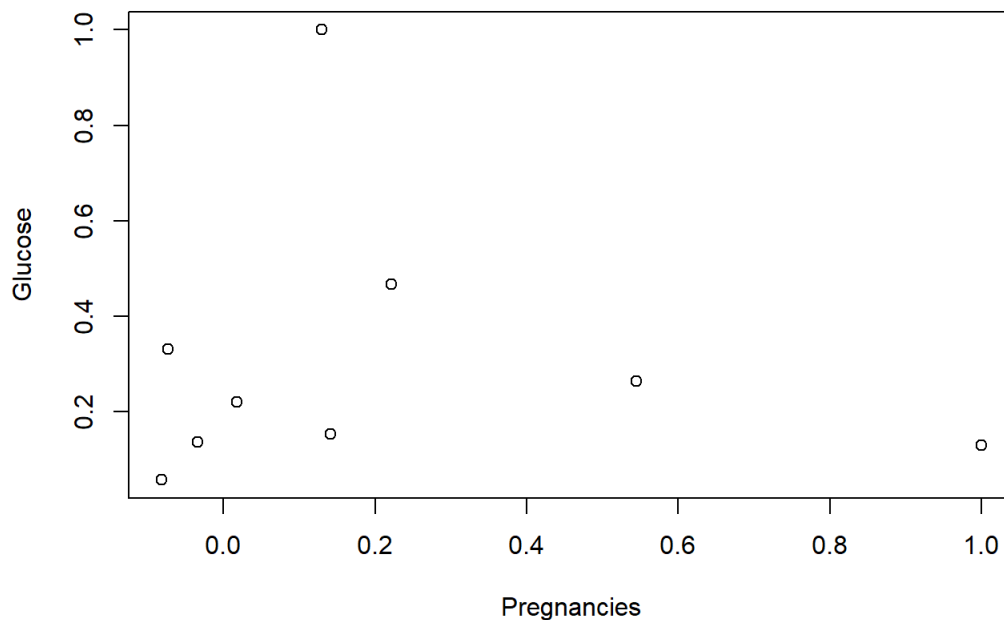
```
# Computing Correlation Matrix
```

```
corr.m.z = cor(diabetes)
```

```
corr.m.z
```

```
##              Pregnancies      Glucose BloodPressure
## Pregnancies      1.00000000  0.12945867   0.14128198
## Glucose          0.12945867  1.00000000   0.15258959
## BloodPressure    0.14128198  0.15258959   1.00000000
## SkinThickness    -0.08167177  0.05732789   0.20737054
## Insulin          -0.07353461  0.33135711   0.08893338
## BMI              0.01768309  0.22107107   0.28180529
## DiabetesPedigreeFunction -0.03352267  0.13733730   0.04126495
## Age              0.54434123  0.26351432   0.23952795
## Outcome          0.22189815  0.46658140   0.06506836
##              SkinThickness      Insulin      BMI
## Pregnancies      -0.08167177 -0.07353461  0.01768309
## Glucose           0.05732789  0.33135711  0.22107107
## BloodPressure     0.20737054  0.08893338  0.28180529
## SkinThickness     1.00000000  0.43678257  0.39257320
## Insulin           0.43678257  1.00000000  0.19785906
## BMI               0.39257320  0.19785906  1.00000000
## DiabetesPedigreeFunction 0.18392757  0.18507093  0.14064695
## Age              -0.11397026 -0.04216295  0.03624187
## Outcome           0.07475223  0.13054795  0.29269466
##              DiabetesPedigreeFunction      Age      Outcome
## Pregnancies      -0.03352267  0.54434123  0.22189815
## Glucose           0.13733730  0.26351432  0.46658140
## BloodPressure     0.04126495  0.23952795  0.06506836
## SkinThickness     0.18392757 -0.11397026  0.07475223
## Insulin           0.18507093 -0.04216295  0.13054795
## BMI               0.14064695  0.03624187  0.29269466
## DiabetesPedigreeFunction 1.00000000  0.03356131  0.17384407
## Age               0.03356131  1.00000000  0.23835598
## Outcome           0.17384407  0.23835598  1.00000000
```

