

Predicting Past Year Identity Theft with the 2016 Identity Theft Supplement of the National Crime Victimization Survey

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Executive Summary

Data analysis was conducted to see if certain predictor variables were associated with past year identity theft. The data used in this analysis came from the 2016 Identity Theft Supplement (ITS) to the National Crime Victimization Survey (NCVS). The results of this analysis found that identity theft was dependent on the majority of the predictors used (age, race/Hispanic origin, annual household income, being a victim of identity theft prior to the past year, having personal information exposed due to a data breach, and using preventative behaviors). Gender was found to be independent of past year identity theft. A logistic regression model, with all predictors excluding sex, predicting past year identity theft was trained on the data. All predictors were found to be significant in predicting the outcome.

```
#adding libraries
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(ggplot2)
library(ggthemes)
library(caret)
```

```
## Loading required package: lattice
```

```
library(car)
```

```
## Loading required package: carData
```

```
##
## Attaching package: 'car'

## The following object is masked from 'package:dplyr':
##
##      recode
```

Loading Data

Data were downloaded from the 2016 ITS study page from the National Archives of Criminal Justice Data to a subfolder entitled “data” in the project on R-Studio, unzipped, loaded into R-Studio and renamed with a shorter name. Due to the size of the datafile, the memory limit had to be increased prior to loading the data in R-Studio.

```
## [1] 20000
```

Data Wrangling

There were 125,165 total persons in the 2016 ITS. Only completed telephone and personal interviews were used in the analysis which left 96,130 interviews or observations in the dataset.

```
##                               Number
## (1) Personal interview      57119
## (2) Telephone interview    39011
## (5) ITS Noninterview       29035
## Total                      125165
```

```
##                               Number
## (1) Personal interview      57119
## (2) Telephone interview    39011
## (5) ITS Noninterview        0
## Total                      96130
```

Created variables that would be used in analysis from the larger ITS dataset.

Individual variables created in the previous step were combined into a smaller dataset and larger dataset was removed.

Summary of the created dataset.

```
## 'data.frame':   96130 obs. of  22 variables:
## $ sex           : Factor w/ 3 levels "(1) Male","(2) Female",...: 2 1 1 1 1 2 1 1 2 2 ...
## $ race          : Factor w/ 21 levels "(01) White only",...: 1 2 6 1 1 1 1 1 1 1 ...
## $ hispanic      : Factor w/ 3 levels "(1) Yes","(2) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ income        : Factor w/ 14 levels "(01) Less than $5,000",...: 14 14 14 14 14 4 13 13 13 13 ...
## $ age           : num  46 50 22 78 50 30 29 62 60 74 ...
## $ pastyearbankacct : Factor w/ 5 levels "(01) Yes","(02) No",...: 1 1 1 1 1 1 1 1 1 1 ...
## $ existing_bank  : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ currentccacct  : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 1 1 1 1 2 1 1 ...
## $ pastyearccacct  : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 NA NA NA NA 2 NA NA ...
## $ existing_credit_card: Factor w/ 5 levels "(01) Yes","(02) No",...: NA NA NA 2 2 2 2 NA 2 2 ...
```

```

## $ other_existing_accts: Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ open_new_acct       : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ personal_info       : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ OUTSIDE_PAST_YEAR   : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 1 2 2 1 2 2 2 2 ...
## $ CHCKD_CR_PAST_YR    : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 1 2 2 1 1 2 2 1 ...
## $ CHNG_PASSWORDS      : Factor w/ 5 levels "(01) Yes","(02) No",...: 1 1 2 2 2 1 1 2 2 2 ...
## $ PURCHASE_IDTHFT_INS : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ SHRED_DOCS          : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 1 1 1 1 1 1 1 2 ...
## $ VERIFY_CHARGES      : Factor w/ 5 levels "(01) Yes","(02) No",...: 1 1 1 1 1 1 1 1 1 1 ...
## $ PROTECT_COMPUTER    : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ PURCHASE_IDTHFT_PROT: Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ notify_breach       : Factor w/ 5 levels "(01) Yes","(02) No",...: 2 2 2 2 2 2 2 2 2 2 ...

```

```

##           sex           race           hispanic
## (1) Male :44908 (01) White only :79770 (1) Yes :12131
## (2) Female :51222 (02) Black only :10051 (2) No :83999
## (8) Residue: 0 (04) Asian only : 4160 (8) Residue: 0
## (03) Am Ind/AK native only: 656
## (07) White-Amer Ind : 530
## (06) White-Black : 304
## (Other) : 659

```

```

##           income           age           pastyearbankacct
## (14) $75,000 and over :33662 Min. :16.00 (01) Yes :85793
## (13) $50,000 to $74,999:17342 1st Qu.:34.00 (02) No :10337
## (12) $40,000 to $49,999: 9330 Median :50.00 (08) Residue : 0
## (10) $30,000 to $34,999: 5811 Mean :49.26 (98) Refused : 0
## (11) $35,000 to $39,999: 5316 3rd Qu.:63.00 (99) Don't know: 0
## (08) $20,000 to $24,999: 5137 Max. :90.00
## (Other) :19532

```

```

##           existing_bank           currentccacct           pastyearccacct
## (01) Yes : 4665 (01) Yes :69446 (01) Yes : 1003
## (02) No :81128 (02) No :26670 (02) No :25681
## (08) Residue : 0 (08) Residue : 0 (08) Residue : 0
## (98) Refused : 0 (98) Refused : 10 (98) Refused : 0
## (99) Don't know: 0 (99) Don't know: 4 (99) Don't know: 0
## NA's :10337 NA's :69446

```

```

##           existing_credit_card           other_existing_accts           open_new_acct
## (01) Yes : 5460 (01) Yes : 815 (01) Yes : 589
## (02) No :64989 (02) No :95315 (02) No :95541
## (08) Residue : 0 (08) Residue : 0 (08) Residue : 0
## (98) Refused : 0 (98) Refused : 0 (98) Refused : 0
## (99) Don't know: 0 (99) Don't know: 0 (99) Don't know: 0
## NA's :25681

```

```

##           personal_info           OUTSIDE_PAST_YEAR           CHCKD_CR_PAST_YR
## (01) Yes : 473 (01) Yes :12267 (01) Yes :44385
## (02) No :95657 (02) No :83692 (02) No :51344
## (08) Residue : 0 (08) Residue : 48 (08) Residue : 80
## (98) Refused : 0 (98) Refused : 39 (98) Refused : 158
## (99) Don't know: 0 (99) Don't know: 84 (99) Don't know: 163

