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INTRODUCTION

Vancouver is known to be an expensive place to live, yet has some of the best food in the world. Our goal is to consider the perspective of a traveler wanting to visit Vancouver; how much would they have to budget for to eat out in Vancouver? To get a better idea of the budget for a traveller, we look at the average cost of a meal for one person in Vancouver as our parameter of interest.

METHODS

Simple Random Sampling:
The format of finding our parameter of interest is by examining the average cost of an entree for one person at each restaurant in Vancouver. By randomly generating addresses around Vancouver through an online address generator then finding the restaurant closest to the address through Google Maps, we are able to randomize the data collection. Then, we pick from the online menu of the restaurant to find what would be enough for a meal and take the average of those entrees to represent the average cost of a meal for that particular restaurant.

The advantage of the simple random sample is that there are a wide variety of restaurants (stratas) in Vancouver and many different stratas which we could have used in addition to cuisine type. Thus, it is more accurate to simply take a simple random sample of the average cost of a meal for an individual with these wide varieties of restaurants in comparison to using broad ranges for stratums in stratified sampling. A limitation is that we may not be able to accurately represent the entire population if there is a significant stratum within the population.

Stratified Sampling:
For stratified sampling methods, we chose to follow the same method of simple random sampling but to search for the nearest restaurant under the particular stratum of interest.

Our stratas are North American, Asian, European, Fast Food, Indian, and Middle Eastern. We categorized restaurants mainly by their geographic regions with exception to fast food and Indian food in particular. The exceptions are present because we do not consider fast food restaurants to accurately represent food from the geographic regions given, and we categorized Indian food because of its significance in the number of restaurants in Vancouver despite being a smaller region geographically compared to the others in the list.

The advantage of the stratified sampling method is that we can better categorize restaurants in Vancouver and show an approximate weight of each stratum categorized. The limitations are that we use broad ranges for each stratum when we could have had more restrictive stratums, such as Chinese, Vietnamese, Japanese, etc. cuisine for Asian restaurants, and that some of the categories

such as pizzerias may have ambiguity when it comes to categorizing it to a stratum. For this example, pizzerias could be North American, Fast Food, or European cuisine.

Sample Size:
Due to the specificity of the experiment, being the average cost of an individual meal within a particular city, we chose to take a preview sample of 30 restaurants through the same sampling method as the simple random sampling category in the proposal shown above. Due to a large standard error in the preview sample and thus a large sample size for a 95% confidence interval, we instead used a targeted error for the confidence interval to be +/- 1 due to the limitation of time. From this calculation in the appendix (R CODE SAMPLE SIZE), we can conclude that our required sample size is the average cost for an individual meal of 120 restaurants.

For stratum proportions (N_h/N), we took the proportion of each stratum relative to the preview sample as a weight reference. Stratum proportions can be seen in the appendix (R CODE SAMPLING DATA ANALYSIS).

RESULTS

For average cost of an individual meal in Vancouver by simple random sampling:
Estimate: 16.46917
Standard Error: 0.4950204
Confidence Interval: (15.49893, 17.43941)

For average cost of an individual meal in Vancouver by stratified sampling:
Estimate: 16.38858
Standard Error: 0.3168788
Confidence Interval: (15.76750, 17.00967)

As a secondary different parameter, we chose to choose the proportion of restaurants with an average meal cost for an individual of over $20 CAD.

