Dataset:

hospitals <- read.csv("Hospitals.csv") tempHosp <- hospitals # create a new dataset so as to not modify the original data

Model 1 (Number following "Table" or "Plot" indicates model number)

Code:

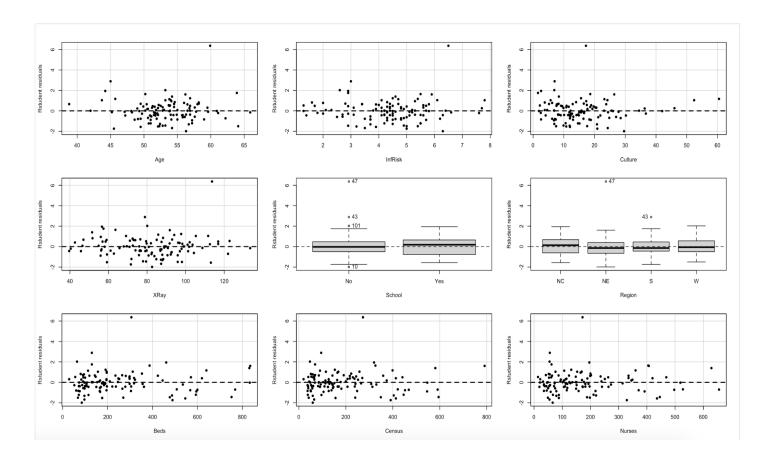
model1 <- lm(LenStay ~ Age + InfRisk + Culture + XRay + School + Region + Beds + Census + Nurses + Services, data = tempHosp)

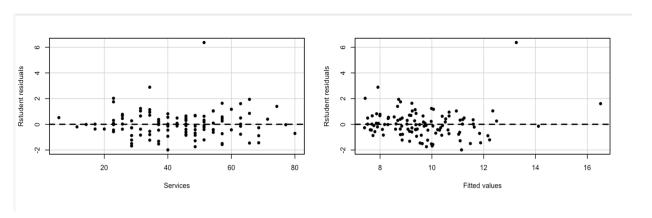
```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
                                                             Anova Table (Type II tests)
                     1.612956
(Intercept) 2.242682
                               1.390 0.167489
                               2.827 0.005668 **
Age
            0.079922
                     0.028266
                                                             Response: LenStay
InfRisk
           0.439665
                     0.127298
                               3.454 0.000812 ***
                                                                        Sum Sq Df F value
                                                                                              Pr(>F)
                     0.015982
                               0.347 0.729299
Culture
           0.005546
                                                                                1 7.9946 0.0056679 **
                                                             Age
                                                                        12.108
XRay
           0.012688
                     0.007147
                                1.775 0.078892
                                                                                1 11.9290 0.0008119 ***
SchoolYes
                                                             InfRisk
                                                                        18.067
           0.266644
                     0.441089
                               0.605 0.546872
           0.812966
                                                             Culture
                                                                         0.182
                                                                                1 0.1204 0.7292992
RegionNE
                     0.351406
                               2.313 0.022744 *
           -0.345311
                     0.313506 -1.101 0.273345
                                                                         4.773
RegionS
                                                             XRay
                                                                                1 3.1517 0.0788924
          -1.067594
                     0.398736 -2.677 0.008672 **
RegionW
                                                             School
                                                                         0.553
                                                                                 1
                                                                                   0.3654 0.5468722
Beds
           -0.004851
                     0.003603 -1.346 0.181224
                                                                        29.928
                                                             Region
                                                                                3 6.5869 0.0004153
                               3.432 0.000872 ***
           0.015182
                     0.004424
Census
                                                             Beds
                                                                        2.745
                                                                                1 1.8127 0.1812243
Nurses
           -0.005891
                     0.002218 -2.656 0.009203 **
                                                             Census
                                                                        17.840
                                                                                1 11.7794 0.0008723 ***
                     0.013774 -0.884 0.378698
Services
          -0.012179
                                                                                1 7.0546 0.0092028 **
                                                                        10.684
                                                             Nurses
                                                             Services
                                                                        1.184
                                                                                1 0.7818 0.3786983
Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' ' 1
                                                             Residuals 151.451 100
Residual standard error: 1.231 on 100 degrees of freedom
                                                             Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' '1
Multiple R-squared: 0.6299,
                            Adjusted R-squared: 0.5855
F-statistic: 14.18 on 12 and 100 DF, p-value: < 2.2e-16
```

