Diet Quality, Diet Motives, and Nutrition Literacy of Vegans, Vegetarians, and Semi-Vegetarians

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DIET QUALITY, DIET MOTIVES, AND NUTRITION LITERACY OF VEGANS, VEGETARIANS, AND SEMI-VEGETARIANS

by

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APPROVED FOR THE DEPARTMENT OF NUTRITION, FOOD SCIENCE AND PACKAGING

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ABSTRACT

DIET QUALITY, DIET MOTIVES, AND NUTRITION LITERACY OF VEGANS, VEGETARIANS, AND SEMI-VEGETARIANS

by Sapna Peruvemba

Individuals consuming plant-based diets have shown favorable dietary behaviors and diet quality. However, differences in diet quality considering motivations to adopt plant-based (vegan, vegetarian, and semi-vegetarian) diets and nutrition literacy, are not well known. The primary objective of this study was to assess diet quality, diet motives and nutrition literacy in vegans, vegetarians, and semi-vegetarians. The secondary objective was to investigate the association between diet motives and dietary quality. In this cross-sectional study, 223 participants completed an online survey and food frequency questionnaire. The study used the Healthy Eating Index-2015 to measure dietary quality, the Food Choice Questionnaire to measure diet-related motives, and the Nutrition Literacy Assessment Instrument to measure nutrition literacy. Vegans had higher diet quality (80.8±6.5 out of 100, p<0.001) compared to vegetarians (75.1±9.1), and semi-vegetarians (76.8±7.5). Ethics was the top diet motive for 69.4% of vegetarians, while health was the top motive for 50% of vegans and 45.3% of semi-vegetarians. No differences in nutrition literacy were observed among groups; the overall mean score was 59.0±3.1 (out of 64). An increased importance of health (p=0.004) and natural content (p=0.016) was associated with increased diet quality, whereas an increased importance of sensory appeal (p=0.047) and weight control (p=0.033) was associated with decreased diet quality. Overall, the plant-based population has high diet quality and nutrition literacy. Future programs can make public health messages that encourage plant-heavy diets more appealing by considering top motives and nutrition literacy.
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LIST OF ABBREVIATIONS

AND — Academy of Nutrition and Dietetics
HEI — Healthy Eating Index
DGA — Dietary Guidelines for Americans
MDS — Mediterranean Diet Score
VLI — Vegetarian Lifestyle Index
FCQ — Food Choice Questionnaire
NLit — Nutrition Literacy Assessment Instrument
DHQ III — Diet History Questionnaire III
Chapter 1: Literature Review

Introduction

Plant-based diets are increasing in popularity, both in the public and in the scientific community. A national Harris Poll conducted by the Vegetarian Resource Group in 2020 identified that 6% of the US adult population, or 15.2 million adults, identified as vegetarian, and 3% comprised vegans (VRG Blog Editor, 2020). Moreover, 25% of the US adult population stated that they sometimes or always bought vegan meals when eating outside of home (VRG Blog Editor, 2020). Plant-based diets, which include vegan, vegetarian, and semi-vegetarian diets, are high in fruits, vegetables, nuts, seeds, legumes, and whole grains, and have been shown to reduce chronic disease risk and mortality (Melina et al., 2016; Schwingshackl et al., 2018). According to the Academy of Nutrition and Dietetics (AND), a vegan diet is one that excludes all animal products, a vegetarian diet is one that includes only dairy and/or eggs, and a semi-vegetarian diet includes all animal products but limits meat intake (Melina et al., 2016).

Current literature focuses on the comparatively higher diet quality and health outcomes in vegans and vegetarians than in omnivores. Plant-based individuals are often motivated by health and ethics, as well as have high health literacy, factors that are thought to contribute to the healthier dietary behaviors in this population (Janssen et al., 2016). Janssen et al. (2016) states that ethical reasons typically relate to animal rights and welfare, and environmental reasons include greenhouse gas emissions from food production, deforestation due to animal agriculture, and lack of natural resources.
Religious groups like Hindus and Seventh Day Adventists also encourage the consumption of a vegetarian diet due to animal welfare beliefs (Janssen et al., 2016). The 2020 Dietary Guidelines Advisory Committee reported that dietary patterns have not changed within the past decade. Most Americans continue to under consume plant-based foods (fruit, vegetables, and whole grains) and meet or surpass recommended amounts for protein foods and solid fats (Dietary Guidelines Advisory Committee, 2020). The purpose of this literature review is to identify what motivates people to follow vegan, vegetarian, and semi-vegetarian diets and how these motives relate to diet quality so that we can develop strategies to help consumers to better meet the dietary guidelines.

PubMed and Google Scholar were used to search for original peer-reviewed journal articles. Peer-reviewed studies were identified through the keywords “vegan”, “vegetarian”, “semi-vegetarian”, “plant-based”, “diet quality”, “nutrition literacy”, and “vegan motives”.

**Diet Quality Overview**

Diet quality measures an individual’s compliance with dietary guidelines to determine if an eating pattern is nutritionally adequate (Krebs-Smith et al., 2018). Methods of assessing diet quality include short questionnaires and dietary indices, which study both adequacy of beneficial food groups and nutrients (e.g., legumes), and moderation of harmful food groups and nutrients in the diet (e.g., trans fat) (Parker & Vadiveloo, 2019). Researchers prefer to examine food groups and nutrients together, since evaluating individual foods or nutrients will fail to consider their synergistic effects (Clarys et al., 2014). Those with diet quality scores in the highest quintile had a 13-23% decrease in all-cause, cancer, and cardiovascular
mortality compared to those with diet quality scores in the lowest quintile (Reedy et al., 2018).

According to Krebs-Smith et al. (2018), the Healthy Eating Index (HEI) determines how well a diet meets the U.S. Dietary Guidelines for Americans (DGAs). This diet quality index consists of 13 components: total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total proteins, seafood and plant protein, fatty acids, refined grains, sodium, saturated fats, and added sugars (Krebs-Smith et al., 2018).

Another common method, the Mediterranean Diet Score (MDS), includes seven beneficial (vegetables, legumes, fruits and nuts, cereal, and fish), and three detrimental components (meat, poultry, and dairy products) (Trichopoulou et al., 2003). The Vegetarian Lifestyle Index (VLI) contains 11 dietary components based on the Loma Linda University Vegetarian Food Guide Pyramid (Le et al., 2018). This methodology assesses whole grains, legumes, soy and meat substitutes, vegetables, fruits, nuts and seeds, and vitamin B-12 rich foods for adequacy, and sweets, vegetable oil, dairy, egg, and meat and fish consumption for moderation (Le et al., 2018).

While both HEI and MDS are common indices to examine diet quality, the HEI does not require all food groups to be consumed to deliver a high score, whereas the MDS requires all diet components to be included for a diet to score high (Reedy et al., 2018). This makes it difficult for those with restrictive diets like the vegan diet to receive superior MDS scores due to the lack of certain food groups. The VLI is more accommodating to vegan and vegetarian diets (Le et al., 2018).
Based on National Health and Nutrition Examination Survey data from 2011-2012, the mean HEI-2015 score was 56.6 in the American population (Reedy et al., 2018). Conrad et al. (2017) discovered that mean HEI-2010 scores were 16 points higher in non-meat eaters (72.8) compared with meat-eaters (56.4) in 2007-2012 National Health and Nutrition Examination Survey data. A Belgian study by Clarys et al. (2014) found the highest HEI total scores in vegans (65.4), followed by semi-vegetarians (59.4), and pescatarians and lacto-ovo-vegetarians (58.7). Similarly, a Seventh-Day Adventist study by Le et al. (2018), utilizing the VLI, found non-vegetarians to have the lowest mean VLI score (6.38 out of 14), and vegans to have the highest mean VLI score (9.27 out of 14). While Clarys et al. (2014) reported greater diet quality scores in semi-vegetarians than in pescatarians and lacto-ovo-vegetarians, Le et al. (2018) found that lacto-ovo-vegetarians scored next highest to vegans in diet quality, followed by pescatarians, and semi-vegetarians. Further investigation is warranted to determine differences in diet quality among these plant-based diet groups.

In the Hargreaves et al. (2020) study, the highest frequency of fruit and vegetable consumption was seen in vegans, followed by pescatarians, whereas the lowest consumption was observed in semi-vegetarians and ovo-lacto-vegetarians. Gili et al. (2019) observed that the vegan diet was characterized by the highest consumption of whole grains, legumes, nuts and seeds compared with the lacto-ovo-vegetarian, pescatarian, semi-vegetarian, and non-vegetarian diets. Both Gili et al. (2019) and Hargreaves et al. (2020) noticed the lowest intakes of sweets and soft drinks and regular intake of seafood or plant proteins in vegans and pescatarians, while non-vegetarians had the highest intakes of sweets and soft drinks. While seafood or plant protein intake was low in non-vegetarians, this group was characterized by
the most regular intake of dairy and eggs (Gili et al., 2019). These observations provide insight into the higher diet quality scores seen in plant-based individuals compared to those not following a plant-based diet.