```

```

##           CHNG_PASSWORDS           PURCHASE_IDTHFT_INS           SHRED_DOCS

```

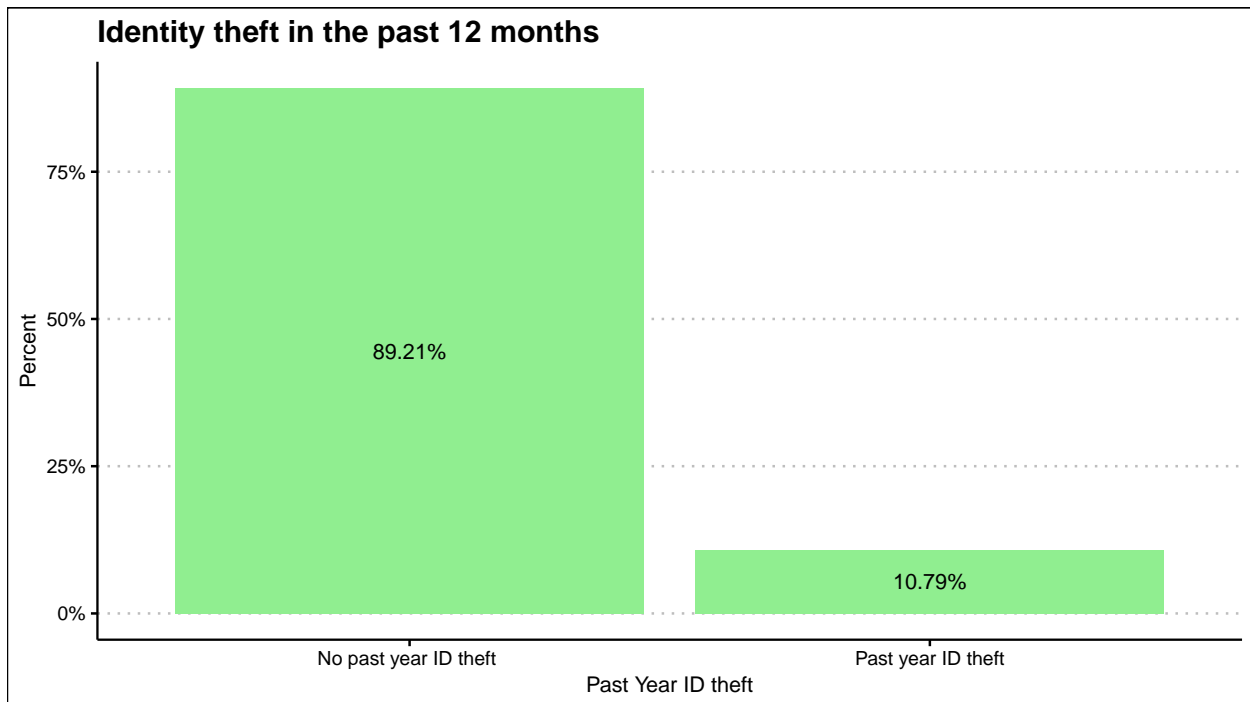
##	(01) Yes	:36861	(01) Yes	:12149	(01) Yes	:67772
##	(02) No	:58670	(02) No	:83440	(02) No	:27942
##	(08) Residue	: 88	(08) Residue	: 88	(08) Residue	: 92
##	(98) Refused	: 250	(98) Refused	: 193	(98) Refused	: 196
##	(99) Don't know:	261	(99) Don't know:	260	(99) Don't know:	128
##						
##						
##	VERIFY_CHARGES		PROTECT_COMPUTER		PURCHASE_IDTHFT_PROT	
##	(01) Yes	:75419	(01) Yes	:16447	(01) Yes	: 4881
##	(02) No	:20344	(02) No	:79001	(02) No	:90756
##	(08) Residue	: 94	(08) Residue	: 100	(08) Residue	: 100
##	(98) Refused	: 180	(98) Refused	: 209	(98) Refused	: 217
##	(99) Don't know:	93	(99) Don't know:	373	(99) Don't know:	176
##						
##						
##	notify_breach					
##	(01) Yes	:11037				
##	(02) No	:84652				
##	(08) Residue	: 102				
##	(98) Refused	: 179				
##	(99) Don't know:	160				
##						
##						

Recoded variables, collapsing categories and computing necessary categories and variables for analysis.

Exploratory analysis

Past year identity theft

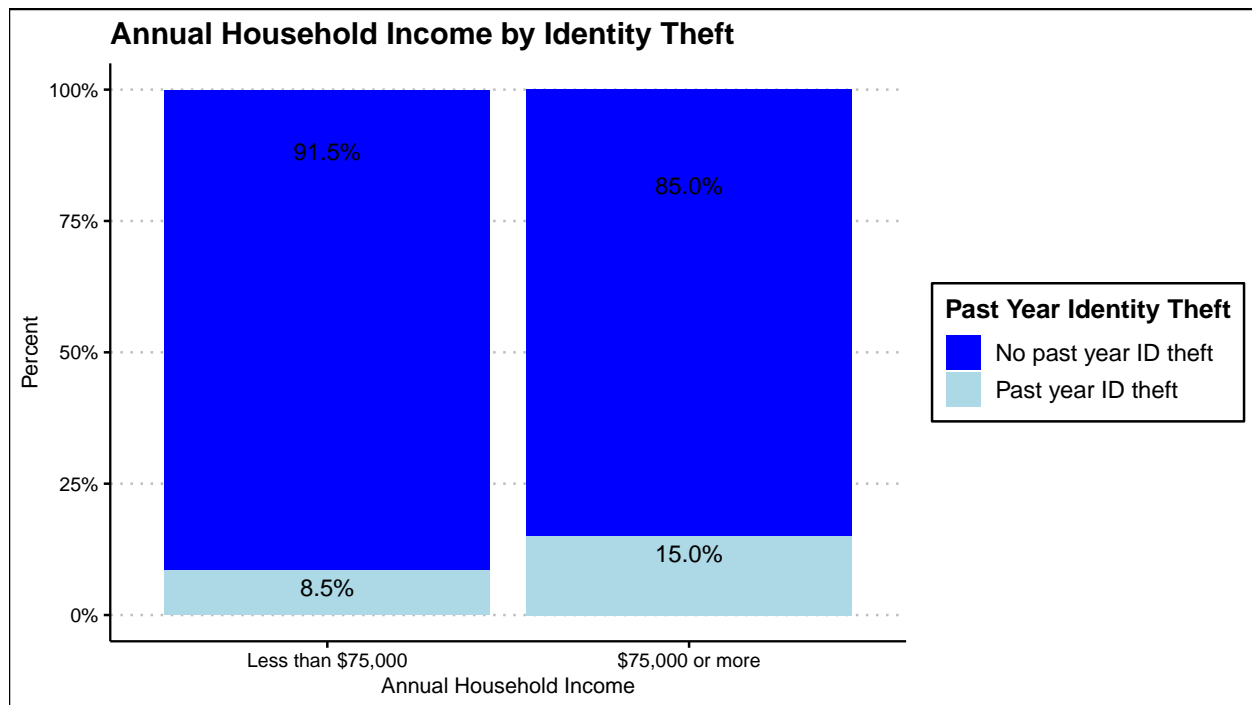
About 11% of the sample reported at least one type of identity theft (misuse of an existing account, misuse of personal information to open new account, or misuse of personal information for other fraudulent purposes) in the past year while 89% of the sample reported no identity theft.