Table 1a. Anova output and global F-test output

Code:

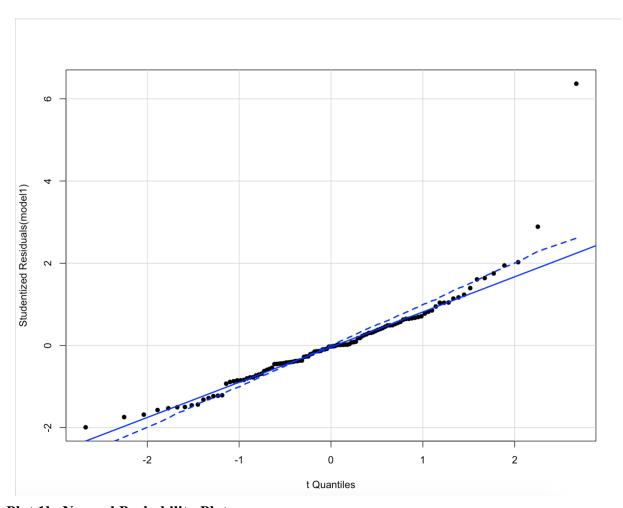
summary(model1)
Anova(model1)





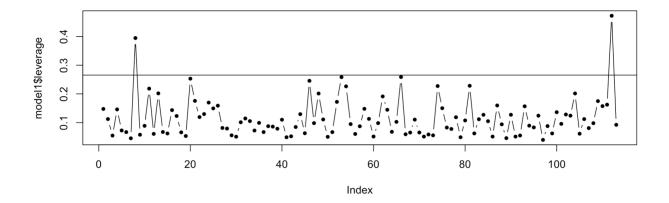
Plot 1a. Residuals vs. Predicted Plots

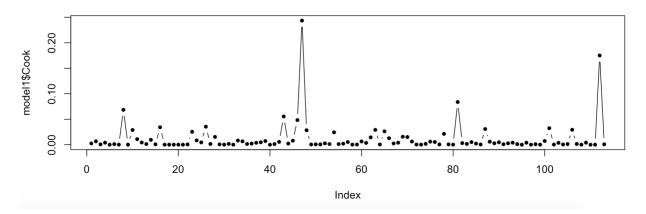
residual Plots (model 1, type = "rstudent", pch = 16, quadratic = FALSE, id = FALSE, tests = FALSE)



Plot 1b. Normal Probability Plot

qqPlot(model1,envelope=FALSE,pch=16,id=FALSE)





Plot 1c. Residuals vs. Leverages plot and Cook's distance plot

```
#HIGH LEVERAGE

n = nrow(tempHosp)

p = 10

leverage.cutoff <- 3*p/n

model1$leverage <- hatvalues(model1)

plot(model1$leverage,type="b",pch=20)

abline(h = leverage.cutoff)
```

#COOK'S DIST model1\$Cook <- cooks.distance(model1) plot(model1\$Cook,type="b",pch=20)

```
> cor(tempHosp$Beds, tempHosp$Census)
  Variables Tolerance
                             VIF
                                   [1] 0.9809977
1
        Age 0.85021570 1.176172
2
    InfRisk 0.46410296 2.154694
                                   > cor(tempHosp$Census, tempHosp$Nurses)
3
    Culture 0.50542828 1.978520
                                   [1] 0.907897
4
       XRay 0.70608230 1.416265
                                   > cor(tempHosp$Beds, tempHosp$Nurses)
5 SchoolYes 0.53898638 1.855334
                                   [1] 0.9155042
6
   RegionNE 0.58231265
                        1.717291
7
    RegionS 0.61921830 1.614939
8
    RegionW 0.69356705 1.441822
9
       Beds 0.02801183 35.699204
10
     Census 0.02923000 34.211423
     Nurses 0.14173293 7.055523
11
   Services 0.30846950 3.241812
12
```

