

test_interaction_data

August 10, 2018

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Get Glow dataset

```
glow <- read_glow_dataset()
```

model interactions - main effects

```
model_z1 <- glm(FRACTURE ~ AGE, family = binomial, data = glow)
model_z2 <- glm(FRACTURE ~ WEIGHT, family = binomial, data = glow)
model_z3 <- glm(FRACTURE ~ HEIGHT, family = binomial, data = glow)
model_z4 <- glm(FRACTURE ~ BMI, family = binomial, data = glow)
model_z5 <- glm(FRACTURE ~ PRIORFRAC, family = binomial, data = glow)
model_z6 <- glm(FRACTURE ~ PREMENO, family = binomial, data = glow)
model_z7 <- glm(FRACTURE ~ MOMFRAC, family = binomial, data = glow)
model_z8 <- glm(FRACTURE ~ ARMASSIST, family = binomial, data = glow)
model_z9 <- glm(FRACTURE ~ SMOKE, family = binomial, data = glow)
model_z10 <- glm(FRACTURE ~ RATERISK, family = binomial, data = glow)
```

```
## AGE          0.05289    0.01163    4.548 5.42e-06 ***
## WEIGHT       -0.005197   0.006415  -0.810    0.418
## HEIGHT      -0.05167    0.01709   -3.022   0.00251 **
## BMI          0.005758    0.017185    0.335   0.73760
## PRIORFRACYes 1.0638      0.2231     4.769 1.85e-06 ***
## PREMENOYes   0.05077     0.25921    0.196    0.845
## MOMFRACYes   0.6605      0.2810     2.351   0.0187 *
## ARMASSISTYes 0.7091      0.2098     3.381 0.000723 ***
## SMOKEYes     -0.3077      0.4358    -0.706    0.48
## RATERISKSame  0.5462      0.2664     2.050   0.0404 *
## RATERISKGreater 0.9091      0.2711     3.353   0.0008 ***
```

> code below:

This leads us to consider the covariates above that are significant in the univariate results above at the 25% level.

AGE, HEIGHT, PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK {SAME, GREATER}

```

# fit a univariate logistic regression model for each covariate
# continuous - AGE WEIGHT HEIGHT BMI
# categorical - PRIORFRAC PREMENO MOMFRAC ARMASSIST SMOKE RATERISK

# model0
#model_z1 <- glm(FRACTURE ~ AGE, family = binomial, data = glow)
#model_z2 <- glm(FRACTURE ~ WEIGHT, family = binomial, data = glow)
#model_z3 <- glm(FRACTURE ~ HEIGHT, family = binomial, data = glow)
#model_z4 <- glm(FRACTURE ~ BMI, family = binomial, data = glow)
#model_z5 <- glm(FRACTURE ~ PRIORFRAC, family = binomial, data = glow)
#model_z6 <- glm(FRACTURE ~ PREMENO, family = binomial, data = glow)
#model_z7 <- glm(FRACTURE ~ MOMFRAC, family = binomial, data = glow)
#model_z8 <- glm(FRACTURE ~ ARMASSIST, family = binomial, data = glow)
#model_z9 <- glm(FRACTURE ~ SMOKE, family = binomial, data = glow)
#model_z10 <- glm(FRACTURE ~ RATERISK, family = binomial, data = glow)

#summary(model_z1)
#summary(model_z2)
#summary(model_z3)
#summary(model_z4)
#summary(model_z5)
#summary(model_z6)
#summary(model_z7)
#summary(model_z8)
#summary(model_z9)
#summary(model_z10)

# not interesting due to all variables (i.e. SUB_ID, SITE_ID, PHY_ID)
# model00 <- glm(FRACTURE ~ ., family = binomial, data = glow)
# summary(model00)

# full model, order by continuous, then factor
model0 <- glm(FRACTURE ~ AGE + WEIGHT + HEIGHT + BMI + PRIORFRAC + PREMENO + MOMFRAC + ARMASSIST + SMOKE + RATERISK, family = binomial, data = glow)
summary(model0)

```

```

##
## Call:
## glm(formula = FRACTURE ~ AGE + WEIGHT + HEIGHT + BMI + PRIORFRAC +
##      PREMENO + MOMFRAC + ARMASSIST + SMOKE + RATERISK, family = binomial,
##      data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6811  -0.7228  -0.5639  -0.1008   2.2182
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -15.74709   12.67053  -1.243  0.21394
## AGE           0.03895    0.01476   2.640  0.00829 **
## WEIGHT       -0.12189    0.08664  -1.407  0.15949
## HEIGHT        0.06620    0.07825   0.846  0.39755
## BMI           0.33181    0.22339   1.485  0.13745
## PRIORFRACYes  0.67577    0.25012   2.702  0.00690 **

```

```

## PREMENOYes      0.10080    0.28540    0.353    0.72395
## MOMFRACYes      0.63438    0.30784    2.061    0.03933 *
## ARMASSISTYes    0.36102    0.25647    1.408    0.15924
## SMOKEYes       -0.31228    0.46216   -0.676    0.49923
## RATERISKSame    0.42256    0.28144    1.501    0.13324
## RATERISKGreater 0.75645    0.29944    2.526    0.01153 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 503.84  on 488  degrees of freedom
## AIC: 527.84
##
## Number of Fisher Scoring iterations: 4

# fit model # note - should remove below model1
model0_fitted <- update(model0, . ~ . - WEIGHT - BMI - PREMENO - SMOKE)
summary(model0_fitted)

##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##      ARMASSIST + RATERISK, family = binomial, data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.66692  -0.72502  -0.56338  -0.03841   2.22148
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.70935     3.22992   0.839  0.40157
## AGE             0.03434     0.01305   2.632  0.00848 **
## HEIGHT        -0.04383     0.01827  -2.400  0.01640 *
## PRIORFRACYes    0.64526     0.24606   2.622  0.00873 **
## MOMFRACYes      0.62122     0.30698   2.024  0.04300 *
## ARMASSISTYes    0.44579     0.23281   1.915  0.05551 .
## RATERISKSame    0.42202     0.27925   1.511  0.13071
## RATERISKGreater 0.70692     0.29342   2.409  0.01599 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.50  on 492  degrees of freedom
## AIC: 523.5
##
## Number of Fisher Scoring iterations: 4

# build model with following covariates (drop WEIGHT, BMI, PREMENO, SMOKE)
# AGE, HEIGHT, PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK {SAME, GREATER}