Annual household income

About two thirds of the sample were in households with annual incomes of less than \$75,000 (65%) while the remainder (35%) were in households with annual incomes of at least \$75,000. Within each income category the majority of respondents did not report experiencing identity theft in the past year. However, 15% of persons in households with incomes of \$75,000 or more reported past year identity theft, compared to 9% of those in other households.

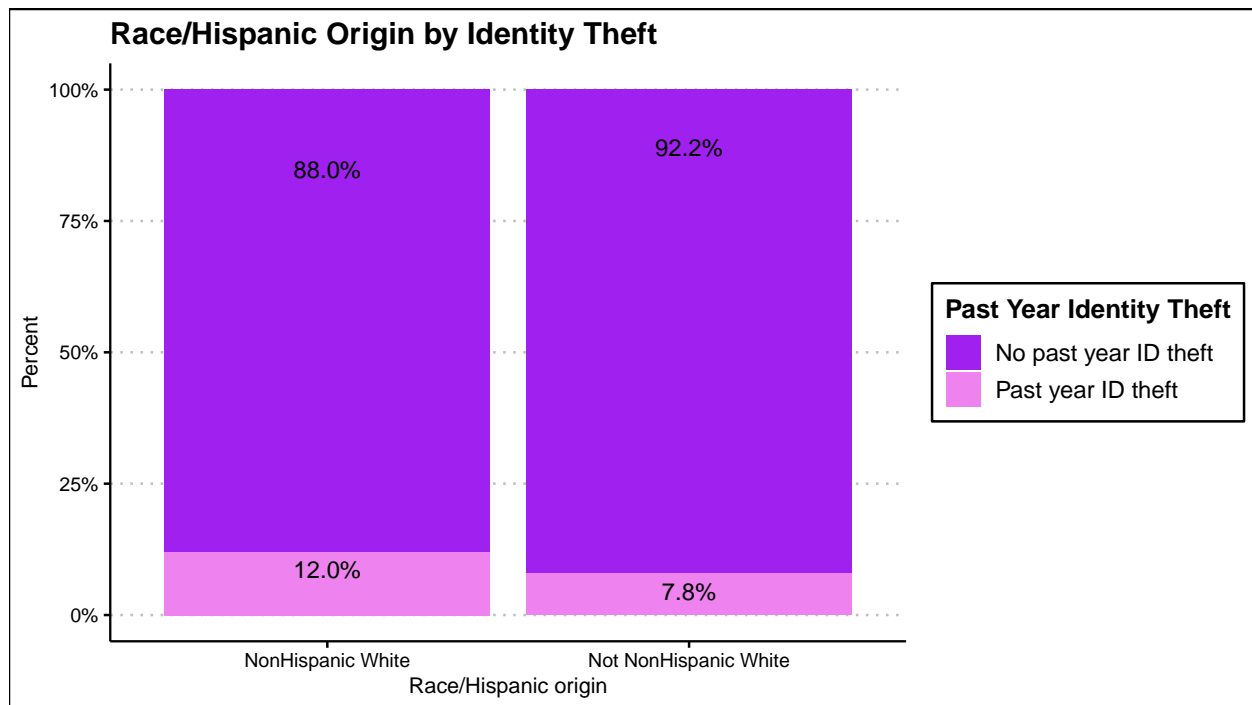
##	Count	Percentage
## Total	96130	100
## Less than \$75,000	62468	65
## \$75,000 or more	33662	35



Race/Hispanic origin

Seventy one percent of respondents were NonHispanic White while 29% were belonged to other race/Hispanic origin groups. Twelve percent of nonHispanic Whites reported past year identity theft compared to 8% of other persons reported identity theft in the past year.

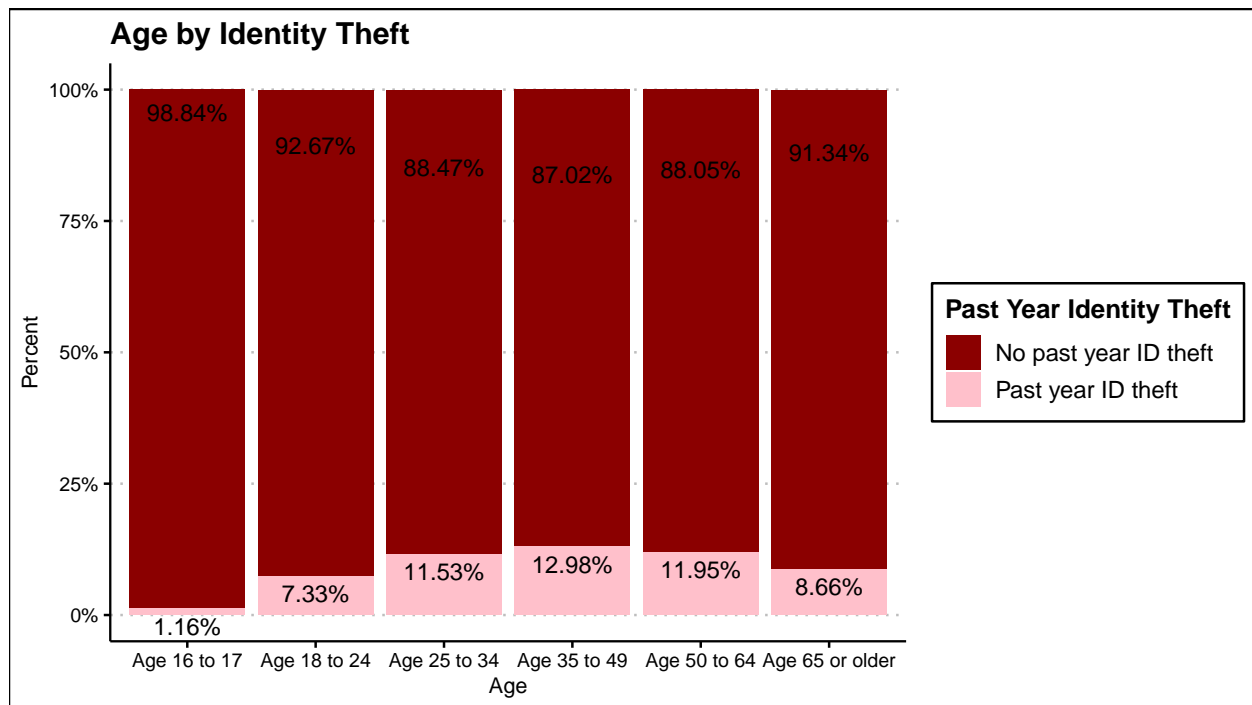
##	Count	Percentage
## Total	96130	100
## NonHispanic White	68265	71
## Not NonHispanic White	27865	29



