# 506 Problem Set 3

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GitHub repository: https://github.com/EmiiilyLiu/STATS_506

```r
setwd("F:/Desktop/STATS 506/STATS_506")
```

## Problem 1

### (a)

```
. do "K:\PS3 Q1.do"

. * (a) Import and merge data
. * Refer to:
. * chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.stata.com/ma
> nuals13/dimportsasxport.pdf
. * chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.stata.com/ma
> nuals/dmerge.pdf
. import sasxport5 "K:\VIX_D.XPT"

. save "K:\temp_VIX_D.dta", replace
file K:\temp_VIX_D.dta saved

. import sasxport5 "K:\DEMO_D.xpt"

. merge 1:1 seqn using "K:\temp_VIX_D.dta", keep(match) nogenerate

    Result                      Number of obs
    -----------------------------------------
    Not matched                             0
    Matched                             6,980
    -----------------------------------------

. count
  6,980
```

### (b)

```
. * (b)
. * Refer to:
. * chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.stata.com/manuals/rtab
. * view the merged data
. * describe
. * age group variable
. gen age_group = "0-9" if ridageyr < 10
(6,980 missing values generated)
```

```
. replace age_group = "10-19" if ridageyr >= 10 & ridageyr < 20
variable age_group was str1 now str5
(2,207 real changes made)

. replace age_group = "20-29" if ridageyr >= 20 & ridageyr < 30
(1,021 real changes made)

. replace age_group = "30-39" if ridageyr >= 30 & ridageyr < 40
(818 real changes made)

. replace age_group = "40-49" if ridageyr >= 40 & ridageyr < 50
(815 real changes made)

. replace age_group = "50-59" if ridageyr >= 50 & ridageyr < 60
(631 real changes made)

. replace age_group = "60-69" if ridageyr >= 60 & ridageyr < 70
(661 real changes made)

. replace age_group = "70-79" if ridageyr >= 70 & ridageyr < 80
(469 real changes made)

. replace age_group = "80-89" if ridageyr >= 80 & ridageyr < 90
(358 real changes made)

. replace age_group = "90-99" if ridageyr >= 90
(0 real changes made)

. gen wear = .
(6,980 missing values generated)

. replace wear = 1 if viq220 == 1
(2,765 real changes made)

. replace wear = 0 if inlist(viq220, 2, 9)
(3,782 real changes made)

. * Use mean of viq220==1 within each age group representing proportion
. table age_group, nototals statistic(mean wear)

---------------------
```

```
          |      Mean
----------+----------
age_group |
  10-19   |   .3208812
  20-29   |   .3258786
  30-39   |   .3586667
  40-49   |   .3699871
  50-59   |   .5500821
  60-69   |   .6222222
  70-79   |   .6689038
  80-89   |   .6688103
---------------------


.
.
```

