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A Qualitative Study Of Rural Plant-Based Eaters' Knowledge And Planning For Nutritional Adequacy

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A QUALITATIVE STUDY OF RURAL PLANT-BASED EATERS' KNOWLEDGE AND PLANNING FOR NUTRITIONAL ADEQUACY

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ABSTRACT

***Objective*:** To determine to what degree rural plant-based eaters engage in nutritional planning regarding nutrients commonly lacking in diets that exclude or limit animal-source foods (Vitamin B12, Vitamin D, omega-3 fatty acids, calcium, iron, iodine, zinc, and protein).

***Design*:** Semi-structured interviews were completed via phone or video conference. Interview questions explored dietary choices and degree of knowledge and planning for nutrients on concern. A brief diet questionnaire was conducted online.

***Setting*:** Vermont, USA

***Participants*:** 28 rural Vermont residents aged 19-77 years who identified as flexitarian, pescatarian, vegan or vegetarian.

***Results*:** Participants had a positive outlook about the healthfulness of a plant-based diet, but recognized limitations to accessing specific nutrients, especially Vitamin B12, Vitamin D, and omega-3 fatty acids. They shared strategies that they intentionally used to meet needs including eating a varied diet, seeking out specific foods, and taking dietary supplements. Participants showed varying degrees of nutrition knowledge, with vegans generally presenting as the most knowledgeable. Gaps in knowledge related to bioavailability, food sources of specific nutrients, and certain nutrients, especially zinc and iodine. Participants noted a lack of local professional plant-based nutrition expertise and sought information through various avenues.

***Conclusions*:** While there is some knowledge and planning for a plant-based diet among these rural plant-based eaters, there are inconsistencies and gaps in knowledge. Public health and nutrition interventions should focus on addressing identified challenges to dietary adequacy.

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CHAPTER 1: COMPREHENSIVE LITERATURE REVIEW

1.1 Introduction

Plant-based diets have become increasingly popular for health, environmental and ethical reasons. The term "plant-based" can represent a range of eating patterns from vegan, which eliminates all animal products, to flexitarian, which allows modest amounts of meat, dairy, eggs, and other animal products. There is mounting evidence that suggests minimally processed plant-based diets have the potential to improve both individual and environmental health[1].

Plant-based diets rich in whole foods, such as fruits, vegetables, nuts, seeds, and legumes have been associated with a reduced risk for diet related chronic diseases[2–6], and with improved digestive health[7,8]. Further, diet is one of the highest impact actions an individual can make to address their environmental burden and it is more immediate and accessible than other lifestyle changes such as avoiding air travel, living car-free and having fewer children[9]. It is estimated that eating a plant-based diet can decrease an individual's carbon footprint by up to 73%[10]. Simply reducing, but not eliminating animal products has been shown to significantly reduce personal greenhouse gas emissions, water footprints and land use[11]. Plant-based diets offer a strong potential contribution to addressing systematic climate concerns while nourishing a growing population[1].

Despite these potential food system benefits, there are challenges to the widespread adoption of plant-based dietary patterns. For example, specific micronutrients are either not present in sufficient quantities in plant-based foods or they are not as easily absorbed[12,13]. The Academy of Nutrition and Dietetics (AND) advises that plant-based

diets can be nutritionally adequate, but there are key nutrient gaps that require careful dietary planning for optimal health outcomes [12], which is knowledge that may not be available to many individuals. There is also reason to believe that plant-based diets may not be as accepted in some more rural areas of the country due to the cultural significance of meat and dairy as well as other complex socioeconomic differences[14]. Despite rural areas growing a majority of the food produced in the United States, they experience lower access to food resources as compared to nonrural areas[15–17]. In particular, consumption of adequate fresh fruits and vegetables may be limited due to long distances needed to travel to stores or financial limitations[16,18]. Since rural populations are also at a higher risk for health disparities due to limited access to health care[15], nutritional deficiencies from a plant-based diet have the potential to have a greater negative impact on overall health.

Due to this there is a need to explore the intersection of plant-based diets and nutritional planning in rural populations to understand what gaps in knowledge and practice exist. We can look to those who already engage in a plant-based diet in rural settings for context about what makes them successful and to what degree they plan for nutritional adequacy. This insight can be used to determine how plant-based diets can best benefit rural populations, both individually and systemically.

1.2 Changes in Plant-Based Dietary Patterns Overtime

In the United States, more individuals are choosing to eat less meat, despite the number of vegetarians and vegans remaining stable. In a nationally representative survey conducted in 2015, 2/3 of participants reported decreased meat consumption over the past

three years, citing cost and health as the primary motivators [19]. In a 2019 Gallup Poll, 23% of respondents indicated that they have been eating less meat over the last year, citing health and environment as main drivers[20]. According to another Gallup Poll, the number of people identifying as vegan or vegetarian in the United States has stagnated at 3-5% between 1999-2018, indicating that although many people are reducing meat consumption, they are not necessarily becoming vegan or vegetarian[21].

Accompanying these trends, 2022 sales data from the Plant-Based Foods Association shows a 6.6% one-year growth in plant-based food sales, a rate that has continued year-over year and has exceeded $8B[22]. While this data reflects processed plant-based foods such as non-dairy milk alternatives and meat analogues rather than whole plant foods, it suggests changing preferences and a need for more information about how individuals eating a plant-based diet are planning for nutrients of concern.

1.3 Environmental Benefits and Social Challenges of Plant-Based Diets

Meat and dairy production have been shown to contribute 57% of the global food production emissions, which make up 1/3 of all greenhouse gases[23]. In addition to greenhouse gas emissions, animal agriculture contributes significantly to water use, land use and pollution[24]. Thus, scholars and activists have identified reducing animal agriculture in favor of plant-based diets as a major area of climate action.

In 2019, the EAT-Lancet Commission of international experts in nutrition, health, agriculture, sustainability and policy identified a link between human health boundaries and planetary health boundaries within the food system[1]. They developed an integrated

health and sustainability agenda, called the "planetary health diet" which consists of a large diversity of plant-based foods and a reduced amount of animal products, refined grains, highly processed foods and added sugars[1]. The commission also set targets on sustainable food production, which developed boundaries for greenhouse gas emissions, cropland use, water use, nitrogen and phosphorus application and biodiversity loss to prevent irreversible and potentially catastrophic shifts in the climate as set out by the Paris Agreement[1]. The study estimated that about 11 million lives could be saved by shifting to this dietary pattern by improving health and mitigating climate risks[1].

While it provides a strong framework, the EAT-Lancet study was criticized for not addressing the adequacy of micronutrients that are typically only found in animal foods in sufficient quantities[25] and that there would need to be shifts to cultural cuisines as well as education about how to develop a healthy plant-based diet, which cannot be done without addressing the socioeconomic barriers to adequate nutrition, plant-based or otherwise.

1.4 Health Benefits Associated with Plant-Based Diets

Mounting evidence shows that a diet high in minimally processed fruits, vegetables and whole grains is associated with a decreased risk for diet related chronic diseases like type-2 diabetes, hypertension, stroke and cardiovascular disease[2–6], and with improved digestive health and gut microbiome diversity[7,8]. Whereas diets high in animal products – especially red and processed meats – are linked to certain adverse health outcomes including type 2 diabetes, cardiovascular disease, and certain cancers [26,27].

However, not all plant-based diets are created equal and overall diet quality is an important consideration. The health benefits of plant-based diets are in-part due to the increased dietary fiber and micronutrients and decreased saturated fat that is inherent in eating a higher in fruits and vegetables. When higher amounts of added sugars and processed foods are consumed in the place of fruits, vegetables and whole grains, some of the benefits are lost. To help study the links between the quality of different plant-based diets and health outcomes, Satija et al. developed a plant-based diet index (PDI) that designates plant foods with positive scores and animal foods with negative scores[28,29]. This index was further refined into a healthful plant-based diet index (hPDI) and unhealthful plant-based diet index (uPDI), which designates healthy plant-based foods with positive scores and less healthy plant-foods with negative scores. The uPDI assigns positive scores to less healthy plant foods and negative scores to healthy plant foods and animal foods.

1.5 Nutrients of Concern in Plant-Based Diets

While minimally processed plant-based diets have been associated with positive health outcomes, it is important to consider the adequacy of specific micronutrients, which are either not present in sufficient quantities in plant-based foods or not as easily absorbed. These nutrient gaps must be addressed with proper dietary planning for optimal health. Evidence shows that vegans and vegetarians are at risk for deficiencies of specific nutrients compared to omnivores[13]. These specific nutrients of concern are: Vitamin B12, Vitamin D, omega-3 fatty acids, calcium, iron, iodine, zinc, and protein[12].

1.5.1 Vitamin B12

Among other functions, Vitamin B12 is important for red blood cell production and DNA synthesis[30]. A B12 deficiency can lead to issues with cognition and red blood cells as well as elevated homocysteine, which is a cardiovascular disease marker [30]. It is mainly found in animal-sourced foods and vegans must rely on supplementation or fortified foods such as plant-based milk alternatives and nutritional yeast[31]. Studies have shown that those consuming a plant-based diet are at a higher risk for deficiency. A cross sectional study on British men demonstrated that 52% of vegans were deficient in Vitamin B12, whereas 0% of omnivores were[32]. Vegetarians who consume eggs and/or milk are also at risk of B12 deficiency, but to a lesser degree than vegans[33].