```

```
model1 <- glm(FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK, family = binomial, data = glow)
summary(model1)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK, family = binomial, data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.66692  -0.72502  -0.56338  -0.03841   2.22148
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.70935     3.22992   0.839  0.40157
## AGE             0.03434     0.01305   2.632  0.00848 **
## HEIGHT        -0.04383     0.01827  -2.400  0.01640 *
## PRIORFRACYes    0.64526     0.24606   2.622  0.00873 **
## MOMFRACYes      0.62122     0.30698   2.024  0.04300 *
## ARMASSISTYes    0.44579     0.23281   1.915  0.05551 .
## RATERISKSame    0.42202     0.27925   1.511  0.13071
## RATERISKGreater 0.70692     0.29342   2.409  0.01599 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.50  on 492  degrees of freedom
## AIC: 523.5
##
## Number of Fisher Scoring iterations: 4
```

```
# from above result, adding back the removed covariates we see they are not needed to keep the remaining
# this becomes the model, adding back removed covariates WEIGHT, BMI, PREMENO, SMOKE the coefficients d
# this becomes the main effects model
```

```
# need to check scale of logit for remaining continuous variables AGE HEIGHT
# assume HEIGHT is linear in logit
```

The main effects model

```
model1 <- glm(FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK, family = binomial, data = glow)
```

use lrtest from package lmerTest

test interactions for the following:

5. AGE: [HEIGHT, PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK]

6. HEIGHT: [PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK]
7. PRIORFRAC: [MOMFRAC, ARMASSIST, RATERISK]
8. MOMFRAC: [ARMASSIST, RATERISK]
9. ARMASSIST: RATERISK

total 15 interactions

```
library(lmtest)
```

```
## Loading required package: zoo
```

```
##
```

```
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      as.Date, as.Date.numeric
```

```
# model AGE* , HEIGHT* , PRIORFRAC*
```

```
model_effects <- glm(FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK, family = binomial)
lrtest(model_effects)
```

```
## Likelihood ratio test
```

```
##
```

```
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK
```

```
## Model 2: FRACTURE ~ 1
```

```
##      #Df  LogLik Df  Chisq Pr(>Chisq)
```

```
## 1      8 -253.75
```

```
## 2      1 -281.17 -7 54.835  1.608e-09 ***
```

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# (5) AGE: [HEIGHT, PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK]
```

```
test <- model_effects
```

```
test <- update(test, . ~ . + AGE:HEIGHT)
```

```
summary(test)
```

```
##
```

```
## Call:
```

```
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +  
##      ARMASSIST + RATERISK + AGE:HEIGHT, family = binomial, data = glow)
```

```
##
```

```
## Deviance Residuals:
```

```
##      Min        1Q      Median        3Q        Max
```

```
## -1.66848 -0.73323 -0.56252  0.02069  2.23640
```

```
##
```

```
## Coefficients:
```

```
##              Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept)    14.749125  23.931667   0.616   0.5377
```

```
## AGE          -0.135869   0.335087  -0.405   0.6851
## HEIGHT       -0.119095   0.149402  -0.797   0.4254
## PRIORFRACYes 0.634947   0.246751   2.573   0.0101 *
## MOMFRACYes   0.623682   0.307316   2.029   0.0424 *
## ARMASSISTYes 0.447271   0.232895   1.920   0.0548 .
## RATERISKSame 0.435127   0.280319   1.552   0.1206
## RATERISKGreater 0.707865  0.293394   2.413   0.0158 *
## AGE:HEIGHT    0.001065   0.002095   0.508   0.6113
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.24  on 491  degrees of freedom
## AIC: 525.24
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
## AGE:HEIGHT
## Model 2: FRACTURE ~ 1
## #Df LogLik Df Chisq Pr(>Chisq)
## 1 9 -253.62
## 2 1 -281.17 -8 55.096 4.23e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + AGE:PRIORFRAC)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
## ARMASSIST + RATERISK + AGE:PRIORFRAC, family = binomial,
## data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.48423  -0.74080  -0.53895  -0.00078   2.26588
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    0.63708    3.35881   0.190 0.849565
## AGE             0.05669    0.01649   3.437 0.000589 ***
## HEIGHT        -0.04058    0.01828  -2.220 0.026406 *
## PRIORFRACYes    4.85428    1.86766   2.599 0.009346 **
## MOMFRACYes     0.66973    0.30857   2.170 0.029972 *
```

