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Modeling Consumer Behavior For High Risk Foods

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Modeling Consumer Behavior for High Risk Foods

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Biographical Sketch

Megan Elizabeth Watkins graduated from East Carolina University with a Bachelors of Science in General Engineering with a concentration in Bio-Process Engineering in May 2010. Since graduation she has been working in the industry as a Process Engineer. Currently, she is pursuing studies in Industrial and Systems Engineering to further her knowledge base of processes and logistics.

Dedication

I dedicate this research to my family who always encourages me to reach new heights.

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Abstract

According to the Centers for Disease Control and Prevention (CDC), one in six Americans become ill or die from foodborne contaminations (CDC, 2011). Contamination (intentional or unintentional) can occur at any point in the food supply chain. Flaws in security, quality control, or transportation are some examples of how food is susceptible to intentional acts of sabotage. Certain foods are more susceptible to contamination such as meats, dairy, fruits, vegetables, and eggs. In order to build a secure and resilient food supply chain network, food producers and manufacturers need to have the ability to assess contamination risks resulting from manufacturing processes. This research quantifies risk as a function of purchasing and consumption frequency of food susceptible to recalls. A survey is constructed and administered to identify consumption and purchasing behavior of high risk foods. Using the data from the survey, a logistic regression model is developed to determine the likelihood of purchasing high risk food items based on shopping behavior and demographic information. Subsequently, a Poisson regression model is developed to predict consumers' consumption frequency. The results of the research will lead to a better understanding of consumer behavior in relation to food choices. Furthermore, understanding purchasing and consumption behavior will enable food producers to design better policies for securing the nation's food supply.

CHAPTER 1

Introduction

1.1 Impact of Food Contamination in America

In 2011, approximately 48 million Americans became ill from food contamination, 128,000 were hospitalized, and 3,000 died from contaminated food products (CDC, 2011). The majority of those Americans became sick from unspecified agents, as seen in Table 1. Unspecified agents as described by the Centers for Disease Control and Prevention (CDC) are microbes, chemicals, or substances not typically present in food. Table 1 displays the estimate of annual number of domestically acquired, food-borne illnesses, hospitalizations, and deaths due to 31 pathogens and unspecified agents transmitted through food in the United States (CDC, 2011) Furthermore, these agents have not been identified as causing gastroenteritis illness.

Particular foods carry a higher risk of food-borne illness. The categories of foods that carry the most risk are produce, baked goods, dairy, and meat (Epstein, 2013). All of these categories make up the average American diet. Americans consume on average 1.05 cups of fruit, 2.53 cups of vegetables, 1.77 cups of dairy, and 5.68 ounces of protein a day (USDA, 2007-2010).

Table 1

Estimate of Annual Number of Food-borne Illnesses

Foodborne Agents	Estimated annual number of illnesses (90% credible interval)	%	Estimated annual number of hospitalizations (90% credible interval)	%	Estimated annual numbers of deaths (90% credible interval)	%
31 Know Pathogens	9.4 million (6.6-12.7 million)	20	55,961 (39,534-75,741)	44	1,351 (712-2,268)	44
Unspecified Agents	38.4 million (19.8-61.2 million)	80	71,878 (9,924-157,340)	56	1,686 (396-3,338)	56
Total	47.8 million (28.7-71.1 million)	100	127,839 (62,529-215,562)	100	3,037 (1,492-4,938)	100

The source of food-borne outbreaks can be traced to several distribution channels in the food supply chain. Table 2 identifies the locations where contaminated food is consumed. Of the 106 different food vehicles driving food-borne outbreaks, Table 2 displays the outbreaks associated with meat, dairy, fruits, vegetables, baked goods, and bread. According to the Food-borne Outbreak Online Database (*Foodborne Outbreak Online Database (FOOD)*, 2012) , 765 food contamination events occurred in the year 2012. It should be noted that not all instances of contamination are reported to the CDC.

Table 2

Food Location (Foodborne Outbreak Online Database (FOOD), 2012)

Location	Count of Total Ill	Count of Total Hospitalization	Count of Total Death	Count of Food Vehicle
Other; Restaurant - Sit-down dining	3	3	3	
Private Home	129	126	128	84
Private Home; Restaurant - "Fast-food"(drive up service or pay at counter); Restaurant - Sit-down dining	2	2	2	1
Private Home; Restaurant - other or unknown type; Unknown	1	1	1	
Private Home; Restaurant - Sit-down dining	13	13	13	7
Private Home; School	1	1	1	1
Private Home; Workplace, not cafeteria	2	2	2	2
Restaurant - "Fast-food"(drive up service or pay at counter)	32	32	32	5
Restaurant - "Fast-food"(drive up service or pay at counter); Restaurant - Sit-down dining	2	2	2	
Restaurant - other or unknown type	11	11	11	4
Restaurant - other or unknown type; Restaurant - Sit-down dining	1	1	1	1
Restaurant - Sit-down dining	311	308	308	106
Grocery Store	3	3	3	2
Restaurant - "Fast-food"(drive up service or pay at counter); Workplace, not cafeteria	1	1	1	
Private Home; Unknown	1	1	1	1
Restaurant - "Fast-food"(drive up service or pay at counter); Unknown	1	1	1	
Restaurant - "Fast-food"(drive up service or pay at counter); Restaurant - Sit-down dining; School	1	1	1	1
Grand Total	**515**	**509**	**511**	**215**

There are two governmental agencies responsible for the protection of the food supply chain. The U.S. Department of Agriculture (USDA) is responsible for the monitoring of meat, processed eggs, and poultry. They set the policy by which food manufacturers must comply. The Food and Drug Administration (FDA) oversees all other foods and enforces policies in which food manufacturers adhere to for the safety of the food supply network. The FDA is also responsible for notifying the US population when food is contaminated. Once a recall is issued, the FDA monitors the company's actions of verifying that customers are informed, and that the product is located and removed (FDA, 2012). If the company does not comply, the FDA can take legal action.

1.2 Consequences of Recalls

Recalls of food occur because of the presence of Listeria, glass fragments, metal fragments, salmonella, E.coli, and spoilage organisms (CDC, 2011). Among Americans likely to become ill from food contamination, the majority of consumers are unaware of recalls that may affect them or their household. Six out of ten Americans report having never looked for recalls in their homes and ten percent of Americans never found a recalled product (Hallman, Cuite, & Hooker, 2009). Recalls for food are posted on the FDA website and are reported in the news. The FDA has recently been more creative using emails to notify the US population of recalls. Research has shown four in ten Americans would be interested in signing up for email notifications from the government, but only 6% of Americans actually signed up for the service (Hallman et al., 2009).

1.3 Dilemma of Food Safety

With over 319 million people living in the United States, (Bureau, 2014) suppliers have to keep up with the demands of food. Mainstream food production companies prepare food in

bulk. A model for a product is to finalize a recipe then to scale up the production of the product. For example, the recipe that once made twenty cookies is now making 200,000 cookies an hour. The scaling up of a product can be difficult. The ingredients may behave differently, flavors change, and equipment issues arise (Scott, Bowser, & McGlynn, 2014). Products produced from the scale up could include errors in added ingredients or inconsistency in machines that could affect the product condition.

In some cases food is produced in poor conditions. In 2014, an incident was reported to the FDA to shut down a facility for "unsanitary conditions" caused by a leaky metal roof with rust, and other contaminants dripping into food production equipment (Andrews, 2014). The environment of food production plays a role in the quality of the product being produced. The USDA and the FDA have policies and cleanliness recommendations, but cases of food safety violations still occur. The FDA recently had to investigate a fortune cookie plant in Atlanta, GA infested with vermin (Lipka, 2014). Because the production facilities cleanliness record is not transparent, violations of FDA standards pose a food safety risk to Americans.

1.4 Research Mission

The objective of this research is to understand the frequency in which high-risk foods are consumed in order to assess the vulnerability of getting sick from a food contamination outbreak. A survey is used to collect data regarding high risk food purchases to analyze the consumer behavior data, establish relationships, and patterns of consumer behavior. A statistical model is constructed to characterize consumer behavior based on demographic and geographic factors. The relationships established from the model can identify high risk populations for certain types of high risk foods within a geographic area. The information could potentially decrease the

mortality and morbidity associated with food contamination outbreaks and increase the American public trust in the food system.

Surveys from the USDA and other government agencies have been conducted to collect information on American eating habits. Databases of nutrient intake of Americans have been generated by government agencies from administered surveys. The generated databases are concerned with how much Americans are eating and the alignment of the recommended dietary food intake. Databases are measuring the amount of sugar, starch, vitamins, and minerals consumed in a day. Few databases include the source or type of the food being consumed. Most existing research is focused on household purchases, but not tracking volume of food type from different retail locations (Carlson, Kinsey, & Nadav, 1998).

Knowing who is likely to get sick from outbreaks will enable the health care system to be more responsive. Awareness of the symptoms can allow prompt and accurate treatment of patients with food-borne illnesses. In some cases, food poisoning can be mistaken for flu symptoms. Understanding the progression of the purchasing and consumption behavior can aid in the prevention of Americans becoming sick.

This research will answer the following research questions:

1. What is the frequency of consumers going to the market?
2. What is the frequency of consumers going to restaurants?
3. How often do consumers purchase certain items at the market?
4. What is the risk to certain individuals based on demographic or geographic characteristics?
5. What type of meals are consumers more likely to eat at home or in a restaurant?
6. How far do consumers travel to markets, fast food places, or restaurants?

The conclusion of this research can provide a framework to apply to other geographic areas and to identify high-risk populations for certain food supply chains when there is a contamination outbreak.

CHAPTER 2

Literature Review

2.1 Overview of Literature

Numerous surveys are performed in consumer purchasing and consumption behavior research, but many do not describe frequency, buying behavior, and consumption habits in relation to demographic information. Tables 3 and 4 organize the studies in relation to targeted factors of research. Consumer behavior relates to purchasing behavior by culture and/or frequency. This section will summarize the relevant literature and statistical techniques used for collecting consumer information.

2.2 Surveys Related to Consumer Purchasing Behavior

Consumer purchasing behavior is the action and/or thought related to making a purchase. Consumer behavior can be repeated behavior or demographically influenced. Several studies have been conducted that show food buying habits vary based on demographic factors. Research has indicated the primary age of grocery purchases occur at 25 or older and that age influences the item purchased (Paul & Rana, 2012). Age suggests a particular lifestyle of the individual. A multitude of studies focus on the importance of demographic factors although other research indicate that the intention to purchase is influenced by age and education level (Paul & Rana, 2012). Education may alter choices based on knowledge, while age affects choices based on experiences. Age was a factor in the findings of consumption behavior for different age groups in the study of "Consumption over the Life Cycle" (Gourinchas & Parker, 2002). From the survey data it was discovered households behave as 'buffer-stock' consumers in their early working years and a certainty equivalent life-cycle hypothesis of household as retirement approaches (Gourinchas & Parker, 2002). A Certainty Equivalent Life-Cycle Hypothesis of households was

used by (Gourinchas & Parker, 2002) to describe consumers that are not acquiring assets and start saving more. The change in household behavior correlates to the concept that demographic information such as age and education can play a major role in characterizing consumer behavior. Therefore, different elements make up the understanding of what influences consumers to buy certain items.

Trivedi (2011) studied the impact of demographic information on trends in two locations. Census data and retail store data was used for the research. Retail stores capture data of what consumers are purchasing for forecast purposes. The study showed that location and type of product could impact the proportion of healthy products purchased.

Table 3

Collection of Studies

	Data Collection		**Sampling Method**		**Target Population**	
Authors	**Survey**	**Existing Database**	**Stratified**	**Random**	**Store Customer**	**Public**
(Daelman et al., 2013)	•		•			•
(Daly, Parsons, Wood, Gill, & Taylor, 2011)	•			•		•
(Degeratu, Rangaswamy, & Wu, 2000)	•		•			•
(Firat, Kutucuoglu, Saltik, & Tunçel, 2013)						•
(Gomez, Schneid, & Delaere, 2014)	•			•		•
(Kacen & Lee, 2002)	•			•		•
(Kapinos & Yakusheva, 2011)	•			•		•
(Longnecker, Harper, & Kim, 1997)		•		•		•
(Paul & Rana, 2012)	•			•	•	
(Palan, 2001)		•		•		•

2.3 Frequency of Consumer Behavior

The measurement of repeated behavior is frequency. In many studies, frequency of individuals is captured by a survey. Research studies have targeted different types of frequency related to food such as 1) food storage, 2) food preparation, 3) locations of shopping, and 4) number of meals. Collectively, all studies focused on either two points: intent of purchase or customer awareness.