**Macronutrients**

In a 2015 Kristensen et al. study, vegans reached the recommended daily intake of energy, carbohydrates, and fats but did not meet the recommendation for daily protein intake set by the Nordic Nutrition Recommendations. Johnston et al. (2018) similarly found that vegans had a 29% lower protein intake compared to omnivores, while other macronutrients did not present significant differences. Researchers observed better fatty acid profiles in vegans than in non-vegetarians (Johnston et al., 2018; Kristensen et al., 2015). Specifically, vegan subjects had higher polyunsaturated fatty acid intake and lower saturated fat, monounsaturated fatty acid, trans fat, and cholesterol intake compared to the general Danish population (Kristensen et al., 2015). The vegan group also had higher fiber and lower added sugar intake than the non-vegetarian group (Kristensen et al., 2015).

A review by Sakkas et al. (2020) found protein to be the most worrisome macronutrient in the vegan diet, which is consistent with previous findings by Kristensen et al. (2015) and Johnston et al. (2018). Most plant proteins, like legumes for example, contain some essential amino acids but not all (Melina et al., 2016). The components within common plant foods, such as phytates and tannins, may hinder protein absorption as well. However, the AND has stated that if a vegan diet is planned and properly balanced with a variety of foods in the diet, all essential amino acids can be obtained solely from plant sources (Melina et al., 2016).
**Micronutrients**

While the AND has stated that plant-based eating can be nutritionally adequate, there are concerns with certain nutrients, such as iodine, zinc, calcium, vitamin B12, vitamin D, and omega-3 polyunsaturated fatty acids (Elorinne et al., 2016; Kristensen et al., 2015; Schüpbach et al., 2017). The vegan diet is characterized by high fruit and vegetable consumption, leading to increased phytochemical and vitamin intake in the body (Elorinne et al., 2016). Schüpbach et al. (2017) and Allès et al. (2017) found that magnesium, vitamin C, and folate intake and status was highest in vegans and most likely to be inadequate in non-vegetarians. Beta-carotene, potassium, iron, and vitamin E intake and status were also highest in the vegan group and lowest in the non-vegetarian groups in Schüpbach et al. (2017) and Kristensen et al. (2015) studies. Despite this observation, one of the major concerns of vegan diets is the risk of micronutrient deficiencies.

Kristensen et al. (2015), Elorinne et al. (2016), and Schüpbach et al. (2017) listed vitamin B12 and vitamin D as common deficiencies among vegan subjects since these vitamins are predominantly found in animal-based foods. However, the vitamin B12 status among vegans consuming vitamin B12 supplements was significantly higher than those not supplementing (342 pmol/l vs. 274 pmol/l), and the prevalence of deficiency was lower in the supplementing group (Schüpbach et al., 2017). The low vitamin D intake in the vegan group, combined with insufficient calcium intake observed in vegans from the Allès et al. (2017) and Clarys et al. (2014) studies may indicate high susceptibility to osteoporosis in vegans. It is important to note that vitamin D intake may not be indicative of vitamin D status in the body, since this vitamin can be synthesized from sun irradiation as well (Schüpbach et al., 2017). Other
micronutrients of concern in vegans include iodine and zinc, since flesh foods and dairy products were popular dietary sources of these nutrients in the countries studied (Schüpbach et al., 2017).

While Kristensen et al. (2015) and Elorinne et al. (2016) found selenium intake and status to be low in vegans, and Allèes et al. (2017) found inadequate pantothenic acid intake in vegans, Schüpbach et al. (2017) did not find any significant differences in selenium or pantothenic acid status between vegan and omnivore subjects. Similarly, Kristensen et al. (2015) and Allèes et al. (2017) found vitamin A and riboflavin intake to be low in vegans, whereas other studies did not report significant differences in these nutrients between vegan and non-vegetarian subjects. Seeing as Kristensen et al. (2015) studied Danish subjects, Elorinne et al. (2016) studied Finnish subjects, Allèes et al. (2017) studied French subjects, and Schüpbach et al. (2017) studied Swiss subjects, these conflicting findings may be the result of studying specific populations that differ in cultural eating habits and food availability.

Diet Motives Overview

A person's dietary behaviors may be driven by several individual psychological reasons. These motives may be divided into two types: intrinsic and extrinsic motives. An intrinsically motivated person performs a behavior because it is personally rewarding to them, e.g., the food choice aligns with their ethical or health beliefs, while an extrinsically motivated person performs a behavior to receive an external reward, such as choosing food for lower body weight, improved mood, or cheaper prices (Satia et al., 2001). Intrinsically motivated dieters have been shown to have increased dietary adherence compared to extrinsically motivated
diets, since their motives for choosing foods are not likely to be swayed by external factors (Cruwys et al., 2020). There is a consensus in the literature that ethics and health are the most popular motives to following any plant-based diet (Cruwys et al., 2020; Dyett et al., 2013; Janssen et al., 2016; Radnitz et al., 2015; Vizcaino et al., 2020). However, the research is not in agreement when it comes to categorization of these motives (Miki et al., 2020). The label “ethical” has been used to describe everything from religion to animal rights to the environmental impact of food (Miki et al., 2020). Some studies (Hagmann et al., 2019; Radnitz et al., 2015) classify health and weight-related motives into different sections instead of grouping them together like other researchers have done (Dyett et al., 2013; Janssen et al., 2016). For this literature review, dietary motives were categorized into two main sections as established by the literature: ethics-related, and health-related motives.

Most studies assessed motives using open-ended survey questions regarding motivations to follow a diet. Importance of motives was assessed through a Likert-type scale indicating the level of agreement with different motive-related statements in a few studies (Hagmann et al., 2019; Janssen et al., 2016). Whereas, Radnitz et al. (2015) had subjects rank motivations based on personal importance. Some studies required one motive to be selected, whereas others, like the Janssen et al. (2016) study, allowed subjects to choose multiple motivations, stating that 81.8% of subjects selected more than one motive. Cruwys et al. (2020) utilized the Food Choice Questionnaire (FCQ), a 36-item questionnaire including the natural content, sensory appeal, convenience, health, familiarity, and other motives to choosing foods. Previous studies have shown that individuals often report more than one motive to follow a diet or make dietary choices (Lindeman & Väänänen, 2000; Miki et al., 2020). Methods, such
as the FCQ with Likert scale, and ranking questions, better captured the complexity of
different motivational factors in food choice and their relative importance (Lindeman &
Väänänen, 2000; Miki et al., 2020). Consequently, studies that solely measured participants’
top motive to follow their diet failed to consider the multidimensionality of food choice
motivation (Lindeman & Väänänen, 2000; Miki et al., 2020).

**Ethics-Related Motives**

Vizcaino et al. (2020) found that vegetarian subjects applied their ethical beliefs in their
daily lives through the food they chose to consume. In the Cruwys et al. (2020) study, vegan
subjects stated guilt and disgust for eating an animal, the idea that animals are equals, and
respect for animals as specific reasons for adopting their diet. These beliefs may stem from
the disapproval of animal agricultural practices, and the animal suffering and disregard for
animal rights it allows (Dyett et al., 2013; Radnitz et al., 2015). Janssen et al. (2016) reports
that around 80% of vegan subjects agreed that animals deserve to die of natural causes, and
77% of subjects stated that they would not purchase animal products even if there was a
guarantee that the animals were treated well.

According to Vizcaino et al. (2020), these beliefs are not limited to vegan subjects.
Vegetarians and flexitarians also exhibit the desire to consume plant-based foods to show
animal empathy.

Evidence indicates that the production of animal-based foods depletes our natural
resources on a larger level than do plant-based foods (Vizcaino et al., 2020). According to
Pimentel and Pimentel (2003), 25 kilocalories of fossil fuels are expended to generate one
kilocalorie of animal protein, and beef production alone requires forty times that amount of
energy. As a result, animal agriculture alone is responsible for 10-12% of global greenhouse gas emissions, as well as substantial natural resource use (Friel et al., 2009). On the other hand, only 2 kcal of fossil fuels are expended to generate one kcal of plant protein (Pimentel & Pimentel, 2003). Consequently, researchers studying vegans and vegetarians have noticed that natural resource preservation, climate change activism, sustainability, and natural land conservation are common environmental reasons for being vegan, vegetarian, or semi-vegetarian (Janssen et al., 2016). Plant-based individuals often choose to follow this diet, as it reduces meat and dairy consumption, and the related environmental burden from livestock farming.