```
## ARMASISTYes      0.41887      0.23395      1.790 0.073391 .
## RATERISKSame     0.43496      0.28053      1.551 0.121014
## RATERISKGreater  0.72044      0.29561      2.437 0.014804 *
## AGE:PRIORFRACYes -0.05864      0.02583     -2.270 0.023188 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 502.34  on 491  degrees of freedom
## AIC: 520.34
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASIST + RATERISK +
## AGE:PRIORFRAC
## Model 2: FRACTURE ~ 1
## #Df LogLik Df Chisq Pr(>Chisq)
## 1 9 -251.17
## 2 1 -281.17 -8 59.991 4.679e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + AGE:MOMFRAC)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
## ARMASIST + RATERISK + AGE:MOMFRAC, family = binomial, data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.58376  -0.72859  -0.56182  -0.02562   2.22962
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.59055     3.24368   0.799  0.42450
## AGE             0.03633     0.01393   2.609  0.00908 **
## HEIGHT        -0.04402     0.01827  -2.409  0.01601 *
## PRIORFRACYes    0.65010     0.24630   2.639  0.00830 **
## MOMFRACYes     1.57119     2.31121   0.680  0.49662
## ARMASISTYes     0.45447     0.23374   1.944  0.05185 .
## RATERISKSame    0.42505     0.27940   1.521  0.12819
## RATERISKGreater 0.71044     0.29363   2.420  0.01554 *
## AGE:MOMFRACYes -0.01353     0.03264  -0.414  0.67854
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.33  on 491  degrees of freedom
## AIC: 525.33
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##      AGE:MOMFRAC
## Model 2: FRACTURE ~ 1
##      #Df  LogLik Df  Chisq Pr(>Chisq)
## 1      9 -253.66
## 2      1 -281.17 -8 55.005  4.406e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + AGE:ARMASSIST)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##      ARMASSIST + RATERISK + AGE:ARMASSIST, family = binomial,
##      data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6352  -0.7272  -0.5646  -0.0295   2.2329
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.33972    3.33003   0.703  0.48230
## AGE             0.03990    0.01785   2.235  0.02542 *
## HEIGHT        -0.04395    0.01827  -2.406  0.01614 *
## PRIORFRACYes    0.64031    0.24609   2.602  0.00927 **
## MOMFRACYes      0.63376    0.30795   2.058  0.03959 *
## ARMASSISTYes    1.24419    1.76410   0.705  0.48063
## RATERISKSame     0.42815    0.27964   1.531  0.12575
## RATERISKGreater  0.71996    0.29494   2.441  0.01464 *
## AGE:ARMASSISTYes -0.01132    0.02479  -0.457  0.64802
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
```



```
## Null deviance: 562.34 on 499 degrees of freedom
## Residual deviance: 507.29 on 491 degrees of freedom
## AIC: 525.29
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
## AGE:ARMASSIST
## Model 2: FRACTURE ~ 1
## #Df LogLik Df Chisq Pr(>Chisq)
## 1 9 -253.65
## 2 1 -281.17 -8 55.043 4.331e-09 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + AGE:RATERISK)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
## ARMASSIST + RATERISK + AGE:RATERISK, family = binomial, data = glow)
##
## Deviance Residuals:
## Min 1Q Median 3Q Max
## -1.68668 -0.74463 -0.56590 -0.02638 2.34976
##
## Coefficients:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) 0.53632 3.53444 0.152 0.87939
## AGE 0.06673 0.02473 2.698 0.00697 **
## HEIGHT -0.04496 0.01840 -2.443 0.01456 *
## PRIORFRACYes 0.65827 0.24598 2.676 0.00745 **
## MOMFRACYes 0.65241 0.30765 2.121 0.03395 *
## ARMASSISTYes 0.48569 0.23443 2.072 0.03828 *
## RATERISKSame 3.28427 2.27575 1.443 0.14898
## RATERISKGreater 4.25804 2.28873 1.860 0.06282 .
## AGE:RATERISKSame -0.03999 0.03151 -1.269 0.20438
## AGE:RATERISKGreater -0.05021 0.03202 -1.568 0.11690
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 562.34 on 499 degrees of freedom
## Residual deviance: 504.79 on 490 degrees of freedom
## AIC: 524.79
##
## Number of Fisher Scoring iterations: 5
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##   AGE:RATERISK
## Model 2: FRACTURE ~ 1
##   #Df  LogLik Df Chisq Pr(>Chisq)
## 1   10 -252.40
## 2    1 -281.17 -9 57.54  3.982e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# (4) HEIGHT: [PRIORFRAC, MOMFRAC, ARMASSIST, RATERISK]
```

```
test <- model_effects
test <- update(test, . ~ . + HEIGHT:PRIORFRAC)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##   ARMASSIST + RATERISK + HEIGHT:PRIORFRAC, family = binomial,
##   data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6670  -0.7274  -0.5615  -0.0037   2.2377
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    3.79297    3.89138   0.975  0.32970
## AGE             0.03395    0.01307   2.597  0.00941 **
## HEIGHT        -0.05041    0.02253  -2.238  0.02524 *
## PRIORFRACYes  -2.41864    6.03699  -0.401  0.68869
## MOMFRACYes     0.63692    0.30850   2.065  0.03896 *
## ARMASSISTYes   0.43526    0.23394   1.861  0.06281 .
## RATERISKSame   0.42634    0.27946   1.526  0.12711
## RATERISKGreater 0.70410    0.29356   2.399  0.01646 *
## HEIGHT:PRIORFRACYes 0.01915    0.03770   0.508  0.61146
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.24  on 491  degrees of freedom
## AIC: 525.24
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##   HEIGHT:PRIORFRAC
## Model 2: FRACTURE ~ 1
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1    9 -253.62
## 2    1 -281.17 -8 55.092  4.236e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + HEIGHT:MOMFRAC)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##   ARMASSIST + RATERISK + HEIGHT:MOMFRAC, family = binomial,
##   data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.62068  -0.74163  -0.55649   0.06604   2.26717
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    4.73834    3.51132   1.349  0.17719
## AGE             0.03385    0.01307   2.589  0.00961 **
## HEIGHT          -0.05646    0.02021  -2.794  0.00521 **
## PRIORFRACYes     0.68102    0.24763   2.750  0.00596 **
## MOMFRACYes      -11.35526    7.64959  -1.484  0.13770
## ARMASSISTYes     0.47848    0.23444   2.041  0.04126 *
## RATERISKSAME     0.42455    0.28002   1.516  0.12949
## RATERISKGreater  0.70475    0.29372   2.399  0.01642 *
## HEIGHT:MOMFRACYes 0.07401    0.04718   1.569  0.11675
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 505.08  on 491  degrees of freedom
## AIC: 523.08
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
```

