Is the Binghamton Community Eating Enough Vegetables?

A Mixed-Methods Study of Veggie Meter Scores and Lay Beliefs on Food

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Fruit and vegetable (F&V) intake reduces the risk of chronic diseases and premature death, but the majority of the U.S. population fails to meet F&V recommendations. There is a lack of research about Broome County residents' dietary quality. Thus, this study aims to (a) evaluate F&V consumption in relation to sociodemographics using the Veggie Meter®, and (b) examine whether lay beliefs of healthy foods translate to decision-making processes of students when selecting meals. Using a mixed-methods research (MMR) design, participants were sampled using the Veggie Meter® and two Qualtrics surveys. Recruitment occurred on the Binghamton University campus and at two local farmers' markets. Participants were Binghamton University affiliates, or Broome County residents and were over 18 years old. Participants were asked to fill out the "Veggie Meter® Survey" and, if surveyed on the Binghamton University campus, the "Perceptions Survey." The tests conducted found a significant relationship between Veggie Score and sex, indicating that male participants had significantly higher Veggie Scores than female participants in the sample. No significant relationships were found between age and veggie score, or between survey location and veggie score. Qualitative analysis showed that participants believed that nutrients determine the health quality of foods; they frequently did not make meal decisions based on these beliefs, highlighting an intention-behavior gap. The findings suggest a relationship between biological sex and veggie score, as well as a large intention-behavior gap, even among students who accurately identified key aspects of healthy foods.

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1 Introduction

1.1 Significance

Many adolescents and young adults have suboptimal diet quality and eating habits, which can potentially continue through the rest of adulthood. Adolescents tend to practice erratic eating habits characterized by meal skipping, frequent snacking, unorthodox meals, and high intake of ultra-processed foods (UPFs), making it difficult to meet nutritional recommendations (McKinley et al., 2005). Studies have shown that consumption of UPFs can increase the risk of developing an array of non-communicable diseases, including obesity, type-2 diabetes, digestive system cancers, and many other life-altering chronic illnesses (Rico-Campà et al., 2019). Conversely, college students and American adults are not consuming enough nutrient-dense whole foods, primarily fruits and vegetables. The majority of the U.S. population does not consume enough fruits and vegetables despite their ability to reduce the risk of chronic disease and premature death (May et al., 2020). Extensive research has shown that fruits and vegetables are the cornerstone of a healthy diet, and many nutritional studies therefore consider F&V intake an outcome variable. F&V consumption among both sexes is subpar; however, studies show that women are more aware of their body image and care more about their appearance than men, which leads them to engage in more healthful dietary practices (Alkazemi, 2019).

1.2 Knowns and Unknowns

To improve dietary outcomes among college students and American adults, it is important to understand the population's lay beliefs and nutritional knowledge to inform future interventions. Nutritional knowledge closely aligns with correct scientific and nutritional principles (Yahia et al., 2016). Lay beliefs are subjective, usually nonscientific, and informal beliefs that the general public holds to help explain the phenomena that occur in the surrounding world (Kilby & Sherman, 2020). Several meta-analyses and RCTs explore the relationship between nutritional knowledge and overall dietary quality. One such example studied the effects of nutrition labels on dietary quality in college students. This analysis examined 22 different studies and identified that 16 of these studies found nutrition label exposure to be associated with improved diet (Christoph & An, 2018). Less is known, however, about the relationship between lay beliefs and overall dietary quality; even less is known about the lay beliefs of Binghamton University students and local Broome County residents. Understanding the lay beliefs of Binghamton University students and Broome County Residents has the potential to help future researchers develop new interventions to increase F&V consumption, veggie-meter scores, and overall dietary quality.

1.3 Research Aims

Little is currently known about the objective dietary quality of Binghamton Students and Broome County residents or their dietary knowledge. There is a general lack of understanding about college students' lay beliefs regarding healthy foods, and their thought processes while making food choices. While meal-decision making may be influenced by individual lay beliefs, many other environmental or situational factors may also contribute to their choices (Zigmont & Bulmer, 2015). This study is a mixed-methods research study; lay beliefs will be analyzed qualitatively, while veggie scores and their correlations with sociodemographic variables will be analyzed quantitatively. This study employs an exploratory approach to assess lay beliefs as they relate to dietary quality and sociodemographic variables. The primary research aim is to answer the question: What are the overall dietary scores of Binghamton students and Broome County residents (as measured by skin carotenoid status via the Veggie Meter®), and how does this correlate with sociodemographic variables? How may lay beliefs influence the veggie scores? The secondary research aim is to assess, through the use of the Veggie Meter®, whether or not sociodemographics correlate with veggie score.

2 Methods

2.1 Participants and Sampling

This study was approved by the Institutional Review Board of a public higher education institution in New York. Research was conducted ethically to protect the rights, welfare, confidentiality, and privacy of participants. All participants were informed of the project and provided their consent before beginning the survey. Participants were eligible to participate in the Veggie Meter® portion of the study if they were at least 18 years of age, an undergraduate student at Binghamton University, and/or a current resident of Broome County. The perceptions survey portion of the study required that participants were at least 18 years of age, undergraduate students at Binghamton University, possessed a Binghamton University meal plan, and had eaten in the dining halls within the past academic year. A convenient sample was recruited through tabling in high-traffic areas on Binghamton University's main campus and at the Broome County and Binghamton farmers markets, emailing, flyers, social media posts, and announcements through B-Line. The sample size for this study was 323 participants. Data were collected via surveys using Qualtrics. The Veggie Meter® survey included questions to collect Veggie Meter® scores, nutrition attitudes after using the Veggie Meter®, and some sociodemographic information. The perceptions survey included both open-ended and multiple-choice questions to collect both qualitative and quantitative data for this mixed-methods study.

2.2 Measures

To objectively measure F&V consumption as an outcome variable, a Veggie Meter® device was used. The Veggie Meter® is a portable tool that uses pressure-mediated reflection spectroscopy (RS) to measure carotenoid levels in a participant's skin and blood. Carotenoids are red, yellow, and orange pigments often found in fruits and vegetables. These pigments stay in the skin and blood, allowing the Veggie Meter® to collect an objective measure of F&V consumption. Participants were asked to insert their non-dominant index finger into the Veggie Meter®. Three separate veggie-meter readings for each participant were recorded using the same finger, and the mean of these three scores was the participant's Veggie Meter® score. The majority of research that utilizes the Veggie Meter® as a measure uses the mean of three attempts to measure Veggie Meter® scores, because averaging the mean of three scores to produce a final Veggie Meter® score reduces variability and error of the machine (Radtke et al., 2021). Participants received a score between 0-800, and were asked to report their score in the Veggie Meter® survey. In 2020, a study determined that it is feasible to use the Veggie Meter® in school-based settings as it is easy to set up, objective, and overcomes self-reporting biases (May et al., 2020).
Sociodemographic variables and lay beliefs were also used to analyze the results of the Veggie Meter® across different datasets. Participants were asked about their biological sex (male, female, or prefer not to say) and their self-reported health status (poor, fair, good, very good, or excellent).

2.3 Qualitative Data Analysis

Qualitative data were analyzed using NVivo. Before being imported into NVivo, the data were screened to remove any unusable responses. After being imported into NVivo, the data were analyzed using an explanatory approach. Participants were asked about their beliefs about what makes foods healthy, and they will also be asked about their actual decision-making process when they are selecting meals. Two codebooks will be created to categorize the main responses to each of these questions, respectively. After the conclusion of data coding, the results will be analyzed within the NVivo software for frequencies and exemplar codes to ensure their variability. Data will then be visualized using the software to enable easier understanding and dissemination of results.