1.5.2 Vitamin D

Vitamin D is important for a variety of functions including bone health and immunity. It can be made by the skin with sufficient exposure to ultraviolet (UV) radiation but due to geographic location and other factors, it may be difficult produce in sufficient quantities[31]. Since few food sources have significant vitamin D (fatty fish, fortified milks, UV exposed mushrooms), many people rely on supplementation or fortification regardless of diet type[31].While Vitamin D is a challenging nutrient for all dietary patterns, studies have demonstrated that those consuming vegan or vegetarian diets are more likely to be deficient in Vitamin D than pescatarians and omnivores[34].

1.5.3 Omega-3 Fatty Acids

Omega-3 fatty acids are important for brain and cardiovascular health. They are essential, meaning that they must be consumed and cannot be created by the body. There are 3 main types: eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and α-linolenic acid (ALA)[31]. DHA/EPA are typically found in seafoods and algae-based supplements and are the most biologically active[31]. ALA is found in some nuts and seeds including flaxseeds, chia seeds, hemp seeds and walnuts, but must be converted by the body before being biologically active[31]. Since ALAs are poorly converted in the body, they must be consumed in larger quantities[35,36]. Blood and tissue levels of DHA and EPA, are typically lower in vegans and vegetarians than non-vegetarians [35].

1.5.4 Calcium

Calcium is important for bone health and nerve function, among other things. The most common source of calcium is cow's milk, but it is also present in a variety of plant-based foods such as dark green leafy vegetables, tofu and fortified plant-milks. Studies have shown that vegans have lower calcium consumption than vegetarians or omnivores[37]. In addition, calcium is less bioavailable in plant-sources due to binding with compounds such as oxalates[31]. Calcium absorption is improved with the presence of vitamin D and with foods with lower oxalate content[31]. In vegans, the risk of fracture is increased only for those who consume low calcium demonstrating the importance of careful planning, especially for those who do not consume dairy[38].

1.5.5 Iron

Iron has a variety of functions in the body including transporting oxygen in the blood and boosting immunity. Animal-based heme iron is more bioavailable than plant-based non-heme sources of iron such as beans, lentils, greens and fortified grains[39,40]. Studies have shown that vegans and vegetarians consume higher amounts of iron than omnivores[37], but have lower serum ferratin and higher rates of iron deficiency anemia[41]. Iron absorption can be inhibited by plant compounds called phytates and the presence of calcium and increased by pairing it with vitamin C rich foods[31].

1.5.6 Iodine

Iodine is a mineral important for the creation of thyroid hormones and plays an essential role in metabolism. It is most commonly found in seafood and dairy[42], but sources for those on a plant-based diet include seaweed, iodized salt and supplements[31]. Studies have shown that overall, vegans and vegetarians are at a higher risk for iodine deficiency than those with less restrictive diets, however vegans who consume seaweed regularly are able to exceed intake goals[43,44]. This evidence points towards the need for vegans and vegetarians to access iodine through iodized salt or seaweed [45,46].

1.5.7 Zinc

Zinc is important for a variety of functions including immunity and wound healing. It is most commonly found in animal foods, but there are a variety of plant-based foods such as nuts, seeds, grains and legumes. While zinc deficiencies are not common in western

vegetarians, at risk populations like older adults, children and pregnant/lactating women should be aware that zinc absorption is decreased by high phytate content in many plant-based sources of zinc[47]. Certain preparation methods can help improve the absorption of zinc from plant-based sources, such as pairing with acidic foods or soaking/sprouting[48].

1.5.8 Protein

Typically, vegetarians and vegans meet or exceed overall protein requirements, but many plant-based proteins are missing or low in one or more essential amino acids[49]. Plant-based eaters must focus on obtaining all essential amino acids by complementing a variety of plant-based protein sources, or consuming complete proteins, such as soy products[49]. This requires a plant-based eater to consume a wide range of protein foods to ensure that all essential amino acids are covered throughout the course of the diet. For example, combining grains and legumes will complement each other to promote better proportions of essential amino acids[50]. While it is often recommended to eat meals that include complementary proteins, consumption can be spread out across the day[12,51].

To address these nutritional gaps, health care providers recommend careful planning including consuming a variety of plant-based foods to cover a wider nutritional base in combination with supplementation including fortified foods, vitamin/mineral supplements and foods with specific nutrients like nutritional yeast, algae, seaweed, chia, hemp and flax [13].

The Academy of Nutrition and Dietetics released a position paper recognizing that an appropriately planned vegetarian or vegan diet can be healthful, nutritionally adequate and may provide health benefits in the prevention of certain diet related diseases at all life stages [12]. The 2020-2025 Dietary Guidelines for Americans includes recommendations for a vegetarian dietary pattern, but there is no mention of a vegan dietary pattern, with the exception of recommending pregnant or lactating women consult with their doctors before engaging in one [52]. The guidelines provide a Healthy Vegetarian Dietary Pattern for toddlers 12-23 months who are no longer receiving human milk and for ages 2 and older. This pattern is higher in soy products, beans, peas, lentils, nuts, seeds and whole grains, but includes eggs and dairy and does not include explicit directions on addressing all of these nutrients of concern.

1.6 Need for and Challenges to a Nutritionally Adequate Plant-Based Diet Among Rural Populations

1.6.1 Rural Health Disparities

While increases in plant-based dietary patterns are being observed in the United States, it is likely that there are differences in the rate of adoption regionally. Although over one-sixth of the United States population lives in a rural area [53], there are few studies that have investigated food choice or nutritional planning among a representative sample of rural residents. In particular, there is a lack of data for adoption of plant-based diets in rural areas. However, well documented health disparities in rural populations have been connected to reduced healthcare access and other socioeconomic factors including income,

education, and geographic location [15]. An increased prevalence of diet related health conditions such as high blood pressure, cardiovascular disease and type-2 diabetes have been observed, compared to urban communities [54].

Research has demonstrated that addressing these concerns is a high priority among rural communities. Healthy People is a United States Health and Human Services initiative which sets national public health objectives every 10 years[55]. It does not distinguish for different sub-populations, so Rural Healthy People was created as a counterpart, recognizing that rural populations have unique health concerns and public health interventions are often not applied to rural and urban areas equally[54,56]. The researchers surveyed rural stakeholders to better assess which health priorities are most important to them. In both the 2020 and 2030 studies, access to quality health care was deemed the most important priority and nutrition/diet related disease concerns were consistently in the top ten concerns, demonstrating the importance of nutrition intervention in these communities[54,56].

Since rural populations are already at an increased risk for health disparities, the need to understand and plan for nutritional adequacy in a plant-based diet is more pressing for these individuals. More broadly, addressing specific nutrients of concern could benefit all rural residents, including non-plant-based eaters, since those in rural areas have been shown to have lower diet quality even after controlling for other characteristics such as race, income, and education[57].

1.6.2 Challenges to Adopting a Plant-Based Diet in Rural Areas

Increased consumption of minimally processed fruits, vegetables, and whole grains could offset some of the disparities discussed above. However, there may be decreased access to, or consumption of fresh fruits and vegetables compared to urban areas [16,18], and higher consumption of red meat and lower consumption of lean meat [58,59]. While many factors contribute to lower rates of fruit and vegetable intake and higher rates of meat consumption in rural areas, some of this has been attributed to economic shifts due to the loss or consolidation of culturally significant industries, such as manufacturing and farming that reduces development and resources within the community [60].

Compared to non-rural residents, food access is more challenging for rural residents. Food access can be broken into 5 dimensions as described by Caspi *et al.*: availability, accessibility, affordability, acceptability, and accommodation[61]. With fewer retail options, longer distances to stores, limited access to public transportation[62] and lower income[53], rural communities are challenged by each of these dimensions. Not only must culturally appropriate food be present, but individuals must be able to access it and have enough money to purchase it. This is especially challenging for those who have a lower income and have been shown to live further from stores and have less access to personal transportation[63].The USDA reported that close to 11% of rural households reported food insecurity in 2021[64], in part due to these factors.

Thus, the ecological context (i.e., food environment) in which rural residents are making their food decisions may contribute to lower fruit and vegetable consumption and misbalanced meals. Potential reasons include decreased freshness and variety as well as

increased price, as compared to urban areas[16]. For example, it is becoming increasingly common for individuals in rural areas to purchase food from dollar stores and super stores, which tend to stock more ultra-processed, calorically dense, and nutrient poor foods than traditional grocery stores[63]. Studies have shown that not having a supermarket within a neighborhood is negatively associated with consumption of fresh fruits and vegetables[65]. With these challenges of obtaining food more generally, prioritizing nutritional adequacy may be more challenging for rural residents.