The study of Daelman et al. (2013) used a survey to measure the frequency of consumer purchases in order to predict consumption. The probability of a product being consumed by an individual is based on the given frequency of purchase (Daelman et al., 2013). The results of this study revealed a direct correlation to consumer consumption. Daelman et al, also examined the effects of food contamination due to unsafe food preparation habits.

The research of Daly et al. (2011) studied the link between food consumption and obesity. A survey was used to measure frequency for eight different food types. The different groups were 1) meat, fish, and eggs, 2) dairy, 3) vegetables, 4) fruit, 5) baked goods, and snacks, 6) sugar, spreads, and dressings, 7) non-milk beverages, and 8) bread and cereal (Daly et al., 2011). Food group levels were identified in this research but no relationship was established between rate of purchase and location of consumed food groups. However, Gomez et al. (2014) showed that the frequency of dairy consumption among a Spanish population is influenced by perceived healthiness, convenience, naturalness, nostalgia, ease to eat, and tastiness. The findings of this study focused on frequency, but did not relate purchasing frequency to the number of visits to the grocery store.

Eating inside the home and outside the home can have a big impact on food purchases that target young adults. Kapinos and Yakusheva (2011) targeted young adults and their

purchasing habits based on eating occasion, location, food purchase, and food purchase by store type. The study concluded that individuals make purchasing decisions based on food quality, pricing variety, availability, travel patterns, and social/cultural influences. Frequency of purchasing was measured by shopping visits in 14 days. Information of what was purchased during the visit was not measured.

Meal frequency can account for the foods being consumed. In 1997, Longnecker, Harper and Kim established a trend among meal frequency to calorie intake (Longnecker et al., 1997). The 1988 Nationwide Food Consumption Survey database of Americans monitored participants for 24 hours to quantify the daily ingested calories. The category of calorie intake was limited to greater than or less than 150 calories. From the database, the average of three meals per day was established. The study made a relationship between meal frequency and calorie intake, but the results are not well defined in terms of what is being consumed.

Table 4

Frequency Collection of Studies

	Frequency			Factors			
Author	**Consumption**	**Location**	**Purchasing**	**Culture/ Influence**	**Food Storage**	**Health**	**Environment**
(Daelman et al., 2013)	•			•	•		
(Daly et al., 2011)	•	•				•	
(Degeratu et al., 2000)			•				•
(Firat et al., 2013)				•			
(Gomez et al., 2014)	•			•			
(Kacen & Lee, 2002)			•	•			
(Kapinos & Yakusheva, 2011)		•		•		•	
(Longnecker et al., 1997)	•					•	
(Paul & Rana, 2012)			•			•	
(Palan, 2001)			•				

2.4 Intent-Consumer Behavior

Purchasing intent is the connections and associations an individual makes while shopping. Therefore, purchasing intent pinpoints the reasons why individuals choose different brands, colors, and advertisements associated with a product. Both practitioners and academics are interested in determining whether there are systematic differences in consumer choice behavior (Degeratu et al., 2000). Different factors lead into why consumers choose different products. Analysis of the study suggested that the environment plays a major role in consumer behavior. Influence and status play roles in a consumption culture (Firat et al., 2013). Certain purchases exhibit wealth or popularity among peers. Another side to the consumer choice is experience or prior knowledge. In Paul and Rana (2012) study of organic food, consumers purchased organic food because they knew the food selection was a healthy choice. The association of "organic" made it the only choice for some consumers when purchasing products. The "organic" label association is called inference. A "halo effect" occurs with products when consumers infer and attribute values based on their opinions of the product (Degeratu et al., 2000).

Consumer consumption is thought of in many different aspects. The biggest theory behind consumer consumption is influence. Influence is a force or motive that compels a person to make a choice. Influence can come from culture, advertisement, or other environmental stimuli. Research conducted on factors that influence impulse buying divides individuals as being from an individualist culture or a collectivist culture (Kacen & Lee, 2002). Individualist cultures internalize emotions and do not seek peer social influence. Collectivist cultures display emotion and seek peer influence. Culture shapes behavior and response to particular environmental cues. China is described as an individualist culture and has the lowest impulse

buying (Kacen & Lee, 2002). Compared to China the United States is a collectivist society. The United States experiences impulse buying based on what the culture defines to be the trend.

Gender is another factor in consumption behavior. It is argued that women value possessions for emotional values and relationship reasons, while men value possessions for function and instrumental reasons (Kacen & Lee, 2002). Men and women are nurtured in different ways growing up thereby leading to an influence of certain responses on environmental stimuli (Palan, 2001). Grocery shopping is impacted by gender. Men, having the ideology of practicality, will gravitate to food staples such as milk, bread, meat, and eggs. Women, operating from an emotional attachment, will buy staple items but will purchase items with emotional connection such as favorite cookies from childhood.

2.5 Analysis Methods

Descriptive and predictive models have been used to characterize food purchases and consumption behavior. A number of studies have used regression models to describe consumer behavior with respect to food purchase and consumption. The studies of Kacen and Lee (2002), displayed an impact of traits connected to buying impulses, culture, arousal, and pleasure on the impulsive buying behavior of individuals from several countries. Yoo et al. (2006) examined the demographic and economic difference between purchasing prepared fruits/vegetables versus fresh fruit/vegetables. Trivedi (2011) used a regression model to measure the significance of location relative to health food purchasers.

Data can be transformed into many forms using different types of models, and synthesis tools. Regression models are used in research when searching for a relationship among numerous independent variables and a dependent variable. A moderated regression model was used to determine the influence of relevant independent variables on impulsive buying behaviors of

consumers (Kacen & Lee, 2002). Regression models can also reveal the likelihood of an occurrence. Regression analysis may be the simplest tool for relating a dependent variable to explanatory variables (Trivedi, 2011).

Yoo et al. (2006) used a polytomous logistic regression model to analyze the relationship between frequencies of food purchasing. The study used regression analysis to compare the frequency of purchasing prepared fruits/vegetables to fresh fruits/vegetables. The findings were broken down by demographics showing an economic stratification to shopping visits. Other research took a geographical approach to defining the collected data. The geographical perspective was used to measure the significance of location relative to healthy food purchasers (Trivedi, 2011). The spatial model used multiple regression to reveal that there is a relationship, but noise in the data prevented validation of the strength of the trend.

2.6 Contribution to Research

The majority of literature discussed views consumer behavior from marketing and attractiveness of product and/or concepts. Understanding why consumers are attracted to certain choices is the base for most studies on consumer behavior. Existing research has identified factors in which certain demographics can shape data results. This research will use demographic data to identify different characteristics among food consumers to predict the likelihood of buying high-risk foods. Consumption behavior has been studied in many forms such as attitudes, influencing factors, advertising affects, food safety, and gender identity. Past research has tried to account for the reason why consumers make their purchasing choices. This research is exploring how consumers' behavior and food consumption practices affect the likelihood that a consumer will be exposed to a contaminated food product.

CHAPTER 3

Methodology

3.1 Problem Overview

This research is concerned with measuring the likelihood of a consumer purchasing high risk foods, which are susceptible to contamination. The characterization of these findings can lead to a model that shows the population at risk when food is recalled. The framework for this research methodology consists of acquiring shopping habits by survey, differentiating the survey results by economic and demographic factors, and synthesis of the data by use of regression models. Figure 1 defines the pathway of research.

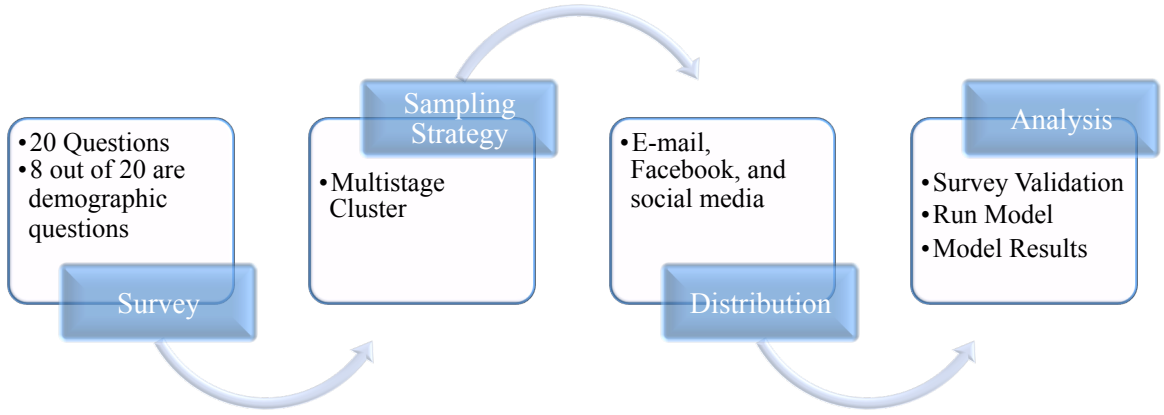

Figure 1. Model of Methodology

3.2 Survey Design

The survey is designed to address the following objectives: (1) understand the frequency in which consumers shop; (2) know the items purchased on shopping visits; (3) identify whether consumers eat meals at home or outside the home; and (4) understand the proximity of consumer's home to their shopping location. The previous survey questions from, "Are We Sick Yet: Assessing Consumer Mortality From Food Contamination in Multiple Distribution Channels" (Teasley, 2013), were examined and altered based on informal peer reviews to

determine the effectiveness of the survey questions. The new survey included the following criteria: (1) ensured the questions were simple to drive automatic responses; (2) eliminated confusion among persons responding to the questions. Wording of the questions were changed to be more direct. Answer choices were grouped in automatic responses classified as natural responses for persons filling out the survey. The new survey was designed to ease the understanding of questions regarding all aspects in which high risk foods are consumed. Refer to Appendix B for survey questions. Several questions within the survey were used to validate the responses received. The validation questions are listed in Table 5.

Table 5

Validation Questions

Question	Type of Response
Question 9: In the last 30 days, how many times have you been to the grocery store?	Any numerical value
Question 10: In the last 30 days, how many times did you buy the following food from the grocery store? (dairy, meat, vegetables, bread, baked desserts, and eggs)	Any numerical value
Question 13: Does your purchasing behavior in the last 30 days reflect what you do on a regular basis?	Yes or No

The validation questions insure consistency in behavior of surveyors. Consistency in measuring behavior was important because this study was focused on shopping frequency. Surveyors with inconsistent shopping behavior are not used in the analysis. Table 6 summarizes the validation criteria.

Table 6

Survey Validation Criteria

Criteria
Rule 1: Question 10 ≤ Question 9
Rule 2: Response to Question 13 = Yes

If a survey violates rule 1 or rule 2, the response is discarded. A discrepancy between questions #9 and #10 depict an irregular shopping behavior. Violating rule 2 implies the shopping behavior reported is inconsistent.

The survey is designed to answer four questions:

1) What is the frequency of purchasing high-risk foods?

2) What is the time until consumption of high risk foods?

3) How many meals are consumed at different food distribution channels?

4) What consumption and purchasing behaviors differ by socio-economic and demographic factors?

3.3 Sampling Strategies

Sampling is the act of organizing a population and gathering information from part of the population as a representation of the whole population. An important factor of sampling is to make sure all the demographics represented in the population are present in the sample. The presence of the different representations decreases the amount of bias in the sample. Sample bias is a reflection of poor sampling. The research for this topic was conducted using two sampling strategies as follows: 1) the multistage cluster sampling and 2) the accidental sampling.

3.3.1 Multistage cluster sampling strategy. A multistage cluster sample is selecting a set group of clusters within the population. The clusters have desired characteristics needed for representation of an unbiased sample. The multistage clusters represented in this research were the different zip codes within the City of Greensboro, North Carolina. Each zip code is diverse in terms of its demographic information. The first step in the sampling strategy was to isolate zip codes for the study. The second step was to take a sub sample based on age, sex, race, and economical level. The sub sample method ensured that a heterogonous population was represented in the sample. There was a degree of error with this sampling plan. The error occurs with not gathering enough respondents of a diverse background. Without the diversity, the sample is biased resulting in a poor sampling method. The distribution of surveys and response of surveyors will increase or decrease the error. Reaching a wider audience will decrease the amount of error. The collection of zip codes will correspond to the population represented within the city.