```
plot(cormm.z)
```



```
diabetes_pca <- prcomp(diabetes, scale=TRUE)
diabetes_pca
```

```
## Standard deviations (1, ..., p=9):
## [1] 1.5337867 1.3320330 1.0584069 0.9391245 0.9190340 0.8572446 0.6988730
## [8] 0.6466693 0.6204113
##
## Rotation (n x k) = (9 x 9):
##
##          PC1          PC2          PC3          PC4
## Pregnancies    -0.2159984    0.52744611 -0.1645123    0.16088274
## Glucose         -0.4367568    0.09563451  0.3914174   -0.32712336
## BloodPressure   -0.3004554    0.04625339 -0.6297053    0.01105718
## SkinThickness   -0.3072920   -0.44839783 -0.2943260    0.07401586
## Insulin         -0.3363324   -0.35534569  0.1416535   -0.09763514
## BMI            -0.3973420   -0.21031643 -0.2519303   -0.16321892
## DiabetesPedigreeFunction -0.2376345   -0.17519467  0.2853247    0.87352658
## Age            -0.2786556    0.53320237 -0.1261179    0.17111166
## Outcome        -0.4156528    0.15476805  0.3946151   -0.18167421
##
##          PC5          PC6          PC7          PC8
## Pregnancies    -0.21176571    0.456773101 -0.07851795   -0.54064221
## Glucose         -0.10877916   -0.382749448  0.20799965    0.02524536
## BloodPressure    0.05937792   -0.607867100 -0.32670833   -0.16280013
## SkinThickness   -0.17180950    0.397956778 -0.28199843    0.43491377
## Insulin         -0.65037442    0.008730189  0.08221649   -0.26883758
## BMI            0.52745778    0.241007894  0.57252374   -0.16646311
## DiabetesPedigreeFunction 0.15655457   -0.171628373  0.05719014   -0.09316407
## Age            -0.20428857   -0.001054913  0.29942807    0.61489048
## Outcome        0.37793701    0.171378976 -0.58037812    0.06827401
##
##          PC9
## Pregnancies    -0.26505155
## Glucose         -0.58107579
## BloodPressure    0.06830645
## SkinThickness   -0.39477039
## Insulin         0.47845101
## BMI            0.12644026
## DiabetesPedigreeFunction -0.04961786
## Age            0.28875418
## Outcome        0.31756221
```

```
summary(diabetes_pca)
```

```
## Importance of components:
##
##          PC1    PC2    PC3    PC4    PC5    PC6
## Standard deviation 1.5338 1.3320 1.0584 0.93912 0.91903 0.85724
## Proportion of Variance 0.2614 0.1971 0.1245 0.09799 0.09385 0.08165
## Cumulative Proportion 0.2614 0.4585 0.5830 0.68100 0.77485 0.85650
##
##          PC7    PC8    PC9
## Standard deviation 0.69887 0.64667 0.62041
## Proportion of Variance 0.05427 0.04646 0.04277
## Cumulative Proportion 0.91077 0.95723 1.00000
```

```
plot(diabetes_pca)
(eigen_diabetes <- diabetes_pca$sdev^2)
```

```
## [1] 2.3525016 1.7743120 1.1202251 0.8819549 0.8446234 0.7348682 0.4884234
## [8] 0.4181811 0.3849102
```

```
names(eigen_diabetes) <- paste("PC",1:9,sep="")
eigen_diabetes
```

```
##          PC1    PC2    PC3    PC4    PC5    PC6    PC7
## 2.3525016 1.7743120 1.1202251 0.8819549 0.8446234 0.7348682 0.4884234
##          PC8    PC9
## 0.4181811 0.3849102
```

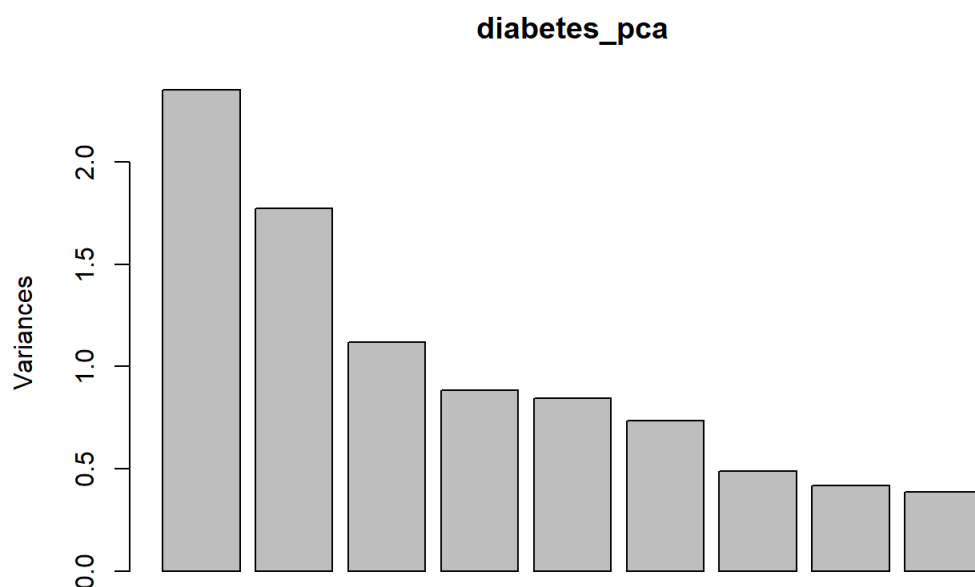
```
head(diabetes_pca$x)
```

```
##          PC1          PC2          PC3          PC4          PC5          PC6
## [1,] -1.7558028  1.1110186  0.2086554  0.33348787  0.481394261  0.43272041
## [2,]  1.5064398 -0.5590413 -0.6502039  0.22978395 -0.004884372  0.11923298
## [3,] -0.6503982  1.9283197  2.0064327 -0.02611202  0.233903264 -0.67360542
## [4,]  1.5863640 -1.0643810 -0.4741330 -0.58027536 -0.297234935  0.07085043