### (c)

```
. * (c)
. * Refer to *chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.st
> ata.com/manuals/rlogistic.pdf
. * https://www.stata.com/support/faqs/statistics/outcome-does-not-vary/
. * chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.stata.com/ma
> nuals13/restatic.pdf
. * http://repec.org/bocode/e/estout/esttab.html
. * http://repec.org/bocode/e/estout/estout.html
. replace viq220 = 0 if viq220 == 2
(3,780 real changes made)

. replace viq220 = . if viq220 == 9
(2 real changes made, 2 to missing)

. logistic viq220 ridageyr

Logistic regression                                     Number of obs =  6,545
                                                        LR chi2(1)    = 443.37
                                                        Prob > chi2   = 0.0000
Log likelihood = -4235.9433                             Pseudo R2     = 0.0497

------------------------------------------------------------------------------
```

```
      viq220 | Odds ratio   Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
    ridageyr |    1.02498   .0012356    20.47   0.000     1.022561    1.027405
       _cons |    .283379   .0151461   -23.59   0.000     .2551952    .3146755
------------------------------------------------------------------------------
Note: _cons estimates baseline odds.

. eststo model1

. estat ic

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |          N   ll(null)  ll(model)      df         AIC        BIC
-------------+---------------------------------------------------------------
      model1 |      6,545  -4457.627  -4235.943       2    8475.887    8489.46
-----------------------------------------------------------------------------
Note: BIC uses N = number of observations. See [R] IC note.

. logistic viq220 ridageyr i.riagendr i.ridreth1

Logistic regression                                     Number of obs =  6,545
                                                        LR chi2(6)    = 641.49
                                                        Prob > chi2   = 0.0000
Log likelihood = -4136.8805                             Pseudo R2     = 0.0720

------------------------------------------------------------------------------
      viq220 | Odds ratio   Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
    ridageyr |   1.022831   .0012912    17.88   0.000     1.020303    1.025365
  2.riagendr |    1.65217   .0875831     9.47   0.000     1.489127    1.833064
             |
    ridreth1 |
          2  |   1.169203    .192081     0.95   0.341     .8473273    1.613349
          3  |   1.952149   .1366952     9.55   0.000     1.701803    2.239322
          4  |    1.29936   .0995052     3.42   0.001     1.118264    1.509783
          5  |   1.917442   .2596352     4.81   0.000     1.470495    2.500236
             |
       _cons |   .1593479   .0124169   -23.57   0.000     .1367784    .1856414
------------------------------------------------------------------------------
```

```
Note: _cons estimates baseline odds.

. eststo model2

. estat ic

Akaike's information criterion and Bayesian information criterion

-----------------------------------------------------------------------------
       Model |          N   ll(null)  ll(model)      df        AIC        BIC
-------------+---------------------------------------------------------------
      model2 |      6,545  -4457.627   -4136.88       7   8287.761   8335.266
-----------------------------------------------------------------------------
Note: BIC uses N = number of observations. See [R] IC note.

. logistic viq220 ridageyr i.riagendr i.ridreth1 indfmpir

Logistic regression                                     Number of obs =  6,247
                                                        LR chi2(7)    = 625.30
                                                        Prob > chi2   = 0.0000
Log likelihood = -3946.9041                             Pseudo R2     = 0.0734

------------------------------------------------------------------------------
      viq220 | Odds ratio   Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
    ridageyr |   1.022436    .001324    17.14   0.000     1.019845    1.025035
  2.riagendr |   1.675767   .0910025     9.51   0.000      1.50657    1.863967
             |
    ridreth1 |
          2  |   1.123021   .1889653     0.69   0.490     .8075333    1.561764
          3  |   1.651244   .1240886     6.67   0.000     1.425098    1.913277
          4  |   1.230456   .0974736     2.62   0.009     1.053503     1.43713
          5  |   1.703572   .2387583     3.80   0.000     1.294384    2.242114
             |
    indfmpir |   1.120301   .0198376     6.42   0.000     1.082087    1.159865
       _cons |   .1331659   .0116903   -22.97   0.000     .1121161    .1581678
------------------------------------------------------------------------------
Note: _cons estimates baseline odds.

. eststo model3
```

```
. esttab model1 model2 model3, eform cells(b(star fmt(3)) se(par fmt(3))) stats(
> N r2_p aic, labels("Sample Size" "Pseudo R^2" "AIC")) mtitle("Model 1" "Model
> 2" "Model 3") label

-------------------------------------------------------------------
                              (1)             (2)             (3)   
                          Model 1         Model 2         Model 3   
                             b/se            b/se            b/se   
-------------------------------------------------------------------
Glasses/contact le~                                                 
Age at Screening A~R        1.025***        1.023***        1.022***
                          (0.001)         (0.001)         (0.001)   
Gender=1                                    1.000           1.000   
                                              (.)             (.)   
Gender=2                                    1.652***        1.676***
                                          (0.088)         (0.091)   
Race/Ethnicity - R~1                        1.000           1.000   
                                              (.)             (.)   
Race/Ethnicity - R~2                        1.169           1.123   
                                          (0.192)         (0.189)   
Race/Ethnicity - R~3                        1.952***        1.651***
                                          (0.137)         (0.124)   
Race/Ethnicity - R~4                        1.299***        1.230** 
                                          (0.100)         (0.097)   
Race/Ethnicity - R~5                        1.917***        1.704***
                                          (0.260)         (0.239)   
Family PIR                                                  1.120***
                                                          (0.020)   
-------------------------------------------------------------------
Sample Size              6545.000        6545.000        6247.000   
Pseudo R^2                  0.050           0.072           0.073   
AIC                      8475.887        8287.761        7909.808   
-------------------------------------------------------------------
Exponentiated coefficients

.
```