Age

Twenty eight percent of the sample was age 50 to 64 while nearly one in four (24%) were age 35 to 49. 23% of the sample was age 65 or older. The remainder of the sample was under the age of 35. Thirteen percent of persons age 35 to 49 reported experiencing past year identity theft, compared to 7% of persons age 18 to 34 and 9% of persons age 65 or older.

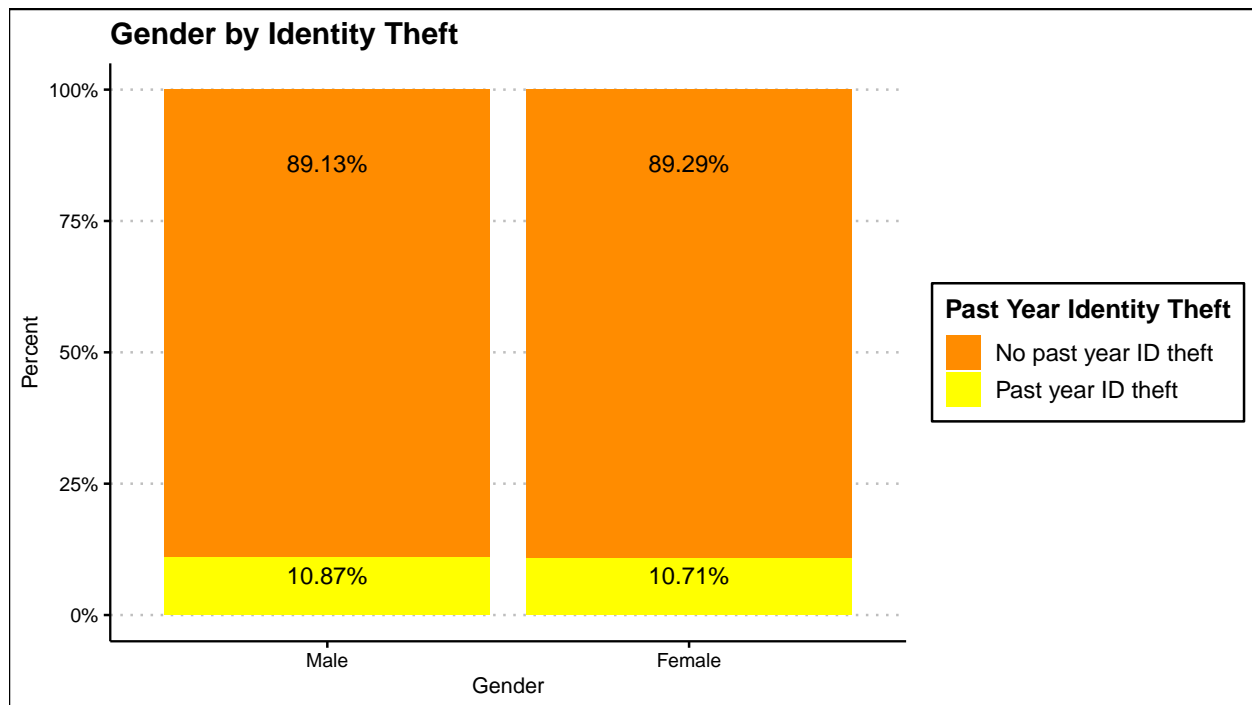
##	Count	Percentage
## Total	96130	100
## Age 16 to 17	1986	2
## Age 18 to 24	7826	8
## Age 25 to 34	14740	15
## Age 35 to 49	23147	24
## Age 50 to 64	26621	28
## Age 65 or older	21810	23



Gender

More than half of the sample (53%) was female while the remainder (47%) was male. Past year identity theft was experienced by 11% of males and a similar percentage of females.

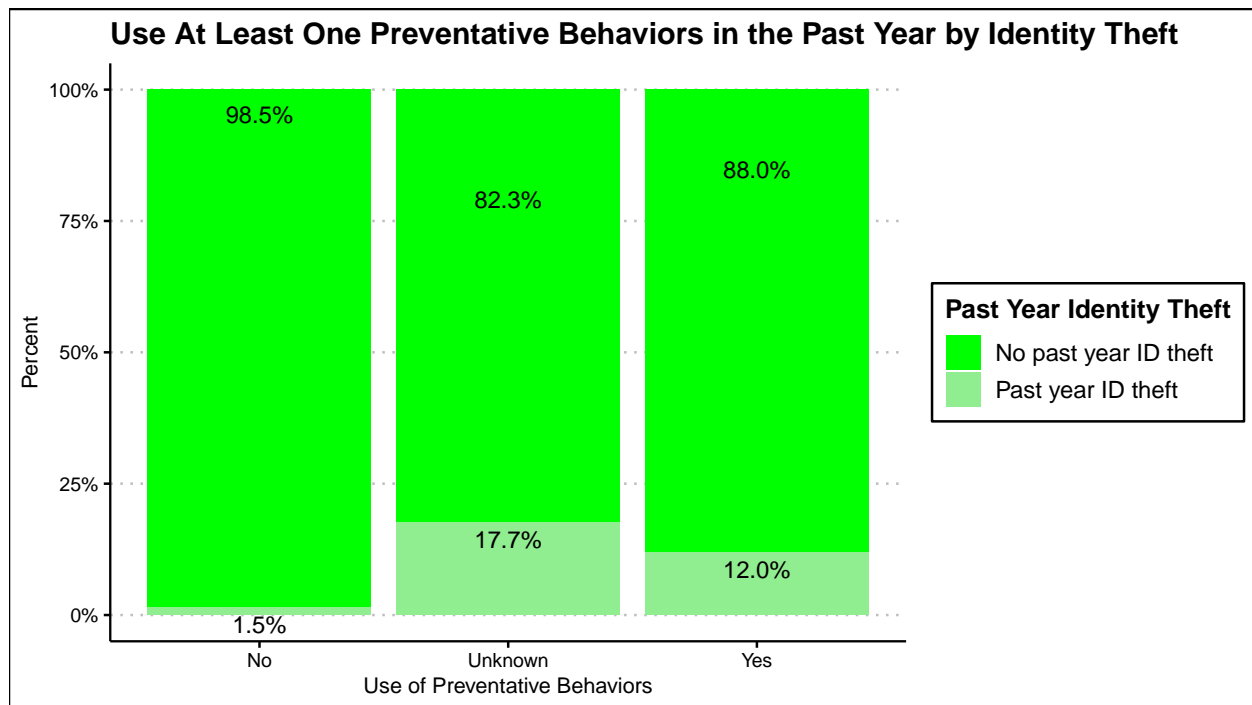
##	Count	Percentage
## Total	96130	100
## Male	44908	47
## Female	51222	53
## Unknown	0	0