```
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##   HEIGHT:MOMFRAC
## Model 2: FRACTURE ~ 1
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1    9 -252.54
## 2    1 -281.17 -8 57.258  1.603e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + HEIGHT:ARMASSIST)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##   ARMASSIST + RATERISK + HEIGHT:ARMASSIST, family = binomial,
##   data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6742  -0.7177  -0.5638  -0.1472   2.1734
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -0.57428    4.12234  -0.139  0.88920
## AGE             0.03401    0.01308   2.601  0.00931 **
## HEIGHT        -0.02318    0.02432  -0.953  0.34051
## PRIORFRACYes    0.67913    0.24841   2.734  0.00626 **
## MOMFRACYes     0.58729    0.30807   1.906  0.05660 .
## ARMASSISTYes    7.53985    5.77628   1.305  0.19179
## RATERISKSame    0.41583    0.27981   1.486  0.13725
## RATERISKGreater 0.70729    0.29369   2.408  0.01603 *
## HEIGHT:ARMASSISTYes -0.04419    0.03594  -1.229  0.21890
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 505.98  on 491  degrees of freedom
## AIC: 523.98
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##   HEIGHT:ARMASSIST
## Model 2: FRACTURE ~ 1
```

```
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1    9 -252.99
## 2    1 -281.17 -8 56.352  2.409e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + HEIGHT:RATERISK)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + HEIGHT:RATERISK, family = binomial,
##       data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.64936  -0.72375  -0.57251  -0.05841   2.22612
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      3.25641     5.81516   0.560  0.57549
## AGE              0.03321     0.01310   2.536  0.01122 *
## HEIGHT          -0.04674     0.03532  -1.323  0.18573
## PRIORFRACYes     0.64451     0.24655   2.614  0.00895 **
## MOMFRACYes       0.62504     0.30650   2.039  0.04142 *
## ARMASSISTYes     0.44610     0.23290   1.915  0.05544 .
## RATERISKSame     2.93823     7.29965   0.403  0.68730
## RATERISKGreater -3.15056     7.29448  -0.432  0.66581
## HEIGHT:RATERISKSame -0.01577     0.04550  -0.347  0.72890
## HEIGHT:RATERISKGreater 0.02394     0.04528   0.529  0.59695
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 506.55  on 490  degrees of freedom
## AIC: 526.55
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##           HEIGHT:RATERISK
## Model 2: FRACTURE ~ 1
##   #Df  LogLik Df  Chisq Pr(>Chisq)
## 1   10 -253.28
## 2    1 -281.17 -9 55.786  8.624e-09 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# (3) PRIORFRAC: [MOMFRAC, ARMASSIST, RATERISK]
```

```
test <- model_effects
test <- update(test, . ~ . + PRIORFRAC:MOMFRAC)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + PRIORFRAC:MOMFRAC, family = binomial,
##       data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.52616  -0.73215  -0.54992   0.02399   2.25279
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.97592     3.23781   0.919  0.35804
## AGE              0.03598     0.01313   2.741  0.00612 **
## HEIGHT          -0.04652     0.01837  -2.533  0.01130 *
## PRIORFRACYes      0.80102     0.26285   3.047  0.00231 **
## MOMFRACYes        0.95902     0.35985   2.665  0.00770 **
## ARMASSISTYes      0.43294     0.23384   1.851  0.06411 .
## RATERISKSame      0.41959     0.28027   1.497  0.13437
## RATERISKGreater   0.71282     0.29401   2.425  0.01533 *
## PRIORFRACYes:MOMFRACYes -1.07823     0.65021  -1.658  0.09726 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 504.75  on 491  degrees of freedom
## AIC: 522.75
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##       PRIORFRAC:MOMFRAC
## Model 2: FRACTURE ~ 1
##   #Df LogLik Df Chisq Pr(>Chisq)
## 1    9 -252.37
## 2    1 -281.17 -8 57.59  1.382e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + PRIORFRAC:ARMASSIST)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + PRIORFRAC:ARMASSIST, family = binomial,
##       data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.69860  -0.71874  -0.56691  -0.04199   2.21033
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.90711    3.25923   0.892  0.37241
## AGE              0.03434    0.01306   2.630  0.00854 **
## HEIGHT          -0.04486    0.01842  -2.436  0.01487 *
## PRIORFRACYes     0.52412    0.34418   1.523  0.12780
## MOMFRACYes      0.63247    0.30798   2.054  0.04001 *
## ARMASSISTYes    0.36456    0.28322   1.287  0.19803
## RATERISKSAME    0.42507    0.27929   1.522  0.12802
## RATERISKGreater  0.68837    0.29591   2.326  0.02000 *
## PRIORFRACYes:ARMASSISTYes 0.24587    0.48467   0.507  0.61194
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.24  on 491  degrees of freedom
## AIC: 525.24
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##       PRIORFRAC:ARMASSIST
## Model 2: FRACTURE ~ 1
##   #Df LogLik Df  Chisq Pr(>Chisq)
## 1    9 -253.62
## 2    1 -281.17 -8 55.093  4.235e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + PRIORFRAC:RATERISK)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + PRIORFRAC:RATERISK, family = binomial,
##       data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.69776  -0.71989  -0.56384  -0.03822   2.21130
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.733523   3.235459   0.845  0.39819
## AGE            0.034508   0.013060   2.642  0.00823 **
## HEIGHT        -0.043896   0.018313  -2.397  0.01653 *
## PRIORFRACYes    0.564292   0.497212   1.135  0.25641
## MOMFRACYes     0.623104   0.307302   2.028  0.04260 *
## ARMASSISTYes   0.429891   0.236033   1.821  0.06856 .
## RATERISKSame   0.426181   0.324504   1.313  0.18907
## RATERISKGreater 0.632806   0.355571   1.780  0.07513 .
## PRIORFRACYes:RATERISKSame 0.001597   0.625563   0.003  0.99796
## PRIORFRACYes:RATERISKGreater 0.208811   0.624586   0.334  0.73814
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 507.32  on 490  degrees of freedom
## AIC: 527.32
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##       PRIORFRAC:RATERISK
## Model 2: FRACTURE ~ 1
##   #Df LogLik Df  Chisq Pr(>Chisq)
## 1   10 -253.66
## 2    1 -281.17 -9 55.015   1.21e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# (2) MOMFRAC: [ARMASSIST, RATERISK]
```