Table 1b. VIF output and correlations

Code:

```
ols_vif_tol(model1)
cor(tempHosp$Beds, tempHosp$Census)
cor(tempHosp$Census, tempHosp$Nurses)
cor(tempHosp$Beds, tempHosp$Nurses)
```

```
model2 <- lm(LenStay ~ Age + InfRisk + Culture + XRay + School + Region + Census + Nurses + Services, data = tempHosp)
```

```
Variables Tolerance
                            VIF
         Age 0.8536011 1.171507
1
2
     InfRisk 0.4804537 2.081366
3
     Culture 0.5180458 1.930331
4
        XRay 0.7060893 1.416251
5
   SchoolYes 0.5568362 1.795860
    RegionNE 0.6297585 1.587910
7
     RegionS 0.6200648 1.612735
8
     RegionW 0.6981455 1.432366
9
      Census 0.1360935 7.347888
10
      Nurses 0.1503007 6.653327
    Services 0.3316289 3.015419
```

Table 2a. VIF output

Code:

ols_vif_tol(model2)

Code:

tempHosp\$NursePerson <- tempHosp\$Nurses / tempHosp\$Census

#We now proceed with a variable that has the ratio for average nurses/average daily hospital patients.

model3 <- lm(LenStay ~ Age + InfRisk + Culture + XRay + School + Region + Census + NursePerson + Services, data = tempHosp)

```
Variables Tolerance
                              VIF
1
           Age 0.8550171 1.169567
2
       InfRisk 0.4786091 2.089388
3
       Culture 0.5232812 1.911018
4
          XRay 0.6964141 1.435927
5
     SchoolYes 0.5567031 1.796290
6
      RegionNE 0.6288709 1.590152
7
       RegionS 0.6167636 1.621367
8
       RegionW 0.6441908 1.552335
        Census 0.2716812 3.680785
10 NursePerson 0.6928434 1.443327
11
      Services 0.3333499 2.999851
```

Table 3a. VIF output

Code:

 $ols_vif_tol(model3)$

Subsets Regression Summary

Model	R-Square	Adj. R-Square	Pred R-Square	C(p)	AIC	SBIC	SBC	MSEP	FPE	HSP	APC
1	0.2846	0.2781	0.2538	76.8216	434.2539	111.6991	442.4361	298.0404	2.6842	0.0240	0.7412
2	0.4604	0.4404	0.4075	33.1433	408.3742	82.4570	424.7385	226.8389	2.0987	0.0188	0.5690
3	0.5232	0.5009	0.4536	18.8440	396.4026	71.0066	415.4943	202.3126	1.8881	0.0169	0.5118
4	0.5551	0.5299	0.4758	12.5643	390.5835	65.6805	412.4026	190.5512	1.7937	0.0161	0.4861
5	0.5823	0.5544	0.4911	7.5011	385.4569	61.2709	410.0034	180.5926	1.7145	0.0154	0.4646
6	0.6013	0.5706	0.5076	4.5516	382.1809	58.7616	409.4548	173.9960	1.6659	0.0149	0.4513
7	0.6088	0.5746	0.5064	4.6016	382.0327	59.1224	412.0340	172.3610	1.6642	0.0149	0.4508
8	0.6111	0.5730	0.5016	6.0025	383.3645	60.7942	416.0931	173.0082	1.6844	0.0151	0.4562
9	0.6111	0.5688	0.4937	8.0000	385.3616	63.0295	420.8177	174.7000	1.7149	0.0154	0.4644