Of the fifteen zip codes within Guildford county four zips codes were chosen 27405, 27408, 27407, and 27410. In total, the chosen zip codes make up 50 percent of the Greensboro, North Carolina population. Each zip code was chosen based on the demographic hierarchy of population, race, median income, and education. The methodology of selecting zip codes is displayed in Figure 2. The zip code selection method first selects only the high ranking zip codes based on population. Following step one the zip codes which have the highest percentage in the different racial categories for two zip codes were selected. The remaining zip codes were sorted by median income. The median income for the city of Greensboro was compared to the remaining zip codes and the lowest income was removed from the set of zip codes. The last step of the zip code selection process was removing the zip code with the highest high school

education percent with the lowest median income. The average of the chosen zip codes closely matched the demographic factors for all of Greensboro, NC. The constraints of choosing the zip codes is meeting 50% of the City of Greensboro population.

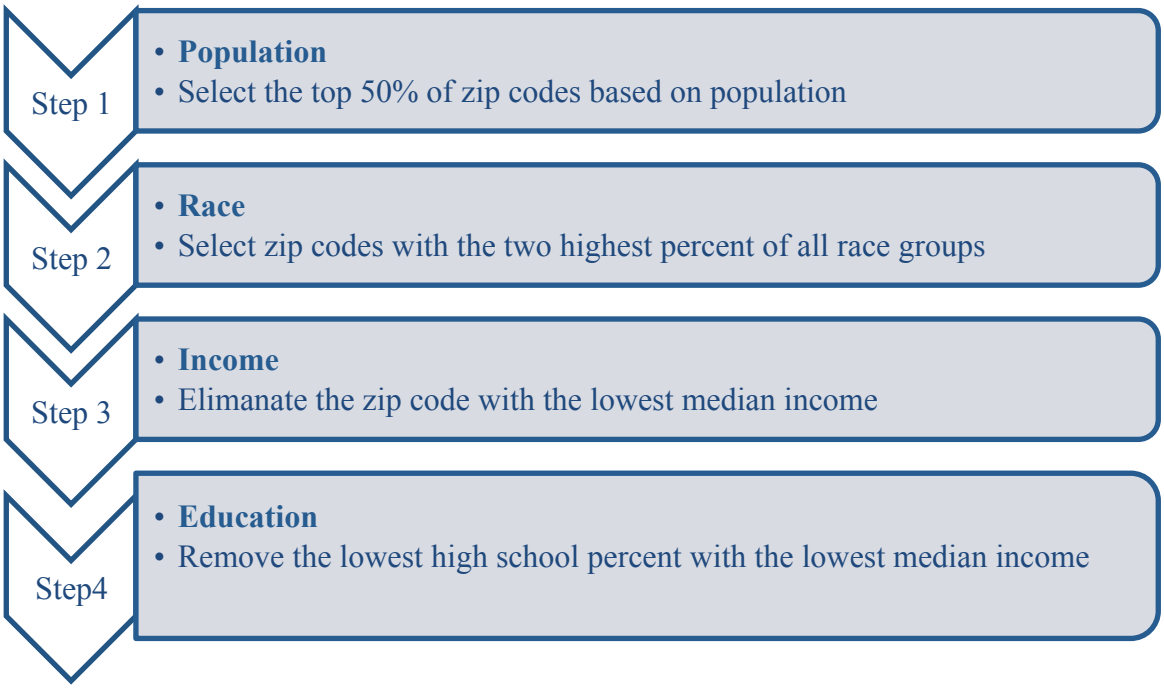

Figure 2. Zip Code Selection Method

The goal was to identify four or five zip codes that are representative of the true population in the City of Greensboro. The sampling zip codes excluded outlying areas of the overall population of Greensboro, North Carolina. The statistical data of all the zip codes in Greensboro, North Carolina is shown in Table 7.

Table 7

Chosen Custer Demographic

Zip Code	Population	Population %	Male/Female (%)	Asian (%)	Black (%)	White (%)	More than 2 races (%)	Median Income ($)	High School (%)	Bachelor Degree (%)	Graduate Degree (%)
24705	43,400	19	46.5/53.5	4.5	58	29.7	2.8	30,299	79.4	15.1	4.2
27407	46,986	21	49.3/50.7	6	25	63	2	44,403	85.2	29.8	8
27408	18,174	8	46.2/53.8	1	7	91	1	65,685	94	54	20.6
27410	50,982	22	46.9/53.1	3	9	86	1	63,703	95.1	53.6	19
Greensboro	227,080	100	47/53	4	40.6	48.4	2.6	39,637	23.64	23.7	11.6

3.3.2 Accidental sampling strategy. Accidental sampling is sampling with no particular criteria. The samples in the population may not display all characteristics. The characteristics of this research are demographic information of a population. Typically, accidental samples consist of those persons available to take the survey, which does not account for all characteristics. To decrease sampling error applied to this research, the focus was to represent all characteristics. The sampling technique is considered successful if the sample is proportional to the demographic of the city of Greensboro.

3.3.3 Sampling strategy distribution. Facebook, Email, and LinkedIn have been the main sources of distribution for the survey. On site distribution of the survey using the different food retail stores in the chosen zip codes could not be completed since many companies do not allow third party surveys to be distributed to their customers. Due to challenges of survey distribution, if surveys were not numerous in the chosen clusters, then accidental sampling strategy is used. See data collection section for survey outcome.

3.4 Survey Analysis

The data collected from the survey was analyzed using Logistic and Poisson Regression. The Logistic Regression Model is used to predict the likelihood of a consumer purchasing of a high-risk food. The Poisson Regression Model is used to measure time to initial consumption of high risk food. Both regression models will help better understand the factors that influence the purchase and consumption of high-risk foods susceptible to contamination. The factors affecting frequency of buying habits will serve as the independent variables for the model.

The independent variables are the responses to the time frame of buying food, period of keeping certain food, eating outside the home, and the high-risk foods bought most often.

Demographic information such as age, gender, location, and income are also used to characterize behavior. Table 8 summarizes the variables used in this research.

Table 8

Research Variables

Research Variables		
Sets	$I=\{1...f\}$	Set of food types
	$L=\{1...n\}$	Set of dining locations (e.g. fast food, restaurant)
	$M=\{1...m\}$	Set of meals (e.g. breakfast, lunch, dinner}
	$D=\{1...k\}$	Set of demographic factors (e.g. gender, ethnicity, income level}
Variables	$X_d(r)$	Classification of respondent for demographic factor $d \in D$ for respondent r
	$Y_{jl}(r)$	The number of meals of type $j \in M$ consumed at location $l \in L$ per week for respondent r
	$Z_{il}(r)$	Equals 1 if food type i consumed at location l; 0 otherwise
	$W_i(r)$	Number of times food type $i \in I$ is purchased in 30 days for respondent r
	$F_i(r)$	Risk Group of food type i in a thirty day period
	$T_i(r)$	Number of days until initial consumption of food type $i \in I$ for respondent r
	$N(r)$	Number of times the store is visited in a 30 day period for respondent r
	$f_i(r)$	Risk by response r of food type i in a thirty day period

In relation to the buying habits, the choices made at the grocery store and/or restaurant have potential to show a trend based on age, gender, race, geographic location, or economic class. The use of demographic factors will lead to a more accurate estimate of the likelihood a particular surveyor will buy a high risk food at the grocery store and/or restaurant.

3.4.1 Logistic Regression. Logistic Regression Models are used to predict a discrete outcome from a set of predictors that can be a mix of continuous, discrete, or dichotomous variables (Tabachnick and Fidell, 2007). A Logistic Regression model is used in this research to identify the likelihood of a surveyor buying (represented by 1) or not buying (represented by 0) high risk food items. The independent variables are the frequency of going to the store, the buying habits of the customer, demographic information, and proximity to the retail product store. The probability of a consumer purchasing a high risk food can be estimated by equation (1), Where, $u = A + B_1X_1 + B_2X_2 + \cdots + B_kX_i$.

$$\widehat{\boldsymbol{Y}}_{\boldsymbol{\iota}} = \frac{\boldsymbol{e^u}}{\boldsymbol{1 + e^u}} \qquad \textbf{Equation (1)}$$

$\hat{Y}_i$ represents the estimated probability of the i^{th} case, A is a constant, X_j are the predictors, and B_k are the coefficients. The logit form of equation (1) is called the log of the odds and is shown in equation (2).

$$\ln\left[\frac{\hat{Y}_i}{1-\hat{Y}_i}\right] = A + B_1X_1 + B_2X_2 + \cdots + B_kX_k \qquad \text{Equation (2)}$$

3.4.1.1 Assumptions of Logistic Regression. While logistic regression is relatively unconstrained with respect to assumptions about the distribution of the predictors (e.g. predictors do not have to be normally distributed, linearly related, or of equal variance within each group), there are a number of practical issues that must be considered when validating the regression model: over fitting, multicollinearity, absence of outliers, and independence of errors (Tabachnik and Fidell, 2007). *Over fitting* can occur if the ratio of the number of cases relative to the number of predicted variables is too small. This could result in extremely high parameter estimates and standard errors, which indicates a problem exists with the model. As a result, the number of cases should be increased or one or more predictors eliminated. *Multicollinearity*

exists when independent variables are correlated. This can cause large standard errors for parameter estimates and/or failure of a tolerance test. Therefore, testing for multicollinearity among predictors should be done to identify and remove redundant variables. Outliers can cause cases to be poorly predicted and can be found by examination of the residuals. Dependence among cases (e.g. over dispersion) should not occur in this research. The survey is designed and administered so that responses are independent (given to a single individual at one time).

3.4.2 Poisson Regression. Poisson law is used to measure frequency distribution in nature, which exhibits Poisson distribution. Poisson distribution is the probability of an event occurring. Poisson Regression includes regressor variables known as x_i, mentioned in the Logistic Regression Model. Regular Poisson Regression is described in equations 5.

$$P(y;\mu) = \frac{e^{-\mu}\mu^{y}}{y!} \qquad \text{(Equation 5)}$$

With the assumption that μ will not change independently with the new data points equation 6 is created (Jewell, 2004).

$$P(y;\beta) = \frac{e^{-T_i[\mu(x_i,\beta)]}[T_i\mu(x_i,\beta)]^{y_i}}{y_i!} \qquad \text{(Equation 6)}$$

Poisson models are used to count response data. The y_i corresponds to the surveyors' response to survey while t_i is a factor of time. The time factor of this research is a thirty day time period. The analysis of the Poisson Regression Model will help determine what characteristics have an impact on the consumption frequency of the population.

3.4.2.1 Assumptions of Poisson regression. The assumptions with Poisson Regression are the response in the regression following a Poisson distribution. This assumption infers that

(1) the response is equal to the mean and, (2) the variance of the response is equal to the mean (Kleinbaum, 1994).

3.4.3 At risk group formulation. The groups of people at risk for contamination are identified by demographic factors based on survey responses. Equation 7 is the formulation of the percent of surveyor response to consumption by food type divided by thirty days. The mean time until consumption for all $T_i(r)$ where $W_i(r) > 0$.

$$\bar{T}_i = \frac{(\sum_{r=1,}^{R} T_i(r))}{R} \qquad \text{(Equation 7)}$$

R is the total number of responses. Equation 8 is the average percentage of surveyor response to purchasing high risk foods in thirty days. $f_i(r) = \frac{W_i(r)}{N(r)}$ is the individual risk based on surveyor response.

$$F_i(r) = \frac{\sum_{r=1}^{R} f_i(r)}{R} \qquad \text{(Equation 8)}$$

CHAPTER 4

Results

4.1 Survey Response

There were 83 responses to the survey. However, only 33 responses satisfied the validation criteria. Table 9 summarizes the responses before and after the validation procedure. The demographic characteristics captured in the survey were gender, race, marital status, education, income, and age. The Greensboro column in Table 9 represents the demographic characteristics of Greensboro, N.C. The percentage of the survey response for each category was not homogenous with the demographic of Greensboro. The survey has a lack of male participation. There were not enough distribution of races represented in the survey responses and there was a lack diversity. These factors indicate the sample taken was not representative of the population of Greensboro, NC.