In addition to food access challenges, there is evidence to suggest that vegetarian or vegan diets may not be culturally acceptable to many people in rural areas. Studies have demonstrated that rural cultural norms view meat as a central component of a meal[14,66]. In addition, rural residents have been shown to have stronger meat-eating identities[14]. For example, rural adults reported familial expectation to consume meat every day, enjoy the taste and believe it is an important component of a healthy diet, especially among those who engage in animal agriculture or hunting[14]. With over 39.6 million Americans who engage in hunting and fishing[67] and almost half of the 2.1 million US farms raising livestock[68], these meat-eating identities are likely well established in rural areas where these activities are more common. On top of this, plant-based eating patterns may be perceived as self-righteous[69] or a threat to economic livelihood and traditional ways of eating in rural areas[70]. This resistance by the dominant meat-eating culture has been described as the term "vegetarianism threat" in the literature[71]. Therefore, plant-based diets that emphasize a reduced consumption of meat (but not a complete elimination) may be the most well received and impactful on the overall health of rural populations.

If an individual overcomes these physical and cultural barriers and engages in a plant-based diet, they may face additional challenges associated with eating differently than the dominant culture. While many plant-based eaters have positive feelings about their dietary choice from a health, ethical and/or environmental standpoint, their status as a social minority may lower their overall wellbeing[72]. This is in part due to stigmatization, negative social interactions and having values that conflict with the dominant culture[69]. On top of the food access issues mentioned above, plant-based eaters may be further limited by the availability of foods that fit within their dietary preferences at stores, restaurants and social gatherings and are left with fewer options or those that do not meet their nutritional needs. One study assessed the nutritional quality of vegetarian meals at fast food restaurants and found that only 20% of items on the menu were vegetarian and were lower in calories, fat, protein and higher in sugar and carbohydrates than animal-based options[73]. Due to the social and environmental challenges above, plant-based eaters may be less likely to request modifications, consume foods that do not fit with their dietary preferences or settle for what is available even if it is not satisfying or nutritionally adequate[74].

Thus, it is important to investigate the nutritional knowledge and planning of rural plant-based eaters due to the baseline health disparities, food access issues, and potential cultural barriers, which may put them at higher risk of nutritional deficiency than plant-based eaters in nonrural areas.

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CHAPTER 2: A QUALITATIVE STUDY OF RURAL PLANT-BASED EATERS' KNOWLEDGE AND PLANNING FOR NUTRITIONAL ADEQUACY

2.1 Introduction

Plant-based diets have become increasingly popular for health, environmental and ethical reasons. Sales trends from the United States (U.S.) suggest increasing consumption of plant-based diets nationally[1]. The term "plant-based" is used to represent a wide range of dietary patterns from vegan to flexitarian. In the literature, it has been defined as "[a] diet dominated by fresh or minimally processed plant foods and decreased consumption of meat, eggs and dairy products[2,3]." It does not necessarily mean a vegan or vegetarian diet but can include them.

Mounting evidence shows that plant-based diets high in minimally processed fruits, vegetables and whole grains are associated with a reduced risk for diet related chronic diseases like type-2 diabetes, hypertension, stroke and cardiovascular disease[4–8], and with improved digestive health and gut microbiome diversity[9,10]. Whereas diets high in animal products – especially red and processed meats – are linked to certain adverse health outcomes including type 2 diabetes, cardiovascular disease, and certain cancers [11,12].

While minimally processed plant-based diets have been associated with positive health outcomes, it is important to consider the adequacy of specific micronutrients, which are either not present in sufficient quantities in plant-based foods or are not as easily absorbed. These nutrient gaps must be addressed with proper dietary planning for optimal

health. Evidence shows that vegans and vegetarians are at risk for deficiencies of specific nutrients as compared to omnivores, including Vitamin B12, Vitamin D, omega-3 fatty acids, calcium, iron, iodine, zinc, and protein [13,14].

To address these nutritional gaps, experts recommend careful dietary planning that includes consuming a variety of plant-based foods to cover a wider nutritional base in conjunction with fortified foods, vitamin/mineral supplements and foods with specific nutrients like nutritional yeast, algae, seaweed, chia, hemp and flax [14]. Understanding to what extent plant-based eaters are planning their diets for these nutrients is essential for assessing the overall healthfulness and sustainability of the dietary pattern.

However, there are differences between urban and rural areas due to complex socioeconomic and cultural differences. Compared to populations in nonrural areas, rural populations experience lower access to health care and food resources[15–17]. Despite rural areas growing a majority of the food produced in the United States, access to and consumption of adequate fresh fruits and vegetables may be limited due to long distances needed to travel to stores or financial limitations[16,18]. Evidence on what facilitates plant-based diets among those at high risk to diet related disease- such as rural populations – could be used to support the design of targeted interventions.

The aim of this qualitative study is to explore the nutritional knowledge and practices of rural plant-based eaters to better understand to what degree planning is used to ensure adequate consumption of nutrients of concern. It seeks to address a gap in the literature to help inform health practitioners about what knowledge and practice deficits

exist within rural communities and what trends may emerge in the future as the number of rural plant-based eaters presumably increases over time[19].

2.2 Methods

2.2.1 Study Participants and Data Collection

This qualitative study used data from semi-structured interviews with rural residents in the U.S. state of Vermont who eat a plant-based diet. This study defined a plant-based diet as meeting the national recommendations for fruit and vegetable consumption and limiting intake of red meat, poultry or fish to no more than four times per week.

Rural plant-based eaters were identified through community organizations, local food co-ops, plant-based restaurants, and online postings. Participants were screened using a brief online survey to determine eligibility based on age 18+ years, residence in rural Vermont, and whether they self-identified as consuming a healthy plant-based diet. Residents in all counties of Vermont were eligible except for those in the most urban county, Chittenden. Geography was verified using geolocation. To support sample diversity, recruitment quotas were set at: 1) no more than 6 people per county, 2) no more than 20 people over or under age 50 years and 3) no more than 22 people of the same gender. Prior to participating in an interview, subjects completed a brief online demographic and diet survey (Appendix A). Interviews were conducted by phone or videoconference and ranged between 24 and 69 minutes in length. Participants were compensated $25. The study protocol was approved by the Institutional Review Board at the University of Vermont (protocol ID# 00002156).

A semi-structured interview guide (Appendix B) was developed based on the core concepts of the Theory of Planned Behavior with an additional section that sought to capture knowledge and planning for nutrients of concern in a plant-based diet. Questions explored overall diet, motivations for engaging in a plant-based diet, ease or difficulty of engaging in a plant-based diet, family/community views as well as suggestions for what they think could make eating a plant-based diet easier for others. The last section assessed overall degree of nutritional planning for specific nutrients of concern in a plant-based diet.

2.2.2 Analysis

Interviews were audio-recorded, transcribed, manually cleaned, and imported into NVivo qualitative data analysis software (QSR International Pty Ltd. Version 20 Release 1.6.1) and structurally coded by question. Two different coding approaches were applied; a template analysis to capture strategies and contextual factors that may explain the ability to adopt and maintain a plant-based diet and a deductive approach informed by Grounded Theory to examine degree of nutrition planning related to nutrients of concern commonly lacking in plant-based diets. 11 interviews were opened coded by the first author and two research assistants who met to discuss emergent ideas and themes and two codebooks were created and iteratively refined before being used to code all interviews. The focus of this analysis is the data that were coded in the "Nutrients of Concern" codebook which focused on knowledge and degree of nutritional planning (Appendix C). Prior to coding all interviews with the final codebook, the first author and the other coder achieved an inter-rater reliability of kappa >0.7 for two interviews. Following completion of coding, the first

author wrote a memo for each code to synthesize key themes related to each code. Prior to finalization, the memos were reviewed, discussed, and refined in collaboration with the other coder.

Data were further analyzed by taking in-depth notes on each participant and identifying key characteristics through both the interviews and pre-interview survey responses, which allowed them to be understood contextually. Participants were grouped and characterized not only by diet type but based on other similarities and differences such as level of nutrition knowledge, geography, and specific ideologies/practices. Through this process, key quotes were identified and incorporated into illustrative examples to demonstrate significant ideas.

2.3 Results

A total of 28 adults ranging from 19 to 77 years of age participated in interviews (Table 1). There was diversity in diet type, but over 1/3 (n=11) self-identified as vegan. 88% of those who disclosed their race identified as non-Hispanic white, similar to the demographic composition of rural Vermont[20]. 75% of respondents were female. All self-identified as having average or above average nutrition knowledge.

2.3.1 Overall Attitudes about the Healthfulness of Plant-Based Diets

Overall, participants believed that a plant-based diet is healthful: “I’ve seen it work successfully [for myself] …and lots of people in my life” (Vegetarian, P#06). In fact, about 1/3 of participants (n=10) stated that they do not have any significant concerns about the

nutritional adequacy of a plant-based diet. For example, one pescatarian shared, “There’s not much you can’t get [on a plant-based diet] …and I don’t have any particular concerns” (P#09)

However, when respondents were asked if they had any specific concerns about a plant-based diet, there was an appreciation that plant-based eaters need to be “conscious” or “aware” of a few key nutrients, including Vitamin B12, omega-3 fatty acids, iron, protein, Vitamin D, calcium, iodine and zinc in descending order of predominance. Despite this, there was a general belief that it is easy to meet nutritional needs on a plant-based diet through dietary planning, supplementation, and a varied, minimally processed diet.