For proportion average cost of an individual meal in Vancouver over $20 CAD by simple random sampling:
Estimate: 0.09166667
Standard Error: 0.02607659
Confidence Interval: (0.04055655, 0.14277678)
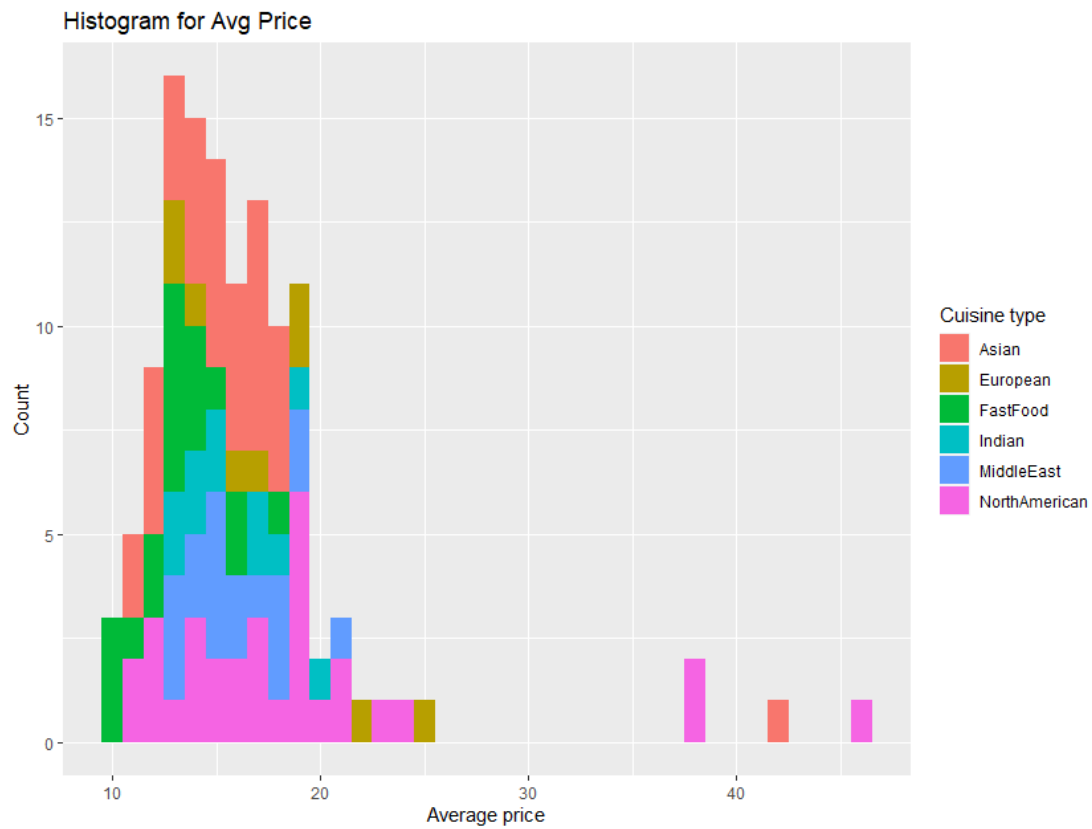
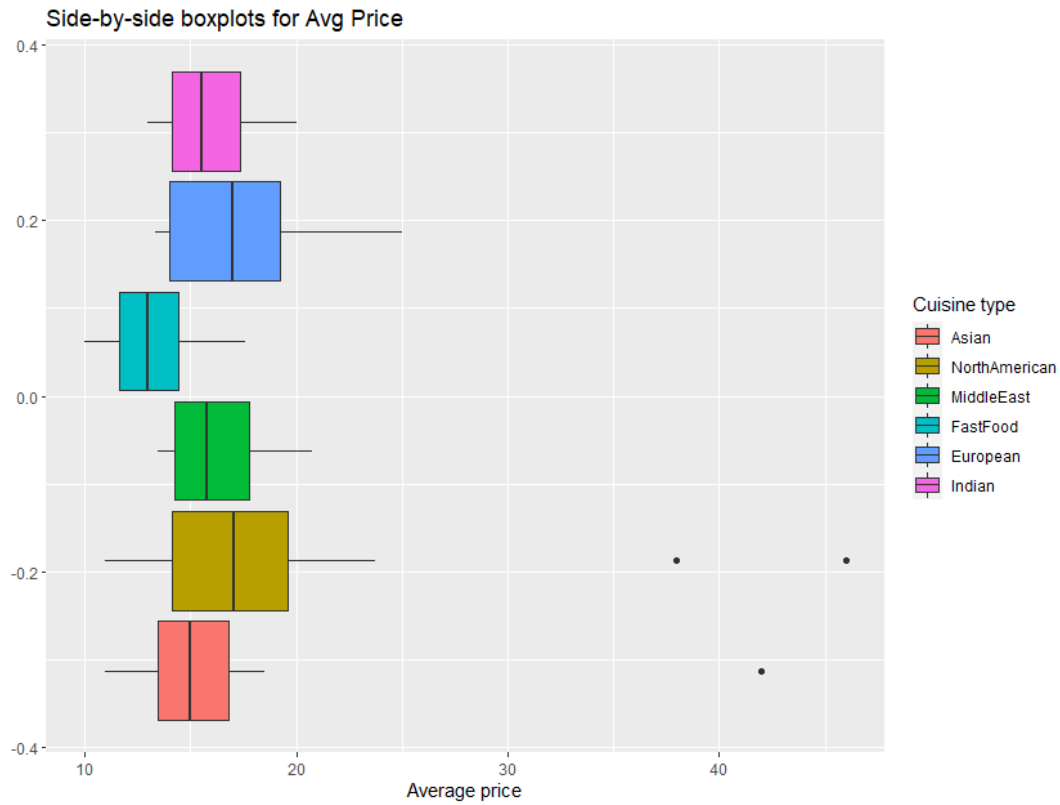For proportion average cost of an individual meal in Vancouver over $20 CAD by stratified sampling:
Estimate: 0.1416667