```
test <- model_effects
test <- update(test, . ~ . + MOMFRAC:ARMASSIST)
summary(test)
```

```
##
```



```
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + MOMFRAC:ARMASSIST, family = binomial,
##       data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.65273  -0.72683  -0.55140   0.03367   2.27218
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.96640     3.25148   0.912  0.36160
## AGE              0.03760     0.01323   2.842  0.00448 **
## HEIGHT          -0.04738     0.01846  -2.567  0.01025 *
## PRIORFRACYes     0.61633     0.24770   2.488  0.01284 *
## MOMFRACYes       1.17111     0.38940   3.007  0.00263 **
## ARMASSISTYes     0.65026     0.25220   2.578  0.00993 **
## RATERISKSame     0.41386     0.28032   1.476  0.13985
## RATERISKGreater  0.71051     0.29445   2.413  0.01582 *
## MOMFRACYes:ARMASSISTYes -1.33817     0.62405  -2.144  0.03201 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 502.83  on 491  degrees of freedom
## AIC: 520.83
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##       MOMFRAC:ARMASSIST
## Model 2: FRACTURE ~ 1
##   #Df LogLik Df  Chisq Pr(>Chisq)
## 1    9 -251.41
## 2    1 -281.17 -8 59.509  5.818e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
test <- model_effects
test <- update(test, . ~ . + MOMFRAC:RATERISK)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##       ARMASSIST + RATERISK + MOMFRAC:RATERISK, family = binomial,
##       data = glow)
```

```
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.73530  -0.73156  -0.56262  -0.02886   2.20217
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.76974     3.23715   0.856  0.39221
## AGE              0.03436     0.01308   2.627  0.00861 **
## HEIGHT          -0.04393     0.01832  -2.398  0.01649 *
## PRIORFRACYes     0.64526     0.24663   2.616  0.00889 **
## MOMFRACYes       0.02648     0.83795   0.032  0.97479
## ARMASSISTYes     0.44890     0.23340   1.923  0.05444 .
## RATERISKSame     0.29742     0.29700   1.001  0.31663
## RATERISKGreater  0.70206     0.31167   2.253  0.02428 *
## MOMFRACYes:RATERISKSame 1.04615     0.95957   1.090  0.27561
## MOMFRACYes:RATERISKGreater 0.36775     0.96207   0.382  0.70227
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 505.79  on 490  degrees of freedom
## AIC: 525.79
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##      MOMFRAC:RATERISK
## Model 2: FRACTURE ~ 1
##      #Df  LogLik Df  Chisq Pr(>Chisq)
## 1    10 -252.90
## 2     1 -281.17 -9  56.542  6.183e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# (1) ARMASSIST: RATERISK
```

```
test <- model_effects
test <- update(test, . ~ . + ARMASSIST:RATERISK)
summary(test)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##      ARMASSIST + RATERISK + ARMASSIST:RATERISK, family = binomial,
##      data = glow)
##
```

```
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6586  -0.7419  -0.5544  -0.0470   2.2531
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.38363    3.22529   0.739  0.45988
## AGE              0.03534    0.01314   2.691  0.00713 **
## HEIGHT          -0.04274    0.01819  -2.349  0.01883 *
## PRIORFRACYes     0.70856    0.25028   2.831  0.00464 **
## MOMFRACYes       0.61378    0.30782   1.994  0.04616 *
## ARMASSISTYes     0.60776    0.44193   1.375  0.16906
## RATERISKSame     0.36244    0.36906   0.982  0.32607
## RATERISKGreater  0.98400    0.38373   2.564  0.01034 *
## ARMASSISTYes:RATERISKSame 0.10760    0.56723   0.190  0.84956
## ARMASSISTYes:RATERISKGreater -0.60953    0.58200  -1.047  0.29496
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 505.42  on 490  degrees of freedom
## AIC: 525.42
##
## Number of Fisher Scoring iterations: 4
```