Preventative behaviors

Nearly nine out of ten persons in the sample (88%) used at least one of the preventative behaviors measured (checked credit report, changed password on financial accounts, had credit monitoring services or identity theft insurance, shredded or destroyed documents containing personal information, checked bank or credit card statements for unfamiliar charges, purchased identity theft protection) in the past 12 months. Eighteen percent of respondents who did not know if they had used a preventative behavior in the past 12 months reported past year identity theft compared to 12% of those who had used at least 1 preventative behavior in the past 12 months. Surprisingly, only 2% of those who did not participate in any preventative behaviors in the past 12 months reported past year identity theft.

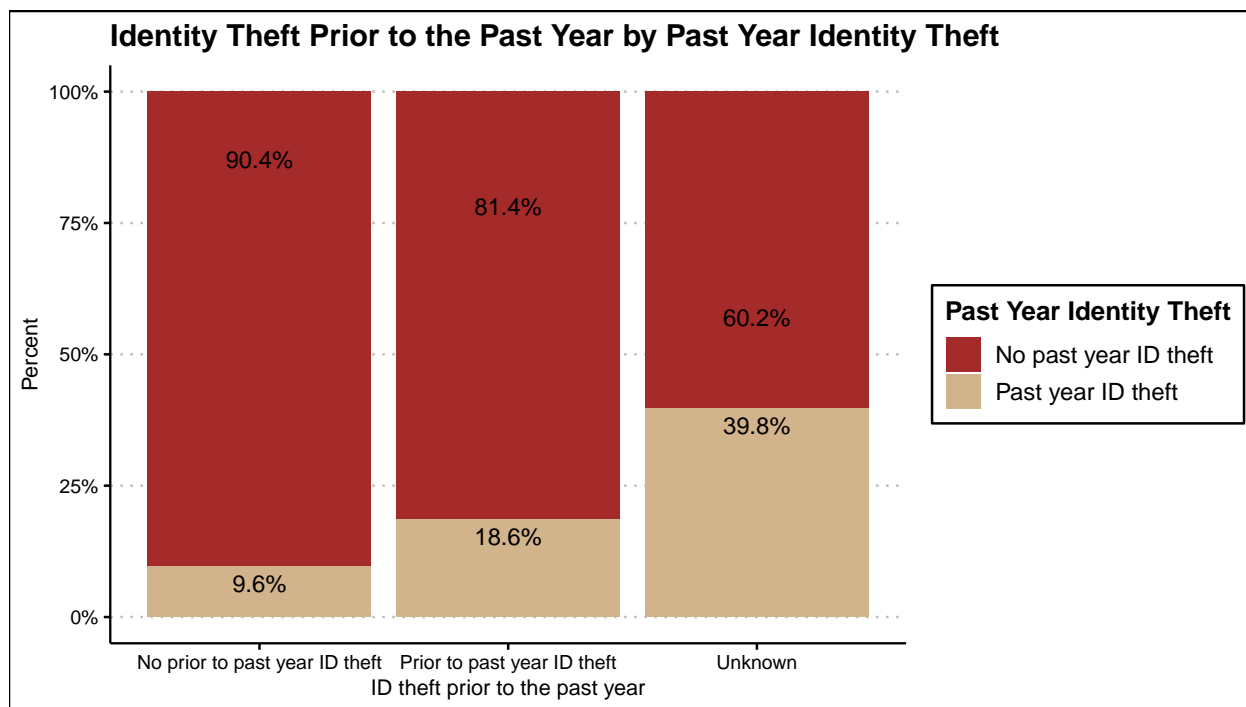
##	Count	Percentage
## Total	96130	100
## No	11066	12
## Unknown	368	0
## Yes	84696	88



Identity theft prior to the past year

Thirteen percent of the sample experienced identity theft (misuse of an existing account, misuse of personal information to create new account or misuse of personal information for other fraudulent purposes) prior to 12 months prior to their ITS interview. The majority of the sample did not experience it. About 40% of respondents who did not know if they were a victim of identity theft prior to the past year experienced identity theft in the past 12 months. This is compared to 10% of those who had no identity theft prior to the past year and 19% of those who had identity theft prior to the past year.

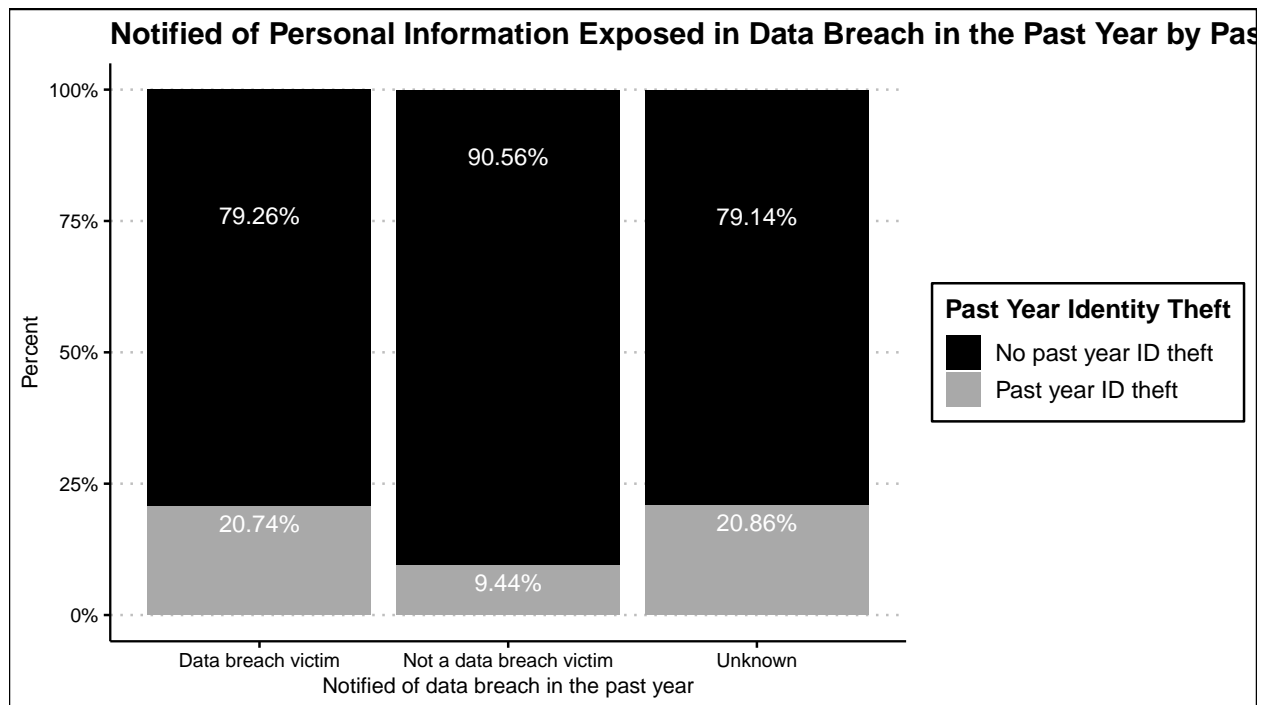
##	Count	Percentage
## Total	96130	100
## No prior to past year ID theft	83692	87
## Prior to past year ID theft	12267	13
## Unknown	171	0