Standard Error: 0.0315126
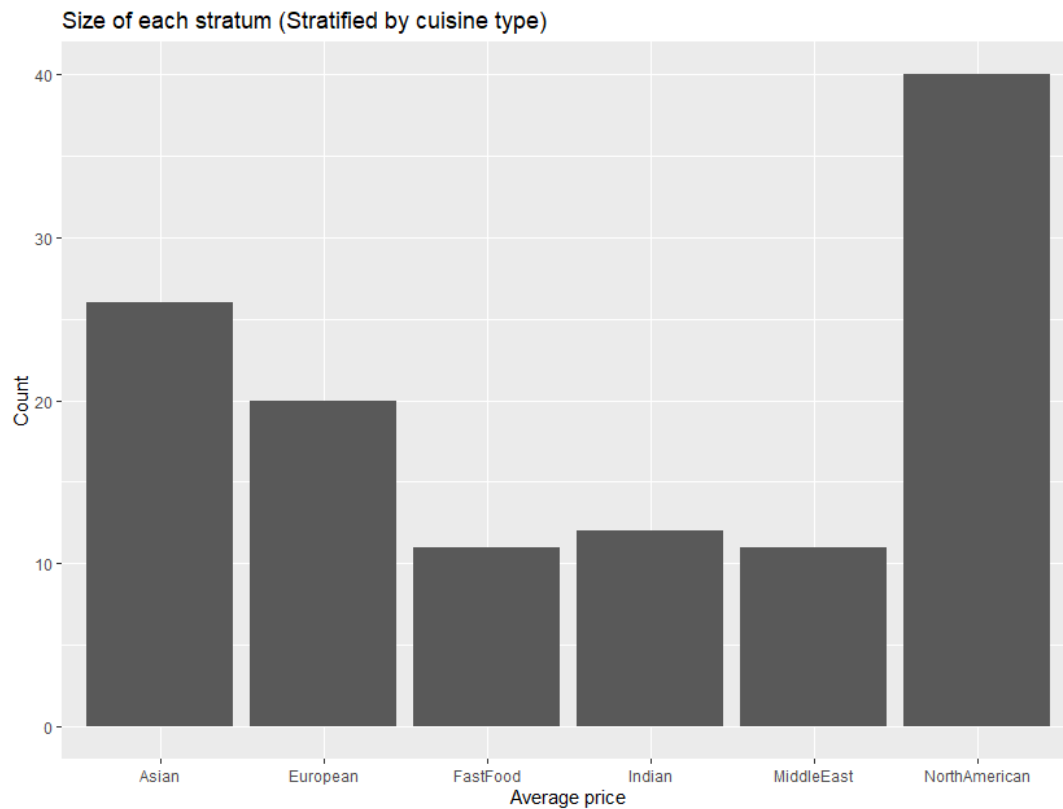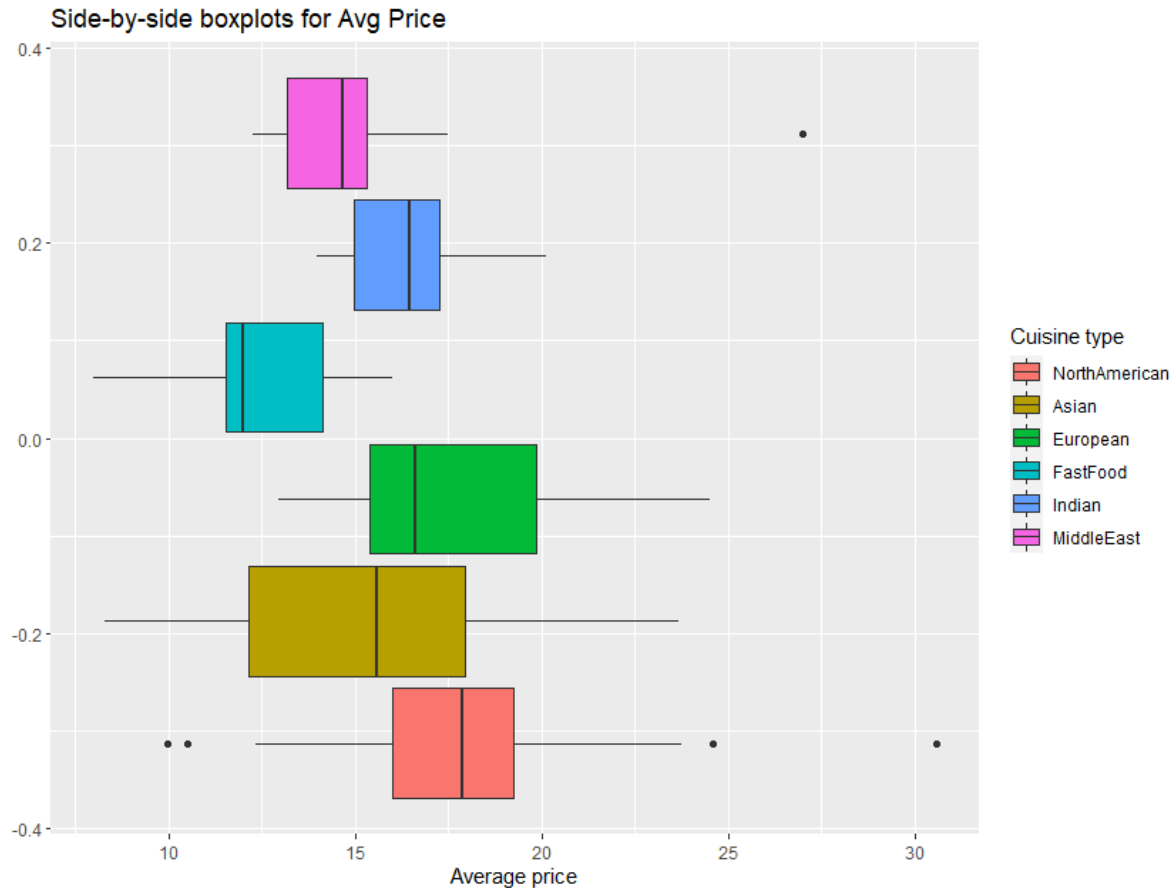Confidence Interval: (0.07990197, 0.20343136)