2.4 Data Analysis Plan

Data was exported from Qualtrics in a numerical format and imported into Posit Cloud. R code provided in "The Quantitative Playbook for Public Health Research in R" (McCarty, 2025) was modified to install R packages (see 'install.R'), import data using`readr`, combine the two imported datasets (`10.20.2025.perceptionsdata.team5.clean.xlsx` and `10.20.2025.data.team5.clean.xlsx`) by passwords (a variable existing in both datasets), and transform VEGGIESCORE to a numeric variable (VEGGIE) with accepted values ranging from 0 to 800. The R package dplyr was used to transform the variables GENDER, SEX, and LOCATION to binary variables in order to conduct multiple independent samples t-tests with these variables and the variable VEGGIE. A descriptive statistics table was then constructed using inline R code, displaying summary statistics for the continuous variables of interest (AGE_1, VEGGIE, HEALTHSTATUS). Histograms were visualized using the R package ggplot2 to ensure normality of continuous variables (VEGGIE, AGE_1, HEALTHSTATUS). This quantitative study aimed to analyze the relationship between participants' Veggie Scores (VEGGIE) and various demographic variables (LOCATION, SEX, GENDER, HEALTHSTATUS, AGE_1). Thus, multiple independent samples t-tests were conducted: between LOCATION and VEGGIE, and SEX and VEGGIE. Additionally, a linear regression was conducted to determine the relationship between AGE and VEGGIE. Finally, a Pearson Correlation coefficient was computed to assess the relationship between perceived health status (HEALTHSTATUS) and Veggie Score (VEGGIE). These relationships were then modeled using the R package ggplot2 as well as ggpubr.

2.5 Load

```
library(tidyverse)
library(psych)
library(knitr)
library(tibble)
library(dplyr)
library(tidyr)
library(scales)     # for number formatting like comma()
library(english)    # to convert numbers to words
library(stringr)    # for text functions like str_c()
library(NHANES)
library(haven)
library(readxl)
library(tableone)
library(ggpubr)
library(devtools)
library(patchwork)
```

```
library(readxl)
```

2.6 Import

```
library(readxl)
library(dplyr)
primary_data <- read_excel("10.20.2025.perceptionsdata.team5.clean.xlsx", col_names = TRUE)
secondary_data <- read_excel("10.20.2025.data.team5.clean.xlsx", col_names = TRUE)
# source:  (Hei & McCarty, 2025) https://shanemccarty.github.io/FRIplaybook/import-once.html
# explanation: import perceptions survey data as data frame primary_data and Veggie Meter surve
```

2.7 Transform

2.7.1 Combine Data Sets

2.7.2 Transform Veggie Scores

```
secondary_data$VEGGIESCORE <- as.numeric(secondary_data$VEGGIESCORE)
# add a filtered 'VEGGIE' column to secondary_data
secondary_data <- secondary_data %>%
  mutate(
    VEGGIE = as.numeric(VEGGIESCORE),
  ) %>%
  filter(VEGGIE >= 50 & VEGGIE <= 800)
# add a filtered 'VEGGIE' column to combined
combined <- combined %>%
  mutate(
    VEGGIE = as.numeric(VEGGIESCORE.y),
    HEALTHSTATUS = as.numeric(HEALTHSTATUS)
  ) %>%
  filter(VEGGIE >= 50 & VEGGIE <= 800)
# source: (Estreich, 2025) https://shanemccarty.github.io/FRIplaybook/dplyr.html
# explanation: filtered out outlier variables from 'VEGGIESCORE' in secondary_data
```

2.7.3 Transform Variables 'GENDER' 'SEX' 'LOCATION'

```
library(dplyr)
# filter 'GENDER' to only include two groups
primary_data <- primary_data %>%
  filter(
    GENDER %in% c(0,1)
  ) %>%
  mutate(
    GENDER = factor(GENDER, levels = c(0,1), labels = c("Male" , "Female"))
  ) %>%
  drop_na(
    GENDER, HEALTHSTATUS
  )
# source: https://nyu-cdsc.github.io/learningr/assets/data-transformation.pdf
# explanation: filtered column 'GENDER' in primary_data to only include two values 'Male' and
```

```
library(dplyr)
# filter 'GENDER' to only include two gruops for pearson correlation
combined <- combined %>%
  filter(
```

```
    GENDER %in% c(0,1)
  ) %>%
  mutate(
    GENDER = factor(GENDER, levels = c(0,1), labels = c("Male" , "Female"))
  )
# source: https://nyu-cdsc.github.io/learningr/assets/data-transformation.pdf
# explanation: filtered column 'GENDER' in combined to only include two values 'Male' and 'Fema
```

```
library(dplyr)
# filter 'SEX' to only include two groups for independent samples t-test
secondary_data <- secondary_data %>%
filter(
  SEX %in% c(0,1)
  ) %>%
mutate(
  SEX = factor(SEX, levels = c(0,1), labels = c("Male" , "Female"))
) %>%
drop_na(
  VEGGIE, SEX
)
# source: https://nyu-cdsc.github.io/learningr/assets/data-transformation.pdf
# explanation: filtered column 'SEX' to only include two values 'Male' and 'Female'
```

```
library(dplyr)
# filter 'LOCATION' to only include two groups for independent samples t-test
secondary_data <- secondary_data %>%
filter(
  LOCATION %in% c(0,1)
  ) %>%
mutate(
  LOCATION = factor(LOCATION, levels = c(0,1), labels = c("Farmers Market" , "Binghamton Unive
) %>%
drop_na(
  VEGGIESCORE, LOCATION
)
# source: https://nyu-cdsc.github.io/learningr/assets/data-transformation.pdf
# explanation: filtered column 'LOCATION' to only include two values 'FARMERS MARKET' and 'BIN
```

3 Results

3.1 Descriptive Statistics

3.1.1 Demographics and Sample Representativeness

r

Variable	n	Mean	Median	SD	Min	Max
AGE	193	27.22	20	15.96	18	89
VEGGIE	193	298.49	299	88.65	65	752
HEALTHSTATUS	50	3.2	3	0.93	1	5

Participants for the quantitative portion, including both Binghamton University students and Broome County residents, were between 18 and 89 years of age (n = 208) with a mean of 27.22 years. The sex distribution for the quantitative portion was majority female, consisting of 111 females and 82 males. The Binghamton University population identifies as 80.1% White, 4.97% Asian, 5.38% Hispanic or Latino, and 5.09% Black or African American, 2.99% two or more races, 0.0465% Native Hawaiian or Other Pacific Islanders, and 0.0748% American Indian or Alaska Native (Data USA, n.d.). The sample population for the qualitative portion, in comparison, was 50.7% White, 30.2% Asian, 9.5% two or more races, 6.3% Black, 1.6% other, and 1.6% Middle Eastern. Zero Binghamton University survey participants reported being Hispanic or Latino or Native Hawaiian or Pacific Islander. Many racial groups were underrepresented, indicating that the sample may not have been representative of the Binghamton University population.