**(d)**

$$\frac{odds(female)}{odds(male)} = \frac{\frac{Pr(viq220=1|female)}{1-Pr(viq220=1|female)}}{\frac{Pr(viq220=1|male}{1-Pr(viq220=1|male)}} = 1.676$$

The odds ratio is 1.676, with $p - value << 0.05$, meaning it is statistically significant. We can conclude that the odds of men and women being wears of glasess/contact lenses for distance vision differs. The odd of women being wears of glasses/contact lenses for distance vision is larger than that of men.

```
. *(d)
. * Refer to:
. * https://stats.oarc.ucla.edu/stata/webbooks/logistic/chapter1/logistic-regression-with-
> apter-1-introduction-to-logistic-regression-with-stata/#:~:text=Stata%20has%20two%20comm
> for,command%20with%20the%20or%20option.
. logit viq220 ridageyr i.riagendr i.ridreth1 indfmpir

Iteration 0:  Log likelihood = -4259.5533
Iteration 1:  Log likelihood = -3948.3256
Iteration 2:  Log likelihood = -3946.9043
Iteration 3:  Log likelihood = -3946.9041

Logistic regression                                     Number of obs =  6,247
                                                        LR chi2(7)    = 625.30
                                                        Prob > chi2   = 0.0000
Log likelihood = -3946.9041                             Pseudo R2     = 0.0734

------------------------------------------------------------------------------
      viq220 | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
-------------+----------------------------------------------------------------
    ridageyr |   .0221883   .0012949    17.14   0.000     .0196504    .0247263
  2.riagendr |   .5162712    .054305     9.51   0.000     .4098355     .622707
             |
    ridreth1 |
          2  |   .1160225   .1682651     0.69   0.490     -.213771    .4458161
          3  |   .5015289   .0751486     6.67   0.000     .3542404    .6488174
          4  |   .2073846   .0792175     2.62   0.009     .0521211     .362648
          5  |   .5327271   .1401516     3.80   0.000     .2580349    .8074192
             |
    indfmpir |   .1135978   .0177073     6.42   0.000      .078892    .1483035
       _cons |   -2.01616   .0877879   -22.97   0.000    -2.188221   -1.844099
------------------------------------------------------------------------------

.
.
.
.
```

```
.
end of do-file

.
```

Since $p - value << 0.05$, meaning the coefficient is statistically significant at 0.05 level, that is the proportion of wearers of glasses/contact lenses for distance vision differs between men and women.

## Problem 2

```r
library(DBI)

## Import the SQLite database of "sakila" data
sakila <- dbConnect(RSQLite::SQLite(), "sakila_master.db")

#' @param x a string as input SQL query
gg <- function(x){
  dbGetQuery(sakila, x)
}

## Get the list of tables in "sakila" database
dbListTables(sakila)
```

```
 [1] "actor"                  "address"                "category"
 [4] "city"                   "country"                "customer"
 [7] "customer_list"          "film"                   "film_actor"
[10] "film_category"          "film_list"              "film_text"
[13] "inventory"              "language"               "payment"
[16] "rental"                 "sales_by_film_category" "sales_by_store"
[19] "staff"                  "staff_list"             "store"
```

```r
## Get lists of columns of the tables
for (i in dbListTables(sakila)){
  cat("Table:", i, "\n")
  print(dbListFields(sakila, i))
  cat("\n")
}
```

```
Table: actor
```

```
[1] "actor_id"    "first_name"  "last_name"   "last_update"

Table: address
[1] "address_id"  "address"     "address2"    "district"    "city_id"
[6] "postal_code" "phone"       "last_update"

Table: category
[1] "category_id" "name"        "last_update"

Table: city
[1] "city_id"     "city"        "country_id"  "last_update"

Table: country
[1] "country_id"  "country"     "last_update"

Table: customer
[1] "customer_id" "store_id"    "first_name"  "last_name"   "email"
[6] "address_id"  "active"      "create_date" "last_update"

Table: customer_list
[1] "ID"       "name"     "address"  "zip_code" "phone"    "city"     "country"
[8] "notes"    "SID"

Table: film
 [1] "film_id"              "title"                "description"
 [4] "release_year"         "language_id"          "original_language_id"
 [7] "rental_duration"      "rental_rate"          "length"
[10] "replacement_cost"     "rating"               "special_features"
[13] "last_update"

Table: film_actor
[1] "actor_id"    "film_id"     "last_update"

Table: film_category
[1] "film_id"     "category_id" "last_update"

Table: film_list
[1] "FID"         "title"       "description" "category"    "price"
[6] "length"      "rating"      "actors"

Table: film_text
[1] "film_id"     "title"       "description"
```

```
Table: inventory
[1] "inventory_id" "film_id"      "store_id"     "last_update"

Table: language
[1] "language_id" "name"        "last_update"

Table: payment
[1] "payment_id"   "customer_id"  "staff_id"     "rental_id"    "amount"
[6] "payment_date" "last_update"

Table: rental
[1] "rental_id"    "rental_date"  "inventory_id" "customer_id"  "return_date"
[6] "staff_id"     "last_update"

Table: sales_by_film_category
[1] "category"    "total_sales"

Table: sales_by_store
[1] "store_id"    "store"       "manager"     "total_sales"

Table: staff
 [1] "staff_id"    "first_name"  "last_name"   "address_id"  "picture"
 [6] "email"       "store_id"    "active"      "username"    "password"
[11] "last_update"

Table: staff_list
[1] "ID"       "name"      "address"  "zip_code" "phone"    "city"     "country"
[8] "SID"

Table: store
[1] "store_id"         "manager_staff_id" "address_id"       "last_update"
```