SIMPLE RANDOM SAMPLING VISUALIZATION

Histogram for Avg Price

Side-by-side boxplots for Avg Price

STRATIFIED SAMPLING VISUALIZATION

Size of each stratum (Stratified by cuisine type)

Side-by-side boxplots for Avg Price

CONCLUSIONS

With the results on their own, it shows that our estimates of $16 as an average meal for one individual in Vancouver to be fairly accurate as both the simple random sample and the stratified sample are within the 16 to 17 dollar range; our proportion of restaurants that have average meals over $20 is 9% and 12% from the simple random sample and stratified sample respectively. In addition, from an intuitive sense, the $16 range for an average meal seems to be relatively reasonable in Vancouver.

Although the data is coherent in terms of intuitive understanding of the lifestyle in Vancouver and the similar results for the different methods used, we still say that there could be bias in the sample and definitely bias in our intuition as university students. For the bias in the sample, this is because our sample size of 120 is small in comparison to the population size of around 6000 restaurants in Vancouver; we cannot confidently say that these results are precise for this reason.

LIMITATIONS

There are a few constraints and points of ambiguity during the study which had to be solved through assumptions:
- The amount of food consumed to be considered a meal for one person is subjective to the individual.
- The amount of food which restaurants provide per entree may vary in size despite all being under the same categories between restaurants or within a restaurant.
- The variance in price and number of main course dishes within a restaurant may vary between restaurants.
- Some of our strata within the study have a very broad range of cuisines as they are categorized by aspects such as continents of which the type of cuisine is from.
- A more accurate estimate could have been provided if not for the time limitation of the study in calculating a very large number of samples.
- A traveller may also want to visit specific restaurants in addition to the cost of an "average" restaurant in Vancouver.
- Fairly broad ranges of cuisine for stratas for stratified sampling means that it is not as accurate as it could be in comparison to a more detailed stratified sampling method

The purpose of our study was to find a general range of Canadian dollars which a traveller should anticipate for when considering a trip to Vancouver and eating around Vancouver; further investigation may be necessary if the traveller has a very restrictive budget or has specific restaurants of interest.