**Health-Related Motives**

Vegan, vegetarian, and semi-vegetarian diets have grown in popularity over the years because of health outcomes related to chronic disease prevention and management (Sakkas et al., 2020). Not only can vegan diets be utilized to prevent a wide array of chronic inflammatory diseases including cardiometabolic disease, diabetes, and rheumatoid arthritis, but they have also shown promise in the management of cardiovascular disease, diabetes, and obesity (Schwingshackl et al., 2018). Even semi-vegetarian subjects, who occasionally consume meat, have experienced improvements in weight and lipid profile after adopting their diet (Vizcaino et al., 2020). Nonetheless, individuals may adopt a plant-based diet due to a variety of health-related motivations. Miki et al. (2020) found that many plant-based eaters believe that meat is unhealthy, and that meat reduction or elimination can improve their health. Cruwys et al. (2020) subjects stated the avoidance of pain and other uncomfortable
symptoms, increased confidence in appearance and weight, and better energy and skin as specific reasons for adopting their diet.

*Dietary Adherence*

Understanding motives behind selected diets is important considering that it may predict better dietary adherence. While many restrictive diets such as weight loss or keto diets have low levels of dietary adherence, vegetarians and vegans are often able to adhere to these diets for years (Cruwys et al., 2020). Cruwys et al. (2020) discovered that personality characteristics, mental health, and intrinsic diet motivators predicted better dietary adherence. Self-efficacy and social identification were highest in vegan subjects, while extrinsic motives like mood and weight control were highest in weight loss subjects (Cruwys et al., 2020). Vizcaino et al. (2020) revealed that those able to adhere to a plant-based diet long-term had a stronger self-regulatory system, including a greater sense of value, planning, and positivity, compared to those unable to adhere to this diet long-term.

*Motives by Diet*

According to a cross sectional study by Cruwys et al. (2020), vegan and vegetarian subjects were strongly motivated by ethical concerns, at 80.5% of vegans and 46.7% of vegetarians reporting ethical motives to adhere to their diet. On the other hand, paleo, gluten-free, and weight loss dieters were largely motivated by health concerns, at 68.8% of gluten-free, 53.8% of paleo, and 48.6% of weight-loss dieters reporting health as the reason to adhere to their diet (Cruwys et al., 2020). A similar result was found by Hagmann et al. (2019), who reported that vegans, vegetarians, and pescatarians were driven by animal welfare and environmental motives, whereas low meat consumers stated weight-related
motives more often. In a Janssen et al. (2016) study that observed solely vegan subjects, 89.4% of vegans mentioned animal-related motives, 69.3% mentioned health-related motives, and 46.8% mentioned environment-related motives.

**Association Between Diet Motives and Diet Quality**

Existing research on the relationship between diet quality and motivation is unclear. A recent study conducted during the COVID-19 lockdown in France reported that increased importance of weight control as a dietary motive was associated with higher diet quality, whereas increased importance of mood as a dietary motive was associated with lower diet quality (Marty et al., 2021). Interestingly, in a Hagmann et al. (2019) study including vegans, vegetarians, pescatarians, and low meat consumers, greater motivation by weight-loss was related to increased meat consumption. Subjective data from this study showed that low meat consumers, who were most likely to be motivated by weight loss, stated increased difficulty in reducing meat consumption compared to individuals following other diets (Hagmann et al., 2019). Radnitz et al. (2015) found that health-motivated vegans incorporated fruits and fruit juice into the diet more often per month ($p = 0.03$) than did those with other motivations.

Moreover, Dyett et al. (2013) found that health-motivated vegans use boiling/steaming often when cooking and choose reduced-fat products whenever possible. These dietary practices reduce saturated fat intake and limiting this undesirable component may contribute to the high diet quality scores seen in vegans.

Individuals without health-related motives demonstrated healthy eating behaviors as well. A Dyett et al. (2013) study in US vegans revealed that 100% of vegans motivated by religion and 82% of vegans motivated by animal-related ethics typically chose reduced-fat products,
thereby limiting undesirable saturated fat intake (Dyett et al., 2013). In a Swiss study by Hagmann et al. (2019) involving vegans, vegetarians, pescatarians, and self-declared low meat consumers, being motivated by animal welfare and enjoying vegetarian products were associated with lower meat consumption. Radnitz et al. (2015) observed that animal-motivated vegans consumed soy-based foods, vitamin D-rich foods, and multivitamins and supplements (specifically vitamin D and B12), more frequently per month than did health-motivated vegans. However, they also reported higher intake of sugary foods per day than their health-motivated counterparts (Radnitz et al., 2015). A French NutriNet-Santé study by Allès et al. (2017) observed that those motivated by sustainability motives such as ethics and environment, and local and traditional food production had a healthier dietary pattern, higher in fruit, vegetable, legume, starch, fish/seafood, and eggs, and lowest in sweet, salty, and fatty foods, and processed meat and cheese, compared to those not motivated by sustainability motives.

Torna et al. (2021) is the first to investigate the relationship between diet motivation and dietary quality among vegetarians. In this study, health-motivated vegetarians had higher HEI-2015 scores than other-motivated vegetarians (p < 0.02), but not animal-motivated vegetarians (Torna et al., 2021). Health-motivated vegetarians ate more whole grains, total protein, seafood and plant protein, compared to other-motivated vegetarians (p < 0.05) (Torna et al., 2021). Compared to animal- and other-motivated vegetarians, health-motivated vegetarians also consumed a higher ratio of poly-and monounsaturated to saturated fatty acids and fiber (p < 0.05) (Torna et al., 2021). Results from this study corroborate that the association between diet quality and diet motivation is observed in vegetarians.
Nutrition Literacy Overview

Health Literacy

The Institute of Medicine defines health literacy as “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” (Neilson-Bowman, 2004, p. 1). There are an estimated 80 million Americans with poor health literacy, which has shown to increase the nation’s hospitalization rates, healthcare costs, and mortality rates (Berkman et al., 2011). Berkman et al. (2011) found that minorities, elderly, and people with lower education and incomes are disproportionately affected by low health literacy. Additionally, Danish individuals with long-term health conditions struggle more to understand health information than the general population, a finding that has not been observed in Americans (Friis et al., 2016). Many of these conditions, including diabetes, cardiovascular disease, and cancer, are prevalent in the United States and influenced by dietary factors (Friis et al., 2016).

Nutrition Literacy

While almost a third of Americans have deficits in health literacy, nutrition literacy levels in the US have not been well established (Berkman et al., 2011). Few health literacy studies include a nutrition component, despite diet being a key risk factor for many chronic diseases. However, a healthy diet is more likely to be adopted and maintained by individuals with nutrition-related skills, motives, and knowledge (Gibbs et al., 2018). Nutrition literacy is the level of ability to evaluate and understand nutrition information and make educated dietary choices (Gibbs et al., 2018).
Registered dietitians identified that macronutrient intake, food group and composition, and basic math and food measurement skills were necessary components of nutrition literacy (Gibbs & Chapman-Novakofski, 2012). Velardo (2015) breaks down the term into three key components: functional, interactive, and critical nutrition literacy. Functional nutrition literacy is the knowledge and understanding of dietary information and its impact on health (Velardo, 2015). Interactive nutrition literacy is the ability to translate the aforementioned knowledge into dietary behavior change (Velardo, 2015). Critical nutrition literacy comprises the analytical and problem-solving skills necessary to overcome barriers to proper nutrition (Guttersrud et al., 2014).

Many tools exist for measuring health literacy and/or numeracy, but few can comprehensively assess nutrition literacy. The Newest Vital Sign is one of the most used, and this 6-item tool partially measures functional nutrition literacy through nutrition label reading (Weiss et al., 2005). Similarly, the Nutritional Literacy Scale only considers functional nutrition literacy by assessing factual knowledge and familiarity reading health information (Diamond, 2007). More recently, the Critical Nutrition Literacy Instrument was developed, and this tool partially measures interactive nutrition literacy and fully measures critical nutrition literacy through questions about perceived ability to critically analyze nutrition information and reduce barriers to healthy eating (Guttersrud et al., 2014). However, the Nutrition Literacy Assessment Instrument (NLit) includes items across all three forms of nutrition literacy (functional, interactive, and critical) (Gibbs et al., 2018). The NLit contains questions regarding knowledge of food groups, nutrient content of foods, relationship between diet and health, portion sizes, nutrition label reading and consumer skills (Gibbs et
al., 2018). While these tools have been used across a range of populations, nutrition literacy has yet to be studied in plant-based individuals.

**Vegetarian Nutrition Literacy**

No current research has comprehensively assessed nutrition literacy in a plant-based population. Existing studies have focused solely on functional nutrition literacy, or in determining nutrition knowledge, in these individuals. Hoffman (2017) theorizes that vegetarians must develop greater nutrition knowledge to justify their diet in a mostly non-vegetarian society, as well as to maintain a nutritionally adequate diet. DeMay et al. (2019) administered a nutrition knowledge questionnaire and observed that vegetarians scored highest on questions relevant to their diet (animal versus plant topics), non-vegetarians scored highest on general nutrition questions, and semi-vegetarians scored highest on complex nutrition questions. This indicated there was no one diet group with more knowledge than the others, although semi-vegetarians had a deeper knowledge of nutrition over vegetarians and non-vegetarians (DeMay et al., 2019). Saintila et al. (2021) similarly reported no significant differences in the level of nutritional knowledge between vegetarians and non-vegetarians. In fact, only 16.1% of vegetarians and 18.4% of non-vegetarians received a score deemed sufficient (>80%) on the nutrition knowledge questionnaire (Saintila et al., 2021). Leonard et al. (2014), on the other hand, observed that vegetarians and semi-vegetarians had slightly higher nutrition knowledge scores than non-vegetarians, although this study measured dietary iron related nutrition knowledge and was not a comprehensive measurement of nutrition literacy. There is a paucity of well-designed studies comprehensively addressing the nutrition literacy of vegetarians. Acquiring this insight will
enable healthcare professionals to provide suitable nutrition education to this population, thereby bridging gaps in knowledge that could put vegetarians at risk for nutritional imbalances.