**(a)**

```
gg("SELECT l.name as language, COUNT(f.film_id) AS frenquncy
   FROM language l
   LEFT JOIN film f
   ON f.language_id = l.language_id
   GROUP BY l.language_id
   ORDER BY COUNT(f.film_id) DESC")
```

```
  language frenquncy
1  English      1000
2  Italian         0
3 Japanese         0
4 Mandarin         0
5   French         0
6   German         0
```

All the films for which we have relevant language information are in English in this database. Therefore, we cannot determine which language, aside from English, is most common for films.

### (b)

```r
## R
## Extract appropriate tables
category <- gg("SELECT * FROM category")
film <- gg("SELECT * FROM film_category")

genre_count <- table(film$category_id)
## Get the most common genre id
most_common_genreID <- names(which.max(genre_count))

## Get the corresponding genre name
most_common_genre <- category$name[category$category_id
                                   == most_common_genreID]

most_common_genre
```

```
[1] "Sports"
```

```r
## SQL answer
gg("SELECT c.name AS genre, COUNT(fc.film_id) AS frequency
   FROM film_category fc
   LEFT JOIN category c ON fc.category_id = c.category_id
   GROUP BY c.name
   ORDER BY frequency DESC
   LIMIT 1")
```

```
   genre frequency
1 Sports        74
```

Both two methods generate the same result: *Sports* is the most common movie genre.

### (c)

```r
## R
## Get the appropriate table
customer <- gg("SELECT * FROM customer_list")

country_count <- table(customer$country)

## Countries have exact 9 customers
country_with9customers <- names(country_count[country_count == 9])

country_with9customers
```

```
[1] "United Kingdom"
```

```r
## SQL answer
gg("SELECT country, COUNT(country) AS frequency
   FROM customer_list
   GROUP BY country
   HAVING frequency=9")
```

```
         country frequency
1 United Kingdom         9
```

Both two methods generate the same result: *United Kingdom* is the country with exact 9 customers.

## Problem 3

```r
data <- read.csv("us-500.csv")
```

**(a)**

```r
## This data set has NO missing value
## so I use the number of the row as the total number of email
sum(is.na(data))
```

```
[1] 0
```

```r
## proportion of email ending with ".net"
sum(grepl("\\.net$", data$email))/nrow(data)
```

```
[1] 0.14
```

**(b)**

```r
## Since an email address must have a "@" and a ".",
## so I delete a "@" and  "." firstly
#' @param x a string
#' @return string deleted an "at" and a "dot"
delete_at_dot <- function(x){
  delete_at <- sub("@", "", x, fixed = TRUE)
  modified_x <- sub(".", "", delete_at, fixed = TRUE)

  return(modified_x)
}

modified_emails <- sapply(data$email, delete_at_dot)

## proportion of email with non alphanumeric character
## except for an "@" and a ".'
sum(grepl("[^a-zA-Z0-9]", modified_emails))/nrow(data)
```

```
[1] 0.506
```