```
lrtest(test)
```

```
## Likelihood ratio test
##
## Model 1: FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
##      ARMASSIST:RATERISK
## Model 2: FRACTURE ~ 1
##      #Df  LogLik Df  Chisq Pr(>Chisq)
## 1    10 -252.71
## 2     1 -281.17 -9  56.912  5.253e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Results from interactions

```
## AGE:HEIGHT          0.001065    0.002095  0.508  0.6113
## AGE:PRIORFRACYes   -0.05864    0.02583  -2.270  0.023188 *
## AGE:MOMFRACYes     -0.01353    0.03264  -0.414  0.67854
## AGE:ARMASSISTYes   -0.01132    0.02479  -0.457  0.64802
## AGE:RATERISKSame   -0.03999    0.03151  -1.269  0.20438
## AGE:RATERISKGreater -0.05021    0.03202  -1.568  0.11690
## HEIGHT:PRIORFRACYes 0.01915    0.03770   0.508  0.61146
## HEIGHT:MOMFRACYes   0.07401    0.04718   1.569  0.11675
## HEIGHT:ARMASSISTYes -0.04419    0.03594  -1.229  0.21890
## HEIGHT:RATERISKSame -0.01577    0.04550  -0.347  0.72890
## HEIGHT:RATERISKGreater 0.02394    0.04528   0.529  0.59695
```

```

PRIORFRACYes:MOMFRACYes -1.07823    0.65021  -1.658  0.09726 .
## PRIORFRACYes:ARMASSISTYes 0.24587    0.48467   0.507  0.61194
## PRIORFRACYes:RATERISKSame    0.001597   0.625563   0.003  0.99796
## PRIORFRACYes:RATERISKGreater 0.208811   0.624586   0.334  0.73814
MOMFRACYes:ARMASSISTYes -1.33817    0.62405  -2.144  0.03201 *
## MOMFRACYes:RATERISKSame    1.04615    0.95957   1.090  0.27561
## MOMFRACYes:RATERISKGreater 0.36775    0.96207   0.382  0.70227
## ARMASSISTYes:RATERISKSame    0.10760    0.56723   0.190  0.84956
## ARMASSISTYes:RATERISKGreater -0.60953    0.58200  -1.047  0.29496

```

Add to main effects model

we find three interactions, AGE:PRIORFRACYes, PRIORFRACYes:MOMFRACYes, MOMFRACYes:ARMASSISTYes

```

model_effects_new <- glm(FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
                        AGE:PRIORFRAC + PRIORFRAC:MOMFRAC + MOMFRAC:ARMASSIST, family = binomial, data =
summary(model_effects_new)

```

```

##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##      ARMASSIST + RATERISK + AGE:PRIORFRAC + PRIORFRAC:MOMFRAC +
##      MOMFRAC:ARMASSIST, family = binomial, data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.47664  -0.74929  -0.51571   0.07753   2.33224
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      1.20626    3.38765   0.356 0.721785
## AGE              0.05949    0.01677   3.547 0.000389 ***
## HEIGHT          -0.04610    0.01854  -2.487 0.012886 *
## PRIORFRACYes     4.63031    1.88158   2.461 0.013860 *
## MOMFRACYes       1.42093    0.42468   3.346 0.000820 ***
## ARMASSISTYes     0.59571    0.25545   2.332 0.019701 *
## RATERISKSame     0.42125    0.28217   1.493 0.135462
## RATERISKGreater  0.72341    0.29695   2.436 0.014847 *
## AGE:PRIORFRACYes -0.05408    0.02602  -2.079 0.037662 *
## PRIORFRACYes:MOMFRACYes -0.83184    0.64852  -1.283 0.199606
## MOMFRACYes:ARMASSISTYes -1.15254    0.61838  -1.864 0.062350 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 496.53  on 489  degrees of freedom
## AIC: 518.53
##
## Number of Fisher Scoring iterations: 4

```

```
# create final model with interactions terms AGE:PRIORFRAC + MOMFRAC:ARMASSIST
model_effects_final <- glm(FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK +
                           AGE:PRIORFRAC + MOMFRAC:ARMASSIST, family = binomial, data = glow)
summary(model_effects_final)
```

```
##
## Call:
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
##      ARMASSIST + RATERISK + AGE:PRIORFRAC + MOMFRAC:ARMASSIST,
##      family = binomial, data = glow)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.6995  -0.7459  -0.5238   0.0620   2.3123
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)      0.96955     3.38252   0.287 0.774392
## AGE              0.05890     0.01666   3.535 0.000408 ***
## HEIGHT          -0.04413     0.01848  -2.388 0.016949 *
## PRIORFRACYes     4.65073     1.88342   2.469 0.013538 *
## MOMFRACYes       1.19902     0.39487   3.036 0.002393 **
## ARMASSISTYes     0.61423     0.25358   2.422 0.015426 *
## RATERISKSAME     0.42626     0.28154   1.514 0.130012
## RATERISKGreater  0.72116     0.29660   2.431 0.015040 *
## AGE:PRIORFRACYes -0.05610     0.02600  -2.158 0.030950 *
## MOMFRACYes:ARMASSISTYes -1.26534     0.62377  -2.029 0.042507 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 562.34  on 499  degrees of freedom
## Residual deviance: 498.17  on 490  degrees of freedom
## AIC: 518.17
##
## Number of Fisher Scoring iterations: 4
```

Final Interaction Model

```
(Intercept)
AGE              0.05890     0.01666   3.535 0.000408 ***
HEIGHT          -0.04413     0.01848  -2.388 0.016949 *
PRIORFRACYes     4.65073     1.88342   2.469 0.013538 *
MOMFRACYes       1.19902     0.39487   3.036 0.002393 **
ARMASSISTYes     0.61423     0.25358   2.422 0.015426 *
RATERISKGreater  0.72116     0.29660   2.431 0.015040 *
AGE:PRIORFRACYes -0.05610     0.02600  -2.158 0.030950 *
MOMFRACYes:ARMASSISTYes -1.26534     0.62377  -2.029 0.042507 *
```

```
FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC + ARMASSIST + RATERISK + AGE:PRIORFRAC + MOMFRAC:ARMASSIST
```

```
library(pROC)
```

```
## Type 'citation("pROC")' for a citation.
```

```
##
```

```
## Attaching package: 'pROC'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
##      cov, smooth, var
```

```
library(vcdExtra)
```

```
## Loading required package: vcd
```

```
## Loading required package: grid
```

```
##
```

```
## Attaching package: 'vcd'
```

```
## The following object is masked from 'package:ISLR':
```

```
##
```

```
##      Hitters
```

```
## Loading required package: gnm
```

```
# vcov(model_effects_final)
```

```
HLtest(model_effects_final)
```

```
## Hosmer and Lemeshow Goodness-of-Fit Test
```

```
##
```

```
## Call:
```

```
## glm(formula = FRACTURE ~ AGE + HEIGHT + PRIORFRAC + MOMFRAC +
```

```
##      ARMASSIST + RATERISK + AGE:PRIORFRAC + MOMFRAC:ARMASSIST,
```

```
##      family = binomial, data = glow)
```

```
##      ChiSquare df      P_value
```

```
##      7.268011  8 0.5080118
```

```
glow$predict_mfinal <- predict(model_effects_final, type = "response")
with(glow, addmargins(table(glow$predict_mfinal > 0.5, glow$FRACTURE)))
```

```
##
```

```
##      No Yes Sum
```

```
## FALSE 354  97 451
```