For the objective, we used these as references to our statement
https://dailyhive.com/vancouver/vancouver-most-expensive-canadian-city
https://dailyhive.com/vancouver/vancouver-world-best-food-cities
This is for our estimate that there are approximately 6000 restaurants in Vancouver
https://www.cbc.ca/news/canada/british-columbia/bc-restaurants-for-sale-easy-to-come-by-hard-to-keep-1.3353317?fbclid=IwAR2OmcYccu2_cp1OhDz3z_j1I1RufShL6FOvdqO24exnIDTI3LvJAG9ukSA

APPENDIX

SIMPLE RANDOM SAMPLING:

Restaurant	CuisineType	Price
Pho NorthVancouver	Asian	13.45
Kokomo	Asian	15
White Spot	NorthAmerican	20.9
Gulberg Mediterranean and Persian Food	MiddleEast	17.75
SADRA	MiddleEast	14.95
KFC	FastFood	17.59
Earl's Kitchen	NorthAmerican	19.5
Red Burrito	FastFood	11
Green Lemongrass	Asian	16
Freshii	FastFood	12.83
Red Chilli Szechuan	Asian	18.5
Ingrain Pastificio	European	22
Cora Breakfast & Lunch	NorthAmerican	19.75
Mr Sushi	Asian	14
Krua Thai Restuarant	Asian	18.5
Yaas Grill House	MiddleEast	16.49
WINGS Tap and Grill	NorthAmerican	23.75
Sweet Avenue Bakery	NorthAmerican	38
Panago Pizza	FastFood	15.95
Ichiban Japanese Kitchen	Asian	18
KFC	FastFood	12.99
Yuko Maki	Asian	16.59
De Dutch	European	19.25
Nando's	FastFood	14.24
Kesari Kitchen	Indian	17
Minemura Sushi	Asian	12.5
Black Bear Neighborhood Pub	NorthAmerican	16.99
The Lobby Restaurant	NorthAmerican	46
Rice and Noodle	Asian	10.99
Anatoli Souvlaki	MiddleEast	18

Nook	European	25
Bonta European Ristorante	European	19
Pho Japolo	Asian	15
Maru Korean Bistro	Asian	12
Sushi Katsu	Asian	16.95
Grab and Go Persian Restaurant	MiddleEast	13.5
KFC	FastFood	13.89
Cazba	MiddleEast	16.99
Sophie's Cosmic Cafe	NorthAmerican	16.49
RAMA	Indian	13
A&W	FastFood	11.53
The Chopped Leaf	Asian	11.85
White Spot	NorthAmerican	23.1
Nando's	FastFood	10.28
Minemura Sushi	Asian	16.25
Maru Korean Bistro	Asian	15
Rice and Noodle	Asian	11.99
Sushi Wara	Asian	12.95
Smoke And Bones	NorthAmerican	37.99
Pho Spot	Asian	14.5
White Spot	NorthAmerican	17.05
Desh Punjab Sweets & Restaurant	Indian	14.29
White Spot	NorthAmerican	18.7
Tacomio	FastFood	12.95
Sciue European Bakery Cafe	European	14
Me and Crepe	Asian	15.95
West Oak	NorthAmerican	16
Zaatar w Zeit	MiddleEast	18.99
David Dosa Company	Indian	15
Haida Sandwhich	MiddleEast	14.99
Chipotle	NorthAmerican	12.35
Panago Pizza	NorthAmerican	13.65
Anatoli Souvlaki	MiddleEast	15
JOEY Restaurants	NorthAmerican	18.5
White Spot	NorthAmerican	18.7