**Association Between Nutrition Literacy and Diet Quality**

Nutrition literacy is shown as a major predictor of diet quality (Gibbs et al., 2018). A Spronk et al. (2014) systematic review of 29 relevant studies found that most showed a significant positive, but weak correlation between nutrition knowledge and dietary intake, although none of these studies assessed all three forms of nutrition literacy. Taylor et al. (2019) discovered that low nutrition literacy indicated a diet characterized by fried and processed foods, red meat, and sugar-sweetened beverages. Whereas those with high nutrition literacy had healthful dietary practices including lower sugar intake, improved energy balance, and increased nut and vegetable intake (Taylor et al., 2019). However, few studies have assessed this relationship using a validated and comprehensive nutrition literacy instrument (Spronk et al., 2014). There is a clear need for further research to strengthen the limited evidence base.

**Summary**

While certain nutrient deficiencies remain a concern, plant-based diets are evidenced to be nutritionally adequate as seen by high HEI, MDS, and VLI total scores. Regardless of diet, plant-based individuals exhibited higher dietary quality than those not following a plant-based diet. Vegans obtained the highest diet quality scores, while vegetarians, semi-vegetarians, and pescatarians obtained comparable scores (Clarys et al., 2014; Le et al., 2018). Vegetarian and vegan diets were also characterized by high dietary adherence, while
the lowest dietary adherence was observed in other restrictive diets like weight loss diets (Cruwys et al., 2020). Ethical and health reasons were the most popular motivators to follow any kind of diet, and these intrinsic motives may be associated with diet quality and dietary adherence (Cruwys et al., 2020; Marty et al., 2021). Higher nutrition knowledge may contribute to the higher diet quality seen in vegetarians, although research using validated, comprehensive nutrition literacy instruments is lacking in this population.

This review featured a variety of diverse populations around the world, as well as many different types of diets. A variety of different diet quality indices were also represented, allowing for greater insight into the diet quality of different eating patterns (Clarys et al., 2014; Le et al., 2018). In older studies, the HEI-2010 was used to measure dietary quality (Clarys et al., 2014). This index was not representative of the most recent HEI released in 2015, which replaced empty calories with saturated fat and added sugars, for a total of 13 components (Krebs-Smith et al., 2018). However, the VLI data allowed a greater range of values that could differentiate between vegetarians and non-vegetarians to be observed (Le et al., 2018). Many of the existing nutrition literacy instruments were also discussed, highlighting the need for development of validated, comprehensive tools to assess all components of nutrition literacy (Spronk et al., 2014). In addition, there was no consensus in the literature about the characterization of motives and assessment methods. Finally, there is value in additional research on the association between dietary motivations and diet quality, and the characterization of nutrition literacy, especially in the vegetarian and vegan population.
Chapter 2: Journal Article

DIET QUALITY, DIET MOTIVES, AND NUTRITION LITERACY OF VEGANS, VEGETARIANS, AND SEMI-VEGETARIANS

ABSTRACT

Objective: Plant-based individuals have shown favorable dietary behaviors and diet quality. However, differences in diet quality considering motivations to adopt plant-based (vegan, vegetarian, and semi-vegetarian) diets and nutrition literacy, are not well known. The primary objective of this study was to assess diet quality, diet motives and nutrition literacy in vegans, vegetarians, and semi-vegetarians. The secondary objective was to investigate the association between diet motives and dietary quality.

Design: Cross-sectional study

Participants: Plant-based adults (n= 223)

Variables measured: The main outcomes measured were diet motives, measured by the Food Choice Questionnaire, nutrition literacy, measured by the Nutrition Literacy Assessment Instrument, and dietary quality, measured by the Diet History Questionnaire III and Healthy Eating Index-2015. Other outcomes captured included dietary pattern (vegan, vegetarian, or semi-vegetarian) and sociodemographic characteristics (e.g., age, sex, race/ethnicity, education, income).

Analysis: A one-way ANOVA was conducted to compare diet quality, nutrition literacy, and diet motives among diets. Multiple linear regression was performed to identify significant predictors of diet quality.

Results: Vegans had higher diet quality (80.8±6.5 out of 100, p<0.001) compared to vegetarians (75.1±9.1), and semi-vegetarians (76.8±7.5). Ethics was the top diet motive for
69.4% of vegetarians, while health was the top motive for 50% of vegans and 45.3% of semi-vegetarians. No differences in nutrition literacy were observed among groups, the overall mean score was 59.0±3.1 (out of 64). An increase in the importance of health and natural content was associated with increased diet quality, whereas an increase in the importance of sensory appeal and weight control was associated with decreased diet quality.

**Conclusions and Implications:** The plant-based population has high diet quality and nutrition literacy. This has implications for future interventions, such as making public health messages that encourage plant-heavy diets more appealing by considering top motives and nutrition literacy.
Introduction

Plant-based diets are increasing in popularity, both in the public and in the scientific community.\(^1\) While a plant-based diet is primarily high in fruits and vegetables, whole grains, pulses, nuts and seeds, it may also include the reduction or exclusion of animal-based foods. For example, a vegan diet excludes all animal-based foods from the diet, a vegetarian diet excludes animal-based foods except for dairy and/or eggs, and a semi-vegetarian diet limits meat and flesh products.\(^2\) A national Harris Poll conducted by the Vegetarian Resource Group\(^1\) in 2020 identified that 6\% of the US adult population, or 15.2 million adults, identified as vegetarian, and half of this number comprised vegans. Moreover, 25\% of the US adult population stated that they sometimes or always bought vegan meals when eating outside of home.\(^1\)

When comparing vegan, vegetarian, semi-vegetarian, and non-vegetarians, vegans had the highest diet quality, followed by lacto-ovo-vegetarians and semi-vegetarians, and non-vegetarians had the lowest diet quality.\(^2,3\) This may be related to higher fruit, vegetable, whole grain, and plant protein intake and lower sweet and soft drink intake among vegans compared with non-vegetarian diets.\(^4,5\) Krebs-Smith et al.\(^6\) state that diet quality measures an individual’s compliance with dietary guidelines to determine if an eating pattern is nutritionally adequate. In a meta-analysis of prospective cohort studies, diets that scored highly on multiple diet quality indices were associated with a decreased risk of cardiovascular disease, cancer, type 2 diabetes, neurodegenerative disease, and all-cause mortality.\(^7\)
Health, sensory appeal, convenience, and price are shown to be the most important diet motives, or reasons for making food choices, in the general American population. However, ethics, such as animal welfare, environmental protection, and religion, and health, are the most popular motives to following a plant-based diet. Vizcaino and coauthors found that plant-based eaters applied their beliefs through the foods they chose to consume. These beliefs included disapproval of animal agriculture and its resulting animal suffering, natural resource depletion, and greenhouse gas emissions. Health is a prominent motivational factor among general and plant-based populations alike, and may be considered for weight control, chronic disease prevention and management, and naturality.

A healthy diet is more likely to be adopted and maintained by individuals with nutrition-related skills, motives, and knowledge. While almost a third of Americans have deficits in health literacy, nutrition literacy levels in the United States have not been well established. Nutrition literacy is the level of ability to evaluate and understand nutrition information and make educated dietary choices. Hoffman hypothesizes that vegetarians must develop greater nutrition literacy to justify their diet in a mostly non-vegetarian society and maintain nutritional adequacy. While Leonard et al. found that vegetarians had higher nutrition knowledge scores than non-vegetarians, DeMay et al. and Saintila et al. reported no significant differences in nutrition knowledge between vegetarians and non-vegetarians.

While many studies have characterized the diet quality of plant-based eaters (vegans, vegetarians, and semi-vegetarians), there is a lack of evidence regarding the diet motives and nutrition literacy among individuals that follow these diets. Additionally, previous research on the relationship between diet motives and diet quality have produced inconsistent results.
The health motive seems to be associated with beneficial dietary behaviors in plant-based individuals.\textsuperscript{10,12,20} Some studies discovered that being motivated by ethics was linked to higher diet quality, while being motivated by weight control and mood was linked to lower diet quality, but these results have not been replicated.\textsuperscript{21,22} Only one study has focused on diet motives and its effect on diet quality in plant-based individuals.\textsuperscript{23} The primary objective of this study was to assess diet quality, diet motives and nutrition literacy in vegans, vegetarians, and semi-vegetarians. The secondary objective was to investigate the association between diet motives and dietary quality. We hypothesized that following a vegan diet, being strongly motivated by health, and having a high nutrition literacy would be associated with higher diet quality.