Notified of exposure due to data breach

Twelve percent of the sample reported that they were notified that their personal information was exposed during a data breach. The majority of the sample (88%) reported that they were not notified that their personal information was exposed during a data breach. Of those who were notified that their information was exposed during a data breach, one in five (21%) reported being victims of identity theft in the past year. This is compared to 9% of those who were not notified that their personal information was exposed in a data breach being victims of past year identity theft.

##	Count	Percentage
## Total	96130	100
## Data breach victim	11037	11
## Not a data breach victim	84652	88
## Unknown	441	0



Data analysis

More data wrangling

Make copies of each variable used in analysis. Unknown level on each individual variable was changed to NA. Individual variables were combined into a single dataset and deleted individual variables. The individual variables were combined into a dataset (its1). The number of complete (cases with no NA values on any variable) and incomplete cases (cases with at least one variable with a value of NA) was summed from the dataset. There were 614 cases with a value of NA on at least one variable with the remaining cases being complete cases

```
## 'data.frame': 96130 obs. of 8 variables:
## $ idtheft : Factor w/ 2 levels "No past year ID theft ",...: 1 1 1 1 1 1 1 1 1 1 ...
## $ incomer : Factor w/ 2 levels "Less than $75,000",...: 2 2 2 2 1 1 1 1 1 1 ...
## $ ager : Factor w/ 6 levels "Age 16 to 17",...: 4 5 2 6 5 3 3 5 5 6 ...
## $ ethnicr : Factor w/ 2 levels "NonHispanic White",...: 1 2 2 1 1 1 1 1 1 1 ...
## $ prevent_total : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 2 2 2 2 2 ...
## $ OUTSIDE_PAST_YEARR: Factor w/ 2 levels "No prior to past year ID theft",...: 1 1 2 1 1 2 1 1 1 1 .
## $ notify_breachr : Factor w/ 2 levels "Data breach victim",...: 2 2 2 2 2 2 2 2 2 2 ...
## $ sexr : Factor w/ 2 levels "Male","Female": 2 1 1 1 1 2 1 1 2 2 ...

##           Number Percent
## Total           96130     100
## Cases with NAs           614         1
## Cases without NAs      95516        99
```

Chi-Square Analysis

Multiple chi-square analyses were run on the dataset with only completed cases. They show that between past year identity theft was dependent on most of the predictors ($p < 0.05$) with the exception of sex ($p > 0.05$).

```
##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$incomer
## X-squared = 972.79, df = 1, p-value < 2.2e-16

##
## Pearson's Chi-squared test
##
## data: its1$idtheft and its1$ager
## X-squared = 552.16, df = 5, p-value < 2.2e-16

##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$sexr
## X-squared = 0.59442, df = 1, p-value = 0.4407

##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$ethnricr
## X-squared = 356.47, df = 1, p-value < 2.2e-16

##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$prevent_total
## X-squared = 1120.4, df = 1, p-value < 2.2e-16

##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$OUTSIDE_PAST_YEAR
## X-squared = 915.56, df = 1, p-value < 2.2e-16

##
## Pearson's Chi-squared test with Yates' continuity correction
##
## data: its1$idtheft and its1$notify_breachr
## X-squared = 1300.4, df = 1, p-value < 2.2e-16
```

Machine Learning

Setup

The dataset was split into training and testing datasets to in an attempt to train a logistics regression model predicting past year identity theft. Sixty percent of data(57,679 cases) was assigned to the training data while the remaining 40% (38,451 cases) went in the test dataset. The training dataset was examined for variables that had near zero or zero variability. There were no variables with zero or near zero variability.

##	freqRatio	percentUnique	zeroVar	nzv
## idtheft	8.271661	0.003467466	FALSE	FALSE
## incomer	1.866322	0.003467466	FALSE	FALSE
## ager	1.156512	0.010402399	FALSE	FALSE
## ethnicr	2.440031	0.003467466	FALSE	FALSE
## prevent_total	7.641901	0.003467466	FALSE	FALSE
## OUTSIDE_PAST_YEARR	6.887260	0.003467466	FALSE	FALSE
## notify_breachr	7.808961	0.003467466	FALSE	FALSE
## sexr	1.141335	0.003467466	FALSE	FALSE