Six of those surveys submitted had Greensboro, NC zip codes accounting for nine percent of total surveys submitted. The other zip codes ranged from all over the United States. Twenty-three surveyors did not provide information for zip codes out of all the surveys collected. The highest concentrations of surveys were from North Carolina. The second highest concentration of surveys was from Maryland. The geographic information of surveys was separated into regions based on the location of the states. The regions consist of southeast, northeast, west, and no zip code information. The regions categorized geographic locations to provide as a classification variable in the logistic regression for the purchasing behavior of the surveyors.

Table 9

Demographic Characteristic from the Survey (In Percentage)

	Characteristics	Before Validation (%)	After Validation (%)	Greensboro (%)
Gender	Male	18	16	46.9
	Female	73	84	53.1
	Blank	9	0	0
Race	Asian	8	16	4
	Black	43	52	40.6
	White	32	32	45.6
	Other	3	0	10.7
	Blank	14	0	0
Marital Status	Married	48	53	46.3
	Widowed	0	0	6.6
	Divorce	12	22	9.8
	Separated	1	3	3
	Never Married	24	22	34.3
	Blank	14	0	0
Education	Less than High School	4	0	13.1
	High School	0	15	22.7
	Some College	0	0	20.9
	Associates Degree	0	0	6.2
	Bachelor Degree	34	0	24.9
	Graduate Degree	51	85	12.1
	Blank	9	0	0
Income	$0-$24,000	5	6	28.4
	$25,000-$49,000	15	9	29.4
	$50,000-$99,000	29	31	26.8
	$100,000-$149,000	28	34	8.8
	$150,000-$199,000	7	9	3.3
	200,000 and more	4	6	3.2
	Blank	12	3	0
Age	18-24	10	14	37.2
	25-44	71	71	28.1
	45 and up	10	14	34.7
	Blank	10	0	0

4.2 Measure of Survey Objectives

There are four objectives the survey was designed to answer. The first objective was finding the frequency in which consumers shop. Understanding frequency will help to

characterize the likelihood of acquiring high-risk foods. In Figure 3, the results of the survey show that households visit to the grocery store an average of 7.63 times in a thirty day period. The most visits to the store were thirty times, and the least visits were zero times. The majority of surveyors visit the store ten times in a thirty-day period.

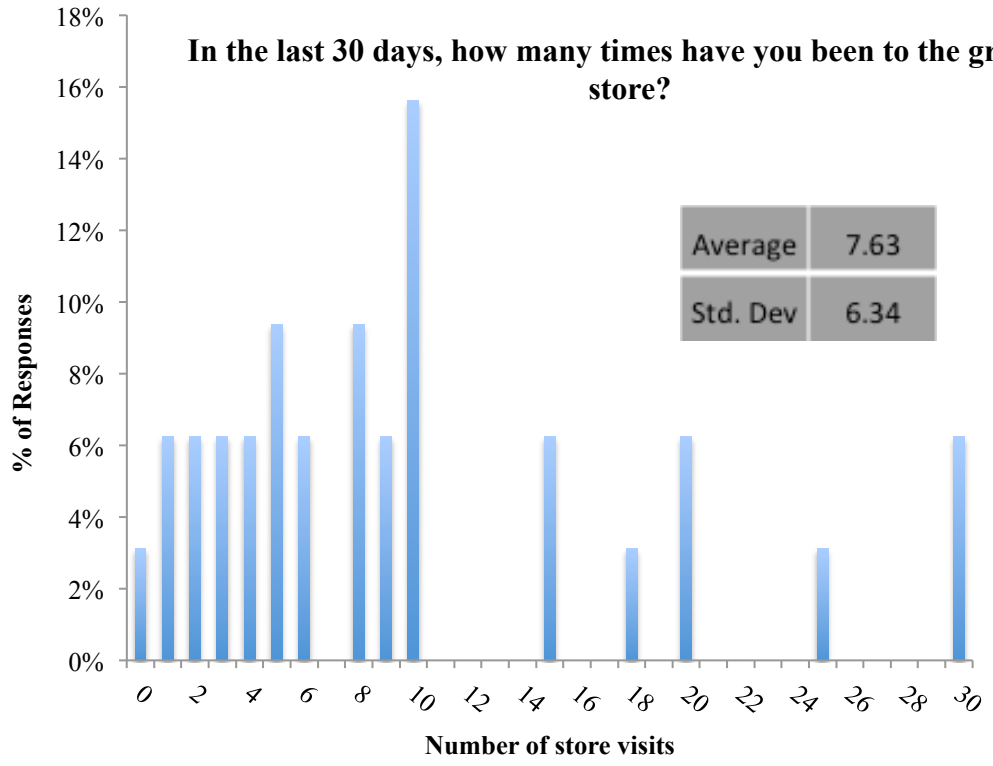

Figure 3. What is the frequency of consumers going to the market?

The second survey objective was to understand the frequency in which items are purchased on shopping visits to the store. One of the variables for the model was to identify the quantity of buying high-risk food items in one month. Figures 4 and 5 display the amount of high-risk foods purchased within thirty days. Both graphs were skewed to the right. This indicates that the surveyors are less likely to purchase meat, dairy, vegetable, and eggs more than four times in thirty days. The purchasing trend of eggs was low occurring one time in thirty days. Dairy and meat show a trend of being purchased at almost two times in thirty days. The high-risk food that

seemed least likely to be purchased was baked goods during the thirty day time period.

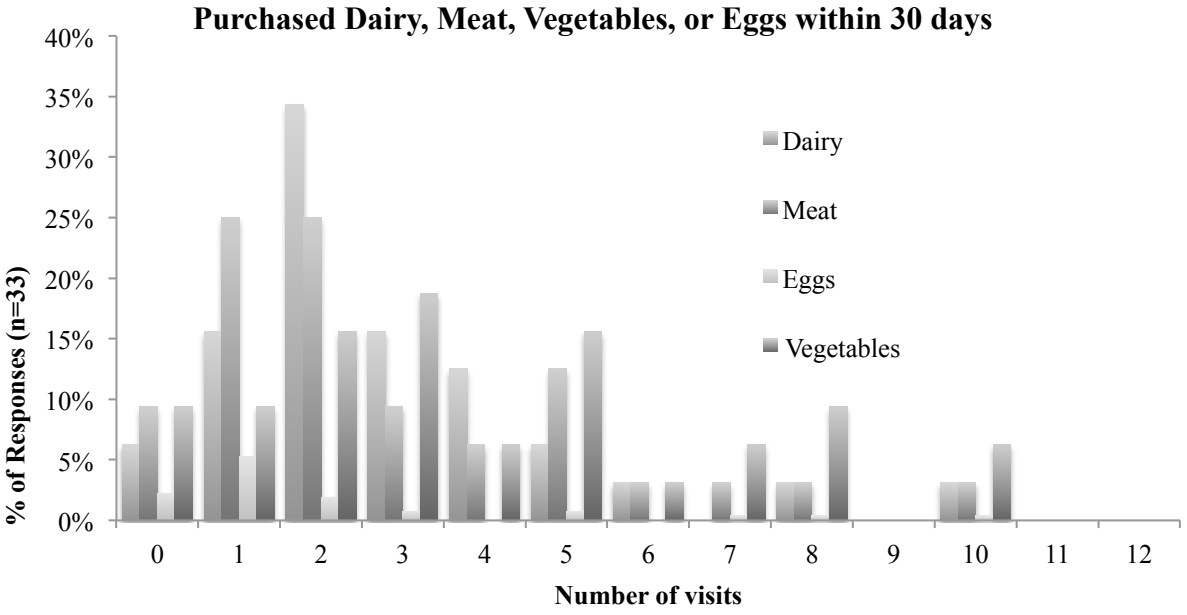

Figure 4. Food Purchased

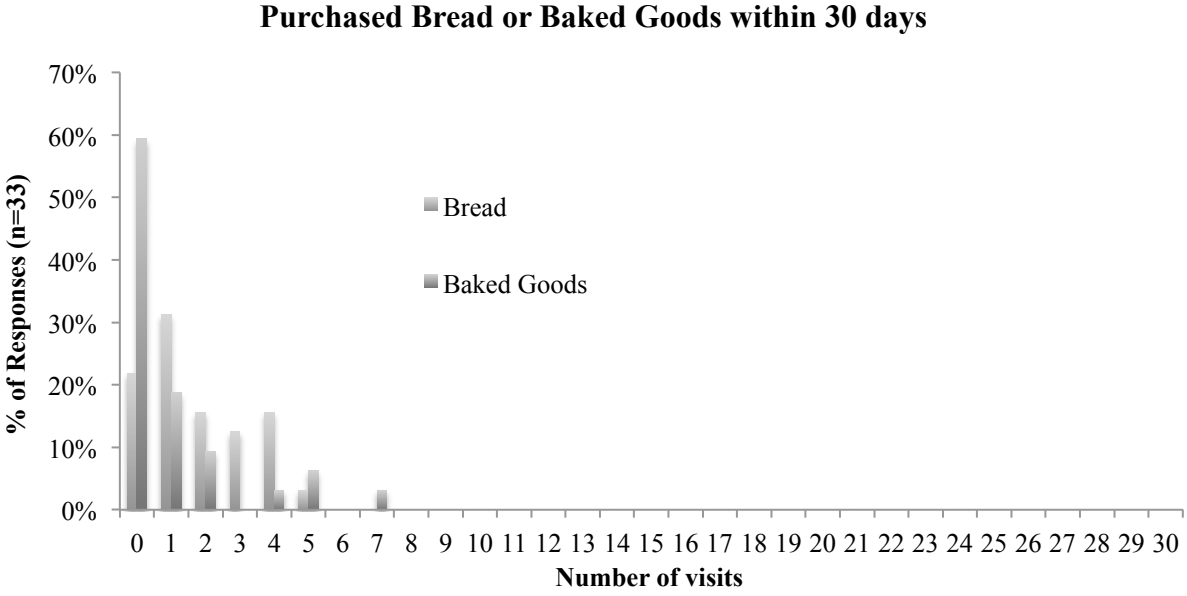

Figure 5. Food Purchased Continued

The third objective of the survey was to identify whether consumers eat meals at home or outside of the home. The survey revealed that the majority of the consumers do not consume

food outside the home. Figures 6 and 7 shows data skewed to the right indicating that among this sample of surveyors eating outside the home does not occur often if not at all. Fast food and restaurant meals at most occur once a week from the survey.