Rice and Noodle	Asian	10.99
Quan Ju De	Asian	42
Donair Dude	MiddleEast	13.45
Taco Bell	FastFood	12
Maru Korean Bistro	Asian	16
Royal Curry	Indian	13
White Spot	NorthAmerican	21.45
Dalina	European	16.4
Alloz Grill	MiddleEast	13.99
Rose Persian Cuisine	MiddleEast	18.99
Sushi Bella	Asian	16.7
Zubu Ramen	Asian	16.8
Grace of India	Indian	15.5
A&W	FastFood	10.28
Anatoli Souvlaki	MiddleEast	14
Taphouse Taverns	NorthAmerican	18.75
Zorbas Greek Kitchen	MiddleEast	17.75
Poke Bar	Asian	17.95
Kokomo	Asian	15
Indian Fusion Restaurant	Indian	17.65
Sunshine Diner	NorthAmerican	14.45
Stuffies Pastry Cafe	NorthAmerican	10.95
Cactus Club Cafe	NorthAmerican	19.25
Sushi Maro	Asian	13.99
Faubourg	European	13.35
Raglans Bistro	MiddleEast	20.75
Echo Cafe	NorthAmerican	16.99
Tacomio	FastFood	12.95
Sushi Umi	Asian	17.5
Mehman Restaurant	MiddleEast	13.5
Tasty Indian Bistro	Indian	20
Roots Cafe	NorthAmerican	10.95
White Spot	NorthAmerican	19.5
Dosa Factory	Indian	16.99
Yummy Donair Kebab	MiddleEast	14.99

Thai House Restaurant	Asian	14.5
Sunshine HIlls and Pizza	European	16.99
Ogenki Sushi	Asian	14.95
Barcelos Flame Grilled Chicken	European	13.33
V-Nam Vietnamese Cuisine	Asian	16.95
Juliet's Diner	NorthAmerican	13.75
Subway	FastFood	15.99
Freshslice Pizza	FastFood	9.99
Tacomio	FastFood	12.95
Juliet's Diner	NorthAmerican	12.5
Surrey Punjab Dhaba	Indian	14
Planetary Burgers	NorthAmerican	12.5
KFC	FastFood	15.19
Cosy Inn Cafe	NorthAmerican	14.99
Jordan Sushi	Asian	12.95
Indian Fusion Restaurant	Indian	18.9
Kalmar Family Restaurant	NorthAmerican	13.29
JamJar Canteen	MiddleEast	16.49
Triple O's	FastFood	14.49
Mary's on Davie	NorthAmerican	15

nasian	neuropean	nfastfood	nindian	nmiddleeast	nNorthAmerican
26	20	11	12	11	40

STRATIFIED SAMPLING:

Restaurant	CuisineType	Price
Eighties Restaurant	NorthAmerican	16.95
Bells and Whistles	NorthAmerican	18.9
White Spot	NorthAmerican	18.7

Cactus Club Café	NorthAmerican	19.25
Tommy's Café	NorthAmerican	16
Gull Bar and Kitchen	NorthAmerican	17.6
Corner Stone Bistro	NorthAmerican	24.6
Bells and Whistles	NorthAmerican	18.5
Church's Texas Chicken	NorthAmerican	13.15
Bin 4 Burger	NorthAmerican	18.5
White Spot	NorthAmerican	17.8
Panago Pizza	NorthAmerican	13.65
White Spot	NorthAmerican	18.7
Fresh Slice Pizza	NorthAmerican	9.99
Cactus Club Café	NorthAmerican	19.25
West Oak	NorthAmerican	16
WINGS	NorthAmerican	23.75
Lift Bar Grill	NorthAmerican	21.2

Bishops	NorthAmerican	30.58
Chipotle	NorthAmerican	12.35
Cactus Club Café	NorthAmerican	19.25
JOEY	NorthAmerican	21.5
Juke Fried Chicken	NorthAmerican	17.75
Boston Pizza	NorthAmerican	14.99
Four Olives	NorthAmerican	21.75
White Spot	NorthAmerican	18.7
Mary's	NorthAmerican	15
Fatburger	NorthAmerican	17.86
The Wolf and Hound	NorthAmerican	18.1
Raglans Bistro	NorthAmerican	13
Taphouse Tavern	NorthAmerican	18.75
Fets Whisky Kitchen	NorthAmerican	16.79
Browns Socialhouse	NorthAmerican	21.25