## [5,] -2.4817566 -2.3580258  2.9236096  3.93404759  1.565329993  0.20026682
## [6,]  1.4426872  1.0547347 -0.2776812 -0.41570434 -0.145266364 -0.63711649
##          PC7          PC8          PC9
## [1,] -0.457360625  1.12367812 -0.49362490
## [2,] -0.366229199  0.85188754 -0.03130377
## [3,] -0.721004746 -0.79284183 -1.06301081
## [4,] -0.344525279 -0.03060397  0.24081177
## [5,]  0.814600055  0.39844558  0.24900243
## [6,] -0.004113885 -0.61235146 -0.18157474
```

```
dim(diabetes_pca$x)
```

```
## [1] 768    9
```

```
plot(diabetes_pca)
```

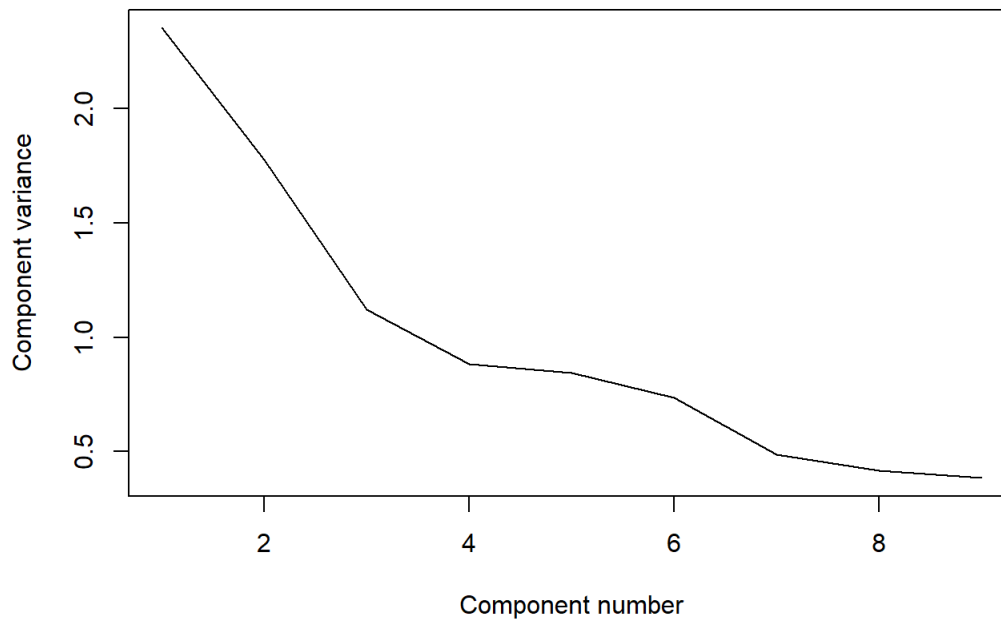


```
summary(diabetes_pca)
```

```
## Importance of components:
##          PC1          PC2          PC3          PC4          PC5          PC6
## Standard deviation    1.5338  1.3320  1.0584  0.93912  0.91903  0.85724
## Proportion of Variance 0.2614  0.1971  0.1245  0.09799  0.09385  0.08165
## Cumulative Proportion 0.2614  0.4585  0.5830  0.68100  0.77485  0.85650
##          PC7          PC8          PC9
## Standard deviation    0.69887  0.64667  0.62041
## Proportion of Variance 0.05427  0.04646  0.04277
## Cumulative Proportion 0.91077  0.95723  1.00000
```

```
plot(eigen_diabetes, xlab = "Component number", ylab = "Component variance", type = "l", main = "Scree diagram")
```

## Scree diagram



```
library(psych)
```

```
## Warning: package 'psych' was built under R version 3.5.3
```

```
##  
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':  
##  
##   %+%, alpha
```

```
vss(diabetes1)
```

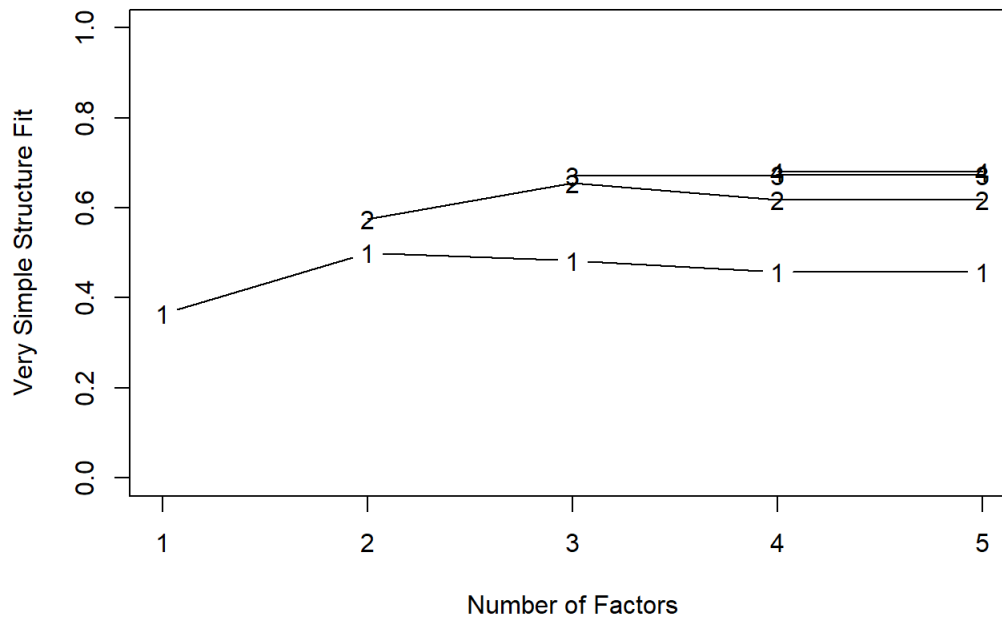
```
## Warning in fac(r = r, nfactors = nfactors, n.obs = n.obs, rotate =  
## rotate, : A loading greater than abs(1) was detected. Examine the loadings  
## carefully.
```

