CRP-analysis

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## Warning: package 'regclass' was built under R version 4.0.4

## Warning: package 'bestglm' was built under R version 4.0.4

## Warning: package 'leaps' was built under R version 4.0.3

## Warning: package 'VGAM' was built under R version 4.0.4

## Warning: package 'randomForest' was built under R version 4.0.4

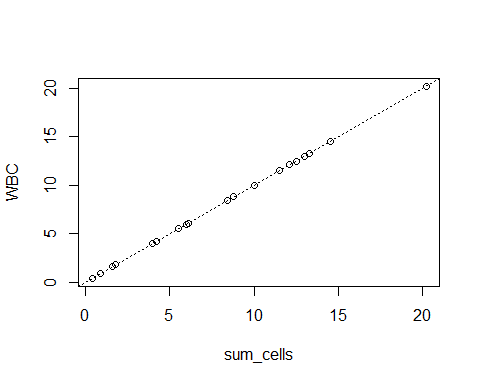
# Analysis of blood analysis data set

## Read data set

tab1<-read.csv2("data\_blood.csv")  
attach(tab1)

## Sum of five subtypes equals white blood cell counts

sum\_cells <- NEU + EOS + BASO + LYM + MONO  
  
plot(sum\_cells, WBC)  
abline(0,1, lty=3)



## Pairwise correlations

round(cor(cbind(NEU, EOS, BASO, LYM, MONO, WBC)),3)

## NEU EOS BASO LYM MONO WBC  
## NEU 1.000 0.211 -0.078 0.451 0.732 0.982  
## EOS 0.211 1.000 0.170 0.134 0.024 0.218  
## BASO -0.078 0.170 1.000 0.053 0.021 -0.045  
## LYM 0.451 0.134 0.053 1.000 0.765 0.601  
## MONO 0.732 0.024 0.021 0.765 1.000 0.831  
## WBC 0.982 0.218 -0.045 0.601 0.831 1.000

## Exact collineartiy

The analysis of the basic regression model will result in the program setting one of the coefficients to NA.

mod <- lm(CRP ~ NEU + EOS + BASO + LYM + MONO + WBC)  
summary(mod)

##   
## Call:  
## lm(formula = CRP ~ NEU + EOS + BASO + LYM + MONO + WBC)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -5.8418 -2.3144 0.4375 3.2276 4.5418   
##   
## Coefficients: (1 not defined because of singularities)  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 10.40609 1.82392 5.705 5.43e-05 \*\*\*  
## NEU 0.65243 0.31278 2.086 0.0558 .   
## EOS -19.47720 7.78284 -2.503 0.0253 \*   
## BASO -6.96221 24.28428 -0.287 0.7785   
## LYM -3.08362 2.07602 -1.485 0.1596   
## MONO -0.04194 2.72566 -0.015 0.9879   
## WBC NA NA NA NA   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 3.744 on 14 degrees of freedom  
## Multiple R-squared: 0.5387, Adjusted R-squared: 0.3739   
## F-statistic: 3.269 on 5 and 14 DF, p-value: 0.03657

Next, VIFs are computed using the package regclass. The function VIF results in an error as there is exact collinearity.

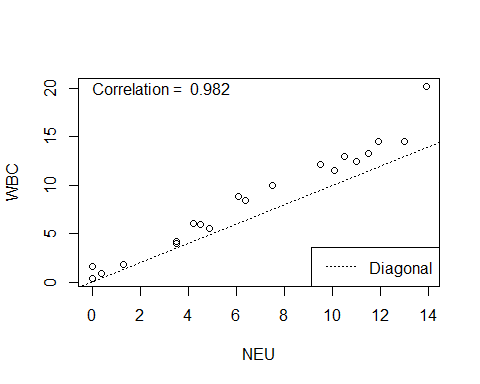
try(VIF(mod))