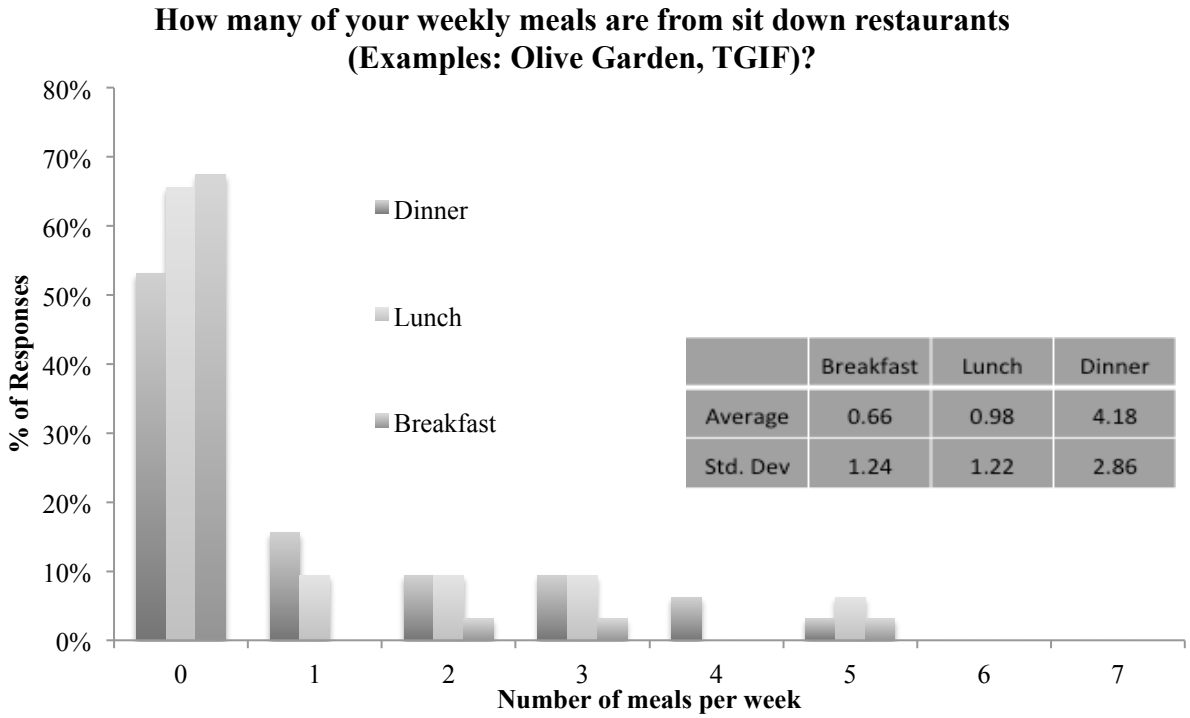

Figure 6. Amount of Weekly Meals at sit down Restaurant

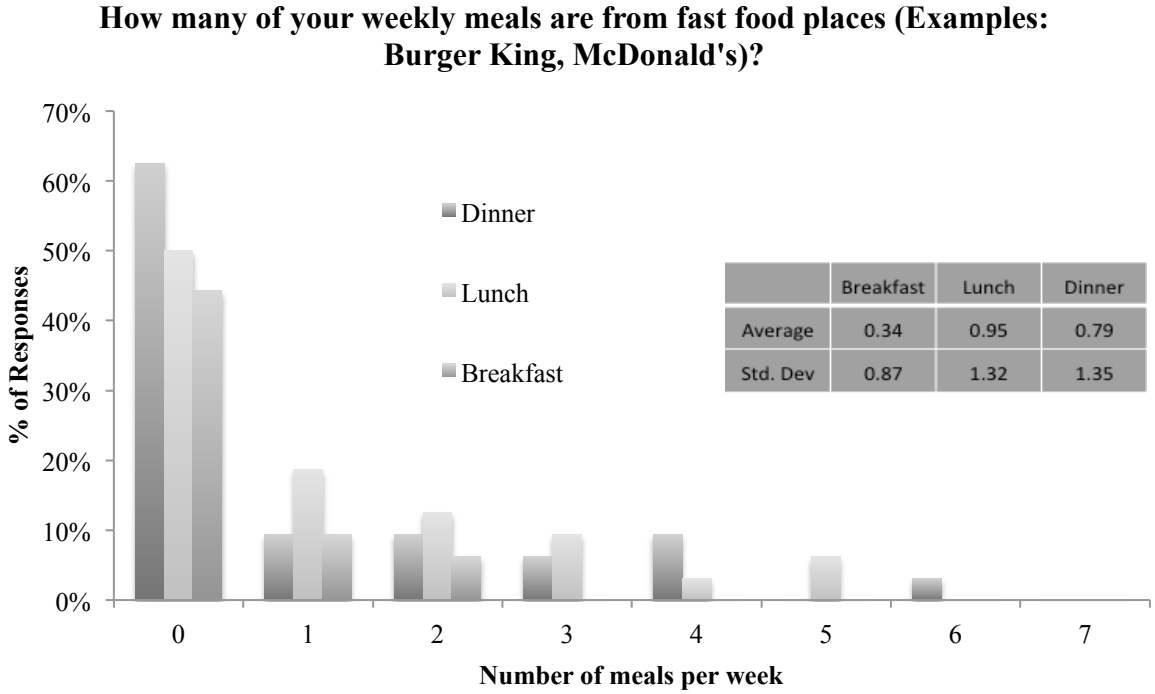

Figure 7. Weekly Meals at a Fast Food Restaurant

The results of the survey showed that preparing dinner at home was most common on a weekly basis in Figure 6. The information of meals matches fast food and restaurants consumed outside of the home. Lunch and breakfast was less likely to be prepared at home. The response of breakfast may or may not include the fact that some surveyors may not regularly consume three meals a day. Figures 6, 7, and 8 have high responses for zero breakfast consumed inside and outside the home.

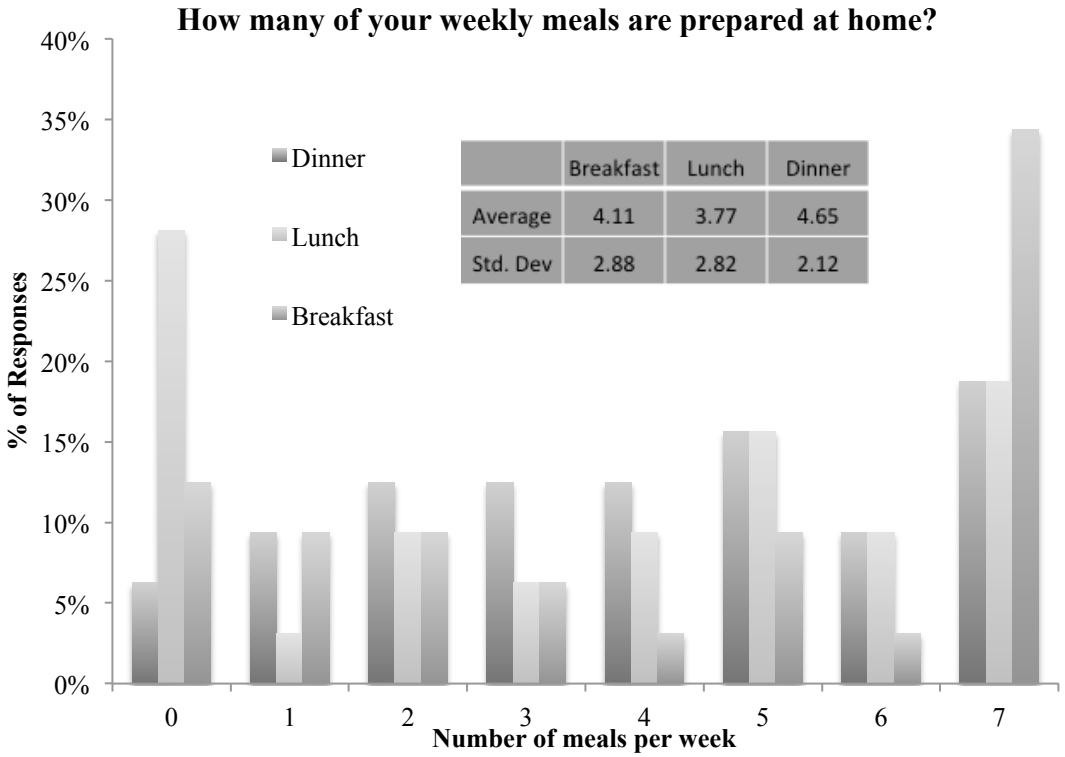

Figure 8. Weekly Meals Prepared at Home

The survey measured the types of foods consumed at restaurants and fast foods. Table 10 below displays the findings of the high-risk foods consumed. The shaded portion of the table shows the highest intake among fast food or restaurant locations. Dairy, vegetables, and baked goods are not consumed as much, likely due to those items not typically being sold at fast food places. Fast food was high in bread, meat, and eggs. Majority of foods on the menu at fast food establishments contain little to no vegetables and dairy. Restaurant consumption was high for dairy, meat, vegetables, and baked goods. Consumption among restaurants shows a larger selection and variety of foods.

Table 10

Fast Food vs. Restaurant

(In percentage)

	Fast Food %	Restaurant%
Dairy	8.33	10.86
Eggs	13.46	10.92
Meat	27.56	24.57
Vegetables	21.79	24.57
Bread	21.79	18.29
Baked Goods	7.05	11.43

The fourth objective was to determine how far consumers' travel to markets, fast foods, or restaurants. Travel distance can narrow down stores in a zip code with frequent visits. For example, if a group of surveyors in the same cluster travel fifteen minutes to the store then most likely their shopping occurred at the same store. Travel by cars is more popular than bus or walking as displayed in Table 11. The time taken to travel to the store reported by fifty percent of the surveyors was five minutes.

Table 11

Mode of Transportation to Grocery Store

Mode of Travel	Percentage	Max	Average	Min
Car	96	35	8.35	1
Walk	3	5	3	1
Other	1	15	15	15

Majority of the survey response were in five-minute increments. Travel time to restaurants and fast food establishments was zero for sixty one percent of responses. Only thirteen percent of respondents traveled five minutes to fast food establishments as displayed in Table 12.

Table 12

Time Traveling to Locations

Travel Time Dinning Outside the Home (Minutes)	Restaurant (Percent)	Fast Food (Percent)
0	76	74
5	9	16
9	1	0
10	5	6
15	7	3
20	2	0
25	0	1

The results of the survey were plotted for distribution analysis. The demographic factors are plotted in a histogram to check an even distribution of categories. Categories with seven or fewer respondents were merged to the next leading category. The race demographic factor merged Asian into the other category. The marital status merged separated and divorced. The education merged some high school and high school together. Income merged $150,000-$199,999 to $200,000 or more along with $15,000-$24,999 to $25,000-$49,999. The merging of the categories contributed to a better performing Logistic and Poisson Regression Models.

4.3 Model Standards

The model hypothesis for Logistic and Poisson Regression is in Table 13 & Table 14. The model is based on a 0.05 significance level. The model test how valuable the model is in predicting the effects of demographics on high risk food.

Table 13

Logistic Model Hypothesis

Logistic Model Hypothesis

Test	Purpose	Null and alternate hypothesis	Decision Rule
Score test for proportional odds	Validate assumption of the ordinal model (odds ratio between adjacent categories are not significantly different)	H_0: The odds ratios between categories are equal. H_a: odds ratios are not equal	Reject H_0 if $p<0.05$ which implies assumptions for **model are not met**.
Likelihood ratio test	Test if model with all predictors is better than model with no predictors	H_0: Slope terms $(B_{1=}B_2 = \cdots = B_k = 0)$ are equal to zero H_a: Slope is not equal to zero	Reject H_0 if $p<0.05$ which implies the model that incorporates predictors is better.
Wald Chi-Square test	Test if a specific predictor is significant	H_0: Slope term for the predictor is equal to zero H_a: slope term is not equal to zero	Reject H_0 if $p<0.05$ which implies the predictor is significant.

A multinomial logistic regression was conducted to determine the likelihood that a person will purchase a food product a specific number of times. The outcome variable is ordinal since it represents the number of times a person purchased a particular product. The number of possible values for the outcome variable is based on the maximum value observed from the survey data.

Table 14

Poisson Model Standard

Poisson Model Hypothesis			
Test	**Purpose**	**Null and alternate hypothesis**	**Decision Rule**
Goodness of Fit: Deviance	Validate the variation of the observed outcomes around the predicted means under Poisson assumption	H_0: High variation around the predicted mean H_a: Low variation around the predicted mean	Reject H_0 if $p<0.05$ which implies the variation is little
Goodness of Fit: Pearson	Test if the high risk food is independent to consumption behavior	H_0: High Risk food and consumption behavior is independent H_a: High Risk food and consumption behavior is not independent	Reject H_0 if $p<0.05$ which implies a relationship between high risk food and consumption
Wald Chi-Square test	Test if a specific predictor is significant	H_0: Slope term for the predictor is equal to zero H_a: slope term is not equal to zero	Reject H_0 if $p<0.05$ which implies the predictor is significant.

The data for the models were preprocessed. The preprocessing occurred to account for the missing information and lack of distribution among categories in survey data. Surveyors were not required to fill out all the demographic information in the survey. Levels within the data were combine based on analysis of the data. The demographic factor race combined Asian to Others based on the small number of response compared to the other races. For marital status only one surveyor answer being separated, therefore Divorced and Separated became the same category. Zip codes were diverse having more than twenty distinct zip codes. The zip codes were separated into levels by geographic location of northeast, southeast, west, and no zip code information. There was a low response in less than high school education. The category was combined to high

school educated. In income the two lowest and the highest incomes were combined based on lack of survey response.