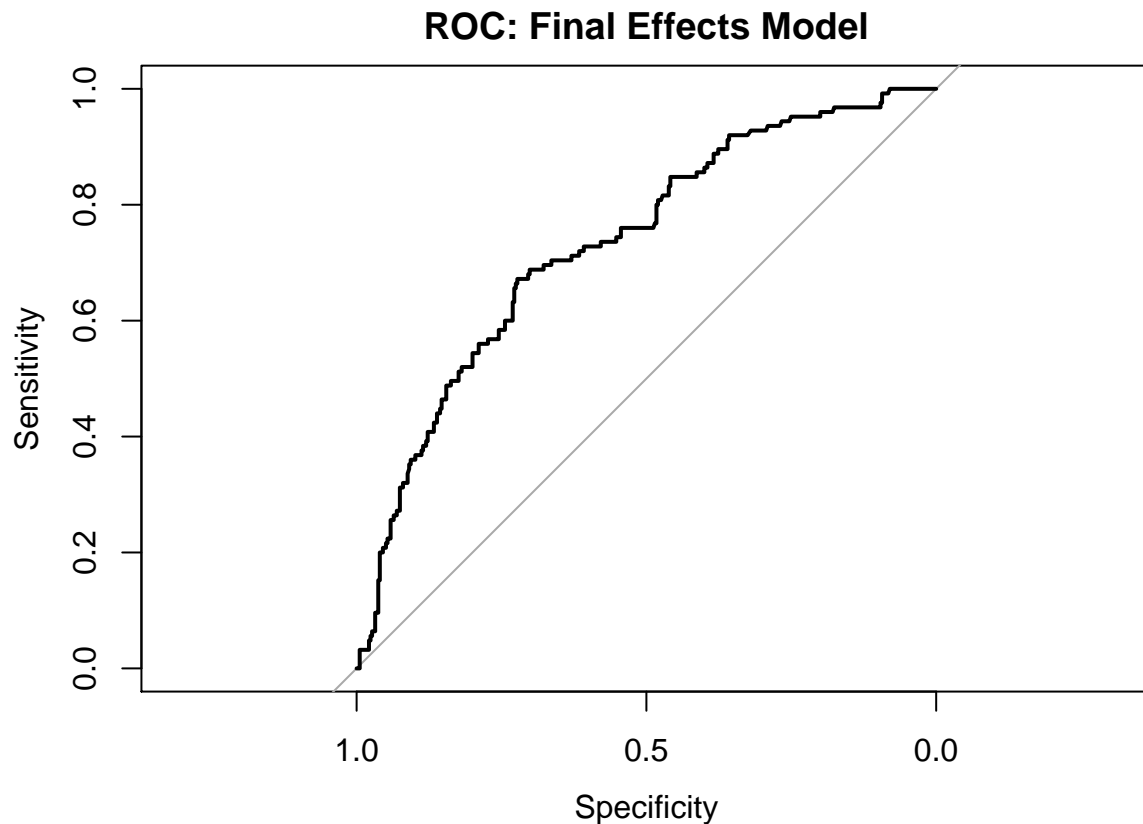
```
## TRUE   21  28  49
```

```
## Sum   375 125 500
```

```
(roc_final_model <- roc(glow$FRACTURE ~ glow$predict_mfinal, data = glow))
```

```
##
## Call:
## roc.formula(formula = glow$FRACTURE ~ glow$predict_mfinal, data = glow)
##
## Data: glow$predict_mfinal in 375 controls (glow$FRACTURE No) < 125 cases (glow$FRACTURE Yes).
## Area under the curve: 0.7331
```

```
plot(roc_final_model, main = "ROC: Final Effects Model")
```



misc

```
## restart with clean data
glow <- read_glow_dataset()
```

```
model_last <- glm(FRACTURE ~ AGE:PRIORFRAC + HEIGHT + MOMFRAC:ARMASSIST + I(as.integer(RATERISK) == 3),
HLtest(model_last)
```

```
## Hosmer and Lemeshow Goodness-of-Fit Test
```

```
##
```

```
## Call:
```

```
## glm(formula = FRACTURE ~ AGE:PRIORFRAC + HEIGHT + MOMFRAC:ARMASSIST +
##       I(as.integer(RATERISK) == 3), family = binomial, data = glow)
```

```
## ChiSquare df P_value
```

```
## 3.10152 8 0.9278259
```

```
summary(HLtest(model_last))
```

```
## Partition for Hosmer and Lemeshow Goodness-of-Fit Test
##
##           cut total obs      exp      chi
## 1 [0.0243,0.0967]    50  47 45.97075  0.1518032
## 2 (0.0967,0.123]    50  46 44.35914  0.2463653
## 3 (0.123,0.152]    50  42 43.19969 -0.1825284
## 4 (0.152,0.18]     50  41 41.81265 -0.1256745
## 5 (0.18,0.213]     50  42 40.34124  0.2611609
## 6 (0.213,0.251]     50  36 38.55936 -0.4121599
## 7 (0.251,0.292]     50  38 36.55362  0.2392312
## 8 (0.292,0.372]     50  32 33.67421 -0.2885110
## 9 (0.372,0.47]      50  28 29.25398 -0.2318447
## 10 (0.47,0.724]     50  23 21.27536  0.3739034
## Hosmer and Lemeshow Goodness-of-Fit Test
##
## Call:
## glm(formula = FRACTURE ~ AGE:PRIORFRAC + HEIGHT + MOMFRAC:ARMASSIST +
##      I(as.integer(RATERISK) == 3), family = binomial, data = glow)
##   ChiSquare df    P_value
##      3.10152  8 0.9278259
```