```
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs  
## = np.obs, : The estimated weights for the factor scores are probably  
## incorrect. Try a different factor extraction method.
```

```
## Warning in fac(r = r, nfactors = nfactors, n.obs = n.obs, rotate =  
## rotate, : An ultra-Heywood case was detected. Examine the results carefully
```



## Very Simple Structure



```
##
## Very Simple Structure
## Call: vss(x = diabetes1)
## VSS complexity 1 achieves a maximum of 0.5 with 2 factors
## VSS complexity 2 achieves a maximum of 0.66 with 3 factors
##
## The Velicer MAP achieves a minimum of NA with 1 factors
## BIC achieves a minimum of NA with 2 factors
## Sample Size adjusted BIC achieves a minimum of NA with 2 factors
##
## Statistics by number of factors
##   vss1 vss2  map dof   chisq   prob sqresid  fit RMSEA  BIC  SABIC
## 1 0.36 0.00 0.081   5 9.5e+01 7.3e-19    3.6 0.36  0.15 61.4    77
## 2 0.50 0.57 0.191   1 1.5e+01 8.4e-05    2.4 0.57  0.14  8.8    12
## 3 0.48 0.66 0.393  -2 2.0e-09      NA    1.9 0.67    NA   NA   NA
## 4 0.46 0.62 1.000  -4 0.0e+00      NA    1.8 0.68    NA   NA   NA
## 5 0.46 0.62    NA  -5 0.0e+00      NA    1.8 0.68    NA   NA   NA
##   complex eChisq   SRMR eCRMS eBIC
## 1      1.0 1.2e+02 8.8e-02 0.12  85
## 2      1.4 1.7e+01 3.3e-02 0.11  10
## 3      1.4 1.8e-09 3.4e-07    NA   NA
## 4      1.7 5.4e-14 1.9e-09    NA   NA
## 5      1.7 5.4e-14 1.9e-09    NA   NA
```

```
#therefore choosing 5 Factors
```

```
#Oblique rotation
```

```
fit.pc <- fa(diabetes1, nfactors=5, rotate="oblimin")
```

```
## Loading required namespace: GPArotation
```

```
fit.pc
```

