Logistic Regression

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Create a Word document from this R Markdown file for the following exercises. Submit the R markdown file and resulting Word document via D2L Dropbox.

## Exercise 1

A study was conducted whereby the type of anesthetic (A or B), nausea after the surgery (Yes or No), the amount of pain medication taken during the recovery period, and age for a random sample of 72 patients undergoing reconstructive knee surgery.

The data is in the file anesthesia.rda.

### Part 1a

Use R to create a two-way table with the type of anesthetic defining the rows and nausea after the surgery as the columns and also produce the output for a chi-square test for independence.

Is there an association between these two categorical variables at a 5% level of significance?

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1a -|-|-|-|-|-|-|-|-|-|-|-

data(anesthesia)  
  
tbl <- table(anesthesia$anesthetic,anesthesia$nausea) # create a table  
colnames(tbl) <- c("No Nausea","Nausea") # add column names  
rownames(tbl) <- c("Anesthetic A","Anesthetic B") # add row names  
tbl

##   
## No Nausea Nausea  
## Anesthetic A 13 26  
## Anesthetic B 23 10

chisq.test(anesthesia$anesthetic,anesthesia$nausea)

##   
## Pearson's Chi-squared test with Yates' continuity correction  
##   
## data: anesthesia$anesthetic and anesthesia$nausea  
## X-squared = 8.0559, df = 1, p-value = 0.004535

Reject the null hypothesis that alpha = 0.05 because p=0.004535.

We find significant evidence to show that the alternative is true, that there is an association between the two categorical variables for type of anesthetic and whether or not the patient experienced nausea.

### Part 1b

Obtain the output from R (including the Wald tests for coefficients - so use “summary” function) for the logistic regression model with nausea as the dependent variable and the type of anesthetic as the predictor variable.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1b -|-|-|-|-|-|-|-|-|-|-|-

# convert to 0's and 1's  
anesthesia$anesthetic2 <- ifelse(anesthesia$anesthetic=="A",1,0)   
anesthesia$nausea2 <- ifelse(anesthesia$nausea=="Yes",1,0)   
  
sickdrug\_reg <- glm(nausea2~anesthetic2,data=anesthesia,family="binomial")  
summary(sickdrug\_reg)

##   
## Call:  
## glm(formula = nausea2 ~ anesthetic2, family = "binomial", data = anesthesia)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -1.4823 -0.8497 0.0254 0.9005 1.5453   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -0.8329 0.3788 -2.199 0.02789 \*   
## anesthetic2 1.5261 0.5088 2.999 0.00271 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 99.813 on 71 degrees of freedom  
## Residual deviance: 90.133 on 70 degrees of freedom  
## AIC: 94.133  
##   
## Number of Fisher Scoring iterations: 4

### Part 1c

What is the outcome of the hypothesis test that the coefficient of **anesthetic** is “zero” vs “not zero” at a 5% level of significance? (use the Wald test from the R output from the logistic regression you performed)

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1c -|-|-|-|-|-|-|-|-|-|-|-

Reject the null hypothesis at the alpha = 0.05 because the z value is 2.999 (greater than 2)

We find significant evidence showing that the true regression coefficient of anesthetic is not zero and has an effect on the dependent variable nausea

### Part 1d

Convert the estimated coefficient of **anesthetic** to an odds ratio and interpret it in the context of the problem.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1d -|-|-|-|-|-|-|-|-|-|-|-

exp(1.5261)

## [1] 4.600201

The odds of getting nausea following the use of anesthetic A 4.6 times as large as the odds of getting nausea following use of anesthetic B, given all other conditions held constant.

### Part 1e

Install the package “mosaic” (if you don’t have it installed already), then load it. Use the oddsRatio function to compute the odds ratio for having nausea for anesthetic A vs B. You may have to refer back to Week 8 for details on odds ratios and the oddsRatio function in R.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1e -|-|-|-|-|-|-|-|-|-|-|-

library(dplyr)

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

library(mosaic)

## Loading required package: lattice

## Loading required package: ggformula

## Loading required package: ggplot2

##   
## New to ggformula? Try the tutorials:   
## learnr::run\_tutorial("introduction", package = "ggformula")  
## learnr::run\_tutorial("refining", package = "ggformula")

## Loading required package: mosaicData

## Loading required package: Matrix

##   
## The 'mosaic' package masks several functions from core packages in order to add   
## additional features. The original behavior of these functions should not be affected by this.  
##   
## Note: If you use the Matrix package, be sure to load it BEFORE loading mosaic.