Training Model

A logistic regression model predicting past year identity theft was trained to the data. All of the predictors with the exception of sex was included in the model. Sex was excluded due to the chi-square analysis showing that sex was independent of past year identity theft. When the model was run 375 cases had to be removed due to missing data, resulting in 57,334 cases used in the model. The results of the logistic regression model showed that all predictors were statistically significant in predicting past year identity theft ($p < .05$) with the exception of the comparison of those age 25 to 34 to those age 35 to 49 ($p > .05$). Based on the odds ratios, the model showed that the odds of a person in households with annual incomes of \$75,000 or more was 0.08 higher than that of a person in a household with annual incomes of less than \$75,000. Each of the age groups tested had a lower odds of being a victim of past year identity theft than those in the reference group, age 35 to 49. The odds of a Non-Hispanic White person being a victim of past year identity theft was 1.3 times that of other persons. Being a victim of identity theft prior to the past year increased the odds of being a victim of identity theft in the past 12 months by a factor of about 1.5 over other persons. Being notified of personal information being exposed in a data breach increased the odds of being a victim of pst year identity theft by a factor of 1.8. One strange result from the model was that not using any of the preventative measures in the past 12 monmths reduced the odds of being a victim of past year identity theft by a factor of 0.2.

```
modFit <- glm(idtheft ~incomer+ager+ethnicr+prevent_total+
              OUTSIDE_PAST_YEARR+notify_breachr,data=training,family="binomial")
summary(modFit)
```

```
##
## Call:
## glm(formula = idtheft ~ incomer + ager + ethnicr + prevent_total +
##      OUTSIDE_PAST_YEARR + notify_breachr, family = "binomial",
##      data = training)
##
```

```
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.9014  -0.5196  -0.4462  -0.3704   3.3136
##
## Coefficients:
##                                Estimate Std. Error z value
## (Intercept)                   -2.40089    0.03883 -61.833
## incomer$75,000 or more          0.38460    0.02844  13.522
## agerAge 16 to 17                -1.57136    0.26359  -5.961
## agerAge 18 to 24                -0.24405    0.06233  -3.916
## agerAge 25 to 34                -0.04950    0.04297  -1.152
## agerAge 50 to 64                -0.12504    0.03620  -3.454
## agerAge 65 or older             -0.34257    0.04144  -8.267
## ethnicrNonHispanic White        0.26895    0.03416   7.874
## prevent_totalNo                 -1.78264    0.10283 -17.335
## OUTSIDE_PAST_YEARRPrior to past year ID theft  0.46664    0.03508  13.303
## notify_breachrData breach victim  0.58995    0.03560  16.573
##                                Pr(>|z|)
## (Intercept)                   < 2e-16 ***
## incomer$75,000 or more          < 2e-16 ***
## agerAge 16 to 17                2.50e-09 ***
## agerAge 18 to 24                9.01e-05 ***
## agerAge 25 to 34                0.249341
## agerAge 50 to 64                0.000551 ***
## agerAge 65 or older             < 2e-16 ***
## ethnicrNonHispanic White        3.43e-15 ***
## prevent_totalNo                 < 2e-16 ***
## OUTSIDE_PAST_YEARRPrior to past year ID theft < 2e-16 ***
## notify_breachrData breach victim < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 39069  on 57308  degrees of freedom
## Residual deviance: 36954  on 57298  degrees of freedom
##      (370 observations deleted due to missingness)
## AIC: 36976
##
## Number of Fisher Scoring iterations: 7
```

```
#Odds ratios for training model
exp(modFit$coeff)
```

```
##                                (Intercept)
##                                0.09063718
##      incomer$75,000 or more
##                                1.46902943
##      agerAge 16 to 17
##                                0.20776261
##      agerAge 18 to 24
##                                0.78344573
##      agerAge 25 to 34
##                                0.95170813
```

```
##                agerAge 50 to 64
##                0.88245793
##                agerAge 65 or older
##                0.70994275
##                ethnicrNonHispanic White
##                1.30858508
##                prevent_totalNo
##                0.16819348
## OUTSIDE_PAST_YEARRPrior to past year ID theft
##                1.59462266
##                notify_breachrData breach victim
##                1.80390138
```

Training Model Diagnostics

Variance inflation factors were generated to determine if there was multicollinearity among the predictors in the training model. The variance inflation factors for all predictors in the model were about 1, showing that there was little to no multicollinearity among the predictors. An Anova model was fit to the training model to determine which factors were predictive in the model. The result of this analysis showed that all predictors were predictive ($p < .05$).

```
#variance inflation factors for training model
vif(modFit)
```

```
##                GVIF Df GVIF^(1/(2*Df))
## incomer        1.064346 1      1.031671
## ager           1.073782 5      1.007144
## ethnicr        1.050297 1      1.024840
## prevent_total  1.019773 1      1.009838
## OUTSIDE_PAST_YEARR 1.055678 1      1.027462
## notify_breachr 1.067781 1      1.033335
```

```
#anova- used for putting factors in and out of training model
anova(modFit, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: idtheft
##
## Terms added sequentially (first to last)
##
##
```

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
## NULL			57308	39069	
## incomer	1	514.80	57307	38554	< 2.2e-16 ***
## ager	5	295.11	57302	38259	< 2.2e-16 ***
## ethnicr	1	172.21	57301	38087	< 2.2e-16 ***
## prevent_total	1	629.64	57300	37457	< 2.2e-16 ***
## OUTSIDE_PAST_YEARR	1	246.24	57299	37211	< 2.2e-16 ***


```
## notify_breachr      1    256.89    57298    36954 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Running Adjusted Model

Another model was ran that was the original training model without the predictor for the use of preventative behaviors in the past 12 months. This was done due to the unusual result in the original training model. Similar results were obtained. The majority of the predictors were found to be statistically significant ($p < .05$). The only exception was that the comparison of persons age 35 to 45 to those age 25 to 34 was not statistically significant ($p > 0.5$). According to the odds ratios for the adjusted model, the odds of persons in households with annual incomes or \$75,000 or more being a victim of past year identity theft increased by 0.1 compared to other persons. Each of the age groups tested had a lower odds of being a victim of past year identity theft than those in the reference group, age 35 to 49. The odds of a nonHispanic White person being a victim of identity theft was 1.4 times the odds of a person of another racial/ethnic group being a victim. Being a victim of identity theft prior to the past year increased the odds of being a victim during the past 12 months by 1.7 compared to other persons. Being notified that personal information was exposed during a data breach increased the odds of being a victim of past year identity theft by 1.9 compared to those who were not notified of being a victim of a data breach.

```
modFit1 <- glm(idtheft ~ incomer+ager+ethnicr++OUTSIDE_PAST_YEARR+notify_breachr
               ,data=training,family="binomial")
#get model estimates for adjusted model
summary(modFit1)
```

```
##
## Call:
## glm(formula = idtheft ~ incomer + ager + ethnicr + +OUTSIDE_PAST_YEARR +
##      notify_breachr, family = "binomial", data = training)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.9220  -0.5206  -0.4268  -0.3729   3.0948
##
## Coefficients:
##                                Estimate Std. Error z value
## (Intercept)                   -2.58556    0.03824 -67.617
## incomer$75,000 or more          0.43107    0.02839  15.183
## agerAge 16 to 17                -2.19501    0.26120  -8.403
## agerAge 18 to 24                -0.31551    0.06195  -5.093
## agerAge 25 to 34                -0.04579    0.04283  -1.069
## agerAge 50 to 64                -0.11953    0.03611  -3.310
## agerAge 65 or older             -0.34732    0.04130  -8.410
## ethnicrNonHispanic White         0.35512    0.03396  10.457
## OUTSIDE_PAST_YEARRPrior to past year ID theft  0.51635    0.03517  14.681
## notify_breachrData breach victim  0.64759    0.03571  18.137
##                                Pr(>|z|)
## (Intercept)                   < 2e-16 ***
## incomer$75,000 or more          < 2e-16 ***
## agerAge 16 to 17                < 2e-16 ***
```