4.4 Purchasing Behavior

Table 15 displays the percentage of respondents that purchase each food type. From those who purchased, Table 16 shows which items were purchased based on demographic factors. Both Tables 15 and 16 indicate the following characteristics about purchasers:

- Mostly married women between the range of 25 to 44 years old;
- Seventy-five percent have a college degree;
- Thirty-five percent have an annual income in the range of $50,000 to $ 99,999;

Table 15

Purchasing Behavior

Demographic	Egg	Dairy	Bread	Meat	Vegetables	Baked Goods
Purchased	84%	81%	81%	84%	91%	50%
Did Not Purchase	16%	19%	19%	16%	9%	50%

Collectively purchasing eggs in the thirty day period happened one time by 40% of those who answered the survey. One surveyor reported that they buy eggs as much as eleven times in a thirty day period. Roughly 89% of the surveyors purchased eggs from one to five times in a thirty day period.

Baked desserts had the least response as far as those who purchased in thirty days. Only 16 participants responded to purchasing baked goods such as cookies, cakes, and pies. One participant purchased baked goods seven times in a thirty day period. Ninety four percent of those participants purchased baked goods one to five times in a thirty day time frame.

Table 16

Purchasing Behavior Demographics

Demographic	Egg	Dairy	Bread	Meat	Vegetables	Baked Goods
			Gender			
Female	77.78%	84.62%	76.92%	85.19%	79.31%	68.75%
Male	22.22%	15.38%	23.08%	14.81%	20.69%	31.25%
			Race			
Asian	10.71%	8.33%	18.18%	12.50%	16.00%	14.29%
Black	42.86%	58.33%	45.45%	54.17%	52.00%	35.71%
White	39.29%	33.33%	45.45%	37.50%	40.00%	42.86%
American Indian or Alaskan Native	3.57%	4.17%	4.55%	4.17%	4.00%	7.14%
Other	3.57%	4.17%	4.55%	4.17%	4.00%	7.14%
			Marital Status			
Married	66.67%	50.00%	69.23%	59.26%	62.07%	68.75%
Never Married	14.81%	26.92%	7.69%	22.22%	17.24%	25.00%
Divorced	14.81%	19.23%	19.23%	14.81%	17.24%	6.25%
Separated	3.70%	3.85%	3.85%	3.70%	3.45%	0.00%
Widowed	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
			Education			
High School or less	0.00%	0.00%	4.55%	4.35%	4.17%	0.00%
High School	4.55%	9.09%	9.09%	4.35%	8.33%	15.38%
Associates degree	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Some college	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
College degree	50.00%	45.45%	45.45%	39.13%	45.83%	46.15%
Graduate degree	45.45%	45.45%	40.91%	52.17%	41.67%	38.46%
			Age			
17 or younger	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
18-24	7.41%	7.69%	3.85%	3.70%	6.90%	12.50%
25-44	51.85%	50.00%	53.85%	59.26%	48.28%	43.75%
45-64	40.74%	42.31%	42.31%	37.04%	44.83%	43.75%
65 or older	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
			Income			
Less than 10k	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10k to 14.9k	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15k to 24.9k	3.70%	4.00%	7.69%	7.69%	7.14%	6.25%
25k to 49.9k	14.81%	16.00%	11.54%	15.38%	10.71%	6.25%
50k to 99.9k	33.33%	36.00%	26.92%	34.62%	32.14%	31.25%
100k to 149.9k	22.22%	24.00%	26.92%	26.92%	25.00%	31.25%
150k to 199.9k	14.81%	12.00%	15.38%	7.69%	14.29%	12.50%
200k or more	11.11%	8.00%	11.54%	7.69%	10.71%	12.50%

4.5 Purchasing Frequency

The frequency of the validated survey data of purchasing high risk foods is displayed in Figure 9. The data in Figure 9 shows that the high risk foods are most likely to be purchased one to five times in a thirty day period. The highest point of frequency in Figure 9 was purchasing eggs by forty percent, which the surveyors purchased once in thirty days. The frequency pattern shows significance among the surveyors who purchase high risk food items one to five time in a thirty day period.

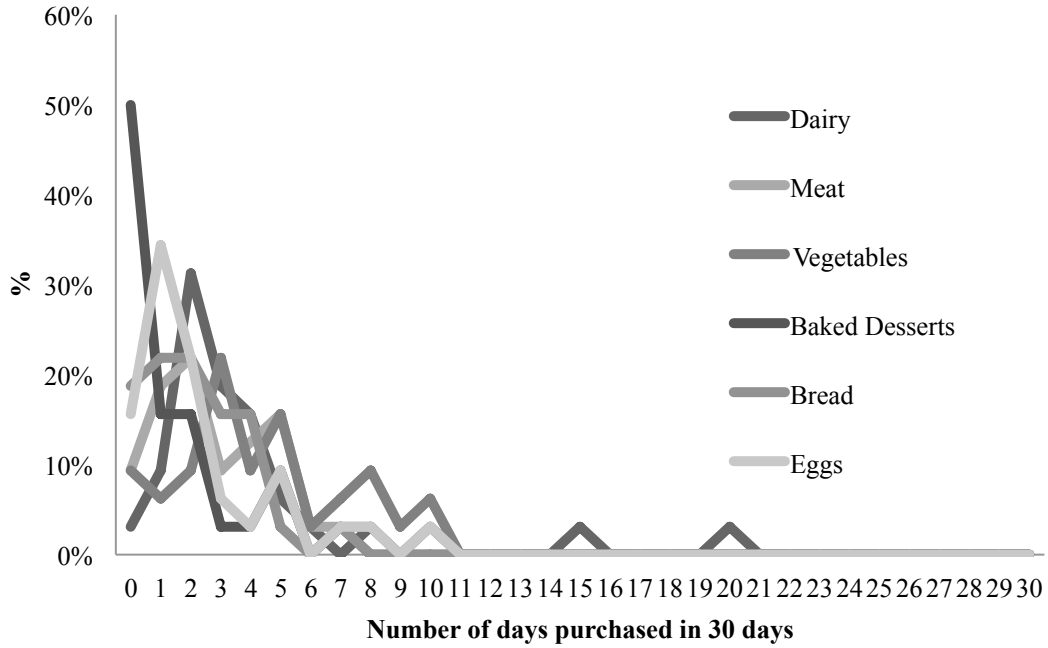

Figure 9. Purchasing Frequency

At most, the time dairy was purchased was fifteen times by one surveyor in a thirty day period. Roughly 88% of the surveyors purchased dairy from one to five times in thirty days. Ninety percent of those who purchased dairy in a thirty day period have a bachelors or graduate degree. Bread was purchased at most seven times in a thirty day period. The response to purchasing bread was 96%, which was purchased one to five times in thirty days. The most meat was purchased eight times in thirty days. Of the thirty three replies to purchasing meat, 87%

purchased meat one to five times in thirty days. Of those participants, 85% were female. Vegetables had the most feedback of purchasing within thirty days. The highest amount for purchasing vegetables was ten times in thirty days. Only 69% of those surveyors purchase vegetables one to five times in thirty days. The rest of the 31% purchased vegetables six to ten times in thirty days.

The purchasing behavior among the five food groups shows a pattern of surveyors purchasing the top five high risk foods from one to five times in a thirty day period. There is a relationship with the visits to the store and purchasing of a high risk food by consumers. Based on the trend found in the data, consumers are likely to grocery shop anywhere from one to five times in thirty day time period.

Each high risk food had a targeted risk of exposure group based on the amount of visits to the store and the time purchased at the store. Dairy demographic indicates that white males with an education level of a bachelors degree or higher are at risk for contamination. Asian females with an education level of high school or higher are more at risk of exposure to meat. American Indian or Alaskan Native and white females are the at risk group for vegetables contamination. Asian males and females are the at risk exposure group for eggs. White males with a bachelors degree are the at risk exposure group for purchasing bread. Figure 10 displays the average percentage of purchased high risk foods based on the highest point. Refer to the appendixes for table of values.

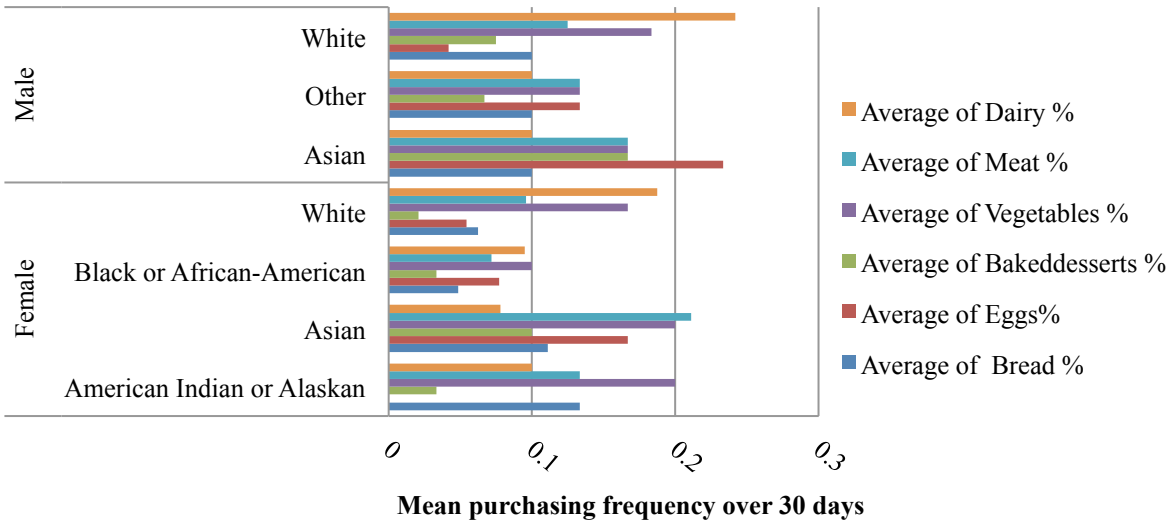

Figure 10. Purchasing at Risk Groups

4.5.1 Logistic regression. Using the SAS Enterprise Guide, a logistic regression was performed for each high risk food. The classification of variables used in different sequences was zip code, race, education, marital status, and income. The demographic information of gender and age were collected with the survey but were not used in the logistic regression due to the lack of diverse distribution. Three different models were run using different combinations of the classification variables. The three models are described in Table 17.

Table 17

Model Variables

Variables	Model 1	Model 2	Model 3
Zip Code	√		
Race	√	√	√
Education	√	√	
Marital Status	√		
Income	√	√	√

In Table 18, data shows the probability for each model based on high risk food type. The *p*-value measures the value of the models in predicting effects of demographic information to high risk food. The models for dairy, meat, and baked goods are of value, which is based on the *p*-value greater than or equal to a 0.05 significance level.

Table 18

Purchasing Model and Classification Variables

Score Test of Proportional Odds			
	Model 1	Model 2	Model 3
Baked Goods	<.0001	<.0001	<.0001
Bread	<.0001	0.0053	0.0066
Dairy	**0.9894**	**0.7254**	0.0004
Egg	0.008	<.0001	<.0001
Meat	**0.1371**	**0.1747**	0.0172
Vegetables	**0.9886**	<.0001	<.0001

4.5.1.1 Logistic Regression Model for Bread, Baked Goods, & Egg. The models for the high risk food egg, bread, and baked goods based on the hypothesis did not meet the assumptions of the ordinal model. However, all of the models showed a quasi-separation of data points. Quasi-separation is when the dependent variable separates one or more independent variables. The quasi- separation for these models occurred due to the response by surveyors to purchasing or not purchasing being limited. The data size response is too small making the quasi-separation effect present.

4.5.1.2 Logistic Regression Model for Meat. Table 19 shows results of the Wald Chi-Squared for Model 1. Model 3 did not meet the assumptions of the ordinal Model, and Model 2 failed to reject the hypothesis for the Likelihood Ratio Test. The results of the Wald Chi-Squared show that race, and marital status used in model 1 are significant predictors of who purchased

meat at the store within a thirty day period. Race and marital status showed an effect on purchasing meat. The chi-squared value is low for the predictors. The effect of race and marital status of purchasing meat is a weak relationship.

Table 19

Chi-Square Comparison Meat

Model 1			
Effect	DF	Chi-Squared	PR>Chi-Squared
Education	3	3.8368	0.2796
Income	4	7.6681	0.1045
Marital Status	2	8.9283	**0.0115**
Race	2	6.6031	**0.0368**
Zip Code	3	2.7611	0.4299

4.5.1.3 Logistic Regression Model for Vegetable. The first model for high risk food vegetables is valuable as a model. The second and third models are not valuable for the high risk food vegetables. The models did not meet the assumptions of the ordinal model. Model 1 show an effect for purchasing vegetables by predictors race, marital status, education, income, and zip code. Table 20 displays the results for model 1. Chi-squared values for model one are higher than previous reviewed. The higher chi-squared value with income and marital status shows a stronger relationship between purchasing vegetables at the store in thirty days. Race has a high values for the chi-squared value but numerically the relationship is not as strong as marital status, and income.