AIC: Akaike Information Criteria

SBIC: Sawa's Bayesian Information Criteria

SBC: Schwarz Bayesian Criteria

MSEP: Estimated error of prediction, assuming multivariate normality

FPE: Final Prediction Error

HSP: Hocking's Sp

APC: Amemiya Prediction Criteria

Table 3b. Best subsets regression summary output

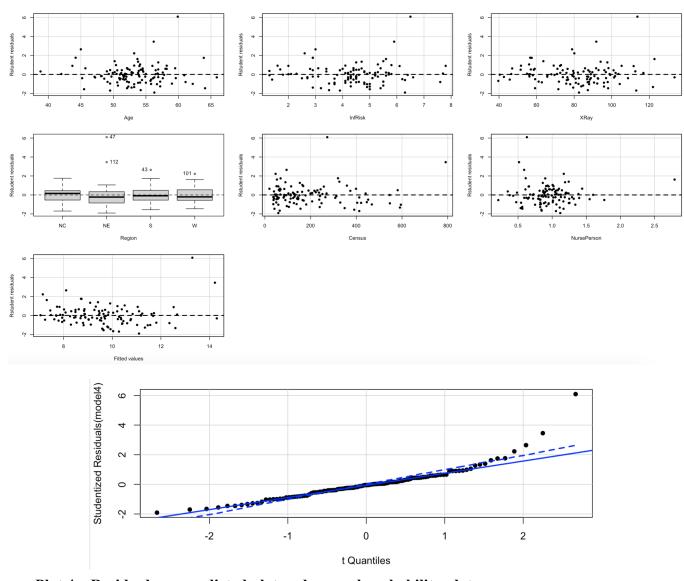
Code:

select = ols_step_best_subset(model3)
select

```
Anova Table (Type II tests)
 Response: LenStay
               Sum Sq Df F value
                                       Pr(>F)
               13.235
                        1 8.4366 0.0044924 **
 Age
               28.544
 InfRisk
                        1 18.1960 4.403e-05 ***
 XRay
                7.798
                         1 4.9709 0.0279270 *
               34.977
                        3 7.4321 0.0001474 ***
 Region
 Census
               22.335
                        1 14.2379 0.0002681 ***
 NursePerson 13.308
                            8.4834 0.0043869 **
                         1
 Residuals 163.147 104
                  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '1
 Sianif. codes:
Anova Table (Type II tests)
Response: LenStay
              Sum Sq Df F value
                                      Pr(>F)
              13.383
                        1 8.6114
                                   0.004119 **
Age
InfRisk
                        1 19.4349 2.561e-05 ***
              30.204
XRay
               7.139 1 4.5936 0.034446 *
              37.566
                        3 8.0573 7.122e-05 ***
Region
              19.434
                        1 12.5046 0.000610 ***
Census
NursePerson 9.409
                        1 6.0544 0.015535 *
Services
               3.072
                        1 1.9769 0.162732
Residuals
             160.075 103
                 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '1
Signif. codes:
Table 3c. Global F-tests for best subsets modelA and best subsets modelB
Code:
best subsets modelA = lm(LenStay ~ Age + InfRisk + XRay + Region + Census +
NursePerson, data = tempHosp)
best subsets modelB = lm(LenStay ~ Age + InfRisk + XRay + Region + Census + NursePerson
+ Services, data = tempHosp)
Anova(best subsets modelA)
Anova(best subsets modelB)
```

Code:

 $model4 = Im(LenStay \sim Age + InfRisk + XRay + Region + Census + NursePerson, data = tempHosp)$



Plot 4a. Residuals vs. predicted plot and normal probability plot

Code:

 $residual Plots (model 4, type="rstudent", pch=16, quadratic=FALSE, id=FALSE, tests=FALSE) \\ qqPlot (model 4, envelope=FALSE, pch=16, id=FALSE) \\$

```
Call:
lm(formula = LenStay ~ InfRisk + XRay + Region + Census + NursePerson +
   InfRisk:Census, data = tempHosp)
Residuals:
   Min
            10 Median
                          30
                                 Max
-2.4265 -0.7497 -0.2095 0.5389 6.3475
Coefficients:
               Estimate Std. Error t value Pr(>|t|)
              8.4236249 0.7768264 10.844 < 2e-16 ***
(Intercept)
              0.0661136  0.1508260  0.438  0.662047
InfRisk
              0.0162049 0.0069945 2.317 0.022474 *
XRay
             0.9566034 0.3206044 2.984 0.003549 **
RegionNE
             RegionS
RegionW
             -0.7881964 0.4006397 -1.967 0.051807 .
             -0.0107840 0.0036150 -2.983 0.003556 **
Census
NursePerson -1.0589416 0.4151215 -2.551 0.012200 *
InfRisk:Census 0.0029142 0.0007344 3.968 0.000133 ***
Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' '1
Residual standard error: 1.214 on 104 degrees of freedom
Multiple R-squared: 0.6256, Adjusted R-squared: 0.5969
F-statistic: 21.73 on 8 and 104 DF, p-value: < 2.2e-16
```