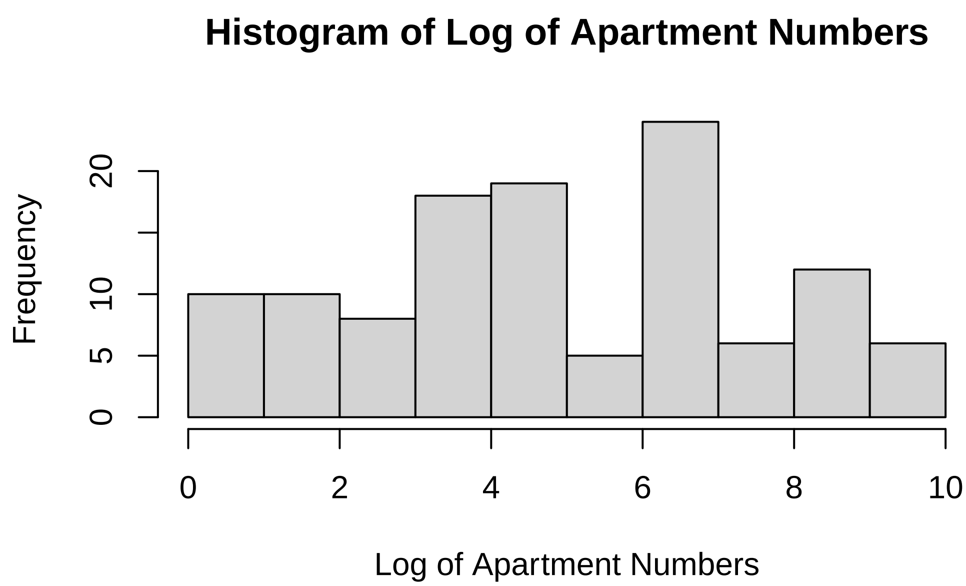
**(c)**

```r
## Get area code
AreaCode_phone1 <- substr(data$phone1,1,3)
AreaCode_phone2 <- substr(data$phone2,1,3)
AreaCode_all <- c(AreaCode_phone1, AreaCode_phone2)

## Count the occurrence of each area code
AreaCode_count <- table(AreaCode_all)

## Get the area code with the highest frequency
names(AreaCode_count[which.max(AreaCode_count)])
```

```
[1] "973"
```

**(d)**

```r
library(stringr)

## Get the apartment number
apartment_num <- str_extract(data$address, "(?<=\\D)(\\d+)$")
numeric_apt_num <- as.numeric(apartment_num)

log_apt_num <- log(numeric_apt_num)

## histogram of the log of the apartment numbers
hist(log_apt_num, main="Histogram of Log of Apartment Numbers",
     xlab="Log of Apartment Numbers")
```