Vera's on the Drive	NorthAmerican	10.5
White Spot	NorthAmerican	17.05
Denny's	NorthAmerican	17.89
Carlos O'Bryans Pub	NorthAmerican	17.63
Earls Kitchen	NorthAmerican	19.5
Triple O's	NorthAmerican	14.49
Globe@YVR	NorthAmerican	17.5
Pelican Seafood Restaurant	Asian	23.68
Shiro Japanese	Asian	15.3
Sushi TonTon	Asian	15.25
Suika Japanese Restaurant	Asian	16
Shin Ka Gyuu	Asian	16.13
Mr Sushi	Asian	14
Moon Sushi	Asian	10.9
Sushi Mori	Asian	18
CC's Chinese Restaurant	Asian	17.95
Woon Lee Inn Restaurant	Asian	15.95
Poke Bar	Asian	17.95
YuShang Hot Pot	Asian	17.95

Royal Seoul House Restaurant	Asian	20.86
Nobu Sushi	Asian	12.95
PokeLani	Asian	15.95
Sansho Sushi & Japanese Dining	Asian	10.74
Little Japan	Asian	10.35
Yama Sushi	Asian	10.34
Hokkaido Ramen Santouka	Asian	15.83
Legendary Noodle	Asian	11.99
Hongdae Pocha Korean BBQ	Asian	20.99
Marutama Ramen Westend	Asian	12.67
Saku	Asian	19.3
Rice and Noodle	Asian	10.99
Papa Roti	Asian	8.3
Maru Korean Bistro	Asian	15
Sopra Sotto Pizzeria	European	19.7
Marcello Ristorante & Pizzeria	European	24.5
Espana Restaurant	European	15.99
Bufala	European	23.25
Café Nido	European	15.4
Bravo Suicina Ristorante	European	15.3
Pepino's Spaghetti House	European	20.3
Espana Restaurant	European	16

Nicli Antica Pizzeria	European	22
Souvlaki	European	16.62
The Cheese Inn	European	17.99
La Mezcaleria	European	20.85
Bonta European	European	19
Cantina Norte	European	13.85
Adesso	European	16.99
Kostas Mediterranean	European	15.33
Faouberg	European	13.35
Dalina	European	16.4
Takis Taverna	European	12.95
Stephos Souvlaki	European	16.62
KFC	FastFood	13.89
Tacomio	FastFood	12.95
A&W	FastFood	11.53
Wendys	FastFood	12
Dairy Queen	FastFood	7.99
A&W	FastFood	11.53
KFC	FastFood	14.5
A&W	FastFood	10.28
A&W	FastFood	11.53
KFC	FastFood	14.4
Subway	FastFood	15.99
Indian Roti Kitchen	Indian	14.99

Sula Indian Restaurant	Indian	17
Raga Restaurant	Indian	20.13
Mumbai Massala	Indian	14.73
Indian Fusion	Indian	15.45
Vaades the Indian Restaurant	Indian	14
Beeryani Indian Bistro	Indian	16.99
Ashiana Tandoori	Indian	16.95
Delhi Indian Bistro	Indian	19.5
Madras Spice Restaurant	Indian	14.99
Akbars own indian restaurant	Indian	18
Modern Handi Indian Cuisine	Indian	16
Donair King	MiddleEast	12.32
Aleph Eatery	MiddleEast	14.67
Mazahr Lebanese Kitchen	MiddleEast	17.5
Sadra Restaurant	MiddleEast	14.94
Big Bite Donair	MiddleEast	13.49
Aleph Eatery	MiddleEast	14.67
Medditerranean Grill	MiddleEast	13.2
Cazba	MiddleEast	12.25
Al Basha	MiddleEast	15.7
Medditerranean Grill	MiddleEast	13.19
Tamam: Fine Palestinian Cuisine	MiddleEast	27

R CODE SAMPLING SIZE:

```
food <- read.csv("food.csv", header=T)
priceSd <- sd(food$Price)
print(priceSd)
n <- (priceSd/(1/1.96))^2
print(n)
```

n is 216

We first took 120 as a measure for the error and found that it is close to within the $1 range for errors

```
food <- read.csv("food.csv", header=T)
priceSd <- sd(food$Price)
print(priceSd)
error <- 1.96*priceSd/sqrt(120)
print(error)
```

Error is 0.97870718058, so we say that it is close to 1 and use that as our confidence interval restriction