**Methods**

In this cross-sectional study, participants had to be 18 years or older, literate in English, and residing within the US for one year or more. In addition, adults were eligible to participate if they self-identified as vegan (defined as excluding all animal products), vegetarian (defined as excluding all animal products besides eggs and/or dairy), or semi-vegetarian (defined as excluding no animal products but limiting meat to \(\leq 1x\) per week). Recruitment took place between August-October of 2021 using purposive sampling methods through Facebook and Instagram social media advertising. As an incentive, participants were able to enter a raffle drawing for one of ten $20 gift cards. The San José State University Institutional Review Board approved this study, and all participants provided informed consent.
Participants completed a 25-minute survey on the Qualtrics survey platform, featuring questions related to demographics, the revised Food Choice Questionnaire (FCQ), the Nutrition Literacy Assessment Instrument (NLit), and questions related to vegetarian nutrition knowledge. The demographic portion included statements about state of residence, gender, Hispanic origin, race, education level, and household income. Participants were asked to rank their top three motives for following their diet, out of the following motives: animal welfare, environment, family/friend influence, health, political reasons, religion/spirituality, taste preference, and weight management. Participants also responded to questions regarding foods excluded from their diet and duration of dietary adherence.

Food choice motives were assessed using the revised FCQ, which Lindeman and Väänänen adapted to include three new ethical scales. The FCQ is used to systematically assess motives that influence dietary choices. This version included 44 items and 11 subscales: health (6 items), mood (6 items), convenience (5 items), sensory appeal (4 items), natural content (3 items), price (3 items), weight control (3 items), familiarity (3 items), ecological welfare (5 items), political values (4 items), and religion (2 items). Participants ranked each food choice statement on a five-point Likert scale (e.g., “It is important to me that the food I eat on a typical day keeps me healthy”, where 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, and 5 = Strongly agree). For each scale, an average of the values for each of the statements was used to create a score ranging from 1 to 5 for each participant.

Nutrition literacy was assessed with the NLit, which has been validated to measure dietary knowledge and nutrition-related skills among adult populations. The NLit included
64 items and six domains: nutrition & health (10 items), energy sources in food (10 items), household food measurement (9 items), food label & numeracy (10 items), food groups (16 items), and consumer skills (9 items). Participants answered multiple-choice questions using informational text, existing knowledge, and pictures/food labels provided. Data for each item were coded as correct/incorrect, with missing answers coded as incorrect. Scores ranged from 1 to 64, with scores of 44 or below indicating likelihood of poor nutrition literacy, scores between 45 and 57 indicating the possibility of poor nutrition literacy, and scores of 58 and above indicating likelihood of good nutrition literacy.

At the end of the survey, participants provided their email addresses to receive a link to the Diet History Questionnaire III (DHQ III), available through the National Cancer Institute webpage. The DHQ III is a validated food frequency questionnaire used to assess food and supplement intake. This questionnaire assessed frequency of intake over the past month using predetermined portion sizes based on national 24-hour dietary recall data. The DHQ III included 135 questions regarding food and beverages, with additional embedded questions to determine the assignment of a question to an item in the 263-item nutrient and food database and 26 questions regarding dietary supplements. Participants chose their consumption frequency from several categories (1 time in the past month, 2–3 times in the past month, 1 time per week, 2 times per week, 3–4 times per week, 5–6 times per week, 1 time per day, 2 or more times per day). The DHQ III asked participants to report their age and gender at the start of the questionnaire. Gender and predetermined portion sizes based on national 24-hour dietary recall data were used to provide a mean nutrient or food group value for each food on the DHQ. These values were used to determine the Healthy Eating Index
(HEI) 2015 score for each participant ranging from 0 to 100. The HEI score is a measurement of diet quality that determines adherence to the *U.S. Dietary Guidelines for Americans*.⁶

A total of 972 participants consented to participate, and 223 (23%) were included in the analyses (Figure 1). Out of the 921 participants who met inclusion/exclusion screening criteria, 387 provided their email address to participate in the DHQ III. Out of this group, only 223 participants completed the DHQ III and were included in the study.

**Figure 1**

*Study Flow Chart*

```
Assessed for eligibility (n= 974)

Excluded (n=350)
- Declined to consent (n=2)
- Not meeting inclusion criteria (n=53)
- Did not start survey (n=46)
- Data not complete (n=249)

Online Survey (n= 624)

Excluded (n=374)
- Did not provide email (n=237)
- Did not complete FFQ (n=137)

Food Frequency Questionnaire (n=250)

Excluded (n=27)
- Incomplete response (n=26)
- Consumed <500 kcal (n=0)
- Consumed >3500 kcal (n=1)

Analyzed (n=223)
```
Using Pearson Chi-square tests, we examined whether age, gender, race, ethnicity, education, income, duration of diet, and self-reported top diet motive differed among the three diet types: vegans, vegetarians, and semi-vegetarians. A one-way ANOVA with a Dunn-Bonferroni post-hoc test was conducted to compare diet quality, nutrition literacy, vegetarian literacy, and food choice motive scores among diet groups. We studied the influence of food choice motives on diet quality by diet group by running a multiple linear regression including the 11 motives as predictors and diet quality as the dependent variable (main model). Using the whole sample, we adjusted the main model for the variables shown in the literature to affect diet quality: education, income, age, gender, total nutrition literacy, and vegetarian literacy. All statistical analyses were performed using SPSS version 27. A priori power analysis was performed using G. Power version 3.1, to require 131 participants per group with 0.15 effect size, 80% power and 0.05 alpha.

**Results**

A total of 223 participants completed the study, out of which 117 were vegan, 51 vegetarian, and 55 semi-vegetarians. **Table 1** shows participants’ characteristics: many participants were female (85%), age 40 and above (72%), white (87%), non-Hispanic (92%), college-educated (86%) and 67% had a household income at or above $50,000. No significant differences were observed in any demographic characteristics among the three diet groups. Vegetarians were more likely to have followed their diet long-term (>5 years) than vegans and semi-vegetarians (p=0.029). Almost half of participants identified ethics as their top motive for following their diet, while 41% of participants identified health and 7%
### Table 1
**Participant Characteristics (n=223)**

<table>
<thead>
<tr>
<th>Age n (%)</th>
<th>Total (n=223)</th>
<th>Vegan (n=117)</th>
<th>Vegetarians (n=51)</th>
<th>Semi-vegetarians (n=55)</th>
<th>p-value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-39</td>
<td>63 (28.3%)</td>
<td>27 (23.1%)</td>
<td>17 (33.3%)</td>
<td>17 (30.9%)</td>
<td>0.252</td>
</tr>
<tr>
<td>40-59</td>
<td>82 (36.7%)</td>
<td>41 (35%)</td>
<td>18 (35.3%)</td>
<td>16 (29.1%)</td>
<td></td>
</tr>
<tr>
<td>60 or more</td>
<td>78 (35%)</td>
<td>49 (41.9%)</td>
<td>16 (31.4%)</td>
<td>22 (40%)</td>
<td></td>
</tr>
<tr>
<td>Gender n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.236</td>
</tr>
<tr>
<td>Male</td>
<td>27 (12.1%)</td>
<td>14 (12%)</td>
<td>9 (17.6%)</td>
<td>4 (7.3%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>190 (85.2%)</td>
<td>101 (86.3%)</td>
<td>39 (76.5%)</td>
<td>50 (90.9%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6 (2.7%)</td>
<td>2 (1.7%)</td>
<td>3 (5.9%)</td>
<td>6 (1.8%)</td>
<td></td>
</tr>
<tr>
<td>Race n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.193</td>
</tr>
<tr>
<td>White</td>
<td>194 (90.2%)</td>
<td>105 (92.9%)</td>
<td>45 (91.8%)</td>
<td>44 (83%)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>11 (5.1%)</td>
<td>4 (3.5%)</td>
<td>3 (6.1%)</td>
<td>4 (7.5%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>10 (4.7%)</td>
<td>4 (3.5%)</td>
<td>1 (2%)</td>
<td>5 (9.4%)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.399</td>
</tr>
<tr>
<td>Hispanic</td>
<td>14 (6.3%)</td>
<td>5 (4.4%)</td>
<td>5 (9.8%)</td>
<td>4 (7.3%)</td>
<td></td>
</tr>
<tr>
<td>non-Hispanic</td>
<td>206 (92.4%)</td>
<td>109 (95.6%)</td>
<td>46 (90.2%)</td>
<td>51 (92.7%)</td>
<td></td>
</tr>
<tr>
<td>Education n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.867</td>
</tr>
<tr>
<td>not a college graduate</td>
<td>32 (14.3%)</td>
<td>17 (14.5%)</td>
<td>6 (11.8%)</td>
<td>9 (16.4%)</td>
<td></td>
</tr>
<tr>
<td>college graduate</td>
<td>191 (85.7%)</td>
<td>100 (85.5%)</td>
<td>45 (88.2%)</td>
<td>46 (83.6%)</td>
<td></td>
</tr>
<tr>
<td>Income n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.933</td>
</tr>
<tr>
<td>less than $50,000</td>
<td>72 (32.9%)</td>
<td>36 (31.3%)</td>
<td>17 (34%)</td>
<td>19 (35.2%)</td>
<td></td>
</tr>
<tr>
<td>$50,000-$99,999</td>
<td>78 (35.6%)</td>
<td>39 (33.9%)</td>
<td>18 (36%)</td>
<td>21 (38.9%)</td>
<td></td>
</tr>
<tr>
<td>$100,000 or more</td>
<td>69 (31.5%)</td>
<td>40 (34.8%)</td>
<td>15 (30%)</td>
<td>14 (25.9%)</td>
<td></td>
</tr>
<tr>
<td>Duration of diet n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.029</td>
</tr>
<tr>
<td>less than 1 year</td>
<td>16 (7.2%)</td>
<td>8 (6.8%)</td>
<td>2 (3.9%)</td>
<td>6 (11.1%)</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>67 (30%)</td>
<td>41 (35.1%)</td>
<td>8 (15.7%)</td>
<td>18 (33.3%)</td>
<td></td>
</tr>
<tr>
<td>more than 5 years</td>
<td>139 (62.3%)</td>
<td>68 (58.1%)</td>
<td>41 (80.4%)</td>
<td>30 (55.6%)</td>
<td></td>
</tr>
<tr>
<td>Top diet motive n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Ethics</td>
<td>110 (49.3%)</td>
<td>54 (47.4%)</td>
<td>34 (69.4%)</td>
<td>22 (41.5%)</td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td>91 (40.8%)</td>
<td>57 (50%)</td>
<td>10 (20.4%)</td>
<td>24 (45.3%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>15 (6.7%)</td>
<td>3 (2.6%)</td>
<td>5 (10.2%)</td>
<td>7 (13.2%)</td>
<td></td>
</tr>
</tbody>
</table>