##   
## Attaching package: 'mosaic'

## The following object is masked from 'package:Matrix':  
##   
## mean

## The following objects are masked from 'package:dplyr':  
##   
## count, do, tally

## The following objects are masked from 'package:stats':  
##   
## binom.test, cor, cor.test, cov, fivenum, IQR, median,  
## prop.test, quantile, sd, t.test, var

## The following objects are masked from 'package:base':  
##   
## max, mean, min, prod, range, sample, sum

### Part 1f

When logistic regression coefficients are negative, the interpretation sometimes has more impact when we switch the perspective and use the reciprocal of the exponentiated coefficient. Find the odds ratio for having nausea for anesthetic B compared to anesthetic A (i.e. take the reciprocal of the odds ratio you computed in part **1d**).

Interpret this odds ratio in the context of the problem.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1f -|-|-|-|-|-|-|-|-|-|-|-

1/4.600201

## [1] 0.2173818

The odds of getting nausea following the use of anesthetic B is only 21.7% as large as the odds of getting nausea following use of anesthetic A, given all other conditions held constant.

### Part 1g

Compute the predicted probability of a reconstructive knee surgery patient having nausea after surgery when anesthetic A was used.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1g -|-|-|-|-|-|-|-|-|-|-|-

newdata <- data.frame(anesthetic2=0,nausea2=1)  
predict(sickdrug\_reg,newdata,type = "response")

## 1   
## 0.3030303

### Part 1h

Compute a 95% confidence interval for the predicted probability of a reconstructive knee surgery patient having nausea after surgery when anesthetic A was used.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 1h -|-|-|-|-|-|-|-|-|-|-|-

worker <- predict(sickdrug\_reg,newdata,se.fit = TRUE)  
C = .95 #confidence level  
crit = qnorm(1-(1-C)/2) # critical value  
lower = exp(worker$fit-crit\*worker$se.fit)/(1+exp(worker$fit-crit\*worker$se.fit))  
upper = exp(worker$fit+crit\*worker$se.fit)/(1+exp(worker$fit+crit\*worker$se.fit))  
c(lower,upper)

## 1 1   
## 0.1714601 0.4773894

## Exercise 2

Continue using the anesthesia.rda data set to do the following.

### Part 2a

Obtain the output from R (including the Wald tests for coefficients - so use “summary” function) for the logistic regression model with nausea as the dependent variable and the amount of pain medication taken as the predictor variable.

At , is there a statistically significant relationship between nausea and the amount of pain medication taken?

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2a -|-|-|-|-|-|-|-|-|-|-|-

sickpain\_reg <- glm(nausea2~painmed,data=anesthesia,family="binomial")  
summary(sickpain\_reg)

##   
## Call:  
## glm(formula = nausea2 ~ painmed, family = "binomial", data = anesthesia)  
##   
## Deviance Residuals:   
## Min 1Q Median 3Q Max   
## -2.8555 -0.6167 -0.1072 0.8206 1.7894   
##   
## Coefficients:  
## Estimate Std. Error z value Pr(>|z|)   
## (Intercept) -3.062742 0.764501 -4.006 6.17e-05 \*\*\*  
## painmed 0.037487 0.008833 4.244 2.20e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## (Dispersion parameter for binomial family taken to be 1)  
##   
## Null deviance: 99.813 on 71 degrees of freedom  
## Residual deviance: 68.049 on 70 degrees of freedom  
## AIC: 72.049  
##   
## Number of Fisher Scoring iterations: 5

Reject the null hypothesis at the alpha = 0.05 because the z value is 4.244 (greater than 2)

We find significant evidence showing that the true regression coefficient of pain is not zero and affects the dependent variable nausea.

### Part 2b

Convert the estimated coefficient of **painmed** to an odds ratio and interpret it in the context of the problem.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2b -|-|-|-|-|-|-|-|-|-|-|-

exp(0.037487)

## [1] 1.038199

The odds of taking an additional one unit of pain medication and getting nausea increase is 3.81% larger than the odds of getting nausea and not having taken the additional unit of pain medication anesthetic A, given all other conditions held constant.

### Part 2c

Compute the predicted probabilities of a reconstructive knee surgery patient having nausea in the recovery time after surgery for when 50 units of pain medication are used and also for when 100 units of pain medication are used.

Comment on these two probabilities.

### -|-|-|-|-|-|-|-|-|-|-|- Answer 2c -|-|-|-|-|-|-|-|-|-|-|-

ml50 <- data.frame(nausea2=1, painmed =50)  
ml100<- data.frame(nausea2=1, painmed = 100)  
  
predict(sickpain\_reg,ml50,type = "response")

## 1   
## 0.2335485

predict(sickpain\_reg,ml100,type = "response")

## 1   
## 0.6650716

The predicted probability of a recontructive knee surgery patient having nausea in the recovery time after surgey nearly triples when the dosage of pain medication is doubled from 50 units to 100 units. This leads me to suspect a “toxic” level well before the dosage of 125 units where nausea is an all but certain probability.