```
## Factor Analysis using method = minres
## Call: fa(r = diabetes1, nfactors = 5, rotate = "oblimin")
## Standardized loadings (pattern matrix) based upon correlation matrix
##
##      MR2  MR1  MR3  MR4 MR5  h2  u2 com
## Age      0.67 -0.07  0.12 -0.01  0  0.47 0.53 1.1
## BMI      -0.07  0.65  0.11  0.01  0  0.47 0.53 1.1
## Outcome   0.33  0.30 -0.21  0.30  0  0.51 0.49 3.7
## Insulin   -0.19  0.00  0.19  0.37  0  0.13 0.87 2.1
## BloodPressure 0.13  0.13  0.61  0.01  0  0.49 0.51 1.2
##
##      MR2  MR1  MR3  MR4 MR5
## SS loadings      0.64 0.63 0.51 0.30 0.00
## Proportion Var    0.13 0.13 0.10 0.06 0.00
## Cumulative Var    0.13 0.25 0.35 0.41 0.41
## Proportion Explained 0.31 0.30 0.25 0.14 0.00
## Cumulative Proportion 0.31 0.61 0.86 1.00 1.00
##
## With factor correlations of
##      MR2  MR1  MR3  MR4 MR5
## MR2 1.00 0.19  0.19  0.30  0
## MR1 0.19 1.00  0.31  0.70  0
## MR3 0.19 0.31  1.00 -0.17  0
## MR4 0.30 0.70 -0.17  1.00  0
## MR5 0.00 0.00  0.00  0.00  1
##
## Mean item complexity = 1.8
## Test of the hypothesis that 5 factors are sufficient.
##
## The degrees of freedom for the null model are 10 and the objective function was 0.35 with Chi Square of 268.92
## The degrees of freedom for the model are -5 and the objective function was 0
##
## The root mean square of the residuals (RMSR) is 0
## The df corrected root mean square of the residuals is NA
##
## The harmonic number of observations is 768 with the empirical chi square 0 with prob < NA
## The total number of observations was 768 with Likelihood Chi Square = 0 with prob < NA
##
## Tucker Lewis Index of factoring reliability = 1.039
## Fit based upon off diagonal values = 1
## Measures of factor score adequacy
##
##      MR2  MR1  MR3  MR4 MR5
## Correlation of (regression) scores with factors 0.75 0.78 0.72 0.71 0
## Multiple R square of scores with factors 0.56 0.61 0.52 0.51 0
## Minimum correlation of possible factor scores 0.12 0.22 0.03 0.01 -1
```

```
#what are factors for each variable , what is affectin and
#Fit based upon off diagonal values = 0.96 higher the better
#residual should be less
round(fit.pc$values, 3)
```

```
## [1] 1.107 0.497 0.433 0.032 0.000
```

```
fit.pc$loadings
```

```
##
## Loadings:
##      MR2  MR1  MR3  MR4 MR5
## Age      0.669      0.117
## BMI      0.647  0.109
## Outcome   0.330  0.296 -0.209  0.298
## Insulin   -0.192      0.193  0.368
## BloodPressure 0.133  0.130  0.610
##
##      MR2  MR1  MR3  MR4 MR5
## SS loadings 0.616 0.528 0.478 0.225 0.000
## Proportion Var 0.123 0.106 0.096 0.045 0.000
## Cumulative Var 0.123 0.229 0.324 0.369 0.369
```

```
#View(fit.pc)
# Loadings with more digits
for (i in c(1,2,3,4,5)) { print(fit.pc$loadings[[1,i]])}
```

```