A common sentiment was that a plant-based diet is more nutritious than a meat-centered diet and can positively impact overall health and wellbeing. As one 77-year-old vegetarian explained, “At my age...I keep expecting [my health] to get worse…but I might actually be getting better in some areas [due to my diet]” (P#18). Several noted that they are significantly healthier than their peers and credited a plant-based diet with a positive impact on chronic health conditions (especially cholesterol levels and cardiovascular health), aging and energy levels. There was a general perception that eating a plant-based diet helps to reduce “inflammation, your risk of cancer, your risk of diabetes, basically all chronic illnesses” (Vegan, P#25).

Participants put an emphasis on the consumption of a varied diet to “cast a wide net”, as opposed to targeting specific nutrients. About half of participants (n=14) mentioned eating a varied diet to ensure nutritional adequacy: “[My family tries] to have a fairly varied diet on a regular basis, so eventually you’re gonna get everything you need” (Pescatarian,

P#09). By doing this, it takes away some of the mental labor needed to plan. For example, one flexitarian shared, “I don’t really think about it that much anymore… I just kinda do it”. Other examples included focusing on balance, macronutrients, local produce, and varied cuisines.

There was also a distinction made between a processed plant-based diet and a whole food plant-based diet. Close to half of participants (n=13) discussed the idea that a plant-based diet is not necessarily healthy because processed vegan “junk food” is readily available. As one vegan put it, “Vegan doesn't equal healthy… there’s so many like junk food vegans and like so many things that like are completely unhealthy and still vegan” (P#24). Several others echoed that sentiment stating that it was easy to overconsume processed foods, thus making it more difficult to get the nutrients and fiber that would be found in whole foods. However, a subset expressed that a vegan diet that includes substantial quantities of processed foods still may be “just a little bit healthier” than the standard American diet and could serve as a transition food or for convenience.

2.3.2 Key Nutrients of Concern

The following sections summarize attitudes, knowledge, and level of concern about each of the nutrients of concern for a plant-based diet. Key insights, illustrative quotes, and resultant recommendations are presented in Table 2.

2.3.2.1 Vitamin B12

Participants who expressed concern for B12 were primarily vegans and vegetarians and 1/3 of participants (n=10) mentioned it in the context of a plant-based diet. As one vegan put it, "B12 is…a vitamin that you get basically from animal products, so being a vegetarian, I just don't get that" (P#15). There was acknowledgement that B12 is difficult to get from plant-based foods and for the most part must be supplemented. For two vegans, B12 was the only nutrient that they were concerned about not getting from their diet.

B12 was the mostly commonly supplemented nutrient discussed, with various forms of supplementation noted including liquid sub-lingual supplements, pills, and multivitamins. 10 participants described specific food sources that they seek out for Vitamin B12. Over half (n=16) mentioned using nutritional yeast for its cheese-like flavor. While six participants acknowledged the nutritional content of nutritional yeast as important, only three use it primarily for nutritional purposes and acknowledge that it "only goes so far." Most of the participants who enjoy nutritional yeast and use it for nutritional content were vegans or vegetarians.

While nutritional yeast was the most common dietary source of B12, fortified foods such as plant-based milk alternatives were mentioned by two participants. An additional 15 participants reported that they consume plant-based beverages but did not mention B12 fortification. One pescatarian mentioned that they don't supplement B12 because they eat eggs, but no other non-vegan participants noted seeking out meat or milk as a source of B12.

2.3.2.2 Vitamin D

Vitamin D was the second most mentioned nutrient. Participants expressed the idea that it is challenging to get enough vitamin D, especially in Vermont in the winter, i.e., "we don't live in a sunshine state…and my own Vitamin D levels were low this past winter" (Flexitarian, P#01). Outside of geographical and seasonal considerations, participants indicated that there aren't many foods that have vitamin D- the only specific example discussed was fortified plant-based milks which were only mentioned by one participant. There was no mention of cow's milk or fish as sources of Vitamin D despite them being included in many plant-based dietary patterns.

As such, supplementation was the most common conscious source of vitamin D for participants. Vitamin D supplements were often taken at the advice of a medical professional. One participant shared that their doctor recommends that "every Vermonter" should be taking vitamin D due to the northern location. No participant said that their medical professional recommended it specifically because of a plant-based diet.

2.3.2.3 Omega-3 Fatty Acids

About 1/3 participants (n=10) discussed omega-3 fatty acids unprompted, including nearly half of the vegans. While there was some awareness of the need to incorporate omega-3s into a plant-based diet, respondents displayed limited knowledge regarding the differences between plant-based alpha-linolenic acid (ALA) and animal-based eicosapentaenoic acid (EPA)/ docosahexaenoic acid (DHA). For example, only one vegan

participant noted that ALA can be converted into DHA/EPA if consumed in sufficient amounts. Four of five participants who discussed taking omega-3 supplements were vegans who took algal based supplements; the other was a pescatarian who took fish oil. While only three mentioned seeking out nuts/seeds specifically because they are "jam packed" with omega-3s, most participants reported enjoying the consumption of flax, chia and/or hemp seeds. These seeds were used interchangeably as additions to foods like yogurt and smoothies and were commonly sought after as a good source of fiber, protein or to fill in general gaps in their diet. Notably walnuts, a rich source of ALAs, were mentioned less than other types of nuts that are lower in ALAs (e.g., almonds and cashews).

2.3.2.4 Calcium

About 40% of participants (n=12) discussed concepts related to calcium. Only three vegans felt that calcium is a nutrient that needs to be monitored on a plant-based diet, but that it is not difficult if you know the sources. However, four participants mentioned a general concern for calcium in the context of other health conditions such as bone health and aging. In these cases, the concern was not related to plant-based diets, but it was a driver for consuming more calcium-rich foods.

One flexitarian participant with a nutrition background mentioned that the bioavailability of calcium in plant sources "can be really limiting" (P#01) as compared to animal sources and a vegan participant accurately articulated that vitamin D is needed to aid in calcium absorption. Neither of these points were expressed as common knowledge among the sample.

Spinach, dark green leafy vegetables, and cruciferous vegetables were discussed as sources of calcium by four participants. Meanwhile, four others were either concerned about getting enough calcium due to not consuming dairy products or not concerned about calcium because they do eat dairy products. Non-vegans were generally less concerned about calcium due to dairy in their diet. All of the people who were concerned about calcium on a plant-based diet were vegan or did not consume a significant amount of cow's milk. However, three discussed fortified non-dairy milk alternatives as a source of calcium.

Overall, the focus was on food sources as opposed to supplementation. No participants mentioned seeking out calcium supplements. One pescatarian participant expressed that, "if I can get calcium from black beans and from bok choy [instead of fortification]…I would prefer that."

2.3.2.5 Iron

Slightly less than half of participants (n=13) described ideas related to iron. It was commonly noted (n=5) as a nutrient of concern on a plant-based diet, but more participants (n=8) discussed iron in the context of general deficiency or specific life stage (i.e., menstruation, menopause), and some uncertainty was expressed about whether these deficiencies were related to a plant-based diet or some other health condition.

Only three participants mentioned taking an iron supplement due to concerns of iron deficiency, otherwise there was some ambivalence about iron: As one flexitarian expressed, "I do wonder about iron, but I don't wonder about it enough to like do anything about it" (P#14).

Only one participant with a background in nutrition noted the decreased bioavailability of iron in plant-based foods, and none mentioned the difference between heme and non-heme iron or use of ascorbic acid to increase absorption.

Overall, there was a focus on getting iron through a variety of plant-based foods like spinach, dark green leafy vegetables, and legumes as opposed to supplementation. However, one vegan mentioned that they likely get enough iron from vegetables but takes a supplement occasionally just to be sure. There was a not a strong belief expressed that red meat is needed for adequate iron and no flexitarian participants mentioned regularly seeking out animal foods like red meat as a source.

2.3.2.6 Iodine

Overall, iodine was not of significant concern for participants in any diet type. Of the six that discussed iodine, only one mentioned it in connection to plant-based diets. Seaweed and iodized salt were the main dietary sources of iodine, and only two participants supplement, as part of a multivitamin. Of the 13 participants who described consuming seaweed, about half (n=7) mentioned knowledge or use of seaweed as a source iodine or other nutrition. However, three people mentioned that they do not enjoy the "ocean" flavor, and don't eat it despite the nutritional benefits.

Seaweed was a widely used ingredient for other participants who did not mention the nutrition content. While most enjoyed seaweed as part of sushi, adding to recipes was also popular. Sprinkling dulse flakes over foods was mentioned by five as an iodine source or a salt alternative. Only two participants mentioned using iodized salt as a source of

iodine. Otherwise, of the 10 participants who discussed iodized salt, six participants mentioned using it infrequently, with a preference for Himalayan salt, sea salt or kosher salt.

2.3.2.7 Zinc

Of the nutrients queried, zinc was the least mentioned, and no one raised concern for it in the context of a plant-based diet, including decreased bioavailability. Although participants often discussed eating foods naturally rich in zinc such as legumes, tofu, nuts and seeds, none described seeking out specific foods as a source of the mineral. A few (n=5) discussed the inclusion of the zinc in their supplementation routine, especially as part of a multivitamin. Among these individuals, the focus was on perceived benefits for aging and immunity.