## Error in VIF(mod) : there are aliased coefficients in the model

## Near collinearity

Now we consider a model with just two variables, NEU and WBC. First we investigate correlation.

plot(NEU, WBC)  
abline(0,1,lty=3)  
text(0,20, paste("Correlation = ", round(cor(NEU, WBC),3)), adj=0)  
legend("bottomrigh", lty=3, legend="Diagonal")



Now we fit the model and evaluate the VIFs.

mod2 <- lm(CRP ~ NEU + WBC)  
VIF(mod2)

## NEU WBC   
## 28.72946 28.72946

Evaluate the model:

summary(mod2)

##   
## Call:  
## lm(formula = CRP ~ NEU + WBC)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -5.7657 -3.7508 -0.5381 3.6528 6.9263   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 8.979 1.800 4.989 0.000112 \*\*\*  
## NEU 2.650 1.157 2.290 0.035071 \*   
## WBC -1.954 0.957 -2.042 0.056982 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 4.256 on 17 degrees of freedom  
## Multiple R-squared: 0.2762, Adjusted R-squared: 0.191   
## F-statistic: 3.243 on 2 and 17 DF, p-value: 0.0641

The regression coefficients are quite extreme, but this results from their meaning:

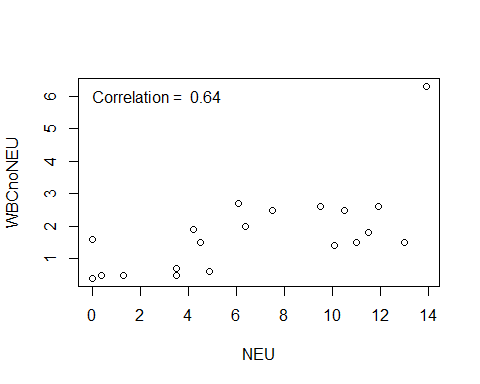
The regression coefficient of NEU has the interpretation of the expected difference in CRP corresponding to a difference of 1 G/L in NEU but keeping WBC constant. From the plot above we see that it is sometimes not possible to increase NEU by 1 G/L and at the same time holding WBC fixed, as NEU is a component of WBC and cannot exceed WBC. Hence the regression coefficient has a problematic interpretation.

Remedy: compute a new variable WBCnoNEU = WBC - NEU

WBCnoNEU <- WBC - NEU

Evaluate correlation again:

plot(NEU, WBCnoNEU)  
text(0,6, paste("Correlation = ", round(cor(NEU, WBCnoNEU),3)), adj=0)

 Fit model and evaluate VIFs:

mod3 <- lm(CRP ~ NEU + WBCnoNEU)  
VIF(mod3)

## NEU WBCnoNEU   
## 1.694783 1.694783

Evaluate the model:

summary(mod3)

##   
## Call:  
## lm(formula = CRP ~ NEU + WBCnoNEU)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -5.7657 -3.7508 -0.5381 3.6528 6.9263   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 8.9788 1.7998 4.989 0.000112 \*\*\*  
## NEU 0.6961 0.2811 2.477 0.024071 \*   
## WBCnoNEU -1.9542 0.9570 -2.042 0.056982 .   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 4.256 on 17 degrees of freedom  
## Multiple R-squared: 0.2762, Adjusted R-squared: 0.191   
## F-statistic: 3.243 on 2 and 17 DF, p-value: 0.0641

The standard errors for the coefficient of NEU is now considerably smaller, and the value of the coefficient is quite different from the model above. Still, the multiple is exactly equal to model mod2. The reason is that the coefficient of NEU now has a different meaning (expected difference in CRP corresponding to a difference in NEU of 1 G/L given constant concentrations of all other components of WBC). However, the coefficient of WBCnoNEU has the same meaning as in Model mod2 (expected difference in CRP corresponding to a difference in WBC of 1 G/L given constant NEU), and hence its value and standard error in model mod3 do not differ from those in mod2.