* Chi-Square

identified other motives (family influence, politics, taste). Vegetarians were more likely to select ethics as their top motive (69%), while vegans (50%) and semi-vegetarians (45%) were more likely to select health as their top motive (p=0.001).

Table 2 shows differences in diet quality, nutrition literacy, and food choice motives by diet groups. Participants had high scores for diet quality (78 out of 100), nutrition literacy (59 out of 64), and vegetarian literacy (5.5 out of 6). Vegans had a higher HEI-2015 score than vegetarians and semi-vegetarians (p<0.001). Regarding nutrition literacy, 74% of our sample
Table 2

*Diet Quality, Nutrition Literacy, and Food Choice Motives Among Groups*

<table>
<thead>
<tr>
<th></th>
<th>Total (n=223)</th>
<th>Vegan (n=117)</th>
<th>Vegetarian (n=51)</th>
<th>Semi-Vegetarian (n=55)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total HEI-2015 (0-100)</td>
<td>78.5 ± 7.8</td>
<td>80.8 ± 6.5</td>
<td>75.3 ± 9.0 b</td>
<td>76.8 ± 7.5 b</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total NLit (0-64)</td>
<td>58.9 ± 3.3</td>
<td>59.2 ± 3.1</td>
<td>58.8 ± 3.6</td>
<td>58.4 ± 3.5</td>
<td>0.381</td>
</tr>
<tr>
<td>Vegetarian Literacy (0-6)</td>
<td>5.53 ± 0.72</td>
<td>5.73 ± 0.6</td>
<td>5.45 ± 0.7</td>
<td>5.20 ± 0.83 b</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FCQ (1-5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ecological welfare</td>
<td>4.36 ± 0.52</td>
<td>4.43 ± 0.46</td>
<td>4.34 ± 0.52</td>
<td>4.22 ± 0.6 b</td>
<td>0.048</td>
</tr>
<tr>
<td>health</td>
<td>4.12 ± 0.54</td>
<td>4.09 ± 0.55</td>
<td>4.01 ± 0.51</td>
<td>4.28 ± 0.52 c</td>
<td>0.028</td>
</tr>
<tr>
<td>sensory appeal</td>
<td>4.12 ± 0.52</td>
<td>4.12 ± 0.5</td>
<td>4.03 ± 0.6</td>
<td>4.23 ± 0.47</td>
<td>0.125</td>
</tr>
<tr>
<td>natural content</td>
<td>4.05 ± 0.91</td>
<td>4.05 ± 0.98</td>
<td>3.86 ± 0.78</td>
<td>4.22 ± 0.84</td>
<td>0.137</td>
</tr>
<tr>
<td>convenience</td>
<td>3.52 ± 0.74</td>
<td>3.55 ± 0.74</td>
<td>3.33 ± 0.69</td>
<td>3.62 ± 0.75</td>
<td>0.094</td>
</tr>
<tr>
<td>weight control</td>
<td>3.47 ± 0.87</td>
<td>3.48 ± 0.90</td>
<td>3.24 ± 0.78</td>
<td>3.68 ± 0.83 c</td>
<td>0.028</td>
</tr>
<tr>
<td>political values</td>
<td>3.41 ± 0.74</td>
<td>3.38 ± 0.72</td>
<td>3.33 ± 0.74</td>
<td>3.53 ± 0.79</td>
<td>0.359</td>
</tr>
<tr>
<td>mood</td>
<td>3.38 ± 0.68</td>
<td>3.33 ± 0.64</td>
<td>3.29 ± 0.73</td>
<td>3.58 ± 0.70</td>
<td>0.046</td>
</tr>
<tr>
<td>price</td>
<td>3.35 ± 0.84</td>
<td>3.29 ± 0.81</td>
<td>3.40 ± 0.84</td>
<td>3.45 ± 0.92</td>
<td>0.465</td>
</tr>
<tr>
<td>familiarity</td>
<td>2.72 ± 0.93</td>
<td>2.59 ± 0.87</td>
<td>2.69 ± 0.97</td>
<td>3.03 ± 0.95 b</td>
<td>0.018</td>
</tr>
<tr>
<td>religion</td>
<td>2.61 ± 1.13</td>
<td>2.58 ± 1.06</td>
<td>2.50 ± 1.25</td>
<td>2.78 ± 1.16</td>
<td>0.406</td>
</tr>
</tbody>
</table>

HEI - healthy eating index-2015; NLit - nutrition literacy; FCQ - food choice questionnaire
(1- strongly disagree, 5- strongly agree)

a ANOVA
b Significantly different from vegans as determined by the Dunn-Bonferroni post-hoc method
c Significantly different from vegetarians as determined by the Dunn-Bonferroni-post hoc method

had good nutrition literacy (≥ 58), 25.6% had possibly poor (45-57) and 0.4% had poor nutrition literacy (≤44), with no significant differences among diet groups. Vegans had a higher vegetarian literacy score compared to semi-vegetarians (p<0.001). Ecological welfare, health, and sensory appeal tended to be of greater importance to all participants. Specifically, vegans valued ecological welfare significantly (p=0.048) more than did semi-vegetarians. Semi-vegetarians valued health and weight control significantly more than did vegetarians (p=0.028). Semi-vegetarians valued familiarity significantly (p=0.018) more than did vegans.

Table 3 presents the influence of food choice motives on total diet quality in the sample after controlling for total nutrition literacy, vegetarian literacy, education, income, age, and gender. The adjusted model explained about 26% of the variance in diet quality. Increased importance of health was associated with a 3.5-point increase in HEI-2015 score (p=0.004),
Table 3

*Influence of Food Choice Motives on Diet Quality Among the Overall Sample of Vegans, Vegetarians, and Semi-Vegetarians (n=223)*

<table>
<thead>
<tr>
<th>Motive</th>
<th>Unstandardized β</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>intercept</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>ecological welfare</td>
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<td>0.054</td>
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<td>health</td>
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<td>0.004</td>
</tr>
<tr>
<td>sensory appeal</td>
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<td>0.047</td>
</tr>
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<td>natural content</td>
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<td>0.016</td>
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<tr>
<td>political values</td>
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<td>0.431</td>
</tr>
<tr>
<td>mood</td>
<td>0.941</td>
<td>0.366</td>
</tr>
<tr>
<td>price</td>
<td>-0.69</td>
<td>0.327</td>
</tr>
<tr>
<td>familiarity</td>
<td>-1.24</td>
<td>0.058</td>
</tr>
<tr>
<td>religion</td>
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<td>0.122</td>
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</tbody>
</table>

*Hierarchical multiple regression with total HEI-2015 as the dependent variable, controlled for total nutrition literacy, vegetarian literacy, education, income, age, and gender*

and increased importance of natural content was associated with a 1.7-point increase in HEI-2015 score (p=0.016). Greater importance of sensory appeal was associated with a 2.4-point decrease in HEI-2015 score (p=0.047), and greater importance of weight control motive was associated with a 1.5-point decrease in HEI-2015 score (p=0.033).