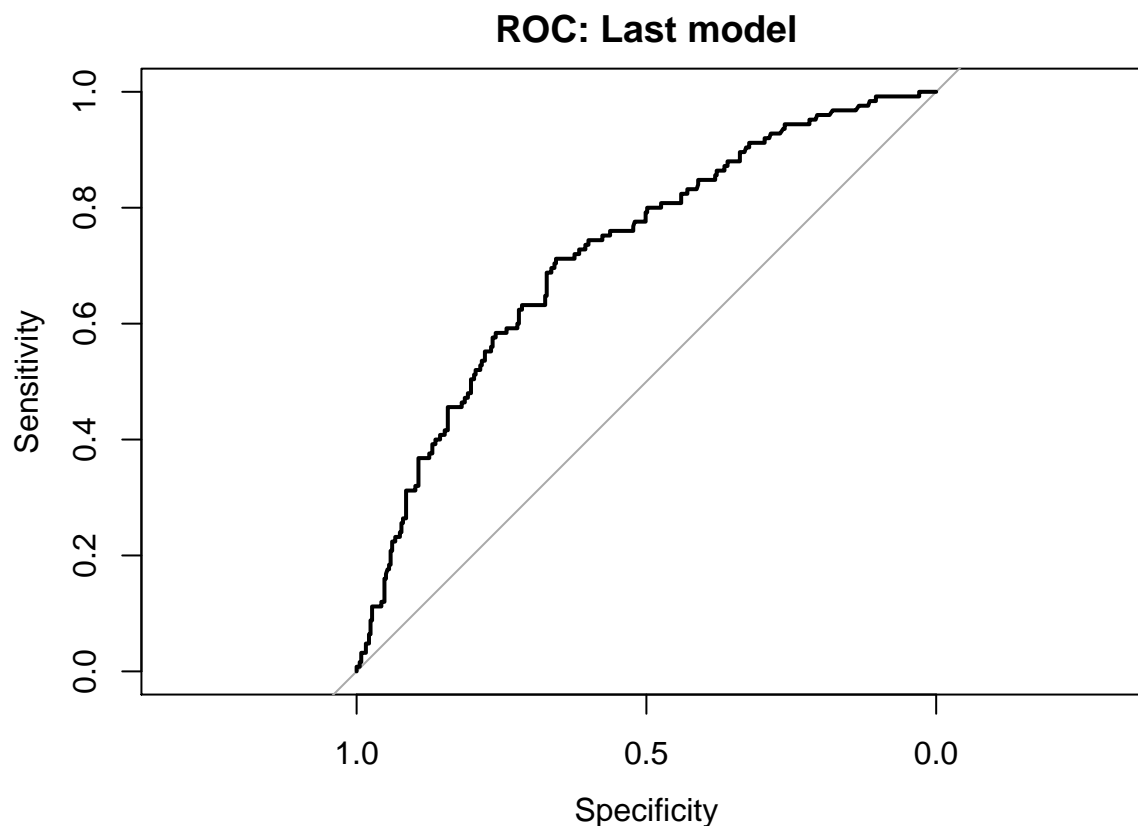
```
# classification table
```

```
glow$predict_last <- predict(model_last, type = "response")
with(glow, addmargins(table(predict_last > 0.5, FRACTURE)))
```

```
##           FRACTURE
##           No Yes Sum
## FALSE 355 103 458
## TRUE   20  22  42
## Sum   375 125 500
```

```
# Sensitivity, specificity, ROC (using pROC)
```

```
roc_model_last <- roc(glow$FRACTURE ~ glow$predict_last, data = glow)
plot(roc_model_last, main = "ROC: Last model")
```

```
# create table
vars <- c("thresholds","sensitivities","specificities")
model_table <- data.frame(roc_model_last[vars])

findIndex <- function(x, y) which.min( (x-y)^2 )
cutPoints <- seq(0.05, 0.75, by = 0.05)

tableIndex <- mapply(findIndex, y = cutPoints, MoreArgs = list(x = roc_model_last$thresholds))

model_table[tableIndex, ]
```

##	thresholds	sensitivities	specificities
## 3	0.05165803	1.000	0.005333333
## 43	0.09905744	0.976	0.128000000
## 120	0.15054070	0.880	0.349333333
## 202	0.20014367	0.760	0.549333333
## 259	0.25035362	0.640	0.674666667
## 316	0.29918726	0.520	0.789333333
## 349	0.34952747	0.416	0.842666667
## 379	0.40012793	0.320	0.893333333
## 401	0.44487716	0.240	0.925333333
## 416	0.49400138	0.176	0.944000000
## 426	0.55045683	0.120	0.954666667
## 443	0.59996390	0.056	0.978666667
## 452	0.65801860	0.024	0.992000000
## 455	0.69417409	0.008	0.994666667

```
## 457 0.71832154      0.008  1.000000000
```

```
# plot
plot(specificities ~ thresholds, xlim = c(0, 1), type = "l",
     xlab = "probability cutoff", ylab = "sensitivity / specificity",
     ylim = c(0, 1), data = model_table, main = "probability sensitivity")
with(model_table, lines(thresholds, sensitivities, col = "red"))
legend(x = 0.75, y = 0.55, legend = c("Sensitivity", "Specificity"),
      lty = 1, col = c("red", "black"))
abline(h = c(0, 1), col = "grey80", lty = "dotted")
```