```
## agerAge 18 to 24 3.52e-07 ***
## agerAge 25 to 34 0.284980
## agerAge 50 to 64 0.000933 ***
## agerAge 65 or older < 2e-16 ***
## ethnicrNonHispanic White < 2e-16 ***
## OUTSIDE_PAST_YEARRPrior to past year ID theft < 2e-16 ***
## notify_breachrData breach victim < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 39090 on 57364 degrees of freedom
## Residual deviance: 37499 on 57355 degrees of freedom
## (314 observations deleted due to missingness)
## AIC: 37519
##
## Number of Fisher Scoring iterations: 6
```

```
#Odds ratios for adjusted model
exp(modFit1$coeff)
```

```
## (Intercept)
## 0.07535364
## incomer$75,000 or more
## 1.53889763
## agerAge 16 to 17
## 0.11135702
## agerAge 18 to 24
## 0.72942017
## agerAge 25 to 34
## 0.95524251
## agerAge 50 to 64
## 0.88733615
## agerAge 65 or older
## 0.70657648
## ethnicrNonHispanic White
## 1.42635361
## OUTSIDE_PAST_YEARRPrior to past year ID theft
## 1.67589790
## notify_breachrData breach victim
## 1.91092043
```

Adjusted model diagnostics

Variance inflation factors were generated on the adjusted model and showed little to no multicollinearity among the predictors. The Anova chi-square results showed that each of the predictors were predictive in the model.

```
#variance inflation factors for adjusted model
vif(modFit1)
```

```
##          GVIF Df GVIF^(1/(2*Df))
## incomer      1.065719  1      1.032337
## ager         1.065367  5      1.006352
## ethnicr      1.049878  1      1.024635
## OUTSIDE_PAST_YEARR 1.060217  1      1.029668
## notify_breachr 1.072608  1      1.035668
```

```
#anova- used for putting factors in and out of adjusted model
anova(modFit1, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: idtheft
##
## Terms added sequentially (first to last)
##
##
##          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
## NULL                      57364      39090
## incomer          1    514.08    57363    38576 < 2.2e-16 ***
## ager             5    296.73    57358    38279 < 2.2e-16 ***
## ethnicr          1    172.39    57357    38107 < 2.2e-16 ***
## OUTSIDE_PAST_YEARR 1    302.15    57356    37805 < 2.2e-16 ***
## notify_breachr   1    305.49    57355    37499 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Test data

```
modFit2 <- glm(idtheft ~ incomer+ager+ethnicr++OUTSIDE_PAST_YEARR+notify_breachr
, data=testing, family="binomial")
#get model estimates for adjusted model ran over test data
summary(modFit2)
```

```
##
## Call:
## glm(formula = idtheft ~ incomer + ager + ethnicr + +OUTSIDE_PAST_YEARR +
##      notify_breachr, family = "binomial", data = testing)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.9129  -0.5353  -0.4254  -0.3663   3.1675
##
## Coefficients:
##              Estimate Std. Error z value
## (Intercept)    -2.56994    0.04639  -55.401
## incomer$75,000 or more    0.49546    0.03469   14.284
## agerAge 16 to 17    -2.43981    0.35715   -6.831
## agerAge 18 to 24    -0.43687    0.07881   -5.544
```

```
## agerAge 25 to 34 -0.03696 0.05213 -0.709
## agerAge 50 to 64 -0.09803 0.04375 -2.241
## agerAge 65 or older -0.37649 0.05094 -7.391
## ethnicrNonHispanic White 0.31098 0.04158 7.478
## OUTSIDE_PAST_YEARRPrior to past year ID theft 0.48642 0.04282 11.360
## notify_breachrData breach victim 0.61716 0.04317 14.297
## Pr(>|z|)
## (Intercept) < 2e-16 ***
## incomer$75,000 or more < 2e-16 ***
## agerAge 16 to 17 8.42e-12 ***
## agerAge 18 to 24 2.96e-08 ***
## agerAge 25 to 34 0.478
## agerAge 50 to 64 0.025 *
## agerAge 65 or older 1.46e-13 ***
## ethnicrNonHispanic White 7.52e-14 ***
## OUTSIDE_PAST_YEARRPrior to past year ID theft < 2e-16 ***
## notify_breachrData breach victim < 2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 26097 on 38246 degrees of freedom
## Residual deviance: 24989 on 38237 degrees of freedom
## (204 observations deleted due to missingness)
## AIC: 25009
##
## Number of Fisher Scoring iterations: 7
```

```
#Odds ratios for adjusted model ran over test data
exp(modFit2$coeff)
```

```
## (Intercept)
## 0.07654015
## incomer$75,000 or more
## 1.64125331
## agerAge 16 to 17
## 0.08717724
## agerAge 18 to 24
## 0.64605727
## agerAge 25 to 34
## 0.96371578
## agerAge 50 to 64
## 0.90662091
## agerAge 65 or older
## 0.68626871
## ethnicrNonHispanic White
## 1.36476104
## OUTSIDE_PAST_YEARRPrior to past year ID theft
## 1.62647751
## notify_breachrData breach victim
## 1.85364963
```

Diagnostics of adjusted model ran over test data

```
#variance inflation factors for adjusted model ran over test data  
vif(modFit2)
```

```
##              GVIF Df  GVIF^(1/(2*Df))  
## incomer      1.065668 1      1.032312  
## ager         1.068079 5      1.006608  
## ethnicr      1.056203 1      1.027717  
## OUTSIDE_PAST_YEARR 1.050027 1      1.024708  
## notify_breachr 1.063807 1      1.031410
```

```
#anova- used for putting factors in and out of adjusted model ran over test data  
anova(modFit2, test = "Chisq")
```

```
## Analysis of Deviance Table  
##  
## Model: binomial, link: logit  
##  
## Response: idtheft  
##  
## Terms added sequentially (first to last)  
##  
##  
##          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)  
## NULL                38246      26098  
## incomer             1   412.64    38245    25685 < 2.2e-16 ***  
## ager                 5   240.89    38240    25444 < 2.2e-16 ***  
## ethnicr              1    89.05    38239    25355 < 2.2e-16 ***  
## OUTSIDE_PAST_YEARR   1   175.89    38238    25179 < 2.2e-16 ***  
## notify_breachr       1   190.44    38237    24989 < 2.2e-16 ***  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```