Table 4a. Stepwise regression results

Code:

```
step1 <- step(model4,scope=~.^2,direction="both",trace=1,k=log(n)) summary(step1)
```

```
cInfRisk
 cXRay
                                 4.478 1 3.2249 0.0755173
Region 33.621 3 8.0707 7.148e-05 ***

CCensus 19.479 1 14.0279 0.0002999 ***

cNursePerson 6.390 1 4.6018 0.0343359 *
 Region:cInfRisk 12.941 3 3.1065 0.0298552 *
 cInfRisk:cCensus 17.842 1 12.8492 0.0005218 ***
 Residuals 140.247 101
Sum Sq Df F value Pr(>F)
cInfRisk 37.548 1 26.9433 1.087e-06 ***
cXRay 4.829 1 3.4650 0.0655885 .
Region 33.621 3 8.0418 7.393e-05 ***
cCensus 20.420 1 14.6532 0.0002242 ***
cNursePerson 7.588 1 5.4450 0.0216057 *
Region:cCensus 12.437 3 2.9748 0.0352084 *
                                Sum Sq Df F value
                                                                           Pr(>F)
 cCensus:cInfRisk 13.825 1 9.9202 0.0021506 **
 Residuals 140.751 101
                                 Sum Sq Df F value
                                                                           Pr(>F)
CInfRisk 27.446 1 20.0723 1.969e-05 ***
cXRay 4.464 1 3.2645 0.0737735 .
Region 33.621 3 8.1961 6.178e-05 ***
cCensus 15.877 1 11.6114 0.0009425 ***
cNursePerson 9.585 1 7.0099 0.0094063 **
Region:cNursePerson 15.087 3 3.6779 0.0146071 *
cInfRisk:cCensus 18.084 1 13.2259 0.0004367 ***
Residuals 138.101 101
Residuals
                                  138.101 101
```

Table 4b. Testing other possible interactions with global F-test

```
possible1 = lm(LenStay ~ Region:cInfRisk+ cInfRisk + cXRay + Region + cCensus + cNursePerson + cInfRisk:cCensus, data = tempHosp)

Anova(possible1)

possible2 = lm(LenStay ~ Region:cCensus+ cInfRisk + cXRay + Region + cCensus + cNursePerson + cInfRisk:cCensus, data = tempHosp)

Anova(possible2)
```

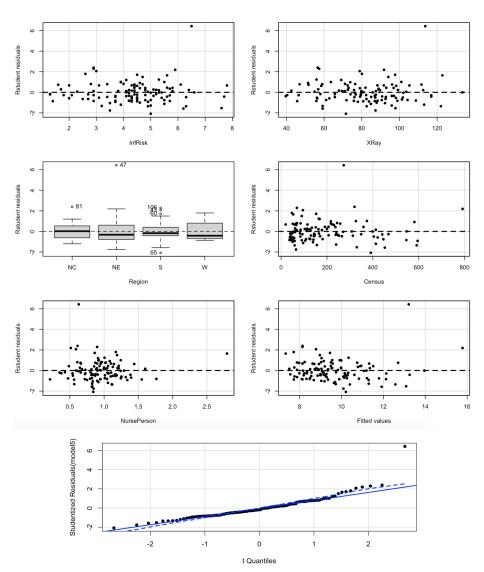
possible3 = lm(LenStay ~ Region:cNursePerson+ cInfRisk + cXRay + Region + cCensus + cNursePerson + cInfRisk:cCensus, data = tempHosp)