R CODE DATA ANALYSIS:

```
> rm(list = ls())
>
> #install.packages("plotrix")
> #install.packages("tidyverse")
> library("tidyverse")
> library("plotrix")
>
> N <- 6000
> n <- 120
>
> #---Simple Random Sample---
> SRSsample <-read.csv("SRS.csv", header = TRUE)
>
> #SRS mean
> SRS.mean <- mean(SRSsample$Price)
>
> #SRS standard error
> SRS.se <- sqrt((1 - (n/N)) * var(SRSsample$Price) / n)
>
> #SRS confidence interval
```

```
> SRS.CI.Upper <- SRS.mean + 1.96*SRS.se
> SRS.CI.Lower <- SRS.mean - 1.96*SRS.se
> SRS.CI <-c(SRS.CI.Lower, SRS.CI.Upper)
>
> #---Stratified Sample---
> StratifiedSample <-read.csv("StratifiedSample.csv", header = TRUE)
> attach(StratifiedSample)
> n.hSTR <- tapply(Price, CuisineType, length)
> detach(StratifiedSample)
>
> n.hSTR/n
       Asian    European    FastFood     Indian
   0.21666667   0.16666667   0.09166667   0.10000000
   MiddleEast NorthAmerican
   0.09166667   0.33333333
>
> #STR mean
> stratmean <- aggregate(Price ~ CuisineType, data = StratifiedSample, mean)
> stratmean
   CuisineType    Price
1        Asian 15.20462
2     European 17.61950
3     FastFood 12.41727
4        Indian 16.56083
5   MiddleEast 15.35727
6 NorthAmerican 17.86675
> STR.mean <- sum((n.hSTR/n)*stratmean$Price)
>
> #STR standard error
> stratse <- aggregate(Price ~ CuisineType, data = StratifiedSample, std.error)
> stratse
   CuisineType    Price
1        Asian 0.7462229
2     European 0.7276040
3     FastFood 0.6754838
4        Indian 0.5530267
5   MiddleEast 1.2544409
6 NorthAmerican 0.5958627
> STR.se <- sqrt(sum( (n.hSTR/n)^2 * (stratse$Price)^2 ))
>
```

```
> #STR confidence interval
> STR.CI <-c(STR.mean - 1.96*STR.se, STR.mean + 1.96*STR.se)
>
> #---Binary Parameter---
> #SRS binary parameter, Price > $20
> SRSsample %>%
+   summarize(lg_20 = Price > 20) %>%
+   group_by(lg_20) %>%
+   summarize(count = n()) %>%
+   mutate(prop = count/n)
# A tibble: 2 x 3
  lg_20 count   prop
  <lgl> <int>  <dbl>
1 FALSE   109 0.908
2 TRUE     11 0.0917
>
> SRS.phat <- (11/120)
> SRS.phat.se <- sqrt(1 - (n/N)) * sqrt(SRS.phat*(1 - SRS.phat)/n)
> SRS.phat.CI <- c(SRS.phat - 1.96*SRS.phat.se, SRS.phat + 1.96*SRS.phat.se)
>
> #STR binary parameter, Price > $20
> StratifiedSample %>%
+   summarize(lg_20 = Price > 20) %>%
+   group_by(lg_20) %>%
+   summarize(count = n()) %>%
+   mutate(prop = count/n)
# A tibble: 2 x 3
  lg_20 count  prop
  <lgl> <int> <dbl>
1 FALSE   103 0.858
2 TRUE     17 0.142
>
> STR.phat <- (17/120)
> STR.phat.se <- sqrt(1 - (n/N)) * sqrt(STR.phat*(1 - STR.phat)/n)
> STR.phat.CI <- c(STR.phat - 1.96*STR.phat.se, STR.phat + 1.96*STR.phat.se)
>
> #---Mean Summaries---
> #SRS
> SRS.mean
[1] 16.46917
```

```
> SRS.se
[1] 0.4950204
> SRS.CI
[1] 15.49893 17.43941
>
> #STR
> STR.mean
[1] 16.38858
> STR.se
[1] 0.3168788
> STR.CI
[1] 15.76750 17.00967
>
> #---Proportion Summaries---
> #SRS Proportion for Price > $20
> SRS.phat
[1] 0.09166667
> SRS.phat.se
[1] 0.02607659
> SRS.phat.CI
[1] 0.04055655 0.14277678
>
> #STR Proportion for Price > $20
> STR.phat
[1] 0.1416667
> STR.phat.se
[1] 0.0315126
> STR.phat.CI
[1] 0.07990197 0.20343136
```