2.3.2.8 Protein

All 28 participants were prompted to discuss protein, but there was also a significant amount of unprompted discussion throughout. There were mixed opinions about whether a plant-based diet has adequate protein, but interestingly, no vegans mentioned being worried about adequate protein. Instead, they focus on variety or believe that protein is over-emphasized by American culture: “I think we overemphasize protein as a culture. So I don't ever worry about that and I feel strong…I've never felt weak…as a vegetarian” (Pescatarian, P#27).

About 1/3 of participants (n=9) discussed protein complementing. Vegans and vegetarians were the most knowledgeable, while flexitarians and pescatarians were either

not as knowledgeable or concerned. Of the six participants that discussed pairing beans and grains to create a complete protein, two vegan participants discussed learning that complementing does not have to happen at the same meal. Two vegan participants also mentioned seeking out plant-based foods with complete protein such as like tofu and quinoa, so that complementing is not necessary. Two pescatarian participants shared that they are aware of protein complementing but consume a varied diet to meet amino acid needs instead of actively combining foods.

A wide variety of protein foods were mentioned. The most common plant-based sources were tofu, tempeh and legumes. Of note, six participants described beans as being a staple in their diet, consuming it daily or weekly. For non-vegans, animal-based protein sources such as fish, poultry, eggs and dairy were important aspects of getting enough protein, but they also consumed a variety of plant-based proteins.

About 1/5 of participants (n=6) shared that they prefer whole food protein options (such as beans, nuts and seeds) over more processed protein foods. There were some negative health perceptions about heavily processed meat alternatives, but five participants expressed the idea that less processed convenience foods like precooked tofu made plant-based proteins easier and more accessible.

2.3.3 Source of Nutrition Information

Over 80% (n= 23) of participants discussed both formal and informal sources of nutrition information. Health practitioners (both traditional and alternative) were the most mentioned (n=12). Of these, eight participants said that they get nutrition information from

mainstream practitioners or lab results. Among these participants, medical professionals were considered trusted sources, but one participant expressed the sentiment that that doctors do not have adequate nutrition education and over-prescribe medication instead of looking at diet/lifestyle changes: “until the medical community gets more committed to nutrition and the impacts on health, I don’t think much is going to change” (Vegan, P#8). While one participant mentioned that she sees a plant-based doctor, several others mentioned that they wish they had access to providers with this training and/or that plant-based nutrition programs, e.g., receiving fruit and vegetable vouchers from the doctor or cooking classes offered through the health center, were more widespread. There was limited reference to the use of registered dietitians. Four participants mentioned receiving nutrition and supplementation advice from alternative health professionals such as naturopaths, acupuncturists, herbalists, and medical mediums. About 1/3 of participants (n=10) discussed receiving nutrition information through informal sources, such as discussions with friends and family and mixed media (e.g., books, podcasts and websites). There were no clear trends between a participant’s diet type and where they sought out knowledge.

2.4 Discussion

This study provides the first exploration of nutritional planning of plant-based eaters in the rural United States and highlights successes and limitations. Despite evidence that suggests diets that limit animal-source foods may not be culturally acceptable in some rural areas[21], a recent population survey in Vermont showed that over 1/3 of adults identify with a dietary pattern that falls under the umbrella of “plant-based”[22], highlighting

the importance of understanding the information needs of rural plant-based eaters. While plant-based diets are promoted as healthy and "sustainable" dietary patterns, potential nutrient gaps must be considered when discussing the overall healthfulness. This may be particularly relevant given diet-related health disparities in rural areas[15–18] and the unique challenges to healthy food access[16,18]. Insight from current rural plant-based eaters can be used to inform nutritional guidance and interventions, as the number of plant-based eaters is expected to continue growing[1,19].

We found plant-based eaters to have a positive outlook about the healthfulness of a plant-based diet and largely focus on meeting their nutritional needs using whole food plant-based ingredients that are readily available in rural co-ops and grocery stores (e.g., fruits, vegetables, nuts, seeds and legumes) or supplementation. Few relied heavily on highly processed, less accessible, or costly food items such as spirulina, protein powder and meat/dairy/egg alternatives to acquire key nutrients of concern.

The level of knowledge and degree of conscious planning varied across the sample. While important for all diet types (especially those who consume heavily processed or nutrient poor foods), nutritional planning is the most important for vegans due to their more limited diet. In this sample vegans tended to be the most knowledgeable, demonstrating that they may need less guidance than those who are elsewhere on the plant-based spectrum. However, not all vegans were fully aware of nutritional planning needs showing that even within a relatively educated group there remain gaps in knowledge and practice.

Participants were particularly aware of the need for B12, Vitamin D and omega-3s on a plant-based diet, which is important because these nutrients may be particularly

challenging to access through foods, especially for vegans. While nutritional yeast was used to get B12, it is less effective at improving B12 status than supplementation [35] and may not be accessible to many rural residents. Similarly, fortified non-dairy beverages were used as sources of B12 but fortification in plant-based beverages can vary significantly between brands[23] or be absent in homemade versions. There may also be some limited absorption of nutrients in plant-based beverages either due to the form of fortification, lack of solubility, or binding with plant components[23,24].

While Vitamin D can be produced by the body, it is difficult to create in sufficient quantities in northern Vermont. Recommending cow's milk, fortified-nondairy beverages and fatty fish can be helpful, but it may be insufficient to meet nutritional needs in isolation[25]. Thus, supplementation, especially among those who do not consume fish and in the winter would help ensure adequacy. However, Vitamin D was already the most recommended supplement by health practitioners due to its limited sources outside of the scope of a plant-based diet.

Participants demonstrated limited knowledge regarding reduced availability of EPA/DHA omega-3s in a plant-based diet, suggesting a need for increased education, particularly for those who do not consume fish. Despite vegans expressing more knowledge and concern about omega-3s and the relative popularity of nuts and seeds among vegans, it is unlikely they are consuming high enough amounts of ALA omega-3 fatty acids due to the low and variable conversion rate[26]. A fish oil or algal-based supplement may be a helpful dietary complement but comes with cost considerations. While encouraging intake of fortified foods like nutritional yeast, nuts, seeds, and fortified beverages may be helpful,

supplementation and routine monitoring may offer more effective means of ensuring adequacy of these nutrients.

Other nutrients were less considered and may need more intervention and education. Few participants were aware that zinc and iodine were nutrients of concern. In addition, few were aware of the differences in bioavailability for calcium, iron and zinc and did not express knowledge regarding how to improve absorption. Participants did not consciously or consistently seek these nutrients; however, they are more readily available in a wide variety of foods.

Protein seems to be the least concerning nutrient to address, despite limited knowledge expressed regarding complete proteins. The sample reported consuming a wide variety of plant-foods containing protein throughout the diet, and studies show that protein needs are often exceeded in the average American diet (including vegans and vegetarians)[27].

The variation seen in nutrition knowledge and practices suggests a need for more health practitioners with specialized training in plant-based nutrition in rural areas. However, considering that access to basic health care is already limited in rural areas[15], access to those who specialize in plant-based nutrition may be a difficult hurdle to achieve. Participants supplemented what they learned from health professionals with the internet and word of mouth, which has varying levels of quality[28]. Thus, bolstering existing programs that partner medical practices with community organizations and increasing targeted opportunities for rural plant-based eaters to boost their nutrition literacy may help bridge the current gap in nutrition support[29].

While there was some mention of specialty products that contain nutrients of concern, not all plant-based eaters utilize them, possibly due to lack of knowledge, interest, or cost barriers. It may be beneficial to promote what is already available and accepted in rural areas rather than foods that may be more difficult to find or inaccessible in rural regions (e.g., hemp seeds, dulse). This sample demonstrated the importance of local co-ops and community organizations as resource hubs, suggesting settings for community based nutritional workshops that could be helpful in building knowledge around plant-based eating. Online grocery shopping through companies with national reach could help improve access to plant-based foods where availability is limited locally, however it has been shown that there are some barriers to the adoption of online grocery shopping in rural areas[30,31].

This study is subject to several limitations. First, some participants were recruited through co-op grocery stores and plant-based restaurants, which may not represent the broader population of plant-based eaters. Second, this study included participants with various types of plant-based diets. Further inquiries could be performed on single diet types to gain more in-depth knowledge about each group. Lastly, the sample was relatively homogenous, with a slightly higher proportion of female participants and higher income and education than the average Vermonter[20]. Therefore, it is not possible to discern from this analysis whether the respondents reflect the general population of rural plant-based eaters in Vermont, but it offers insight into lived experience that can be used as a basis for future explorations.

2.5 Conclusion

While a varied minimally processed plant-based diet has health benefits, it may not be realistic for plant-based eaters – especially those in rural areas – to get all nutrients of concern through food. Yet, there is little awareness of the need for nutritional planning among this population except for B12, Vitamin D, and omega-3 fatty acids, and gaps in knowledge exist even for those nutrients. It is evident that intervention is needed for plant-based diets to achieve their potential. This is especially important in rural areas, where the benefits of a plant-based diet could have the highest impact due to pernicious health disparities and potential environmental, economic, and cultural barriers to eating a nutritious plant-based diet. While community education, public health programs and healthcare professionals who specialize in plant-based nutrition are important solutions, they only offer a top-level approach to address gaps in nutrition knowledge and practice.