3.1.2 Primary Variables

```
library(ggplot2)
# create a histogram for age
age.hist <- ggplot(secondary_data, aes(x = AGE_1)) + geom_histogram(binwidth = .5) + theme_bw(
print(age.hist)
```

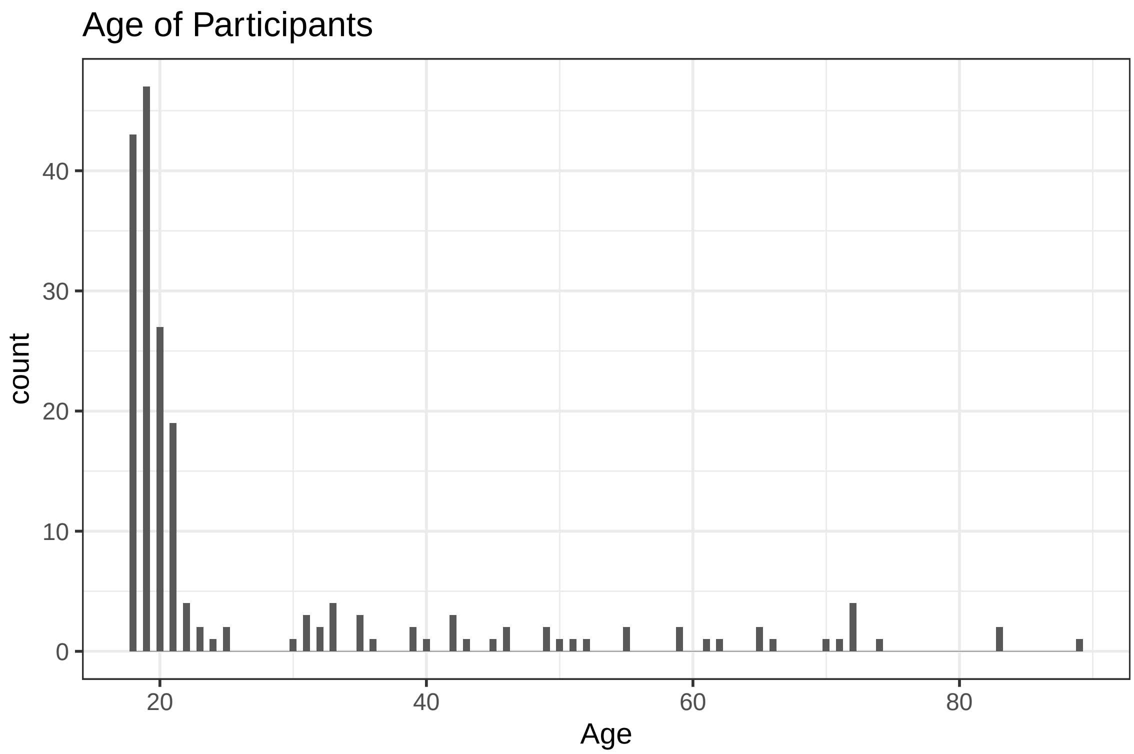

Figure 1: Figures 1. Histogram depicting the distribution of age of participants.

```
ggsave("plot/age_hist.png" , width = 8, height = 6)
# source: https://rstudio.github.io/cheatsheets/data-visualization.pdf
# explanation: made histograms to check for normal distributions
```

```
library(ggplot2)
# create a histogram for veggie score
ggplot(secondary_data, aes(x = VEGGIE)) + geom_histogram(binwidth = 10) + theme_bw() + ggtitle
```

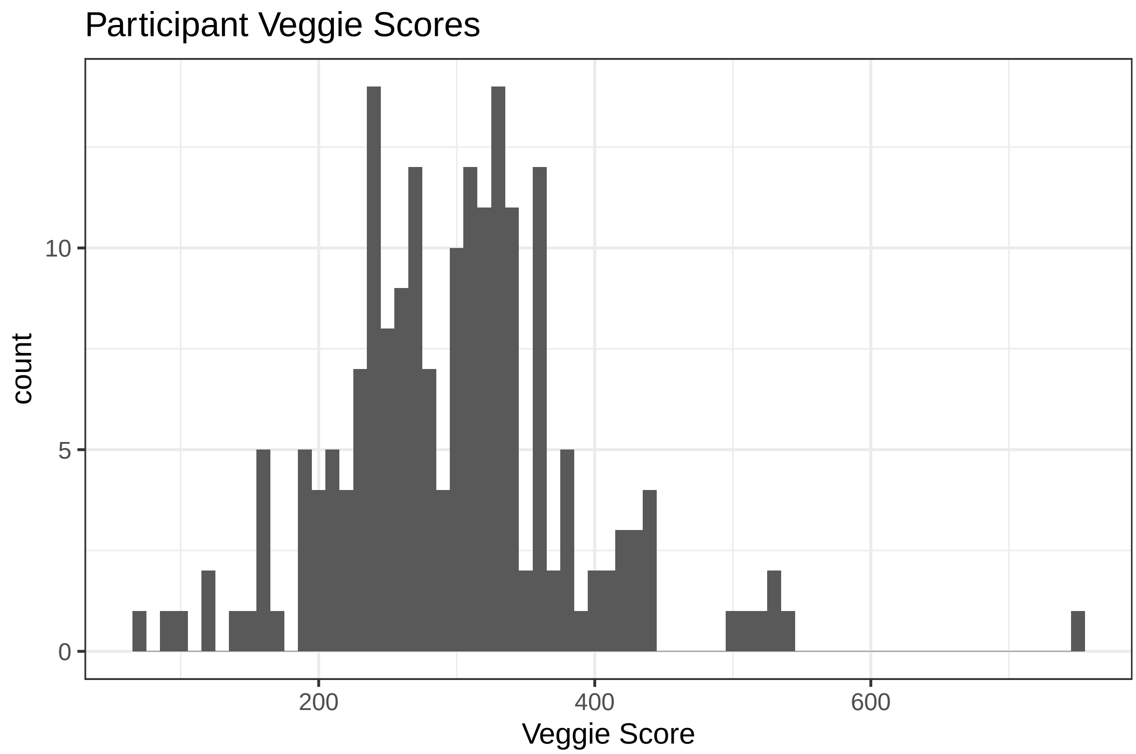

Figure 2: Figure 2. Histogram depicting the distribution of veggie scores of participants.

```
ggsave("plot/veggie_hist.png")
# source: https://rstudio.github.io/cheatsheets/data-visualization.pdf
# explanation: made histograms to check for normal distributions
```

```
library(ggplot2)
# create a histogram for healthstatus
ggplot(combined, aes(x = HEALTHSTATUS)) + geom_histogram(binwidth = .5) + theme_bw() + ggtitle
```