Anova(possible3)

Note: Anova results are in order of code

Code:

model5 <- lm(LenStay ~ InfRisk + XRay + Region + Census + NursePerson + InfRisk:Census, data = tempHosp)



Plot 5a. Residuals vs. predicted plots and normal probability plot

Code:

residualPlots(model5,type="rstudent",pch=16,quadratic=FALSE,id=FALSE,tests=FALSE) qqPlot(model5,envelope=FALSE,pch=16,id=FALSE)

	Variables	Tolerance	VIF
1	InfRisk	0.32153156	3.110115
2	XRay	0.71694015	1.394817
3	RegionNE	0.68038495	1.469756
4	RegionS	0.65354166	1.530124
5	RegionW	0.66814518	1.496681
6	Census	0.04256648	23.492664
7	NursePerson	0.73809612	1.354837
8	<pre>InfRisk:Census</pre>	0.03398529	29.424497

Table 5a. VIF output

ols_vif_tol(model5)

Model 6 || Final Model

```
Code:
```

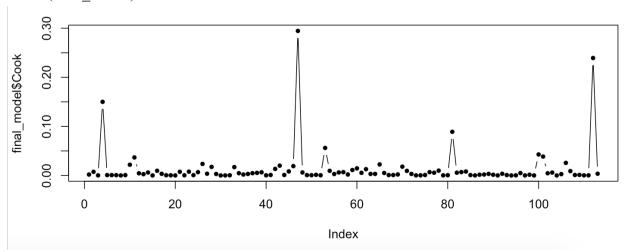
```
final model = lm(LenStay ~ cInfRisk + cXRay + Region + cCensus + cNursePerson +
cInfRisk:cCensus, data = tempHosp)
summary(final model)
Anova(final model)
Residuals:
    Min
            1Q Median
                          30
                                Max
 -2.4265 -0.7497 -0.2095 0.5389 6.3475
Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
                9.3932257   0.2198023   42.735   < 2e-16 ***
 (Intercept)
                cInfRisk
               0.0162049 0.0069945 2.317 0.022474 *
 cXRay
               0.9566034 0.3206044 2.984 0.003549 **
RegionNE
               RegionS
               -0.7881964   0.4006397   -1.967   0.051807
RegionW
 cCensus
                0.0019070 0.0009055
                                   2.106 0.037621 *
cNursePerson -1.0589416 0.4151215 -2.551 0.012200 *
 cInfRisk:cCensus 0.0029142 0.0007344
                                   3.968 0.000133 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '1
Residual standard error: 1.214 on 104 degrees of freedom
Multiple R-squared: 0.6256, Adjusted R-squared: 0.5969
F-statistic: 21.73 on 8 and 104 DF, p-value: < 2.2e-16
Anova Table (Type II tests)
Response: LenStay
                 Sum Sq Df F value
                                     Pr(>F)
cInfRisk
                 29.707 1 20.1680 1.842e-05 ***
                 7.906 1 5.3677 0.0224738 *
cXRay
Region
                 33.621 3 7.6084 0.0001196 ***
cCensus
                 20.420 1 13.8635 0.0003195 ***
                 9.585 1 6.5072 0.0121997 *
cNursePerson
cInfRisk:cCensus 23.194 1 15.7462 0.0001334 ***
Residuals
              153.188 104
Signif. codes: 0 '*** 0.001 '** 0.01 '* 0.05 '.' 0.1 ' '1
```

Table 6a. Anova results and global F-test

Code:

summary(final model)

Anova(final_model)



Plot 6a. Cook's Distance Plot

Code:

final_model\$Cook <- cooks.distance(final_model)
plot(final_model\$Cook,type="b",pch=20)</pre>

Analysis of Variance Table

Table 6b. Partial F-test comparing reduced model to full model

Code:

```
full_model = lm(LenStay ~ Age + InfRisk + Culture + XRay + School + Region + Beds + Census + Nurses + Services + InfRisk:Census + NursePerson, data = tempHosp)

anova(final_model, full_model)
```