Table 20

Chi-Square Comparison Vegetables

Model 1			
Effect	DF	Chi-Squared	PR>Chi-Squared
Education	3	8.7362	0.0330
Income	4	20.3510	0.0004
Marital Status	2	20.4544	<.0001
Race	2	13.3621	0.0013
Zip Code	3	10.2165	0.0168

4.5.1.4 Logistic Regression Model for Dairy. Model 1 and Model 2 meet the assumptions of an ordinal model. Model 2 fail to reject the hypothesis for the Likelihood Ratios Test implying no predictors are better in the model. Model 1 displayed in Table 21 has one predictor that shows an effect on purchasing dairy in thirty days. The predictor marital status was a weak relationship to purchasing dairy in thirty days based on the low chi-squared value.

Table 21

Chi-Square Comparison Dairy

Model 1			
Effect	DF	Chi-Squared	PR>Chi-Squared
Education	3	5.9870	0.1122
Income	4	7.2539	0.1231
Marital Status	2	8.1736	**0.0168**
Race	2	6.0169	0.0494
Zip Code	3	6.2823	0.0987

4.6 Consumption Behavior

The consumption habits among the entire survey participants show a demographic trend of married women who obtained their bachelors, or graduate degree. The survey result suggested the majority of these individuals are cooking in the home and preparing meals in a thirty day period. The individual high risk food results varied. The time period in which consumers waited before use of a high risk food was measured along with their likeliness of consuming the high risk food at a restaurant, or a fast food establishment. The income level suggests lifestyles of a 40 hour work week; therefore, agreeing with the statistic that the population is visiting the store no more than 10 times in a month. Figure 11, shows the number of times in a week a surveyor will consume a meal inside, or outside the home.

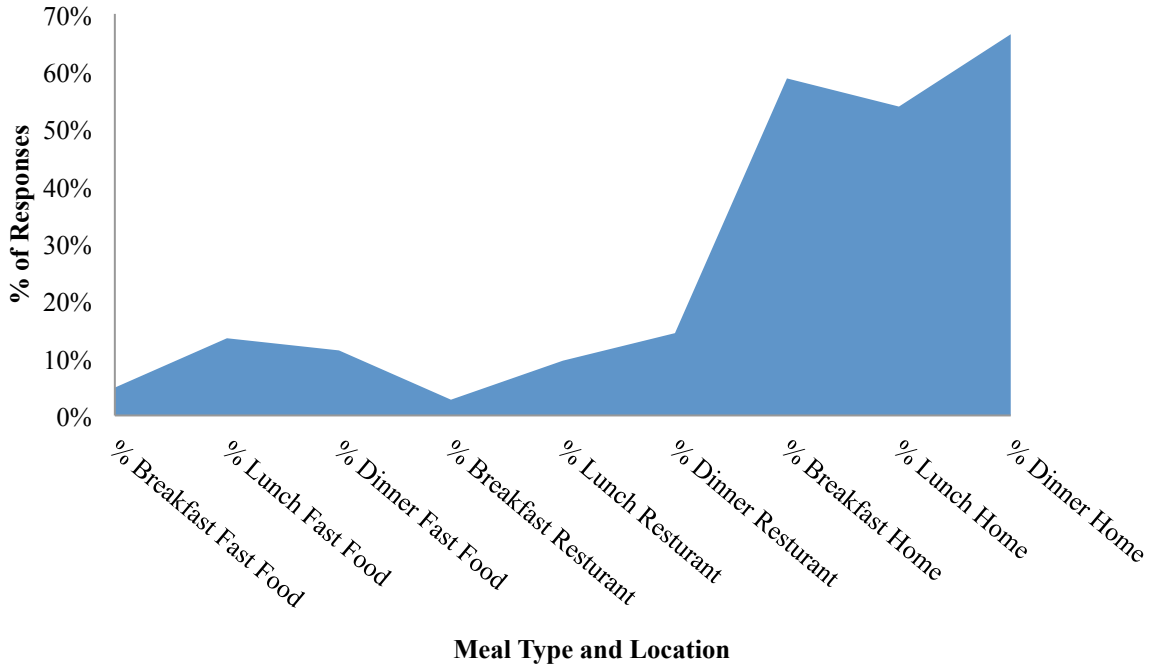

Figure 11. Location of Meal Consumption

4.6.1 Consumption Time After Purchased. The results given for time until initial consumption varied based on the perishability or temperature sensitivity of food items.

Vegetable, bread, and dairy had a high percentage of individuals consuming in zero to three days from initial purchase. In the survey results, ninety-three percent of survey participants consumed vegetables zero to three days after purchase. Ninety-seven percent of consumers ate bread within zero to three days after purchase.

Ninety-four percent of respondents consumed dairy within zero to three days. The high percentages of consumption for vegetables, bread, and dairy relates to the rates of perishable food. Eighty-seven percent of people consumed eggs within zero to three days. Eggs are a perishable item although consumers did not consume eggs at the same rate as bread, vegetables, and dairy. Meat was consumed at a rate of 78% within zero to three days. The longest wait of consumption after purchase was 30 days. The time period suggested that the meat was frozen, or a canned meat product. The distribution of consumption of meat after purchase ranged from five to ten, and twenty days after purchase. The other top three high risk foods did not vary in distribution that reached 30 days. Baked desserts had the smallest range. One hundred percent of the surveyors who purchased baked dessert consumed the products within zero to four days. The baked dessert category had the lowest responses by the survey.

4.6.2 Consumption Frequency. Figure 12, summarizes time before consumption by response rate. The highest average of consumption frequency is meat shown in Table 22. The standard deviation for meat is the largest. Vegetables and meat had the most survey responses for consumption. Baked desserts had the lowest average and standard deviation for initial time to consumption.

Table 22

Consumption Statistics

	Baked Desserts	Bread	Dairy	Eggs	Meat	Vegetables
Average	0.57	1.08	1.28	1.74	3.07	1.53
Standard Deviation	0.93	1.17	1.56	1.70	4.68	1.79
Coefficient of Variation	1.63	1.08	1.22	0.98	1.52	1.17

The results show that baked goods and dairy are the most likely to be consumed within the same day or two days after purchased. Meat has the most variation of consumption among the data. Collectively, the high risk foods are consumed within zero to eight days of purchase.

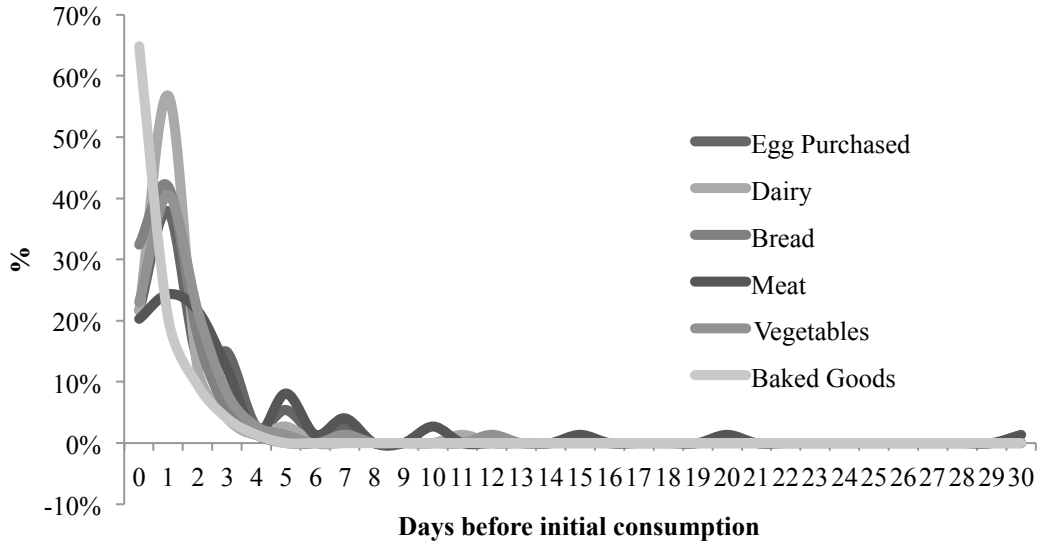

Figure 12. Frequency of Consumption

Figure 13, displays average consumption rate by demographic factor. A group is considered at risk if the time before consumption is low represented by the lowest point on the figure. The consumption of dairy shows white females with graduate degrees are at risk for contamination. Meat has a at risk group of female African Americans with a high school education and males of

other races with a graduate degree. Vegetables and eggs at risk group are African-American males with some college education. Asian women with bachelors degrees are the at risk group for baked desserts. The African-American males and Asian females are the at risk group for bread. The survey results averaged together produced the at risk groups for consumption. The average numbers of risk groups are based on the days after purchase the surveyor is to eat the high risk food. Refer to the appendixes for table of values. Table A2 in the appendix has detailed information.

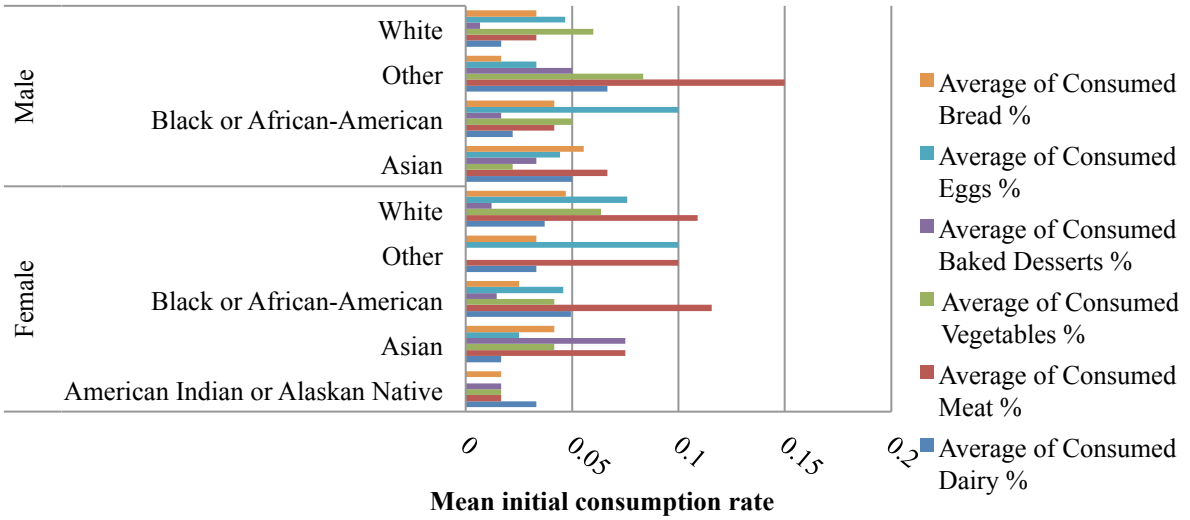

Figure 13. Consumption at Risk Group

4.6.3 Poisson Regression. The results of the Poisson regression for the consumption data are displayed in Table 22 reflected the logistic regression for dependent variables. The classification variables used in different sequences were zip code, race, education, marital status, and income. The three models were repeated with the first model of classification variables of zip code, race, education, marital status, and income. The second model classification variables of race, income, and education. The third model classification variables of race and income. In Table 23, the probability of each model of high risk food is shown. All of the models for

vegetables and meat are valuable based on the 0.05 significance level. The *p*-value shows that dairy and bread models were not valuable models. The egg and baked dessert data were unable to fit the Poisson Regression model. This occurrence is due to a result of the limited distribution in responses of consumption of eggs and baked desserts.