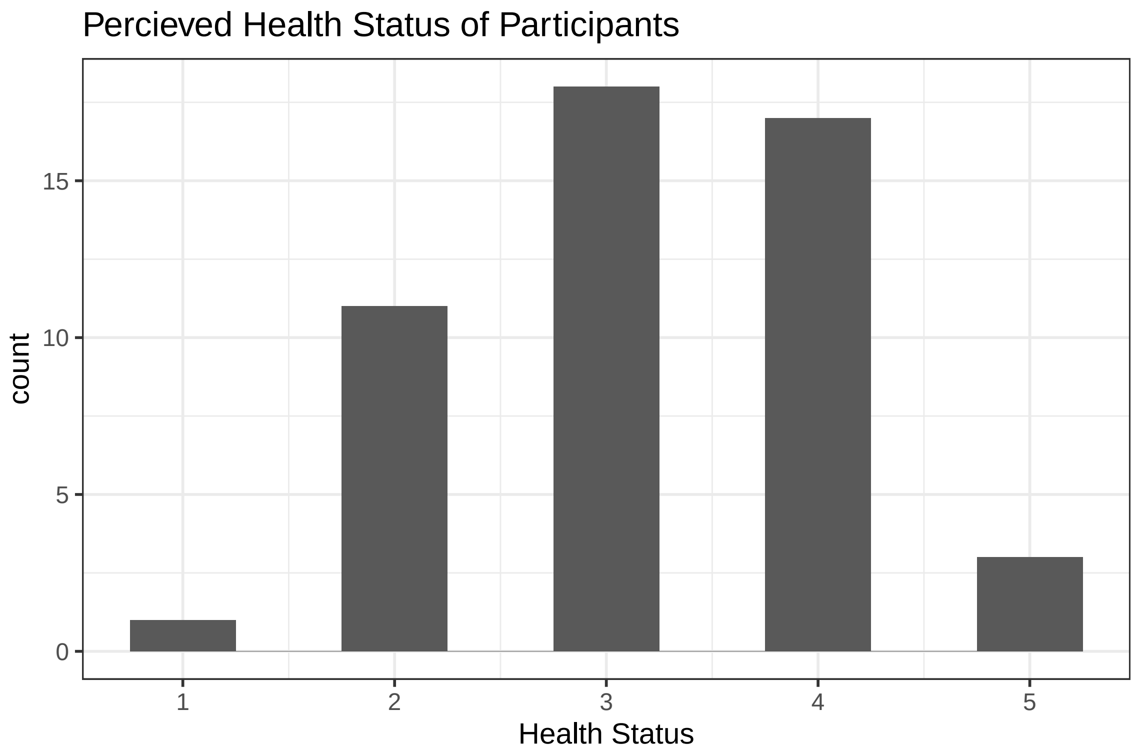

Figure 3: Figures 3. A histogram depicting the distribution of health status score among participants

```
ggsave("plot/healthstatus_hist.png" , width = 8, height = 6)
# source: https://rstudio.github.io/cheatsheets/data-visualization.pdf
# explanation: made histograms to check for normal distributions
```

3.1.3 Primary and Secondary Variables

3.1.3.1 Sex and Veggie Score

```
library(ggpubr)
library(ggplot2)
# create a second density plot for SEX and VEGGIESCORE
plot.sex.veggie <- ggdensity(secondary_data, x = "VEGGIE" ,
          add = "mean" , rug = TRUE ,
          color = "SEX" , fill = "SEX" ,
          palette = c("#ff8c6b" , "#e8a7d0"),
          title = "Distribution of Veggie Scores by Sex" ,
          xlab = "Veggie Score" ,
          ylab = "Density",
          add.params = list(linewidth = 1 , alpha = 1,
                            linetype = "dashed")) # change color of average lines
# customize x-axis to range from 100 to 800
plot.sex.veggie <- plot.sex.veggie + scale_x_continuous(breaks = seq(100, 800, by = 100)) +
```

```
theme(axis.text = element_text(hjust = 0.5), plot.title = element_text(hjust = 0.5))
print(plot.sex.veggie)
```

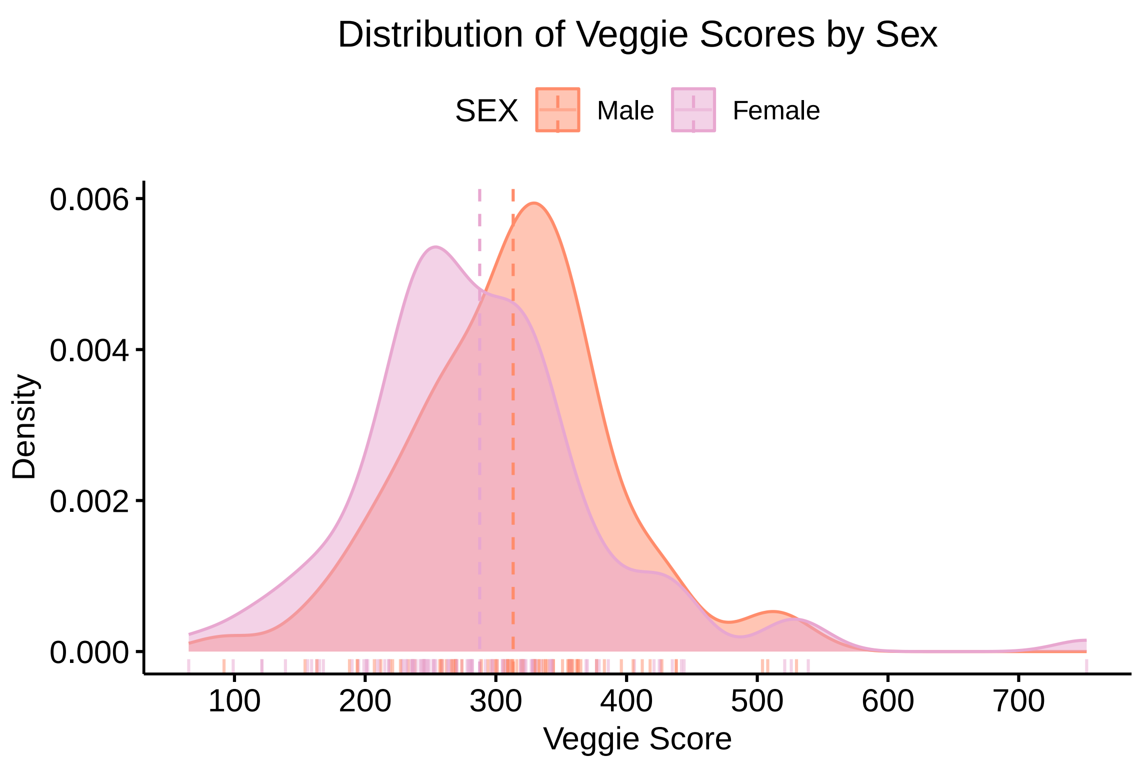

Figure 4: Figure 4. Density plot depicting the distributions of veggie scores of males in orange and female in pink. An independent samples t-test showed a statistically significant difference between male and female veggie scores (t = 2.0588 , p < 0.05).

```
ggsave("plot/veggiescore_sex_plot.png",
       plot = plot.sex.veggie,
       width = 10, height = 4, dpi = 300)
# source: https://stackoverflow.com/questions/21563864/ggplot2-overlay-density-plots-r (2014)
# explanation: created a veggie score distribution plot to visualize the difference between mal
```

```
# run independent sample t-test
t_test_results <- t.test(VEGGIE ~ SEX,
                         data = secondary_data,
                         var.equal = FALSE) # Use TRUE if Levene's test p > 0.05
print(t_test_results)
```

```

    Welch Two Sample t-test

data:  VEGGIE by SEX
t = 2.0588, df = 189.06, p-value = 0.04088
```

```
alternative hypothesis: true difference in means between group Male and group Female is not equ
95 percent confidence interval:
  1.071344 50.100047
sample estimates:
  mean in group Male mean in group Female
            313.2073             287.6216
```

```
# source: https://www.datacamp.com/tutorial/t-tests-r-tutorial
# explanation: ran an independent samples t-test on differences between veggie score by gender
```

An independent samples t-test was conducted to compare respondents' veggie scores based on biological sex. The test revealed a statistically significant difference between male (M = 313.2) and female (M = 287.62) respondents on fruit/vegetable consumption (t = 2.06, p = 0.041). The density plot in Figure 4 below displays veggie score distributions for the sample of men and the sample of women, showing that the median and mean for men are higher than those for women.