It is clear based on these results that a purely individual effort to address nutrients of concern on a plant-based diet is insufficient due to knowledge and resource gaps. Thus, to make plant-based eating more healthful and realistic for rural populations, a more systemic shift is required. Among other systems-level interventions, this could include shifts in retail/transportation infrastructure to make nutrient rich plant-based foods and supplements more readily available and affordable; farm-to-school to programs that expose young people to locally-available produce and introduce nutritional principles; and the participation of rural food service institutions such as hospitals, schools, and restaurants in efforts to normalize nutritionally balanced plant-centered meals. In fact, rural communities (especially Vermont) may be in a particularly good position to make these types of changes

by leveraging their agricultural resources to emphasize local eating, co-ops, and farm-level involvement and education. This could also serve to help the broader population who may also struggle with these nutrients of concern. A cultural shift that emphasizes the importance of a varied, minimally processed, predominantly plant-based diet will at baseline provide a food environment that promotes overall nutrition and health.

Future studies could focus on determining if these trends are consistent in other rural areas. In addition, dietary intake and lab results could be evaluated to determine how prevalent nutritional deficiencies are among rural plant-based eaters. Finally, intervention research could help to determine if working with a health professional specializing in plant-based nutrition improves health outcomes, as compared to those who rely on other sources of nutrition information.

Table 1: Sociodemographic characteristics of participants

	n	Percent[1]
Age		
Under 50 years old	13	46.4
Over 50 years old	15	53.6
Sex		
Female	21	75
Male	7	25
Education		
< Bachelor's Degree	5	17.9
Bachelor's degree	13	46.4
Graduate Degree	9	32.1
Income		
Less than $24,999	6	21.4
$25,000-$74,999	9	32.1
$75,000-$99,999	7	25
$100,000 or greater	6	21.4
Race/Ethnicity		
Non-Hispanic White	22	78.6
BIPOC	3	10.7
Did not disclose	3	10.7
Rurality[2]		
Counties in metro area of fewer than 250,000 population	6	21.4
Nonmetro counties with an urban population of 20,000 or more, adjacent to a metro area	11	39.3
Nonmetro counties with an urban population of 2,500 to 19,999, adjacent to a metro area	5	17.9
Nonmetro counties with an urban population of 2,500 to 19,999, not adjacent to a metro area	6	21.4
Diet Type		
Flexitarian	6	21.4
Pescatarian	6	21.4
Vegan	11	39.3
Vegetarian	5	17.9

[1]Due to rounding not all numbers sum to 100

[2]Based on USDA Rural-Urban Continuum Code (RUCC) metrics

Table 2: Summary of key insights, illustrative quotes, and practical recommendations to improve adequacy of each of the nutrients queried.

Nutrient or Topic	Key Insights	Illustrative Quotes	Practical Recommendation
Overall Attitudes About Healthfulness	-Minimal concern outside of basic awareness for key nutrients -Focus on variety as way to meet most nutritional needs -Belief that a minimally processed plant-based diet is health promoting	*As long as you're an educated consumer [you can get what]…you need to eat to make sure you stay healthy…[otherwise it's] not going to be healthy. It's not gonna work, and it probably won't last.* -- ***Pescatarian, Female, 58, P#09*** *I'm 64 years old, I've never been happier, healthier in my life and stronger. And my siblings who have [the] same genetics as me who have not eaten as me, well, well, there you have it, you know.* -- ***Pescatarian, Female, 64, P#17***	- Encourage wide variety of minimally processed plant-based foods - Education about core nutrients that are most challenging to get from foods like Vitamin B12, Vitamin D and DHA/EPA omega-3s
Vitamin B12	-Overall high awareness of the limitations on a plant-based diet -Highest concern among vegans -Commonly Supplemented -Use of nutritional yeast for both supplementation and flavor	*[I take] B12 is because that's a vitamin that you get basically from animal products….So being a vegetarian, I just don't get that.* --***Vegan, Female, 64, P#15*** *I'd say the B12 is the only thing I kind of take like with a dietary mindset…the only thing I can think of that I eat that has B12 in it is like B12 fortified nutritional yeast…* -- ***Vegan, Male, 38, P#20***	-Supplementation due to limited food sources especially among vegans (sub-lingual, B-complex) -Encourage nutritional yeast and fortified non-dairy beverages that contain Vitamin B12 in combination with supplementation
Vitamin D	-Concern for all Vermonters regardless of diet type due to geography and limited food sources -Commonly recommended as a supplement by health care practitioners	*I don't know what foods are great in vitamin D….. [and] I don't always get out a lot, so like I just started taking [a vitamin D supplement] for peace of mind.* -- ***Vegan, Male, 38, P#20*** *If you're not getting [vitamin D] from dairy, which is fortified with vitamin D, then then you gotta get it from a supplement. So we take a vitamin B3 and a vitamin D.* -- ***Vegan, Male, 32, P#25***	-Supplementation due to limited food sources, especially among those who do not consume fish and during winter -Encourage fortified non-dairy beverages that contain Vitamin D in combination with supplementation

Omega-3 Fatty Acids	-Knowledge and concern most common among vegans -Limited knowledge about distinction between ALA and EPA/DHA -Use of algal based DHA/EPA omega-3 supplements among a small sub-set -Nuts and seeds commonly consumed, but not necessarily as a conscious ALA Omega-3 source	*"….with the Omega fatty acids our bodies just need that. And…like most things that if you're just eating a vegan diet and not thinking about it, you're just not gonna get that probably. And so again I think that's something to like seek out or make sure you're having at least like a certain level."*--***Vegan, Male, 44, P#24*** *[Our Omega supplement] comes from algae oil, which is the…basis of how fish get it…"* -- ***Vegan, Male, 32, P#25***	- Education about types of Omega-3s. - Algae based EPA/DHA supplement for vegans - Encourage creative ways to integrate walnuts, hemp, chia and flax to maximize ALA omega-3 consumption. -Omega-3s less of a concern for those who consume fish.
Calcium	-Focused on food sources as opposed to supplementation -Some belief that dairy is needed for adequate calcium -Less concern among non-vegans -Limited knowledge about decreased bioavailability of calcium in plant-based foods or role of Vitamin D in absorption	*Usually I… dry and powder greens, and then I put that in everything. So to try to keep the calcium because there's a lot of calcium in dark greens….* --**Vegan, Female, 52, P#11** *Hopefully if you're eating dairy, you're going to get to plenty of calcium. But the bioavailability of calcium and iron in a lot of plant-based foods can be really limiting. So just being conscious of that.* --**Flexitarian, Female, 61, P#01**	-Encourage continued consumption of dark green leafy vegetables and tofu as sources of calcium -Vitamin D supplement to improve absorption -Education about oxalate/phytate heavy foods

Iron	-Across all diet types, concern not necessarily related to a plant-based diet and more common with those who menstruate -Focus on iron rich foods as opposed to supplementation -Not a large conception that red meat is needed for adequate iron -Limited knowledge about decreased bioavailability of plant-based sources	*…I'm not sure I'm getting enough of this iron…they don't let me donate blood because my iron's too low….But that's a common problem for menstruating people anyway, so it might be unrelated to the diet.* -- **Flexitarian, Female, 33, P#12** *Because we select from all different types of veggies… I don't worry about [iron] too much, but I do try to stick with some of the green leafys to keep my iron up.* --**Vegan, Female, 51, P#02**	-Encourage consumption of spinach, dark green leafy vegetables, and fortified grains -Education about role calcium in inhibiting absorption and role of vitamin C in increasing absorption
Iodine	- Minimal concern about iodine in the context of a plant-based diet across all diet types -Seaweed/dulse was a popular food for both nutritional and taste purposes -Preference for seaweed as a source of iodine over iodized salt	*I make sure I have at least a pinch of dulse every day to try and make sure there's enough iodine because that is a quick deficiency you can run into if you have it, yeah.* -- ***Vegan, Female, 64, P#05*** *I don't use, just like iodized salt a lot. Like I even use like a substitute like seaweed more than that probably.* -- ***Vegan, Male, 44, P#24***	-Education about limited sources of iodine -Encourage consumption of seaweed (dulse shaker, sushi, seaweed snacks soups stews, etc), especially for those on a limited sodium diet
Zinc	-Limited knowledge about limitations of zinc absorption in a plant-based diet -Wide consumption of zinc containing foods, without mention of zinc.	*N/A*	-Education regarding methods to enhance zinc absorption such as pairing with acidic foods or soaking/sprouting.