Table 4 shows the crude model for food choice motives’ influence on diet quality by diet group. Greater value of natural content was associated with higher HEI-2015 scores in vegans (p=0.012) and vegetarians (p=0.045) but not semi-vegetarians (p>0.05). Increased importance of price was associated with lower HEI-2015 scores in vegans (p=0.037). Increased importance of health was positively associated with HEI-2015 scores in vegetarians only (p=0.031). Greater importance of familiarity was associated with decreased HEI-2015 scores in semi-vegetarians (p=0.046).
### Discussion

The primary aim of this study was to assess and compare the diet quality, motives, and nutrition literacy of vegans, vegetarians, and semi-vegetarians. Overall, participants had high scores for diet quality, nutrition literacy, and vegetarian literacy. Vegans had a higher diet quality score than vegetarians and semi-vegetarians. Ecological welfare, health, and sensory appeal were the most valued motives in the sample. Specifically, vegans valued ecological welfare more than semi-vegetarians. Semi-vegetarians valued health and weight control more than vegetarians. Nutrition literacy was not different among diet groups, although vegans had a higher vegetarian literacy score compared to semi-vegetarians. An increase in the importance of health and natural content was associated with increased diet quality, whereas an increase in the importance of sensory appeal and weight control was associated with decreased diet quality.

### Table 4

**Influence of Food Choice Motives on Diet Quality Among the Three Groups**

<table>
<thead>
<tr>
<th>Motive</th>
<th>Vegan</th>
<th>Vegetarian</th>
<th>Semi-vegetarian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unstandardized β</td>
<td>Unstandardized β</td>
<td>Unstandardized β</td>
</tr>
<tr>
<td></td>
<td>p-value</td>
<td>p-value</td>
<td>p-value</td>
</tr>
<tr>
<td><strong>intercept</strong></td>
<td>73.7</td>
<td>50.1</td>
<td>65.5</td>
</tr>
<tr>
<td></td>
<td>&lt;0.001</td>
<td>0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ecological welfare</td>
<td>1.066</td>
<td>4.57</td>
<td>3.326</td>
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<tr>
<td></td>
<td>0.484</td>
<td>0.125</td>
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<tr>
<td>health</td>
<td>2.441</td>
<td>6.936</td>
<td>1.036</td>
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<tr>
<td></td>
<td>0.095</td>
<td>0.031</td>
<td>0.696</td>
</tr>
<tr>
<td>sensory appeal</td>
<td>-2.118</td>
<td>-4.592</td>
<td>-5.002</td>
</tr>
<tr>
<td></td>
<td>0.150</td>
<td>0.086</td>
<td>0.055</td>
</tr>
<tr>
<td>natural content</td>
<td>1.822</td>
<td>4.267</td>
<td>1.254</td>
</tr>
<tr>
<td></td>
<td><strong>0.012</strong></td>
<td><strong>0.045</strong></td>
<td><strong>0.442</strong></td>
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<tr>
<td>convenience</td>
<td>-0.847</td>
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<td>1.911</td>
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<tr>
<td></td>
<td>0.367</td>
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<td>0.342</td>
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<tr>
<td>weight control</td>
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<td>0.068</td>
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<tr>
<td></td>
<td>0.527</td>
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<td>0.989</td>
</tr>
<tr>
<td>mood</td>
<td>1.265</td>
<td>1.342</td>
<td>2.228</td>
</tr>
<tr>
<td></td>
<td>0.274</td>
<td>0.593</td>
<td>0.300</td>
</tr>
<tr>
<td>price</td>
<td>-1.78</td>
<td>0.058</td>
<td>0.519</td>
</tr>
<tr>
<td></td>
<td><strong>0.037</strong></td>
<td>0.973</td>
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<tr>
<td>familiarity</td>
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<td>-3.294</td>
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<tr>
<td></td>
<td>0.306</td>
<td>0.459</td>
<td><strong>0.046</strong></td>
</tr>
<tr>
<td>religion</td>
<td>-0.326</td>
<td>1.572</td>
<td>1.464</td>
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<tr>
<td></td>
<td>0.572</td>
<td>0.136</td>
<td>0.131</td>
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</table>
When comparing vegan, vegetarian, and semi-vegetarian diets, vegans were found to have the highest diet quality scores, which has been confirmed by other studies.\textsuperscript{2,3,5,23} Mean HEI scores ranged from 65.4 to 70.9 in vegans, 58.7 to 60.9 in vegetarians, and 59.4 in semi-vegetarians.\textsuperscript{2,23} In comparison, the mean HEI-2015 score was 56.6 in the American population.\textsuperscript{26} Previous research found that vegans consumed more fruits, vegetables, and legumes, and fewer products high in sodium, added sugar, and saturated fat.\textsuperscript{2,4,5} Gili et al.\textsuperscript{4} also found that vegans consumed more whole grains, nuts and seeds compared with other plant-based and omnivorous diets alike.

Nutrition literacy was favorable in this population, with no differences in total nutrition literacy among groups, but higher vegetarian literacy in vegans. Studies characterizing nutrition literacy in plant-based participants are limited, and existing findings are contradictory. DeMay et al.\textsuperscript{18} and Saintila et al.\textsuperscript{19} reported no significant differences in the level of nutritional knowledge between vegetarian and non-vegetarian diets, which is consistent with our findings. However, Leonard et al.\textsuperscript{17} observed that vegetarians and semi-vegetarians had higher total knowledge scores than non-vegetarians. Similarly, Hoffman et al.\textsuperscript{16} discovered that the more restrictive the diet, the greater the nutrition knowledge, with vegans scoring highest, followed by ovo-lacto-vegetarians. DeMay et al.\textsuperscript{18} found that vegetarians (including vegans) scored higher on questions relevant to their diet compared to non-vegetarians, which supports the greater vegetarian literacy seen in vegans. Those following a vegan or vegetarian diet may develop greater nutrition knowledge to justify their diet in a mostly non-vegetarian society and maintain a nutritionally adequate diet.\textsuperscript{16}
When making dietary choices, vegans valued ecological welfare more than did semi-vegetarians. This is in line with previous findings, which indicate that vegan and vegetarians view their dietary patterns as a manifestation of their animal and environmental values.\textsuperscript{9,20,27} Many vegetarians endorsed disgust of animal products or affinity for vegetarian alternatives, and therefore valued taste preferences more than other diet groups.\textsuperscript{20,27,28} However, our study found no differences in sensory appeal among vegans, vegetarians, and semi-vegetarians. Whereas semi-vegetarians valued health and weight control more than vegetarians, a finding that is in line with the literature.\textsuperscript{20,28} Familiarity and mood were stronger motives in semi-vegetarians than in vegans, although post-hoc findings for mood were nonsignificant, likely due to a weakly significant effect (p=0.046). While most studies did not assess familiarity or mood specifically, semi-vegetarians were shown to value ‘personal’ motives, which often include these motives.\textsuperscript{28}

The link between diet motivation and diet quality can be observed in plant-based populations as well. Increased importance of health and natural content motives were positively associated with HEI-2015 scores. Generally, the literature shows that health-motivated individuals are likely to have higher diet quality, and this was seen in plant-based individuals as well.\textsuperscript{21,23,29} However, many studies did not utilize the FCQ and therefore did not measure natural content as a separate motive from health. Our results also show that greater importance of sensory appeal and weight control were associated with decreased HEI-2015 scores. Research has shown that sensory appeal is positively associated with consumption of highly palatable, processed foods high in added sugar, saturated and trans fats, which may explain poorer diet quality scores.\textsuperscript{30}
Inconsistent with the present findings, a recent study found that increased importance of weight control was correlated with increased diet quality. However, among plant-based dieters, stronger weight-loss motivation was related to higher meat intake. While weight control is related to health, it is driven by the external reward of a goal weight, which is subject to change, thereby altering dietary behaviors and quality. Allès et al. found that those with ecological motives were more likely to follow healthy diets. Though vegans greatly valued ecological welfare and had the highest diet quality of the groups, the ecological welfare motive was not found to be a predictor of higher diet quality in this study. Greater importance of familiarity was associated with decreased HEI-2015 scores in semi-vegetarians, and similar results were found in non-vegetarians. Animal-based foods may be familiar staples in the diets of semi-vegetarians and non-vegetarians alike, and therefore they may be included over healthier alternatives.