3.1.3.2 Location and Veggie Score

```
library(ggpubr)
library(ggplot2)
# create a second density plot for LOCATION and VEGGIESCORE
plot.location.veggie <- ggdensity(secondary_data, x = "VEGGIE" ,
          add = "mean" , rug = TRUE ,
          color = "LOCATION" , fill = "LOCATION" ,
          palette = c("#ff8c6b" , "#e8a7d0"),
          title = "Distribution of Veggie Scores by LOCATION" ,
          xlab = "Veggie Score" ,
          add.params = list(linewidth = 1 , alpha = 1, linetype = "dashed")
          + scale_x_continuous(breaks = seq(100, 800, by = 100))) # change color of average lin

plot.location.veggie
```

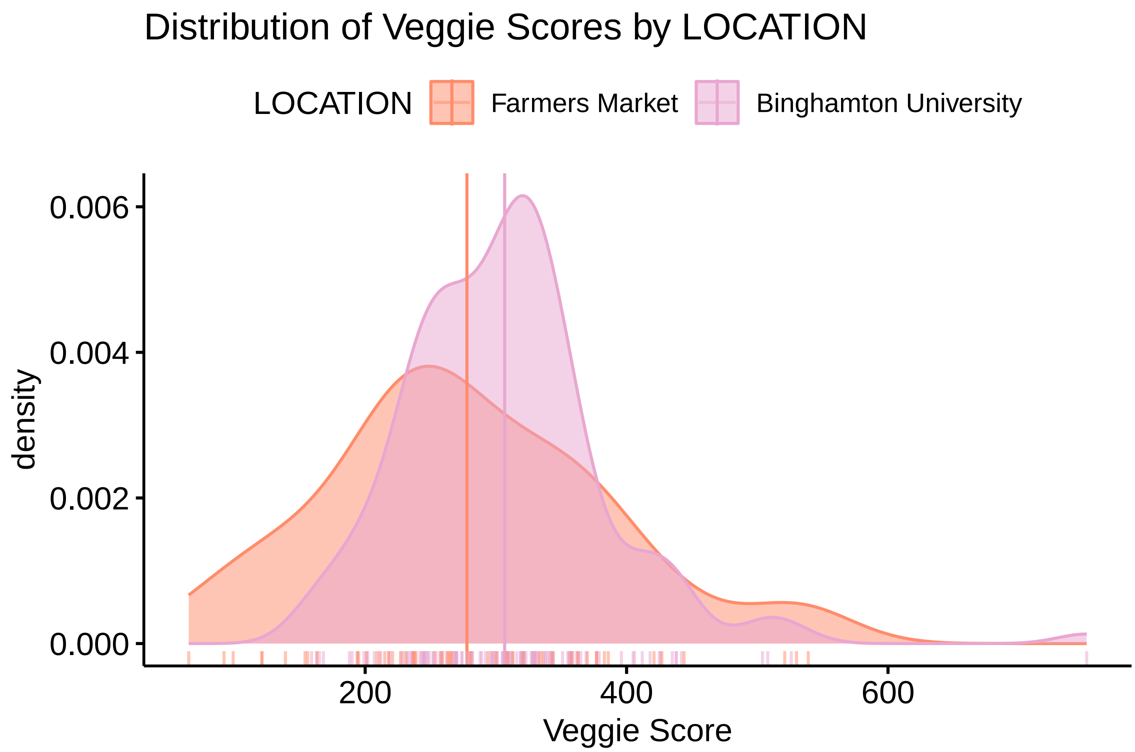

Figure 5: Density plot depicting the distributions of veggie scores taken at the farmers market in orange and at Bighamton University in pink

```
ggsave("plot/veggiescore_location_plot.png",
       plot = plot.location.veggie,
       width = 11, height = 6, dpi = 300)

# source: https://stackoverflow.com/questions/21563864/ggplot2-overlay-density-plots-r (2014)
# explanation: created a veggie score distribution plot to visualize the difference between pa
```

```
# run independent sample t-test
t_test_results <- t.test(VEGGIE ~ LOCATION,
                         data = secondary_data,
                         var.equal = FALSE) # Use TRUE if Levene's test p > 0.05
print(t_test_results)
```

```

	Welch Two Sample t-test

data:  VEGGIE by LOCATION
t = -1.8057, df = 78.155, p-value = 0.07482
alternative hypothesis: true difference in means between group Farmers Market and group Bingha
95 percent confidence interval:
 -60.684406   2.958714
sample estimates:
```

```
mean in group Farmers Market mean in group Binghamton University
                    277.8545                             306.7174
```

```
# soruce: https://www.datacamp.com/tutorial/t-tests-r-tutorial
# explanation: ran an independent samples t-test on differences of veggie score between locati
```

A second independent samples t-test was conducted to examine differences in F/V consumption based on one of two surveying locations: Binghamton University (to approximate students) or Broome County Farmers' Market (to approximate the Broome County community). The test showed no statistically significant relationship between the two variables, suggesting that Binghamton University students and Broome County residents did not have significantly different veggie scores (t = -1.81, p = 0.075). Despite this, participants surveyed at Binghamton University (M = 306.72) had a higher mean veggie score than those surveyed at the Broome County Farmers Market (M = 277.85). The density plot in Figure 5 below displays veggie score distributions for participants surveyed at the Broome County Farmers Market (orange) and at Binghamton University (pink), showing that the mean veggie scores are higher for those surveyed at Binghamton University.

3.1.3.3 Age and Veggie Score

```
library(ggplot2)
# create a scatter plot of age and veggiescore
plot.age.veggie <- ggplot(secondary_data, aes(x = AGE_1, y = VEGGIE)) + geom_point() + geom_smo

plot.age.veggie
```