Protein	-Tofu, tempeh, beans and lentils were the most commonly consumed plant-based protein foods -Mixed level of concern about adequacy of protein on a plant-based diet, no concern expressed by vegans. -Moderate knowledge among vegans and vegetarians about protein complementing	*I generally follow the guidelines of some kind of grain with bean combination, because it makes it more of a complete protein… but try to keep that mindful.—**Vegan, Female, 52, P#11*** *I think that [protein is] the biggest thing that people freak out about...I think we overemphasize protein as a culture. So I don't ever worry about that and I feel strong like I've never felt weak…as a vegetarian* **-- *Pescatarian, Female, 30, P#27*** *[By] not eating meat I lack [protein and B12] in my diet, so I supplement those by either seeking out extra protein or like focusing on it in particular, or by taking a supplement.* -- **Vegetarian, Female, 20, P#06**	-Encourage a wide variety of minimally processed protein foods, as opposed to emphasizing formal protein complementing
Source of Nutrition information	-Most common and trusted source were medical professionals -Limited access to health care professionals who specialize or are aware of plant-based nutrition -Otherwise, reliance on mixed media of varying qualities and word of mouth -Desire for more programs that promote plant-based eating	*Until the medical community gets more committed to nutrition and the impacts on health, I don't think much is going to change. It's very easy to go to the doctor and just say give me a script.* -- **Vegan, Male, 72, P#08** *When I worked at [a co-op], there was a voucher program…through… the UVM Doctor Networks and so folks ….show up for certain appointments…[and are given] a coupon book…[for] fresh vegetables…then…they would redo the health data. Give them another book of coupons…I think if [our local health network] could be involved with that kind of program, that would be amazing.*-- **Vegan, Female, 51, P#02** *There's so much information out there and so much of it…can't be true because it contradicts other things …I've gotten to the point where…the only things about nutrition that I know to be completely true are water is good for you…and vegetables are probably good for you.* – **Flexitarian, Female, 33, P#27**	-Build medical or RDN practices that specialize in plant-based nutrition in rural communities (physically or virtually). -Encourage reputable sources of plant-based nutrition -Complete routine monitoring of the nutrients above to ensure adequacy and adjust supplementation and nutrition counseling accordingly -Bolster existing food access organizations to bridge the gap between the community and the medical field

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APPENDICES

A. Demographic and Diet Survey

Are you aged 18 years or older?

- ○ Yes
- ○ No

What is your zip code?

_____

Have you lived in a rural area for at least two years?

- ○ Yes
- ○ No

In the typical week, how many times do you eat red meat, poultry or fish?

- ○ Five times or more
- ○ Four times or fewer
- ○ I don't eat any red meat, poultry or fish

In the typical day, how many cups of vegetables do you eat?
(Examples of 1 cup of vegetables include 3 broccoli spears, 1 cup of cooked leafy greens, 2 cups of lettuce, 12 baby carrots, 1 large sweet potato, or 1 large tomato)

- ○ 2.5 cups or more
- ○ Less than 2.5 cups
- ○ I do not eat any vegetables

In the typical day, how many cups of fruit do you eat?
(Examples of 1 cup of fruit include 1 small apple, 1 large banana, 1 large orange, 8 large strawberries, 1 medium pear, 2 large plums, or 1/2 cup of dried fruit.)

- ○ 2 cups or more
- ○ Less than 2 cups
- ○ I do not eat any fruit

In general, do you believe that you are a healthy eater?

- ○ Yes
- ○ No

Are you willing to take part in an audio-recorded interview?

- ○ Yes
- ○ No

Do you share a household with anyone who has previously participated in this study?

- ○ Yes
- ○ No

In what county do you live?

_____

Which if the following dietary patterns do you most closely identify with?

- ○ Pesco-vegetarian (consuming no meat but fish)
- ○ Flexitarian (limiting consumption of red meat, poultry or fish to 4 or fewer times per week)
- ○ Vegan (not consuming any animal products)
- ○ Vegetarian (not consuming any red meat, poultry or fish)
- ○ Other _____

Compared to the average American, I would rate my nutrition knowledge as:

- ○ Above Average
- ○ Average
- ○ Below Average

B. Semi-Structured Interview Guide

- **Opening Questions that Develop Rapport**:
    - Can you tell me about what you ate for dinner last night?
        - Probe: Is this a "typical" meal for you?
        - Probe: If not, what would be considered typical?

    - Overall, how would you describe the way that you eat?
        - Probe: If you were to tell a friend about the types of foods you eat, how you identify, those sorts of things.

- **SHOW DIAGRAM OF A PLANT-BASED DIET (Image 1)**
    - Define plant-based diet in the context of this study
        - A dietary pattern **dominated by fresh fruits and vegetables and minimally processed plant-foods** and *decreased* consumption of meat and animal products. It doesn't necessarily mean vegan or vegetarian, but it includes them. You'll see in this diagram, that about half the plate is fruit and vegetables, and we've got these smaller slivers for meat and animal products (or if someone wanted to eat plant-base alternatives), and here this section for plant sourced proteins, like nuts seeds and legumes, this section would get bigger, as someone eats less animal-based proteins from the other section.

- **Personal Perspectives and Experiences of Eating Plant-Based**:
    - I'm curious to learn more about why you eat a plant-based dietary pattern.
        - Probe: What are some of the reasons that you do it?

    - What was your experience starting a plant-based diet?
        - Probe: How long have you been eating this way?

    - On a 10-point scale from 'very easy' to 'very difficult', how would you categorize your personal experience eating a plant-based diet in rural Vermont?
        - Probe: What made you choose this number?
        - Probe: What factors make it easy?
        - Probe: What factors make it difficult? (cost, time, availability, seasonality, etc?)

- **Outside Perceptions of Plant-Based Diet:**
    - What do you think the people that you normally eat with think about a plant-based diet?
        - Probe: Do you ever get pushback?
        - Probe: Do the people around you eat in similar ways?
        - Probe: Are there differences between friends and family?

        - Probe: What do you siblings think?

    - What do you think other people in your community think about plant-based diets?

- **Community Recommendations**:
    - If you were to give tips to a friend or a neighbor about how to eat a plant-based diet, what would you say?
        - Probe: Do you have tips, hacks or recommendations that make eating a plant-based diet easier in general?
        - Probe: How did you learn about that?

    - If you could make a change in your community that would make it easier for other people to eat plant-based, what would it be?
        - Probe: Tell me more about that.
        - Probe: How would you suggest that change gets implemented?

- **Questions about nutrients of concern**:
    - Do you have any concerns about the overall healthfulness of a plant-based diet?
        - Probe: Tell me about them.
        - Probe: Are there any nutrients that you are concerned about on a plant-based diet?

    - What do you think about when choosing plant-based protein foods?
        - Probe: What are your thoughts on plant-based meat alternatives?

    - Do you seek out any specific foods or food combinations to fill in possible gaps in your diet from eating very little animal products?
        - For example: Peanut butter and jelly sandwich to make a complete protein or nutritional yeast for B12?
        - Probe: I am interested to hear more about that.

    - ***Specific questions based on responses to the survey such as:***
        - Nutrients Concerned About:
            - I see from the survey that you are not concerned about any nutrients; can you tell me more about what you do to cover all of your nutritional bases?
            - I also noticed that you put _____ as a nutrient that you're concerned about, and I'm curious to see if you've ever thought about taking a supplement for that as well?
            - I see that you are concerned about ____ can you tell me a little bit about that?

        - Vitamins/Supplements Regularly Taken:
            - From the survey I can see that you take a few supplements like _____. Can you tell me a little but more about your decision to take them? How long have you been taking them?
            - From the survey I see that you don't take any supplements, can you tell me a little bit more about that?
        - Foods Consumed Often:
            - From the survey, I see that that _____ are a staple in your diet- can you tell me a little bit more about how those fit into your diet?
        - Foods Consumed Rarely/Never:
            - I see that you rarely or never eat foods like _____. What comes to mind when you think about those foods?

- **Closing questions**:
    - Is there anything else about eating a plant-based diet in your community that you would like to share?
    - Is there anything else about diet planning that we haven't talked about that you would like to mention?

C. Nutrients of Concern Codebook

CODING GUIDELINES

- Anytime a **primary** question directly precedes a piece of text to be coded, include the question in the coded text. However, if the question and the relevant text are separated, there is no need to code the question.
- Include **follow-up** questions immediately preceding a piece of text only if it helps to clarify the content.
- If there is back and forth in an exchange, do not code the middle content if it is not relevant; make it two separate sections as opposed to one large one with non-relevant information in the middle.
- Only code as much text as is relevant to clarify meaning and context of a comment.
- Include interviewer/interviewee identifiers
- Do not include "ums" etc., unless they occur in the middle of a segment of text.
- Code complete sentences.

CODE	DEFINITION	WHEN TO USE	WHEN NOT TO USE	EXAMPLES
AA. NUTRIENTS OF CONCERN AND SUPPLEMENTATION	*Discussion regarding specific nutrients of concern in a plant-based diet in either the context of general nutrition or supplementation*			
AA1. OMEGA-3 FATTY ACIDS	See AA.	See AA.	See AA.	
AA2. IRON	See AA.	See AA.	See AA.	
AA3. ZINC	See AA.	See AA.	See AA.	
AA4. IODINE	See AA.	See AA.	See AA.	"So when I cut back the salt, I was doing more Himalayan salt was what was in there and became very aware that I was probably going to start running an iodine deficiency."
AA5. CALCIUM	See AA.	See AA.	See AA.	*"So choosing dairy products to get to enough calcium. Um, just the bioavailability of calcium and plant-based foods is pretty poor."*
AA6. VITAMIN D	See AA.	See AA.	See AA.	