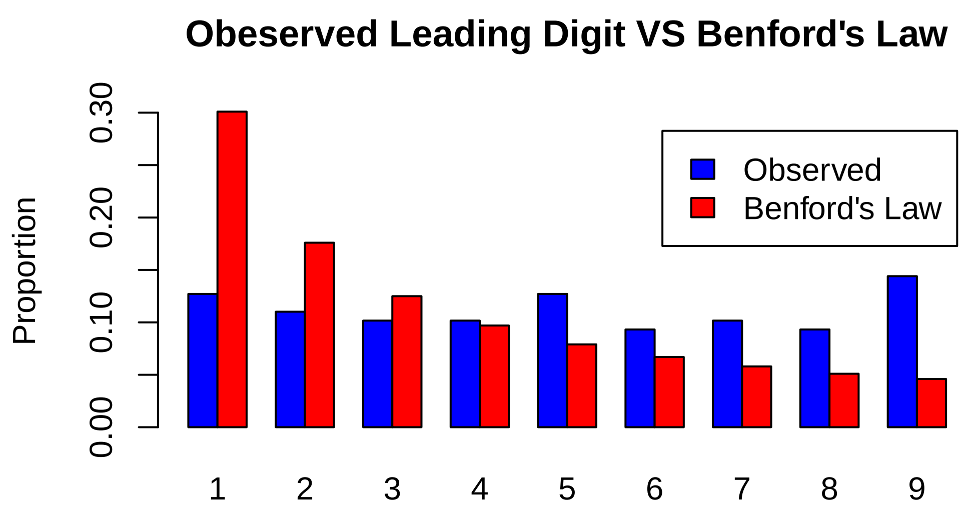

**(e)**

```
## the leading digit of each apartment number
leading_digit <- substr(apartment_num,1,1)

## distribution of the leading digit
dist_leading_digit <- table(leading_digit)/sum(!is.na(leading_digit))

## Refer to https://en.wikipedia.org/wiki/Benford's_law
benford_prob <- c(0.301, 0.176, 0.125, 0.097, 0.079, 0.067,
                  0.058, 0.051, 0.046)

comparison <- data.frame(
  Digit = 1:9,
  Observed = as.numeric(dist_leading_digit),
  Benford = benford_prob
)

comparison
```

```
  Digit    Observed Benford
```

```
1      1 0.12711864   0.301
2      2 0.11016949   0.176
3      3 0.10169492   0.125
4      4 0.10169492   0.097
5      5 0.12711864   0.079
6      6 0.09322034   0.067
7      7 0.10169492   0.058
8      8 0.09322034   0.051
9      9 0.14406780   0.046
```

```r
## visualize the comparison
barplot(rbind(comparison$Observed, comparison$Benford),
        beside = TRUE, col = c("blue", "red"), names.arg = 1:9,
        legend.text = c("Observed", "Benford's Law"),
        ylab = "Proportion",
        main = "Obeserved Leading Digit VS Benford's Law")
```




The distribution of observed apartment numbers shows significant difference from that of Benford's Law. We can conclude that the apartment numbers do **not** appear to follow Benford's law and they would **not** pass as real data.

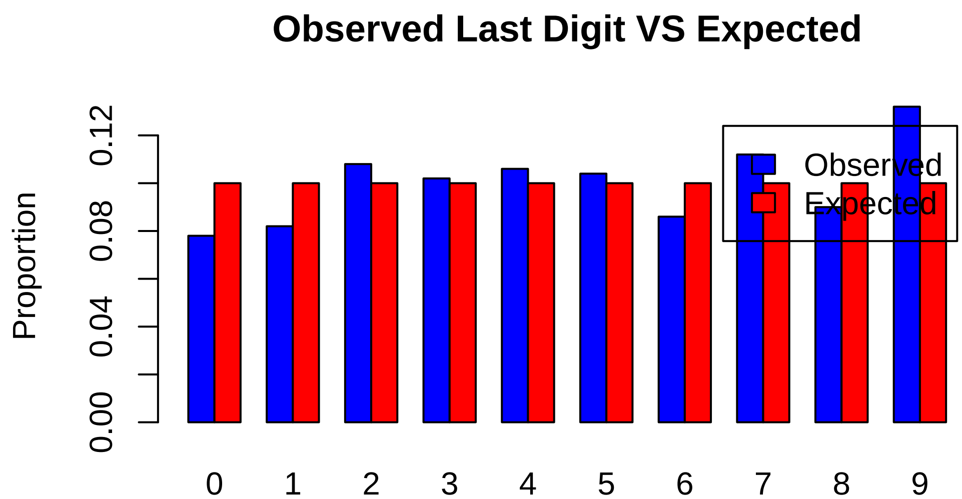
**(f)**

```r
## get the street number of each address
all <- str_extract_all(data$address, "\\d+")
street_num <- sapply(all, function(x) x[1])

## last digit of each street number
last_digit <- str_sub(street_num, start= -1)

## distribution of the last digit
dist_last_digit <- table(last_digit)/sum(!is.na(last_digit))

## assume they are uniform
expected_dist <- rep(1/10, 10)

comparison_last_digit <- data.frame(
  Digit = 0:9,
  Observed = as.numeric(dist_last_digit),
  Expected = expected_dist
)

comparison_last_digit
```

```
   Digit Observed Expected
1      0    0.078      0.1
2      1    0.082      0.1
3      2    0.108      0.1
4      3    0.102      0.1
5      4    0.106      0.1
6      5    0.104      0.1
7      6    0.086      0.1
8      7    0.112      0.1
9      8    0.090      0.1
10     9    0.132      0.1
```

```r
## visualize the comparison
barplot(rbind(comparison_last_digit$Observed,
              comparison_last_digit$Expected),
        beside = TRUE, col = c("blue", "red"), names.arg = 0:9,
        ylab = "Proportion",
        main = "Observed Last Digit VS Expected",
```

```
        legend.text  =  c("Observed", "Expected"))
```




We assume the distribution of last digit is uniform, and conclude that 9 occurs the most often, while 1 and 2 the least, and the rest are basically uniform.