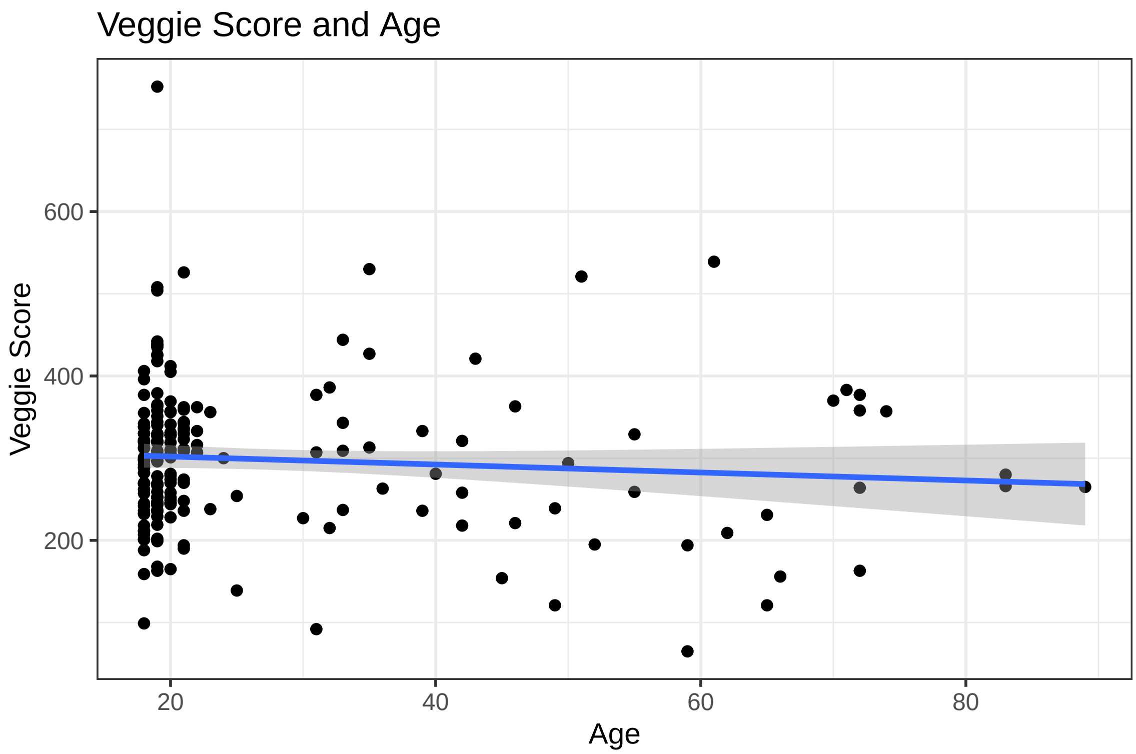

Figure 6: Figure 6. Scatter plot depicitng the relationship between age and veggie score. A linear regression was run which did not show a stastically significant relationship between veggie score and age (F = 1.47 , p = .227)

```
ggsave("plot/veggiescore_age_plot.png",
       plot = plot.age.veggie,
       width = 11, height = 6, dpi = 300)

# source: https://stackoverflow.com/questions/21563864/ggplot2-overlay-density-plots-r (2014)
# explanation: created a scatter plot depicting the relationship between age and veggie score
```

```
# linear model for age and veggiescore
lm_age_veggie <- lm(AGE_1 ~ VEGGIE, data = secondary_data)
summary(lm_age_veggie)
# source: https://www.datacamp.com/tutorial/linear-regression-R
# explanation: ran a linear regression on the relationship between veggie score and age
```

A linear model for age and veggie score found that the relationship between age and veggie score was not statistically significant. This means there was no statistically significant relationship between age and veggie score (F = 1.47, p = 0.23). Figure 6 shows there is a very weak, negative correlation between age and veggie score in the sample.

3.1.3.4 Health Status and Veggie Score

```r
library(dplyr)
library(ggplot2)
# Calculate means and 95% CI for each health status group
health_veggie_summary <- combined %>%
  group_by(HEALTHSTATUS) %>%
  summarise(
    Mean = mean(VEGGIE, na.rm = TRUE),
    SD = sd(VEGGIE, na.rm = TRUE),
    N = sum(!is.na(VEGGIE)),
    SE = SD / sqrt(N),
    CI_lower = Mean - 1.96 * SE,
    CI_upper = Mean + 1.96 * SE
  )
# Create the plot
health_veggie_plot_CI <- ggplot(health_veggie_summary, aes(x = HEALTHSTATUS, y = Mean)) +
  geom_col(fill = "#deffddff", color = "black", alpha = 0.7) +
  geom_jitter(data = combined,
              aes(x = HEALTHSTATUS, y = VEGGIE),
              width = 0.2,
              alpha = 0.15,
              size = 1.5,
              color = "black") +
  geom_errorbar(aes(ymin = CI_lower, ymax = CI_upper),
                width = 0.25,
                linewidth = 0.8) +
  scale_x_continuous(
    breaks = 1:5,
    labels = c(
      "1: Poor",
      "2: Fair",
      "3: Good",
      "4: Very Good",
      "5: Excellent"
    )
  ) +
  labs(
    x = "Subjective Health Status",
    y = "Average Veggie Score"
  ) +
  theme_bw()
health_veggie_plot_CI
```

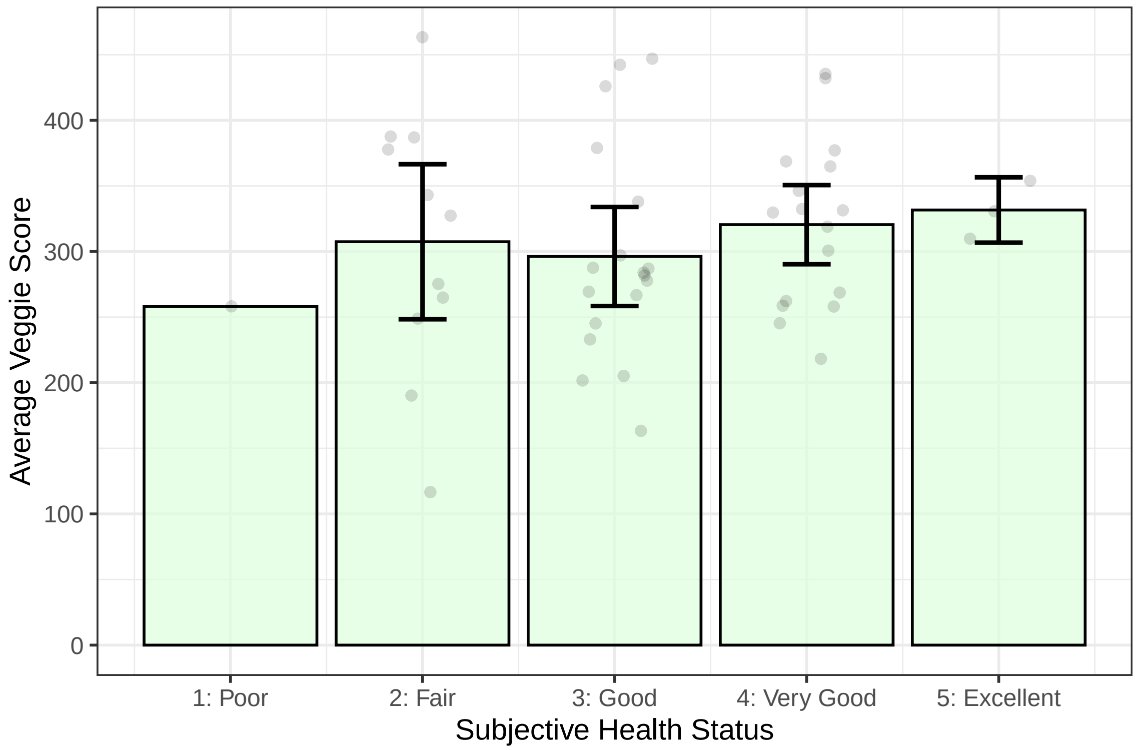

Figure 7: Figure 7. A bar graph depicting the relationship between perceived health status and average veggie score of Binghamton University students with 95% confidence intervals and individual data points.

```
ggsave("plot/health_veggie_plot_CI.png",
       plot = health_veggie_plot_CI,
       width = 11, height = 6, dpi = 300)
#source 1: The FRI Playbook (McCarty, 2025)
#explanation: creating a bar graph to display reported health status and average veggie score w
```

```
library(ggplot2)
library(tidyr)
# create a scatterplot of health status and veggie score
veggie.health.plot <- combined %>%
  drop_na(HEALTHSTATUS, VEGGIE, GENDER) %>%
  ggplot(aes(x = HEALTHSTATUS, y = VEGGIE)) +
  geom_jitter(aes(color = GENDER), width = 0.2, alpha = 0.6) +
  geom_smooth(method = "lm", se = FALSE, color = "#ceedc5ff")+
  xlab("Health Status") +
  ylab("Veggie Score") +
  theme_bw() +
  scale_x_continuous(
    breaks = c(1, 2, 3, 4, 5),
    labels = c("Poor", "Fair", "Good", "Very Good", "Excellent")) +
  scale_color_manual(
    name = NULL,
```

```
    values = c("Male" = "#ff8c6b", "Female" = "#e8a7d0"),
    labels = c("Male" , "Female")
  ) +
theme(axis.text = element_text(size = 10, hjust = 0.5), plot.title = element_text(hjust = 0.5)
print(veggie.health.plot)
```