AA7. VITAMIN B12	See AA.	See AA. Include reference to other B vitamins as well.	See AA.	
AA8. MULTIVITAMIN	See AA.	See AA.	See AA.	
AA9. OTHER NUTRIENT OR SUPPLEMENT	If participant mentions a different nutrient that they are concerned about or supplement that they take that is not listed in AA1-AA8.	See AA. Includes adopting a plant-based diet for lower cholesterol/saturated fat Include comments if a participant notes that they have no nutritional concerns for a plant-based diet.	See AA..	*"I feel like red meat is probably bad for you. Umm… I mean, my cholesterol is okay, but I feel, for cholesterol purposes, I just feel [pause]… it's healthier."* *"I take…Magnesium… I also take a probiotic."*
AA99. GENERAL REASONS FOR NOT TAKING SUPPLEMENTS	Comments related to not taking vitamins and supplements	Including that they prefer to get nutrients from foods or never thought about it		*"I haven't ever felt the need to take them. I know that the water… I know that a lot… I shouldn't say, no… I have read or been told that a lot of them are not as bioavailable as food sources. And like I don't know… they could degrade in the jar."* *"I don't think that [supplements are] necessary. I don't feel deficient in anything. I believe our bodies absorb most of our nutrients through food."*
BB. SPECIFIC FOODS FOR NUTRIENTS OF CONCERN	Use to capture discussion regarding practices and ideals related to specific foods that contain nutrients of concern *Use this code when the foods are mentioned, regardless of the context is about how the foods relate to nutrients of concern; also include discussion of why a participant chooses NOT to consume a specific food*			
BB1. NUTRITIONAL YEAST	See CC.	See CC.		

BB2. WALNUTS	See CC.	See CC. Include discussion about other nuts as well		
BB3. SEEDS	See CC.	See CC. Includes chia, hemp and flax.		
BB4. ALGAE/SPIRULINA	See CC.	See CC.		
BB5. FORTIFIED NON-DAIRY MILKS	See CC.	See CC. Include discussion of non-dairy milks, even if they do not explicitly mention fortification		
BB6. SEAWEED	See CC. Includes reference to dulse	See CC.		
BB7. IODIZED SALT	See CC.	See CC.		
BB8. PROTEIN POWDER	See CC. Include discussion of Collagen Powder.	See CC.		
BB9. OTHER FOODS THAT COVER A NUTRIENT OF CONCERN THAT WAS NOT INCLUDED IN THE SURVEY	Comments related to using specific foods to address a nutrient of concern on a plant-based diet that was not included on this list	Examples include: Dairy for calcium or DGLV for iron		*"…if I can get calcium from black beans and from bok choy and other options… cabbage, broccoli all have great calcium in it. I would prefer that."*
CC. PROTEIN CONSIDERATIONS		Do not use; parent code.		
CC1. PROTEIN SOURCES	Use for general discussion of plant- based protein (includes egg and dairy)	Includes discussion of meeting protein needs or specific protein foods.	Do not use if content is specifically related to other DD. categories such a protein complimenting, and sensory factors.	*"So I guess any kind of legumes and beans… for sure. Nuts are huge and I use them in different ways…And then of course, you know, tofu. My kids eat tempeh as well."* *"So I know that I can't have a lot of soy because I'm sensitive to it, so that unfortunately rules out… that's part of the reason why I'm so big on beans, right? I have some tofu, but I can't have a lot of it,*

				and I can't do like soy milks or stuff like that just because I react to it." *"Am I getting enough protein? I'm like, you probably are honey, because we all typically get too much protein."*
CC2. PROTEIN COMPLIMENTING	When participants describe the idea of combining proteins source to create a complete protein			*"I generally follow the guidelines of some kind of grain with bean combination, because it makes it more of a complete protein. I try to incorporate it on some... usually anyways, but try to keep that mindful."* *"I read one time that rice and beans makes a complete protein. I don't even know if that's 100% true, but I remembered it and believed it. And so when I have rice I do beans with the rice, almost always. "*
CC3. SENSORY FACTORS ASSOCIATED WITH PROTEIN FOODS	Comments describing the importance of sensory factors when choosing protein foods, including taste, texture and satiety			*"But I'm usually looking for something more from a staying power. So looking for protein in a meal as a stick with you."* *"I'm not counting macros and trying to make sure everything is correct I'm like… I feel like I would be tired or something if I wasn't getting enough protein."*
DD. MISCELLANEOUS NUTRITION TOPICS		Do not use; parent code.		
DD1. IMPORTANCE OF VARIETY/NUTRITIONAL DENSITY TO MEET NEEDS	Comments related to using variety and/or nutritionally dense foods to cover nutritional bases (using variety to cast a wide net)	Include discussion of balance.		*"I think I've just become more aware of seeking out those more higher nutritional, better foods and making sure that even if we don't eat them all the time, that we're still incorporating them into our diet instead of just eating the same things all*

				the time. Maybe that's more of it… is getting more of a variety has been more of a focus for me."
DD2. SOURCE OF NUTRITION INFORMATION	Comments regarding where the participant gets their nutrition information from	This could include health professionals, media, general discussion "I've heard" or "I've read", etc Includes using blood work to check levels and inform decision to supplement.	Do not use if general information not specifically related to nutrition; use C1. GENERAL INFORMATION SOURCES in positive deviant codebook	*"So just that everything is grounded in some sort of medical consult with my acupuncturist, or someone in terms of recommendation."* *"They have, you know, they have doctors, scientists on the show. And if it would just go over every, every podcast is like a different nutrition topic."*
DD3. CHALLENGES TO THE NUTRITIONAL ADEQUACY OF PLANT BASED DIETS	Comments related to experience getting doubted about the nutritional adequacy of plant-based diets	Include questions like "How do you get enough protein, iron, etc.?"		*"What's wrong with you? Where are you getting your protein? You've heard… if you're plant-based, you've heard all the stories….Where are you getting your calcium? All that stuff. And it's just like… we just don't get on the soapbox anymore."* *"What do you eat?" "I can't imagine trying to figure out what to eat if I couldn't eat those things." And also the perception is somehow I'm missing out because I don't eat processed and fast food and meats and things like that."*
DD4. PROCESSED FOODS AND HEALTH	Comments that discuss processed foods in the context of health	Include comments related to "junk food vegans" and health of plant-based meat alternatives		*"The more we can get like actual like whole foods instead of just like this processed stuff is like that's really like what's important to base [health around]…And then also that like vegan doesn't equal healthy…."* *"I like [plant-based meat alternatives], I enjoy them, but I try not to like, eat them too much because like Yeah, it's just like*

				processed stuff that it's vegan, but it it's not healthy."
DD5. FOOD HACKS	Creative ideas for integrating foods with nutrients of concern to make a plant-based diet easier	Include examples of using plant-based alternatives to make a food that is not normally plant-based plant-based (i.e., cashew cheese); Can include ingredients that are not specifically mentioned in **CC. SPECIFIC FOODS FOR NUTRIENTS OF CONCERN**		*"For the almond milk and I'd say what we incorporate them in, we do we make vegan pancakes so that calls for a plant milk."* *"I dry and powder greens, and then I put that in everything. So to try to keep the calcium because there's a lot of calcium in dark greens, so that's one of them."* *"Oh, flax. Yeah and I use that as just egg substitute."* *"All my carrot tops get turned into pesto. And Kale stem pesto and such….And if I can't process it, toss it into the freezer so that I can deal with it at another time."* *"It's called the, it's the vegan feta pasta…. it uses cashews, nutritional yeast, garlic powder, pasta and tofu. And basically you kind of just, you grind it up into like uh, it's like, it's like a vegan feta."*
DD6. OTHER CONCEPTS RELATED TO NUTRITIONAL ASPECTS OF A PLANT-BASED DIET.	Capture other concepts related to nutrition or nutritional planning on a plant-based diet not captured elsewhere in the codebook.	Include comments related to the GI adjustment needed for plant-based diets due to increased fiber Include comments that show a general understanding of basic nutritional concepts not tied to a specific nutrient or		*"…they need to figure out which proteins they can digest best and enjoy best. Whether it's beans, whether it's tofu, whether it's like eating just a ton of your protein, heavier vegetables. I know some people are really bothered when they're adjusting to eating more beans."* *"There were definitely was like uh a period where consuming the increased*

		supplement, including but not limited to bioavailability, nutrient needs, needs for nutritional planning on a plant-based diet Include comments related to changed in nutritional needs throughout the lifecycle (i.e. aging, etc)		*amount of fiber, it… Yeah, there's like an adjustment period with your thought to get used to it."* *"I've gotten to the point where I tell people the only things about nutrition that I know to be completely true are water is good for you in moderation, and vegetables are probably good for you."* *"And obviously there's a whole other side of that, that I know about is that, you know, your body only takes up a certain amount of, you know, the bio availability side of it that your body, like, digests a certain amount."* *"And we evolved with the plants, eating the plants and eating a huge variety of plants, far above what people today eat….And I don't think that our physical bodies have evolved with the pace of the changes in food that we've introduced and become dependent on as a species. So I think it's essential for… to continue our physical wellbeing. The nutritional deficiencies are creating long term changes…"*