## [1] 0.6691348
## [1] -0.06577584
## [1] 0.1173003
## [1] -0.01371583
## [1] 7.517829e-15
```

```
# Communalities
fit.pc$communality
```

```
##          Age          BMI          Outcome          Insulin BloodPressure
##    0.4696878    0.4706203    0.5081298    0.1274868    0.4929153
```

```
# Rotated factor scores, Notice the columns ordering: RC1, RC3, RC2 and RC4
fit.pc$scores
```

```
##          MR2          MR1          MR3          MR4          MR5
## [1,] 1.293781717 0.4488283514 -0.0347154073 0.687675487 1.792075e-13
## [2,] -0.276899150 -0.6956025483 -0.1005076314 -0.678256768 -1.565038e-13
## [3,] 0.457321352 -0.2101551616 -0.7208675256 0.371503907 3.022903e-14
## [4,] -0.820158918 -0.4638932263 -0.1454118736 -0.503918008 -1.415069e-13
## [5,] 0.071752833 0.9799937756 -0.9444880017 1.375256974 2.164896e-13
## [6,] -0.257292578 -0.6767428839 0.1143696332 -0.749417238 -1.547352e-13
## [7,] -0.045571438 0.2564017725 -1.0165001417 0.811015323 8.569493e-14
## [8,] -0.932771058 -0.7798376663 -1.9770023140 -0.083140408 -1.920539e-13
## [9,] 1.144362838 0.7656255590 0.0496265536 1.354851802 3.055703e-13
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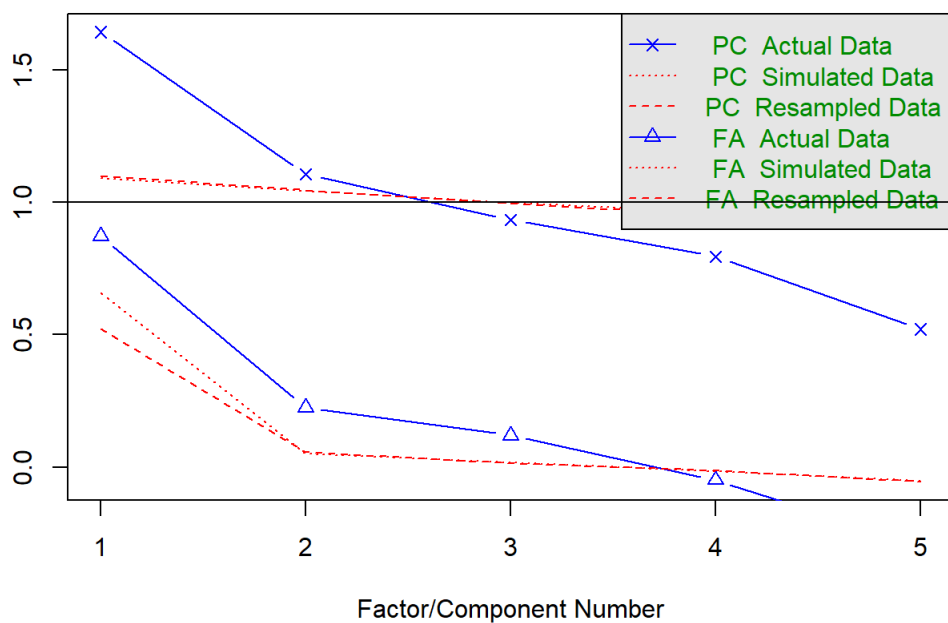
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## [756,] 0.705185478 0.9549448189 0.4225987348 0.854083299 2.300875e-13
## [757,] 0.239666765 -0.1501617860 0.8596774855 -0.605905150 -4.938011e-14
## [758,] 1.367433331 0.6123619244 0.0496170220 0.778520372 2.081924e-13
## [759,] -0.531022628 0.1170032857 0.4056531013 -0.366956905 -5.493081e-14
## [760,] 2.192064300 0.6989673956 0.8095668475 0.668039923 2.680029e-13
## [761,] -0.790460495 -0.6057729901 -0.4028779629 -0.564931208 -1.710763e-13
## [762,] 0.888754258 1.1595936731 0.1886897809 1.018399545 2.583063e-13
## [763,] -0.177372581 -1.0040946572 -0.2969949463 -0.794157861 -1.948112e-13
## [764,] 1.176325047 -0.1489243702 0.7729338528 -0.243161005 4.388421e-14
## [765,] -0.521926702 0.0095174391 0.2139449808 -0.361485553 -6.859666e-14
## [766,] -0.339604250 -0.5454737828 0.1039601903 -0.563724093 -1.217178e-13
## [767,] 1.089878673 0.1210171294 -0.5220667638 0.625650840 1.209384e-13
## [768,] -0.661065229 -0.3812044171 0.0222917441 -0.576324756 -1.354965e-13
```

```
# Play with FA utilities
```

```
fa.parallel(diabetes1) # See factor recommendation
```

eigenvalues of principal components and factor analysis

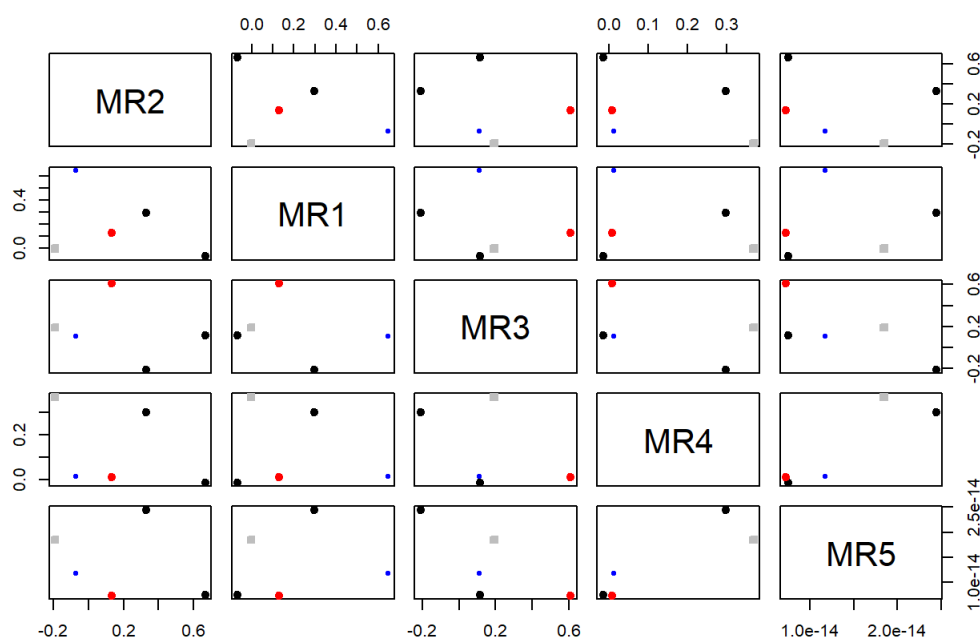
## Parallel Analysis Scree Plots



```
## Parallel analysis suggests that the number of factors = 0 and the number of components = 2
```

```
fa.plot(fit.pc) # See Correlations within Factors
```

## Factor Analysis



```
fa.diagram(fit.pc) # Visualize the relationship
```

## Factor Analysis