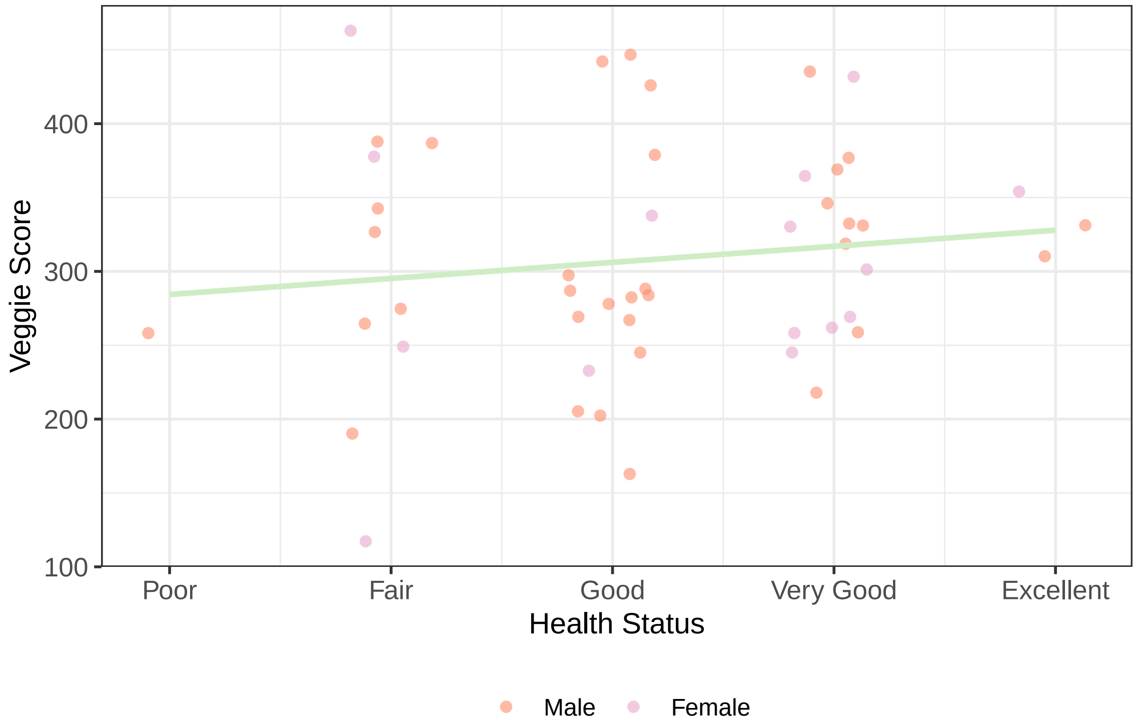

Figure 8: Figure 8. Scatter plot depicitng the relationship between perceived health status and veggie score. The colors of points correspond to gender of participants. Orange for male, pink for female. A pearson correlation was run which did not show a stastically significant relationship between veggie score and age (F = 1.47 , p = .227). An independent samples t-test was also run which did not show a statistically significant difference between the perceived health status of male and female participants.

```
ggsave("plot/veggiescore_health_plot.png")
# source: https://stackoverflow.com/questions/21563864/ggplot2-overlay-density-plots-r (2014)
# explanation: created a scatter plot depicting the relationship between perceived health statu
```

```
# pearson correlation for perceived health status and veggie score
cor.test(combined$HEALTHSTATUS, combined$VEGGIE, method = "pearson", use = "complete.obs")
```

```

    Pearson's product-moment correlation

data:  combined$HEALTHSTATUS and combined$VEGGIE
t = 0.91818, df = 48, p-value = 0.3631
```

```
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.1525464  0.3952727
sample estimates:
      cor
0.1313798
```

```
#source: (cor Function in R, 2025) https://www.r-bloggers.com/2025/03/cor-function-in-r-calcula
#explanation: running a pearson correlation test to examine statistical significance of the rel
```

Finally, a Pearson correlation showed no statistically significant relationship between reported health status and veggie score, suggesting that veggie score does not predict reported health status ($r = 0.13$, $p = .36$). Although these tests do not show statistical significance, it should be noted that among those who reported a health status of 5 (excellent) the average veggie score was about 325. On the other hand, the average veggie score for participants who reported a health status of 1 (poor) was just over 250. Despite these differences, the findings fail to reject the null hypothesis that reported health status is not correlated with veggie score. Individuals report the same level of health status regardless of their veggie score. Figure 8 shows a weak, positive correlation between participants' perceived health status and their Veggie Score.

3.2 Qualitative Results

Lay beliefs regarding decisions around the meal selection process, and lay beliefs of what constitutes "healthy" foods, were coded separately. For lay beliefs about healthy foods, 168 coded instances were recorded, and responses were coded into seven main categories (Table 2). For the decision-making process, 187 coded instances were recorded, and responses were coded into 19 main categories, with 14 subsequent child codes (Table 3). 301 total codes were yielded.

3.2.1 Lay Beliefs about Healthy Foods

Table 2 indicates the responses that participants gave to the question "List 3 healthy foods, and explain why you think they are healthy." 12 responses were excluded from the data due to a lack of relevant content. The coding frequencies and categories are listed below: Micronutrients ($n = 69$), Macronutrients ($n = 48$), Naturalness ($n = 20$), Processing ($n = 11$), Lack of added ingredients ($n = 9$), Feelings After Eating ($n = 8$), and Moderation ($n = 3$). The two most prominent codes were micronutrients and macronutrients. Responses that fell under the Micronutrient category emphasized micronutrients such as vitamins, fiber, and antioxidants as reasons to explain the health of a food. One participant claimed that oranges were healthy because "they are a good source of Vitamin C," while another participant said that blueberries were healthy because they "are high in fiber, micronutrients, and phytochemicals." Responses that fell under the macronutrient category emphasized carbohydrates, fats, or protein as reasons why a food, in their mind, is considered healthy. One participant stated that avocados are healthy because "they contain healthy fats," and another participant stated that oatmeal is healthy because "it contains good carbs." Lesser prominent codes included processing, naturalness, and a lack of added ingredients. The processing lay belief indicates participants who associated healthy foods with foods that were "minimally processed" or "whole foods." Examples include one participant who stated that carrots were healthy because “they are vegetables and they are not processed,” and another participant stated that salads were healthy because “they contain fiber and are not processed.” The next lay belief analyzed was the naturalness belief, characterized by the moral or intuitive belief that natural, real, or pure foods are healthier than artificial foods. One participant stated they believed oranges, raw cheese, and honey were healthy because “they come from natural sources and have been used for generations.” The lack of added ingredients category held participants who believed that the absence of certain excessive ingredients, such as sugar, salt, artificial sweeteners, or preservatives, made a food healthy. One participant in this category described grilled chicken as healthy because it didn’t contain “added sugars,” and another said grilled chicken was healthy due to the absence of “oil.” Other minor categories included feelings after eating and moderation. Those who fell into the feelings after eating category believed that foods were healthy because of the way these foods make them feel afterwards, or the way certain foods assist bodily functions. One participant referred to a myriad of foods as healthy because they were “super foods that give you high energy.” Lastly, participants in the moderation category emphasized either keeping calories to a minimum or keeping portions to a minimum when deciding what foods to consider “healthy.” One participant stated that carrots are healthy because they are “low in calories per serving.” Another participant emphasized the fact that whole grains were healthy because they are not “calorically dense.”