To date few studies have investigated the overall diet quality, diet motives and nutrition literacy in plant-based individuals. While Torna et al. have investigated the relationship between diet motives and diet quality in vegetarians, our study is novel in that it differentiated between vegans and vegetarians and included semi-vegetarians. Plant-based individuals often report multiple motives to dietary adherence and using the FCQ allowed several motives to be measured rather than requiring participants to choose their top motive. Our sample is representative of vegetarians in Western societies, who tend to be mostly (>75%) female, non-Hispanic white, middle-aged (40-60 years), with more than a high school education and a household income within the US middle-class range.
To our knowledge, this is the first study to measure nutrition literacy in plant-based individuals using the validated NLit instrument. However, as the NLit has not been adapted for restrictive diets, it is unclear whether this instrument is appropriate to measure nutrition literacy in this population. Additionally, nutrition literacy levels in the American population have not been determined, as most studies to date were conducted in adults with chronic conditions,\textsuperscript{14,32} so interpretation of our nutrition literacy scores is limited. Since our participants were highly educated, at or above middle class, with high nutrition literacy, the low variability in NLit scores may explain the lack of association between diet quality and nutrition literacy. This study also did not include a control group of non-plant-based individuals. The time-intensive design of this study, which included a 25-minute survey and an hour-long validated food frequency questionnaire, may have limited our findings. Only 35\% of survey respondents completed the DHQ and were included in this study, therefore, this study is prone to selection bias. However, demographics of study participants who completed the DHQ were similar to those who did not.

Conclusion and Implications

The present study supports the hypothesis that plant-based individuals have higher diet quality and nutrition literacy than the general population. When comparing plant-based diet groups, vegans had the highest diet quality, and nutrition literacy levels were similar. This study also contributes new evidence that intrinsic motivations to following a plant-based diet are associated with greater diet quality, while extrinsic motivations are associated with poorer diet quality. Plant-based individuals who were motivated by health or natural content had
higher diet quality. On the other hand, those who were motivated by sensory appeal or
weight control had lower diet quality.

Diet motives and nutrition literacy should be considered in future research, as these
factors may provide insight into dietary behaviors. Organizations can develop more
influential public health campaigns that promote plant-based diets based on top-rated motives
and existing nutrition knowledge. In patients adopting new diets, healthcare professionals can
develop strategies to shift patient motivation from extrinsic to intrinsic, to facilitate
successful dietary adherence. Future studies may benefit from including a larger group of
participants and separating vegans and vegetarians into different groups to account for
differences in characteristics as shown in this study. There is no consensus regarding the
definition of the semi-vegetarian diet, and its differences from flexitarian and low-meat diets.
Defining these terms more clearly will allow researchers to better establish diet quality,
nutrition literacy, and motivations in these individuals.

Furthermore, there is a need for validated nutrition literacy instruments to be adapted to
measure nutrition knowledge and skills specific to plant-based nutrition. Existing dietary
assessment instruments such as the DHQ III must also include more vegetarian-specific items
in their food databases. Collecting more accurate nutrition literacy and dietary intake data
through these instruments, will allow healthcare professionals to determine the prevalence of
common nutrient inadequacies in this population, and potential knowledge gaps that may
contribute to inadequate nutrition.
References


Chapter 3: Summary and Recommendation

Summary

A person’s dietary practices are complex, as they are influenced not only by external factors, but also by psychological factors including beliefs and motivations about food. For many plant-based individuals, adopting their diet is a conscious decision to eliminate or reduce animal-derived foods for moral or health reasoning. Plant-based individuals, including vegans, vegetarians, and semi-vegetarians, have exhibited healthier dietary behaviors and higher diet quality as compared to omnivores. These strong motivations by health and ethics, as well as high health literacy, are thought to contribute to the healthier dietary behaviors in this population. However, current research is lacking to establish nutrition literacy in plant-based individuals. Moreover, many studies do not compare different plant-based diets, but rather integrate them into one group. Therefore, variation in diet motives between plant-based eaters is unclear. Because of these gaps in the literature, this study aimed to assess the diet quality, diet motives and nutrition literacy of vegans, vegetarians, and semi-vegetarians. Additionally, the study sought to investigate the association between diet motives and dietary quality.

The present study partially supports our hypothesis that plant-based individuals have high diet quality and nutrition literacy, with vegans showing the highest diet quality and vegetarian literacy. While previous literature has found that vegans have higher diet quality when compared to plant-based individuals and omnivores alike, it was surprising that there were no differences in nutrition literacy among diet groups. However, vegetarian literacy was highest in vegans out of all groups. This could indicate that the NLit was unable to capture
differences since it was not adapted to suit a plant-based population. This study also contributes new evidence that motivations to following a plant-based diet are associated with diet quality. Consistent with previous research, we found that plant-based individuals motivated by health or natural content had higher diet quality, while those motivated by sensory appeal or weight control had lower diet quality. In the literature, vegans consistently rate ecological welfare as their top motivation to follow their diet, and this has been associated with healthy dietary behaviors. Although we expected strong motivation by ecological welfare to predict higher diet quality, no such association was found in this study.

**Recommendations**

Diet motives and nutrition literacy should be considered in future research, as these factors may provide insight into dietary practices. This cross-sectional study also highlights the need for more studies that include multiple plant-based diet groups. Furthermore, there is a need for tailored instruments to measure nutrition literacy specific to plant-based nutrition and diet quality in those with restrictive diets. Our findings provide insight into diet-related knowledge, skills, and motives that may predict the high diet quality and beneficial diet behaviors seen in this population. Information from this study can be used by nutrition educators to better understand the prevalence of nutrition-related knowledge gaps that could translate to specific nutrient inadequacies in this population. Future public health campaigns encouraging plant-heavy diets would benefit from considering motivation as a predictor to making plant-based dietary choices.
References


Dietary Guidelines Advisory Committee. 2020. *Scientific report of the 2020 Dietary Guidelines Advisory Committee: Advisory report to the Secretary of Agriculture and the*


Hargreaves, S. M., Araújo, W., Nakano, E. Y., & Zandonadi, R. P. (2020). Brazilian vegetarians diet quality markers and comparison with the general population: A


Appendix A: IRB Approval

SAN JOSE STATE UNIVERSITY
HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD
IRB Notice of Approval

Date of Approval: 6/29/2021

Study Title: Diet Motives and Dietary Quality in Vegans, Vegetarians, and Semi-Vegetarians

Principal Investigator (PI): Dr. Giselle Pignotti

Other SJSU Team Members:

SJSU Student(s): Sapna Peruvemba

Funding Source: Circle of Friends

IRB Protocol Tracking Number: 21144

Type of Review:
- ☑ Exempt Registration: Category of approval §46.104(d)(2ii)
- □ Expedited Review: Category of approval §46.110(a)(i)
- □ Full Review
- □ Modifications
- □ Continuing Review

Special Conditions:
- ☑ Waiver of signed consent approved
- □ Waiver of some or all elements of informed consent approved
- □ Risk determination for device:
- □ Other:

Continuing Review:
- ☑ Is not required. Principal Investigator must file a status report with the IRB one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.
- □ Is required. An annual continuing review renewal application must be submitted to IRB one
Appendix B: Consent Form

Researchers
1. Sapna Peruvemba – San Jose State University graduate student
2. Giselle Pignotti PhD, RD – San Jose State University faculty, associate professor

Purpose
The overall purpose of this study is to determine how motivation to following a vegetarian-type diet affects overall dietary quality. Understanding the motivational component to diet may inform more effective strategies to help consumers maintain a healthy diet and incorporate more plant-based foods into their diet. A secondary purpose of this study is to determine nutrition knowledge among vegetarians, which may also influence dietary intake.

Procedures
You will complete an online survey about dietary motivations, nutrition knowledge, and diet quality. This survey can be completed on either a smartphone or laptop and should take approximately 25-30 minutes to complete. If you meet the eligibility criteria for this research study, you will be invited to provide your email address in order to participate in the diet history questionnaire and receive a full report of your diet and nutrient intake.

Potential Risks
There will be a few pictures of animal-based foods in this survey. Please feel free to skip any questions that may cause discomfort.
Potential Benefits
It is hoped that the information you provide in this study will help us better understand the role motivation and nutrition knowledge may play in dietary quality and maintaining a successful vegetarian-type diet. In addition, the full nutrition report received after completing the Diet History Questionnaire will allow insight into your current dietary/nutrient intake and needs.

Compensation
You will be entered into a raffle to win one of ten $20 Amazon or Whole Foods gift cards.

Confidentiality
Please be assured that your responses will be kept completely confidential. The results will be reported in aggregate form only and you will not be identified individually in any publication from this study. The study’s principal investigator and student investigator will have access to the data, which will be accessed through secure university sign-on only.

Your Rights
Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice. You also have the right to skip any question you do not wish to answer. We will never share what you said with anyone else or report it in any identifiable way. We will always do everything we can to respect and protect your privacy.

Contact Information
If you would like to contact the Principal Investigator in the study to discuss this research, please e-mail Dr. Giselle Pignotti at giselle.pignotti@sjsu.edu and/or the research assistant Sapna Peruvemba at sapna.peruvemba@sjsu.edu

Agreement to Participate
Please select from the choices below. If you click agree, it is implied that you have read the information above about the research, your rights as a participant, and give your voluntary consent. Please print out a copy of this page and keep it for your records.

☐ Yes
☐ No