Table 23

Consumption Goodness of Fit Values

	Deviance *p*-Values		
	Model 1	Model 2	Model 3
Baked Goods	-	-	-
Bread	0.088	0.054	0.086
Dairy	0.109	0.100	**0.049**
Egg	-	-	-
Meat	**0.000**	**0.000**	**0.000**
Vegetables	0.124	**0.021**	**0.004**

4.6.3.1 Poisson Regression Model for Meat. All of the models for high risk food meat displayed in Table 24 are valuable by rejecting the null hypothesis for the Deviance and Pearson goodness of fit test. However, the predictor variables for all models do not show an effect in consumption of meat. Income showed an effect for Model 2 and Model 3. The chi-squared values for Model 2 and Model 3 are high showing a strong relationship between meat consumption and income. Model 2 showed education having an effect with a high chi-squared value. The higher chi-squared value the stronger the relationship between meat consumption and the predictor variable.

Table 24

Chi-Squared Comparison Meat

	Model 1			Model 2			Model 3		
Effect	DF	Chi-Squared	PR>Chi-Squared	DF	Chi-Squared	PR>Chi-Squared	DF	Chi-Squared	PR>Chi-Squared
Education	4	9.0145	**0.0607**	4	21.84	**0.000**			
Income	2	4.4884	0.1060	5	21.72	**0.01**	5	24.96	**0.00**
Marital Status	4	5.2519	0.2624						
Race	2	0.1855	0.9114	3	2.48	0.478	3	1.75	0.627
Zip Code	3	1.5756	0.6649						

4.6.3.2 Poisson Regression Model for Vegetable. Model 2 and Model 3 were of value for consumption of vegetables by the goodness of fit test. Table 25 has the chi squared values of each predictor variable for the models. Model 1 fail to reject the null hypothesis of the Deviance goodness of fit test. Model 2 showed education, income, and race having a connection to the consumption of vegetables. Education and income had the highest chi-squared values. Income had an effect in both models with moderately high chi-squared values representing the strength of the relationship. Race and income show the strongest relationship between consumption of vegetables.

Table 25

Chi-Squared Comparison Vegetables

	Model 2			Model 3		
Effect	DF	Chi-Squared	PR>Chi-Squared	DF	Chi-Squared	PR>Chi-Squared
Education	5	10.19	0.070			
Income	4	13.63	**0.009**	5	12.36	**0.030**
Race	3	9.96	**0.019**	3	5.0	0.172

4.7 Results Discussion

The results of the survey limited the study potential to develop strong trends among demographic factors of purchasing and consumption. The demographic factors of income and education were identified by the consumption models but were not strong relationships. The logistic regression model did not show favorable results for any demographic factor. Certain models for the regressions were limited because of the survey participation. The Logistic and Poisson Regression differed in in the levels of the models based on the responses of the survey. Surveyors are not required to answer all demographic questions leaving some of the levels of the independent variables empty. The logistic regression used the validated data, which was smaller than the data of the entire survey response. The survey had a total of 83 responses, which was used to analyze consumption behavior. The survey data for purchasing behavior was 33 responses based on the validation of data. The validation removed all surveyors of inconsistent purchasing habits. The distribution of the survey results displayed that the majority of the participants were female, black, and held a bachelors degree or higher. The results of the survey were not reflective of the targeted sampling plan or reflective of the America population at large. The poor distribution resulted in the merging of categorizes in order to obtain a better fit regression models.

The results found in the data were comparable to the literature review. The study (Carlson et al., 1998) has similar feedback of eating outside the home growing popular with time. The results in this study show a large number eating outside the home for breakfast and lunch. Eating location is a risk factor contributor to contamination of food. The results from this survey showed that consumers were more likely to consume meat and vegetables in a fast food and restaurant establishment. The (CDC, 2012) study reported meat, vegetables, and dairy

being the most high risk foods contributing to illness with the number one location being restaurants. The study assessing consumer purchasing and consumption behavior supports the sources of contamination and the risk of consumption of high risk food groups. Current literature is limited on frequency of high risk foods with focus on purchasing or consumption behavior.

CHAPTER 5

Future Work

Food is a needed source of energy and nutrients. The majority of foods eaten on a daily basis are high risk foods. The American public consumes food multiple times a day. Contamination in any of the high risk foods can result in significant health risks. A model to analyze the impact of a contamination outbreak on the general public has the potential to save lives. The model can be used as a warning tool to identify whom is affected by contamination based on geographic and demographic information.

The study has produced a method to quantify a way to distinguish purchasing and consumption of high risk foods. Intentional and unintentional contamination of food occurs on a regular basis. Understanding purchasing and consumption habits will provide consumers a targeted alert and response of a food contamination epidemic. The study related demographic information to purchasing and consumption habits.

The present study has demonstrated that only a few demographic factors are significant to particular high risk food groups. The results of the significant factors are not conclusive to make a generalization on the entire population of United States. The results are inconclusive based on the lack of diversity in demographics and number of responses. The survey received 84 responses. The number of responses for purchasing behavior was reduced to 33 once the validation data was completed. In both data set collections, the majority of the respondents are female, and married.

Literature is limited in purchasing and consumption of high risk foods for a diverse population. There has been no study that looks into demographics as a factor in consumption and purchasing behavior in relation to the likelihood of consuming or purchasing a contaminated

product. The current study is analyzing important factors in order to identify a trend in behaviors of purchasing and consumption.

The future work of the study is to address the limited data by redistributing the survey. A partnership with a third party will yield a larger collection of data. The demographic categories will be analyzed to find the risk factors that contribute to food purchases and consumption. The removal of the limitations of this study will reveal conclusive results to generalize for an entire population.

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Appendix A

Risk Group

Table A1

Purchasing at risk groups

Gender	Race	Education	Average Dairy %	Average Meat %	Average Vegetables %	Average Baked Desserts %	Average Eggs %	Average Bread %
Female	American Indian or Alaskan Native	High School	0.100	01.333	0.200	0.033	0.00	0.133
	Asian	Less than High School	0.000	0.067	0.066	0.00	0.00	0.067
		High School	0.067	0.333	0.266	0.133	0.333	0.100
		Graduate Degree	0.167	0.233	0.266	0.166	0.067	0.067
	Black or African-American	Bachelors Degree	0.078	0.088	0.100	0.050	0.072	0.055
		Graduate Degree	0.113	0.060	0.093	0.0267	0.087	0.053
		Some College	0.100	0.050	0.116	0.000	0.067	0.017
	White	Bachelors Degree	0.120	0.113	0.200	0.020	0.047	0.933
		Graduate Degree	0.300	0.667	0.111	0.022	0.067	0.011
Male	Asian	Graduate Degree	0.100	0.167	0.166	0.166	0.233	0.100
	Other	Some College	0.100	0.133	0.133	0.067	0.133	0.100
	White	Bachelors Degree	0.667	0.167	0.300	0.167	0.067	0.233
		Graduate Degree	0.100	0.10	0.233	0.000	0.033	0.033
		Some College	0.100	0.116	0.100	0.067	0.033	0.067

Table A2

Consumption at risk group

Gender	Race	Education	Average Dairy %	Average Meat %	Average Vegetables %	Average Baked Desserts %	Average Eggs %	Average Bread %
Female	American Indian or Alaskan Native	High School	0.033	0.033	0.033	0.033	0	0.03333
	Asian	Bachelors Degree	0.033	0.067	0.067	0.133	0.033	0.100
		Graduate Degree	0	0.067	0	0.100	0	0
		High School	0.033	0	0.033	0	0.033	0.033
		Less Than High School	0	0.167	0.033	0	0.033	0.033
	Black or African-American	Associate Degree	0.033	0.133	0.133	0.033	0.033	0.0167
		Bachelors Degree	0.0385	0.0458	0.042	0.0167	0.050	0.025
		Graduate Degree	0.0744	0.1643	0.026	0.01429	0.045	0.024
		High School	0	0.233	0.100	0	0.133	0
		Some College	0.0167	0.076	0.038	0.0095	0.033	0.033
	Other	Graduate Degree	0.033	0.100	0	0	0.100	0.033
	White	Bachelors Degree	0.029	0.054	0.067	0.008	0.113	0.033
		Graduate Degree	0.433	0.158	0.056	0.0138	0.047	0.058
		Some College	0.033	0.033	0.100	0.0167	0.100	0.033
Male	Asian	Graduate Degree	0.050	0.067	0.022	0.033	0.444	0.056
	Black or African-American	Bachelors Degree	0.033	0.033	0.033	0.067	0.067	0.10
		Some College	0.033	0.067	0.083	0	0.167	0.033
	Other	Bachelors Degree	0.100	0.233	0.100	0	0.033	0
		Bachelors Degree	0.033	0.067	0.067	0.100	0.033	0.033
	White	Graduate Degree	0.033	0.067	0.100	0	0.100	0.067
		Some College	0.0167	0.050	0.100	0.0167	0.067	0.050

Appendix B

Survey

Customer Purchasing Behavior for Food Retail and Food Service Industries

1. In what ZIP code is your home located? (Enter 5-digit ZIP code)
   ZIP:

2. Are you male or female?
   a. Male
   b. Female

3. What is your race classification?
   a. Asian
   b. Black or African-American
   c. American Indian or Alaskan Native
   d. Native Hawaiian or other Pacific Islander
   e. White
   f. Other :

4. What is your marital status?
   a. Married
   b. Widowed
   c. Divorced
   d. Separated
   e. Never married

5. What is the highest school level completed?
   a. Less than high school degree
   b. High School
   c. Some College but no degree
   d. Associate degree
   e. Bachelors degree
   f. Graduate degree

6. Which category below includes your age?
   a. 17 or younger
   b. 18-24
   c. 25-44
   d. 45-64
   e. 65 or older

7. How much does your household make per year?
   a. Less than 10,000
   b. 10,000-14,999
   c. 15,000-24,999
   d. 25,000-49,999
   e. 50,000 – 99,999
   f. 100,000 – 149,999
   g. 150,000-199,999
   h. 200,000 or more

8. How many people (by age) currently live in your household? (Including yourself)

Less than 5	
5-17	
18-24	
25-44	
45-64	
65 or older	

9. In the last 30 days, how many times have you been to the grocery store?

Exempted
11/18/13

10. In the last 30 days, how many times did you buy the following food from the grocery store?

Dairy (*Examples: milk, cheese, yogurt*)	
Meat (*Examples: beef, chicken, fish*)	
Vegetables (*Examples: lettuce, tomato*)	
Baked desserts (*Examples: cake, pie*)	
Bread	
Eggs	

11. How many days after purchase do you store the food (in refrigerator or pantry) before you first eat it?

Dairy (*Examples: milk, cheese, yogurt*)	
Meat (*Examples: beef, chicken, fish*)	
Vegetables (*Examples: lettuce, tomato*)	
Baked desserts (*Examples: cake, pie*)	
Bread	
Eggs	

12. Approximately how far do you travel from your home to the grocery store **(in minutes)**?

13. How do you typically travel to the grocery store?
    a. Car
    b. Bus
    c. Walk
    d. Other:

14. Does your purchasing behavior in the last 30 days reflect what you do on a regular basis?
    a. Yes
    b. No

15. How many of your weekly meals are from fast food places *(examples: Burger King, McDonalds)*?

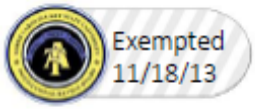
Breakfast	
Lunch	
Dinner	

16. How many of your weekly meals are from sit down restaurants (*examples: Olive Garden, TGIF)*?

Breakfast	
Lunch	
Dinner	

17. How many of your weekly meals are prepared at home?

Breakfast	
Lunch	
Dinner	



18. What types of foods do you eat at fast food places ? (Circle all that apply) (if number 15 >0)
    a. Dairy *(Examples: milk, cheese, yogurt)*
    b. Eggs *(Examples: scrambled or biscuit combination)*
    c. Meat *(Examples: beef, chicken, fish)*
    d. Veggies *(Examples: tomatoes, lettuce)*
    e. Bread
    f. Baked Goods *(Examples: cake, pie)*
    g. Fruit or Smoothies

19. What types of foods do you eat at sit down restaurants? (Circle all that apply) (if number 16>0)
    a. Dairy *(Examples: milk, cheese, yogurt)*
    b. Eggs *(Examples: scrambled or biscuit combination)*
    c. Meat *(Examples: beef, chicken, fish)*
    d. Veggies *(Examples: tomatoes, lettuce)*
    e. Bread
    f. Baked Goods *(Examples: cake, pie)*
    g. Fruit or Smoothies

20. Approximately, how far do you travel from your home **(in minutes)** for fast food?

21. Approximately, how far do you travel from your home **(in minutes)** to eat at a restaurant?