3.2.2 Meal Decision-Making Lay Beliefs

Table 3 shows responses to the questions: “Reflect on your decision-making process when deciding what to eat in the dining halls. Provide a list that generally captures how you think and make a decision about what food(s) to select.” and “What was the last meal you ate, and what pros & cons did you weigh when considering what to consume. For this meal, what other foods did you consider eating before selecting your final choice, and explain why you chose this meal over other choices.” 12 responses were excluded from the data due to a lack of relevant content. Three of the main codes are listed: Food label: (n=64), Perceptions of food (n=36), & Current offerings (n=22). Codes are organized by frequency, with only detailed excerpts being used as exemplars. Further detailed information regarding these codes, as well as subsequent codes, can be located in the appendix.

3.2.3 Food Label

The excerpts from this code arose from both qualitative questions, as students reported both what made foods objectively healthy, as well as their own decision-making processes. Respondents gave diverse answers pertaining to many parts of the food label, as reflected below: “A bagel was what I last ate and it had mostly carbs but not protein or nutrients” / “I dont really think about macros just calories” / “Calorie, nutrition balance, how much protein and fiber it has” / “Prices, sugars, calories” / “Look at calorie content, saturated fat, sugar, and protein” These exemplars reflected participants’ considerations when picking which meals to eat or not eat, with emphasis on the food label.

3.2.4 Perceptions of Food

Many of the excerpts of this code emerged from the second qualitative question, “What was the last meal you ate, and what pros & cons did you weigh when considering what to consume. For this meal, what other foods did you consider eating before selecting your final choice, and explain why you chose this meal over other choices."Participants provided many answers regarding what they think when actually choosing a meal: "Nutrients, production, perception of food" / "Something semi-healthy and low calorie" / "How expensive and healthy it looks" These excerpts show respondents who consider how they see the food as healthy, whether it visually seems healthy, or if the participant thinks the nutritional profile of the food makes it so.

3.2.5 Current Offerings

Many responses which were coded under Current Offerings arose from the second qualitative question, "What was the last meal you ate, and what pros & cons did you weigh when considering what to consume. For this meal, what other foods did you consider eating before selecting your final choice, and explain why you chose this meal over other choices."As it appears to be a point that participants did not consider when thinking objectively, but once participants had to choose a meal in real life, this became a situational factor. "What is available (I am a super picky eater)" / "I considered eating cereal but they didn't have the one I wanted" / "I had chicken and rice but they didn't have vegetables which was rather upsetting" / "Sometimes though I walk in C4 hungry and will walk out if nothing appeal to me" / "Generally just eat what is there and there usually isn't much nutritious choice" These responses show that participants are aware of this situational constraint, and they are aware that this constraint may be negatively affecting their health, as is stated outright by #5, as well as implied by #3 when stating no vegetables were available.

4 Discussion

This mixed-methods study provides new evidence regarding fruit/vegetable consumption for Binghamton University and Broome County residents, along with associated lay beliefs on food. The results suggest that biological sex is related to veggie score, and, even though participants can accurately identify aspects of healthy foods, situational factors still result in an intention-behavior gap. These results support the original hypothesis that male participants would have higher veggie scores. When examined with the Social Ecological Model in mind, these findings raise the idea that despite veggie scores being higher than the national average and participants demonstrating nutrition knowledge, there are still environmental factors that block participants from regularly consuming nutrient-dense foods. These results are consistent with McKinley et al., while also extending the literature by focusing on an underrepresented sample.

4.1 Main Findings

The findings of this study suggest a significant intention-behavior gap, in which conceptual understanding of nutrition fails to directly translate into proper dietary practice, due to environmental constraints (Figure 5). Although a chi-squared analysis showed no significant differences between lay beliefs and the sociodemographic variable 'gender' (Table 4), it is clear that many environmental factors influenced students' decision-making process when selecting meals. The main quantitative finding of this study is that male participants, on average, have statistically significantly higher veggie scores than female participants. Higher veggies scores indicate that male participants in Broome County consume higher levels of fruits and vegetables than female participants. The findings are both supported and challenged by other research. A study conducted in 2003 focused on older adults and found that women ate significantly more F&V than men. Only 16% of men were found to eat the recommended five or more servings of F&V a day compared to about 34% of women (Baker & Wardle, 2003). However, a 2013 study that collected dietary scores found that adult women had higher total dietary scores than men did (Hiza et al., 2013). These opposing findings suggest that more work is needed to identify indicators of dietary behaviors by sex. On the other hand, the qualitative findings clearly reinforce the existing literature, which shows that young adults frequently make food choices based on price, convenience, and environmental access rather than solely on nutritional information (Li et al., 2022). These findings also align with the preexisting literature by asserting that lay beliefs, emotional reasoning, and environmental factors are important determinants of food selection and, by extension, health. The quantitative research hypothesized that males would have higher veggie scores than females; older participants would have higher veggie scores on average; and Broome County residents would also have higher veggie scores on average. The former hypothesis was supported, but the latter two hypotheses showed no significant differences and were therefore not supported. For the qualitative portion, it was hypothesized that students' knowledge and beliefs would not directly translate into proper dietary practices, such as consuming fruits and vegetables, which would theoretically lead to a higher veggie score. This hypothesis was supported by a variety of environmental factors that participants reported, which directly influenced decision-making processes when selecting nutritious foods such as fruits and vegetables. These findings align with the socio-ecological model, which postulates that students make food choices based on a variety of individual factors (personal beliefs and nutrition knowledge) and also a variety of external factors (time, convenience, and current offerings) The finding that these external factors often impede individual choices is consistent with the ecological determinants of health (Wardle et al., 2000).

4.2 Strengths and Limitations

This study provides an insight into the Broome County population's diet quality, nutrition knowledge, and meal decision-making. The mixed-methods design allowed for a broader understanding of these variables. Additionally, using both an objective and a subjective measure for health status gave valuable insight into the gap between health-status perceptions and reality. Discrepancies in this research may stem from a lack of literature on the Veggie Meter®. Additionally, the sample size presents a significant limitation for the qualitative results of this study. Unfortunately, significant attrition was observed between these two surveys—many participants who completed the Veggie Meter® and entered their biological data failed to fill out the second survey and therefore failed to provide qualitative data. Furthermore, research using larger, more representative samples is necessary to clarify whether location, sex, and age are true predictors of veggie score. Additional studies may also examine veggie scores longitudinally to better understand carotenoid level variability.

4.3 Broader Implications and Future Work

Dietary interventions on Binghamton University's campus and in Broome County should consider biological sex when developing community interventions, as sex appears to affect F&V consumption. Additionally, it should be considered that Binghamton University's campus does not have worse access to fruits and vegetables than the surrounding county. This would, however, raise questions regarding the quality of F&V access in Broome County as a whole. The qualitative findings show that future nutritional interventions need to go beyond simply providing factual information regarding nutrition and food selection- they need to pair factual information with environmental strategies such as improving the offerings of on-campus dining and promoting tasty, convenient, and nutritious food recipes for those who do not rely on campus dining. In short, future nutrition interventions should incorporate both individual knowledge, beliefs, and environmental factors that impact how students feel and act in real-world contexts.

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